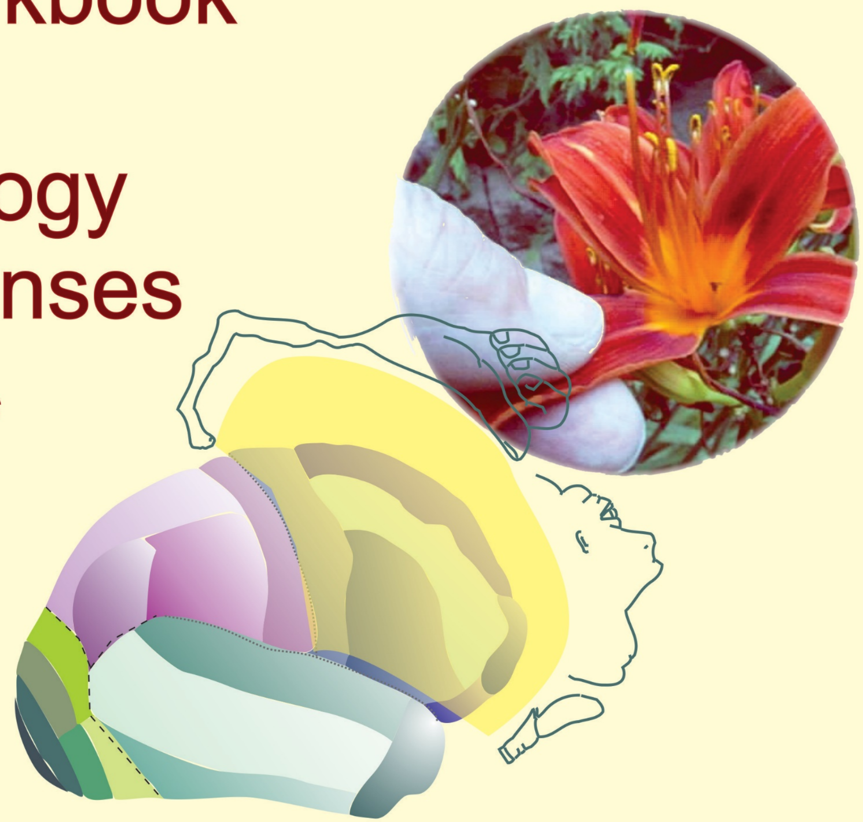
Q & A Workbook for Physiology of the Senses

by

Tutis Vilis



Preface

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Tutis Vilis.
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About the Author

Tutis Vilis is a Professor of Physiology at the University of Western Ontario at London, Ontario. He has been teaching at the Schulich School of Medicine since 1976 and has been teaching Sensory Physiology since 1981. Tutis Vilis' research has been devoted to understanding sensory and motor neurophysiology. This research was continuously funded for more than 40 years by the Canadian Institutes of Health Research. Tutis Vilis has published over 100 refereed journal articles and book chapters. For more information, see www.tutis.ca .

Other books by Tutis Vilis:

- *The Physiology of the Senses* available for iOS devices or Mac on iTunes and on Kindle for all devices.
- *My Brain Notes for Medical Students* available for iOS devices or Mac on iTunes and on Kindle for all devices.
- *Survival Skills for Graduate Students* available on Kindle.

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In particular I thank my wife Rita, whose constant support and insightful and tireless editing made this book possible.
As well, my thanks go to our children Elena, Aleks, and Jurgis and grandchildren Kaz, Sven, Oliver, Finley, Braelyn, and Riley.

If you find any errors or would like to make any other comments about this book, feel free to contact me at vilis@uwo.ca .

Introduction

This a workbook of questions and answers that reinforce, clarify and expand the concepts presented in The Physiology of the Senses. For each of this book's 12 chapters, a series of practice problems are presented to review and extend the book's basic conceptual building blocks. For each question an explanation is given for why one answer is more correct than the others and why each of the others are less so. These problems are important because they allow students to develop and perfect their problem-solving skills, skills that can then be applied to any field of study. The goal of both books is to provide students with a simple introduction to how our senses function. I have tried to minimize the clutter of new terms introduced. This is because I have found that a huge number of terms is a hindrance to the understanding of underlying concepts. These books emphasize how things work rather than what they are called.

Students have been attracted to my course in Sensory Physiology here at Western because success in the course is based not on an ability to memorize, but largely on one's **problem-solving** ability. I have placed this emphasis on problem-solving because it is a necessary skill for all types of career, including graduate studies and clinical practice. My enthusiasm for problem-solving stems from my bachelor's and master's degrees in engineering. This field relies on problem-solving as a tool for learning. I have found that biology, physiology and medicine depend more in memorization. This Workbook is my modest attempt to change that.

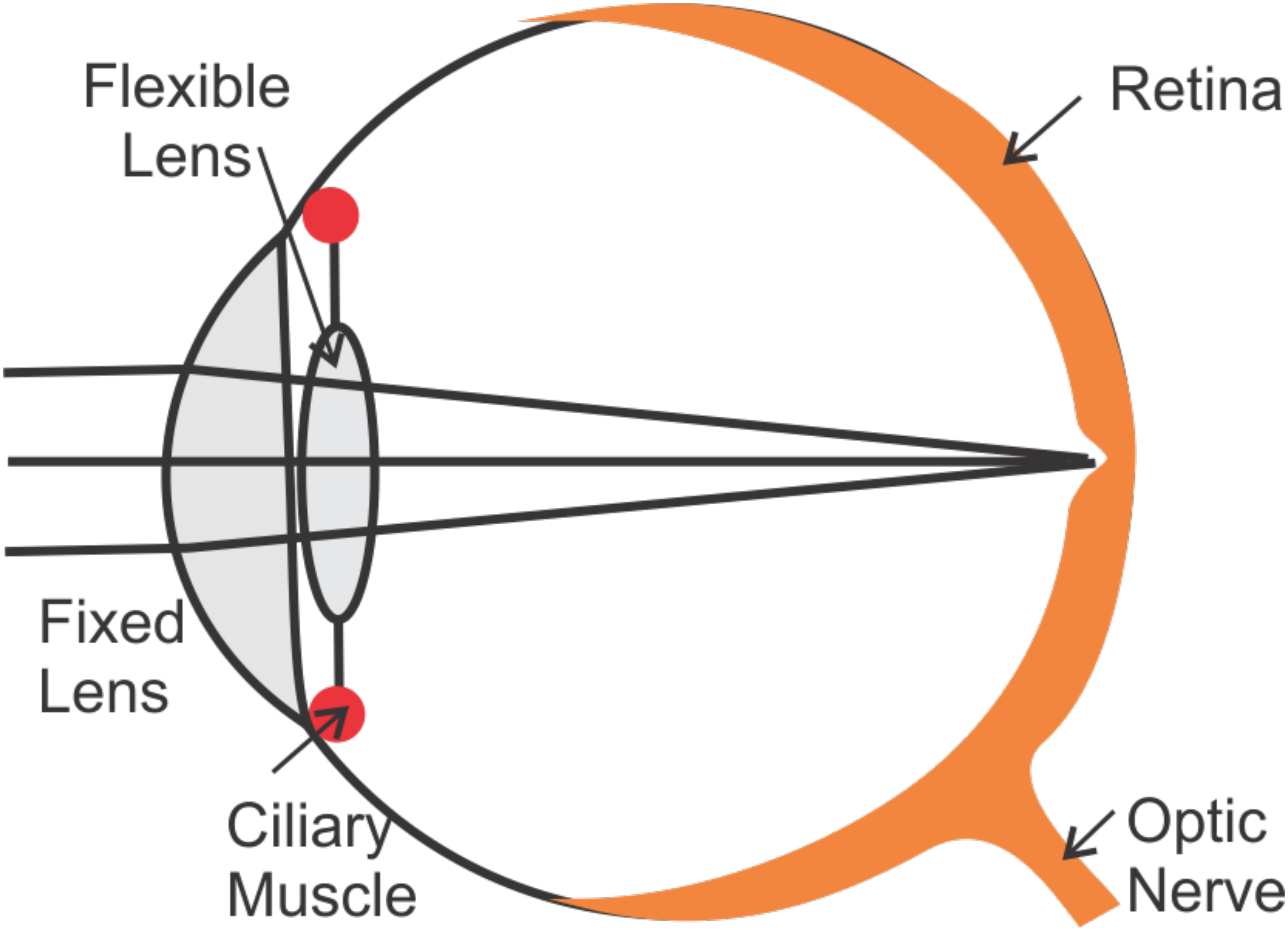
In the first lecture here at Western, the students are asked a problem used by Microsoft to select potential employees: "Why are manhole covers mostly round?" We compared the astonishing number of possible answers and discovered that:

- there is often more than one right answer,
- some right answers are better than others, and
- which answer is better can vary depending on circumstances.

These points form the **key guiding principles** of the Workbook.

Both books provide students with an introduction to the function of the many stages the nervous system uses to process our sensory inputs including those of touch, taste, pain, smell, vision, motion and hearing. The focus is on a concise and lucid description for how the various brain regions function and interact. Each sensory modality is used to exemplify a particular aspect of sensory processing from how stimuli are encoding at the periphery to the feature extraction processes of the sensory cerebral cortex. The first half deals with vision - from its detection in the eye to the function of the cerebral cortex in the recognition of objects, including faces and the cortical role in directing one's actions to these objects. This emphasis on vision stems from the fact that more is known about vision than the other senses and because the mechanisms adopted by the visual system are mirrored and adopted by the other senses.

Chapter 1: The Eye



Problem 1: An individual is diagnosed by an optometrist as being far-sighted. A corrective lens is prescribed because: (pick the four possible causes)

a) of retinal damage.	
b) the eyeball is too long.	
c) the eyeball is too short.	
d) the lens is too flat.	
e) the lens has lost its ability to spring back to its normal round shape.	
f) the springs that attach the lens to the ciliary muscle are not taut enough.	
g) the ciliary muscle cannot contract.	

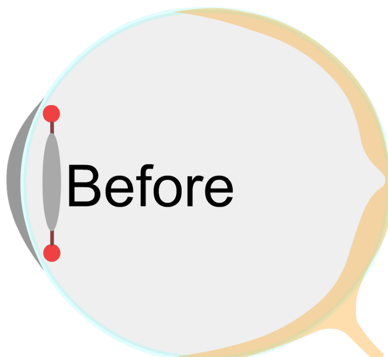
Problem 1: An individual is diagnosed by an optometrist as being far-sighted. In this case, a corrective lens is applied because (pick the four correct answers)

Answer

a) of retinal damage.	No. Retinal damage cannot be corrected by corrective lenses.
b) the eyeball is too long.	No. This patient is near-sighted. To correct for this, the patient is prescribed a concave lens. This lens helps to refocus the object onto the retina rather than in front of it.
c) the eyeball is too short.	**Yes.** The eyeball is too long when one is far-sighted.
d) the lens is too flat.	**Yes.** If the lens was too flat one would be far-sighted.
e) the lens has lost its ability to spring back to its normal round shape.	**Yes.** If the lens has lost its ability spring back to its normal round shape one would be far-sighted.
f) the springs that attach the lens to the ciliary muscle are not taut enough.	No. If the springs that attach the lens to the ciliary muscle are too loose, the lens springs back to its normal round shape and the patient becomes near-sighted.
g) the ciliary muscle cannot contract.	**Yes.** If the ciliary muscle cannot contract then the lens remains too flat, and the patient becomes far-sighted.

Problem 2: Suppose you selected laser surgery to correct a problem of not being able to focus on near objects. What would the laser cut and what is the shape of the cut?

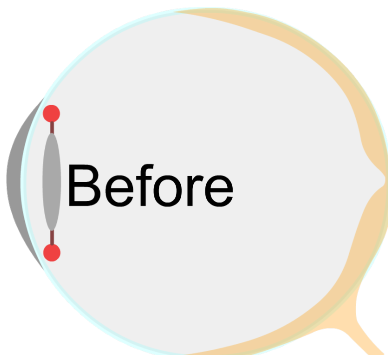
Select one. (Before is the shape before surgery. After is that after surgery.)

		Make the outer edge of cornea thinner.		Make the middle of the cornea thinner
		Make the flexible lens rounder.		Make the flexible lens thinner

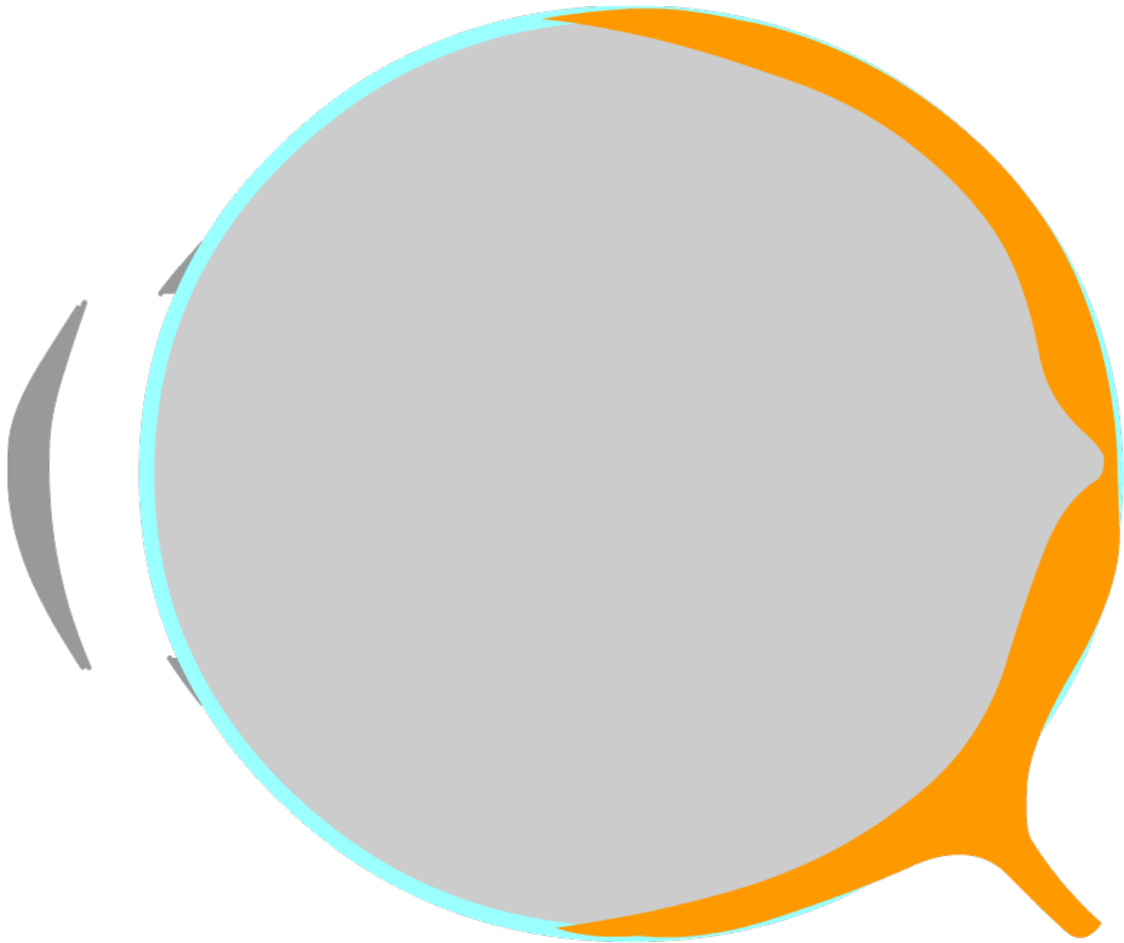
Problem 2: Suppose you selected laser surgery to correct a problem of not being able to focus on near objects. What would the laser cut and what is the shape of the cut?

Select one. (Before is the shape before surgery. After is that after surgery.)

Answer

		Make the outer edge of cornea thinner. **Correct.** A laser cuts the cornea, the fixed lens at the front of the eye. Because the variable lens is too flat, you want to make the cornea rounder i.e. more convex.		Make the middle of the cornea thinner. No. To view something close, the cornea should be rounder.
		Make the flexible lens rounder. No. A laser cuts the cornea, the fixed lens at the front of the eye.		Make the flexible lens thinner. No. A laser cuts the cornea, the fixed lens at the front of the eye.

However, the cornea, particularly at the edge, is rather thin. A cut at this edge makes this even thinner. The eye can rupture if the pressure inside becomes too high or the pressure outside the eye becomes too low (such as when one goes climbing high in the Andes).

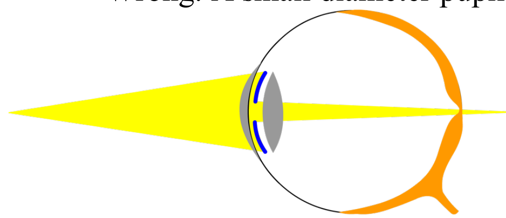
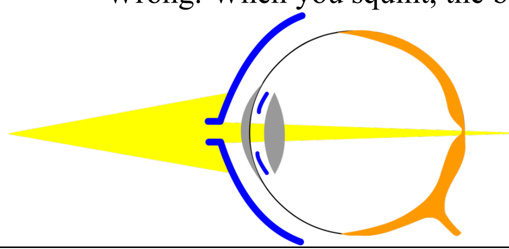


Problem 3: Which of the following do not determine the sharpness of images formed on the retina?

a) The thickness rather than the curvature of the cornea (the fixed lens)	
b) The curvature of the flexible lens	
c) The length of the eyeball	
d) The pupil diameter	
e) The distance between the upper and lower eye lids	

Problem 3: Which of the following do **not** determine the sharpness of images formed on the retina?

Answer

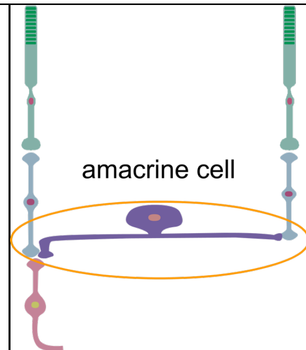
a) The thickness rather than the curvature of the cornea (the fixed lens)	**Correct!** Because the thickness of the cornea is small, it is its curvature that focuses light onto the back of the eye. For this reason, laser surgery adjusts the curvature of the cornea.
b) The curvature of the flexible lens	Wrong. The curvature of the flexible lens **does** determine the sharpness of the images.
c) The length of the eyeball	Wrong. The length of the eyeball **does** determine the sharpness of the images.
d) The pupil diameter	Wrong. A small diameter pupil can improve the focus of the image  by reducing the diameter of the blurred image at the back of the retina.
e) The distance between the upper and lower eye lids.	Wrong. When you squint, the beam of light becomes narrower as  does the area of blur on the retina.

Problem 4: Why must some amacrine cells use action potentials rather than graded potentials?

a) Amacrine cells connect rods, in the peripheral retina, to ganglion cells which are also in the peripheral retina.	
b) Their receptive fields are large.	
c) One requires action potentials to conduct information over large distances.	
d) All of the above.	

Problem 4: Why must some amacrine cells use action potentials rather than graded potentials?

Answer

a) Amacrine cells connect rods, in the peripheral retina, to ganglion cells which are also in the peripheral retina.	 Yes, rods, amacrine cells, and the ganglion cells that they connect to are located in the peripheral retina. But this is not why they require action potentials.
b) Their receptive fields are large.	Yes. They connect many rods each having a large spacing. Thus, amacrine cells need to conduct information over large distances. That is true, but not the best answer.
c) One requires action potentials to conduct information over large distances.	Yes. One requires action potentials to conduct information over large distances. That is true, but you also need a and b to understand why you have large distances.
d) All of the above.	**Correct.** All the above are all true. Amacrine cells connect rods in the peripheral retina to ganglion cells which are also in the peripheral retina. The periphery receptive fields are large. They connect many rods, each having a large spacing. Thus, amacrine cells need to connect to ganglion cells over large distances. Graded potentials cannot send information over large distances, but action potentials can.

Problem 5: Early visual scientists thought that a large bright light would best activate ganglion cells. Why were they wrong?

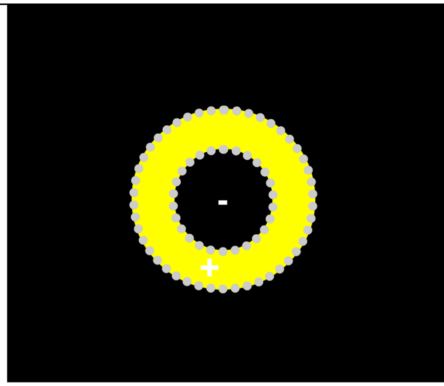
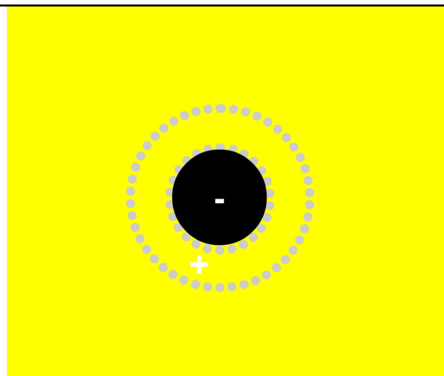
a) Because a bright light would saturate rods and cones.	
b) Because ganglion cells have an antagonist receptive field.	
c) Because a large light would activate too many ganglion cells.	

Problem 5: Early visual scientists thought that a large bright light would best activate ganglion cells. Why were they wrong?

Answer

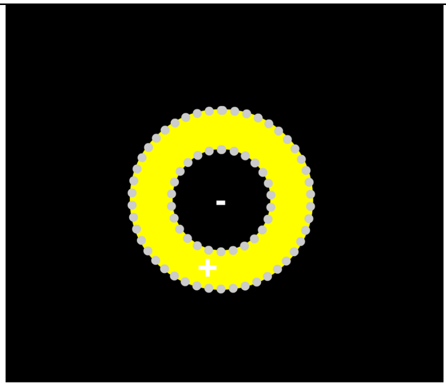
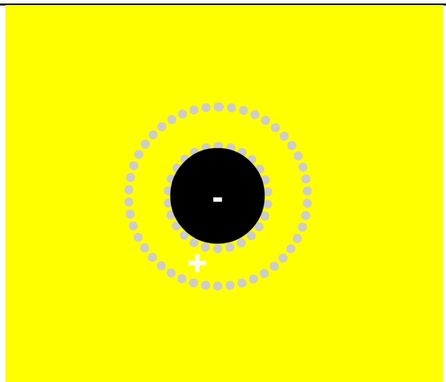
a) Because a bright light would overload rods and cones.	Yes, it is true that an overload of rods and cones would produce **less** ganglion cell activation. But they found **no** activity in most ganglion cells. Why is that?
b) Because ganglion cells have an antagonist receptive field.	**Yes, this is correct.** A large light activates both the center and the antagonist surround for ganglion cells over a large portion of the retina. The excitatory influence of the center is cancelled by the inhibitory influence of the surround.
c) Because a large light would activate too many ganglion cells.	They found **no** activity in most ganglion cells. Why is that?

Problem 6. Which stimulus would maximally activate an off-centre ganglion cell.

 a	
 b	

Problem 6. Which stimulus would maximally activate an off-centre ganglion cell?

Answer

 a	**Yes.** A light that fills the excitatory surround will produce the maximal activity.
 b	**This is also true.** One that fills everything but the inhibitory center. This is because it doesn't matter whether it is light or dark outside the cell's receptive field (the larger circle).

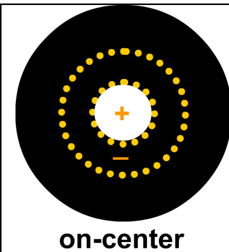
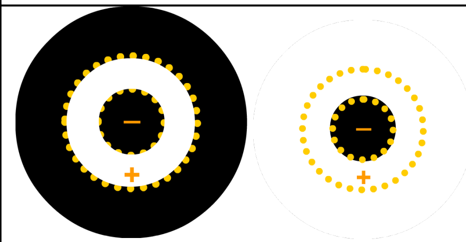
Problem 7: Which type of ganglion cell, on- or off-centre, is used to read the letters on this page?

a

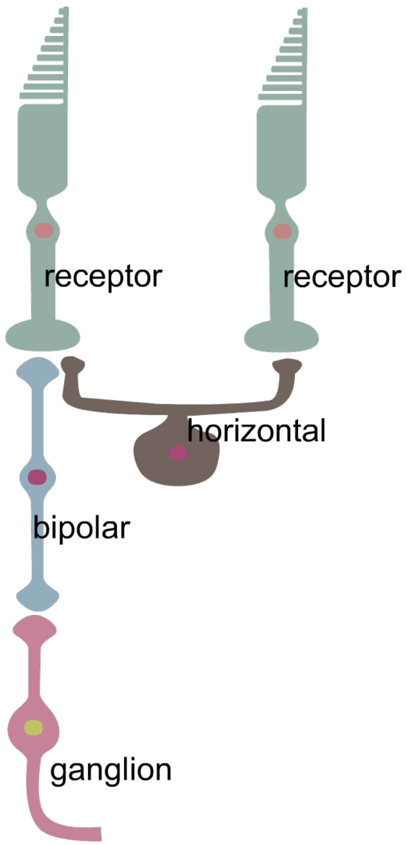
b

Problem 7: Which type of ganglion cell, on- or off-centre, is used to read the letters on this page?

Answer

 **a**	 No. The on-centre receptive field is best activated by a spot of light against a black background. Thus, these respond best for white letters against a dark background.
 b	 **Correct.** The off-centre receptive field is best activated by a white donut of light against a black background or by a black dot against a white background.  Note how this off-centre receptive field with its on surround is ideal for detecting a black dot on a white sheet. Similarly, on-centre cells would be good at detecting white characters on a black page.

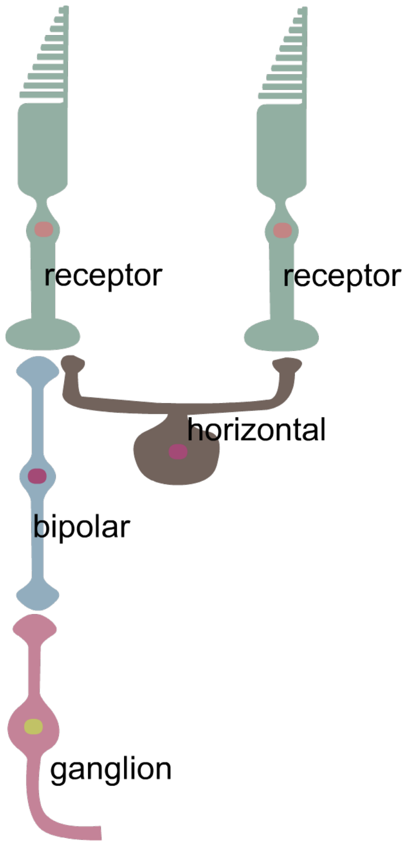
Problem 8: In which cell type does one first see an antagonist surround?



a) ganglion cell
b) bipolar cell
c) horizontal cell
d) receptor

Problem 8: In which cell type does one first see an antagonist surround? Click on your choice.

Answer

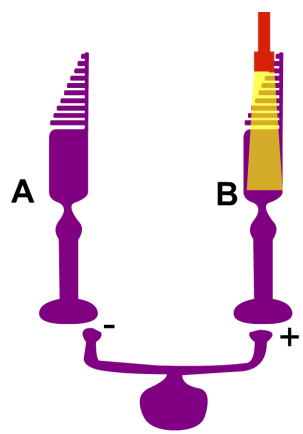


a) ganglion cell
   Yes, these have an antagonist surround but these are not the first.
b) bipolar cell
   Yes, these have an antagonist surround but these are not the first.
c) horizontal cell
   Yes, these have an antagonist surround but these are not the first.
d) receptor
   Correct.

The term "antagonist surround" means that stimuli in the center and surround of the receptive field have opposite effects.

This occurs first in the receptors, the rods and cones.

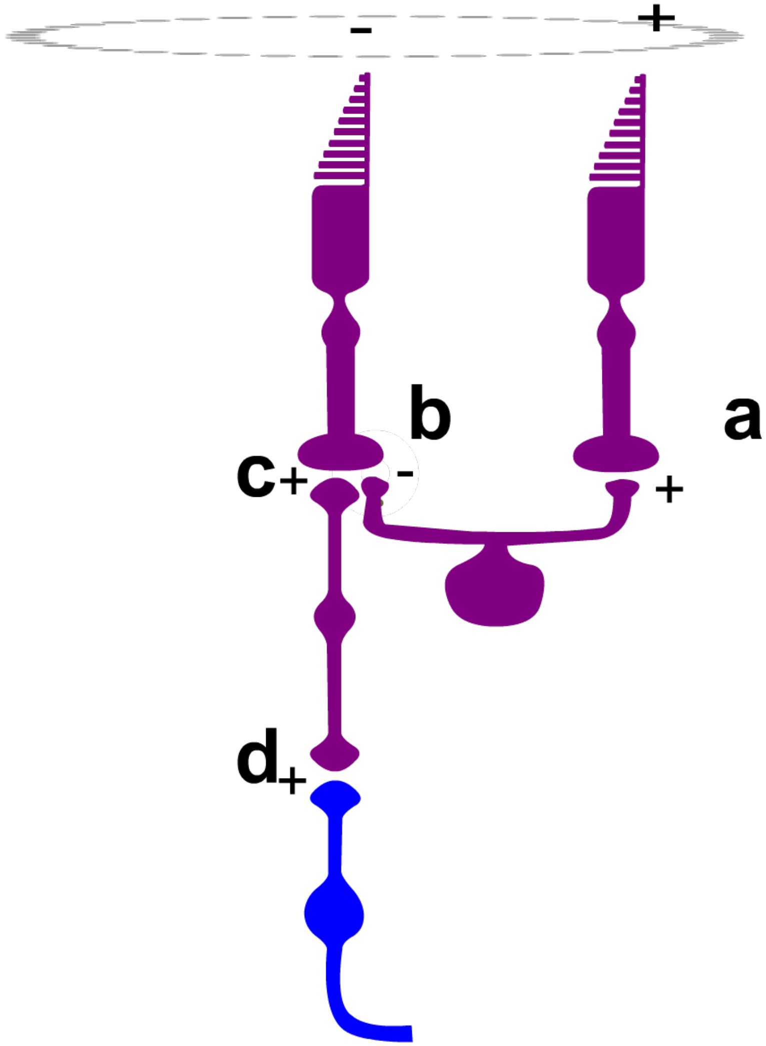
Recall that the response of a cone to light in the center is hyper polarization. When exposed to light, the voltage inside a cone decreases. This is the response of all rods and cones to light.



But the response of the center cone A to a light in the surround cone B is depolarization in cell A. This is mediated by inhibition from the horizontal cell B. Less inhibition to A, results in an increase of voltage in cell A.

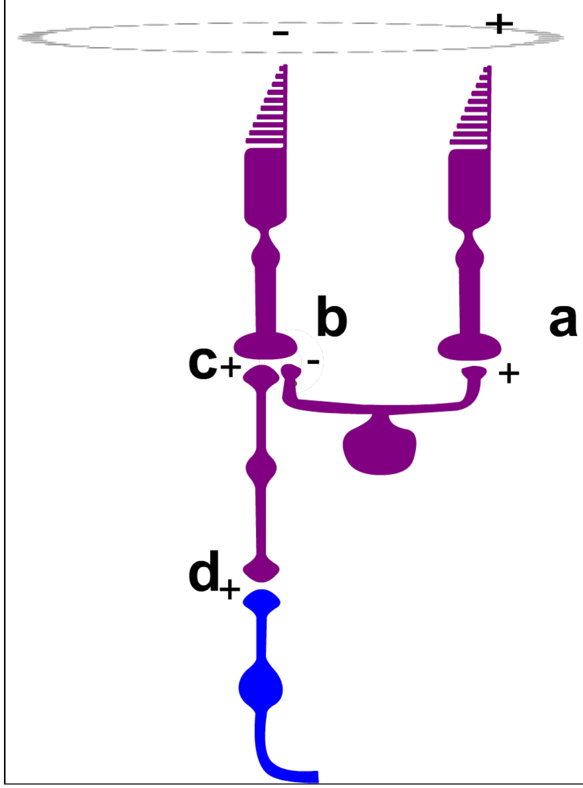
Problem 9: Which connection would one change (from excitatory to inhibitory or vice versa) to convert this on-center ganglion cell to an off-centre cell?

a) ?
b) ?
c) ?
d) ?

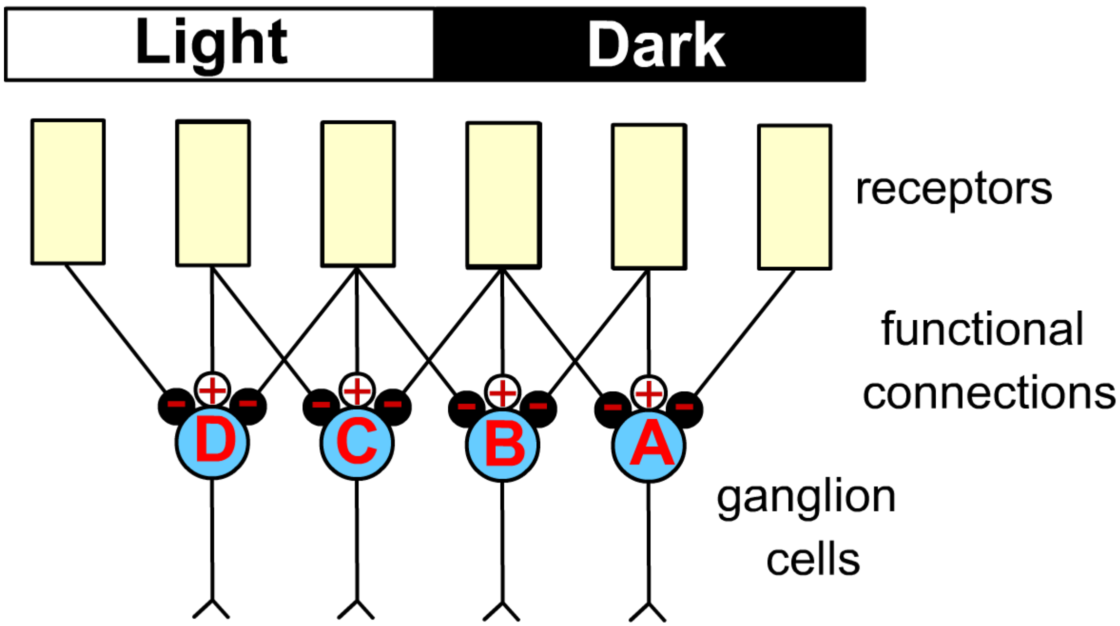


Problem 9: Which connection would one change (from excitatory to inhibitory or vice versa) to convert this on-center ganglion cell to an off-centre cell?

Answer

	a) No, this would only reverse the sign of the surround. b) No, this would also only reverse the sign of the surround. **c) Yes,** that is correct. Half the ganglion cells have a -here and are on center and the other half have a + here and are off center. Half excite and half inhibit bipolar cells. d) This is correct as well and will achieve the same as c). But for some reason the eye uses option c).

Problem 10: How ganglion cells accentuate edges. Which of the following is true? The firing rate of cell



a) D is greater than that of A.

b) D is less than that of C.

c) D is greater than that of C.

d) B is greater than that of A.

Assumptions:

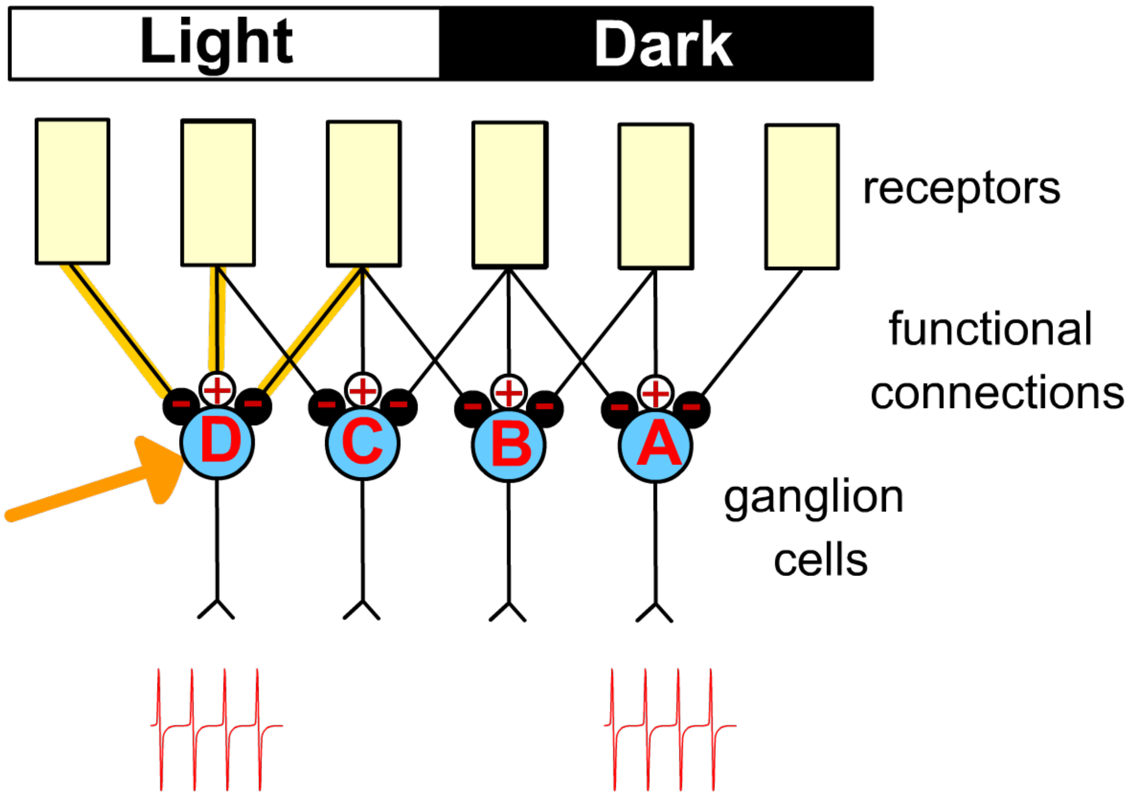
Each of the 4 are on-center ganglion cells.

The center and surround cancel each other, that is, one + equals two -'s.

+ signifies that light increases the firing rate of the ganglion cell.

- signifies that light decreases the firing rate.

Problem 10: How ganglion cells accentuate edges. Which of the following is true? The firing rate of cell



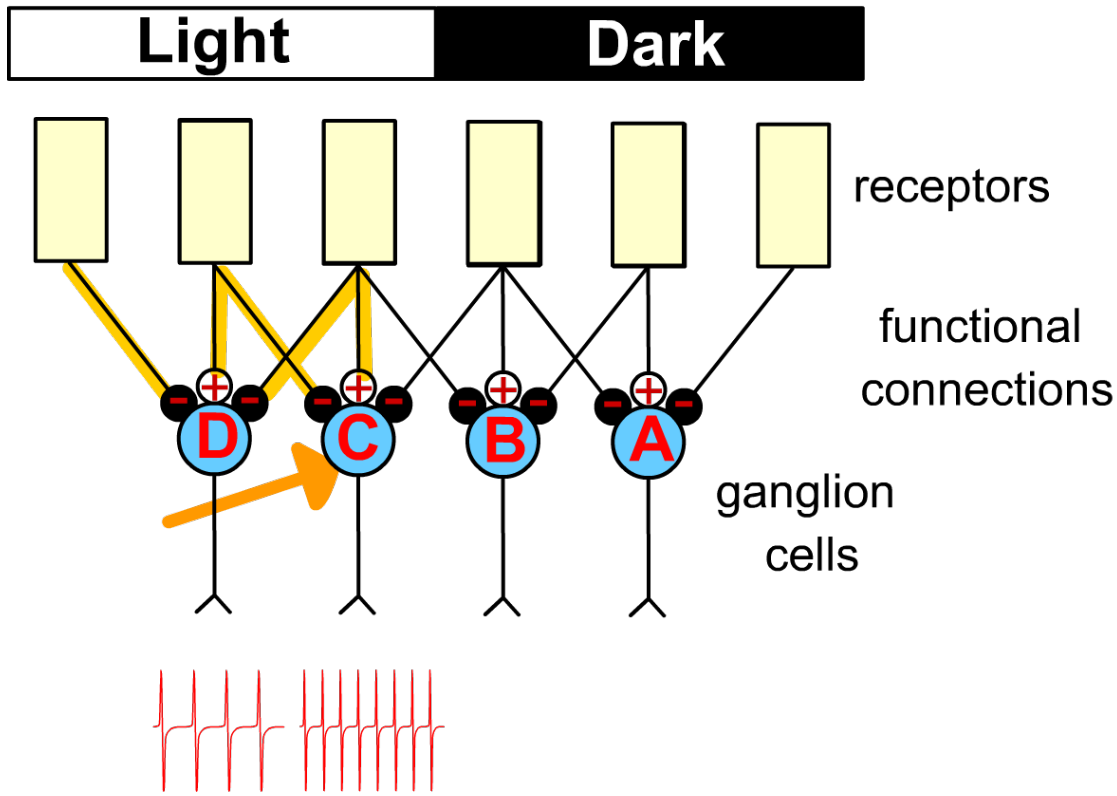
a) D is greater than that of A.

Answer

No. Cells D and A have the same firing rate.

In D, all 3 receptors are in the light. So, all of the inputs are active. The + is canceled by the 2 -'s. As in A, the firing rate does not change. It continues firing at its basal rate.

Problem 10: How ganglion cells accentuate edges. Which of the following is true? The firing rate of cell



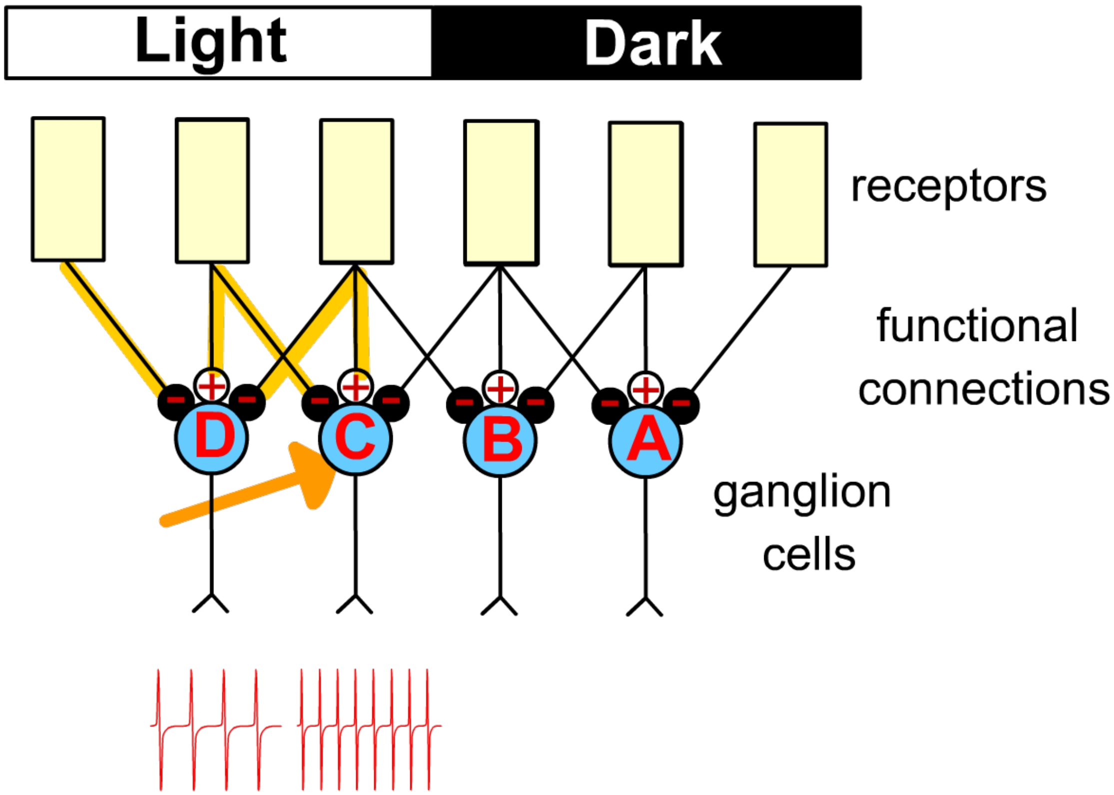
b) D is less than that of C.

Answer

Correct.

This cell receives a + and only one -
Thus, this cell fires more than cell D.

Problem 10: How ganglion cells accentuate edges. Which of the following is true? The firing rate of cell



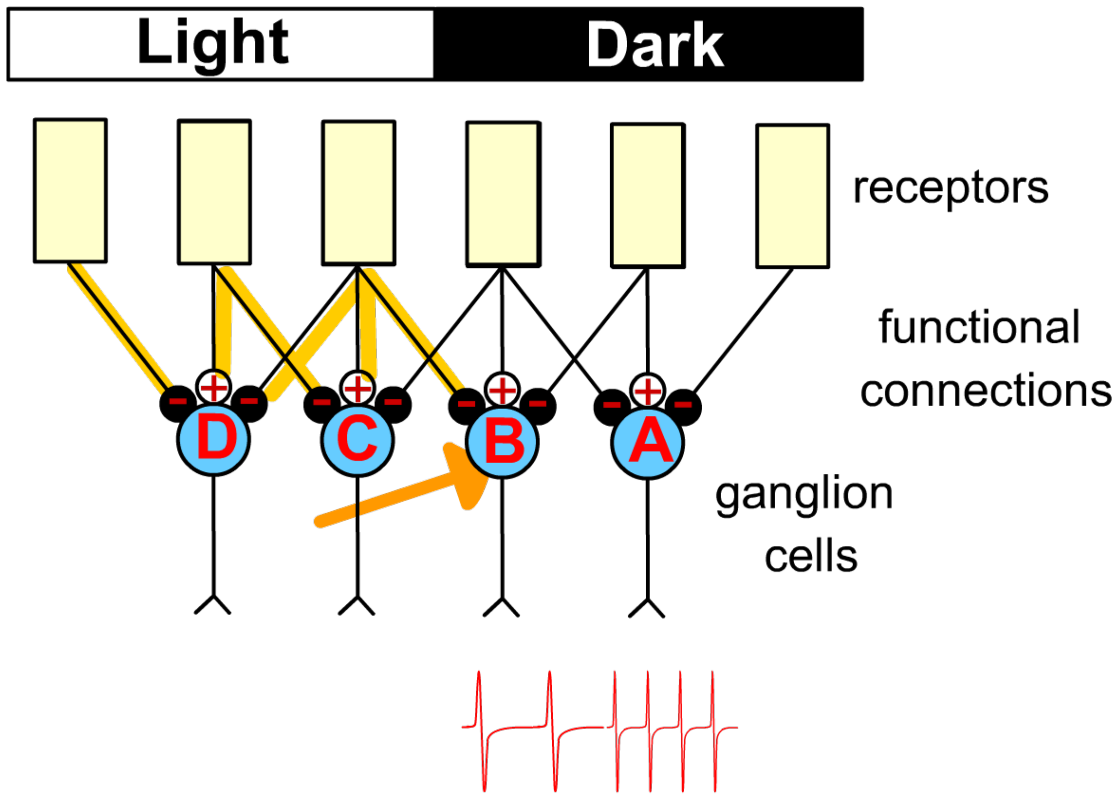
c) D is greater than that of C.

Answer

No.

This cell receives a + and only one -.
Thus this cell fires more than cell D.

Problem 10: How ganglion cells accentuate edges. Which of the following is true? The firing rate of cell



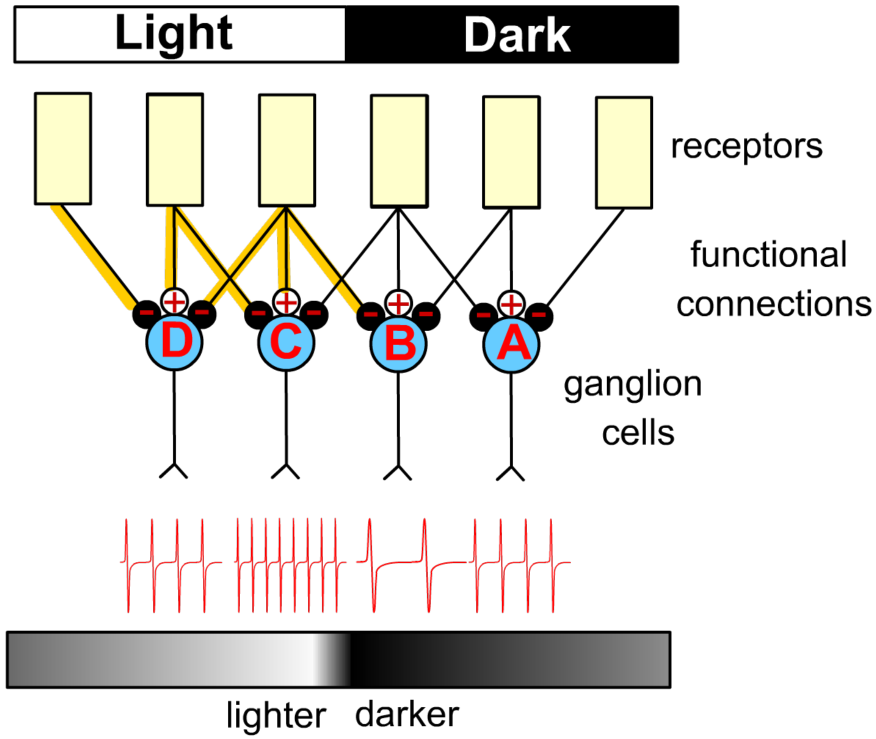
d) B is greater than that of A.

Answer

No.

Because B receives one – input it is more inhibited than A and thus produces more action potentials.

Problem 10: How ganglion cells accentuate edges. Which of the following is true? The firing rate of cell



The image that the eye sends the brain resembles this.

Answer

Thus, the only cells that change their firing rates are those at the Light/Dark edge.

Problem 11: Which has the darker center square?

Problem 11: Which has the darker center?

Answer

In fact, both centers are the same shade. What caused the illusion?

Problem 11: Which has the darker center?

Answer

What caused the illusion?

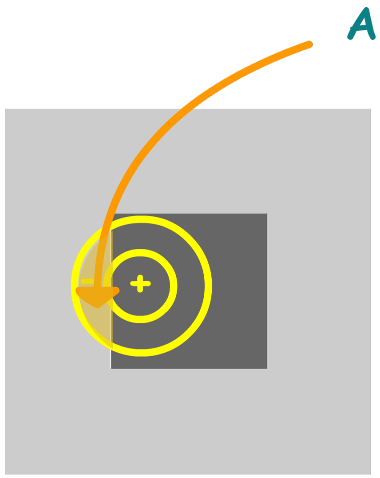
These are the receptive fields of two ganglion cells. Which is firing less?

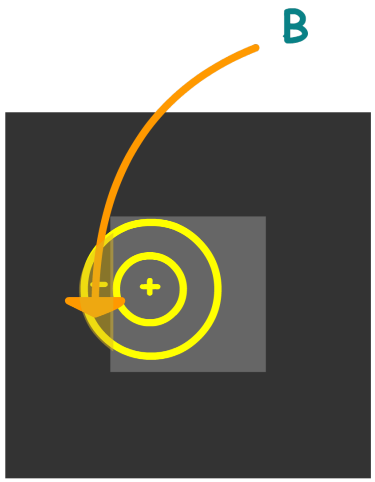
Problem 11: Which has the darker center?

Answer

What caused the illusion?

Because area A is brighter than area B, Area A inhibits the ganglion cell more.





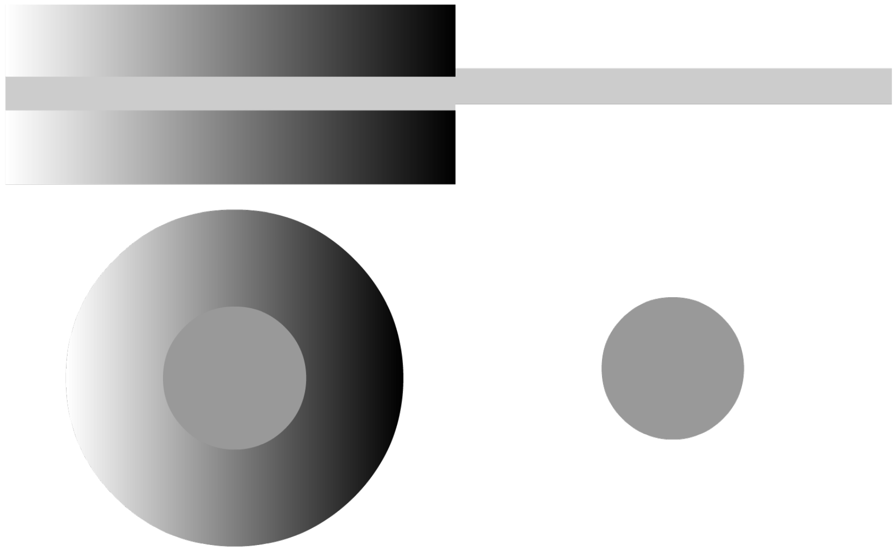
Thus, this cell is **more** inhibited, fires less and tells the brain that this center is **darker**.

While this cell is **less** inhibited, fires more and tells the brain that this center is **brighter**.

Problem 11: Which has the darker center?

Other examples of this illusion.

The center is uniform in the top middle bar and bottom middle circle.

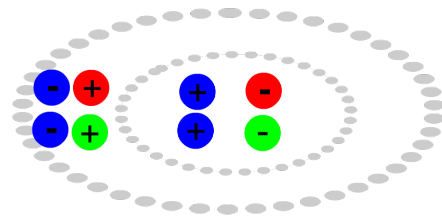


Problem 12: In a yellow-blue double opponent cell, what happens to the firing frequency when we explore the receptive field with a small spot of white light? Explain why.

a) When the spot shines in the center there is an increase and when in the surround there is a decrease.	
b) When the spot shines in the center there is an increase and when in the surround there is also an increase.	
c) When the spot shines in the center there is a decrease and when in the surround there is also a decrease.	
d) When the spot shines in the center or surround there is no change.	

Problem 12: In a yellow-blue double opponent cell, what happens to the firing frequency when we explore the receptive field with a small spot of white light? Explain why.

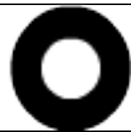
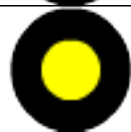
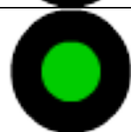
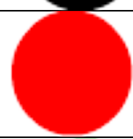
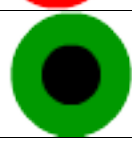
Answer



double opponent

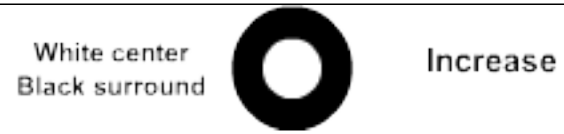
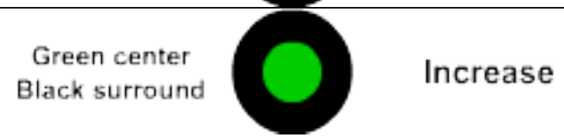
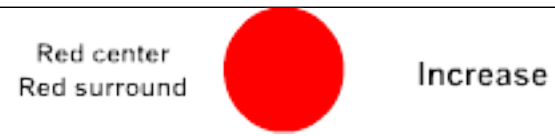
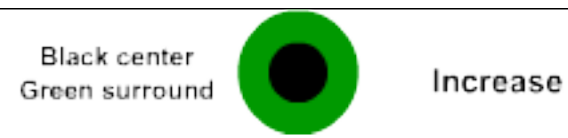
a) When the spot shines in the center there is an increase and when in the surround there is a decrease.	No. Hint the light is white, which generates no net response from the receptors.
b) When the spot shines in the center there is an increase and when in the surround there is also an increase.	No. Hint, white light is a mixture of all the colors.
c) When the spot shines in the center there is a decrease and when in the surround there is also a decrease.	No. Hint white light is a mixture of all the colors. Thus, it activates red, green, and blue cones.
d) When the spot shines in the center or surround there is no change.	Correct. White light is a mixture of all the colors. Thus, it activates red, green, and blue cones. The surround contains red, green, and blue cones. Activating all of these results in no net response. The center also contains red, green, and blue cones. Activating all of these again results in no net response.

Problem 13: Suppose you record from a double opponent cell that is activated by blue light in the center. Suppose light of the colors indicated below are shone on the center or surround of this double opponent cell's receptive field. Which of the following would be the correct cell response?

White center Black surround		Increase	
Yellow center Black surround		Increase	
Green center Black surround		Increase	
Red center Red surround		Increase	
Black center Green surround		Increase	

Problem 13: Suppose you record from a double opponent cell that is activated by blue light in the center. Suppose light of the colors indicated below are shone on the center or surround of this double opponent cell's receptive field. Which of the following would be the correct cell response?

Answer

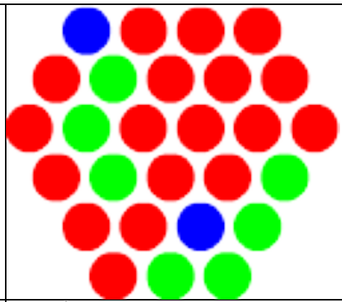
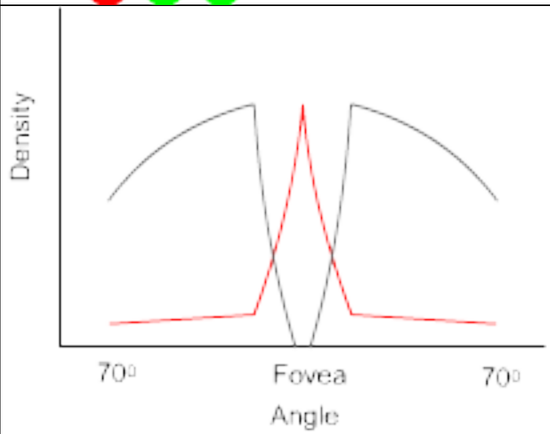
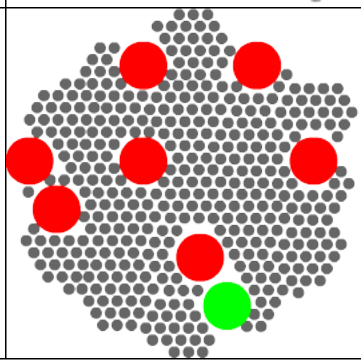
	No. White light contains all the colors, including blue and yellow. If the center is B+ (i.e. shows an increased response for blue light), then it should also be Y- (i.e. shows a decreased response to yellow light). The two would cancel and no change in the response would be observed.
	No. If the center is B+ (i.e. shows an increased response for blue light), then it should also be Y- (i.e. shows a decreased response to yellow light).
	No. If the center is B+ (i.e. shows an increased response for blue light), then it should also be Y- (i.e. shows a decreased response to yellow light). Yellow is composed of red and green light. This would activate the G- receptors in the center and result in a decreased response.
	No. If the center is B+ (i.e. shows an increased response for blue light), then it should also be Y- (i.e. shows a decreased response to yellow light). This means there are G- and R- receptors in the center and G+ and R+ receptors in the surround. The responses in the center and surround would cancel and no change in the response would be observed.
	**Correct.** If the center is B+ (i.e. shows an increased response for blue light) then the center should be Y-. This in turn means that the surround should be Y+. Yellow is sensed by red and green receptors. Thus, green light in the surround should produce an increased response.

Problem 14: Where on the retina would one find the highest density of rods?

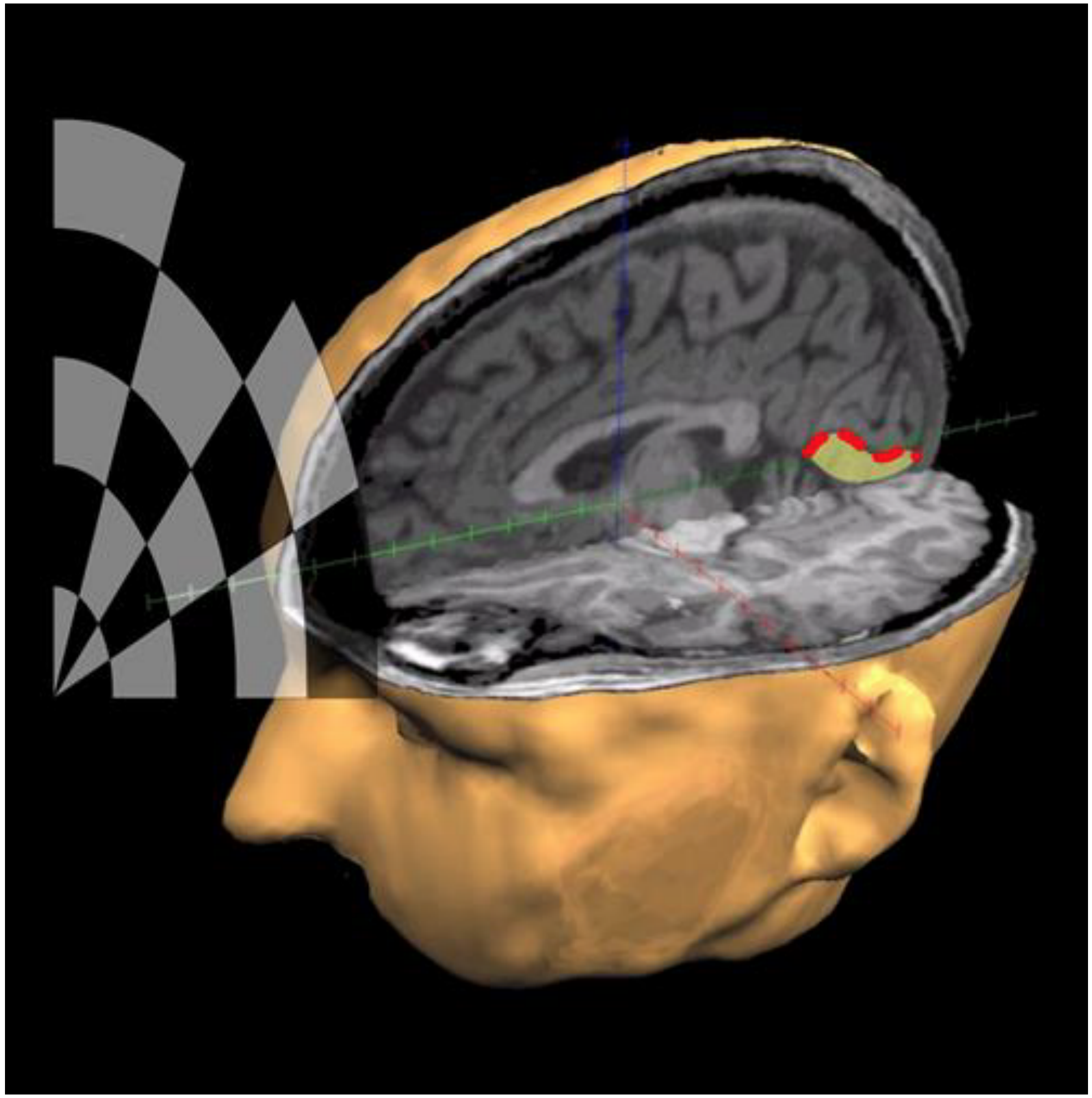
a) In the fovea.	
b) Just outside the fovea.	
c) In the peripheral retina.	

Problem 14: Where on the retina would one find the highest density of rods?

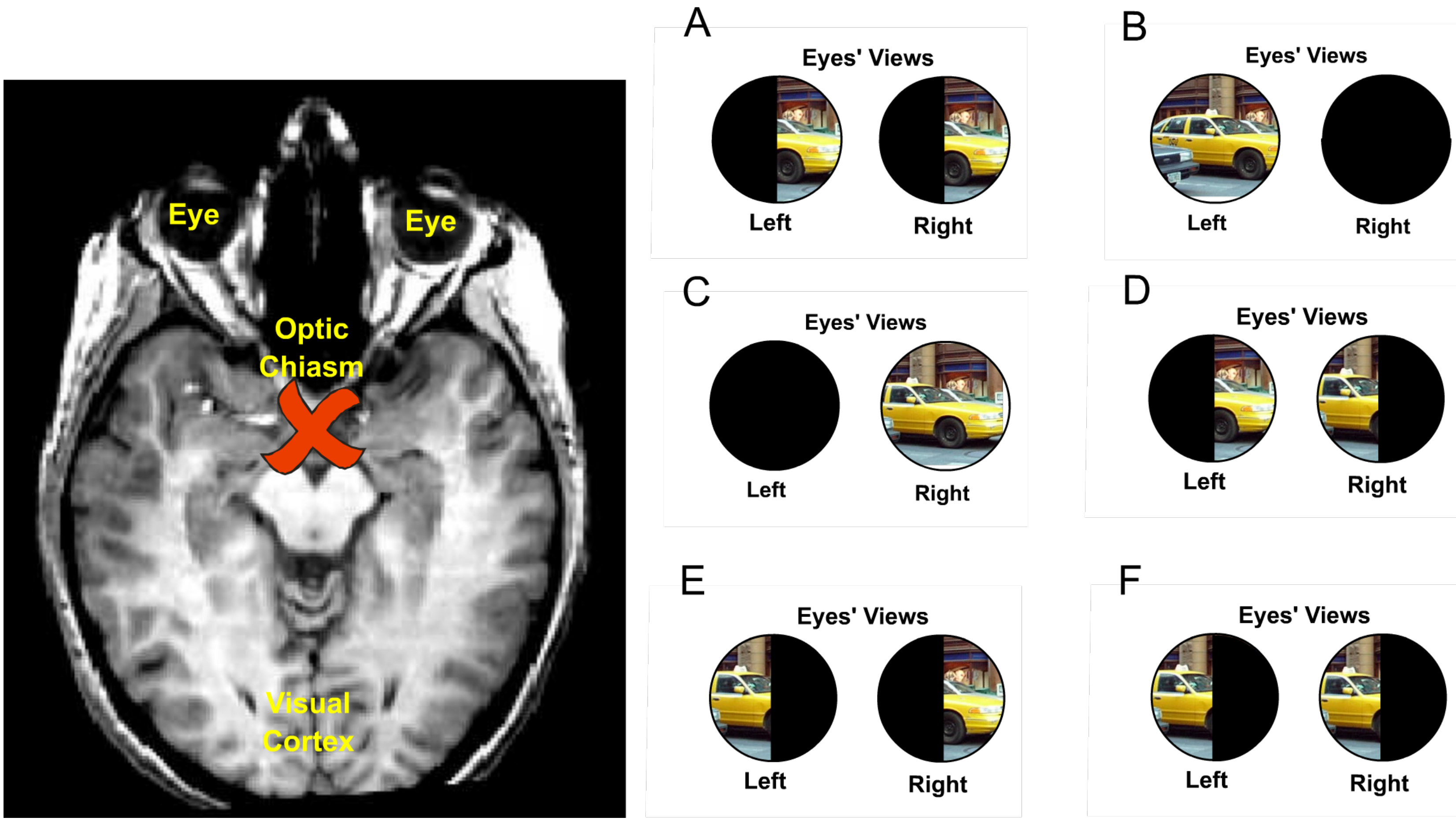
Answer

a) In the fovea.		No. The diagram shows that there are no rods, only cones, in the fovea.
b) Just outside the fovea.		Yes. This is so because of two factors. The red line illustrates the density of cones. The grey line shows the density of rods. 1) As you recall, the size of both rods and cones increases as one moves away from the fovea. Thus, their density decreases. 2) There are no rods in the fovea.
c) In the peripheral retina.		No. As you recall, the size of both rods and cones increase as one moves away from the fovea. Thus, their density decreases in the peripheral retina.

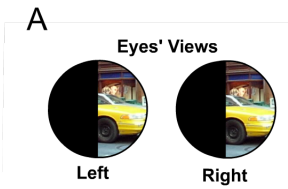
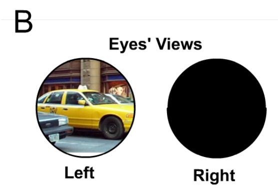
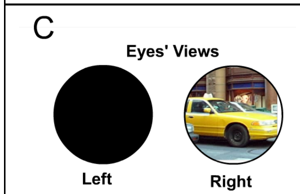
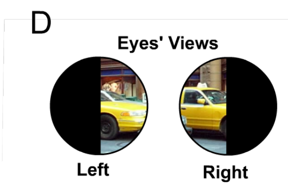
Chapter 2: Visual Cortex

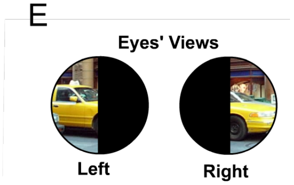
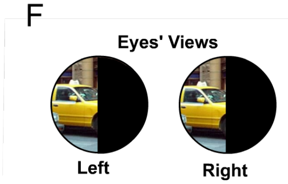


Problem 1: This lesion (X) of the Optic Chiasm would produce which visual field defect?

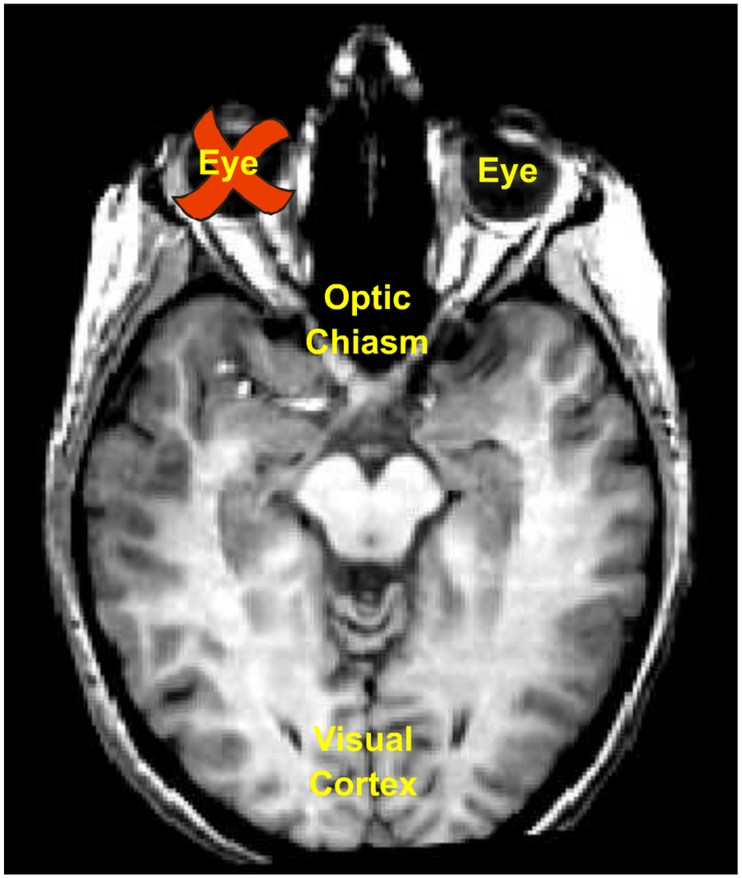


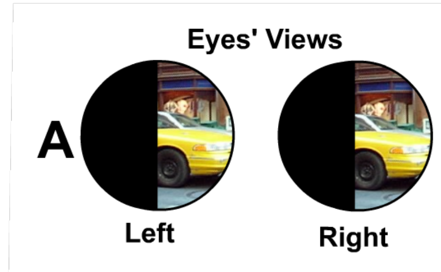
Problem 1: This lesion (X) of the Optic Chiasm would produce which visual field defect?
Answer

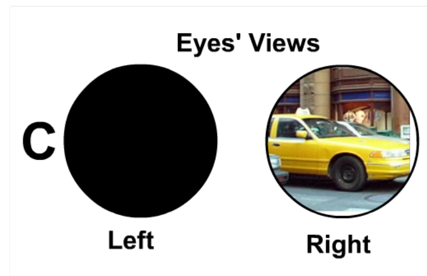
	No. Hint: Yes, the two eyes would be affected, but both would not be affected in the same way.
	No. Hint: Here both eyes are affected.
	No. Hint: Here both eyes are affected. This visual deficit would occur if the left eye lost all vision.
	Yes. Axons from the nasal halves of each eye cross at the chiasm. The nasal retina sees temporally. Thus, a lesion of the chiasm will produce blindness of the temporal views in each eye. When the two views are combined one can see almost everything (i.e. both sides of the taxi). The main thing missing is stereopsis because only one eye contributes to each view. This lesion is said to produce tunnel vision. This is true only if you have a long nose which blocks most of the nasal view from each eye (close your left eye and note your nose with your right).

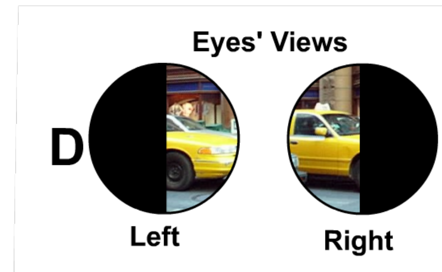
E 	No. Hint: You are close. Yes, the two eyes would be affected, but not in this way.
F 	No. Hint: Yes, the two eyes would be affected, but both would not be affected in the same way.

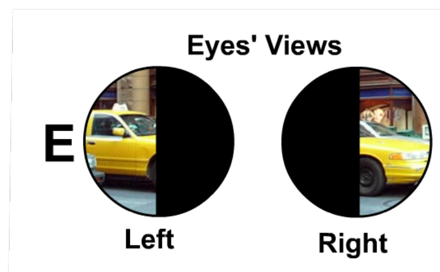
Problem 2: A loss of vision in the left eye will produce which visual field defect?

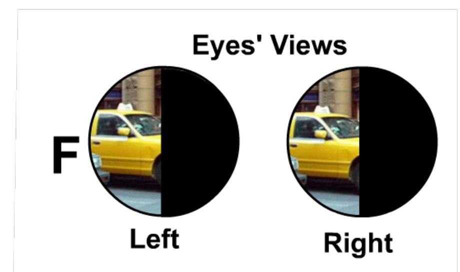






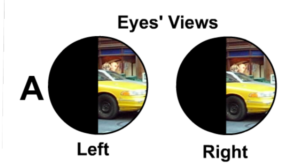
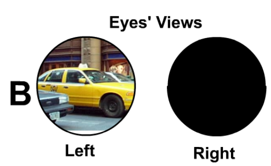
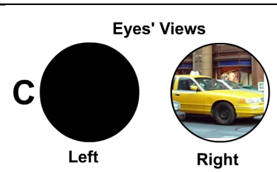
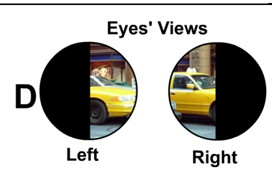
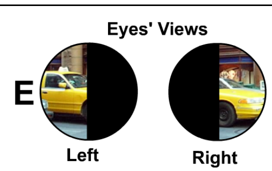
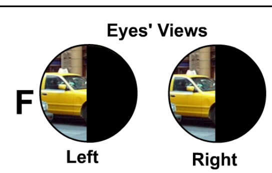




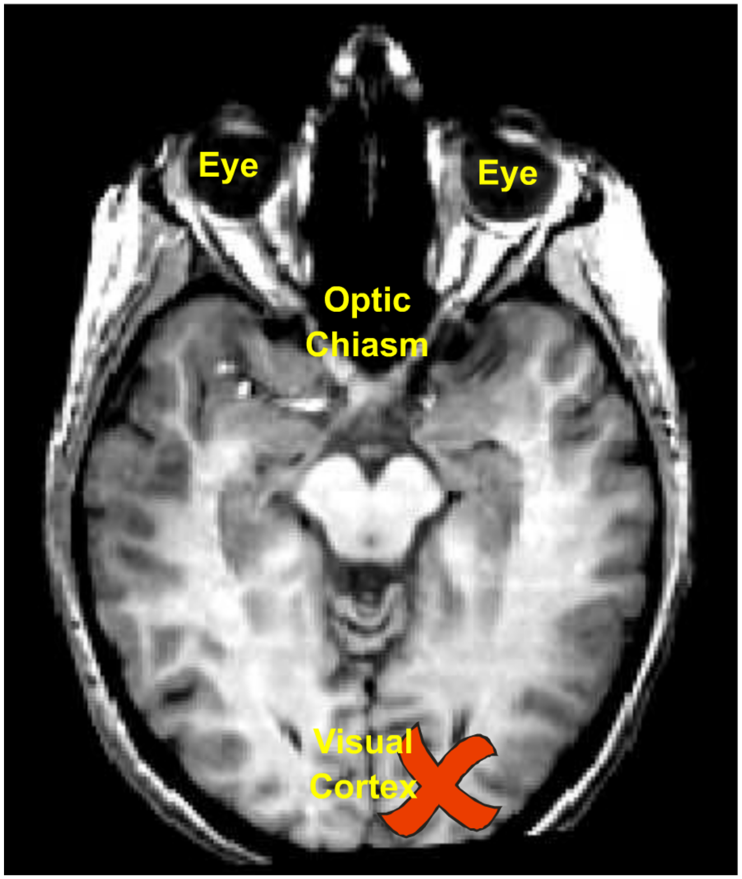


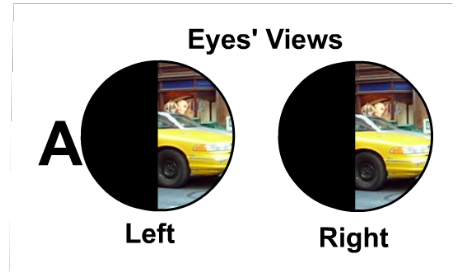
Problem 2: A loss of vision in the left eye will produce which visual field defect?

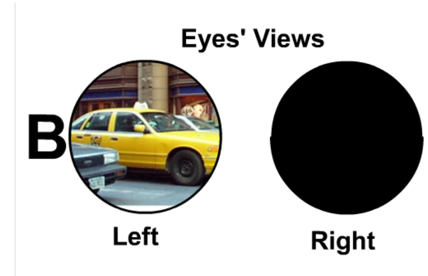
Answer

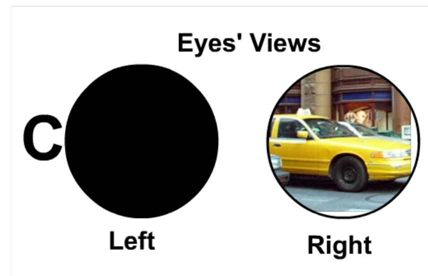
	No. Only one eye is damaged.
	No. But it is true that one eye is blind but it is not the right.
	**Yes.** This is what you would not be able to see if there was damage to the left eye or its optic nerve.
	No. Only one eye is damaged.
	No. Only one eye is damaged.
	No. Only one eye is damaged.

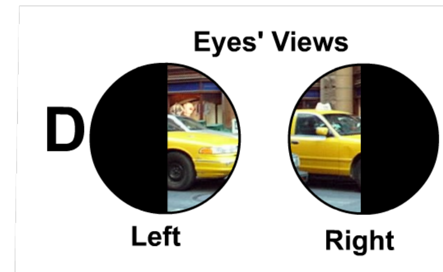
Problem 3: A lesion of the right visual cortex would produce which visual field defect?

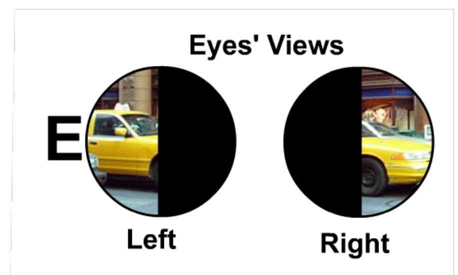


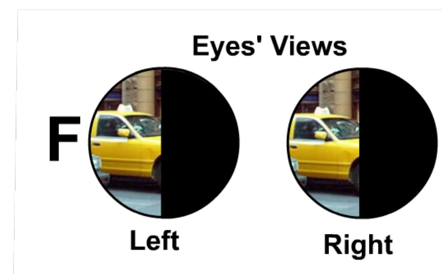






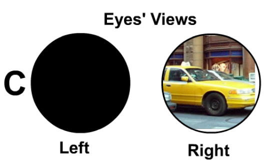
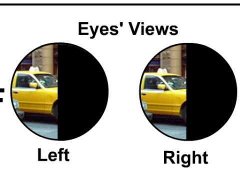






Problem 3: A lesion of the right visual cortex would produce which visual field defect?

Answer

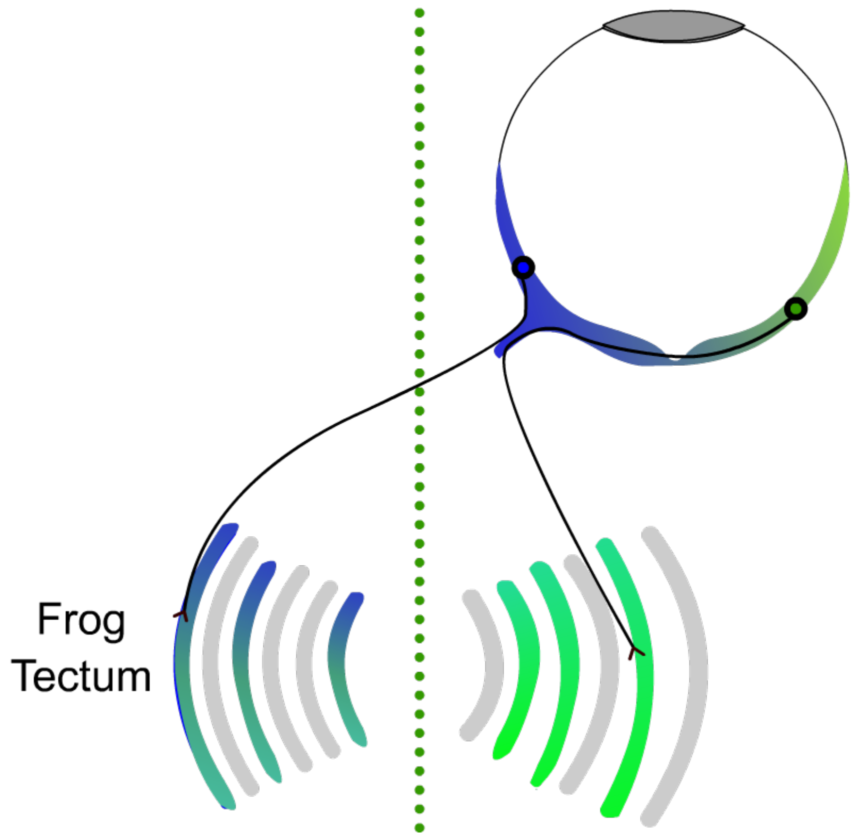
A 	**Very good.** The left visual field from both eyes projects to the right visual cortex. You would be unable to see anything to the **left** of the fovea.
B 	No. Hint: Here both eyes are affected.
C 	No. Hint: Here both eyes are affected. Perhaps you should review Problem 2
D 	No. Perhaps you should review Problem 1.
E 	No.
F 	No. But it is true that one half of the visual field will be blind in each eye.

Problem 4: A tadpole's eye can be removed, rotated 180 degrees, and reinserted. Remarkably the optic nerve will grow back and form a connection to the brain. Which is **false**?

a) In a normal adult frog, activation of the nasal side of the right eye by the image of a fly will generate a tongue moment to the right.

b) If the eye is rotated at a very young stage, before the eye acquires a chemical gradient, activation of the nasal side of the right eye by the image of a fly will generate a tongue moment to the right.

c) If the eye is rotated after it has acquired chemical gradient, activation of the nasal side of the right eye by the image of a fly will generate a tongue moment to the right.



Problem 4: A tadpole's eye can be removed, rotated 180 degrees, and reinserted. Remarkably the optic nerve will grow back and form a connection to the brain. Which **is false**?

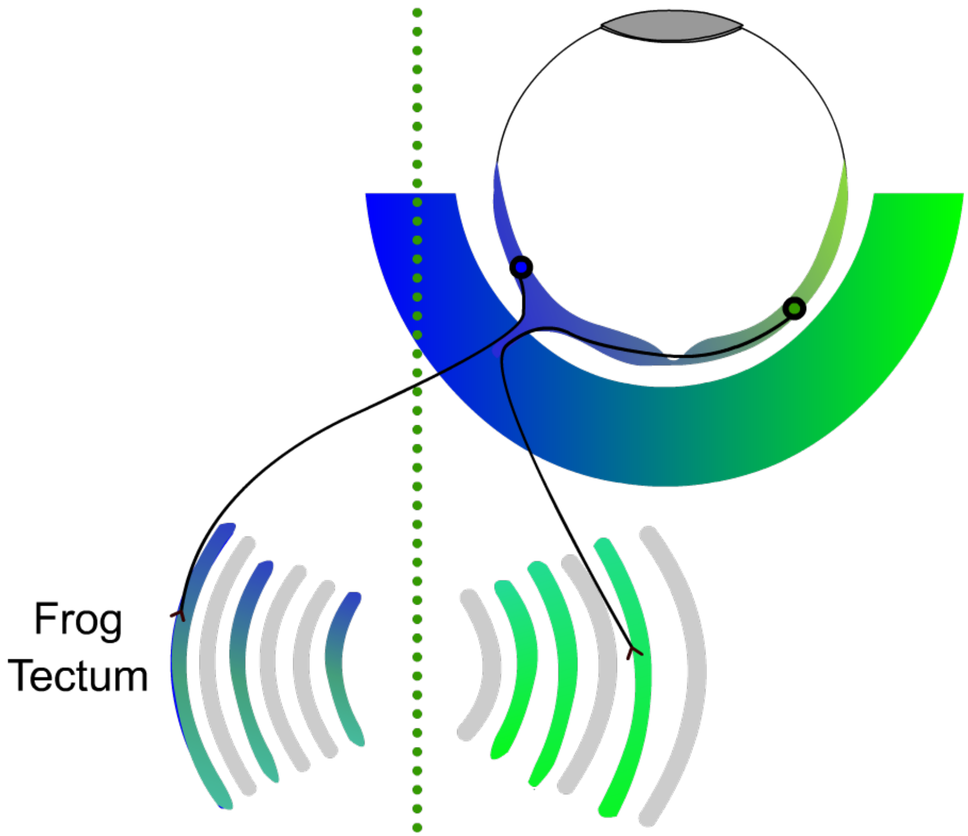
a) In a normal adult frog, activation of the nasal side of the right eye by the image of a fly will generate a tongue moment to the right.

Answer

No.
This is true.

In a normal adult frog, a fly on the right will activate ganglion cells on the nasal side of the right eye and the temporal side of the left eye. Both will project to the left tectum (the frog's equivalent to the superior colliculus). The left tectum generates tongue movements to the right.

Any other wiring would produce a very hungry frog.



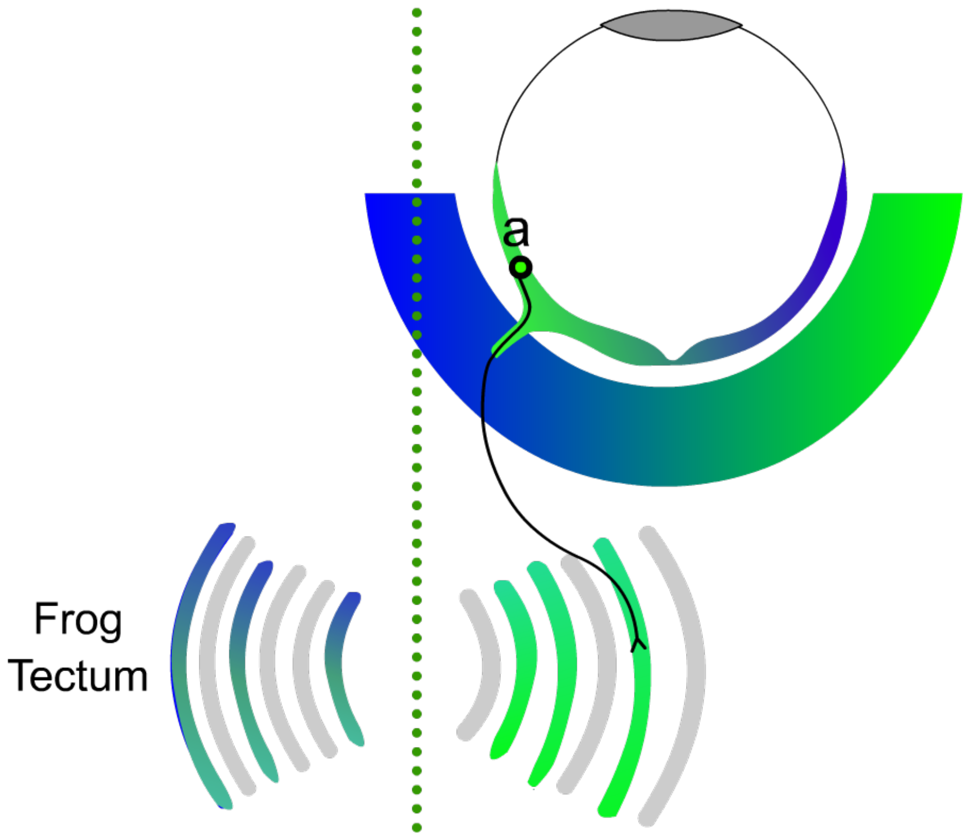
Problem 4: A tadpole's eye can be removed, rotated 180 degrees, and reinserted. Remarkably the optic nerve will grow back and form a connection to the brain. Which is **false**?

b) If the eye is rotated at a very young stage, before the eye acquires a chemical gradient, activation of the nasal side of the right eye by the image of a fly will generate a tongue moment to the right.

Answer

No. This is true. If this surgery is performed at a very early stage in development, before the chemical gradients starts to develop, a normal visual system will evolve.

The correct gradient develops after the eye has been rotated from the real sensed eye's position in the head. A cell is correctly tagged as being on the nasal side of the right eye and its axon grows to the correct location, in the left tectum. The left tectum generates the correct tongue movements to the right.



Problem 4: A tadpole's eye can be removed, rotated 180 degrees, and reinserted. Remarkably the optic nerve will grow back and form a connection to the brain. Which is **false**?

c) If the eye is rotated after it has acquired chemical gradient, activation of the nasal side of the right eye by the image of a fly will generate a tongue moment to the right.

Answer

Yes this is false. If surgery is performed later, a reverse topography will develop: when a fly appears to the right, the adult frog's tongue will be directed to the left, not at the fly.

When the chemical gradient first develops, the ganglion cell (a) "thinks" it is a temporal cell (i.e. one that normally sees the left visual field). After the eye is rotated this cell is now located nasally. The cell, unaware that the eye has been rotated, grows to the right tectum. The right tectum initiates tongue movements to the left.

Problem 5: The receptive fields of some simple cells span both sides of the midline of the retina. But each side projects to the opposite cortex. How does a simple cell receive input from both? Answer. One possibility is that the same simple cell in the left V1 would receive input from the nasal part of the right eye via the

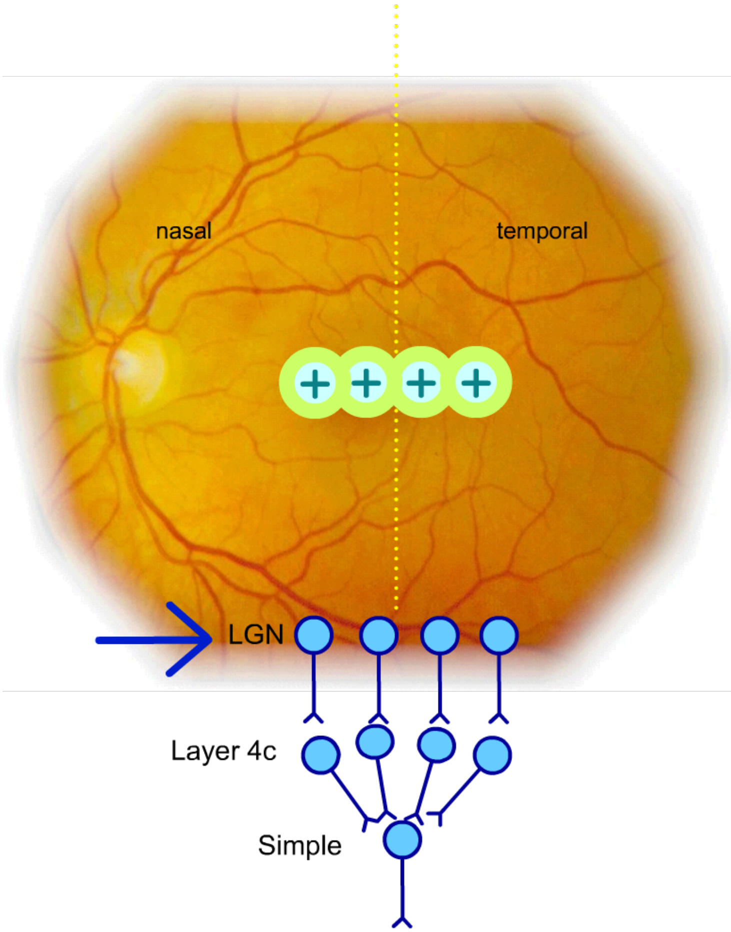
a) corpus callosum and the temporal part of the right eye via the corpus callosum.

b) optic chiasm and the temporal part of the right eye via the corpus callosum.

c) optic chiasm and the temporal part of the right eye via the optic chiasm.

d) corpus callosum and the temporal part of the right eye via the optic chiasm.

Problem 5: The receptive fields of some simple cells span both sides of the midline of the retina. But each side projects to the opposite cortex. How does a simple cell receive input from both?



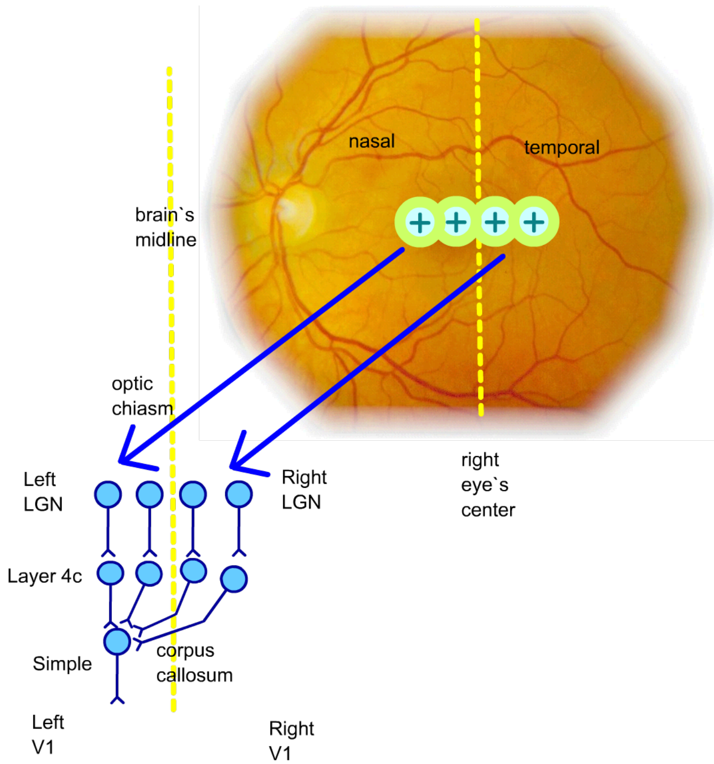
Answer. One possibility is that the same simple cell in the left V1 would receive input from the nasal part of the right eye via the

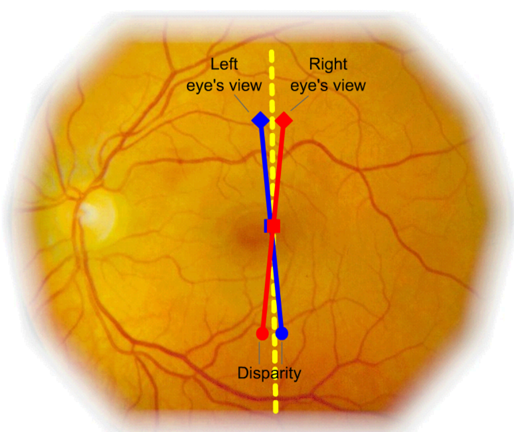
a) corpus callosum and the temporal part of the right eye via the corpus callosum.

Answer

No.

The nasal part of the eye crosses via the optic chiasm.





Problem 5: The receptive fields of some simple cells span both sides of the midline of the retina. But each side projects to the opposite cortex. How does a simple cell receive input from both?

Answer. One possibility is that the same simple cell in the left V1 would receive input from the nasal part of the right eye via the

b) optic chiasm and the temporal part of the right eye via the corpus callosum.

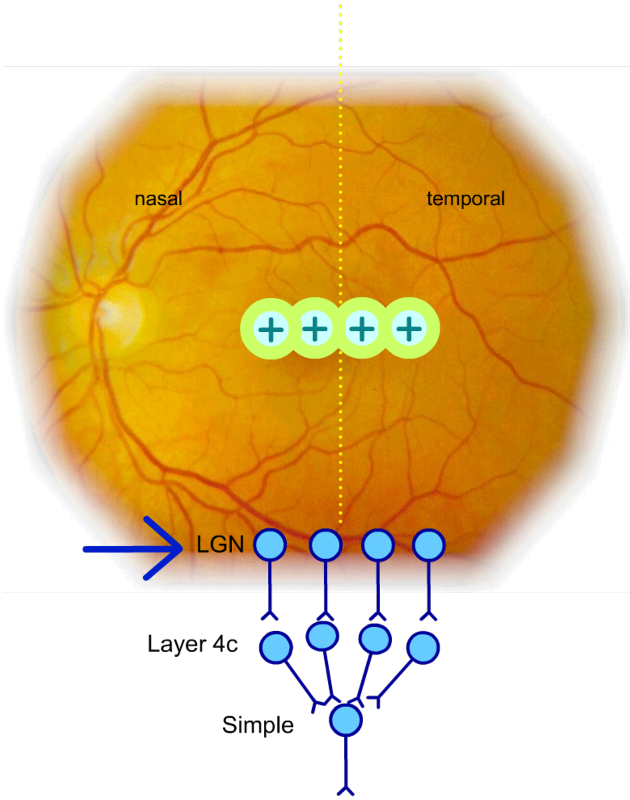
Answer

Correct. A possible solution is that ganglion cells from the nasal retina of the right eye project via the optic nerve and the optic chasm to the left LGN and from there to a simple cell in the left V1.

Ganglion cells from the temporal retina of the right eye project via the optic nerve to the right LGN and then to layer 4c cells in the right V1.

From there, layer 4c cells in the right V1 project via the corpus callosum to the same simple cell in the left V1.

Simple cells with receptive fields along the midline also receive input from both sides of the retina of each eye. They signal retinal disparity and are used for stereopsis.



Problem 5: The receptive fields of some simple cells span both sides of the midline of the retina. But each side projects to the opposite cortex. How does a simple cell receive input from both?

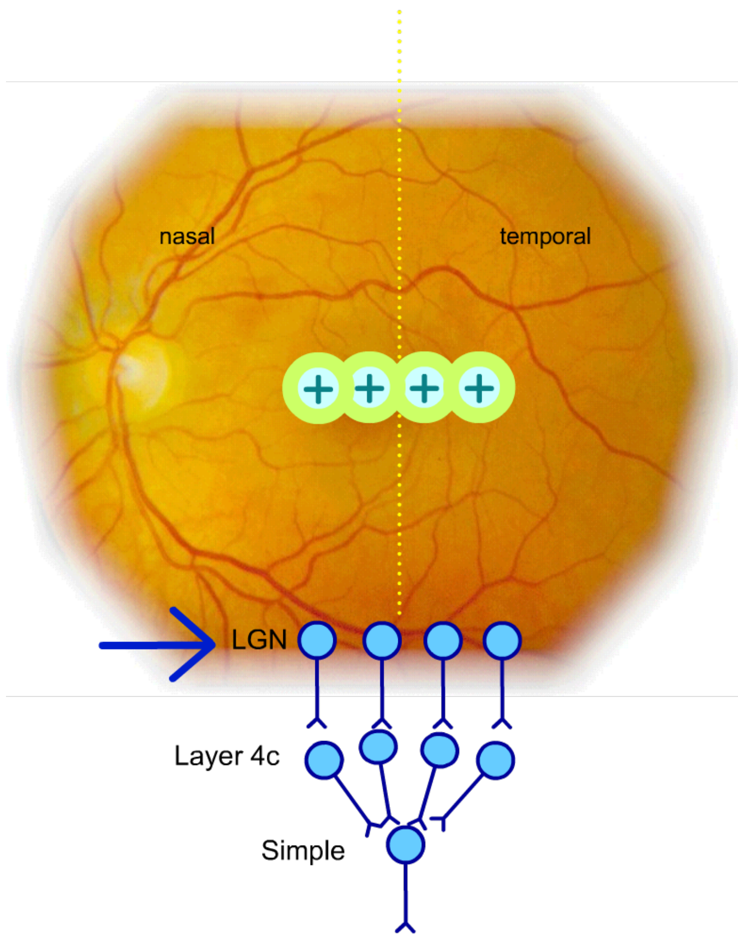
Answer. One possibility is that the same simple cell in the left V1 would receive input from the nasal part of the right eye via the

c) optic chiasm and the temporal part of the right eye via the optic chiasm.

Answer

No.

Only nasal part of the eye crosses via the optic chiasm.



Problem 5: The receptive fields of some simple cells span both sides of the midline of the retina. But each side projects to the opposite cortex. How does a simple cell receive input from both?

Answer. One possibility is that the same simple cell in the left V1 would receive input from the nasal part of the right eye via the

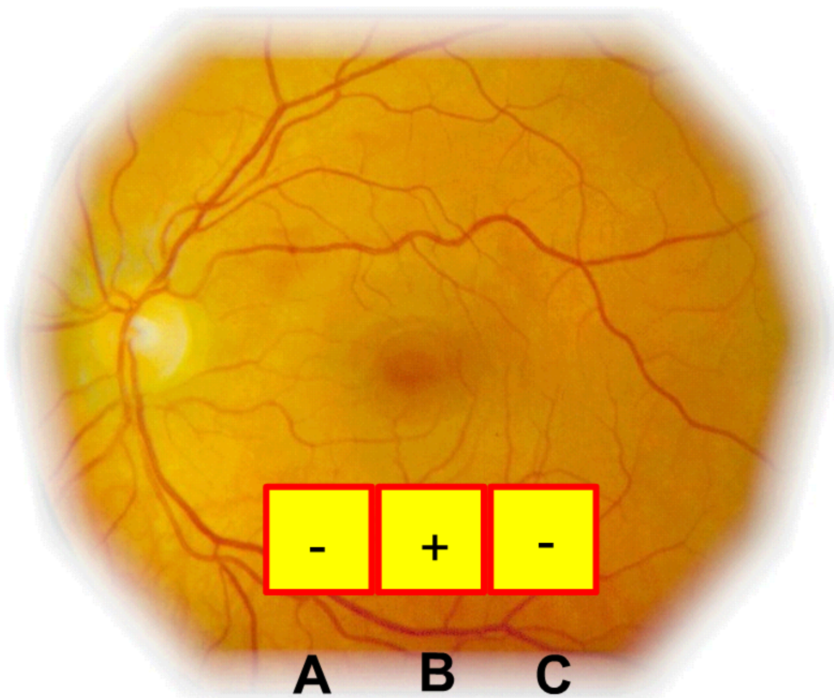
d) corpus callosum and the temporal part of the right eye via the optic chiasm.

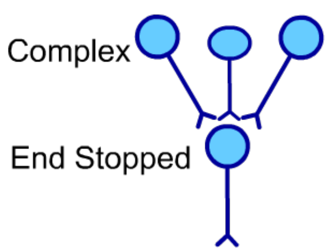
Answer

No.

Only nasal part of the eye crosses via the optic chiasm.

Problem 6: How might the receptive field of an end-stopped cell be produced? Suppose the cell, in the figure illustrated, received the convergence of complex cells, each sensitive to horizontal lines, onto an end-stopped cell. This end-stopped cell is





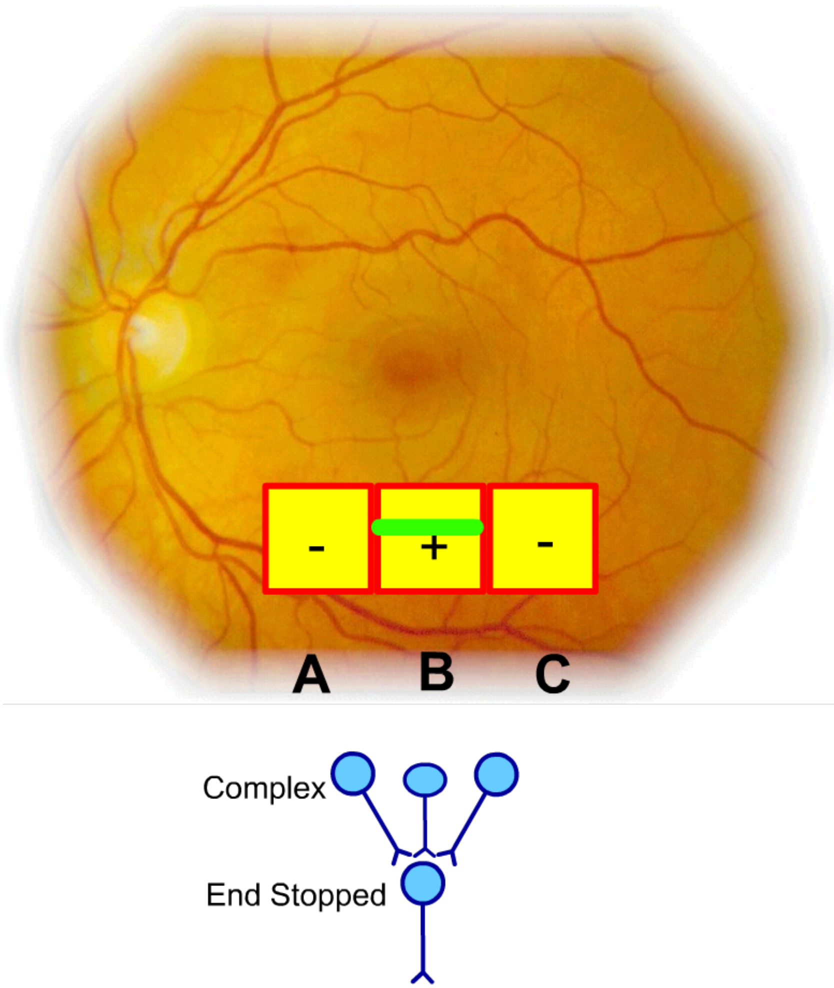
a) minimally activated by a horizontal line the width of the center square B.

b) more activated by a horizontal line shorter than the width of the center square B.

c) not activated by a longer horizontal line: the width of the squares A, B, and C.

d) inhibited by a line with a vertical orientation through B.

Problem 6: How might the receptive field of an end-stopped cell be produced? Suppose the cell, in the figure illustrated, received the convergence of complex cells, each sensitive to horizontal lines, onto an end-stopped cell. This end-stopped cell is



a) minimally activated by a horizontal line the width of the center square B.

Answer

No.

The end-stopped cell is **maximally** activated by this line. If the line got any longer and extended onto the receptive fields of cells A and C, this cell would be less activated.

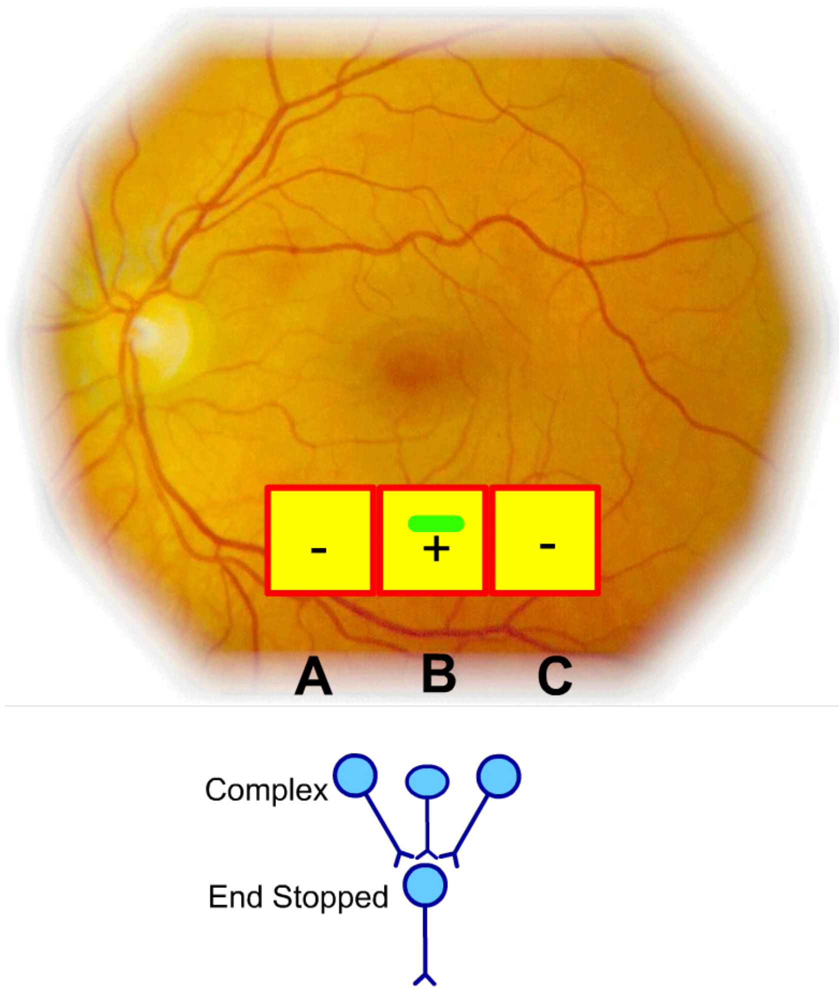
Problem 6: How might the receptive field of an end-stopped cell be produced? Suppose the cell, in the figure illustrated, received the convergence of complex cells, each sensitive to horizontal lines, onto an end-stopped cell. This end-stopped cell is

b) more activated by a horizontal line shorter than the width of the center square B.

Answer

No.

The cell is less activated by a shorter horizontal line because there is less stimulus.



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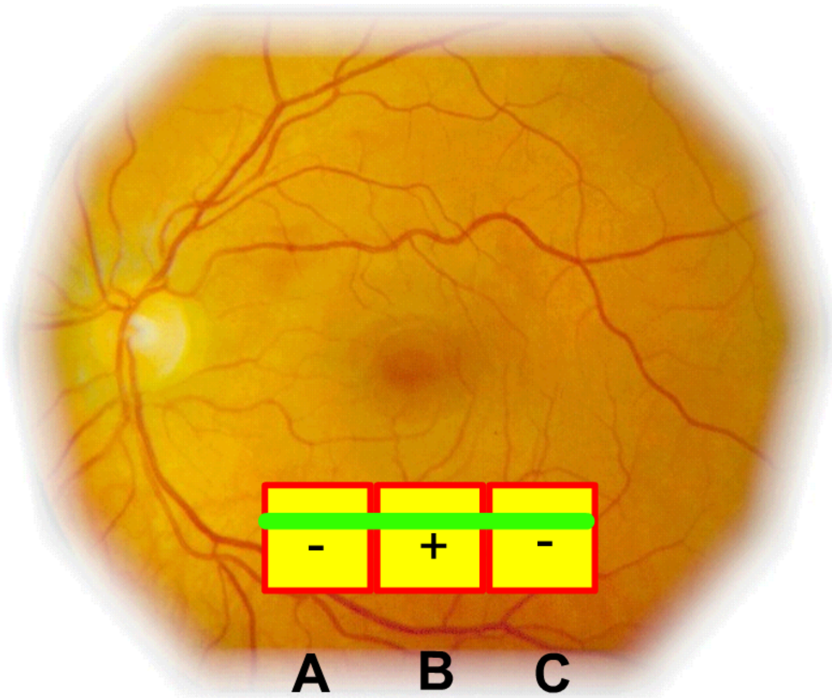
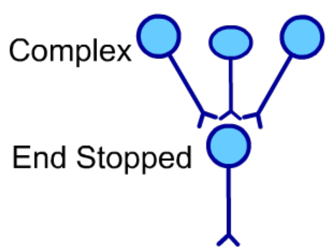




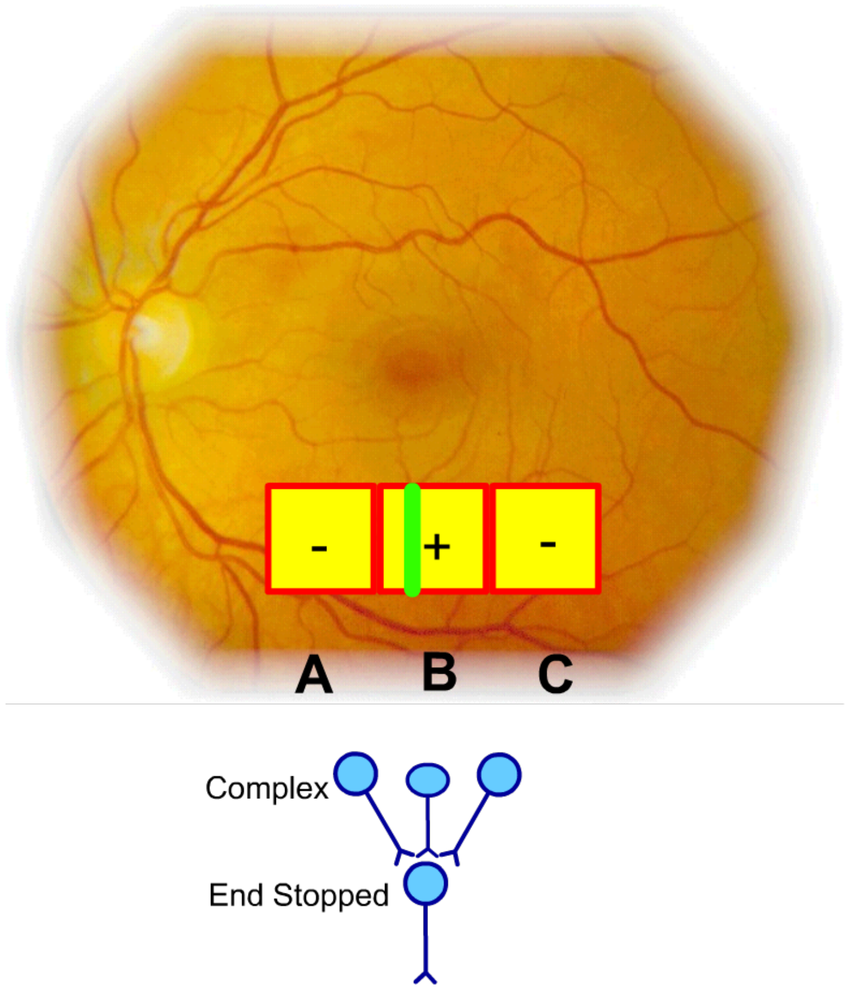
c) not activated by a longer horizontal line: the width of the squares A, B, and C.

Answer

Correct.

The increase in activity produced by complex cell B will be canceled by the inhibition produced by cells A and C.

Problem 6: How might the receptive field of an end-stopped cell be produced? Suppose the cell, in the figure illustrated, received the convergence of complex cells, each sensitive to horizontal lines, onto an end-stopped cell. This end-stopped cell is



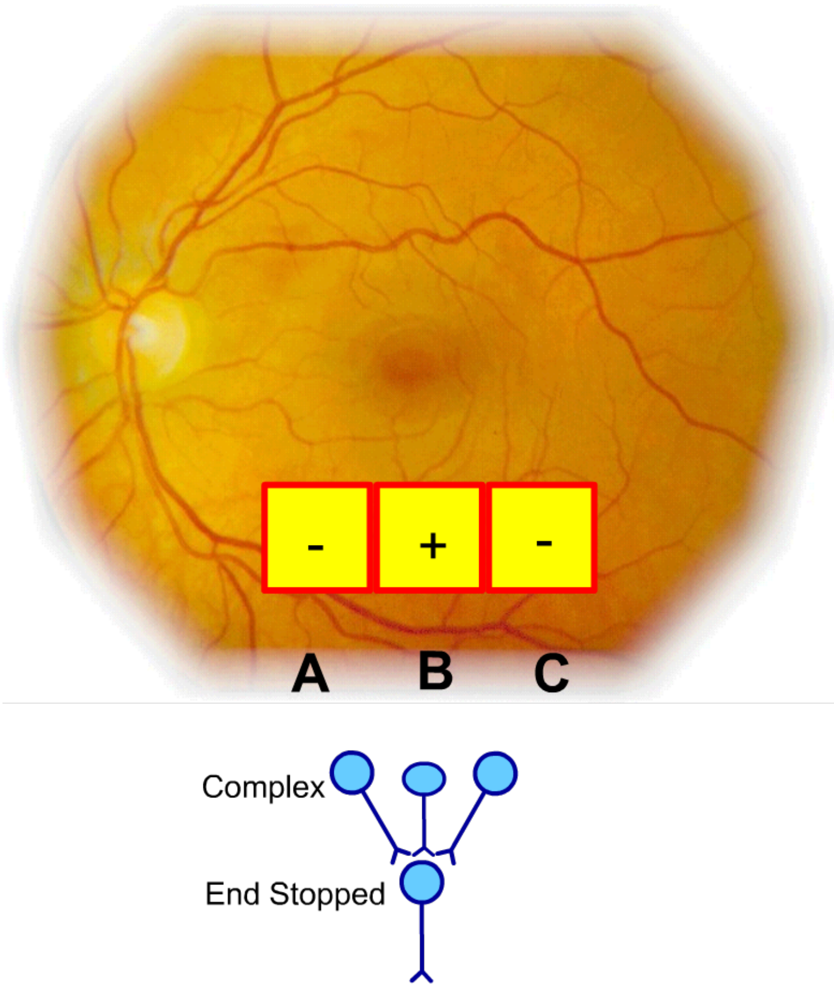
d) inhibited by a line with a vertical orientation through B.

Answer

No.

A vertical line produces little or no activity in the cell B. This end-stop cell is not inhibited by a vertical line because the complex cell B is sensitive only to horizontal lines.

Problem 7: Using the circuit covered in the previous problem, the one illustrating the properties of a horizontal end-stopped cell, describe a situation in which a horizontal line would pop out or stand out from an array of lines of another orientation.



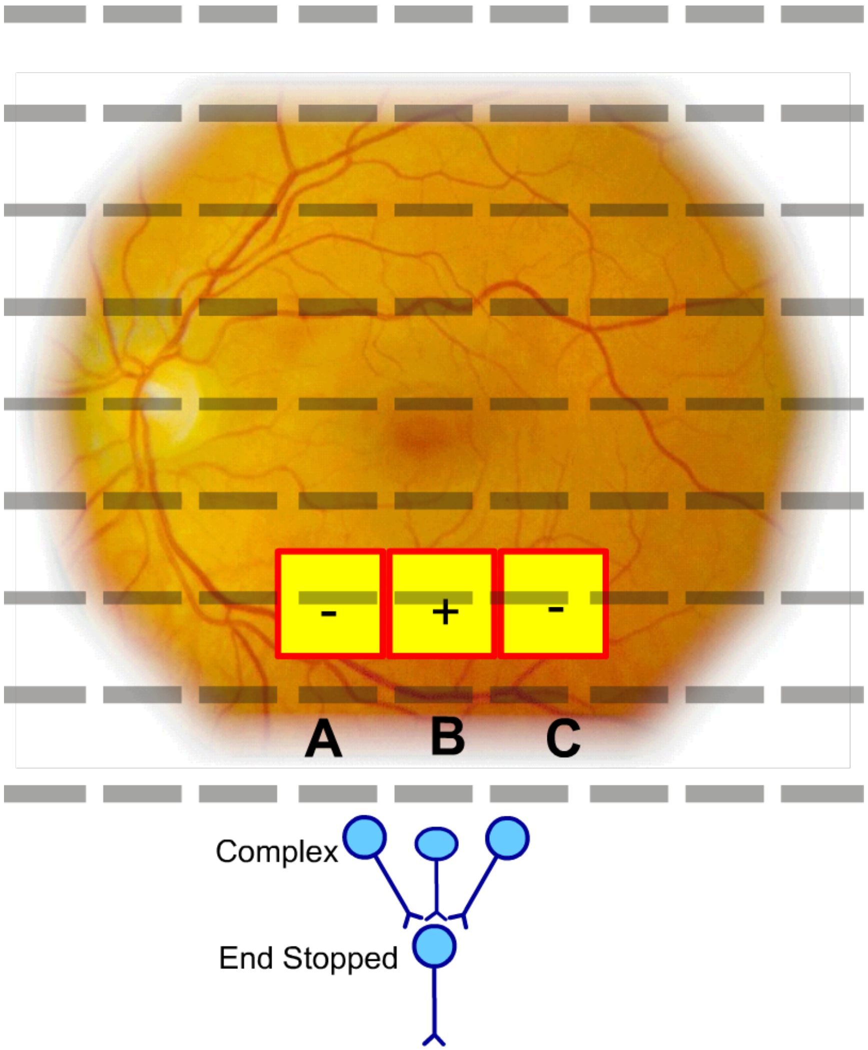
a) Three adjacent lines of the same orientation will excite each other and thus appear less prominent.

b) Three adjacent lines of the same orientation will excite each other and thus appear more prominent.

c) Three adjacent lines of the same orientation will inhibit each other and thus appear more prominent.

d) A horizontal line placed between vertical lines results in minimal activity.

e) A horizontal line placed between vertical lines results the same activity as a single horizontal line.



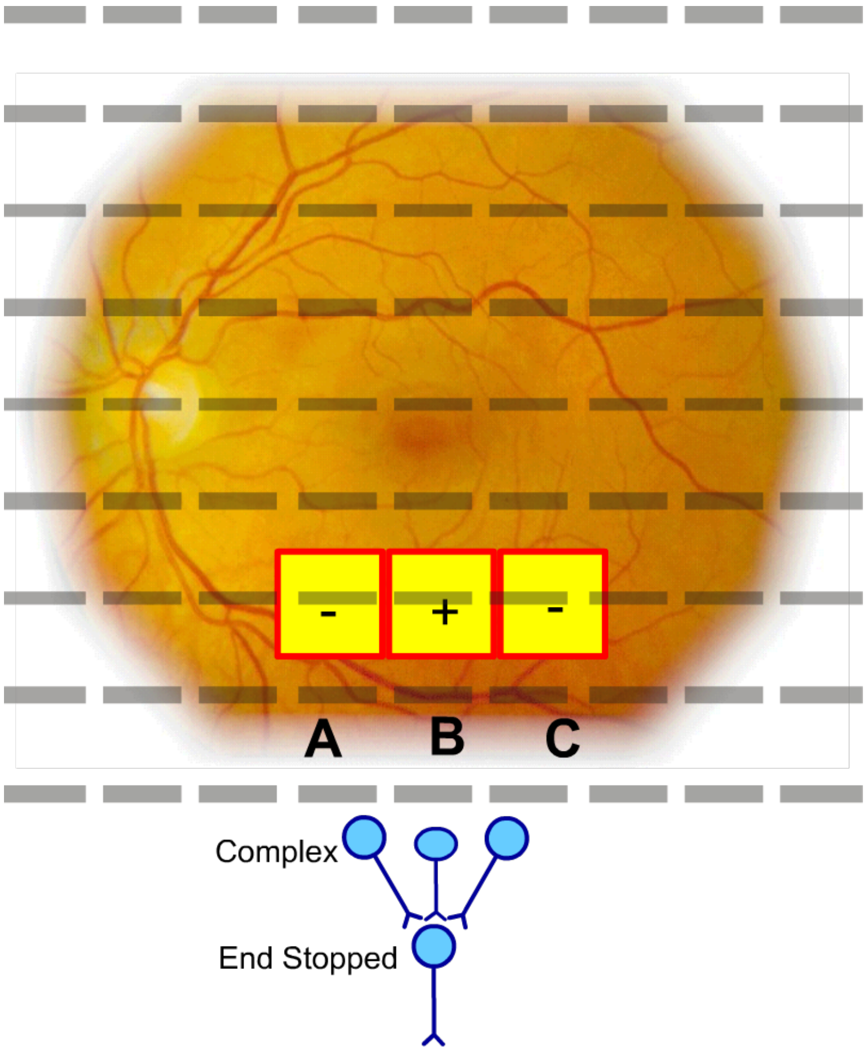
Problem 7: Using the circuit covered in the previous problem, the one illustrating the properties of a horizontal end-stopped cell, describe a situation in which a horizontal line would pop out or stand out from an array of lines of another orientation.

a) Three adjacent lines of the same orientation will excite each other and thus appear less prominent.

Answer

No.
Horizontal lines in A and C, would inhibit that in B.

If A, B, and C "saw" vertical lines, no cell would be activated.



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b) Three adjacent lines of the same orientation will excite each other and thus appear more prominent.

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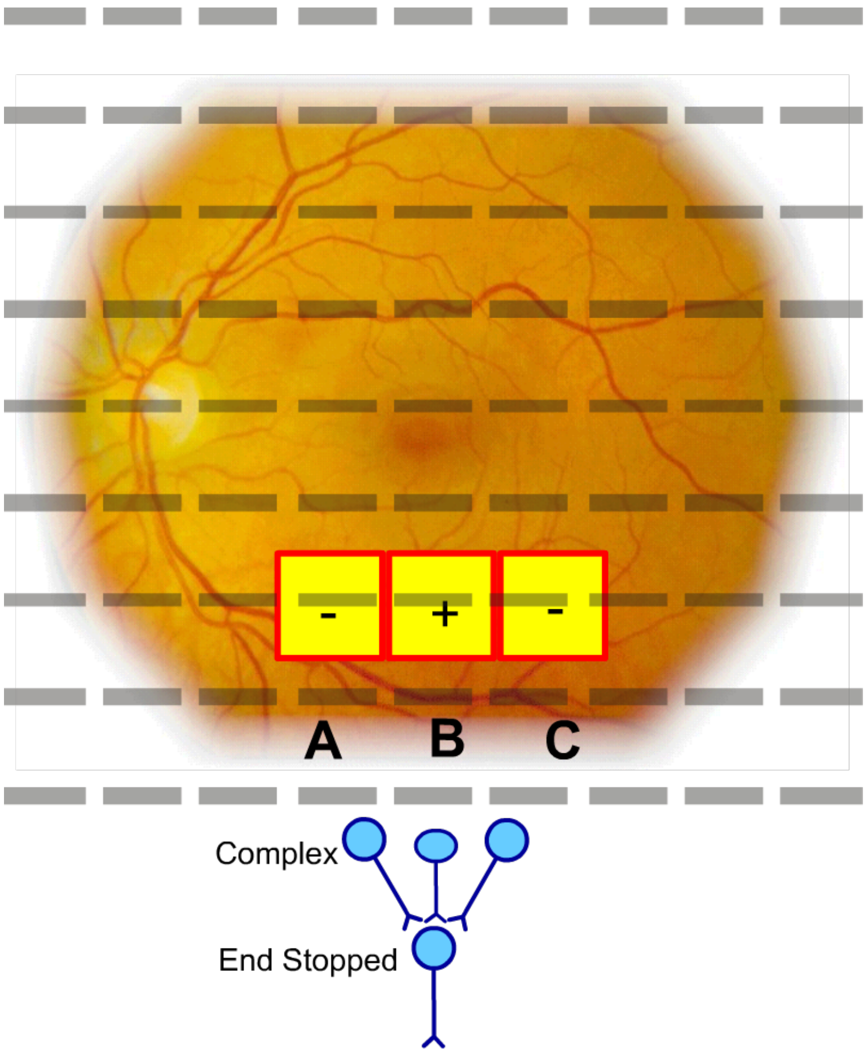


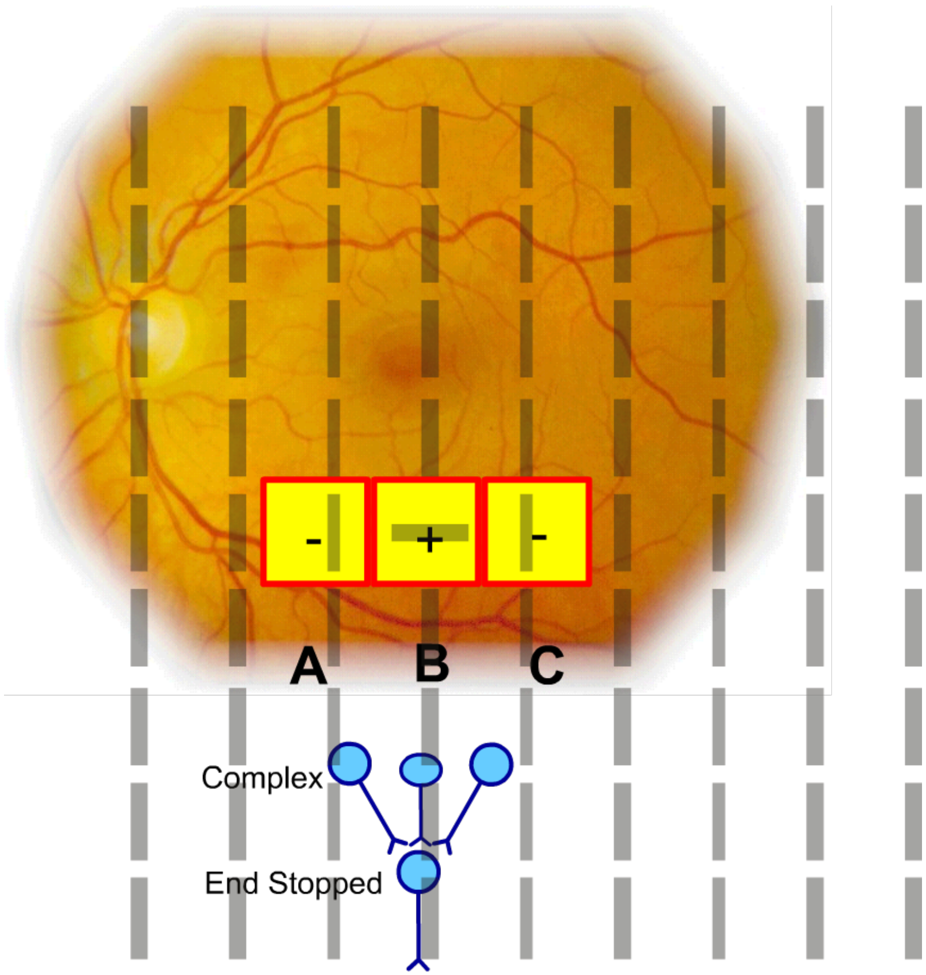
Problem 7: Using the circuit covered in the previous problem, the one illustrating the properties of a horizontal end-stopped cell, describe a situation in which a horizontal line would pop out or stand out from an array lines of another orientation.

c) Three adjacent lines of the same orientation will inhibit each other and thus appear more prominent.

Answer

No.
Horizontal lines in A and C, would inhibit that in B.

If A, B, and C "saw" vertical lines, no cell would be activated.



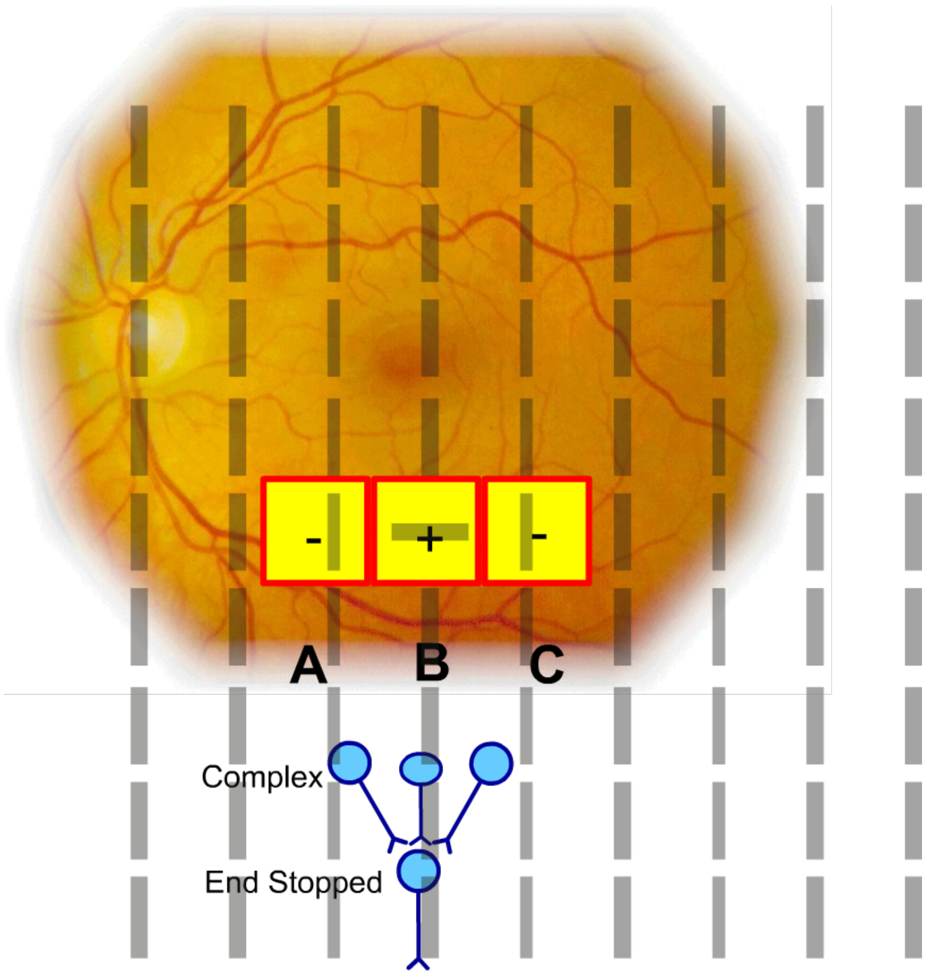
Problem 7: Using the circuit covered in the previous problem, the one illustrating the properties of a horizontal end-stopped cell, describe a situation in which a horizontal line would pop out or stand out from an array of lines of another orientation.

d) A horizontal line placed between vertical lines results in minimal activity.

Answer

No.

Recall that A and C are complex cells that are tuned to horizontal lines. Thus, they will not be activated by a vertical line.



Problem 7: Using the circuit covered in the previous problem, the one illustrating the properties of a horizontal end-stopped cell, describe a situation in which a horizontal line would pop out or stand out from an array of lines of another orientation.

e) A horizontal line placed between vertical lines results the same activity as a single horizontal line.

Answer

Correct.

A and C are complex cells that are tuned to horizontal lines. Thus, they will not be activated by the vertical lines; the same as by no line.

The other horizontally tuned complex cells that receive input from the other vertical lines are also not activated.

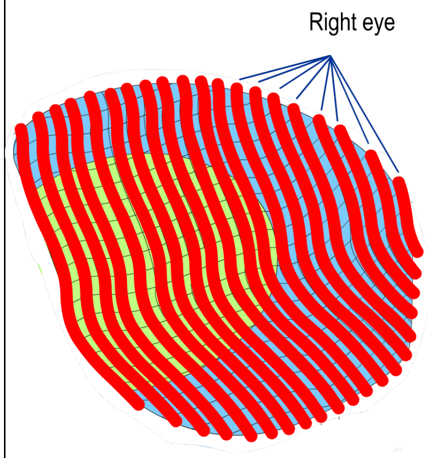
Thus, this horizontally tuned end-stopped cell would filter out all the vertical lines, allowing only the horizontal line to be visible or **pop out**.

Problem 8: 2-deoxyglucose, a radioactive glucose analogue is injected into the brain. This is preferentially taken up by cells that are active. A scene with lots of texture is shown to the right eye. The left eye remains covered. In area V1, one would then see

a) bands of activation that are most prominent in layer 4c.	
b) activation of both ocular dominance columns in only the right cortex.	
c) bands of activation that are equally prominent in all layers.	
d) bands of activation that are more prominent in higher and lower layers.	

Problem 8: 2-deoxyglucose, a radioactive glucose analogue is injected into the brain. This is preferentially taken up by cells that are active. A scene with lots of texture is shown to the right eye. The left eye remains covered. In area V1, one would then see

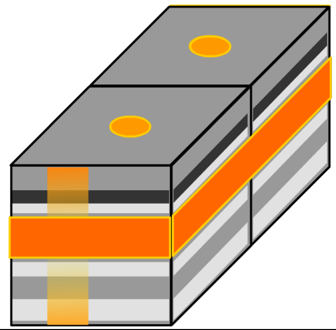
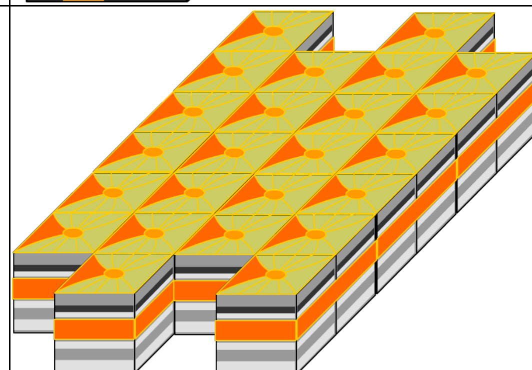
Answer

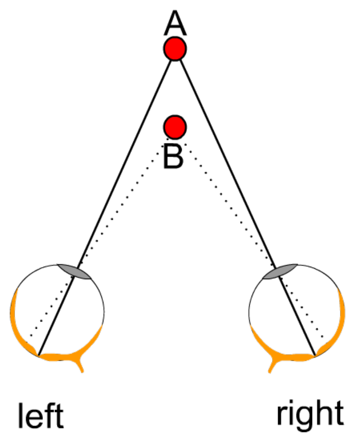
a) bands of activation that are most prominent in layer 4c.	**Correct.**  The radioactivity will accumulate on the side of the ocular dominance columns activated by the right eye in both hemispheres. Bands are visible throughout V1. But they are most prominent in layer 4c because here the monocular cells only receive input from the right eye. Bands are fainter in higher and lower layers because many of these binocular cells receive input from both eyes and thus less input from the right eye.
b) activation of both ocular dominance columns in the only right cortex.	No. The right eye activates both the right and left hemispheres.
c) bands of activation that are equally prominent in all layers.	No. The bands of activation will be most prominent in the layer that receives only the right eye's input.
d) bands of activation that are more prominent in higher and lower layers.	No. The bands of activation will be most prominent in the layer that receives only the viewing eye's input.

Problem 9: Voltage sensitive dyes, that change color depending on the voltage inside the neuron, are injected into the visual cortex. Both eyes are illuminated with lines of one particular orientation. In area V1, one would see

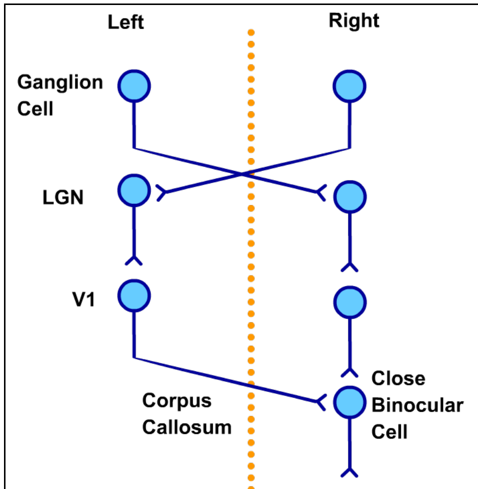
a) bands that are perpendicular to the ocular dominance columns.	
b) bands whose orientation will change depending on the orientation of the displayed lines.	
c) bands that are most prominent in layer 4c.	

Problem 9: Voltage sensitive dyes, that change color depending on the voltage inside the neuron, are injected into the visual cortex. Both eyes are illuminated with lines of one particular orientation. In area V1, one would see

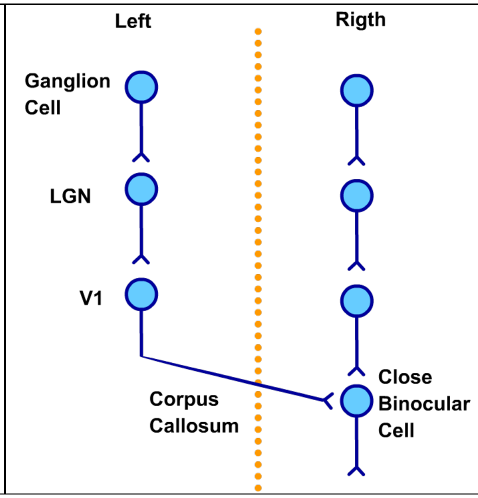
a) bands that are perpendicular to the ocular dominance columns.	 Yes. This is what Hubel and Wiesel, who first observed ocular dominance, thought. However more recent imaging studies have revealed the pin wheel organization shown in the diagram below.
b) bands whose orientation will change depending on the orientation of the displayed lines.	 **Correct.** The bands are most prominent in layers above and below 4c. This is where simple and complex cells are. These are the cells that are selective for orientation. Layer 4c has no orientation preference and shows no banding. A constant activation will be visible in layers 4c because cells here have circular surround receptive fields. These receptive fields are not selective for orientation and thus are activated by all orientations.
c) bands that are most prominent in layer 4c.	No. A constant activation will be visible in layers 4c because cells here have circular surround receptive fields. These receptive fields are not selective for orientation, are activated by all orientations, and thus do not show bands.



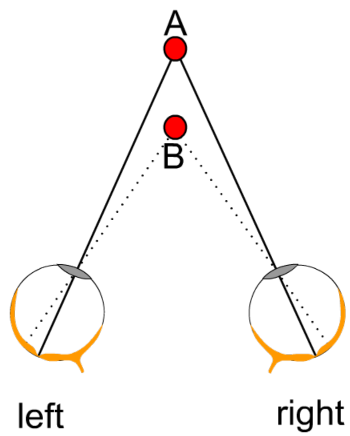
Problem 10: Suppose you were looking at a dot at A. The image of a dot at B activates a single binocular cell in the right V1 by which pathway? The right eye projects to



a) the left LGN, the left V1 and then via corpus callosum to the right V1. The left eye projects to the right LGN and the right V1.

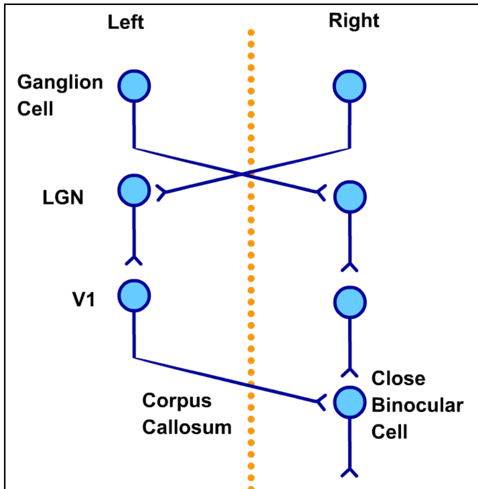


b) the right LGN, and the right V1. The left eye projects to the left LGN, to left V1 and then via corpus callosum to the right V1.



Problem 10: Suppose you were looking at a dot at A. The image of a dot at B activates a single binocular cell in the right V1 by which pathway? The right eye projects to

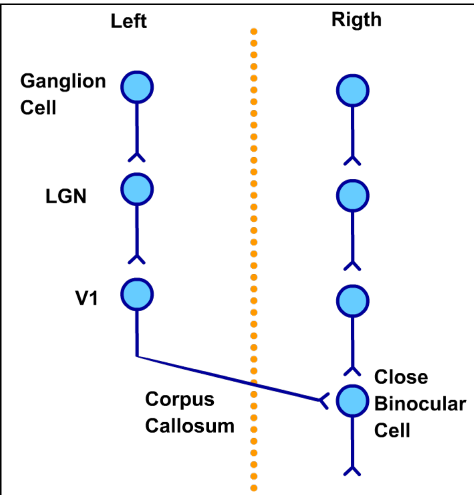
Answer



a) the left LGN, the left V1 and then via corpus callosum to the right V1. The left eye projects to the right LGN and the right V1.) left V1 and then via corpus callosum to the right V1 and from the left eye to the right V1.

No.

The temporal parts of each retina project to the ipsilateral LGN and the ipsilateral V1.

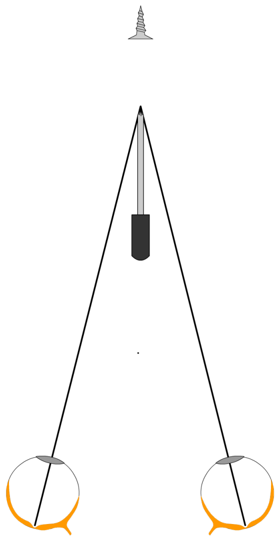


b) the right LGN, and the right V1. The left eye projects to the left LGN, to left V1 and then via corpus callosum to the right V1.

Correct.

The temporal parts of each retina project to the ipsilateral LGN and the ipsilateral V1.

To activate a single binocular cell, the corpus callosum interconnects cells whose receptive fields lie along the midline. One also needs the corpus callosum for stereopsis of far objects. The corpus callosum staples the two sides of the vertical meridian.

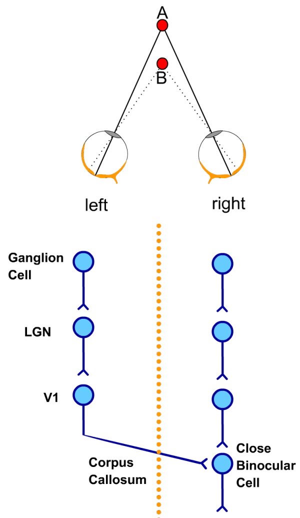


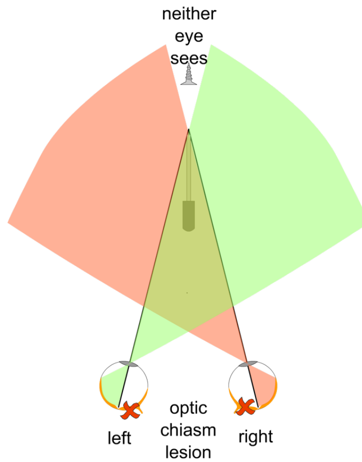
Problem 11: A patient of Dr. David Nicolle complains that when looking at the near tip of a screw driver just before placing it into the more distant head of a screw, the head of the screw disappears. What is the most likely cause of this patient's deficit?

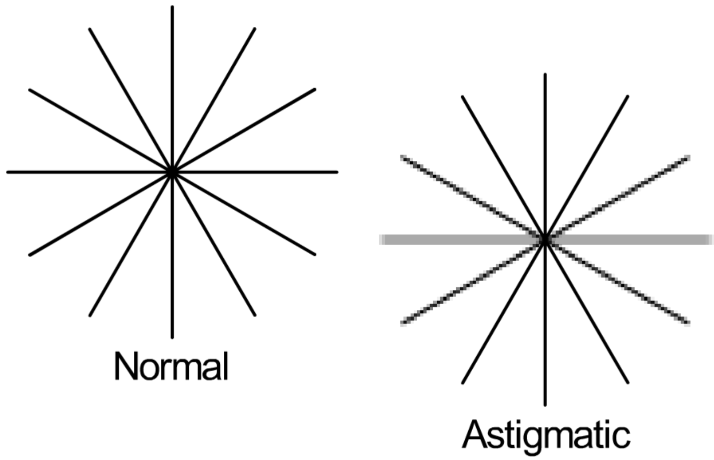
a) The patient suffered from strabismus as a child.	
b) The patient suffers from strabismus.	
c) The patient has a lesion of the corpus callosum.	
d) The patient has a lesion of the optic chiasm.	
e) The patient is perfectly healthy but has placed the head of the screw in his blind spot.	

Problem 11: A patient of Dr. David Nicolle complains that when looking at the near tip of a screw driver just before placing it into the more distant head of a screw, the head of the screw disappears. What is the most likely cause of this patient's deficit?

Answer

a) The patient suffered from strabismus as a child.	No. Such a patient may not be able to see in stereo or have amblyopia but not this symptom.
b) The patient suffers from strabismus.	No. The patient might see double, that is two screw heads, not one.
c) The patient has a lesion of the corpus callosum.	 No. The corpus callosum (CC) stitches together the left and right sides of V1. The CC mediates the retinal disparity of objects that lie on or near the vertical meridian, the interface between the two sides. A lesion of the CC would, in part, result in a loss of stereo vision for close and far binocular cells along the vertical meridian. The images of any near or far object along the vertical meridian end up in the opposite hemisphere. They need the corpus callosum to bring them together.

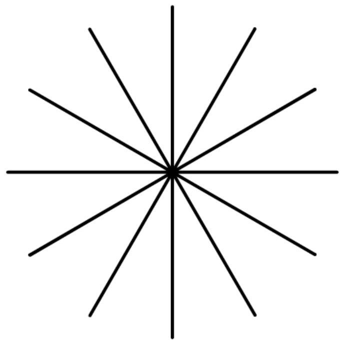
d) The patient has a lesion of the optic chiasm.	 Correct. An optic chiasm lesion causes a loss of vision from the nasal retina and, as you can see on the left, blindness in the region of the far screw.
e) The patient is perfectly healthy but has placed the head of the screw in his blind spot.	No. Our blind spots are in different places in each eye, so unless one eye is closed this can never happen.



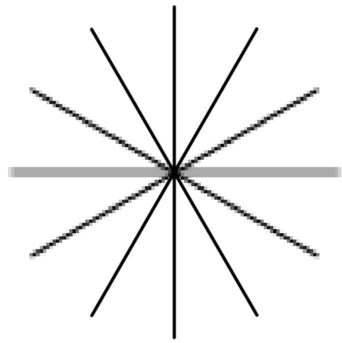
Problem 12: Suppose you had astigmatism from birth. Astigmatism is a distortion of the lenses of the eye such that lines of a particular orientation appear blurred. Suppose as an adult you were fitted with lens that corrected for this astigmatism.

With the help of these lenses would your vision be restored to normal?

a) Yes.	
b) No.	



Normal

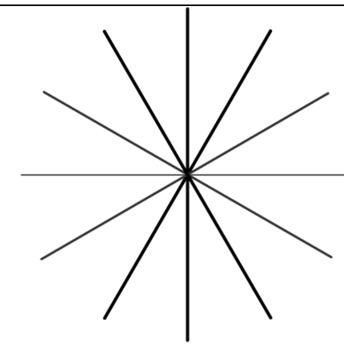


Astigmatic

Problem 12: Suppose you had astigmatism from birth. Astigmatism is a distortion of the lenses of the eye such that lines of a particular orientation appear blurred. Suppose as an adult you were fitted with lens that corrected for this astigmatism.

With the help of these lenses would your vision be restored to normal?

Answer

a) Yes.	Correct. You would see some improvement, but the lines of a particular orientation that had appeared blurred would now be seen more faintly. FYI. You would have meridional amblyopia.  Meridional Amblyopic
b) No.	Incorrect.

Problem 12: Suppose you had astigmatism from birth. Astigmatism is a distortion of the lenses of the eye such that lines of a particular orientation appear blurred. Suppose as an adult you were fitted with lens that corrected for this astigmatism.

With the help of these lenses would your vision be restored to normal?

Would the pin wheel pie in V1 be of equal width? That is would each orientation have the normal equal representation?

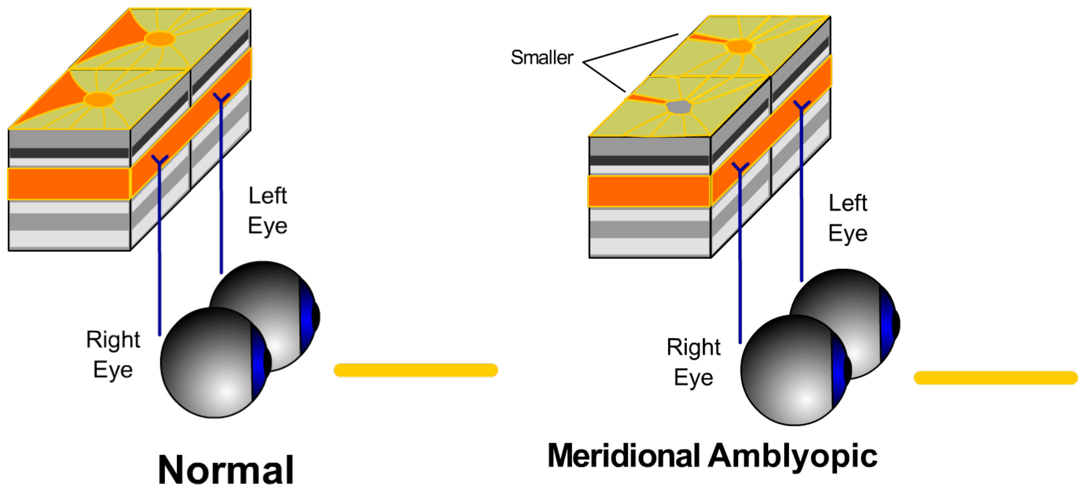
a) Yes	
b) No.	

Problem 12: Suppose you had astigmatism from birth. Astigmatism is a distortion of the lenses of the eye such that lines of a particular orientation appear blurred. Suppose as an adult you were fitted with lens that corrected for this astigmatism.

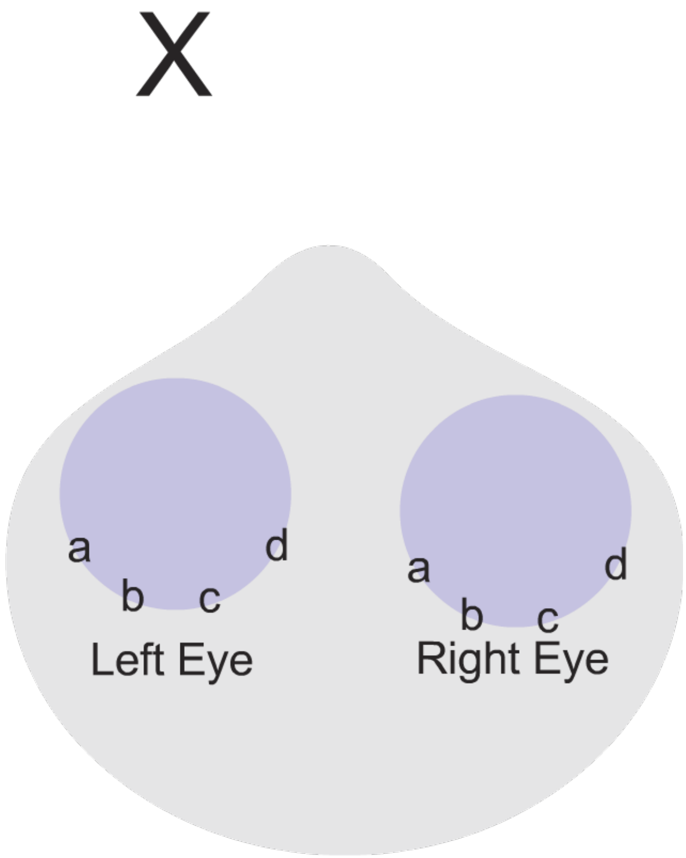
With the help of these lenses would your vision be restored to normal?

Would the pin wheel pie in V1 be of equal width? That is would each orientation have the normal equal representation?

Answer

a) Yes	 **Incorrect.** They would **not** be equal. As one would expect that the angles that are seen more faintly, do so because there are fewer cells representing these orientations. The pies for these orientations have become narrower and the others wider.
b) No.	**Correct**, they would not be equal. As one would expect that the angles that are seen more faintly, do so because there are fewer cells representing these orientations. The pies for these orientations have become narrower and the others wider. The fewer cells representing the flawed orientation would not be compensated by a lens.

Problem 13: Below is a figure of a head as viewed from above. Suppose both eyes look at the X. Pick the letters that are located medial to the fovea (pick one or more).



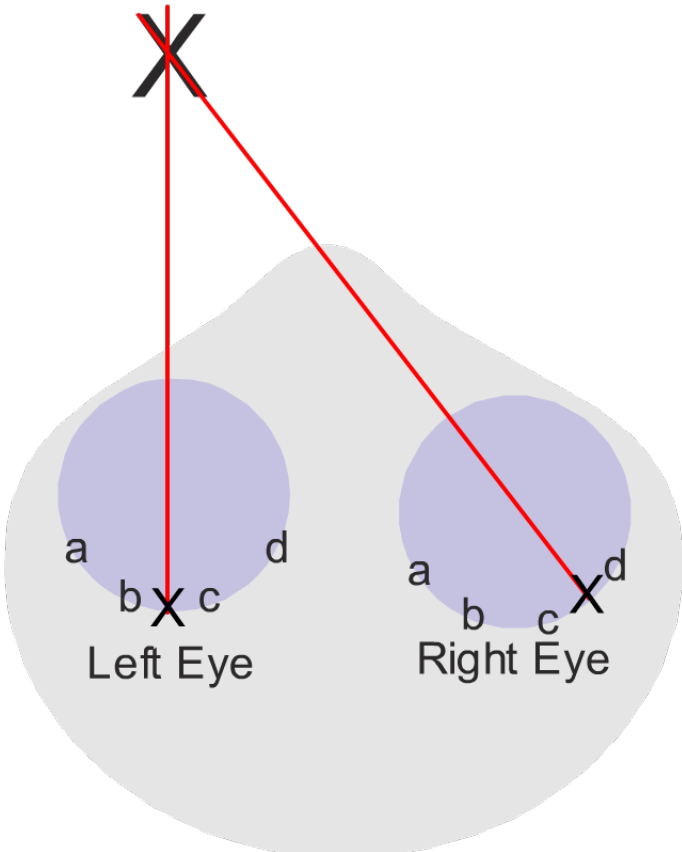
In the right eye

a)
b)
c)
d)

In the left eye

a)
b)
c)
d)

Problem 13: Below is a figure of a head as viewed from above. Suppose both eyes look at the X. Pick the letters that are located medial to the fovea (pick one or more).



Answer

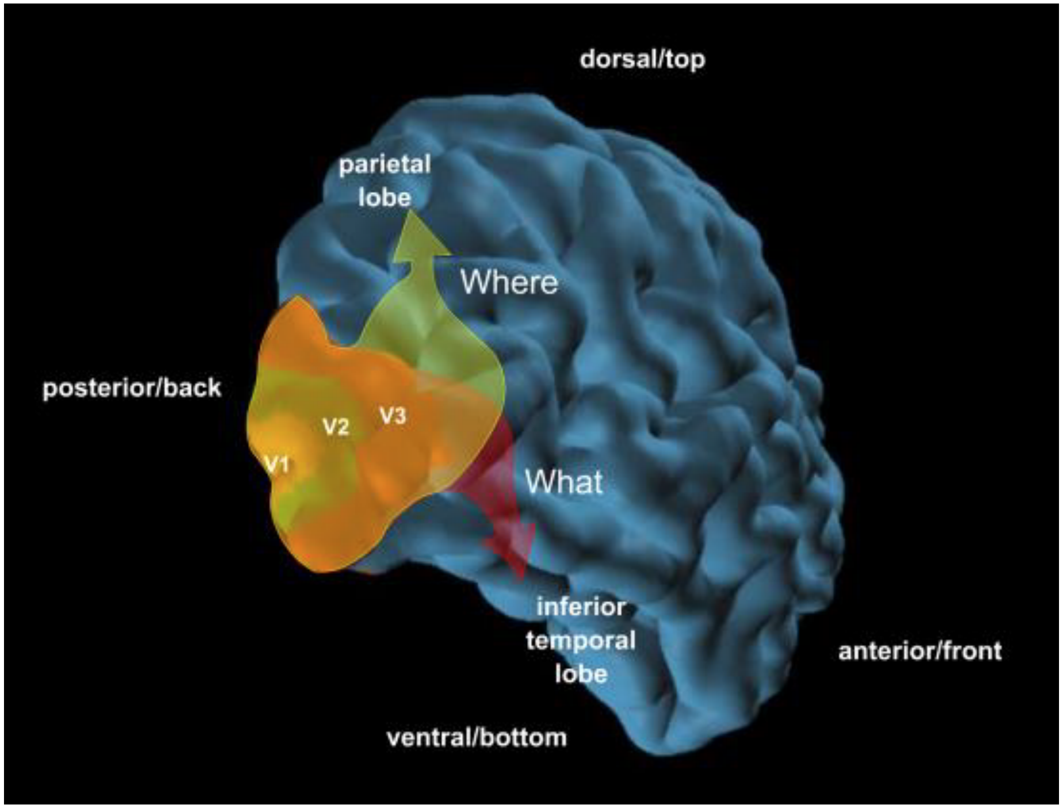
In the right eye

a) **Yes**
b) **Yes**
c) **Yes**
d)

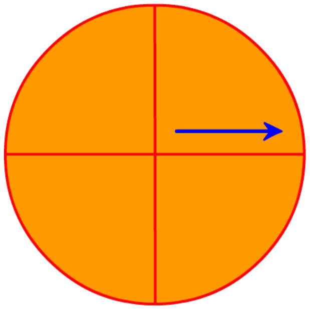
In the left eye

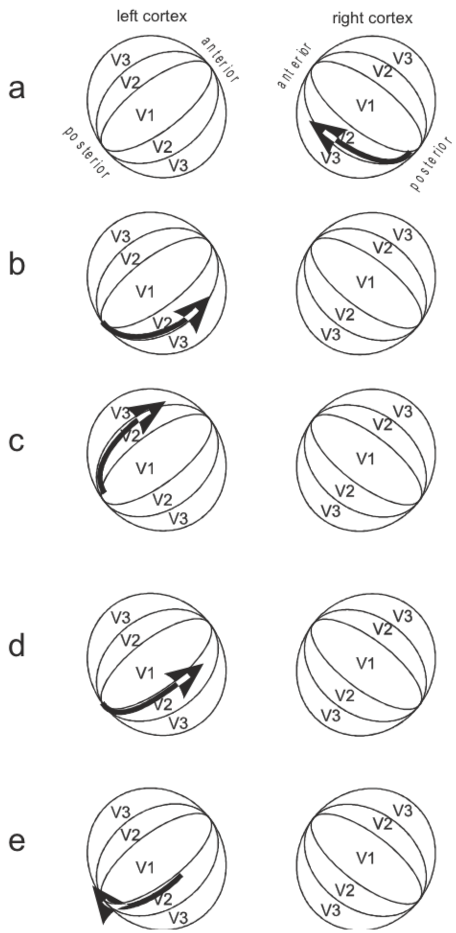
a)
b)
c) **Yes**
d) **Yes**

Chapter 3: Visual Perception of Objects

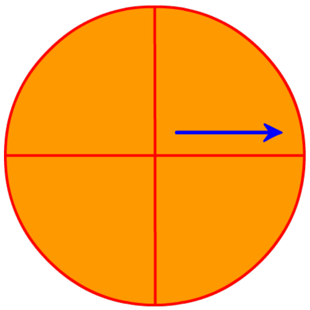


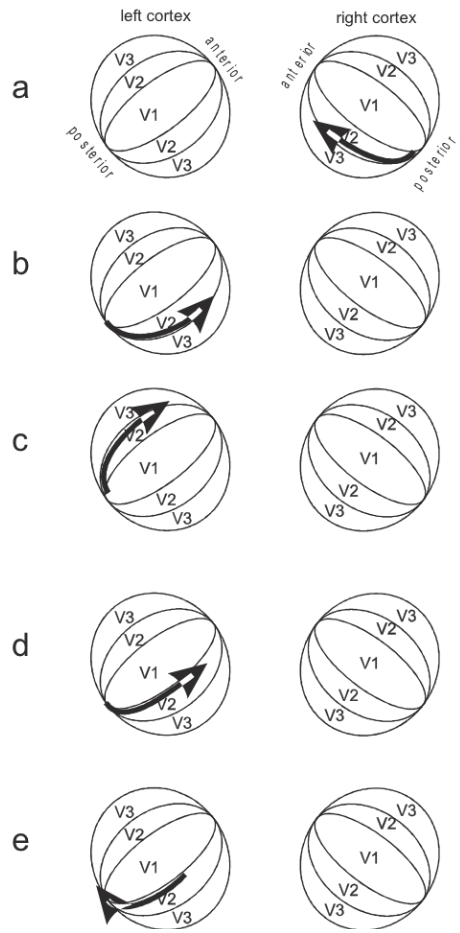
Problem 1: If one stares at the center, where in V2 would the blue arrow be mapped?





Problem 1: If one stares at the center, where in V2 would the blue arrow be mapped?





Answer

a) No. the arrow is in the right visual field. So the arrow would be represented in the left visual field.

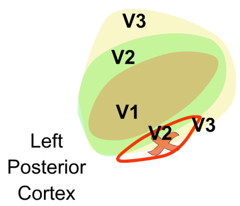
b) **Correct.** The arrow is pointing away from the posterior visual cortex which represents the fovea. The arrow is just above the horizontal in the right visual field. So it is represented below V1 in the left visual cortex close to the V2/V3 border.

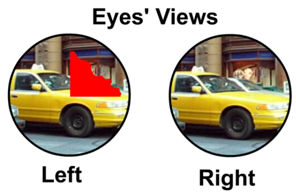
c) No. the arrow is in slightly above the horizontal line. So the arrow would be represented in the lower V2.

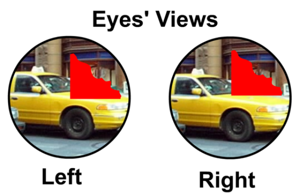
d) No. the arrow points to the right. This is the arrow activated by an arrow pointing up.

e) No. the arrow points to the right. This is the arrow activated by an arrow pointing down from above to the center.

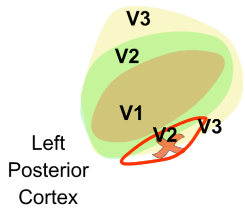
Problem 2: Suppose a patient had a lesion in the lower V2/V3 border in the left visual cortex (red circle). Which visual defect would the subject exhibit?



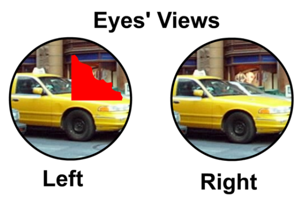




Problem 2: Suppose a patient had a lesion in the lower V2/V3 border in the left visual cortex (red circle). Which visual defect would the subject exhibit? **Answer.**



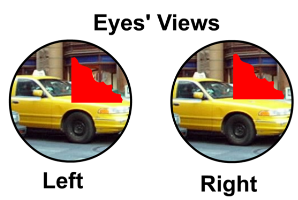
No. A lesion in the lower V2/V3 border in the left visual cortex would produce a loss of vision in the upper right visual field.



No. A cortical lesion affects the vision of both eyes.

No. Only the upper visual field would be affected by the lower V2/V3 lesion.

No. The bottom edge of the visual would be flat because this cortical area represents the right horizontal meridian and visual areas above it. The right upper quadrant is mirrored on both sides of the V2/V3 border



Correct. This is the only lesion that would produce a deficit with a straight border along the horizontal meridian. Other lesions will not follow straight lines. Lesions are messy and do not result in a straight line along the horizontal meridian. This deficit is called quadrantanopia, a loss of vision in one quadrant.

Problem 3: Where within the occipital visual areas would one find the greatest concentration of input from axons that cross via the corpus callosum?

a) Along the bottom of the calcarine sulcus

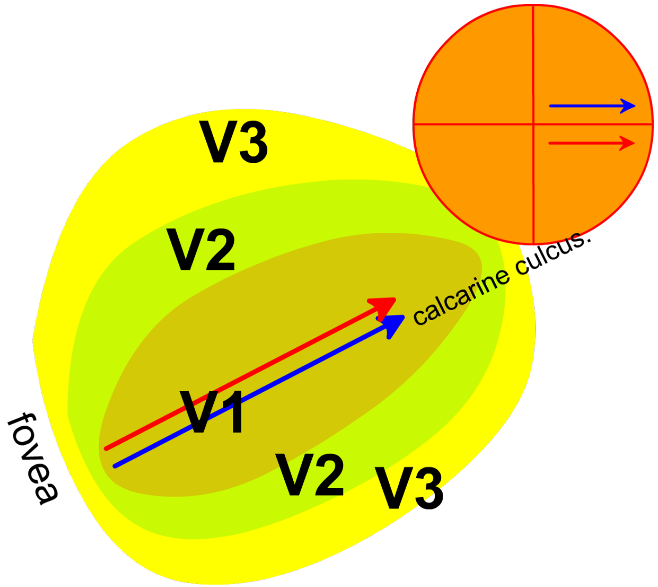
b) Along the V1/V2 border

c) Along the V2/V3 border

d) In area LOC

e) In the inferior temporal cortex

Problem 3: Where within the occipital visual areas would one find the greatest concentration of input from axons that cross via the corpus callosum?

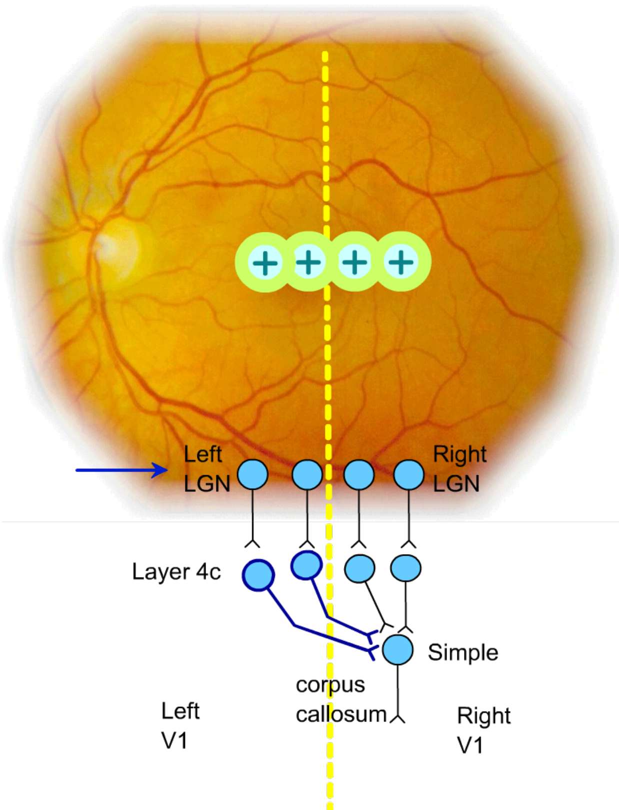


a) Along the bottom of the calcarine sulcus

Answer

No. The bottom of the calcarine is where a horizontal line through the fovea is represented.

Problem 3: Where within the occipital visual areas would one find the greatest concentration of input from axons that cross via the corpus callosum?



b) Along the V1/V2 border.

Answer

Correct!

Because this is where the vertical meridian is mapped.

The corpus callossum extends the receptive fields across the midline, i.e. along the vertical meridian. It staples the two sides of the visual field together. For example, we saw in the problem 4 of chapter 2 that the receptive field of a complex cell that is activated by a horizontal line at midline includes both the left and right visual field. Half of this receptive field is mediated by the corpus callossum. The same holds for binocular cells along the midline.

Problem 3: Where within the occipital visual areas would one find the greatest concentration of input from axons that cross via the corpus callosum?

c) Along the V2/V3 border.

Answer

No. This would cause quadrantanopia.

Problem 3: Where within the occipital visual areas would one find the greatest concentration of input from axons that cross via the corpus callosum?

d) In area LOC.

Answer

No. The lateral occipital complex, LOC, codes the contra lateral visual information as do the other early visual areas. Visual features on one's right are coded in the left V1 and the left LOC. The two sides are not brought together until the inferior temporal cortex.

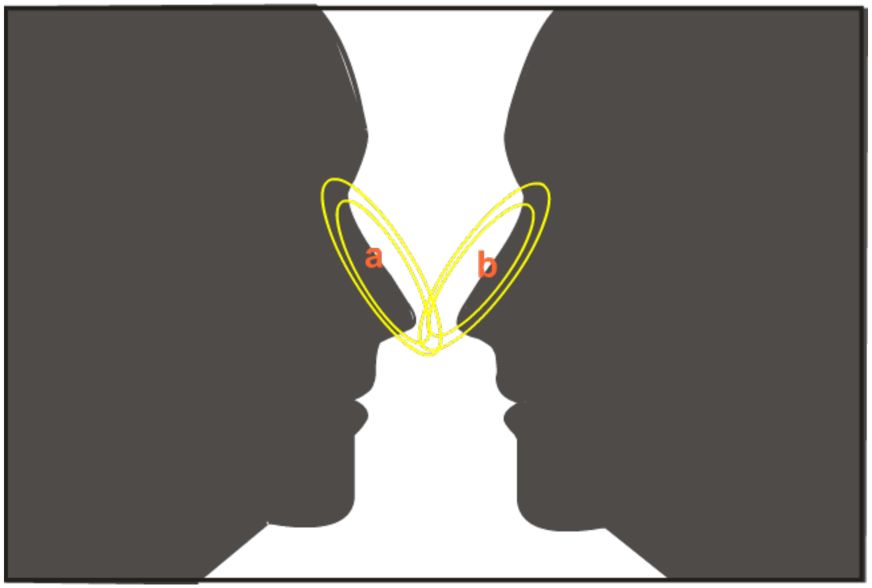
Problem 3: Where within the occipital visual areas would one find the greatest concentration of input from axons that cross via the corpus callosum?

e) In the inferior temporal cortex.

Answer

Yes, you do need the corpus callosum to bring the two sides of an object, such as a face, together but the inferior temporal cortex is in the temporal, not in the occipital cortex.

Problem 4: When one looks at the center of the figure on the right, one sees either a vase or two faces, but not both. What might the cortex be doing when this happens? Hint: imagine the synchrony in two simple cells each seeing the bridge of one nose.



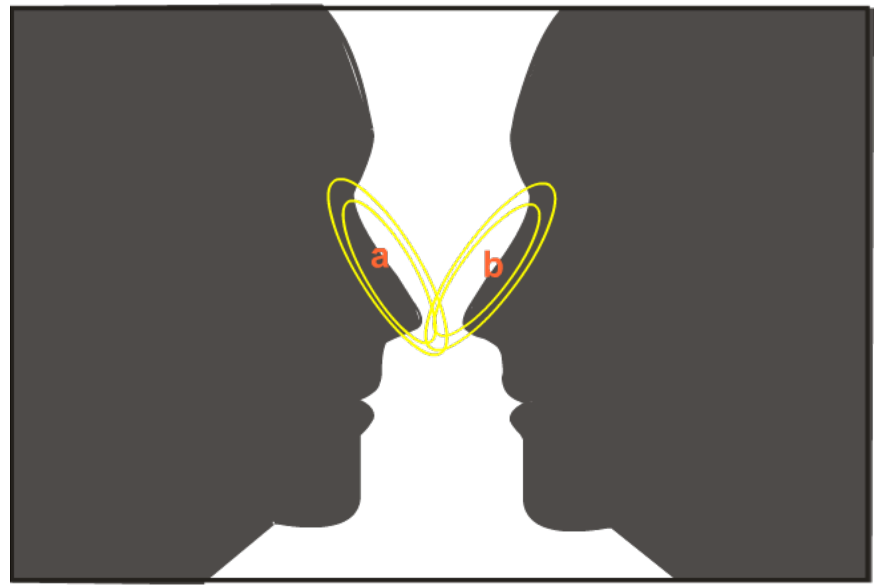
Which is false?

a) When one perceives the vase, neurons with receptive fields a and b, are in opposite hemispheres and will fire synchronously; i.e. at the same time.

b) When one perceives the vase, neurons with receptive fields a and b, are in opposite hemispheres and will fire asynchronously; i.e. at different times.

c) When one perceives two faces, neurons with receptive fields a and b, are in opposite hemispheres and will fire asynchronously; i.e. at different times.

Problem 4: When one looks at the center of the figure on the right, one sees either a vase or two faces, but not both. What might the cortex be doing when this happens? Hint: imagine the synchrony in two simple cells each seeing the bridge of one nose.

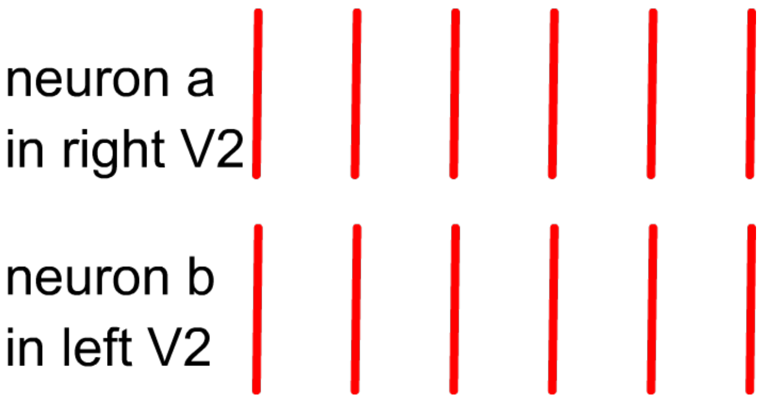


Which is false?

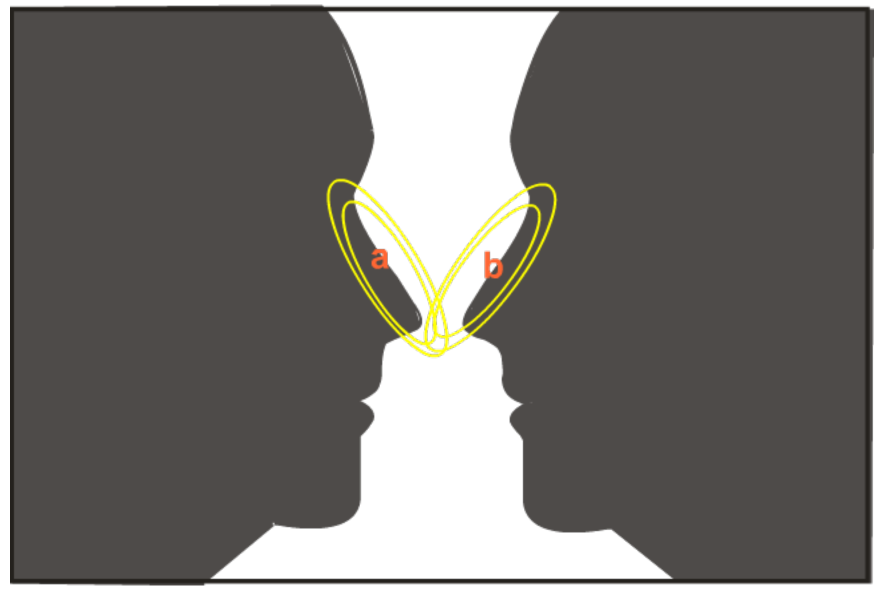
a) When one perceives the vase, neurons with receptive fields a and b, are in opposite hemispheres and will fire synchronously; i.e. at the same time.

Answer

This is true. The neurons fire synchronously because they represent parts of the same object.



Problem 4: When one looks at the center of the figure on the right, one sees either a vase or two faces, but not both. What might the cortex be doing when this happens? Hint: imagine the synchrony in two simple cells each seeing the bridge of one nose.

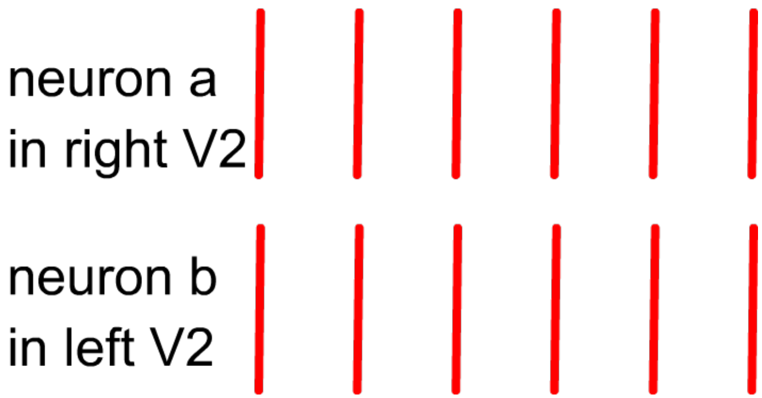


Which is false?

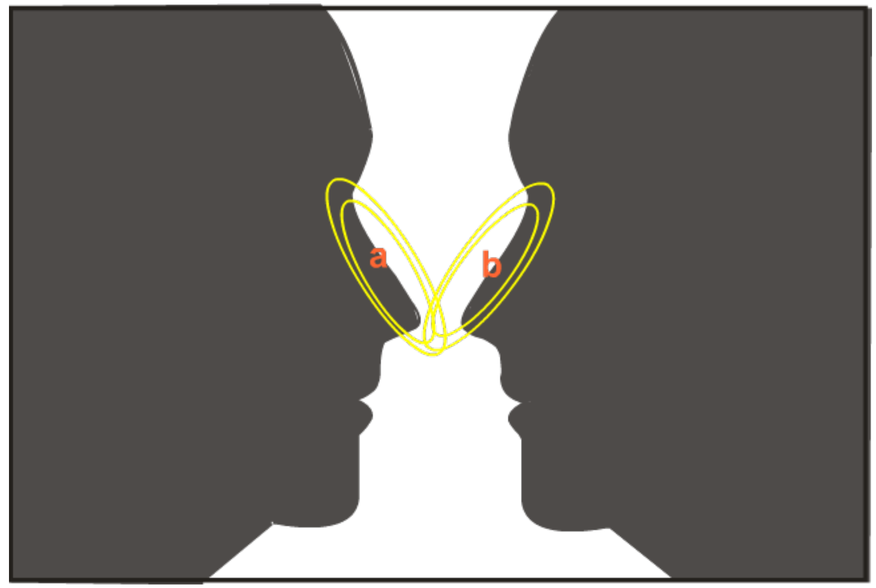
b) When one perceives the vase, neurons with receptive fields a and b, are in opposite hemispheres and will fire asynchronously; i.e. at different times.

Answer

Yes, this is false. The neurons fire synchronously because they represent parts of the same object.



Problem 4: When one looks at the center of the figure on the right, one sees either a vase or two faces, but not both. What might the cortex be doing when this happens? Hint: imagine the synchrony in two simple cells each seeing the bridge of one nose.

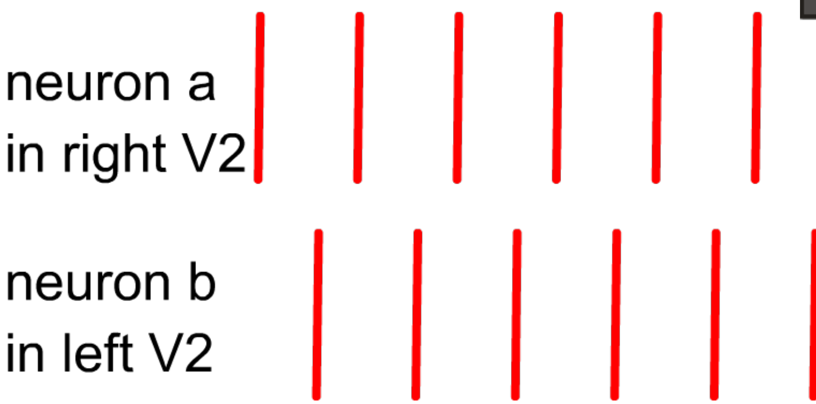


Which is false?

Answer

c) When one perceives two faces, neurons with receptive fields a and b, are in opposite hemispheres and will fire asynchronously; i.e. at different times.

This is true. They are parts of different objects.



Problem 5: Suppose that you recorded from a cell in the inferior temporal cortex and found that it responded vigorously to an image of a face. Would that prove this was a face cell?

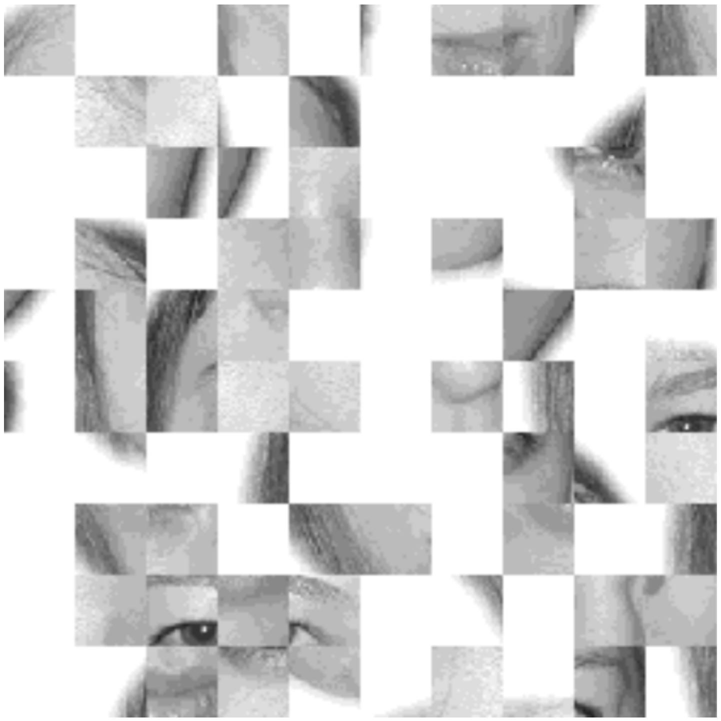
a) Take a photo of a face, cut it up, and scramble it up. The scrambled image will activate the cell.

b) Take a photo of a face, cut it up, and scramble it up. The scrambled image will **not** activate the cell.

c) Show pieces of the cut-up face, one at a time. One will activate the cell.

d) Show pieces of the cut up face, a few at a time. Some will activate the cell.

Problem 5: Suppose that you recorded from a cell in the inferior temporal cortex and found that it responded vigorously to an image of a face. Would that prove this was a face cell?



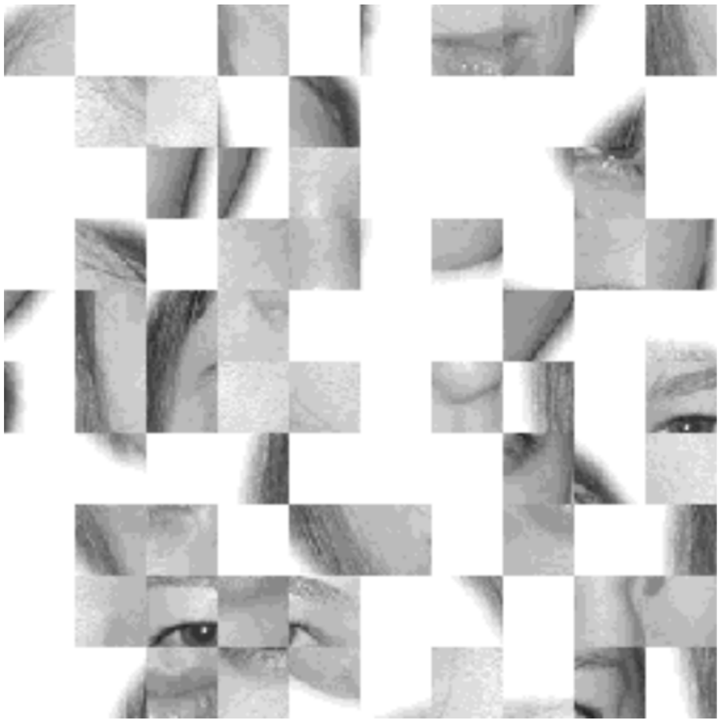
a) Take a photo of a face, cut it up, and scramble it up. The scrambled image will activate the cell.

Answer

No.

Face cells in the inferior temporal cortex would not be activated by only some feature in a face, e.g. an eyebrow. It requires the face features is their normal positions.

Problem 5: Suppose that you recorded from a cell in the inferior temporal cortex and found that it responded vigorously to an image of a face. Would that prove this was a face cell?



b) Take a photo of a face, cut it up, and scramble it up. The scrambled image will **not** activate the cell.

Answer

Correct.

Face cells in the inferior temporal cortex would not be activated by only a feature in a face, e.g. an eyebrow.

The features must be arranged in their normal positions to activate a face cell.

By showing that this cell is activated by the unscrambled version and silent for the scrambled, you have proved that this is a face cell and not one activated by only a single feature such as the eye or lip.

Problem 5: Suppose that you recorded from a cell in the inferior temporal cortex and found that it responded vigorously to an image of a face. Would that prove this was a face cell?

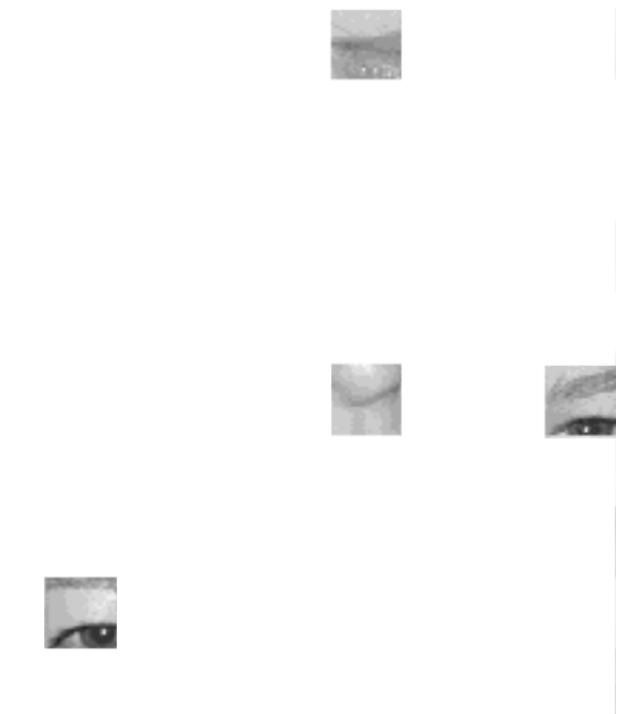
c) Show pieces of the cut-up face, one at a time. One will activate the cell.

Answer

No.

Face cells in the inferior temporal cortex would not be activated by a just a single feature of a face, e.g. an eye

Problem 5: Suppose that you recorded from a cell in the inferior temporal cortex and found that it responded vigorously to an image of a face. Would that prove this was a face cell?



d) Show pieces of the cut-up face, a few at a time. Some will activate the cell.

Answer

No.

Only if the features were arranged in their normal correct position and there were sufficient features would a face cell be activated.

Problem 6: Suppose you scanned the picture of a face with eye movements. What would your fovea see at each instance? How is this different from a normal face? How is the face recognized?

Which is **false**?

a) The fovea would see individual features one at a time.

b) Without knowing where the eye was looking when viewing each feature, the sequence would look like a Picasso painting.

c) To reconstruct the individual features into a face, the brain needs to know where the feature was via the "what" stream (i.e. where the eye was looking at each instance) and place the feature in that location.

d) To reconstruct the individual features into a face, the brain needs to know where the feature was via the "where" stream (i.e. where the eye was looking at each instance) and place the feature in that location.

Problem 6: Suppose you scanned the picture of a face with eye movements. What would your fovea see at each instance? How is this different from a normal face? How is the face recognized?

Which is **false**?

a) The fovea would see individual features one at a time.

Answer

This is true.

Problem 6: Suppose you scanned the picture of a face with eye movements. What would your fovea see at each instance? How is this different from a normal face? How is the face recognized?

Which is false?

b) Without knowing where the eye was looking when viewing each feature, the sequence would look like a Picasso painting.

Answer

This is true.

Problem 6: Suppose you scanned the picture of a face with eye movements. What would your fovea see at each instance? How is this different from a normal face? How is the face recognized?

Which is false?

c) To reconstruct the individual features into a face, the brain needs to know where the feature was via the "what" stream (i.e. where the eye was looking at each instance) and place the feature in that location.

Answer

Correct This is false.

Where information is provided through the "where" stream.

To reconstruct the individual features (snapshots of the bits and pieces) into a face, the brain needs to know where the feature was (i.e. where the eye was looking at each instance) and place the feature in that location.

E.g.:

1) an eyebrow while looking left and up.
2) a mouth while looking down.
3) an eye while looking left and up
4) a nose while looking at center.
5) a hair while looking way left.

Problem 6: Suppose you scanned the picture of a face with eye movements. What would your fovea see at each instance? How is this different from a normal face? How is the face recognized?

Which is false?

d) To reconstruct the individual features into a face, the brain needs to know where the feature was via the "where" stream (i.e. where the eye was looking at each instance) and place the feature in that location.

Answer

This is true.

Problem 7: Patients with a lesion of i) the "where" stream or ii) the "what" stream are asked to a) to pick up a pencil and b) describe its orientation. What can and cannot these patients do in each case. Which is true?

a). A patient with a lesion in the “where” stream can reach to the correct object location.

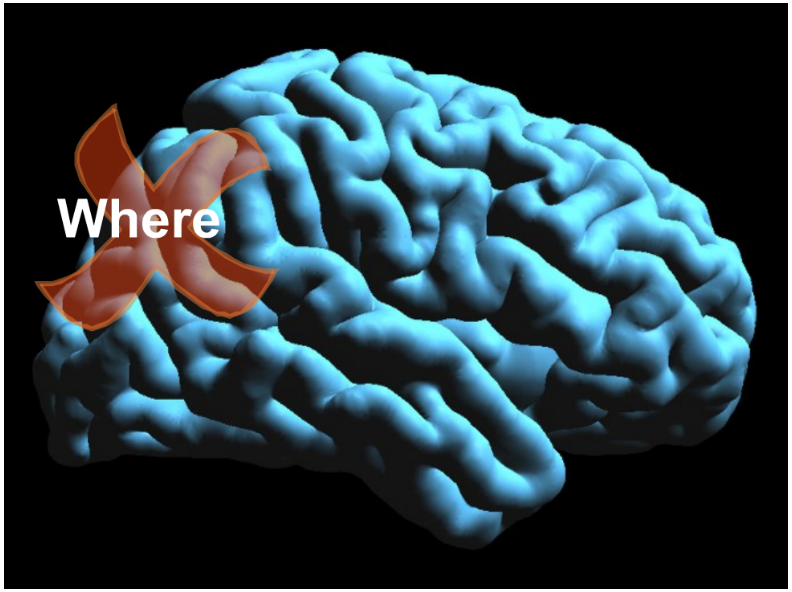
b) A patient with a lesion in the “where” stream can say what the orientation of the pencil is.

c) A patient with a lesion of the “what” stream can say what the orientation of the pencil is.

d) A patient with a lesion of the “what” stream cannot reach to the correct object location.

Problem 7: Patients with a lesion of i) the "where" stream or ii) the "what" stream are asked to a) to pick up a pencil and b) describe its orientation. What can and cannot these patients do in each case.

Which is true?



a). A patient with a lesion in the “where” stream can reach to the correct object location.

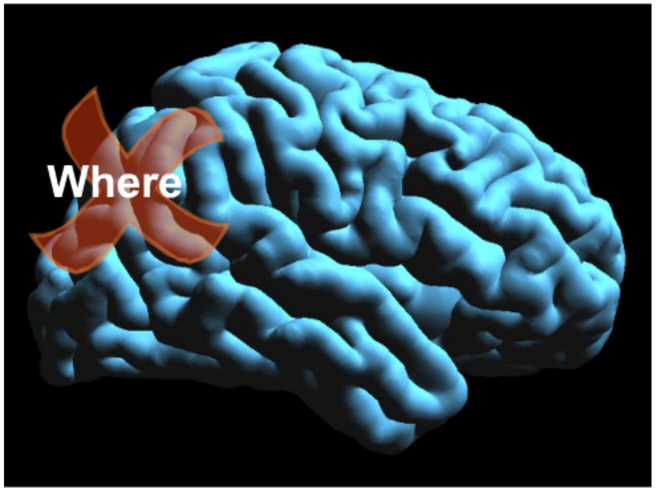
Answer

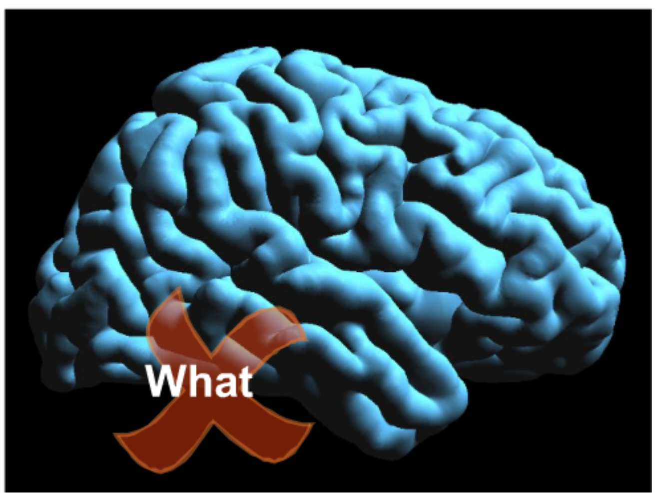
No.

A lesion of "where" stream impedes the coding of the correct reach location.

Problem 7: Patients with a lesion of i) the "where" stream or ii) the "what" stream are asked to a) to pick up a pencil and b) describe its orientation. What can and cannot these patients do in each case.

Which is true?





b) A patient with a lesion in the “where” stream can say what the orientation of the pencil is.

Answer

Correct. The patient can say what the orientation is and that it is a pencil but cannot reach to the correct location or with the correct hand orientation.

The patient can reach to the correct location and orientation but cannot say what the orientation is or that it is a pencil.

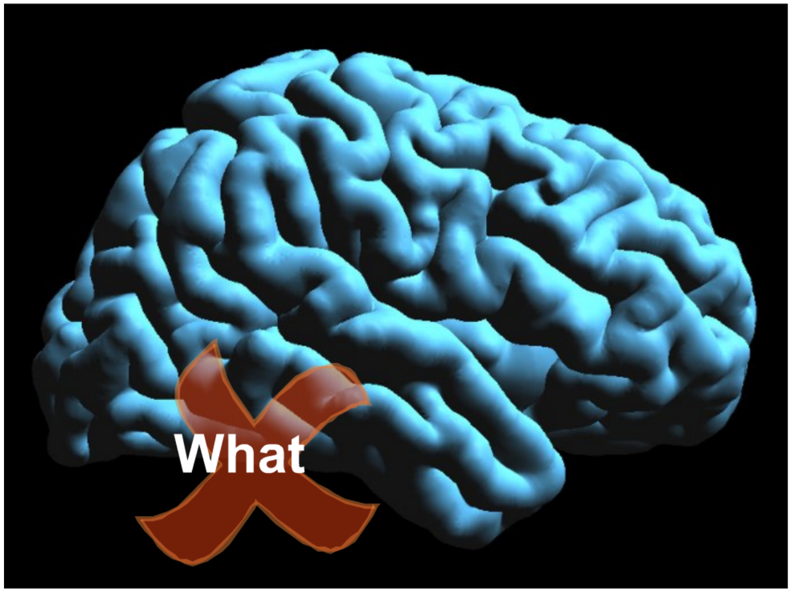
Mel Goodale @uwo.ca found that the "where" stream is used to direct movements and that we are often not conscious of the information in this stream.

The "what" stream is required for conscious perception. It is necessary to be consciously aware in order to verbally describe the spatial orientation of an object.

A patient with a lesion of the "what" stream will pick up the pencil, but not necessarily in the correct orientation for writing with; i.e. tip down. This is because the patient cannot recognize the object as a pencil.

Problem 7: Patients with a lesion of i) the "where" stream or ii) the "what" stream are asked to a) to pick up a pencil and b) describe its orientation. What can and cannot these patients do in each case.

Which is true?



c) A patient with a lesion of the “what” stream can say what the orientation of the pencil is.

Answer

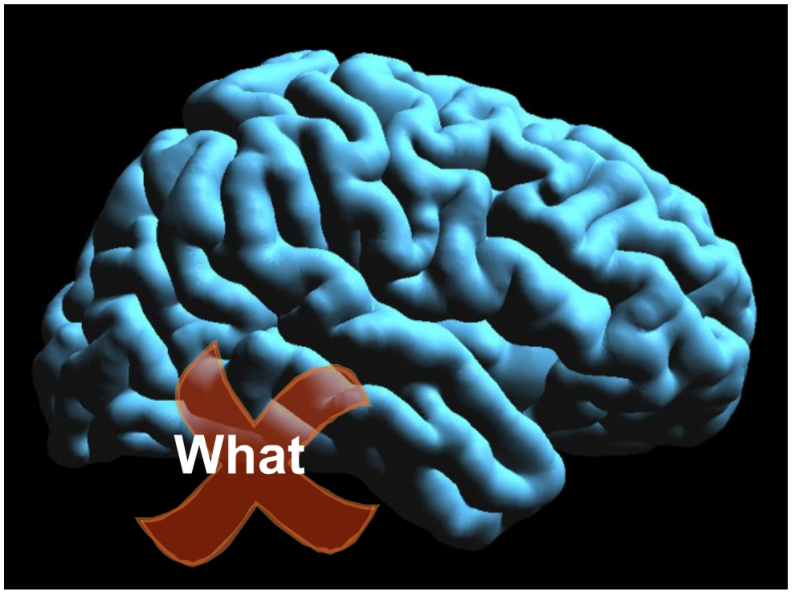
No.

A lesion of "what" stream impedes the coding of object perception. This will also impede the conscious perception of an object's orientation. Such perception is required to verbalize its orientation.

If asked to reach for it the hand, the patient will reach to the pencil with the correct orientation without being conscious of that orientation. The orientation may be incorrect for writing because the patient will not know that it is a pencil.

Problem 7: Patients with a lesion of i) the "where" stream or ii) the "what" stream are asked to a) to pick up a pencil and b) describe its orientation. What can and cannot these patients do in each case.

Which is true?



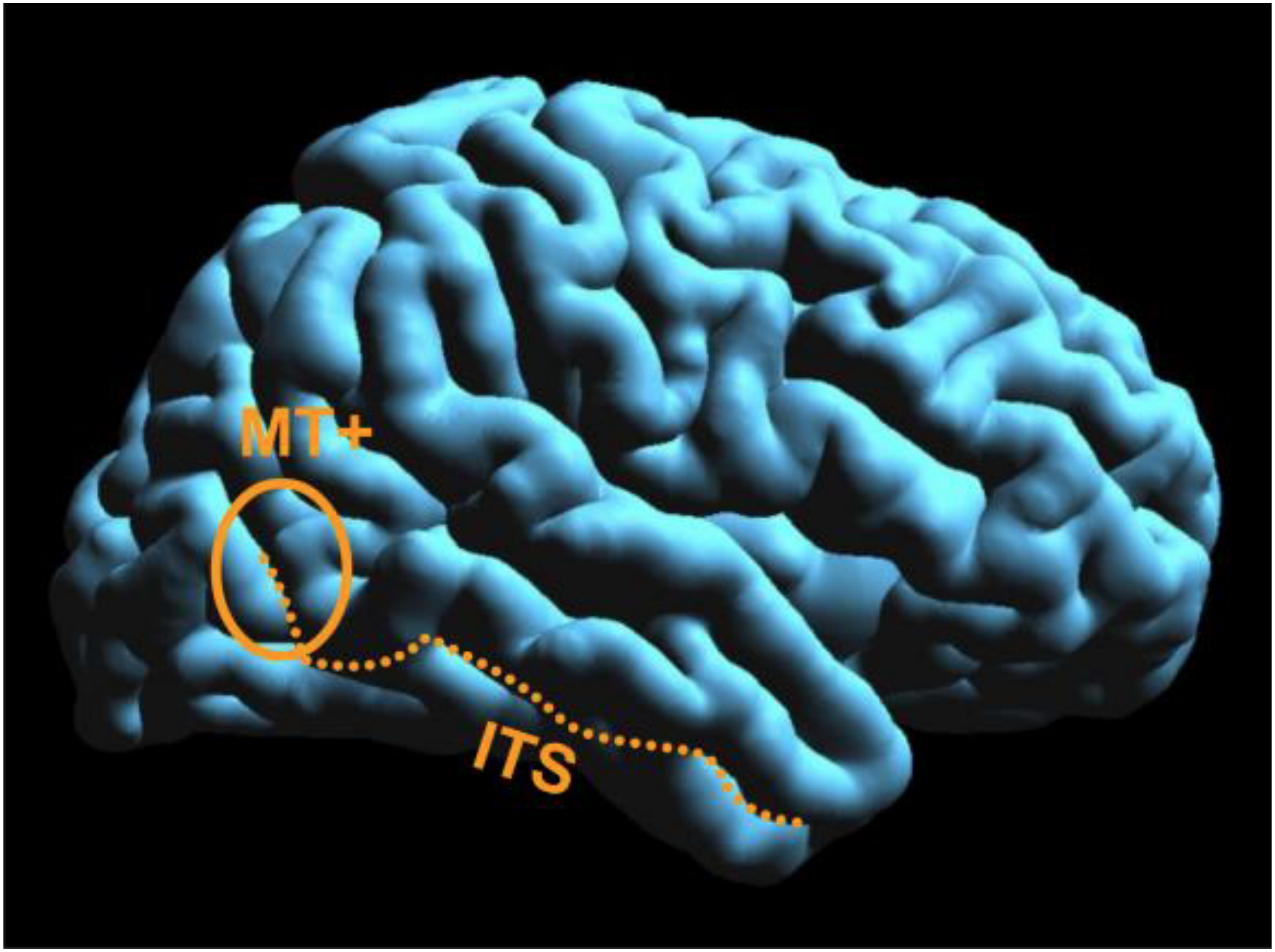
d) A patient with a lesion of the “what” stream cannot reach to the correct object location.

Answer

No.

A lesion of "what" stream impedes the coding of object perception. It does not impede the coding of object location.

Chapter 4: Visual Perception of Motion

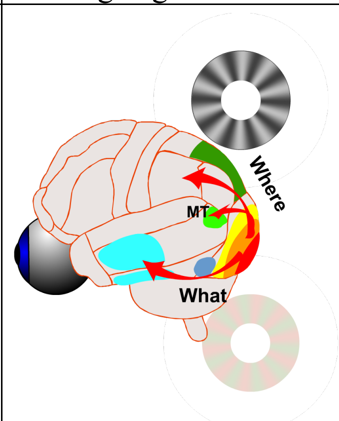
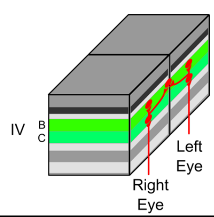


Problem 1: What type of stimuli would **not** activate neurons whose activity signals visual motion?

a). A moving black bar against a white background.	
b) A moving red bar against a white background.	
c) A moving red bar against a less bright green background.	
d) A moving red bar against an equally bright green background.	
e) A stimulus that activates neurons in layer 4B in V1.	
f) A stimulus that activates neurons in area MT.	

Problem 1: What type of stimuli would **not** activate neurons whose activity signals visual motion?

Answer

a). A moving black bar against a white background.	No. This would activate area MT.
b) A moving red bar against a white background.	No. A moving color bar against a white background would be as visible to MT as a grey bar against a white background. They both have a change in brightness. The moving edge would activate area MT.
c) A moving red bar against a less bright green background.	No. A red bar against a green bar of a different brightness will activate MT cell.MT sees in greys. Two colors of different brightness will appear as different shades of grey. A moving edge would be visible.
d) A moving red bar against an equally bright green background.	 **Correct.** Recall that MT receives input largely from the peripheral retina, via the LGN magnocellular layer and layer 4B of V1. This pathway "sees" in black, white and greys (changes in brightness) not in color. Color information is directed primarily along the "what" stream via the LGN parvocellular layer from the fovea. Motion defined by colors of the same brightness does not activate the "where" stream or area MT. Increasing the brightness of the colors in the disk makes their brightness more equal. When the colored rotating disk appears stationary it is similar to perceiving a moving object with an MT lesion.
e) A stimulus that activates neurons in layer 4B in V1.	 No. Cells in layer 4B are orientation sensitive like simple cells. They are also sensitive to motion in particular directions. These send their signal both directly to MT and indirectly via V2 and V3.
f) A stimulus that activates neurons in area MT.	No. Neurons activated by moving stimuli in area MT will induce a sense of motion.

Problem 2: Assume that one is using the neural circuit for visual motion detection discussed in this chapter. Which one of the following would be **false**?

a) The firing rate of the output neuron will increase if the velocity of the moving object increases.

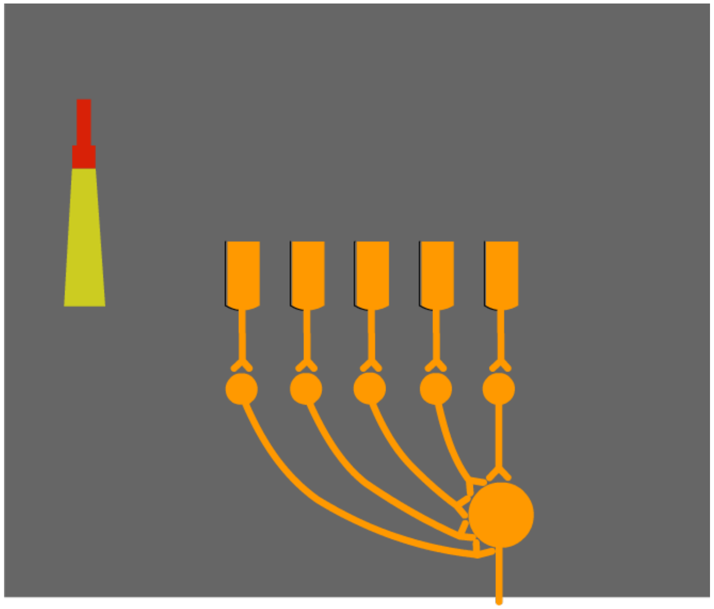
b) To best detect the velocity of a more slowly moving object, one would use a detector with a smaller spacing between the row of light sensing neurons.

c) To best detect the velocity of a more slowly moving object, one would use a detector with a longer delay in the axon from the row of light sensing neurons and the output neuron.

d) Each output neuron is selective for a particular velocity.

e) To best detect an object moving in a different direction one would realign the row of light sensing neurons.

Problem 2: Assume that one is using the neural circuit for visual motion detection discussed in this session. Which one of the following would be **false**?



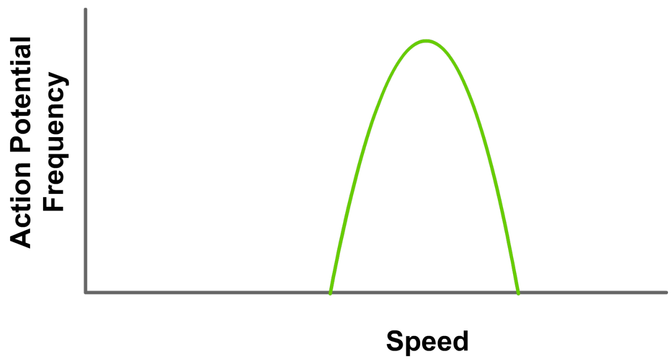
a) The firing rate of the output neuron will increase if the velocity of the moving object increases.

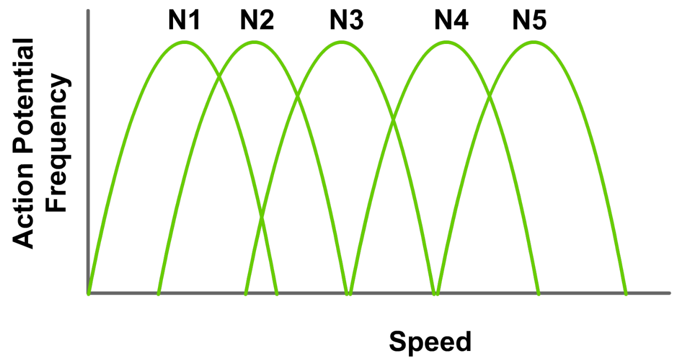
Answer

Correct, this is false.

Suppose that in the circuit on the left the light moved at a velocity that activated the receptors with a timing that caused the action potentials to arrive at the output neuron all at the same time causing it to fire and motion to be perceived. If the light moves faster, the action potentials all arrive at the output neuron at different times. Their effects would not reach threshold and the output neuron would fail to fire.

Problem 2: Assume that one is using the neural circuit for visual motion detection discussed in this session. Which one of the following would be false?





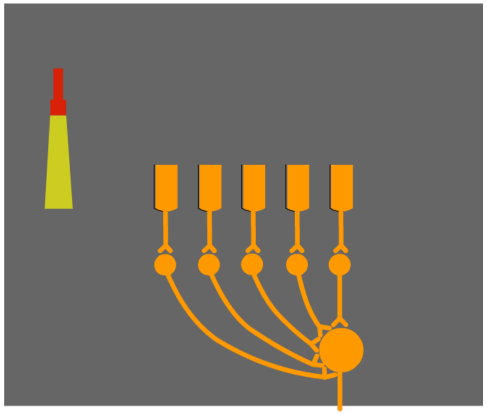
b) To best detect the velocity of a more slowly moving object, one would use a detector with a smaller spacing between the row of light sensing neurons.

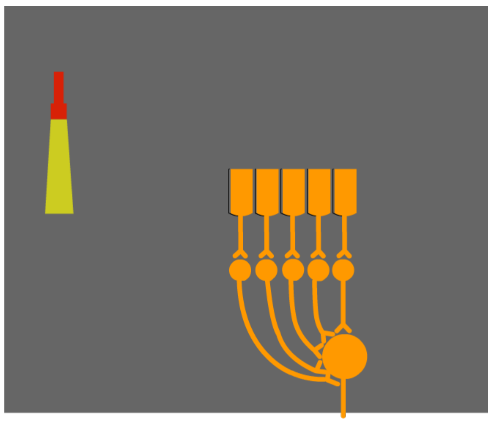
Answer

The neuron on the top left fires best for its preferred velocity.

Different neurons prefer different velocities. Thus velocity (a speed in a particular direction) is coded by a population code: **which neurons** are most active signal a particular velocity, not their firing rates.

Problem 2: Assume that one is using the neural circuit for visual motion detection discussed in this session. Which one of the following would be false?





c) To best detect the velocity of a more slowly moving object, one would use a detector with a longer delay in the axon from the row of light sensing neurons and the output neuron.

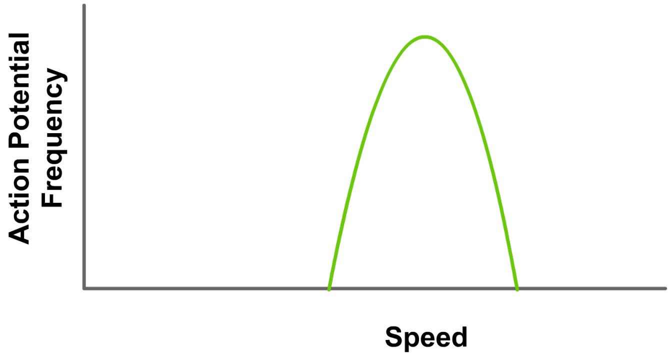
Answer

No this is true

In the top most figure, the light is moving too slowly to activate the output neuron at the same time.

In the lower figure, by placing the receptors closer together and keeping the axon's delays the same as on the top, the action potentials will all arrive at the output cell at the same time. Their effects add, reach threshold, and activate the output neuron which signals that a particular velocity has been detected.

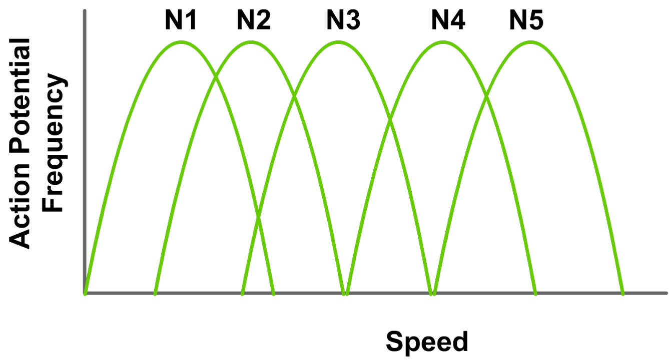
Problem 2: Assume that one is using the neural circuit for visual motion detection discussed in this session. Which one of the following would be false?



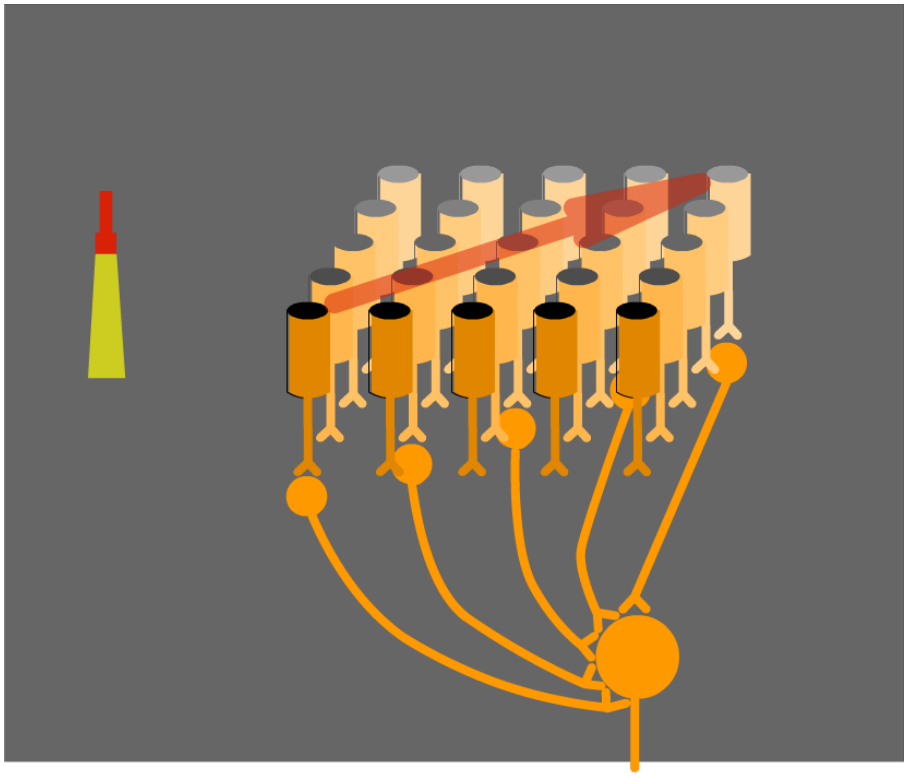
d) Each output neuron is selective for a particular velocity.

Answer

No this is true. Each neuron fires best for a particular velocity. Different neurons prefer different velocities. Thus, speed is coded by a population code: which neuron fires codes the velocity not its particular firing rate.



Problem 2: Assume that one is using the neural circuit for visual motion detection discussed in this session. Which one of the following would be false?

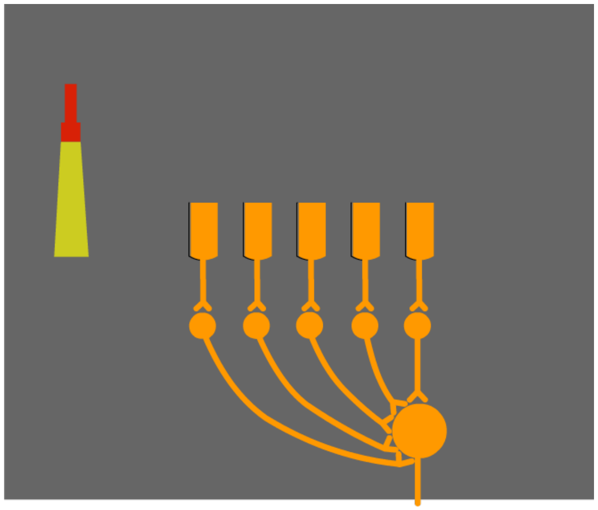


e) To best detect an object moving in a different direction one would realign the row of light sensing neurons.

Answer

No this is true. There is a multitude of output neurons each tuned to a particular direction, and also to a particular speed.

Problem 3: What changes would make this circuit tuned for a faster moving light?



a) Increase the axon diameter between the row of light sensing neurons and the output neuron.

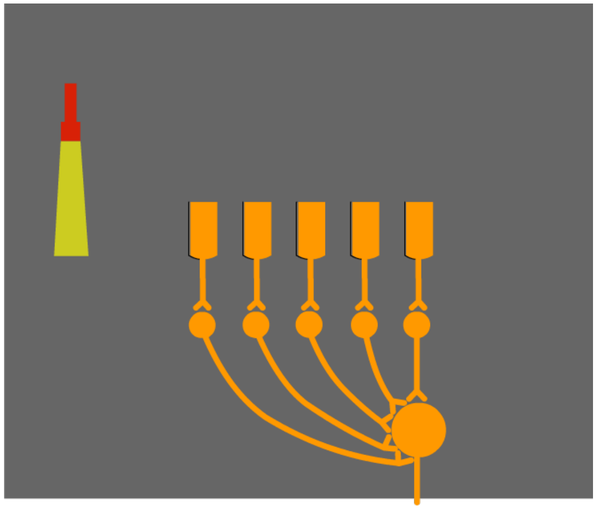
b) Decrease the axon length between the row of light sensing neurons and the output neuron.

c) Place the receptors farther apart along the row of light sensing neurons.

d) Increase the delay in the axon between the row of light sensing neurons and the output neuron.

e) All the above.

Problem 3: What changes would make this circuit tuned for a faster moving light?

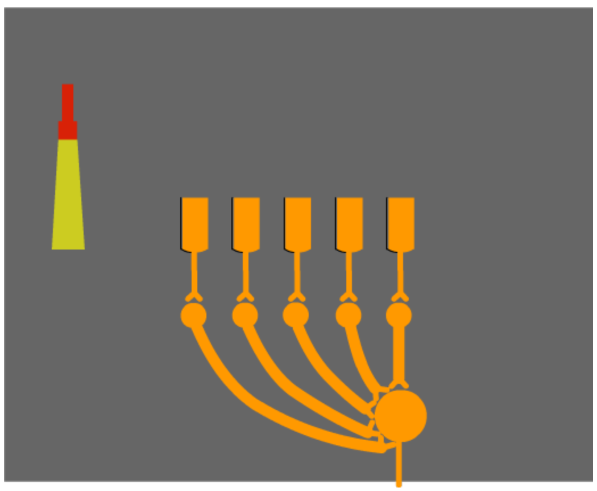


a) Increase the axon diameter between the row of light sensing neurons and the output neuron.

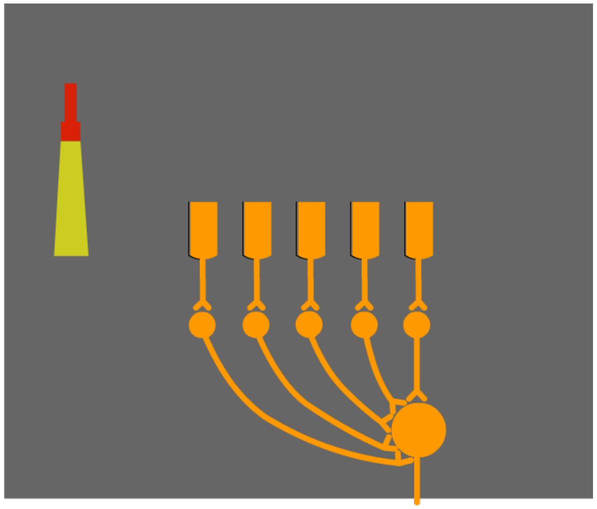
Answer

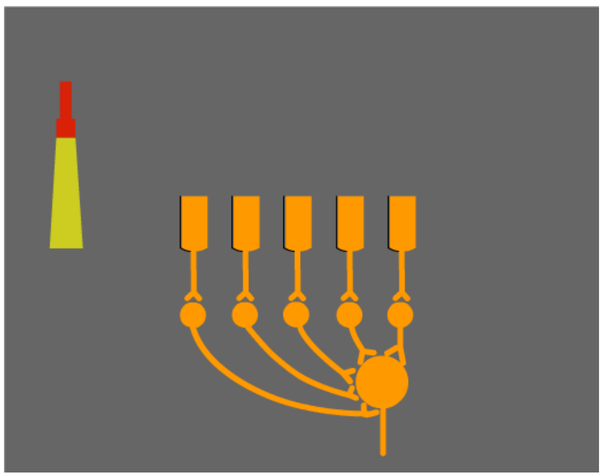
Yes. Increasing the diameter would increase the speed of conduction and allow all the action potentials to arrive at the output neuron at the same time.

Perhaps there are other correct answers.



Problem 3: What changes would make this circuit tuned for a faster moving light?



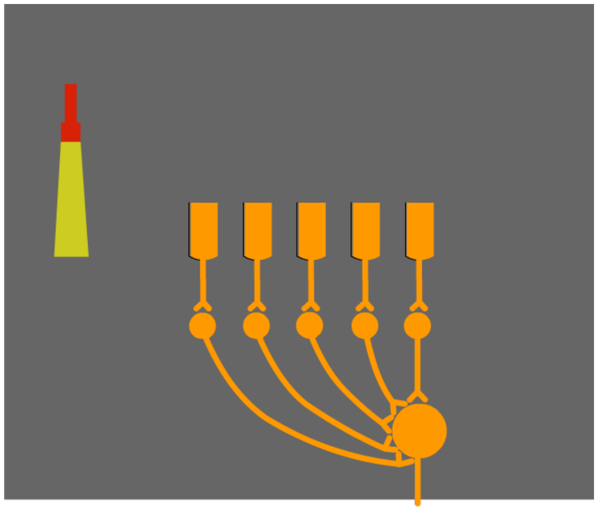


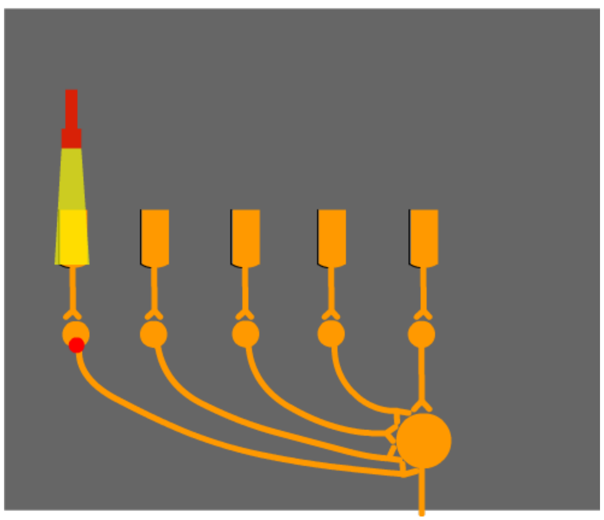
b) Decrease the axon length between the row of light sensing neurons and the output neuron.

Answer

Yes. Decreasing the axon length will decrease the transmission time and allow all the action potentials to arrive at the output neuron at the same time.

Problem 3: What changes would make this circuit tuned for a faster moving light?



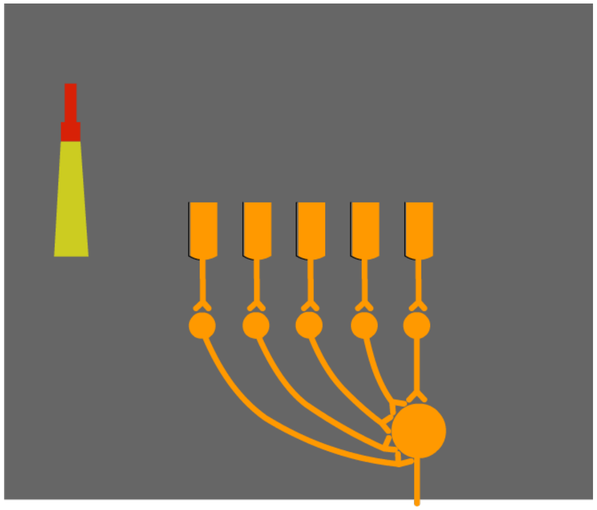


c) Place the receptors farther apart along the row of light sensing neurons.

Answer

Yes. Placing the receptors farther apart between the row of light sensing neurons and the output neuron would fire the receptors at a slower rate, and, if the axon conduction velocity were the same as before, allow all the action potentials to arrive at the output neuron at the same time. But notice that the axons are longer. So this solution would not work unless one made the axons conduct faster.

Problem 3: What changes would make this circuit tuned for a faster moving light?

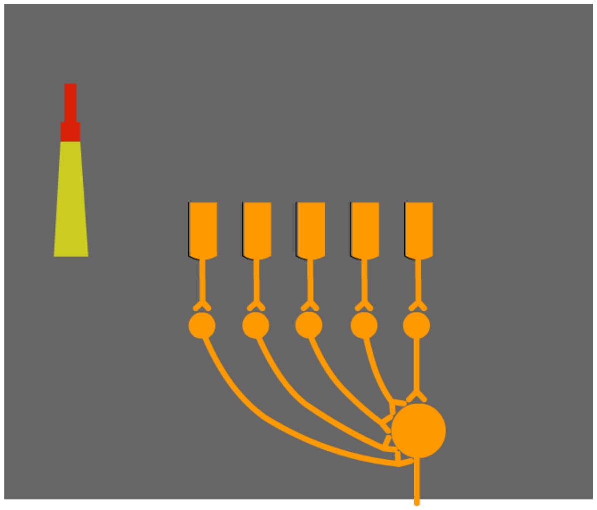


d) Increase the delay in the axon between the row of light sensing neurons and the output neuron.

Answer

No. This would make things worse. You want to decrease the delay.

Problem 3: What changes would make this circuit tuned for a faster moving light?



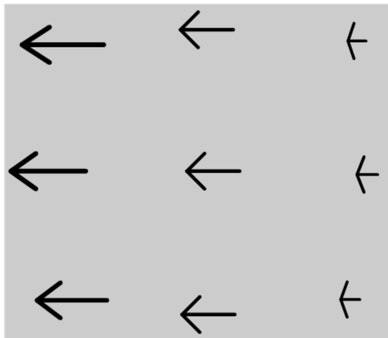
e) All the above.

Answer

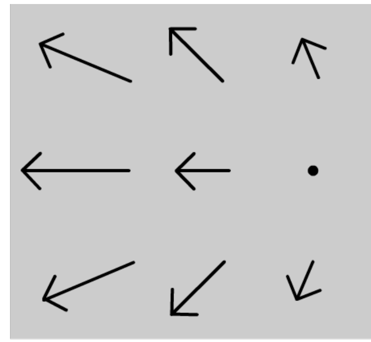
No, d is wrong.

Problem 4. Select the optic flow that would appear on the retina when you were driving a car that was moving forward while turning right.

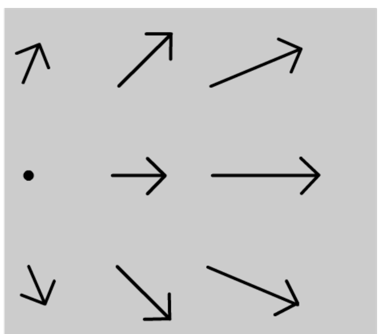
a



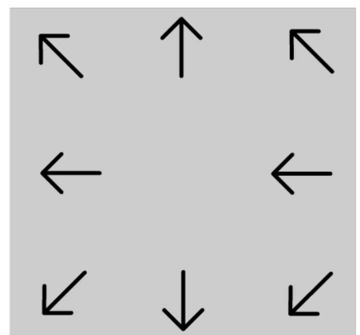
b



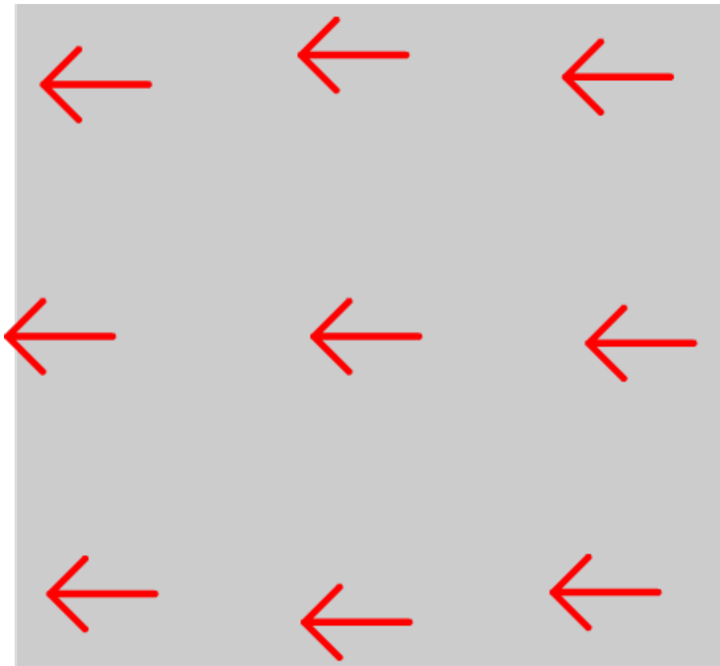
c



d



Problem 4. Select the optic flow that would appear on the retina when you were driving a car that was moving forward while turning right.



Right

Answer a

Close. Recall that this is the optic flow when you turn right.

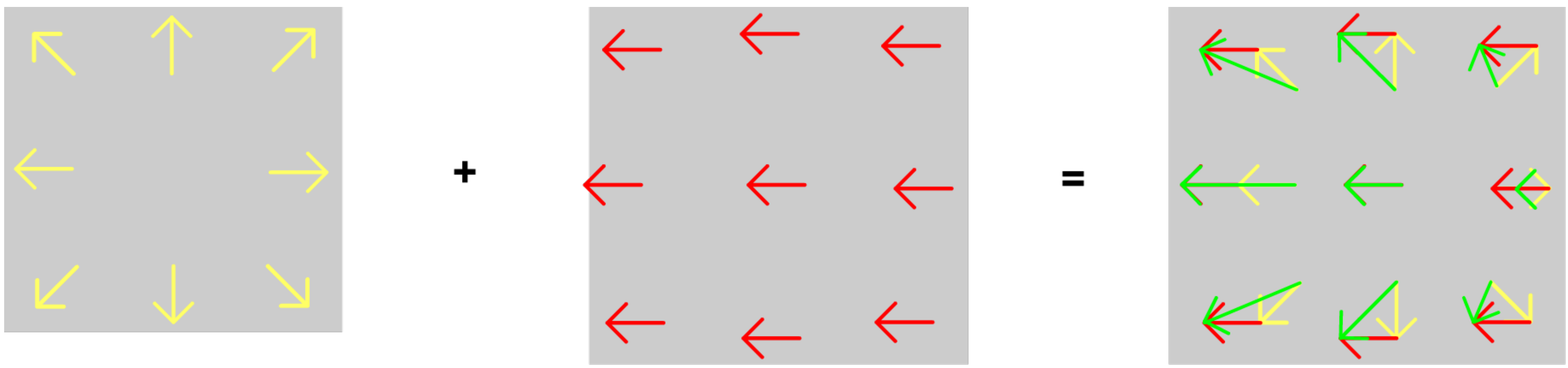
You are moving forward as well.

.

Problem 4. Select the optic flow that would appear on the retina when you were driving a car that was moving forward while turning right.

Answer b

Correct



Forward **Right** **When you do both, the stimulus is the sum of the two.**

Problem 4. Select the optic flow that would appear on the retina when you were driving a car that was moving forward while turning right.

Answer c

Not close

Problem 4. Select the optic flow that would appear on the retina when you were driving a car that was moving forward while turning right.

Answer d

No.

But close.

Problem 5: How does input from several MT cells activate a cell that is selective to the type of optic flow that occurs when you are moving forward?

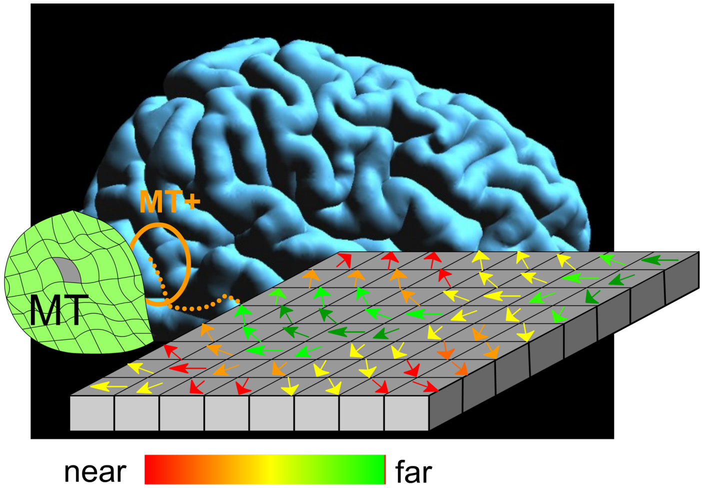
a) A particular column in the area MT is sensitive to the optic flow produced by moving forward.

b) A particular column in the area MSTl is sensitive to the optic flow produced by moving forward.

c). This pattern is detected by several neurons in the right MT.

d) This input, to an MSTd neuron, crosses via the corpus callosum.

Problem 5: How does input from several MT cells activate a cell that is selective to the type of optic flow that occurs when you are moving forward?



a) A particular column in the area MT is sensitive to the optic flow produced by moving forward.

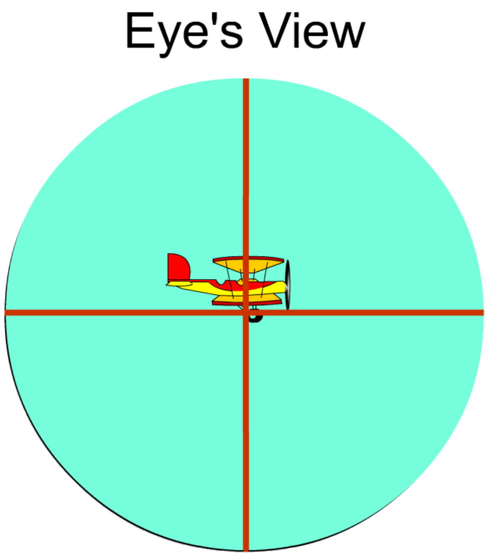
Answer

No.

One particular column receives input from one patch of retina.

The optic flow produced by moving forward comes from the whole retina.

Problem 5: How does input from several MT cells activate a cell that is selective to the type of optic flow that occurs when you are moving forward?



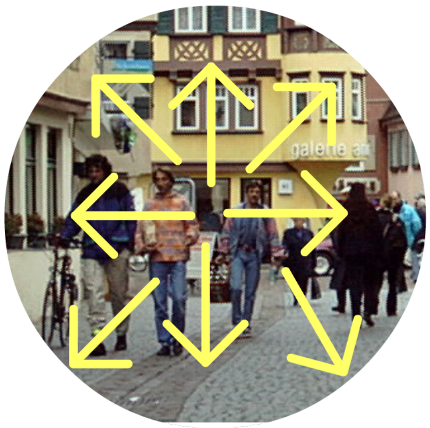
b) A particular column in the area MSTl is sensitive to the optic flow produced by moving forward.

Answer

No.

MSTl neurons are activated by moving objects, not optic flow.

Problem 5: How does input from several MT cells activate a cell that is selective to the type of optic flow that occurs when you are moving forward?



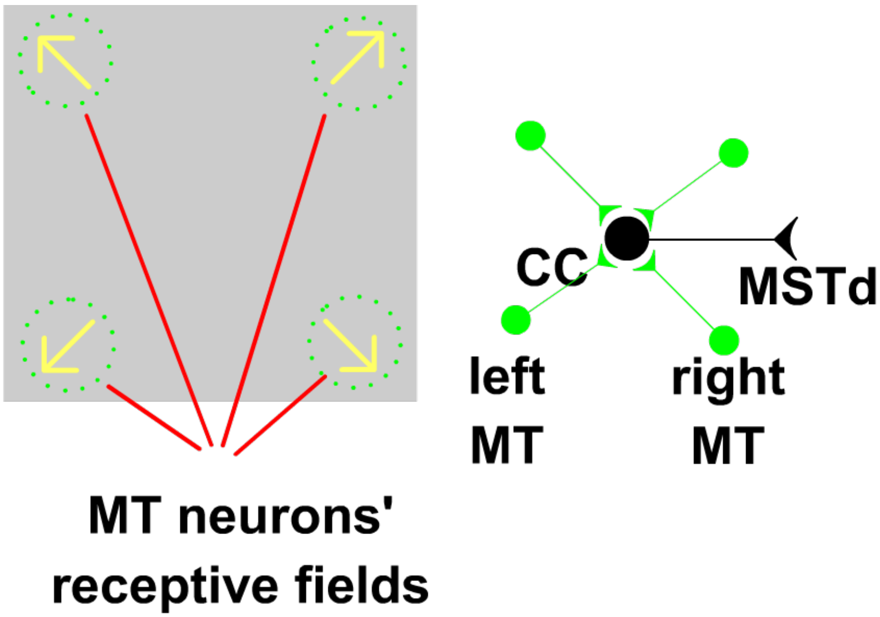
c). This pattern is detected by several neurons in the right MT.

Answer

No.

The MT on the right side detects optic flow from the left visual field. This pattern of optic flow covers both visual fields.

Problem 5: How does input from several MT cells activate a cell that is selective to the type of optic flow that occurs when you are moving forward?



d) This input, to an MSTd neuron, crosses via the corpus callosum.

Answer

Correct. MSTd neurons receive convergent input from most of the retina via MT neurons that are in the left and the right cortex. Inputs from the opposite side cross via the corpus callosum (CC).

Problem 6: A lesion of area MT would **not** cause a problem with

a) crossing the street.

b) filling a glass with water.

c) recognizing people from their gait.

d) catching a ball.

e) sensing the speed of something moving across your skin.

Problem 6: A lesion of area MT would **not** cause a problem with

a) crossing the street.

Answer

Incorrect. This **is** a problem resulting from an MT lesion. Imagine crossing a street if your view was that in the figure on the right. From a still image it is difficult to judge how fast cars are moving and if they are approaching or receding.

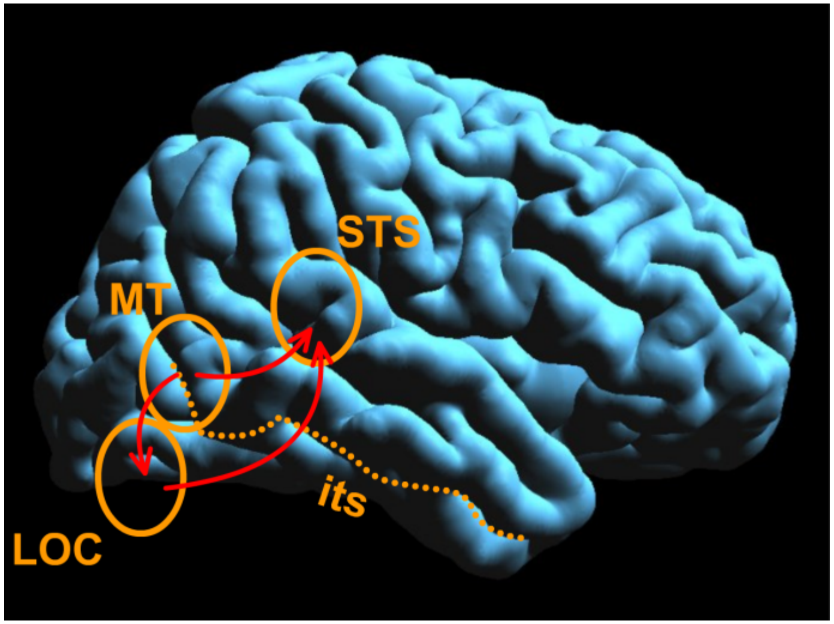
Problem 6: A lesion of area MT would **not** cause a problem with

b) filling a glass with water.

Answer

Incorrect. This **is** a problem resulting from an MT lesion. The patient would have trouble with filling a glass with water without over flowing it. With an MT lesion, the water would seem frozen, like a glacier. From the still-like images the patient could not judge how fast the water is rising.

Problem 6: A lesion of area MT would **not** cause a problem with

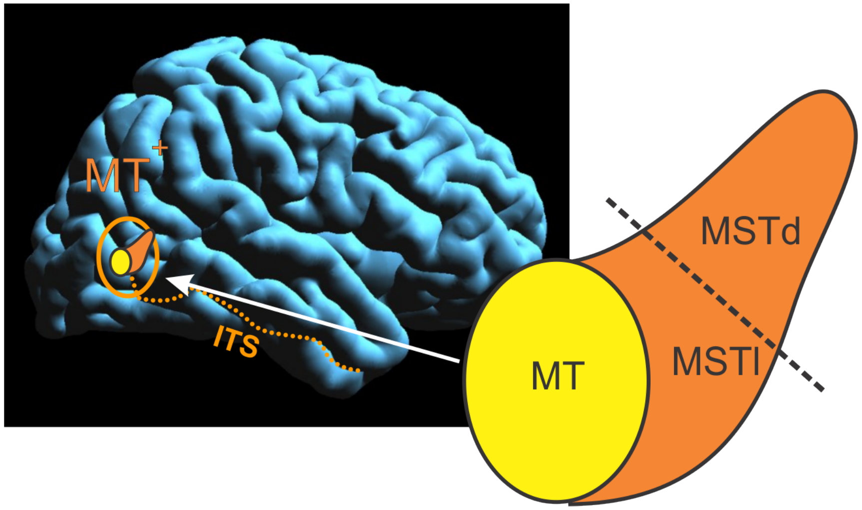


c) recognizing people from their gait.

Answer

Incorrect. This **is** a problem resulting from an MT lesion. The area STS is activated by biological motion and this activity is dependent on MT input.

Problem 6: A lesion of area MT would **not** cause a problem with



d) catching a ball.

Answer

Incorrect. This i**s** a problem resulting from an MT lesion. Area MSTl's computations of the ball's trajectory and speed is dependent on MT input.

Problem 6: A lesion of area MT would **not** cause a problem with

e) sensing the speed of something moving across your skin.

Answer

Correct. This is a **not** a problem resulting from an MT lesion. Acoustic and tactile movement perception is preserved after an MT lesion. MT is a funnel that is specialized for a visual motion signal.

Problem 6: A lesion of area MT would not cause a problem with

More deficits from MT lesions.

- You would not be able to walk down the hall in a straight line. Optic flow is used to correct your heading.
- You will have trouble with following a dialogue. You cannot use lip movements to assist your hearing. Lip reading involves recognizing movements of the lips.
- You cannot detect an animal moving in the woods. You cannot extract objects from motion. Animals in the wild are often invisible when they are still. Often you notice them only as soon as they move.
- You couldn't use the motion of objects at different depths (i.e. parallax) as a depth cue, and hence would have more difficulty separating foreground and background.

Problem 7. In which of the following conditions will you **not** generate corollary discharge? There may be more than one.

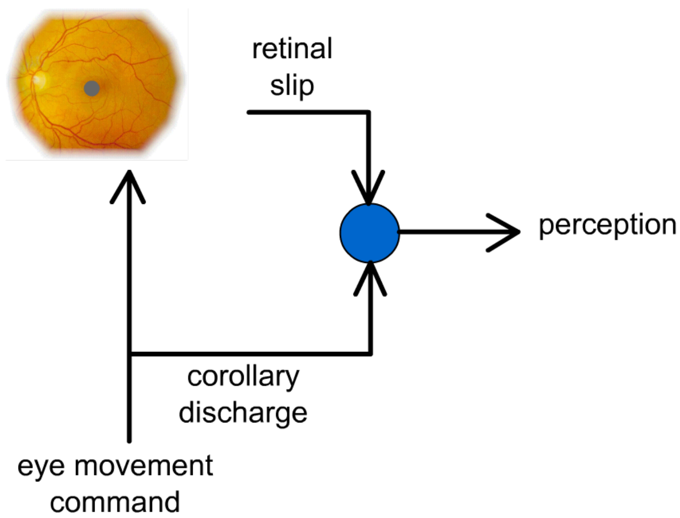
a) One pushes on the side of the eye ball to induce motion of the eye while staring at a dot.

b) The eye moves to follow a moving dot.

c) The eye muscles are paralyzed and the subject attempts to produce eye movements while staring at a stationary dot.

d) The eye jumps back and forth across a stationary dot.

Problem 7. In which of the following conditions will you **not** generate corollary discharge? There may be more than one.



a) One pushes on the side of the eye ball to induce motion of the eye while staring at a dot.

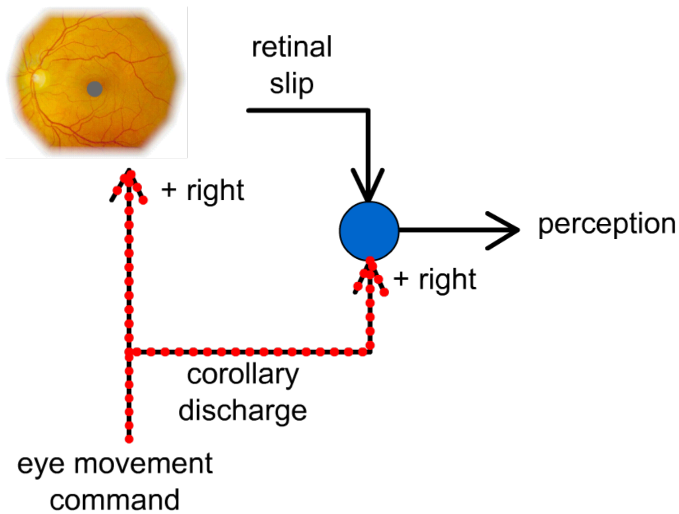
Answer

Correct.

Pushing the eye ball will move the eye but it will not generate an eye movement command. Try it gently on one eye with the other eye closed while looking ate this page. You should see the text on the page move.

Is there another condition?

Problem 7. In which of the following conditions will you **no**t generate corollary discharge? There may be more than one.



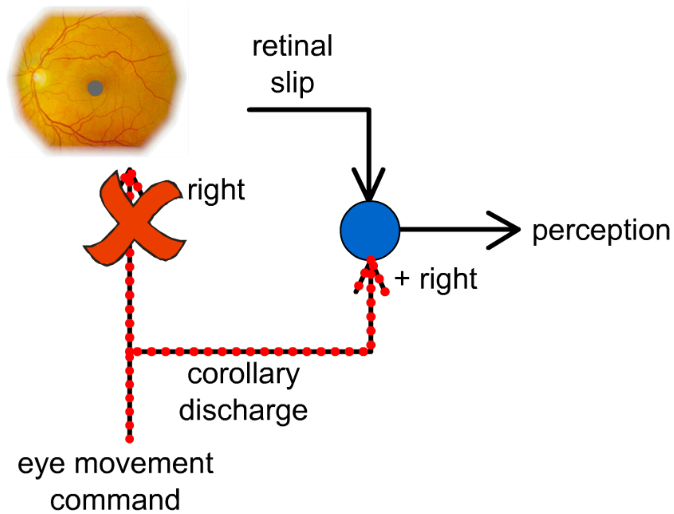
b) The eye moves to follow a moving dot.

Answer

No.

Pursuit eye movements will generate a corollary discharge.

Problem 7. In which of the following conditions will you **not** generate corollary discharge? There may be more than one.

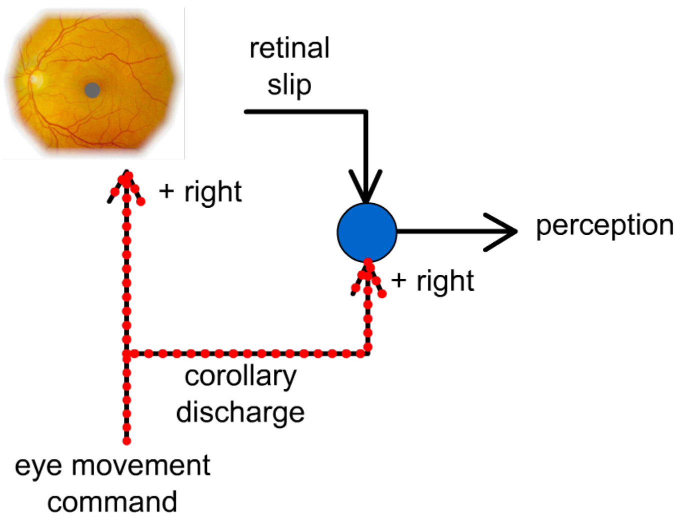


c) The eye muscles are paralyzed and the subject attempts to produce eye movements while staring at a stationary dot.

Answer

No. The effort of trying to make an eye movement will generate a corollary discharge even though it does not generate movement of the eyes.

Problem 7. In which of the following conditions will you **not** generate corollary discharge? There may be more than one.



d) The eye jumps back and forth across a stationary dot.

Answer

No.

Saccadic eye movements will generate a corollary discharge.

Problem 8. In which of the following conditions will there **not** be motion of the dot on the retina (i.e. no retinal slip)? There may be more than one.

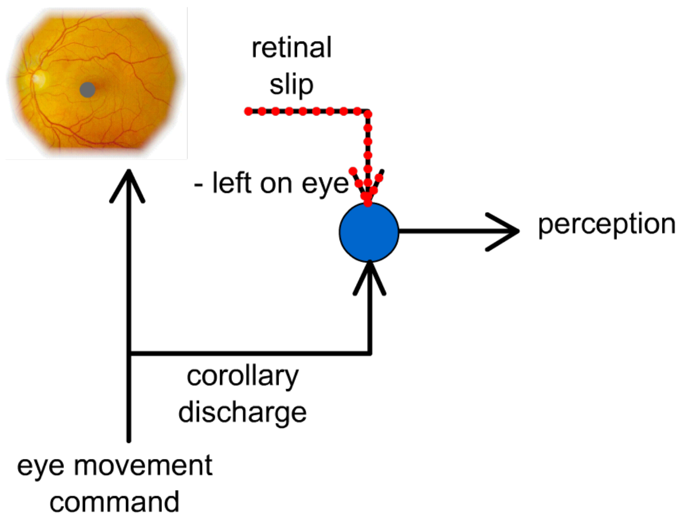
a) One pushes on the side of the eye ball to induce motion of the eye while staring at a dot.

b) The eye moves to follow a moving dot.

c) The eye muscles are paralyzed and the subject attempts to produce eye movements while staring at a stationary dot.

d) The eye jumps back and forth across a stationary dot.

Problem 8. In which of the following conditions will there **not** be motion of the dot on the retina (i.e. no retinal slip)? There may be more than one.



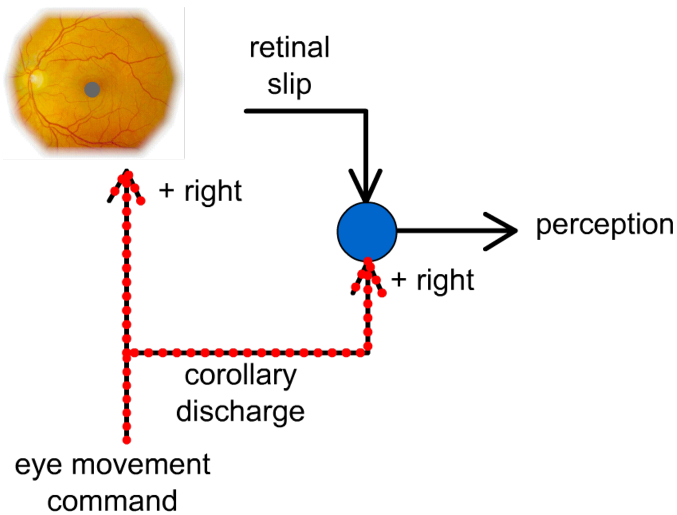
a) One pushes on the side of the eye ball to induce motion of the eye while staring at a dot.

Answer

No. Pushing the eye will cause the image of the dot to slip across the retina.

There will be retinal slip.

Problem 8. In which of the following conditions will there **not** be motion of the dot on the retina (i.e. no retinal slip)? There may be more than one.



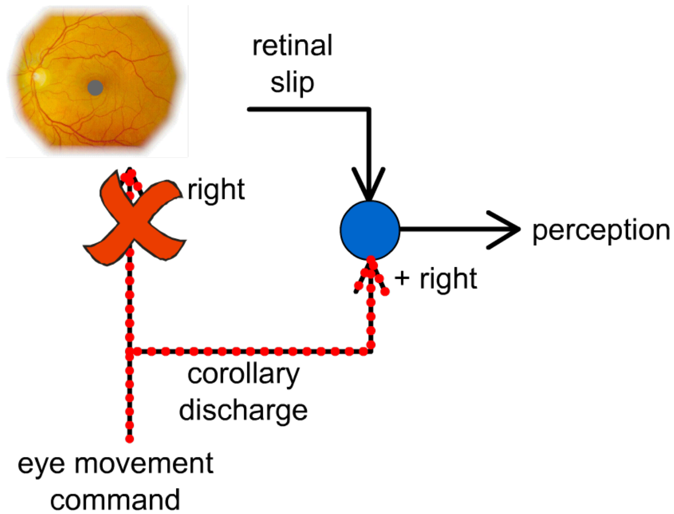
b) The eye moves to follow a moving dot.

Answer

Correct.

If the eye follows the moving dot, the dot will remain centered on the fovea and there will be no retinal slip, at least when looking at a blue sky or a darkened room.

Problem 8. In which of the following conditions will there **not** be motion of the dot on the retina (i.e. no retinal slip)? There may be more than one.

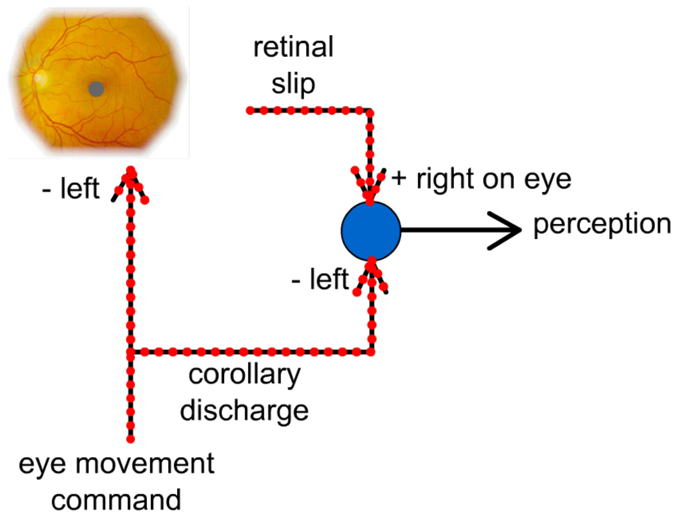


c) The eye muscles are paralyzed and the subject attempts to produce eye movements while staring at a stationary dot.

Answer

Correct. Because the muscles are unable to move the eye there will be no movement of the dot's image.

Problem 8. In which of the following conditions will there **not** be motion of the dot on the retina (i.e. no retinal slip)? There may be more than one.



d) The eye jumps back and forth across a stationary dot.

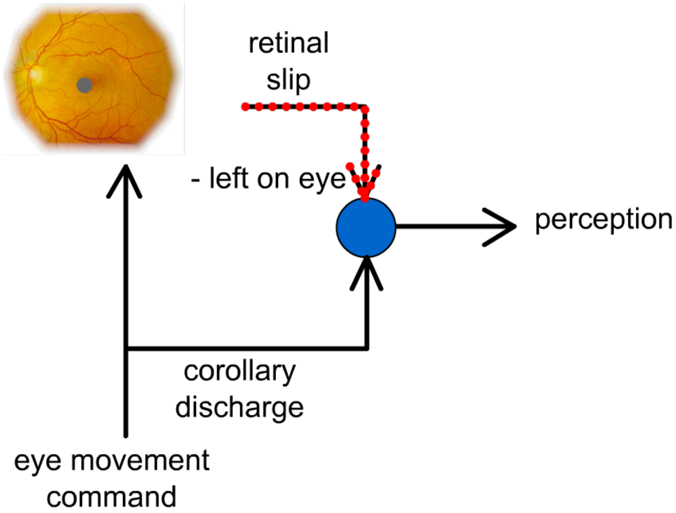
Answer

No. Making a saccade will cause the image of the dot to slip across the retina. There will be retinal slip

Problem 9: In which of the following conditions will you perceive motion of the dot? There may be more than one.

a) One pushes on the side of the eye ball to induce motion of the eye while staring at a dot.
b) The eye moves to follow a moving dot.
c) The eye muscles are paralyzed and the subject attempts to produce eye movements while staring at a stationary dot.
d) The eye jumps back and forth across a stationary dot.

Problem 9: In which of the following conditions will you perceive motion of the dot? There may be more than one.



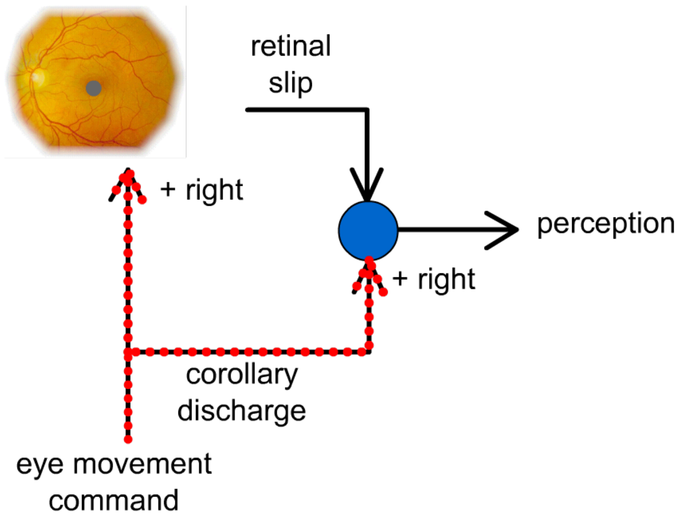
a) One pushes on the side of the eye ball to induce motion of the eye while staring at a dot.

Answer

Correct. The retinal slip causes the stationary dot to appear moving. Try it gently on one eye with the other eye closed while looking ate this page. You should see the text on the page move.

Is there another condition in which you perceive motion?

Problem 9: In which of the following conditions will you perceive motion of the dot? There may be more than one.



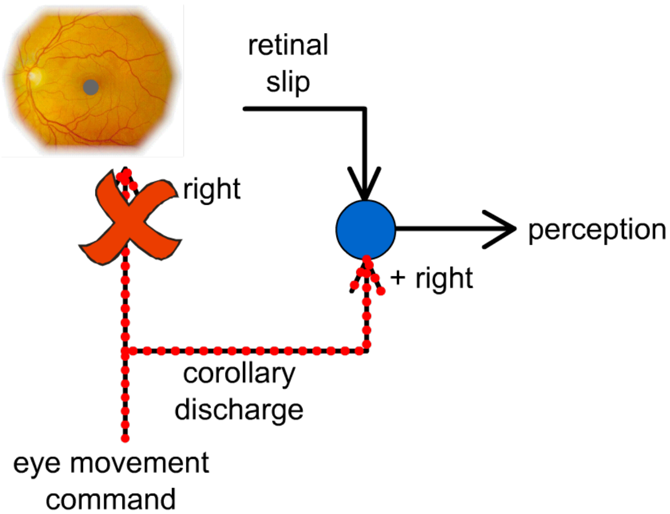
b) The eye moves to follow a moving dot.

Answer

Correct. There no retinal slip but there is corollary discharge. This signals the perception of motion of the dot.

Is there another condition in which you perceive motion?

Problem 9: In which of the following conditions will you perceive motion of the dot? There may be more than one.

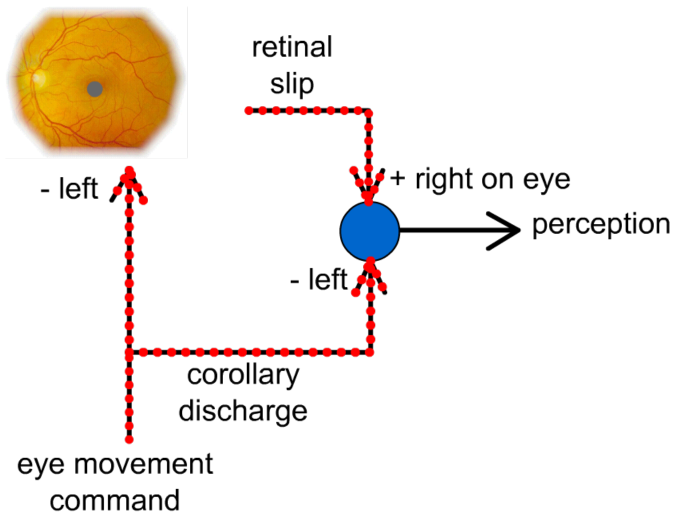


c) The eye muscles are paralyzed and the subject attempts to produce eye movements while staring at a stationary dot.

Answer

Correct. There is no retinal slip but the attempt to move elicits corollary discharge. this signals the perception of motion. The stationary dot appears to move.

Problem 9: In which of the following conditions will you perceive motion of the dot? There may be more than one.

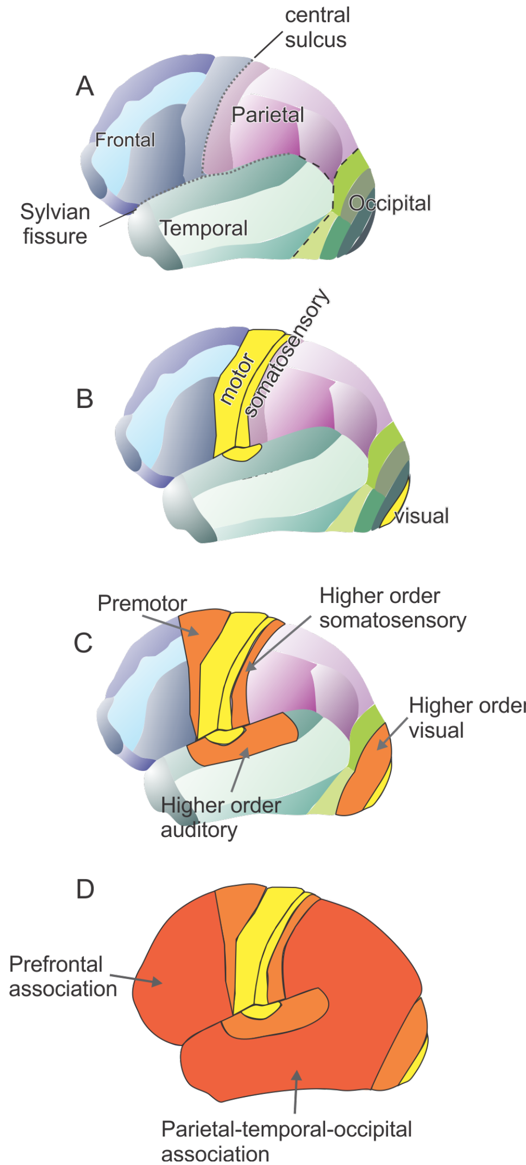


d) The eye jumps back and forth across a stationary dot.

Answer

No. The retinal slip of the dot is cancelled by corollary discharge. The dot is correctly perceived as stationary.

Chapter 5: Association Cortex



Problem 1: Count the number of F's in the following text.

FINISHED FILES ARE THE
RESULT OF YEARS OF SCIENTIFIC
STUDY COMBINED WITH THE
EXPERIENCE OF YEARS

There are

a) 4
b) 5
c) 6
d) 7
e) 8

Problem 1: Count the number of F's in the following text.

Answer

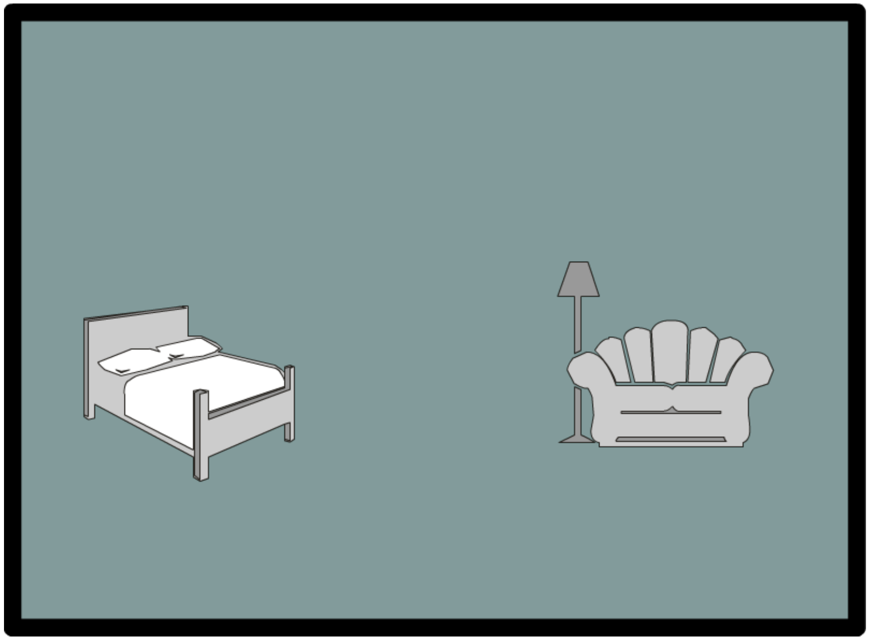
c) Correct

There are 6

FINISHED FILES ARE THE
RESULT OF YEARS OF SCIENTIFIC
STUDY COMBINED WITH THE
EXPERIENCE OF YEARS

You may have missed some of the Fs in the 3 words “OF”. Parietal areas tend to direct attention to the larger words. Attention to the large words can produce neglect of the small words. As we will learn in the next session, the shift in attention is accompanied by activity in the parietal area LIP, which directs eye movements called saccades, to these larger words. Because of the lack of attention and because the small words fall on the peripheral retina with its low acuity, we tend not to notice some of these small words.

Problem 2: Patient TV had neglect due to a right PTO lesion and was asked to imagine standing at entrance door of her bedroom. That bedroom had a bed on the left and a sofa on the right.



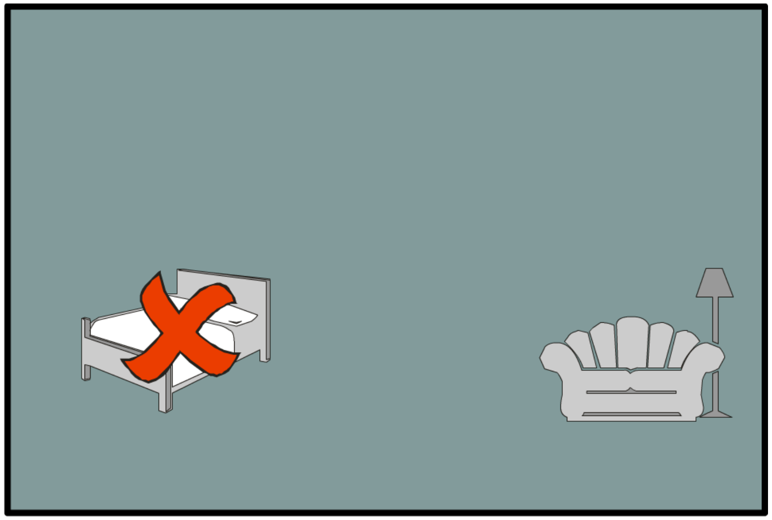
a) Patient TV would not remember the sofa.

b) Patient TV was asked to imagine stepping to the opposite side of the room and turn around. If the lesion affected an egocentric coordinate frame, the patient would now not remember the sofa.

c) Patient TV was asked to imagine stepping to the opposite side of the room and turn around. If the lesion affected an egocentric coordinate frame, the patient would neglect her right leg.

d) Patient TV was asked to imagine stepping to the opposite side of the room and turn around. If the lesion affected an allocentric coordinate frame, the patient would now not remember the sofa.

Problem 2: Patient TV had neglect due to a right PTO lesion and was asked to imagine standing at entrance door of her bedroom. That bedroom had a bed on the left and a sofa on the right.



a) Patient TV would not remember the sofa.

Answer

No.

Patient TV would remember things on the right side of the room and neglect things on the left.

Problem 2: Patient TV had neglect due to a right PTO lesion and was asked to imagine standing at entrance door of her bedroom. That bedroom had a bed on the left and a sofa on the right.

b) Patient TV was asked to imagine stepping to the opposite side of the room and turn around. If the lesion affected an egocentric coordinate frame, the patient would now not remember the sofa.

Answer

Correct.

When patient TV imagined herself standing at the opposite end of the room and again facing the room, she would again not remember things on her left. Thus, she would remember things she had neglected previously and neglect those that she had remembered.

The fact that the objects switch shows that they are still in your long-term memory (i.e. the lesion has not affected this memory) but you cannot focus your attention to them.

In an egocentric coordinate frame, the position of objects in your map change whenever you move. Here the position of objects in your room change whenever you imagined your view point change.

In a famous study of Italian patients, with right PTO lesions, patients were asked to imagine themselves standing at one end of a square in their home town and list what they recall. They listed all the buildings on their right and failed to recall those on their left. Then when asked to imagine themselves standing at the opposite end of the square, they now recalled all the buildings on the right, those that they had just failed to recall.

Problem 2: Patient TV had neglect due to a right PTO lesion and was asked to imagine standing at entrance door of her bedroom. That bedroom had a bed on the left and a sofa on the right.

c) Patient TV was asked to imagine stepping to the opposite side of the room and turn around. If the lesion affected an egocentric coordinate frame, the patient would neglect her right leg.

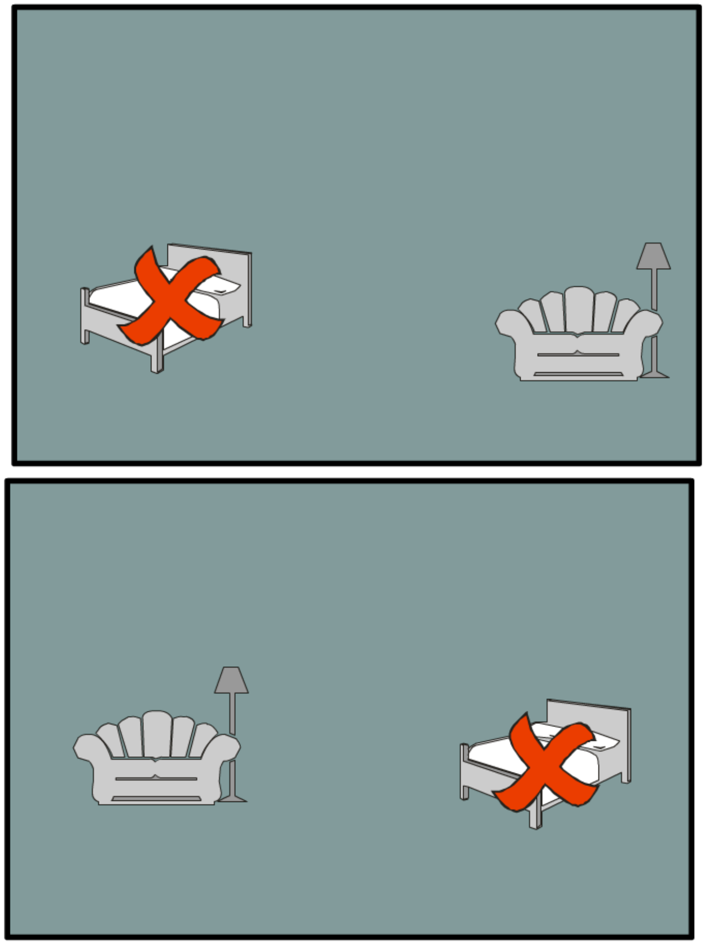
Answer

No.

She would neglect her left side. She may deny that her left leg belongs to her. If she was lying in bed she may complain that someone else's leg was in her bed.

She may have neglected to dress her left side, put on her left glove, left sock or left shoe.

Problem 2: Patient TV had neglect due to a right PTO lesion and was asked to imagine standing at entrance door of her bedroom. That bedroom had a bed on the left and a sofa on the right.



d) Patient TV was asked to imagine stepping to the opposite side of the room and turn around. If the lesion affected an allocentric coordinate frame, the patient would now not remember the sofa.

Answer

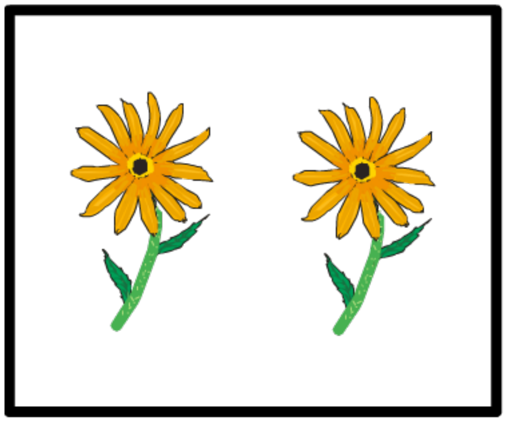
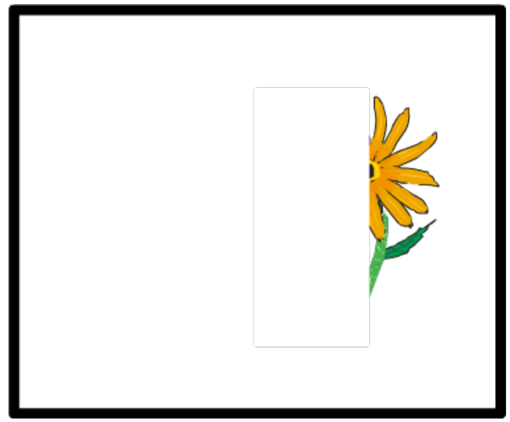
No.

If the representation were allocentric, the same side of the room would be neglected in both views.

Perhaps the first view, that of entering through the door, is a primary (canonical view).

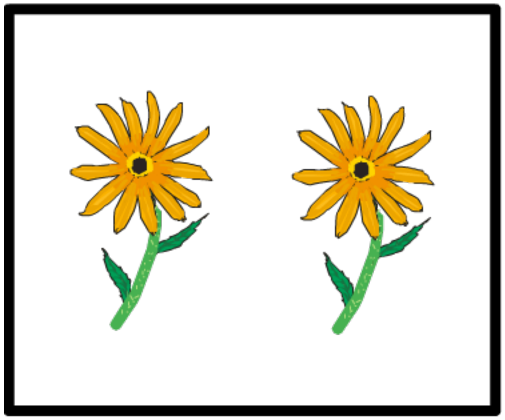
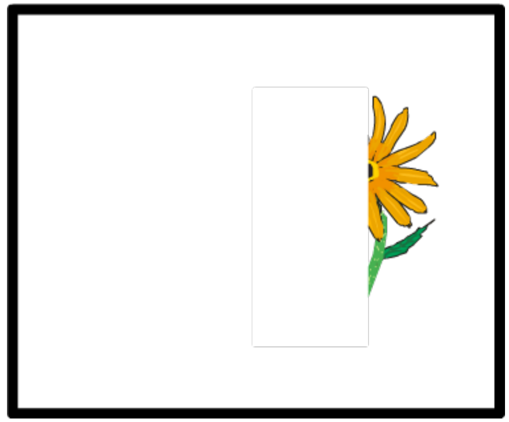
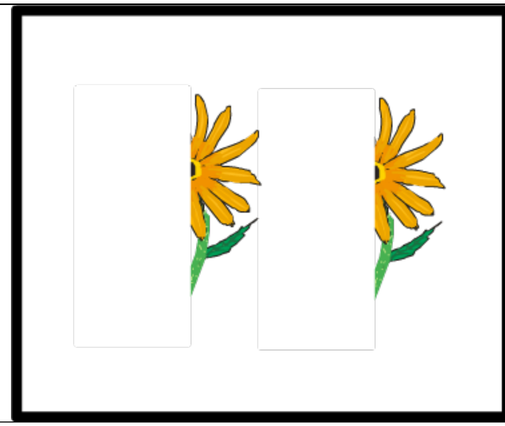
Here the bed is on the left, on coming into the room, and it continues to be neglected when the view point changes to the other side of the room.

Problem 3: A patient with a right PTO lesion is asked to copy the figures drawn in A. What might the patient draw?

 A		a)
		b)

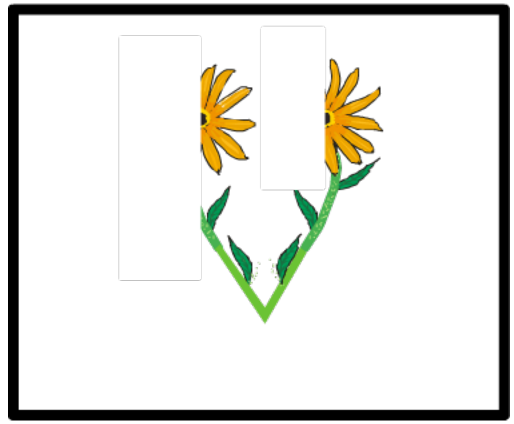
Problem 3: A patient with a right PTO lesion is asked to copy the figures drawn in A. What might the patient draw?

Answer

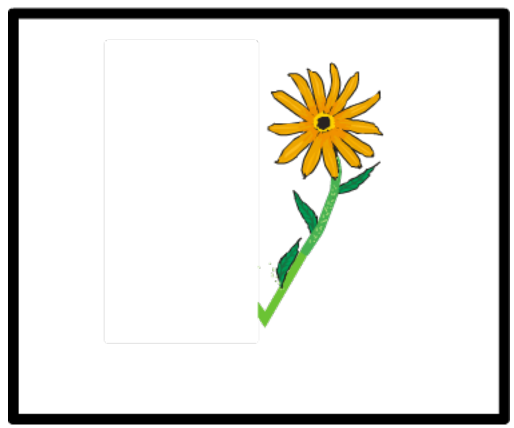
 A	 a) **Correct.** Here a frame is drawn about one of the flowers. The other is not attended to. Neglect affects the left side of the flower that one attends
	 b) Correct as well. Attention may shift from one flower to the other and the patient becomes aware of the right side of each.

Problem 4: A patient with a right PTO lesion is asked to copy the figures drawn in B. What might the patient draw?

B



Draw this.

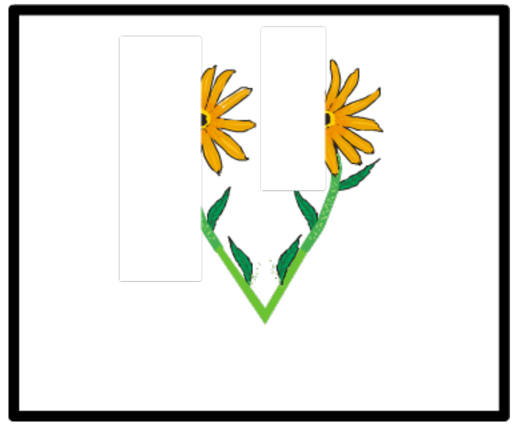


Or this.

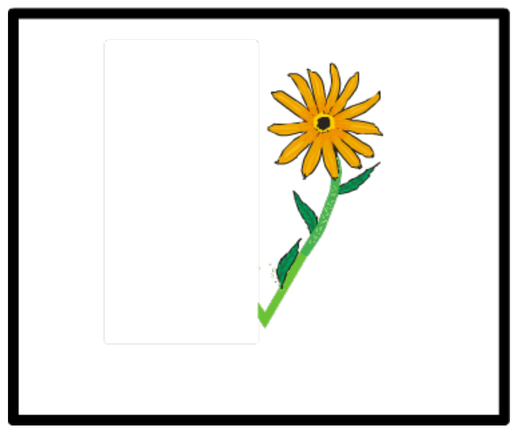
Problem 4: A patient with a right PTO lesion is asked to copy the figures drawn in B. What might the patient draw?

Answer

B



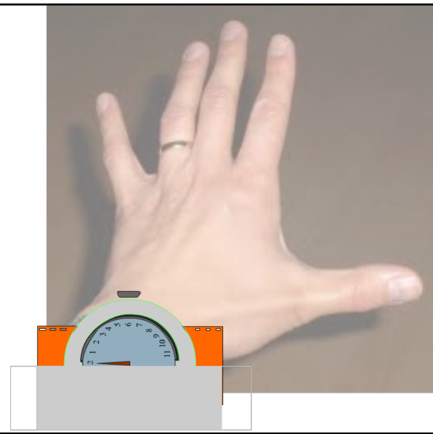
No. Because the stems are joined at the base, the plant is treated as a single flower, not two.



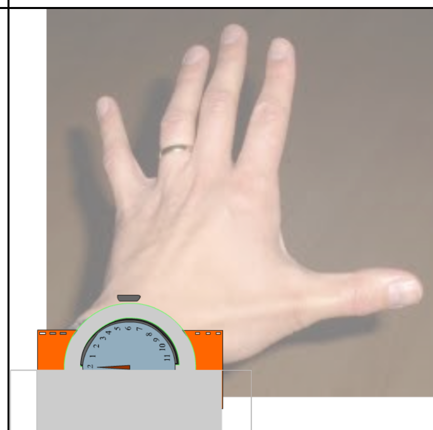
Correct. Here the frame is placed around the whole plant.

The patient neglects the left side of the plant.

Problem 5: Suppose you had a right PTO lesion and were asked to draw the watch on your left arm. What would it look like?

a) You would deny that you had a watch.	
b) It would look like this.	
c) It would look like this.	

Problem 5: Suppose you had a right PTO lesion and were asked to draw the watch on your left arm. What would it look like?
Answer

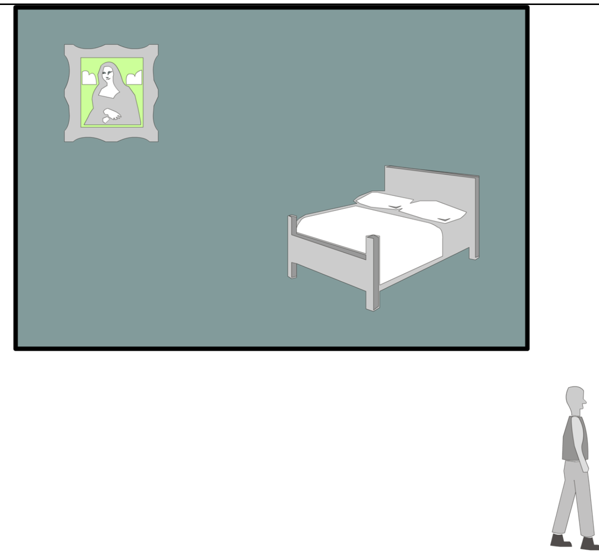
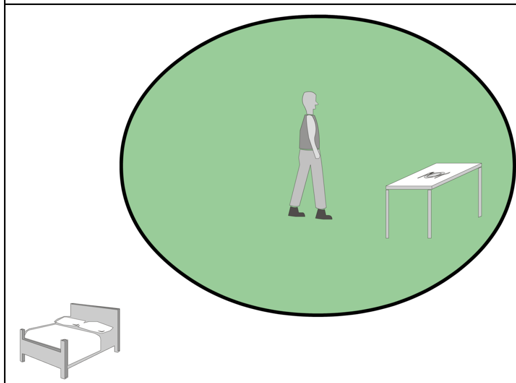
a) You would deny that you had a watch.	No. You would remember that you had a watch. But you may not be aware of the left side of your body including your left arm. If someone pointed out the arm with your watch on it, you might say the it was someone else's arm with your watch.
b) It would look like this.	 **Correct.** You might draw the watch as you see it on your arm and add all the numbers to its right side because you recall that a watch has 12 numbers. But because the watch is turned, you are now neglecting the lower half. This form of allocentric neglect suggests that objects like a watch naturally have a right and left side. It is the left side of the object that you neglect independent of where the object is relative to you.
c) It would look like this.	 No. If you focus your attention on the watch, it is the left side of the watch that will be neglected. But what is neglected here is not the left side of the watch. The winding knob is normally on a watch's right side, at the 3 o'clock position. The 9 o’clock position is the watch's actual left side.

Problem 6: Suppose that the allocentric and egocentric maps are finite; i.e. they have an edge (like edge of the transparency in the model in this Chapter). This is a likely constraint in the brain. The brain's map is not infinite in capacity and thus also has an edge. As you move in an

a). allocentric map you fall off the edge of the current frame (e.g. the current room) and need to replace it with another frame (e.g. the next room).	b) egocentric map you fall off the edge of the current frame (e.g. the current room) and need to replace it with another frame (e.g. the next room).
c). egocentric map some objects fall off the edge of your map. New objects come into view and must be represented.	d) allocentric map some objects fall off the edge of your map. New objects come into view and must be encoded.

Problem 6: Suppose that the allocentric and egocentric maps are finite; i.e. they have an edge (like edge of the transparency in the model). This is a likely constraint in the brain. It is not infinite in capacity and thus also has an edge. As you move in an

Answer

a). allocentric map you fall off the edge of the current frame (e.g. the current room) and need to replace it with another frame (e.g. the next room). Correct. 	b) egocentric map you fall off the edge of the current frame (e.g. the current room) and need to replace it with another frame (e.g. the next room). Wrong. As you walk objects move past you.
 c). egocentric map some objects fall off the edge of your map. New objects come into view and must be represented. **Correct.**	d) allocentric map some objects fall off the edge of your map. New objects come into view and must be encoded. Wrong. Here you move, and the objects remain fixed relative to the room.

Problem 7: Pick the examples of nested egocentric frames.

a) Your finger is nested in your hand and your hand is nested in your arm.

b) Your body is nested in your head.

c) Your eye is nested in your head.

d) The table lamp is nested on the table.

Problem 7: Pick the examples of nested egocentric frames.

Answer

a) Your finger is nested in your hand and your hand is nested in your arm.	Correct. When you move the finger only the finger moves. When you move the body the finger moves as well.
b) Your body is nested in your head.	Wrong. Your head is nested in your body. When your body moves, your head moves as well.
c) Your eye is nested in your head.	Correct. When the eye moves, only the eye moves. When your head moves, your eye moves as well.
d) The table lamp is nested on the table.	Wrong. Objects on the table are usually viewed as allocentric nested coordinates.

Problem 8: Suppose a patient with a right-sided parietal lesion were asked to point straight ahead. Where would this patient point?

a) To his right.

b) Between forward and to the right.

c) Forward.

d) Between forward and to the left.

e) To his left.

Problem 8: Suppose a patient with a right-sided parietal lesion were asked to point straight ahead. Where would this patient point?

Answer

a) To his right.	No.
b) Between forward and to the right.	**Yes.** The patient would point to forward and to the right, because a right sided parietal lesion causes neglect to the left. For the patient everything to the left does not exist. The middle of the patient's world is somewhere between forward and to the right. FYI Read Rossetti et. al. Nature 1998 395(6698):166-9.
c) Forward.	No, a right sided parietal lesion causes neglect on the left.
d) Between forward and to the left.	No, a right sided parietal lesion causes neglect on the left.
e) To his left.	No, a right sided parietal lesion causes neglect on the left.

Problem 9: The following examples of an egocentric representation occur when

a) you re-code only your own remembered location within an environment that changes as you move forward.

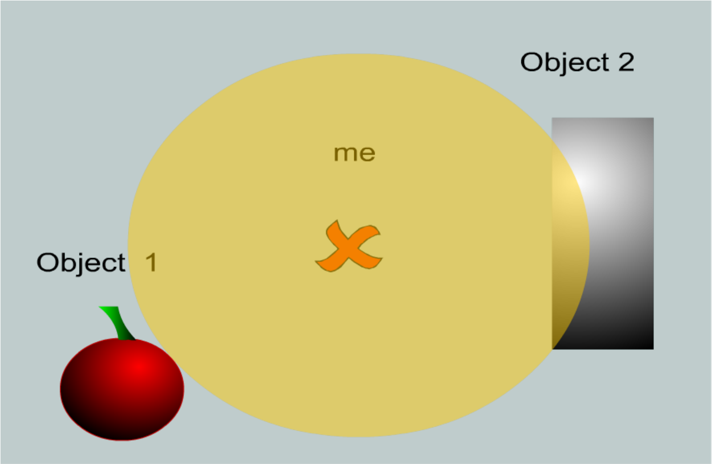
b) what you imagine seeing when standing at one end of your home's street does not change when you imagine viewing the same from the other end of the street.

c) you change the remembered location of every element within an environment as you move forward.

d) if you were a squirrel, you would remember where you buried the nut relative to landmarks in the back yard.

e) you remember the way home by means of sequence of spatial landmarks.

Problem 9: The following examples of an egocentric representation occur when



a) you re-code only your own remembered location within an environment that changes as you move forward.

Answer

No.

In an egocentric representation you re-code the location of all the objects while your location stays fixed.

Problem 9: The following examples of an egocentric representation occur when

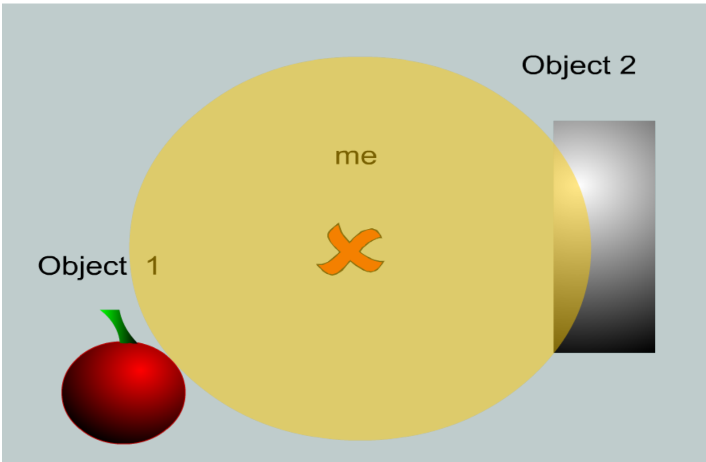
b) what you imagine seeing when standing at one end of your home's street does not change when you imagine viewing the same from the other end of the street.

Answer

No.

It does change. An egocentric representation is view dependent. What you see when standing at the right end of the square and looking to your right is different from what you see when standing at the left end and looking your right.

Problem 9: The following examples of an egocentric representation occur when



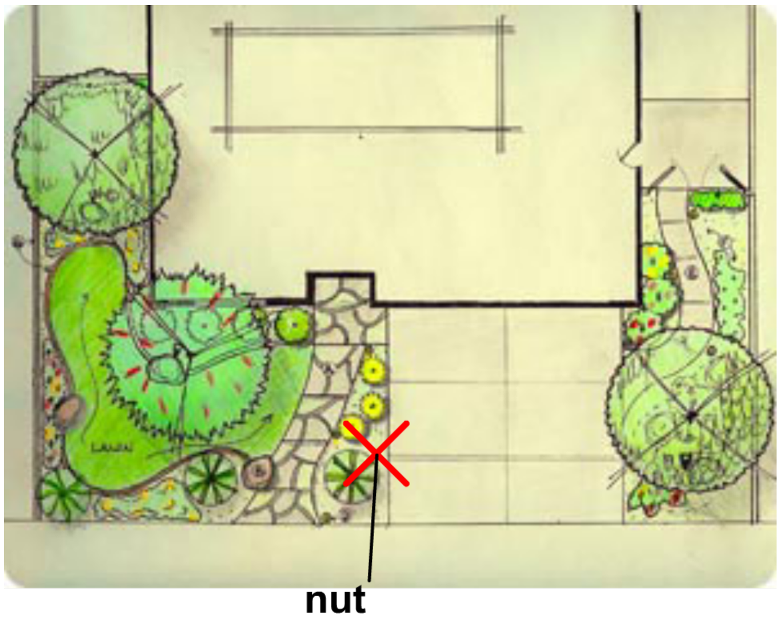
c) you change the remembered location of every element within an environment as you move forward.

Answer

Correct.

In an egocentric representation you re-code the location of all the objects while your location stays fixed.

Problem 9: The following examples of an egocentric representation occur when



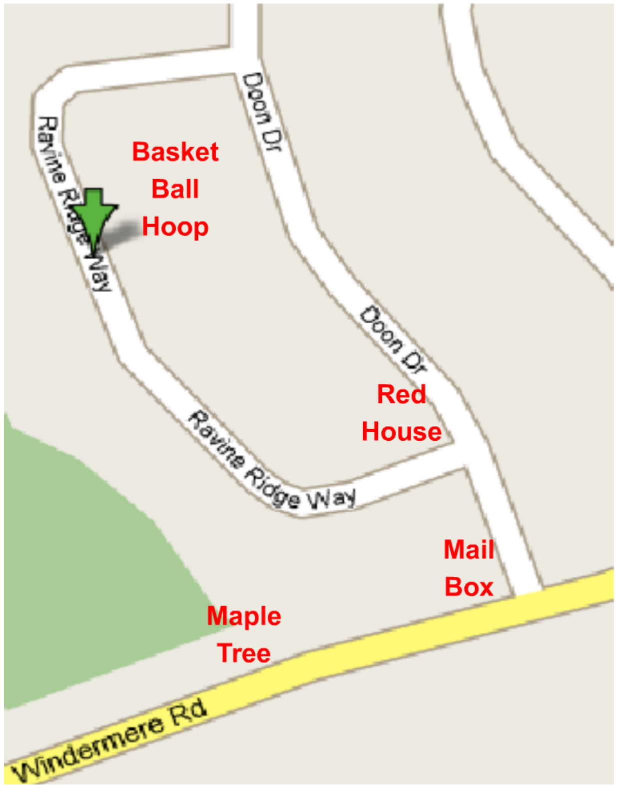
d) if you were a squirrel, you would remember where you buried the nut relative to landmarks in the back yard.

Answer

No.

The nut's location relative to landmarks in the back yard, such as trees, building, and paths, is coded an allocentric representation. This is view independent. A view independent map is useful because it allows the squirrel to locate the nut independent of how it enters the backyard.

Problem 9: The following examples of an egocentric representation occur when



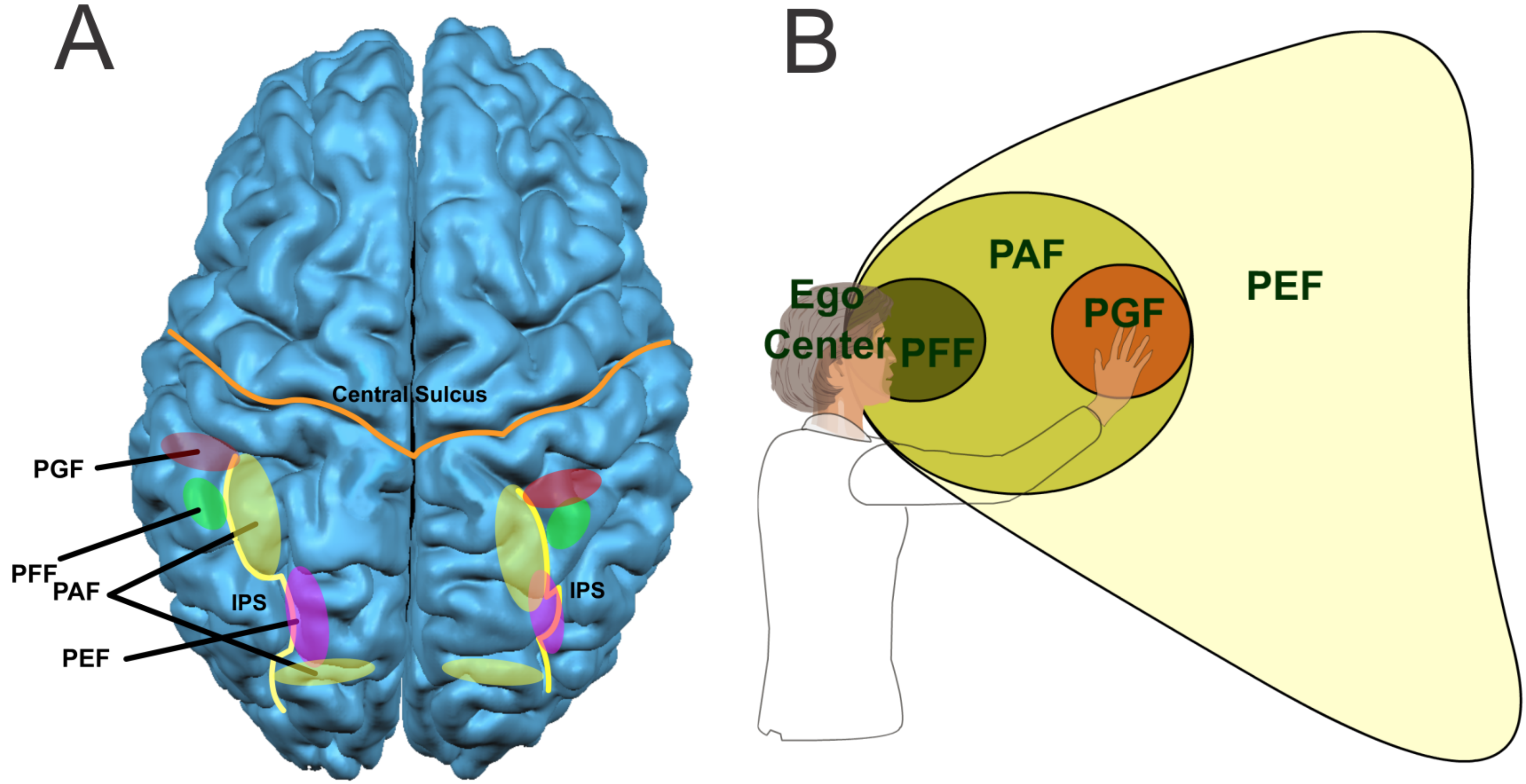
e) you remember the way home by means of sequence of spatial landmarks.

Answer

No.

A sequence of spatial landmarks would form an allocentric map.

Chapter 6: Streams for Visually Guided Actions



Problem 1: Compare two tasks: A) reaching and touching an object and B) reaching and grasping an object. What additional information is required for task B?

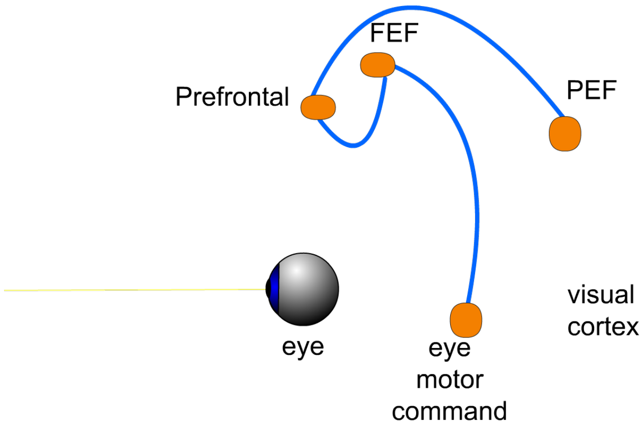
a) Object location from vision.	
b). Arm location from our proprioceptive system.	
c) The real object size.	
d) Recognize what the object is.	
e) A measure of eye position.	

Problem 1: Compare two tasks: A) reaching and touching an object and B) reaching and grasping an object. What additional information is required for task B?

Answer

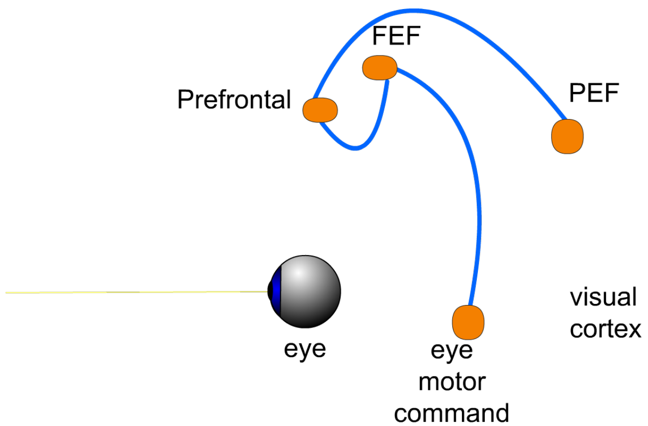
a) Object location from vision.	No. You need to know the object location for both tasks.
b). Arm location from our proprioceptive system.	No. You need to know the arm location for both tasks in order to guide the arm towards the target.
c) The real object size.	**Yes,** for task B you also need to know the real object size not just the size of its image on the retina in order to grasp it accurately.
d) Recognize what the object is.	**Yes,** for task B it is useful to know that the object is a knife in order to determine which end is the handle. That way you can direct your hand towards the handle and not the blade.
e) A measure of eye position.	No. One needs to combine the object position on the retina with the eye position to determine where the target is relative to your body. This is required by both tasks.

Problem 2: For each of the following tasks pick the area or areas that might be most involved.



a) Note the location of the flashed target by shifting your attention to it.	
b) Suppress a saccade to a flashed target.	
c) Compute the location of its mirror image.	
d) Store this location in working memory.	
e) Shift your attention to this location.	
f) Initiate a saccade to this location.	

Problem 2: For each of the following tasks pick the area or areas that might be most involved.



Answer

a) Note the location of the flashed target by shifting your attention to it.	Area **PEF** directs attention and selects the target for movement.
b) Suppress a saccade to a flashed target.	The **FEF** together with a superior colliculus are involved with suppressing saccades and thus in maintaining fixation.
c) Compute the location of its mirror image.	No one knows for sure where this occurs. Perhaps in the frontal or parietal areas.
d) Store this location in working memory.	The **prefrontal areas** are involved in temporarily storing the new computed location.
e) Shift your attention to this location.	The parietal eye fields, **PEF**, is again involved in shifting the attention location stored in the **prefrontal** working memory. Note the reciprocal activity between the two areas.
f) Initiate a saccade to this location.	The initiation of this saccade involves the activation of the frontal eye fields, the **FEF**.

Problem 3: What types of deficits are most likely to occur after a lesion in the right frontal cortex?

a) The patient's eye is deviated to the right.	
b) The patient cannot make voluntary saccades to the left.	
c) The patient cannot make a reflexive saccade to a flashing stimulus in the left visual field.	
d) The patient cannot make remembered saccades to the right.	

Problem 3: What types of deficits are most likely to occur after a lesion in the right frontal cortex?

Answer

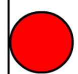
a) The patient's eye is deviated to the right.	Correct. The patient cannot direct saccades to voluntarily selected targets in the left visual field because the patient has no spatial memory for target that appeared in the left visual field and because the frontal eye fields are located in the frontal cortex. Because the patient cannot make voluntary saccades into the left visual field, the patient's eyes become deviated to the right.
b) The patient cannot make voluntary saccades to the left.	Correct. The patient cannot direct saccades to voluntarily selected targets in the left visual field because the patient has no spatial memory for target that appeared in the left visual field and because the frontal eye fields are located in the frontal cortex
c) The patient cannot make a reflexive saccade to a flashing stimulus in the left visual field.	No. The superior colliculus is still able to generate a reflexive saccade to flashing stimuli in the left visual field.
d) The patient cannot make remembered saccades to the right.	No. A lesion of the right prefrontal cortex affects working memory in the left visual field. Thus the patient will not be able to make remembered saccades to the left.

Problem 4: Close one eye and gently push the outside corner side of your other eye. You should sense the things in the world seem to move. This happens because the push on the eye

a) does not create movement of the image on the retina.	
b) is sensed as movement of the eye and this generates corollary discharge.	
c) creates movement of the image on the retina.	
d) creates movement of the image on the retina but does not generate corollary discharge.	
e) does not generate corollary discharge	

Problem 4: Close one eye and gently push the outside corner side of your other eye. You should sense the things in the world seem to move. This happens because the push on the eye

Answer

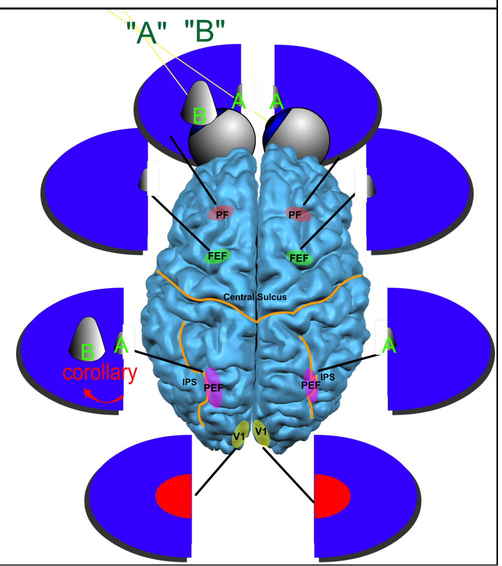
a) does not create movement of the image on the retina.	Incorrect. When you push the eye it moves the eye and the image of the world moves across the retina.
b) is sensed as movement of the eye and this generates corollary discharge.	Incorrect. Corollary discharge is a copy of the command that the brain sends out to rotate the eye. There are sensors in the muscle of the eye that do sense the push of your finger but this does not generate corollary discharge.
c) creates movement of the image on the retina.	 A This is true. In this case you do create movement on the retina and sense movement. But movement on the retina need not produce a sensation of movement. Try this. Stare at the red dot. Then make a saccade to the A. After you make the saccade, where on the retina is the image of the A? After the saccade you should be looking straight at the A. The A should be centered on your fovea. The A appeared to the side before the saccade, then it moved from the periphery of the retina to the fovea. But you don't sense that it moved. Why is this? Recall that this is because when you make a saccade, corollary discharge shifts the locus of activity in FEF (and in PF and PEF) to where it will be after the movement. If the saccade is correct, this shift should match the shift of the image on the retina (produced by eye movement). This match produces the percept of an image that remains still. So movement of the image on the retina need not produce the sensation of movement on its own.
d) creates movement of the image on the retina but does not generate corollary discharge.	**Correct.** With real saccades corollary discharge predicts or cancels the movement on the retina. When you tap your eyes, the image moves on your eyes, but no corollary discharge occurs to cancel this movement.
e) does not generate corollary discharge	It is true that pushing on the eye does not generate corollary discharge. But this does not explain why you see movement.

Problem 5: Suppose Ann stood to the right of Bob and both were in your left visual field. The lights went out and you made a saccade to where you saw Ann. After you completed the saccade to Ann locate the activity representing the locations of Ann and Bob in PEF at the moment before you began a saccade to Bob.

a) Ann is in the right cortex with Bob located to her right.	
b) Ann is in the right cortex with Bob located to her left.	
c) Ann is in the right cortex with Bob in the left cortex.	
d) Bob is in the left cortex in a region to the left of that representing Ann, which in turn is to the left of the foveal representation.	
e) Bob is in the left cortex in a more peripheral region to that representing Ann. Ann is at the foveal representation.	

Problem 5: Suppose Ann stood to the right of Bob and both were in your left visual field. The lights went out and you made a saccade to where you saw Ann. After you completed the saccade to Ann locate the activity representing the locations of Ann and Bob in PEF at the moment before you began a saccade to Bob.

Answer

a) Ann is in the right cortex with Bob located to her right.	Nope. Not even close.
b) Ann is in the right cortex with Bob located to her left.	No. But you are a little closer. This is the situation just before the first saccade to Ann. The activation at Ann is higher than that at Bob because attention is focused to the next saccade, that to Ann.
c) Ann is in the right cortex with Bob in the left cortex.	No. But you are getting close.
d) Bob is in the left cortex in a region to the left of that representing Ann, which in turn is to the left of the foveal representation.	No but you are getting very close.
e) Bob is in the left cortex in a more peripheral region to that representing Ann. Ann is at the foveal representation.	**Correct!** Corollary discharge shifts Ann to the foveal location and Bob to the left cortex in the PF's working memory and PEF. The eye is fixating Ann. So in FEF, a hill is maintained at the fovea. Note that activity representing the location of Bob in PEF now appears **not** where it was seen by the eye but where it would have appeared, were Bob now visible, after the saccade to Ann, in the right visual field and thus the left cortex. 

Problem 6: Frogs do not have a parietal cortex. Frogs use their Superior Colliculus to direct their tongues at flies. Suppose a pair of flies appeared in front of the frog; one to the right and the other to the left. What might the frog do?

a) The frog would sometimes direct its tongue sometimes to the fly on left or sometimes to the fly on the right.	
b) The frog would direct its tongue directly forward.	
c) The frog would direct its tongue towards neither fly.	

Problem 6: Frogs do not have a parietal cortex. Frogs use their Superior Colliculus to direct their tongues at flies. Suppose a pair of flies appeared in front of the frog; one to the right and the other to the left. What might the frog do?

Answer

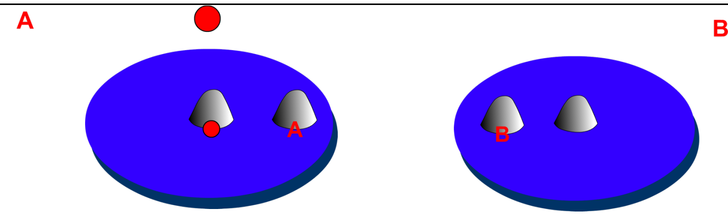
a) The frog would sometimes direct its tongue sometimes to the fly on left or sometimes to the fly on the right.	No. Assuming that the flies were equally potent, there would be nothing that would select one target over the other.
b) The frog would direct its tongue directly forward.	**Correct.** Because frogs do not have a parietal cortex, they have problems directing their attention. Without a parietal focus of attention, a frog cannot select one fly over the other. Thus a frog cannot make a choice between a fly on the left and one on the right. Because there is nothing to stop either movement, both are generated, and the tongue snaps straight ahead between the two flies. The frog would get hungry in a swarm of flies. Perhaps this is why some species such as fish swim in schools. Attention allows us to select from several equally potent visual stimuli. For example, it allows you to look at a particular individual in a room. These experiments are described in Lettvin JY, Maturana HR, McCulloch WS, Pitts WH. 1959. What the Frog's Eye Tells the Frog's Brain. Proceedings of the IRE 47: 1940-51 "When presenting this paper at a conference Jerry Lettvin was laughed off the stage. Yet for the next ten years this paper was the most cited paper in all of science." Wikipedia
c) The frog would direct its tongue towards neither fly.	No. Flies always activate a frog's superior colliculus.

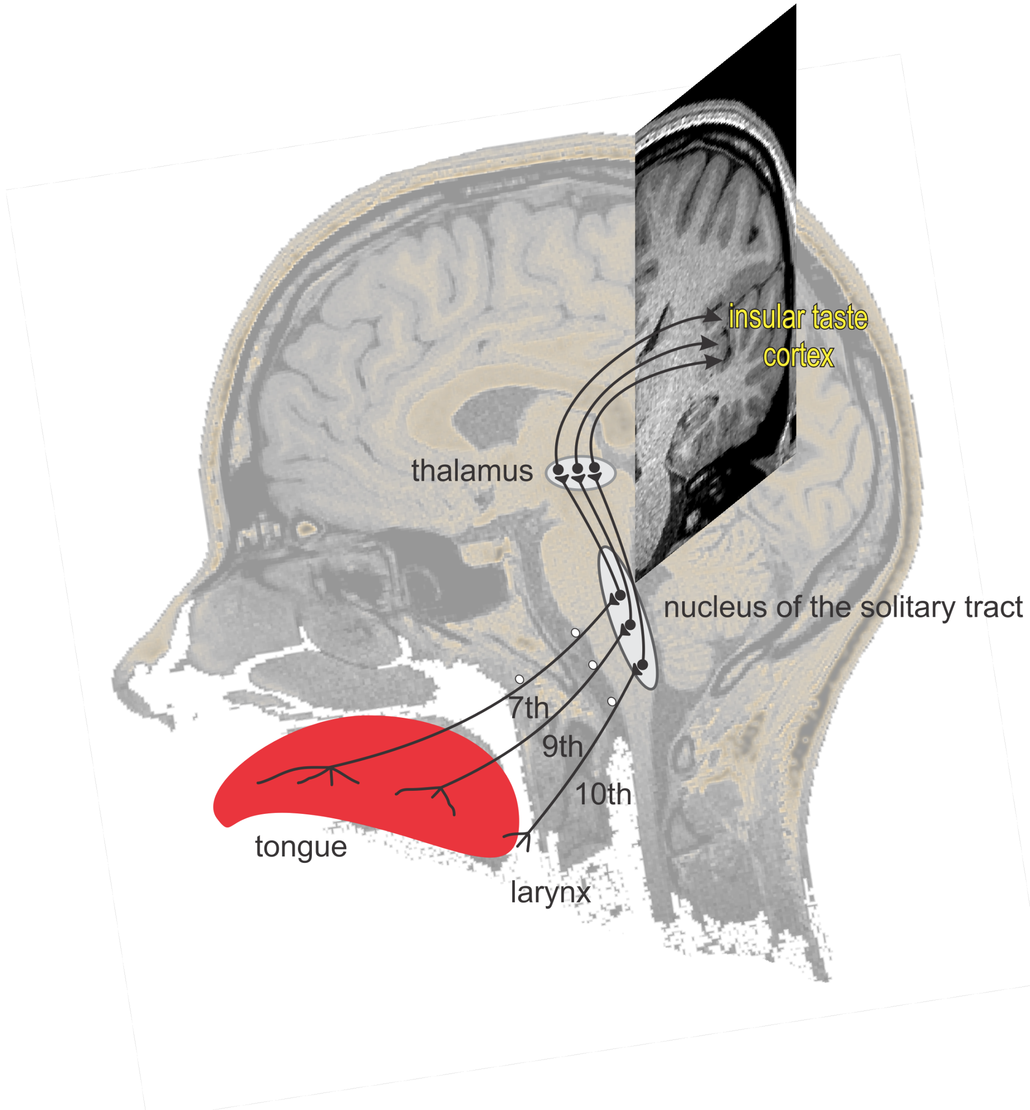
Problem 7: Suppose the task was to look a circle at centre and then at the pictures of Ann or Bob as soon as they appear. In case A, the Ann appears and then the circle disappears. In case B, the circle disappears and then the Bob appears. Which of these stimuli would generate saccades with shorter reaction times (the time from the onset of the peripheral stimulus to when a saccade begins? Suggest why.

a) Saccades to Bob will have shorter reaction times because the hill of activity at the part of the Superior Colliculus that represents the center begins to reduce in size before Bob appears.	
b) Saccades to Ann will have shorter reaction times because the hill of activity at the part of the Superior Colliculus that represents the Ann begins to reduce in size before the fixation point goes out.	
c) Saccades to Bob will have shorter reaction times because Bob appears while the fixation target is still on.	
d) Saccades to Ann will have shorter reaction times because Ann appears at some time after the fixation target is turned off.	
e) Saccades to Bob will have shorter reaction times because the fixation target is still on when Bob appears. Because of this the hill of activity at center prevents the initiation of a saccade.	

Problem 7: Suppose the task was to look a circle at centre and then at the pictures of Ann or Bob as soon as they appear. In case A, the Ann appears and then the circle disappears. In case B, the circle disappears and then the Bob appears. Which of these stimuli would generate saccades with shorter reaction times (the time from the onset of the peripheral stimulus to when a saccade begins? Suggest why.

Answer

a) Saccades to Bob will have shorter reaction times because the hill of activity at the part of the Superior Colliculus that represents the center begins to reduce in size before Bob appears.	 **Correct!** Stimulus A (Ann) appears before the fixation dot disappears. Stimulus B (Bob) appears after the dot disappears. Thus, the hill of activity at the center has begun to reduce in size when the response to Bob appears. This makes it easier to disengage fixation. Thus, if we time reaction time to when Ann or Bob appear, the reaction time is shorter when looking to Bob than to Ann.
b) Saccades to Ann will have shorter reaction times because the hill of activity at the part of the Superior Colliculus that represents the Ann begins to reduce in size before the fixation point goes out.	No. Here, the fixation target is still on when Ann appears. Because of this the "hill" of activity at center remains on preventing the initiation of a saccade.
c) Saccades to Bob will have shorter reaction times because Bob appears while the fixation target is still on.	No. It will be shorter but not for this reason. Here the visual stimulus at fixation is no longer there when Bob appears.
d) Saccades to Ann will have shorter reaction times because Ann appears at some time after the fixation target is turned off.	No. The fixation target is still on when the Ann appears. Try again.
e) Saccades to Bob will have shorter reaction times because the fixation target is still on when Bob appears. Because of this the hill of activity at center prevents the initiation of a saccade.	No. It will be shorter but not for this reason. Here the visual stimulus at fixation is no longer there when Bob appears.

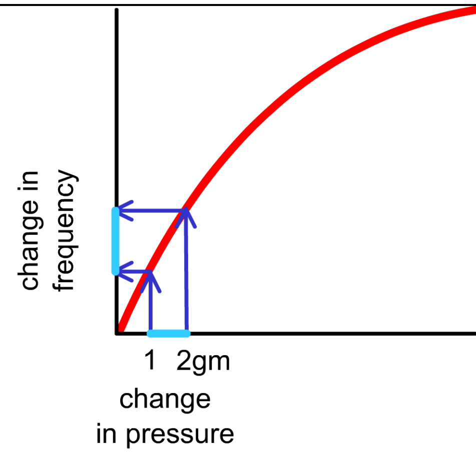
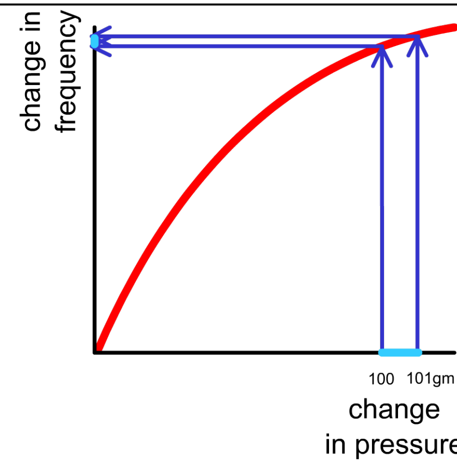
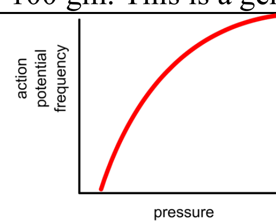

insular taste
cortex
thalamus
nucleus of the solitary tract
7th
9th
10th
tongue
larynx

Problem 1: Why it is easier to distinguish between 1 and 2 gm weights than between 100 and 101 gm weights. This is because

a) the touch afferents are less responsive to the higher weights.	
b) these large weights exert too much pressure against the skin.	
c) the afferent response saturates at the higher weights.	
d) the afferent response to the two changes in weight is the same.	
e) it is not easier to distinguish between 1 and 2 gm weights	

Problem 1: Why it is easier to distinguish between 1 and 2 gm weights than between 100 and 101 gm weights. This is because

Answer

a) the touch afferents are less responsive to the higher weights.	Incorrect. Activity is higher for larger weights.
b) these large weights exert too much pressure against the skin.	Incorrect. 100 gm is not that much. It is the weight of a small apple.
c) the afferent response saturates at the higher weights.	  **Correct.** In both cases, the change in pressure is 1 gm. Because the response saturates, the change in the frequency of action potentials is much less at the high pressure, i.e. at 100 gm. This is a general principle of all sensory afferents and is called Weber's law.
d) the afferent response to the two changes in weight is the same.	 Incorrect. Hint. The answer lies in the shape of this curve.
e) it is not easier to distinguish between 1 and 2 gm weights	Incorrect. Try it yourself with a box, an apple and two coins.

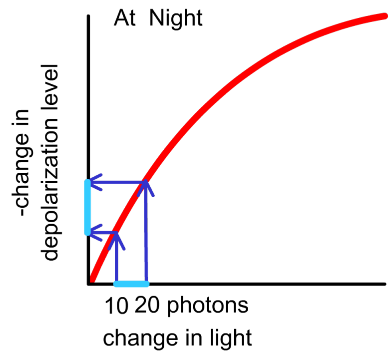
Problem 2: Why are stars not visible in the sky during the day, even though they give off just as much light during the day and at night?

a) For the same reason that it is easier to distinguish between 1 and 2 gm weights than between 100 and 101 gm weights.	
b) Because the sunlight reduces the amount of light coming from the star.	
c) Because the eyes receive fewer photons receptors from the star in the presence of sunlight.	
d) Because the receptors activated by the surround in sunlight inhibit those in the center activated by the star.	

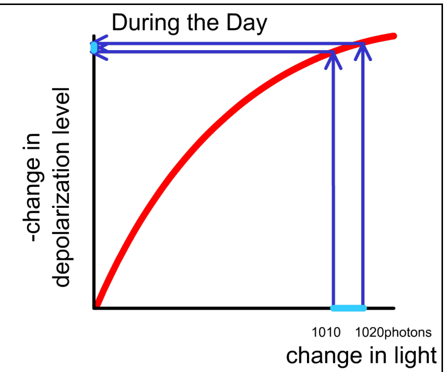
Problem 2: Why are stars not visible in the sky during the day, even though they give off just as much light during the day and at night?

Answer

<table>
<tr><td>a) For the same reason that it is easier to distinguish between 1 and 2 gm weights than between 100 and 101 gm weights.</td><td>



Yes! The difference between the light intensity of the sky and the sky plus the star, remains the same but the receptors become saturated by the sun and the difference in the receptor potential produces only a tiny change during the day. This reason is the same as that for touch.



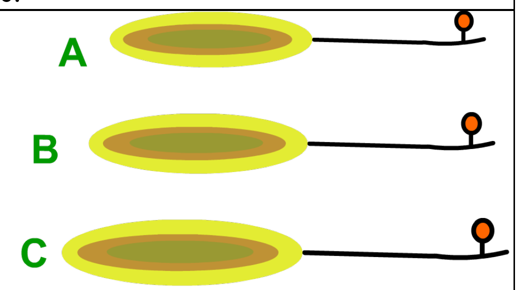
Say a star sends 10 photons to a receptor and the sun 1000. Assume that at night the change is from one star to two, a one-star change in intensity. During the day the change is from the sun plus one star to the sun plus two stars. Because the response of receptors saturates, the change in potential is much less in sunlight. FYI. This type of saturation occurs for all of the senses and is known as Weber's Law named after a physiologist who lived from 1798 to 1878.</td></tr>
<tr><td>b) Because the sunlight reduces the amount of light coming from the star.</td><td>No. The star shines as brightly during the day as at night.</td></tr>
<tr><td>c) Because the eyes receive fewer photons receptors from the star in the presence of sunlight.</td><td>No. The receptors are stimulated by the number of photons the star emits. This is the same, day or night.</td></tr>
<tr><td>d) Because the receptors activated by the surround in sunlight inhibit those in the center activated by the star.</td><td>True. But the receptors in the center are also activated by the same sunlight. Thus, the difference will stay the same for the same reason as in the previous problem.
So, this is not the complete answer.</td></tr>
</table>

Problem 3: Besides the frequency of action potentials, what else might signal a greater pressure?

a) By which afferent is activated.	
b) By the number of afferents that are activated.	
c). Some afferents are activated by a large and not small pressure.	

Problem 3: Besides the frequency of action potentials, what else might signal a greater pressure?

Answer

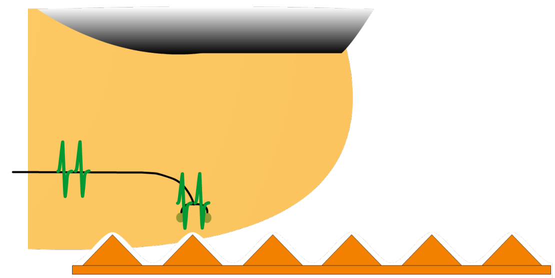
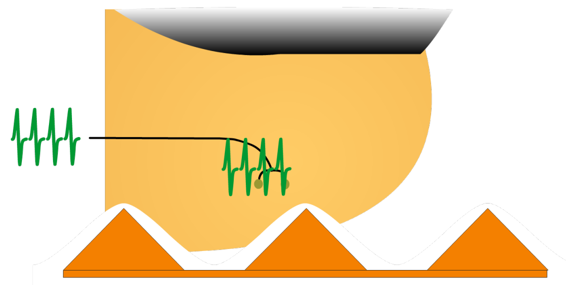
a) By which afferent is activated.	**True.** The receptors on the skin surface are activated by a small pressure and by a large pressure. The receptors deeper in the skin are activated only by a large pressure. Thus activation of RA2 or SA2 would signal a greater pressure.
b) By the number of afferents that are activated.	**Correct.** But for this to occur each afferent must have a different threshold. Some are activated by a small pressure either because they are on the skin surface or the threshold in their afferent's initial segment is a low voltage. Others would be activated by small and large pressures. More afferents reach threshold for a larger pressure than a small pressure. Here for example, only afferent A is recruited for a small pressure while A, B, and C are recruited for a large. 
c) Some afferents are activated by a large and not small pressure.	No. For a large pressure, receptors deep within the skin will be activated. But those on the surface of the skin will be activated as well.

Problem 4: How does one distinguish between fine and rough sandpaper? What is different in the firing frequency of a RA1 receptor as one passes one's finger over fine and rough sandpaper? Which is true?

a) A smooth sand paper generates frequent bursts, each of high frequency.	
b) A rough sand paper generates infrequent bursts, each of low frequency.	
c) The average firing rate elicited by both fine and rough sandpaper is similar.	

Problem 4: How does one distinguish between fine and rough sandpaper? What is different in the firing frequency of a RA1 receptor as one passes one's finger over fine and rough sandpaper? Which is true?

Answer

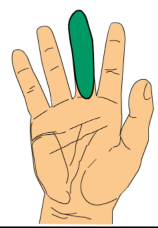
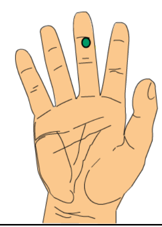
a) A smooth sand paper generates frequent bursts, each of high frequency.	No. A smooth sand paper has more frequent small bumps. This generates frequent bursts, each of low frequency. 
b) A rough sand paper generates infrequent bursts, each of low frequency.	No. A rough sand paper has less frequent, but larger, bumps. This generates infrequent bursts, each of higher frequency. 
c) The average firing rate elicited by both fine and rough sandpaper is similar.	Correct. A smooth sand paper has more frequent small bumps. This generates frequent bursts each of low frequency. A rough sand paper has less frequent, but larger, bumps. This generates infrequent bursts each of higher frequency. Thus, the average frequency of both is similar. It is the pattern, over time, that is important for coding roughness.

Problem 5: RA2 and RA1 receptors are both rapidly adapting. An RA1 receptor is good at detecting texture. Why is a RA2 receptor not good at detecting texture?

a) These receptors are located superficially in the skin.	
b) These receptors have a small receptive field.	
c) Many textures are fine and require small receptive fields to feel them.	

Problem 5: RA2 and RA1 receptors are both rapidly adapting. An RA1 receptor is good at detecting texture. Why is a RA2 receptor not good at detecting texture?

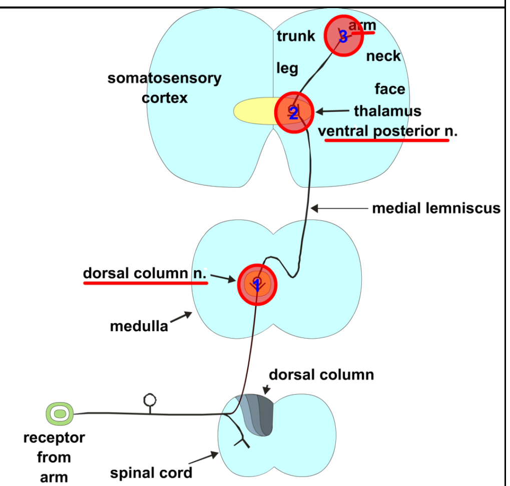
Answer

a) These receptors are located superficially in the skin.	No. RA2 receptors are located deep within the skin.
b) These receptors have a small receptive field.	No. RA2 receptors have large receptive fields.
c) Many textures are fine and require small receptive fields to feel them.	**Correct.** An RA2 receptor is located deep in the skin. Because of this, it has a large receptive field. Most textures are fine and require small receptive fields to feel them. In vision you must look at an object with your fovea, the area of the eye with small receptive fields, to distinguish fine textures. Try to distinguish between textures with your peripheral vision. You cannot. **Large rf of a RA2 receptor**  **Small rf of a RA1 receptor** 

Problem 6: The minimal number of synapses required to transmit a touch signal from an afferent in the hand to a neuron in the somatosensory cortex is

a) 1	
b) 2	
c) 3	
d) 4	
e) 5	

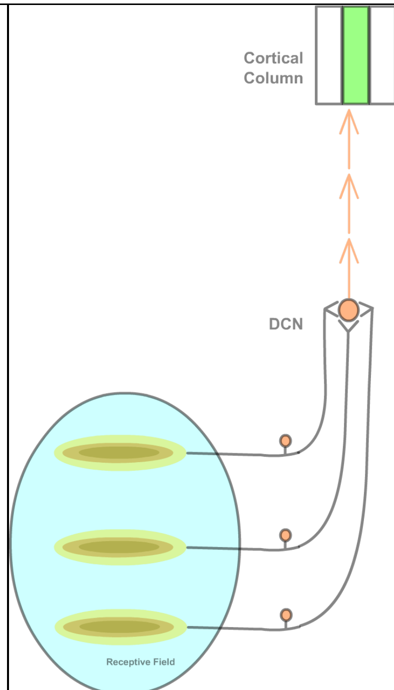
Problem 6: The minimal number of synapses required to transmit a touch signal from an afferent in the hand to a neuron in the somatosensory cortex is

a) 1	You have to be kidding!
b) 2	Wrong.
c) 3	**Correct,** dorsal column nucleus, thalamus, and somatosensory cortex 
d) 4	Wrong.
e) 5	Wrong.

Problem 7: The afferents from the skin on your back show convergence of several touch afferents onto a single DCN cell. These afferents

a) must be all of the same type, i.e. all RA1 or all RA2.	
b). can be of different types, i.e. some RA1s and others RA2s.	
c) can be of different types, one type in the on center and another in the off surround.	

Problem 7: The afferents from the skin on your back show convergence of several touch afferents onto a single DCN cell. These afferents

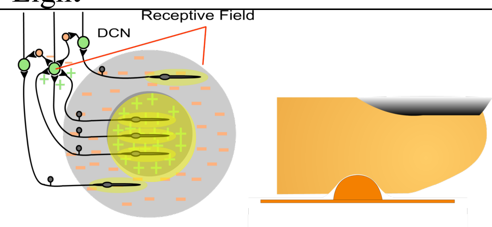
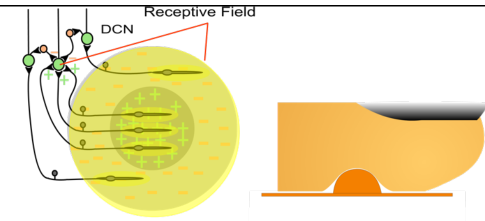
a) must be all of the same type, i.e. all RA1 or all RA2.	 Correct. They must be the same type. If they became mixed, then cortical columns would be activated by a mixture of receptors and the labeled line would not remain pure.
b). can be of different types, i.e. some RA1s and others RA2s.	No.
c) can be of different types, one type in the on center and another in the off surround.	No.

Problem 8: Touch a small bump on a smooth surface. Press lightly on the bump. Next press hard on the bump. Does the size of the bump change?

a) The size of the bump stays the same if you press lightly or hard because the activity of DCN neurons stays the same.	.
b) The size of the bump feels larger when you press hard because the activity of DCN neurons is larger when you press harder.	
c) The size of the bump feels larger when you press hard because the activity of the touch afferents is larger when you press hard.	

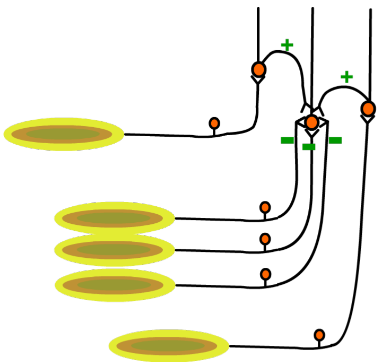
Problem 8: Touch a small bump on a smooth surface. Press lightly on the bump. Next press hard on the bump. Does the size of the bump change?

Answer

<table>
<tr><td>a) The size of the bump stays the same if you press lightly or hard because the activity of DCN neurons stays the same.</td><td>Correct. When you press lightly afferents only in the center of the DCN neuron’s receptive field will be activated. When you press hard there will be increased activation in the center.
As well, afferents in the surround will be activated. The surround will inhibit the DCN neuron and cancel the increased activation from the center. The net result is that the DCN neuron will have a similar activity in the two cases. The antagonist center surround measures the change between the center and the surround. This change remains the same as you press harder. Thus, the bump does not feel bigger when you press harder.<table><tr><td>Light</td><td>Hard</td></tr><tr><td></td><td></td></tr></table></td></tr>
<tr><td>b) The size of the bump feels larger when you press hard because the activity of DCN neurons is larger when you press harder.</td><td>No.

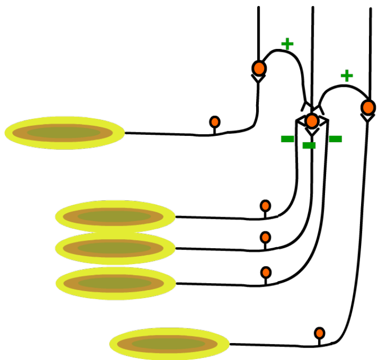
The size of the bump feels the same.</td></tr>
<tr><td>c) The size of the bump feels larger when you press hard because the activity of the touch afferents is larger when you press hard.</td><td>No.

The activity of the touch afferents is larger but the size of the bump feels the same.</td></tr>
</table>



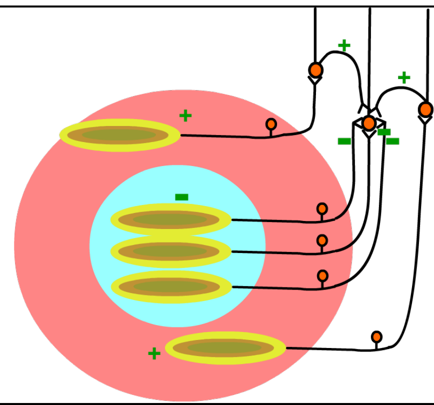
Problem 9: Suppose that a DCN neuron is connected as shown in the diagram. Which of the following statements is true?

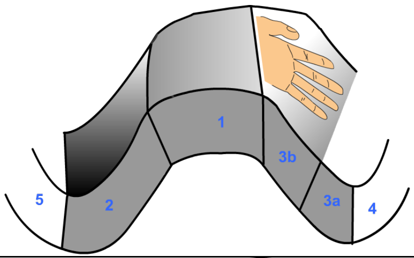
a). This circuit has an on center and off surround receptive field.	
b) This neuron is best activated by a hollow in a surface.	
c) This neuron is best activated by a small bump in the surface.	



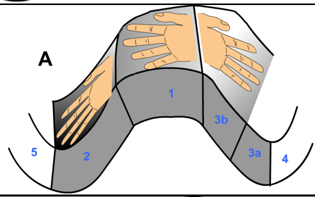
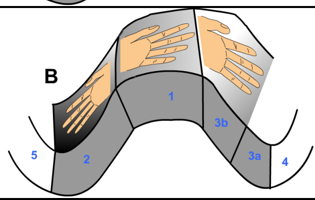
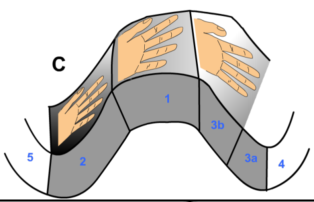
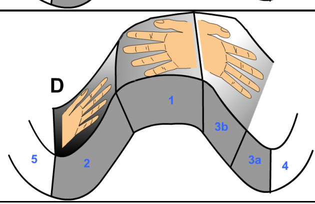
Problem 9: Suppose that a DCN neuron is connected as shown in the diagram. Which of the following statements is true?

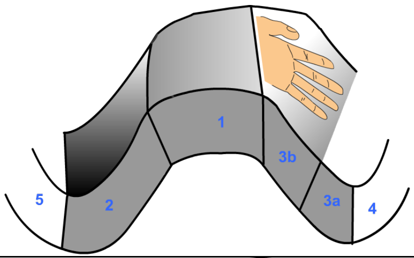
Answer

a). This circuit has an on center and off surround receptive field.	No. The receptors in the center are connected via inhibitory inputs.
b) This neuron is best activated by a hollow in a surface.	 Correct. A hollow in the blue area would give an excitatory response. This is because the outside edge, the red area, would activate the cell. Being hollow. the inside center would not inhibit it. This is similar to an off-centre ganglion cell's response when centered on a black dot.
c) This neuron is best activated by a small bump in the surface.	No. A small bump in the center would activate the middle receptors which would have an inhibitory input.



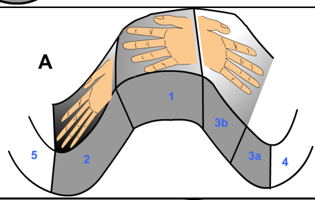
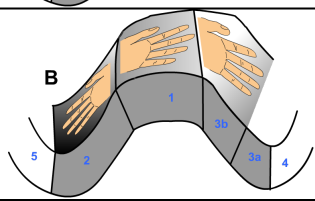
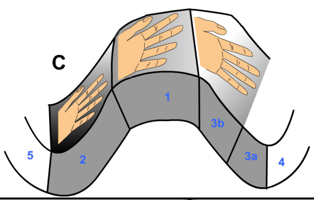
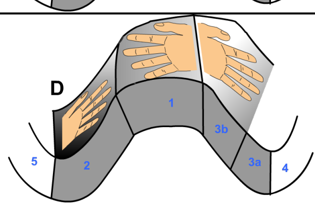
Problem 9: Assume that the same principles that produced mirroring in V1, V2, and V3 apply here. The diagram on the left shows the representation of the hand and fingers in area 3b. Which would be the representation of the hand and fingers in areas 1 and 2?

A 	
B 	
C 	
D 	



Problem 9: Assume that the same principles that produced mirroring in V1, V2, and V3 apply here. The diagram on the left shows the representation of the hand and fingers in area 3b. Which would be the representation of the hand and fingers in areas 1 and 2?

Answer

A 	No. The hand representation is mirrored in area 1 and again in area 2.
B 	No. The hand representation is mirrored in area 1 and again in area 2.
C 	No. The hand representation is mirrored in area 1 and again in area 2.
D 	Correct. The hand representation would be mirrored once in area 1 and once again in area 2. This is similar to the mirroring which we saw in the visual system; V1, V2, and V3.

Problem 10: Imagine that there is a bag containing a number of coins. Imagine that you pick up one and hold the faces between your thumb and your middle finger. What information is required to tell you this is a 5-cent piece and not a thicker quarter?

a) The SA1 surface receptors would tell you how round it is.
b) The RA1 surface receptors would tell you how round it is.
c) The SA2 receptors would tell you how round it is.
d) The SA2 receptors would tell you how thick it is.
e) The RA2 receptors would tell you how thick it is.

Problem 10: Imagine that there is a bag containing a number of coins. Imagine that you pick up one and hold the faces between your thumb and your middle finger. What information is required to tell you this is a smaller, thinner 5-cent piece and not a larger, thicker quarter?

Answer

a) The SA1 surface receptors would tell you how round it is.	Correct. These receptors have a fine acuity for how round something is. They produce a sustained activity
b) The RA1 surface receptors would tell you how round it is.	No. These receptors are good at detecting how smooth the coin is. Each coin would be equally smooth.
c) The SA2 receptors would tell you how round it is.	No. The acuity of these receptors is not fine enough to determine roundness.
d) The SA2 receptors would tell you how thick it is.	Correct. These receptors have a fine acuity for how stretched the skin is. From this the position of each finger can be computed. This can be used to sense of how far apart your thumb is from your middle finger and from that determine how thin the coin is.
e) The RA2 receptors would tell you how thick it is.	No. This receptor is suited to detecting vibrations. It is not suited to determine thickness.

Problem 11: List the similar organizing features found both in the somatosensory and visual systems.

Problem 11: List the similar organizing features found both in the somatosensory and visual systems.

Answer

a) Both have a variety of specialized sub modality receptors. In vision, rods detect black and white while cones detect red, green, and blue. In the somatosensory system one finds receptors that are rapidly adapting and slowly adapting both deep in the skin and on the skin surface. The purpose of this is to extract a variety of rich textures.

b) Both have a variation of receptor field size. The fovea and the skin on your finger tip are similar. Both the fovea and the fingertip have low convergence, a large cortical representation, small receptive field size, and high acuity.

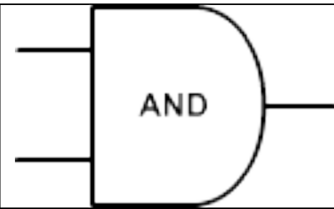
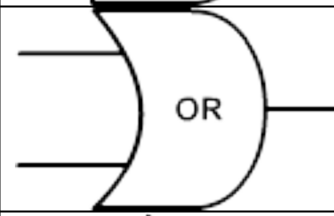
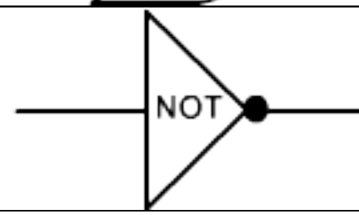
c) Both have antagonist surround receptive fields. The purpose is to extract edges. In vision, this is the location of changes in illumination. In touch, this is the location of changes in pressure.

d) In both, the cortex is topologically organized (but distorted by b).

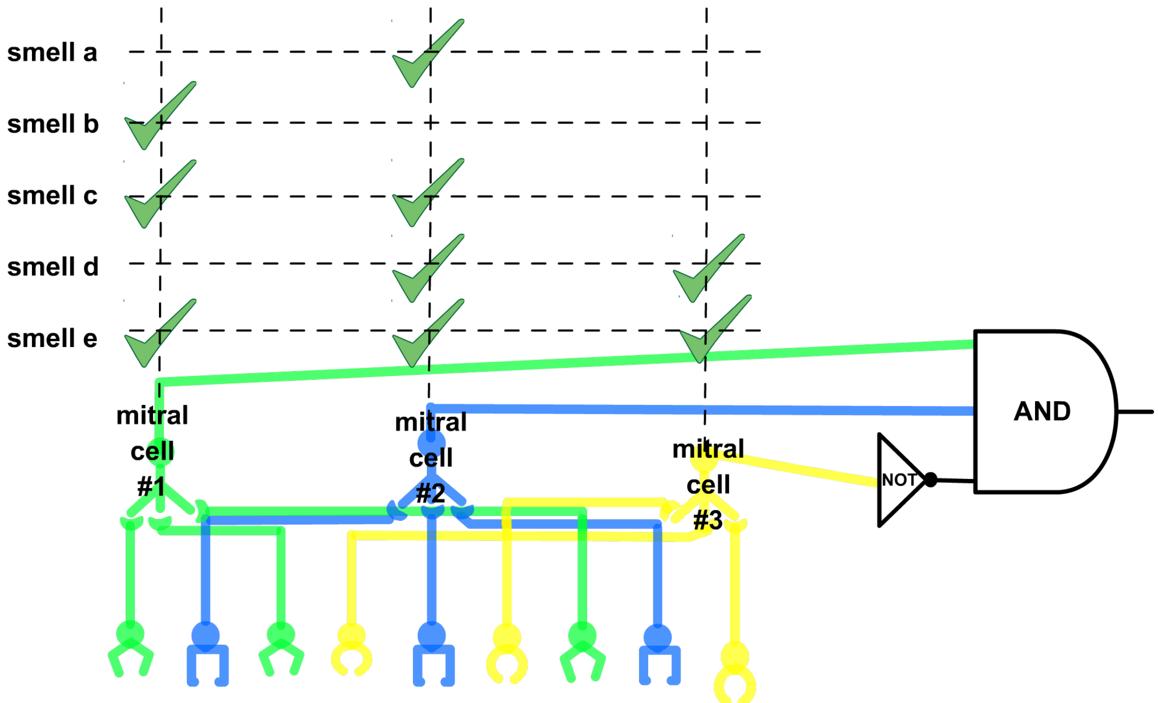
e) In both, the cortex has a columnar organization. In vision the columnar boundaries are defined by orientation and ocular dominance. In somatosensory cortex it is by afferent type.

f) In both, the cortical regions are sequentially connected, each extracting more complex features.

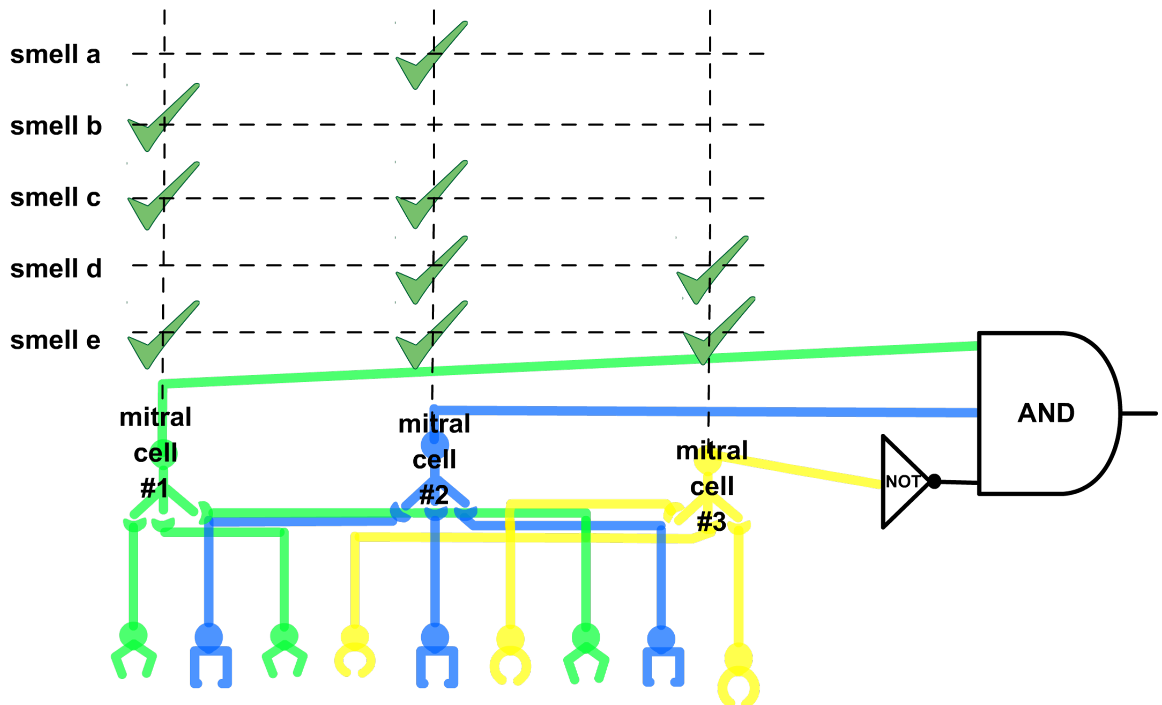
Problem 12: A particular odor is coded by a particular pattern of activated mitral cells. We will look at a very simple model using AND, OR, and NOT gates that can decode simple patterns. Complex computer processors are built using just these three gates.

An AND gate produces an output if all the inputs are on. It produces no output if any input is not on.	
An OR gate produces an output if any of the inputs are on. It produces no output if all inputs are not on.	
A NOT gate produces an output if the input is not on. It produces no output if the input is on.	

Problem 12: Which smell or smells will activate this circuit? Smell “a” activates mitral cell # 2. Smell “b” activates mitral cell #1. Smell “c” activated mitral cell #1 and #2. Smell “d” activates mitral cells #2 and #3. Smell “e” activates mitral cells #1, #2 and #3.



Problem 12: Which smell or smells will activate this circuit? Smell a activates mitral cell # 2. Smell b activates mitral cell #1. Smell c activated mitral cell #1 and #2. Smell d activates mitral cells #2 and #3. Smell e activates mitral cells #1, #2 and #3.

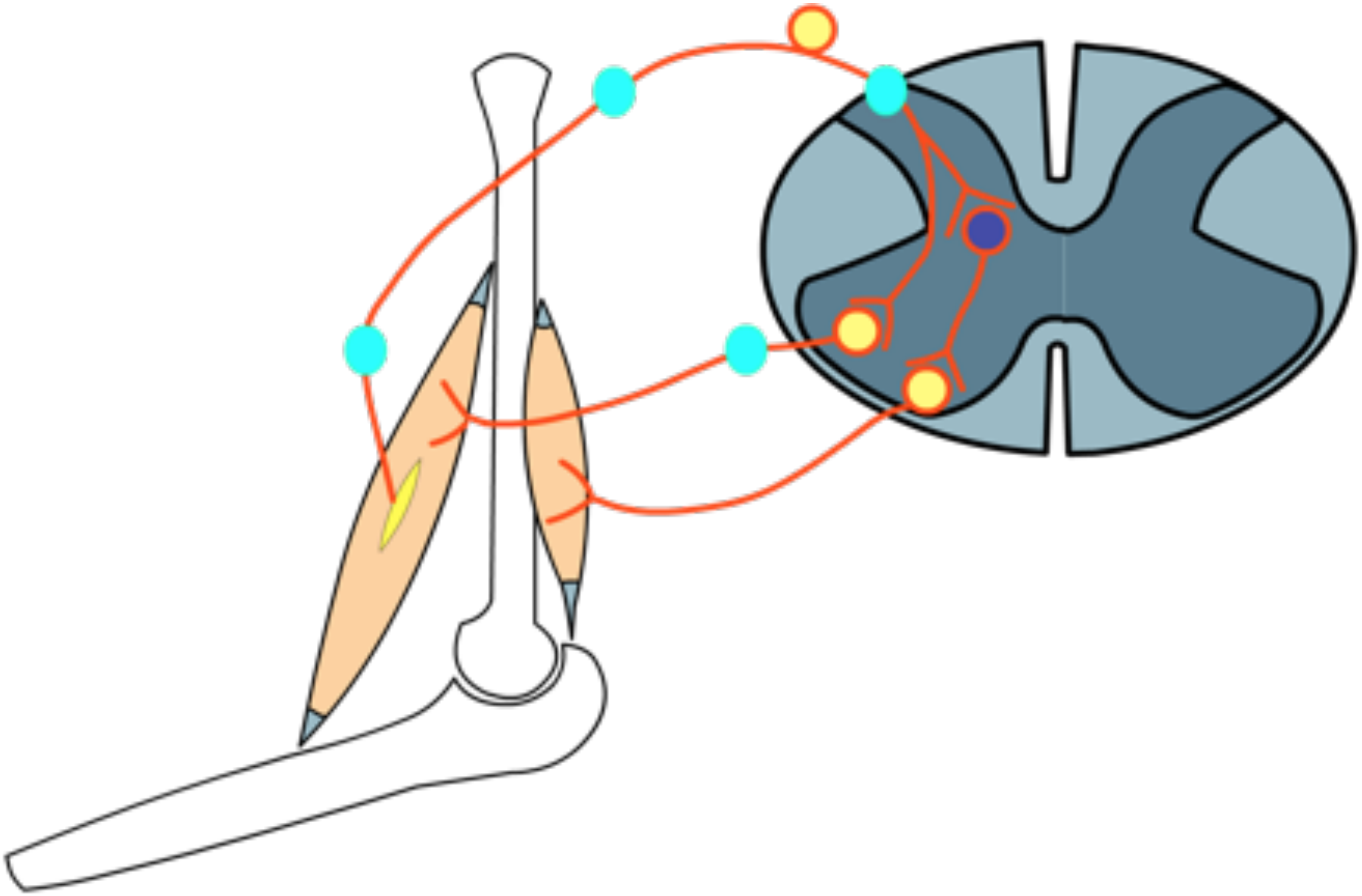


Answer

The circuit needs activation of both mitral cells #1 and #2 but no input from #3.

The only smell that activates this combination of mitral cells is smell c!

Chapter 8: Muscle Sense

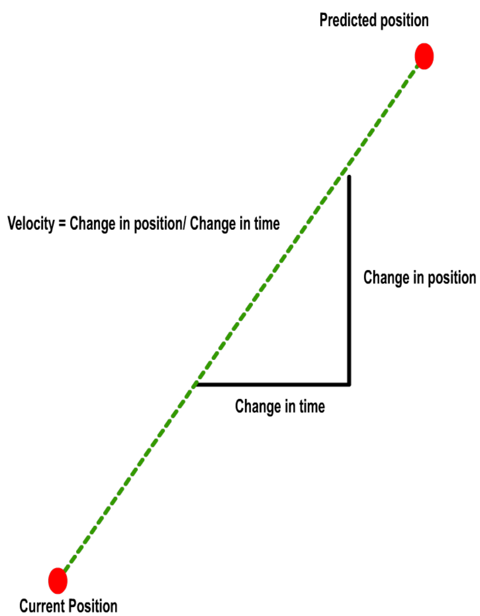


Problem 1: Suppose you are traveling by car from London to Toronto, a 200 km distance, your average speed is 100 km per hour, and your current position is Waterloo, about halfway there. How much longer will it take to reach Toronto?

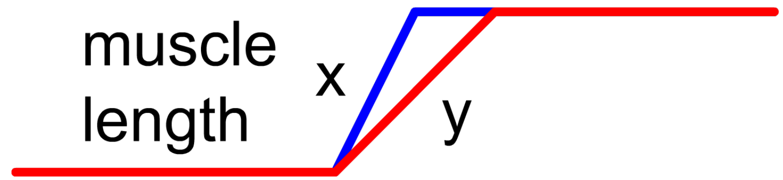
a) Two hours	
b) One hour	
c) Half an hour	

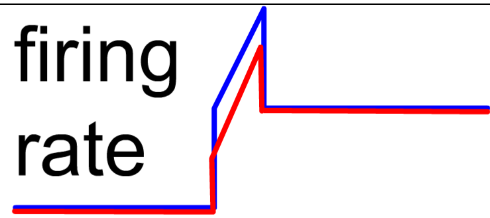
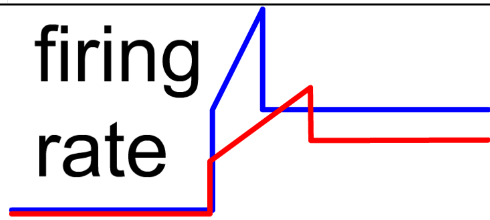
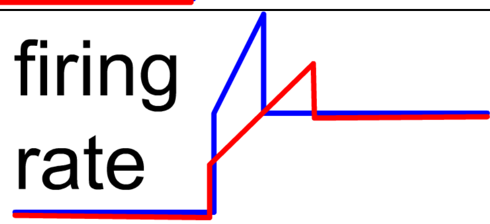
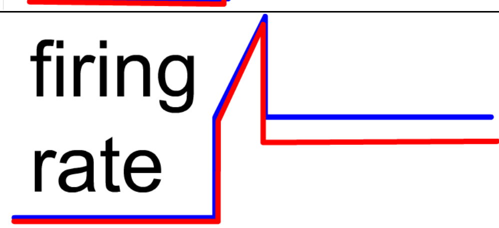
Problem 1: Suppose you are traveling by car from London to Toronto, a 200 km distance, your average speed is 100 km per hour, and your current position is Waterloo, about halfway there. How much longer will it take to reach Toronto?

Answer

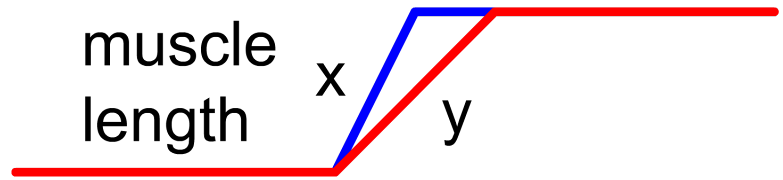
a) Two hours	No. You only have a 100 km left to go.
b) One hour 	Correct. To compute your arrival time, you need two pieces of information. Your distance from Toronto (position) and your speed. Knowing that you are 100 km (position) from Toronto and traveling at 100 km/hr (velocity) allows you to predict that you will arrive in one hour. Without both pieces of information, you cannot make this prediction. Similarly spindle afferents inform the brain how fast the limb is moving, and its current position, thus allowing the brain to predict when your hand will reach your cup in the future. Secondary afferents encode the position. It is a puzzle why 1a afferents encode the combination of velocity and position and not just velocity.
c) Half an hour	No. Not unless you risk a speeding ticket and double your speed.

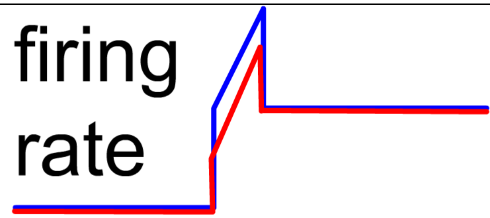
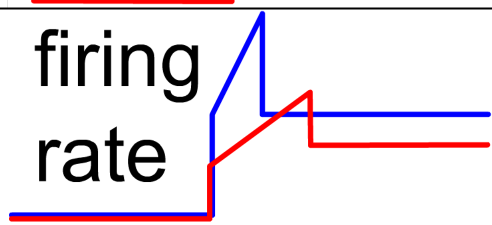
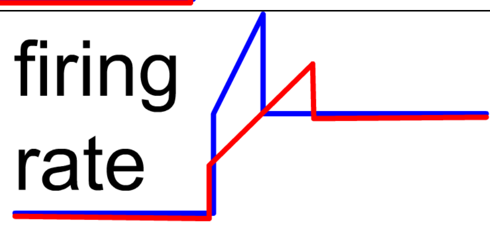
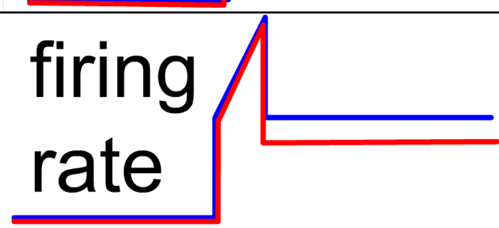
Problem 2: What would the primary, 1a, activity look like for a slower stretch (y)?



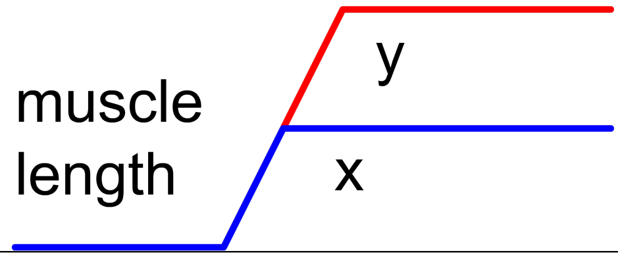
a		
b		
c		
d		

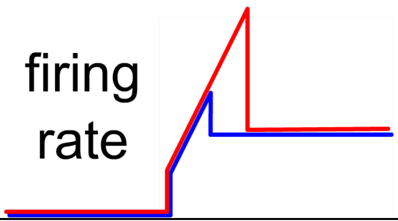
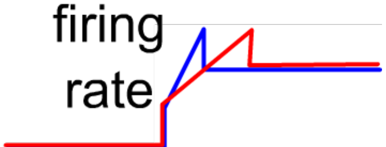
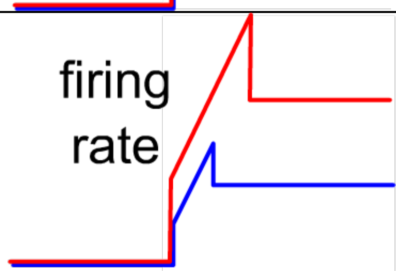
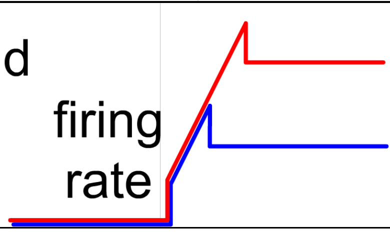
Problem 2: What would the primary, 1a, activity look like for a slower stretch (y)?



a		Close. However, the duration of the slower stretch [y] is twice as long as the fastest stretch [x].
b		Close. However, both [x] and [y] end at the same length and thus the final tonic activity would be the same.
c		Correct. For this slower stretch (y), the primary afferent's firing rate will end at the same tonic level as in "x" but have a smaller and longer phasic response than "x" during the stretch
d		No. In "y" the stretch is slower, thus the phasic portion would be smaller. Also, the final position is the same and thus the final tonic levels will be the same.

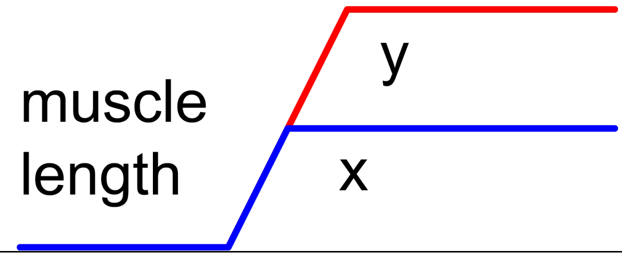
Problem 3: Which of these firing rates of a primary 1a afferent match these two stretches?

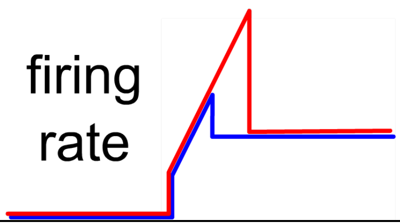
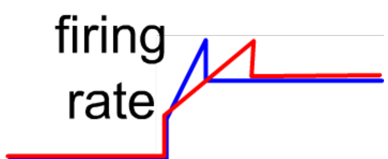
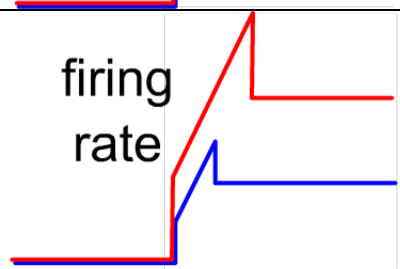
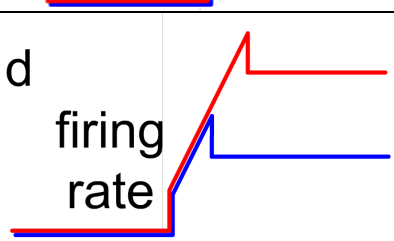
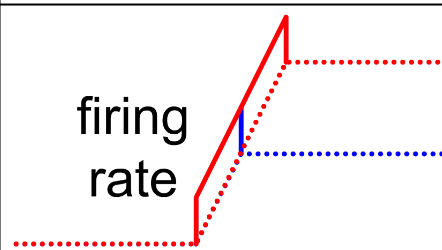


a firing rate 	
b firing rate 	
c firing rate 	
d firing rate 	

Problem 3: Which of these firing rates of a primary 1a afferent match these two stretches?

Answer

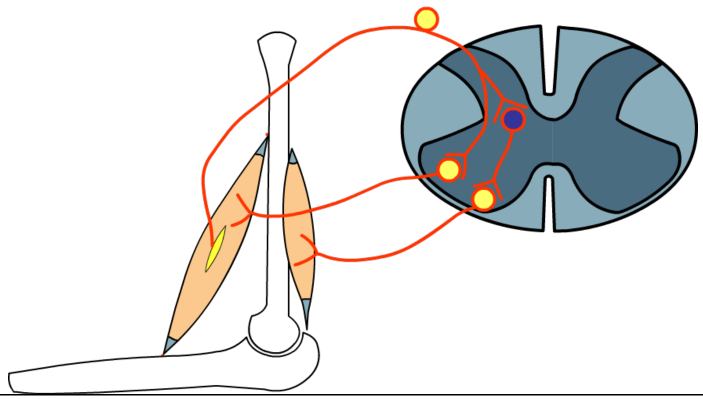


a 	Close. However, since the final positions are different, the final levels of tonic activity should be different as well.
b 	Close. However, since the final positions are different, the final levels of tonic activity should be different as well.
c 	Close. However, since the velocities are the same the phasic responses should be the same during the stretch.
d 	 Correct. For the larger stretch (b), the primary afferent's firing rate will be at a larger tonic level than "a" at the end of the stretch, and have the same size but longer phasic response during the stretch.

Problem 4: An increase in agonist muscle length will **not** produce which reflex response from a 1a receptor?

a) activation of an inhibitory interneuron to the antagonist muscle.	
b) a decrease in alpha motor neuron activity in the antagonist muscle.	
c) a shortening agonist muscle.	
d) a shortening of the antagonist muscle.	
e) a relaxation of the antagonist muscle.	

Problem 4: An increase in agonist muscle length will **not** produce which reflex response from a 1a receptor?



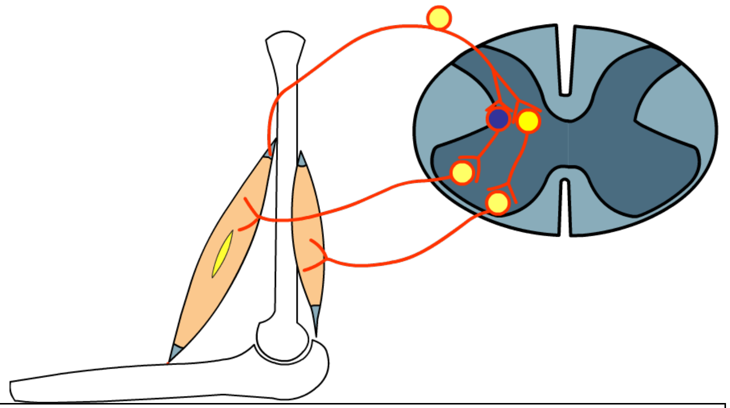
Answer

a) activation of an inhibitory interneuron to the antagonist muscle.	No. This is true. Stretch of the agonist muscle will activate an inhibitory neuron to the antagonist muscle.
b) a decrease in alpha motor neuron activity in the antagonist muscle.	No. This is true. Stretch of the agonist muscle will cause activation of the inhibitory neuron and a decrease in alpha motor neuron activity in the antagonist muscle.
c) a shortening agonist muscle.	No. This is true. Stretch of the agonist muscle will, via the stretch reflex, activate the motor neurons in the agonist muscle, causing it to contract and shorten.
d) a shortening of the antagonist muscle.	Yes, this is false. Stretch of the agonist muscle will, via the stretch reflex, activate the motor neurons in the agonist muscle causing it to contract and shorten. The antagonist muscle would become longer.
e) a relaxation of the antagonist muscle.	No. This is true. Stretch of the agonist muscle will activate an inhibitory neuron to the antagonist muscle. This will relax antagonist muscle.

Problem 5: An increase in agonist muscle tension will **not** produce which reflex response from a 1b receptor?

a) Excitation of the alpha motor neurons in the antagonist muscle.	
b) An increase in antagonist muscle contraction and tension.	
c) A relaxation of the agonist muscle.	
d) An inhibition of the alpha motor neuron in the agonist muscle.	
e) The relaxation of the antagonist muscle.	

Problem 5: An increase in agonist muscle tension will **not** produce which reflex response from a 1b receptor?



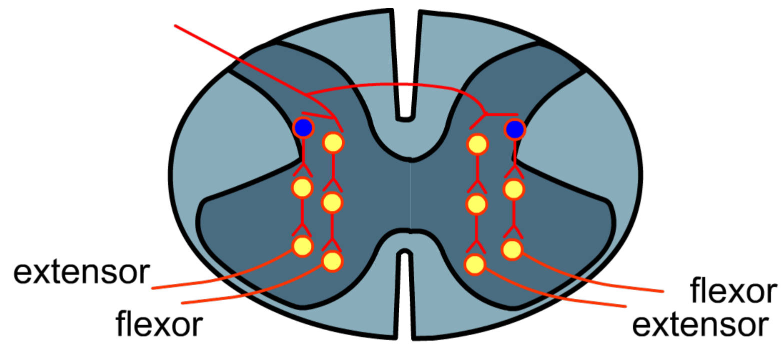
Answer

a) Excitation of the alpha motor neurons in the antagonist muscle.	No. This is true. The alpha motor neurons of the antagonist muscle are activated through an excitatory interneuron.
b) An increase in antagonist muscle contraction and tension.	No. This is true. The alpha motor neurons of the antagonist muscle are activated through an excitatory interneuron. This increases its contraction and tension.
c) A relaxation of the agonist muscle.	No. This is true. The alpha motor neurons of the agonist muscle are inhibited through an inhibitory interneuron. This relaxes the agonist muscle.
d) An inhibition of the alpha motor neuron in the agonist muscle.	No. This is true. The alpha motor neurons of the agonist muscle are inhibited through an inhibitory interneuron.
e) The relaxation of the antagonist muscle.	**Correct.** This is false. The alpha motor neurons of the antagonist muscle are activated through an excitatory interneuron. This produces contraction in the antagonist muscle.

Problem 6: An increase of activity in pain and cutaneous afferents will **not** produce which reflex response?

a) Contraction of ipsilateral flexors.	
b) Relaxation of ipsilateral extensors.	
c) Contraction of extensors on the opposite side.	
d) Relaxation of extensors on the opposite side.	
e) Relaxation of flexors on the opposite side.	

Problem 6: An increase of activity in pain and cutaneous afferents will not produce which reflex response?



Answer

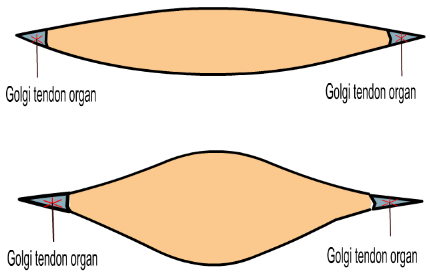
a) Contraction of ipsilateral flexors.	No. This is true. Contraction of the ipsilateral flexors produces a withdraw of the foot from the painful stimulus.
b) Relaxation of ipsilateral extensors.	No. This is true. Contraction of the ipsilateral flexors produces a withdraw of the foot from the painful stimulus. This is assisted if the ipsilateral extensors relax.
c) Contraction of extensors on the opposite side.	No. This is true. Contraction of extensors on the opposite side allows one to maintain posture and balance.
d) Relaxation of extensors on the opposite side.	Yes. This is not true. Contraction of extensors on the opposite side allows one to maintain posture and balance. This is assisted by relaxation in the flexors on that side. As well, contraction of ipsilateral flexors produces a withdraw of the foot from the painful stimulus.
e) Relaxation of flexors on the opposite side.	No. This is true. Contraction of extensors on the opposite side allows one to maintain posture and balance. This is assisted by relaxation in the flexors on that side.

Problem 7: Which of the following will most increase the firing rate of a 1b (Golgi tendon) afferent fiber?

a) Activation of gamma motor neurons.	
b) Activation of alpha motor neurons.	
c) Activation of 1a fibers.	
d) The passive stretch of a muscle.	
e) A tap to the tendon.	

Problem 7: Which of the following will most increase the firing rate of a 1b (Golgi tendon) afferent fiber?

Answer

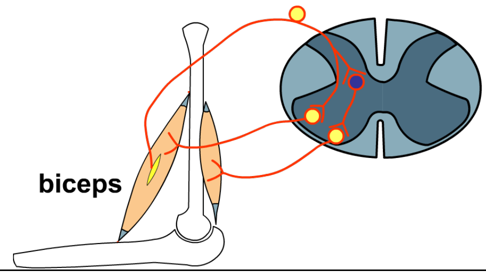
a) Activation of gamma motor neurons.	Incorrect.
b) Activation of alpha motor neurons.	 **Correct**. Golgi tendon organs (1b) are located in the tendon of the muscle, in series with the muscle fibers. Here they become stretched when the muscle contracts. This occurs when the alpha motor neurons are activated. Thus, Golgi tendon organs sense the force the muscle exerts.
c) Activation of 1a fibers.	Close. Yes, activating these fibers will activate monosynaptic reflex and contract the muscle. But there is a better way.
d) The passive stretch of a muscle.	Incorrect. This activates the muscle spindle and not the 1b afferent because there is no tension on the tendon.
e) A tap to the tendon.	Incorrect. Surprisingly, hitting the tendon does not activate the 1b afferent. This afferent is sensitive to tendon stretch. Hitting the tendon stretches the muscle, which in turn activates the muscle spindle.

Problem 8: When agonist muscle length decreases, the 1a stretch reflex will **not** produce which of the following?

a) A decrease of 1a activity.	
b) An increase of alpha motor neuron activity.	
c) Relaxation of the agonist muscle.	
d) An increase of length in the agonist muscle.	
e) The 1a reflex maintains a constant muscle length.	

Problem 8: When agonist muscle length decreases, the 1a stretch reflex will **not** produce which of the following?

Answer

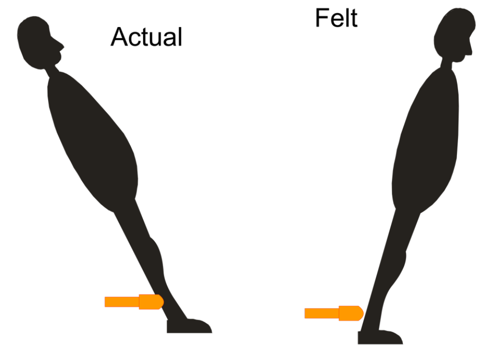


a) A decrease of 1a activity.	No. This is true. When the agonist (biceps) muscle shortens, the muscle spindles inside also shorten. 1a activity thus would decrease.
b) An increase of alpha motor neuron activity.	**Yes, this is false.** When the agonist (biceps) muscle shortens, the muscle spindles inside also shorten. 1a activity thus would decrease, the biceps motor neuron activity decreases, the biceps muscle relaxes, and the muscle lengthens. Thus, the reflex tries to maintain a constant muscle length.
c) Relaxation of the agonist muscle.	**Yes, this is false**. When the agonist (biceps) muscle shortens, the muscle spindles inside also shorten. 1a activity thus would decrease, the biceps motor neuron activity decreases, the biceps muscle relaxes, and the muscle lengthens. Thus, the reflex tries to maintain a constant muscle length.
d) An increase of length in the agonist muscle.	No. This is true. When the agonist (biceps) muscle shortens the muscle spindles inside also shorten. 1a activity thus would decrease, the biceps motor neuron activity decreases, the biceps muscle relaxes, and the muscle lengthens.
e) The Ia reflex maintains a constant muscle length.	No. This is true. When the agonist (biceps) muscle shortens. the muscle spindles inside also shorten. 1a activity thus would decrease, the biceps motor neuron activity decreases, the biceps muscle relaxes, and the muscle lengthens. Thus, the reflex tries to maintain a constant muscle length.

Problem 9: Which would **not** happen if one applied vibration to the extensor muscle of the ankle while standing?

a) The spindles in the extensor muscle are more activated.	
b) You feel that the extensor muscle is more stretched than it really is.	
c) You feel that you are leaning forward.	
d) You fall backward.	
e) You fall forward.	

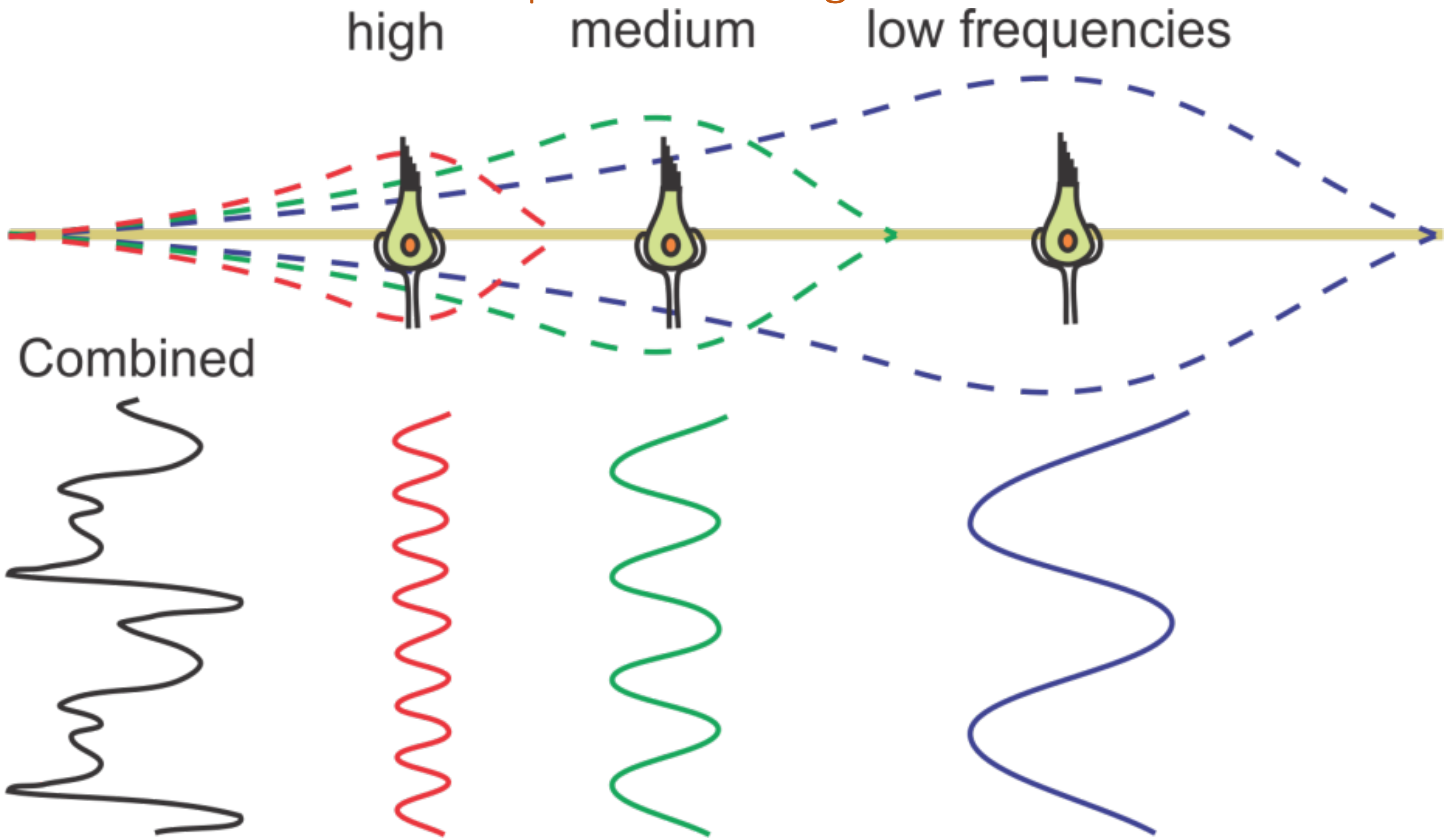
Problem 9: Which would **not** happen if one applied vibration to the extensor muscle of the ankle while standing?



Answer

a) The spindles in the extensor muscle are more activated.	This would happen. A vibration to the extensor muscle will activate muscle spindles.
b) You feel that the extensor muscle is more stretched than it really is.	This would happen. A vibration to the extensor muscle will activate muscle spindles and make you feel that this muscle is more stretched than it really is. That is, you would feel that you are leaning forward.
c) You feel that you are leaning forward.	This would happen. A vibration to the extensor muscle will activate muscle spindles and make you feel that this muscle is more stretched than it really is. That is, you would feel that you are leaning forward.
d) You fall backward.	This would happen. A vibration to the extensor muscle will activate muscle spindles and make you feel that this muscle is more stretched than it really is. That is, you would feel that you are leaning forward. You would respond by trying to straighten up. But you are actually upright. So, when you feel that you are straightening up, you actually lean backward. As a result, you fall backward.
e) You fall forward.	**Correct.** This would not happen. A vibration to the extensor muscle will activate muscle spindles and make you feel that this muscle is more stretched than it really is. That is, you would feel that you are leaning forward. You would respond by trying to straighten up. But you are actually upright. So, when you feel that you are straightening up, you actually lean backward. As a result, you fall backward.

Chapter 9: Hearing

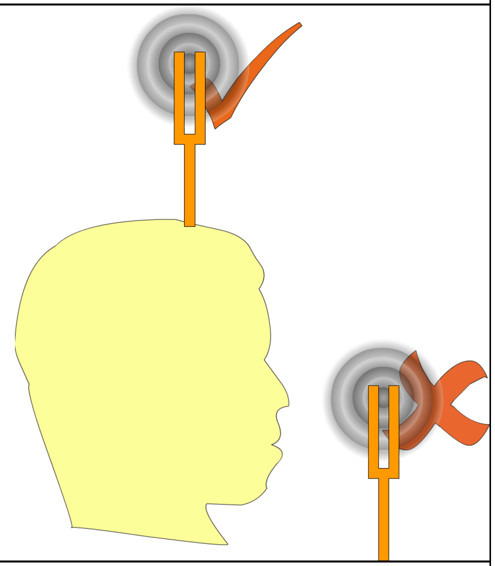


Problem 1: What happens if the ossicles are broken?

a) Most of the sound energy still deflects the oval window.	
b) You would become deaf.	
c) This problem cannot be treated with a hearing aid.	
d) This was the type of deafness suffered by Beethoven. He found he could hear his piano by placing his head against the piano board.	

Problem 1: What happens if the ossicles are broken?

Answer

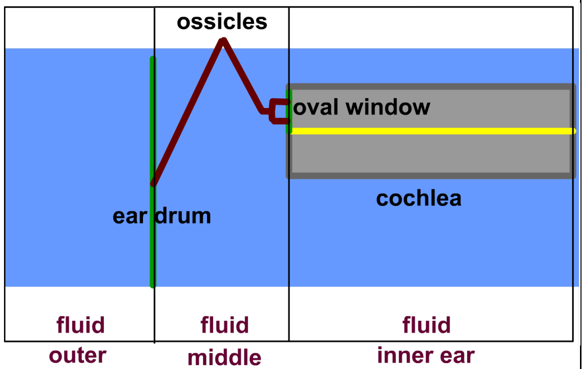
a) Most of the sound energy still deflects the oval window.	No. Because there is fluid behind the oval window and because the wave would also strike the round window at the same time, most of the sound energy would be reflected back.
b) You would become deaf.	No. The hearing level is severely impaired, but some sound is still transmitted through the skull. You can mimic this by putting your fingers in your ears and listening to sounds.
c) This problem cannot be treated with a hearing aid.	No. This is called conduction deafness which can often be treated with external hearing aids. Patients can hear a tuning fork much better when it is placed on the skull. 
d) This was the type of deafness suffered by Beethoven. He found he could hear his piano by placing his head against the piano board.	Yes. This is conduction deafness, which can be treated with external hearing aids. And yes, Beethoven's solution was to place his head against the piano board so that the sound waves could be transmitted through the skull.

Problem 2: Hearing is most impaired when fluid fills the

a) outer ear.	
b) middle ear.	
c) inner ear.	
d) a and b together.	
e) a and c together.	

Problem 2: Hearing is most impaired when fluid fills the

Answer

a) outer ear.	Correct. Because there is water in front of the ear drum, most of the energy in the air molecules will bounce off and not move the ear drum much. Water often fills the outer ear when you go swimming. **But there is a better answer.**
b) middle ear.	Correct. Because there is fluid behind the ear drum, most of the energy in the air molecules will bounce off and not move the ossicles much. Fluid, in effect, short circuits the ossicles. Fluid often fills the middle ear when you have an ear infection. **But there is a better answer.** What else happens if water fills the middle ear? Fluid often fills the middle ear when you have an ear infection. Because there is no pressure outlet on the other side of the round window, the basilar membrane cannot get deflected. Thus, even if the ear drum were deflected and this pushed the oval window through the ossicles, movement of the basilar membrane would be impeded because it would be difficult to deflect the round window against the fluid in the inner ear.
c) inner ear.	Wrong. Normally, there is always fluid in the inner ear.
d) a and b together.	**Correct**, this is the best answer. Because there is fluid in the outer ear, most of the energy in the air molecules will bounce off. Fluid often fills the outer ear when you go swimming or take a shower. Also, fluid in the middle ear would short circuit the ossicles. The combination would have the largest effect. 
e) a and c together.	"a" is correct but "c" is wrong. Normally, there is always fluid in the inner ear.

Problem 3: Your voice sounds different when you hear yourself speak compared to when you hear your voice played back in a recording. When you hear yourself speak you hear all of the following. When you hear a recording of yourself you just hear

a) the sound of your voice reflected from the room.	
b) the sound of your voice transmitted through your skull.	
c) the sound of your voice damped by the middle ear muscles.	

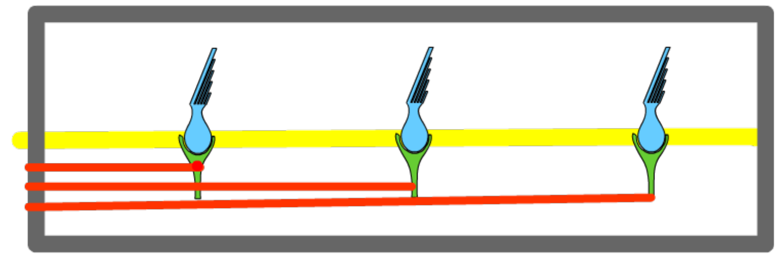
Problem 3: Your voice sounds different when you hear yourself speak compared to when you hear your voice played back in a recording. When you hear yourself speak you hear all of the following. When you hear a recording of yourself you just hear

a) the sound of your voice reflected from the room.	**Yes**, you hear "a", "b", and "c" when you hear yourself speak and you only hear the "a" from a recording of yourself. Try putting your fingers in and out of both ears while you speak. When you put your fingers in, the sound you hear is mostly that being transmitted through your skull. Note that plugging your ears has little effect on the sound that you hear. On the other hand, if you listen to a recording, plugging your ears will have a very large affect. Before you speak, a signal is sent to contract the middle ear muscles. Unless the recording is very loud, the middle ear muscles will not contract reflexively.
b) the sound of your voice transmitted through your skull.	No.
c) the sound of your voice damped by the middle ear muscles.	No. A recording of yourself will not activate the middle ear muscles unless it is very loud.

Problem 4: To produce a good "hearing aid" one should

a) stimulate individual auditory nerve fibers to elicit the sensation of different tones at different frequencies and to elicit the sensation of different sound intensities.	
b) stimulate the whole auditory nerve with different intensities to elicit the sensation of different tones.	
c) stimulate the whole auditory nerve at different frequencies to elicit the sensation of different tones.	
d) stimulate individual auditory nerve fibers at different intensities (voltages) to elicit the sensation of different tones at different intensities.	

Problem 4: To produce a good "hearing aid" one should
Answer

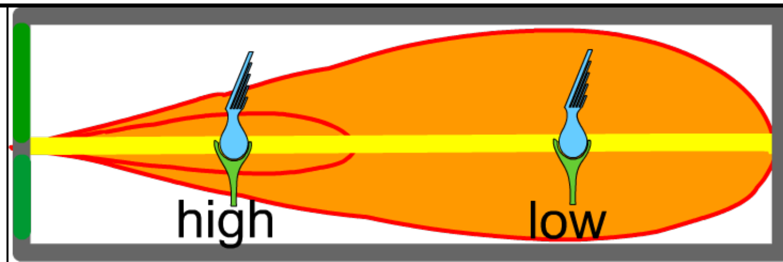
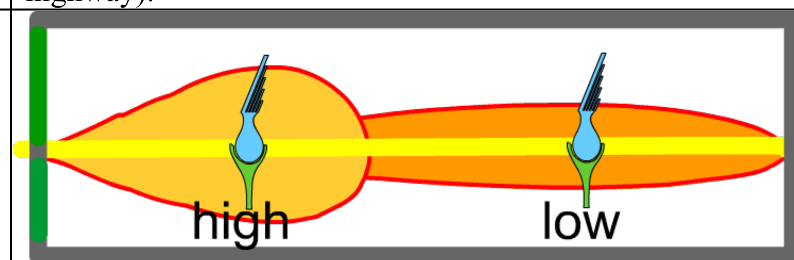
a) stimulate individual auditory nerve fibers to elicit the sensation of different tones at different frequencies and to elicit the sensation of different sound intensities.	Yes. This is correct. If the 8th nerve fibers are intact a cochlear implant may be prescribed. These have several dozen electrodes, each activating a small area of the basilar membrane which are surgically placed along the length of the basilar membrane.  Activating a particular electrode elicits the sensation of a particular pitch. Raising the activation frequency results in more frequent action potentials that sensed as a louder tone of the same pitch.
b) stimulate the whole auditory nerve with different intensities to elicit the sensation of different tones.	Wrong. Stimulating the whole 8th nerve directly would be like activating all areas of the basilar membrane, low frequencies to high frequency, at the same time. This is like striking all the piano keys when all you want to do is hit a single note. Sounds of different frequencies would be perceived as sounds of the same mixture of keys.
c) stimulate the whole auditory nerve at different frequencies to elicit the sensation of different tones.	Wrong. Simulating all the afferents from the hair cells at different frequencies would be perceived as the sound of all the piano keys being struck at different intensities. Low frequency stimuli activate all the afferents at a low frequency of action potentials and thus are perceived as a soft sound and high frequency like a loud sound.
d) stimulate individual auditory nerve fibers at different intensities (voltages) to elicit the sensation of different tones at different intensities.	This is partially correct. If the 8th nerve fibers are intact a cochlear implant may be prescribed. These have several dozen electrodes, each activating a small area of the basilar membrane which are surgically placed along the length of the basilar membrane. Activating a particular electrode elicits the sensation of a particular pitch. However, raising the intensity has an all or nothing effect. Low intensities do not activate an action potential. Moderate intensities that are above threshold would activate action potentials. Higher intensities would **not** elicit more action potentials and thus would not sound louder.

Problem 5: Which of the following sounds are most likely to mask each other, that is, prevent the other from being heard?

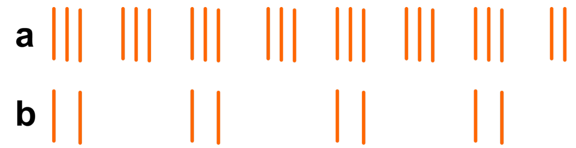
a). A loud low-frequency sound is likely to mask a soft high frequency sound.	
b) A soft low-frequency sound is likely to mask a loud high-frequency sound.	
c) A soft high frequency sound is likely to mask a loud low-frequency sound.	
d) A loud high-frequency sound is likely to mask a soft low-frequency sound.	

Problem 5: Which of the following sounds are most likely to mask each other, that is, prevent the other from being heard?

Answer

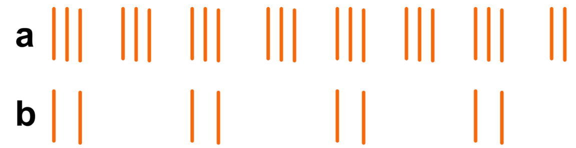
a). A loud low-frequency sound is likely to mask a soft high frequency sound.	 **Correct.** Notice that low frequency sounds move all areas of the basilar membrane to some extent. This is because all waves start at the oval window. High frequency sounds move just the area next to the oval window. This may explain why it is useful to turn up the treble in a noisy environment (e.g. if you are listening to music while in a car on the highway).
b) A soft low-frequency sound is likely to mask a loud high-frequency sound.	 No. As you can see the loud high-frequency sound produces a larger peak than the soft low-frequency sound.
c) A soft high frequency sound is likely to mask a loud low-frequency sound.	No. As you can see in “a” the loud low-frequency sound produces a larger peak than the soft high-frequency sound. So it is the other way around, the low-frequency sound masked out the high-frequency sound.
d) A loud high-frequency sound is likely to mask a soft low-frequency sound.	No. As you can see in “a” and “b” the loud high-frequency sound is louder than the low frequency sound but because low-frequency sound still has a distinct peak, both will still be heard as distinct tones. Note how much different this is from when one has a loud low-frequency sound and soft high-frequency sound. Here the high-frequency sound is truly overwhelmed and masked.

Problem 6: Suppose the frequency of action potentials in an auditory afferent changed from "a" to "b". How has the sound changed?



a) The sounds a and b are the same except sound b is less loud.	
b) The sound b is less loud and at a lower tone or frequency than sound a.	
c) The sound b is less loud and played less often but of the same frequency as sound a.	
d) The sounds a and b are the same except sound b is of a lower frequency.	

Problem 6: Suppose the frequency of action potentials in an auditory afferent changed from "a" to "b". How has the sound changed?



Answer

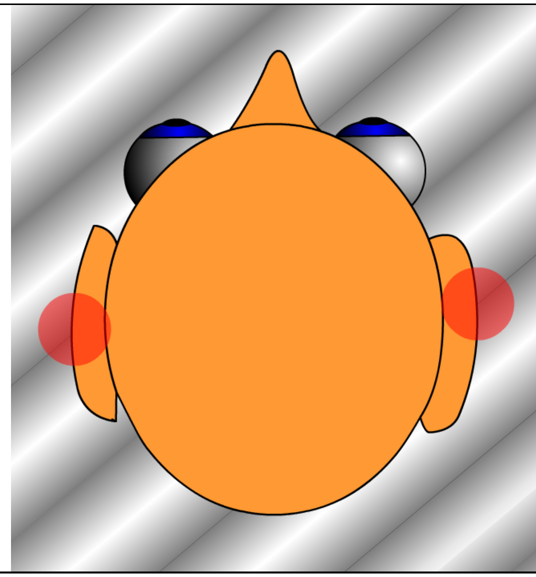
a) The sounds a and b are the same except sound b is less loud.	No. If the only difference was that sound a was played less loud it would look the same except the number of action potentials in each burst would be less. Sound b has fewer beats.
b) The sound b is less loud and at a lower tone or frequency than sound a.	No. The same afferent is being activated in both cases. So, the frequency is the same. Sound b is played less loud because the number of action potentials in each burst is less.
c) The sound b is less loud and played less often but of the same frequency as sound a.	**Correct.** In "b" the sound is less loud and played less often but of the same frequency. It is also less loud because it has only 2 rather than 3 action potentials. The frequency of the sound is the same because the same afferent is activated in "a" and "b". We do not know the frequency of the sound unless we know the location of this hair cell along the basilar membrane. The rhythmic nature of the firing frequency is produced by a repeating sound, e.g. a drum beat or a musical note played repeatedly. In "b" the rhythm is slower.
d) The sounds a and b are the same except sound b is of a lower frequency.	No. The same afferent is being activated in both cases. So, the frequency is the same.

Problem 7: Why are timing differences not accurate for determining the location of high frequency sounds?

a) In high-frequency sounds, two peaks could strike the ears simultaneously and still originate from the side.	
b) The neural system is unable to measure such small timing differences.	
c) High-frequency sounds wrap around the head and are heard by both ears at the same intensity.	

Problem 7: Why are timing differences not accurate for determining the location of high frequency sounds?

Answer

a) In high-frequency sounds, two peaks could strike the ears simultaneously and still originate from the side.	 **Correct.** As you can see in the figure, two different peaks strike ear at the same time. This only happens if the frequency of the sound is high. As you can see in the figure the distance between peaks, the wavelength, is less than the width of the head.
b) The neural system is unable to measure such small timing differences.	No. All sounds travel at the same speed, both high-frequency and low-frequency. Thus, the time difference between low-frequency and high-frequency sounds would be the same.
c) High-frequency sounds wrap around the head and are heard by both ears at the same intensity.	No. It is low-frequency sounds that wrap around head.

Problem 8: Is the filtering of unfamiliar phonemes different from being raised in an environment with only vertical lines?

a) Yes, one would be blind to horizontal lines; however, one would not be deaf to unfamiliar phonemes.	
b) Yes, one would be blind to horizontal lines; however, one would not hear phonemes that one didn't encounter in early life.	
c) Yes, all simple cells with orientation other than vertical would be silenced.	
d) Yes, later in life the auditory filtering process would not impair the ability to learn a new language without an accent, but it would impair the ability to see horizontal lines.	

Problem 8: Is the filtering of unfamiliar phonemes different from being raised in an environment with only vertical lines?

Answer

a) Yes, one would be blind to horizontal lines; however, one would not be deaf to unfamiliar phonemes.	**Correct.** If one was raised in an environment with only vertical lines, one would become blind to horizontal lines. This is because the connections required to form simple cells with a horizontal orientation preference would be lost. Instead, all simple cells would receive connections required for a vertical orientation preference. Thus, you would not see a vertical line when shown a horizontal line. One would not be deaf to the unfamiliar phonemes. The filtering of phonemes in language makes an unfamiliar phoneme sound like a familiar phoneme.
b) Yes, one would be blind to horizontal lines; however, one would not hear phonemes that one didn't encounter in early life.	No. The filtering of phonemes in language makes an unfamiliar phoneme sound like a familiar phoneme. One would not be deaf to the unfamiliar phonemes. When raised in the environment in which L is unfamiliar while R is familiar, the L will sound like an R. When raised in an environment in which L is unfamiliar while R is familiar. 
c) Yes, all simple cells with orientation other than vertical would be silenced.	No. If one was raised in an environment with only vertical lines, the connections required to form simple cells with an horizontal orientation preference would be lost. All simple cells would receive connections required for a vertical orientation preference.
d) Yes, later in life the auditory filtering process would not impair the ability to learn a new language without an accent, but it would impair the ability to see horizontal lines.	No. The auditory filtering process would impair the ability to learn a new language without an accent later in life. The filtering of phonemes in language makes an unfamiliar phoneme sound like a familiar phoneme. When raised in the environment in which L is unfamiliar while R is familiar, the L would sound like an R. This would make it difficult to learn to say the letter L correctly. When raised in an environment in which L is unfamiliar while R is familiar. 

Problem 9: Suppose you conducted the following experiment. Have subjects listen to simple sentences like "Trees can grow", interspersed with sentences like A) "Trees can grew" or B) "Trees can eat".

a) Both A and B would activate Broca's and Wernicke's areas equally.	
b) A would activate Broca's and B Wernicke's.	
c) B would activate Broca's and A Wernicke's.	

Problem 9: Suppose you conducted the following experiment. Have subjects listen to simple sentences like "Trees can grow", interspersed with sentences like A) "Trees can grew" or B) "Trees can eat".

Answer

a) Both A and B would activate Broca's and Wernicke's areas equally.	No. Broca's area is involved in grammar and Wernicke's area is involved with understanding. They would not be equally activated.
b) A would activate Broca's and B Wernicke's.	**Correct.** When one hears sentences like "Trees can grew" one presumably detects an error in grammar; a form error. This would activate Broca's area. When one hears sentences like "Trees can eat" one presumably detects a meaning ambiguity. This would activate Wernicke's area. In fact, this is what was recently shown using functional magnetic resonance imaging in humans by Ni et al in J. Cogn. Neurosci. 2000 13 120 -133
c) B would activate Broca's and A Wernicke's.	No. Wernicke's area is involved with understanding or meaning.

Problem 10: Which are more devastating, Wernicke's lesions or Broca’s?

a) Broca's.	
b) Wernicke's	

Problem 10: Which are more devastating, Wernicke's lesions or Broca’s?

Answer

a) Broca's.	No.
b) Wernicke's	**Correct.** Wernicke's lesions are more devastating because the patient cannot understand and is not aware that she or he cannot understand.

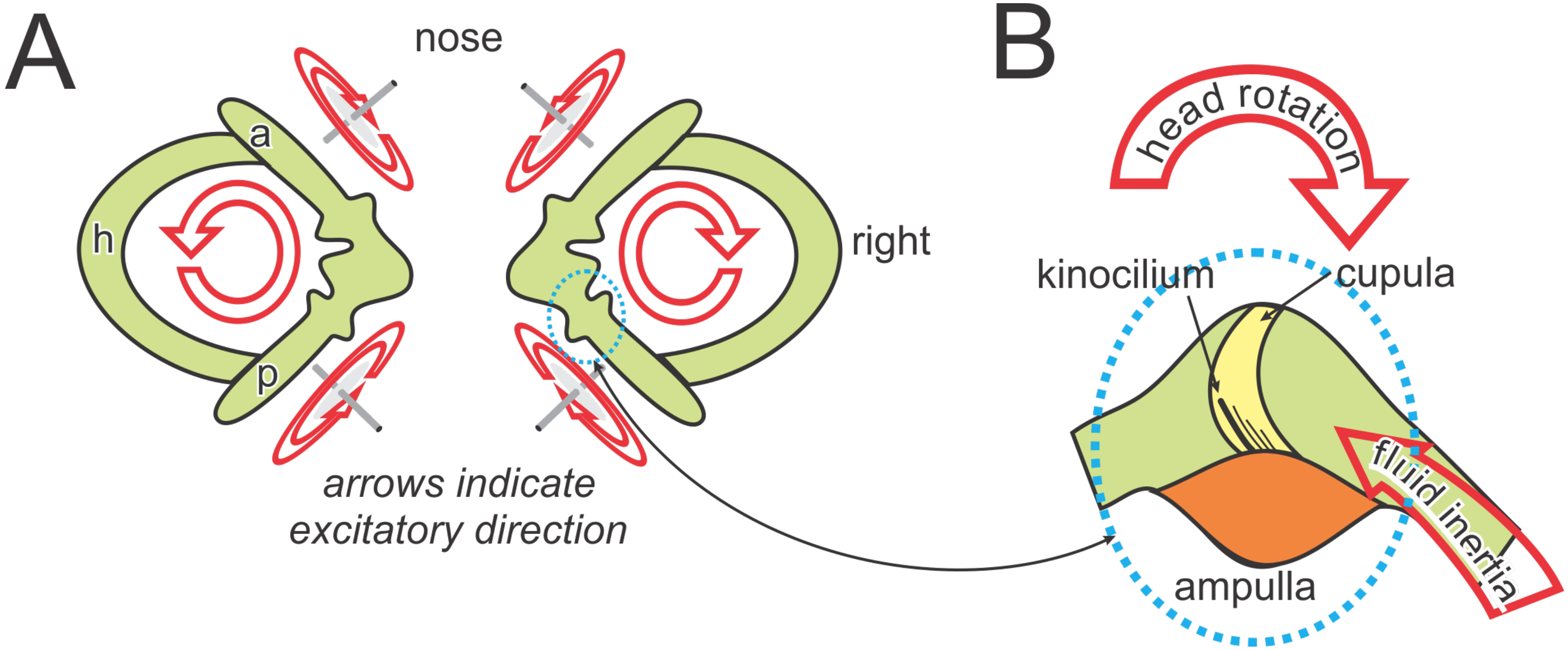
Problem 11: Which are more frustrating, Wernicke's lesions or Broca’s?

a) Broca's.	
b) Wernicke's	

Problem 11: Which are more frustrating, Wernicke's lesions or Broca’s?

Answer

a) Broca's.	Correct. Broca's lesions are more frustrating because the patient understands his mistake due to the intact Wernicke’s area, but the patient cannot correct it.
b) Wernicke's	No.

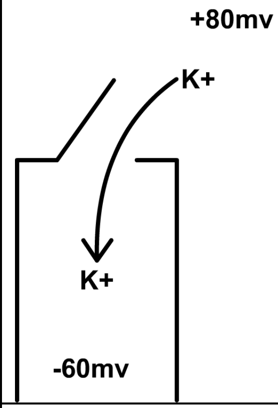

A
nose
a
h
p
right
arrows indicate
excitatory direction
B
head rotation
kinocilium
cupula
fluid inertia
ampulla

Problem 1: Why does potassium enter a hair cell when the channel is opened?

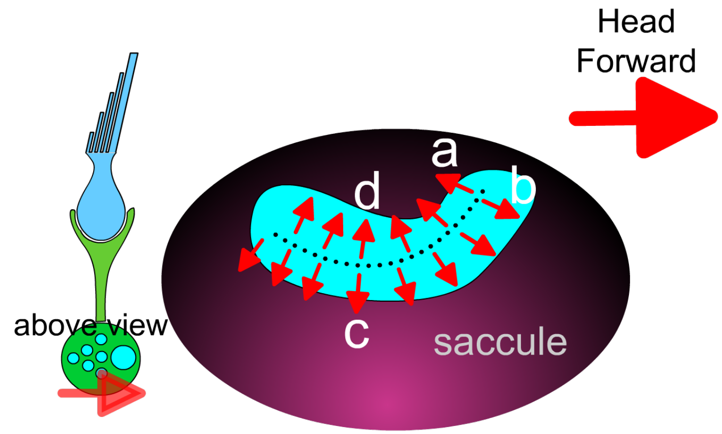
a) Because the concentration of potassium is low inside the cell compared to outside the cell.	
b) Because the concentration of potassium is high inside the cell compared to outside the cell.	
c) Because the high negative charge inside the hair cell pulls the potassium ions into the cell.	
d) Because the high positive charge inside the hair cell pulls the potassium ions into the cell.	
e) Because potassium ions flow out of the hair cell when the channel is opened.	

Problem 1: Why does potassium enter a hair cell when the channel is opened?

Answer

a) Because the concentration of potassium is low inside the cell compared to outside the cell.	No. Hair cells are bathed by endolymph which has a high concentration of K+, about the same as inside the hair cell. Therefore, concentration differences are relatively unimportant in the flow of K+ ions.
b) Because the concentration of potassium is high inside the cell compared to outside the cell.	No. Hair cells are bathed by endolymph which has a high concentration of K+, about the same as inside the hair cell. Therefore, concentration differences are relatively unimportant in the flow of K+ ions.
c) Because the high negative charge inside the hair cell pulls the potassium ions into the cell.	 **Correct!** Normally, the inside of a cell has a high concentration of K+. In neurons, K+ flows out of the cell during an action potential. But hair cells are bathed by endolymph which has a high concentration of K+, about the same as inside the hair cell. Therefore, concentration differences are relatively unimportant in the flow of K+ ions. Recall that the endolymph is charged to +80mv. The inside of the hair cell, like most cells, is at -60mv. This 140mv voltage difference is what drives K+ ion into the cell.
d) Because the high positive charge inside the hair cell pulls the potassium ions into the cell.	No. The inside of the hair cell has a negative charge
e) Because potassium ions flow out of the hair cell when the channel is opened.	No. They flow into the cell.

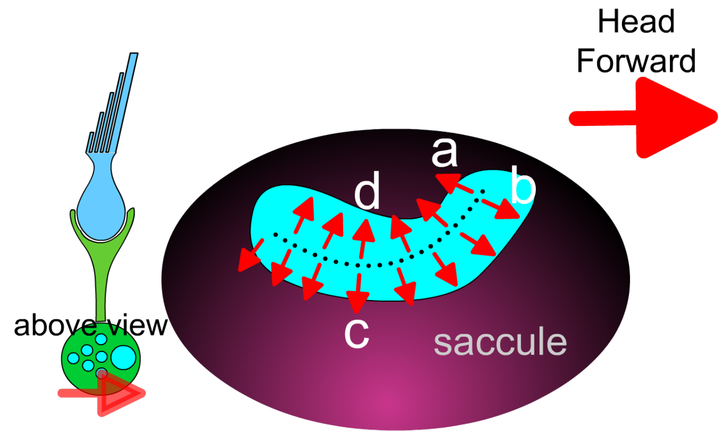
Problem 2: Which hair cell will produce the greatest **increase** in firing rate when the head moves forward?



a)	
b)	
c)	
d)	

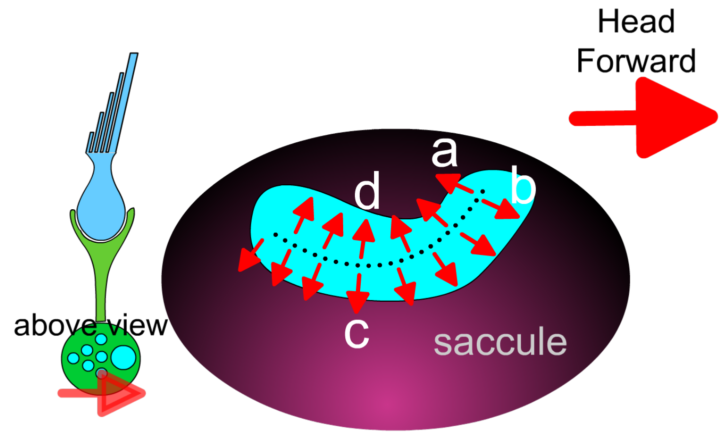
Problem 2: Which hair cell will produce the greatest **increase** in firing rate when the head moves forward?

Answer



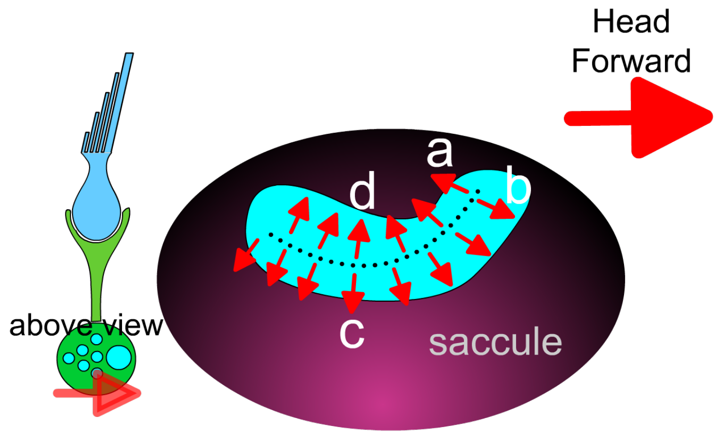
a)	**Yes.** When the head moves forward, this cell (indicated by the green line) will be bent most backward towards the kinocilium allowing lots of K+ to enter the hair cell and produce the greatest increase in firing rate.
b)	No. This cell's firing rate will decrease.
c)	No. This cell's firing rate will not change.
d)	No. This cell's firing rate will not change.

Problem 3: Which hair cell will most **decrease** its firing rate when the head moves forward?



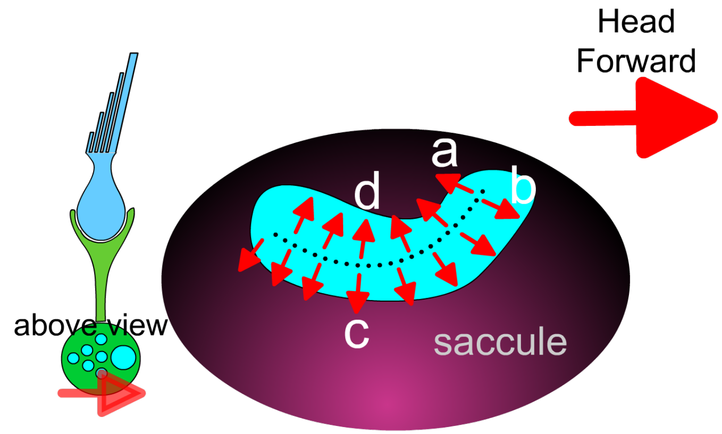
a)	
b)	
c)	
d)	

Problem 3: Which hair cell will most **decrease** its firing rate when the head moves forward?



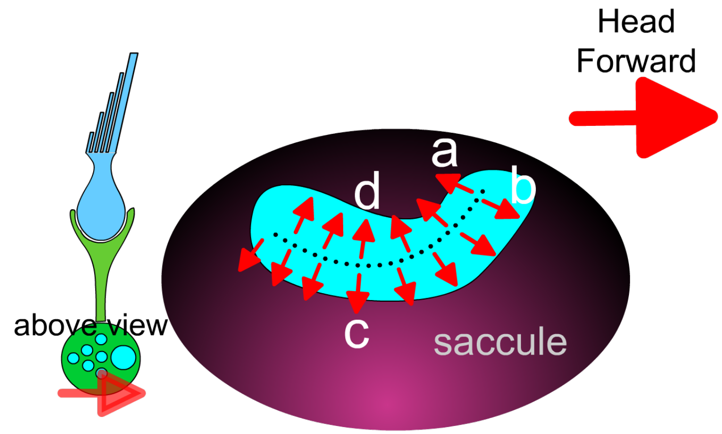
a)	No. This cell's firing rate will increase.
b)	**Yes.** When the head moves forward, this cell (indicated by the green line) will be bent most backward away from the kinocilium preventing K+ from entering the hair cell and produce the greatest decrease in firing rate.
c)	No. This cell's firing rate will not change.
d)	No. This cell's firing rate will not change.

Problem 4: Which cell's or cells' activity will change the least when the head moves forward?



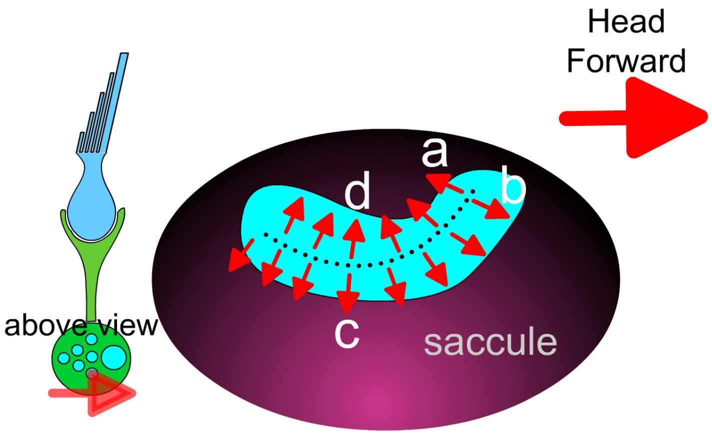
a)	
b)	
c)	
d)	

Problem 4: Which cell's or cells' activity will change the least when the head moves forward?



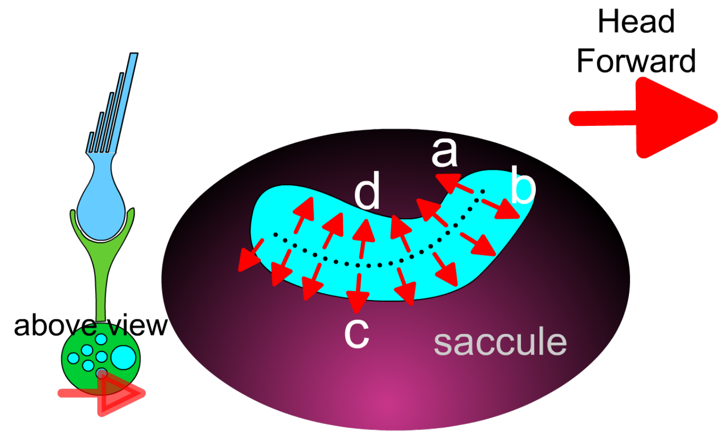
a)	No.
b)	No.
c)	**Yes.** These cells will be bent neither toward nor away from the kinocilium and will thus not change its activity.
d)	**Yes.** These cells will be bent neither toward nor away from the kinocilium and will thus not change its activity.

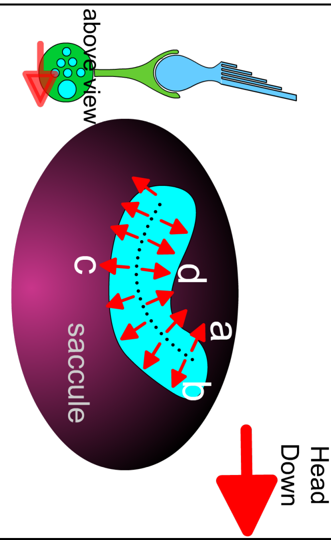
Problem 5: Which hair cells in the saccule are most active after tilting nose down?



a)	
b)	
c)	
d)	

Problem 5: Which hair cells in the saccule are most active after tilting nose down?



a)	No.
b)	 **Yes.** Recall that gravity can also bend the hair cell and change its activity. This cell will be most active when the nose is pointing down. Note that hair cells code two things: 1) the direction in which the head is translating and 2) the direction of gravity.
c)	No.
d)	No.

Problem 6: You are swinging on a swing. The hair cells in your saccule are being activated by
1) translation, the swing moving back and forth and
2) rotation, your head tilting as the swing moves back and forth.
How do you distinguish between the two?

a) by vision.	
b) by the semicircular canals.	
c) by proprioception.	
d) all of the above.	

Problem 6: You are swinging on a swing. The hair cells in your saccule are being activated by
1) translation, the swing moving back and forth and
2) rotation, your head tilting as the swing moves back and forth.
How do you distinguish between the two?

Answer

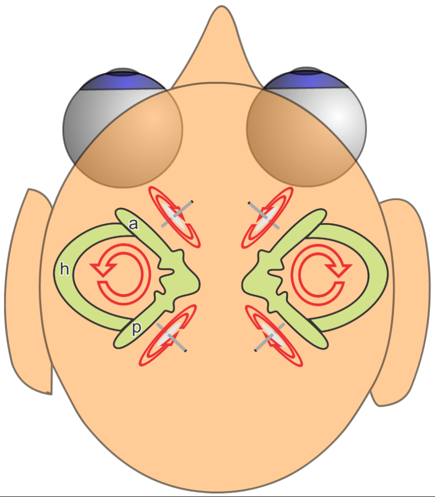
a) by vision.	No
b) by the semicircular canals.	No
c) by proprioception.	No
d) all of the above.	You need help from all three to tell which it is. 1) Vision is important. You can easily see which it is. 2) The semicircular canals help. The tilt is a rotation and thus would activate the hair cells in the canals. 3) Proprioception from your feet, neck etc. also helps the brain compute your body's swinging.

Problem 7: Which of these does **not** occur when you tip your head, nose down?

a) Both anterior canals increase their activity equally.	
b) Both anterior canals are maximally activated.	
c) The horizontal canals do not change their level of activity.	
d) There is a reduction of activity from both posterior canals.	
e) The eyes turn up.	

Problem 7: Which of these does **not** occur when you tip your head, nose down?

Answer



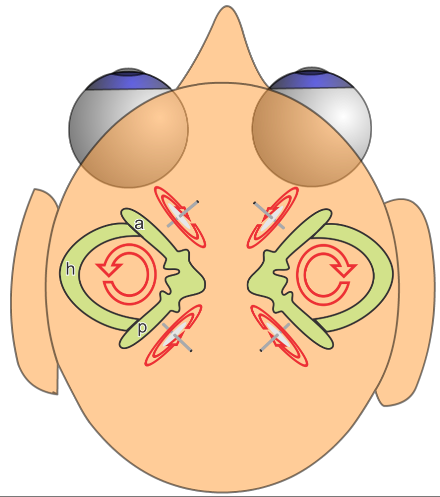
a) Both anterior canals increase their activity equally.	No, as you can see in the diagram, this does occur.
b) Both anterior canals are maximally activated.	**Yes,** this does not occur. The left anterior is best activated when the top of the head tips forward and to the left. Tipping your head nose directly down will produce less activity because this is not in the plane of the anterior canal. The same is true for the right anterior except its maximum occurs when the head tips forward and right.
c) The horizontal canals do not change their level of activity.	No, as you can see in the diagram, this does occur. The horizontal canals are in the plane of the page. Only rotations in this plane will activate them. Tipping your head nose down is perpendicular to plane of the page.
d) There is a reduction of activity from both posterior canals.	No, as you can see in the diagram, this does occur. The anterior and posterior canals are antagonistic push-pull pairs. Whatever the anterior canal does, the posterior canal does the opposite.
e) The eyes turn up.	No, this does occur. When you tip your head down the VOR turns your eyes up. As a result, gaze is stabilized.

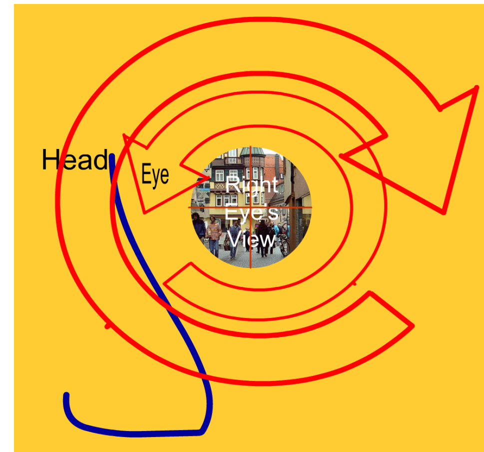
Problem 8: Which of these occur when you tip your head, right ear down?

a) Both left anterior and the left posterior canals increase their activity.	
b) The right horizontal canal increases and the left horizontal canal decreases it's activity.	
c) Both the right anterior and the right posterior canals increase their activity maximally.	
d) There is a reduction of activity from both posterior canals.	
e) The eyes rotate counter clockwise about the direction of gaze.	

Problem 8: Which of these occur when you tip your head, right ear down?

Answer



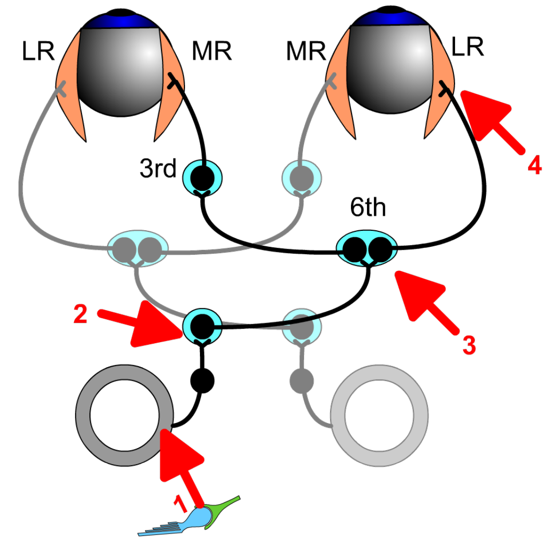


a) Both left anterior and the left posterior canals increase their activity.	No, as you can see in the diagram, the left anterior canal is maximally activated when you tip your head forward and to the left ear. The left posterior canal is maximally activated when you tip your head backward and to the left ear. Tipping your head just left ear down activates both the anterior and posterior left canals but not maximally. The left anterior and left posterior canals decrease their activity when you tilt your head right ear down.
b) The right horizontal canal increases, and the left horizontal canal decreases its activity.	No, as you can see in the diagram, the horizontal canals are in the plane of the page. Only rotations in this plane will activate them. Tipping your head right ear down is perpendicular to plane of the page.
c) Both the right anterior and the right posterior canals increase their activity maximally.	No. As you can see from the diagram, when the head tips forward and right ear down, the head rotates in the plane of right anterior canal. This rotation maximally activates the right anterior canal. When you tip your head, right ear down both the right anterior and the right posterior canals increase their activity but not maximally.
d) There is a reduction of activity from both posterior canals.	No, as you can see in the diagram, there is a reduction in the left posterior and anterior canals. The right anterior and posterior canals increase their activity.
e) The eyes rotate counter clockwise about the direction of gaze.	**Yes,** this is true. In this way the image of the room remains stationary on the retina.

Problem 9: What is the minimal number of synapses that are required in the VOR to convert a head rotation into an eye rotation?

a) 1	
b) 2	
c) 3	
d) 4	
e) 5	

Problem 9: What is the minimal number of synapses that are required in the VOR to convert a head rotation into an eye rotation?



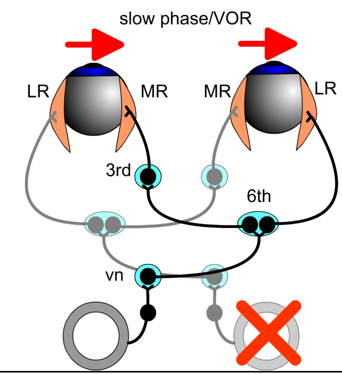
Answer

a) 1	Incorrect.
b) 2	Incorrect.
c) 3	Close.
d) 4	Yes, the correct answer is 4. They are 1) between the hair cell in the cupula and the vestibular nerve 2) in the vestibular nucleus 3) at the motor neuron 4) at the muscle
e) 5	Close.

Problem 10: What happens if there is a lesion of the horizontal canal on the right side and the patient is lying still with the eyes closed? Which statement is **incorrect**?

a) A lesion would produce an imbalance of the normal tonic activity from the vestibular nuclei with the left nucleus now having the greater activity.	
b) The patient would have a sensation of turning to the left.	
c) The imbalance in the VOR would make the patient's eyes turn to the right.	
d) Nystagmus would be observed under the eyelids with the slow phase to the right.	
e) A slow rotation of the head to the right would not be sensed by the right vestibular nucleus. However, the left nucleus would decrease its tonic activity. This would reduce the slow phase of the nystagmus.	
f) Rotations of the head to the left would cause an increase activity in the left vestibular nucleus and a faster slow phase to the right.	
g) With the eyes opened and the head still, the patient would see the room turning to the right.	

Problem 5: What happens if there is a lesion of the horizontal canal on the right side and the patient is lying still with the eyes closed? Which statement is **incorrect**?



Answer

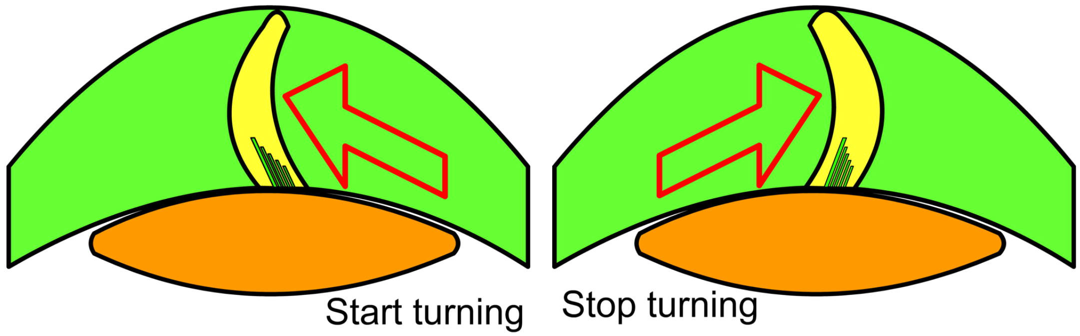
a) A lesion would produce an imbalance of the normal tonic activity from the vestibular nuclei with the left nucleus now having the greater activity.	No. This is correct. As you can see in the figure the left nucleus has the greater activity.
b) The patient would have a sensation of turning to the left.	No. This is correct. As you can see in the figure, the left nucleus has the greater activity. The same would occur if the patient were turning to the left.
c) The imbalance in the VOR would make the patient's eyes turn to the right.	No. This is correct. As you can see in the figure the imbalance in the left vestibular nucleus causes a slow phase to the right. At the same time this would be interrupted by quick phases or saccades to the left.
d) Nystagmus would be observed under the eyelids with the slow phase to the right.	No. This is correct. As you can see in the figure the left nucleus has the greater activity. Thus, the VOR turn the eyes to the right. That is the same direction as the slow phase.
e) A slow rotation of the head to the right would not be sensed by the right vestibular nucleus. However, the left nucleus would decrease its tonic activity. This would reduce the slow phase of the nystagmus.	No. This is correct. As you can see in the figure, the left horizontal canal is intact. Turning the head to the right would decrease its activity. This would lower the imbalance and decrease the VOR.
f) Rotations of the head to the left would cause an increase activity in the left vestibular nucleus and a faster slow phase to the right.	No. This is correct. As you can see in the figure, the left vestibular nucleus would receive an increase in activity and the slow phase velocity would increase.
g) With the eyes opened and the head still, the patient would see the room turning to the right.	**Yes.** This is incorrect. As you can see in the figure, the imbalance causes slow phases to the right. Thus, the patient also sees the room turning to the left.

Problem 11: After a prolonged rotation to the right, what happens when your head suddenly stops turning?

a) The tonic activity in the right vestibular nucleus decreases.	
b) The hair cells in the right horizontal canal are bent toward the kinocilium.	
c) One senses that one has just started rotating to the right.	
d) No nystagmus is generated.	
e) The eyes remain still in the head.	

Problem 11: After a prolonged rotation to the right, what happens when your head suddenly stops turning?

Answer

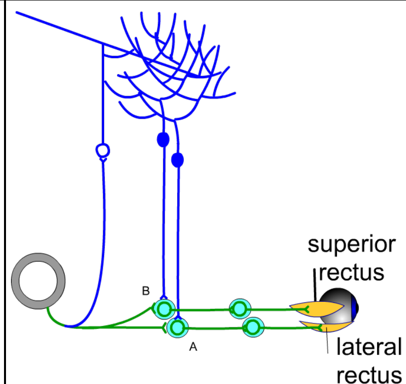
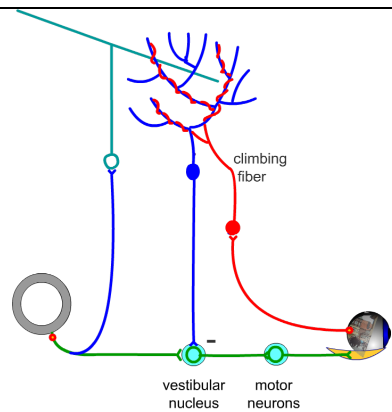


a) The tonic activity in the right vestibular nucleus decreases.	**Correct.** When you suddenly stopped turning, the cupula is bent away from the kinocilium decreasing the flow of potassium ions into the cell and decreasing the tonic activity inside the vestibular afferent. The physics of the cupula in the canal are similar to the physics of a person's body riding in a car. 1) When the car accelerates, you are pushed backwards into your seat. 2) After a while, when the car speed reaches a constant velocity, you spring back to an upright position. 3) When the car brakes for a stop, your body gets thrown forward. 4) Sometime after you stop, your body again slowly becomes upright.
b) The hair cells in the right horizontal canal are bent toward the kinocilium.	No. As you can see in the figure, when you suddenly stopped turning, the cupula is bent away from the kinocilium.
c) One senses that one has just started rotating to the right.	No. When you start to turn to the right, hair cells in the right cupula are activated. When you stop, hair cells in the right cupula decrease in activity and those in the left cupula increase. This is perceived as a head turn to the left.
d) No nystagmus is generated.	No. When you suddenly stopped turning, the cupula in the right horizontal canal is bent away from the kinocilium, decreasing the flow of potassium ions into the cell and decreasing the tonic activity inside the vestibular afferent. This would produce nystagmus in the opposite direction, as that produced when you started to turn to the right.
e) The eyes remain still in the head.	No. A VOR is generated.

Problem 12: How would the VOR change if you exposed the eye to consistent vertical image motion during horizontal head rotations for a few hours?

a) In this new situation, to minimize retinal slip, the eyes must rotate horizontally whenever the head rotates horizontally.	
b) The horizontal semicircular canal must become connected to the medial rectus on the opposite side.	
c) It is unlikely that this involves the climbing fiber input to the cerebellum.	
d) That this happens in a matter of hours suggests the presence of silent synapses, synapses that connect each canal to many muscles, but which are initially weak or even completely silent.	

Problem 12: How would the VOR change if you exposed the eye to consistent vertical image motion during horizontal head rotations for a few hours?

a) In this new situation, to minimize retinal slip, the eyes must rotate horizontally whenever the head rotates horizontally.	No. The eyes must rotate vertically to stabilize vertical image motion.
b) The horizontal semicircular canal must become connected to the medial rectus on the opposite side.	 No. The eyes must rotate vertically to stabilize vertical image motion. Thus, the horizontal semicircular canals must become connected to the vertical eye muscles. Try again.
c) It is unlikely that this involves the climbing fiber input to the cerebellum.	 No. Any change in the VOR involves activation of the climbing fibers by retinal slip.

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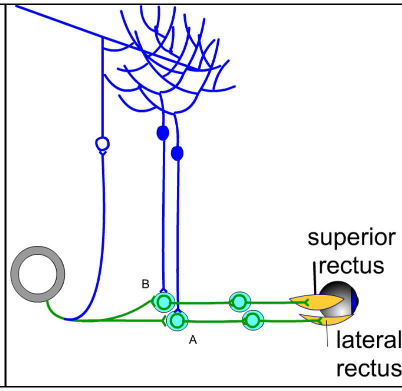
<tr>
<td>d) That this happens in a matter of hours suggests the presence of silent synapses, synapses that connect each canal to many muscles, but which are initially weak or even completely silent.</td>
<td>
</td>
<td>Yes, this indeed appears to be true. Since the eyes must rotate vertically to stabilize vertical image motion, the horizontal semicircular canal connections to the vertical eye muscles are strengthened.</td>
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Problem 13: Suppose because of some disease, your VOR gain dropped. Would the cerebellum repair the VOR if you did not move your head?

a) No, it will not repair the VOR.	
b) Yes, it will repair the VOR.	

Problem 13: Suppose because of some disease, your VOR gain dropped. Would the cerebellum repair the VOR if you did not move your head?

Answer

a) No, it will not repair the VOR.	**Correct.** As long as you did not move your head, there would be no retinal slip. Thus, there will be no activation of climbing fibers and thus no plasticity. Often one feels dizzy because of the VOR gain change. One incorrectly goes to bed. Take home message: you must use your reflexes to keep them tuned. Use it or lose it!
b) Yes, it will repair the VOR.	Wrong.

Problem 14: The elderly often suffer from balance problems. What might be some causes?

a) Because of aging of the vestibular system or loss of muscle strength, the gain in balance reflexes become incorrect.	
b) The loss of balance accentuates a tendency to become more sedentary. They lose it because they don't use it. Lack of activity leads to no cerebellar re-calibration.	
c) The reflexes may be more difficult to re-calibrate because the synapses of the cerebellum in the elderly may not be as plastic as when young.	
d) All of the above.	

Problem 14: The elderly often suffer from balance problems. What might be some causes?

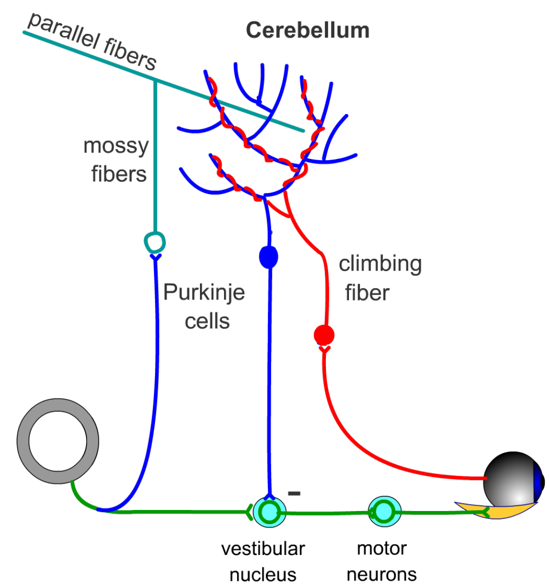
Answer

a) Because of aging of the vestibular system or loss of muscle strength, the gain in balance reflexes become incorrect.	Yes, indeed this does occur. But there are additional causes.
b) The loss of balance accentuates a tendency to become more sedentary. They lose it because they don't use it. Lack of activity leads to no cerebellar re-calibration.	Yes, indeed this does occur. But there are additional causes.
c) The reflexes may be more difficult to re-calibrate because the synapses of the cerebellum in the elderly may not be as plastic as when young.	Yes, indeed this does occur. But there are additional causes.
d) All of the above.	Correct.

Problem 15: Consider the cerebellar repair shop of the VOR (vestibular ocular reflex). Indicate which neuron's or neurons' firing rate is changed after the adaptation/learning is complete (i.e. firing rate relative to the firing rate prior to the initiation of adaptation)

a) vestibular afferents, parallel fibers and Purkinje cells.	
b) vestibular afferents, parallel fibers and climbing fibers.	
c) parallel fibers, climbing fibers, and Purkinje cells.	
d) climbing fibers, Purkinje cells and neurons in the vestibular nucleus.	
e) Purkinje cells, neurons in the vestibular nucleus, and motor neurons.	

Problem 15: Consider the cerebellar repair shop of the VOR (vestibular ocular reflex). Indicate which neuron's or neurons' firing rate is changed after the adaptation/learning is complete (i.e. firing rate relative to the firing rate prior to the initiation of adaptation)



Answer

a) vestibular afferents, parallel fibers and Purkinje cells.	No. Recall this circuit of the cerebellum.
b) vestibular afferents, parallel fibers and climbing fibers.	No. Recall this circuit of the cerebellum
c) parallel fibers, climbing fibers, and Purkinje cells.	No. Recall this circuit of the cerebellum.
d) climbing fibers, Purkinje cells and neurons in the vestibular nucleus.	No. Recall this circuit of the cerebellum.
e) Purkinje cells, neurons in the vestibular nucleus, and motor neurons.	**Yes.** The climbing fiber activation acts as a teacher. It modifies the strength of the connection between the parallel fiber and the Purkinje cell. This modifies the activity of the indirect pathway. The pathway includes the Purkinje cells, neurons in the vestibular nucleus, and motor neurons.

Problem 16: The optimal VOR to a translation of the head is

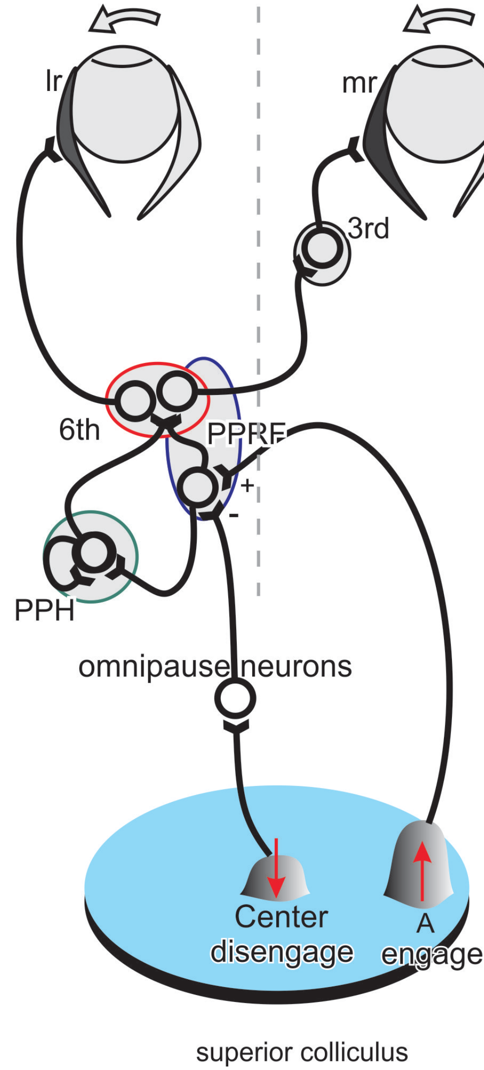
a) the rotations of the eyes are faster when looking at a near target then one that is far.	
b) the rotations of the eyes are slower when looking at a near target then one that is far.	
c) the rotations the eyes are independent of where one is looking.	
d) the rotations of the eyes depend only on how fast one is translating.	
e) no eye rotation. The VOR is activated only by head rotation not translation.	

Problem 16: The optimal VOR to a translation of the head is

Answer

a) the rotations of the eyes are faster when looking at a near target then one that is far.	 **Correct!** The signal from the otoliths also activates the VOR and changes depending on each eye's distance from the target. The closer the target, the faster the eye must rotate.
b) the rotations of the eyes are slower when looking at a near target then one that is far.	No.
c) the rotations the eyes are independent of where one is looking.	No.
d) the rotations of the eyes depend only on how fast one is translating.	No. Distance matters.
e) no eye rotation. The VOR is activated only by head rotation not translation.	No. The otoliths provide a signal to the VOR.

Chapter 11: Eye Movements

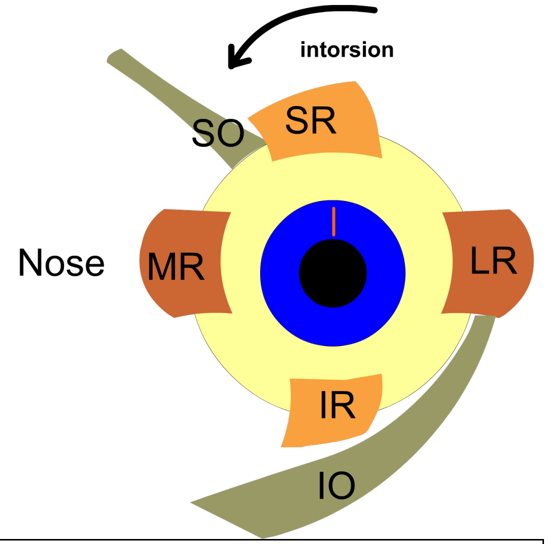


Problem 1: What muscles or muscle pairs must you activate to look up with no torsion?

a) the superior rectus (SR)	
b) the superior rectus (SR) and the superior oblique (SO)	
c) the superior rectus (SR) and the inferior oblique (IO)	
d) the inferior oblique (IO)	
e) the superior rectus (SR) and the lateral rectus (IR)	

Problem 1: What muscles or muscle pairs must you activate to look up with no torsion?

Answer

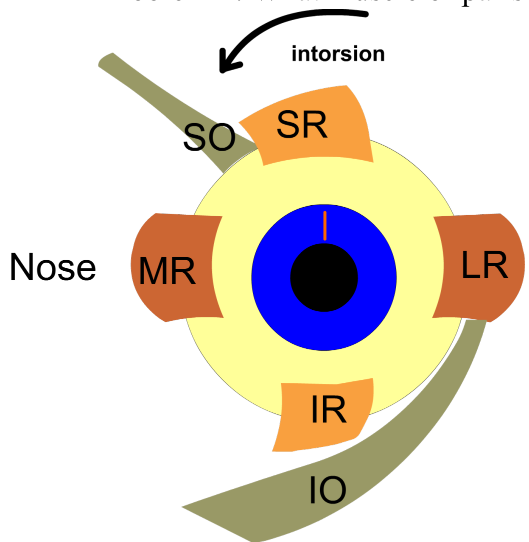


a) the superior rectus (SR)	Yes, the superior rectus (SR) turns the eye up. But it also intorts the eye a little.
b) the superior rectus (SR) and the superior oblique (SO)	No, The superior rectus (SR) turns the eye up and it also intorts the eye a little. The SO intorts the eye (i.e. rotates the top of the eye towards the nose) and depresses it a little. Activating the SO would increase the intorsion produced by the SR.
c) the superior rectus (SR) and the inferior oblique (IO)	**Correct**, if both the SR and IO muscles are activated, the eye turns up. The intorsion of the SR is cancelled by the extorsion of the IO. Note, you need only a little activation of IO to cancel SR's small intorsion.
d) the inferior oblique (IO)	No. The inferior oblique turns the eye up only a little. It also extorts the eye.
e) the superior rectus (SR) and the lateral rectus (IR)	No. Perhaps you should review the actions of the eye muscles and then try again.

Problem 2: What muscle or pairs of muscles must you activate to intort the eye with no vertical movement?

a) the inferior oblique (IO)	
b) the superior oblique (SO)	
c) the superior rectus (SR)	.
d) the superior rectus (SR) and the superior oblique (SO)	
e) the superior rectus (SR) and the inferior oblique (IO)	

Problem 2: What muscle or pairs of muscles must you activate to intort the eye with no vertical movement?



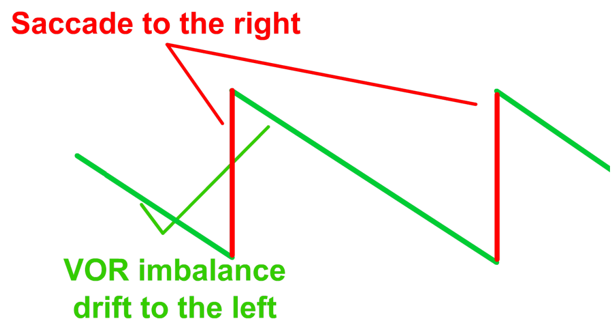
Answer

a) the inferior oblique (IO)	No. The inferior oblique extorts the eye.	
b) the superior oblique (SO)	Yes, the superior oblique (SO) muscle intorts the eye. But also, it turns the eye down a little.	
c) the superior rectus (SR)	No. The SR intorts the eye a little but also turns the eye up a lot.	
d) the superior rectus (SR) and the superior oblique (SO)	**Yes,** the superior rectus (SR) intorts the eye a little. However, its main function is to turn the eye up. The superior oblique (SO) muscle also intorts the eye. But also, it turns the eye down a little. If both the SR & SO muscles are activated, the eye intorts and the vertical components cancel. Note, you need only a little activation of SR to cancel the SO's small vertical component.	
e) the superior rectus (SR) and the inferior oblique (IO)	No. It also turns the eye up only a little. That will not intort the eye with no vertical movement.	

Problem 3: In nystagmus caused by a lesion of the left horizontal canal, what factor or factors would most increase the frequency of nystagmus (the frequency with which the slow phase is interrupted by a quick phase)?

a) Rotation of the head in the direction of the slow phase.	
b) Rotation of the head to the left.	
c) An effort to look in the direction of the slow phase.	
d) An effort to look in the direction opposite to the slow phase.	
e) None of the above.	

Problem 3: In nystagmus caused by a lesion of the left horizontal canal, what factor or factors would most increase the frequency of nystagmus (the frequency with which the slow phase is interrupted by a quick phase)?



Answer

a) Rotation of the head in the direction of the slow phase.	Nope. A lesion of the left horizontal canal would produce an imbalance. The right side would generate more activity and one would sense that one was rotating to the right. As in a real rightward rotation the slow phase would be to the left and quick phases to the right. Rotation of the head in the direction of the slow phase, that is to the left, would decrease the activity of the right horizontal canal. This would slow the slow phase and generate a less frequent quick phase.
b) Rotation of the head to the left.	Nope. A lesion of the left horizontal canal would produce an imbalance. The right side would generate more activity and one would sense that one was rotating to the right. As in a real rightward rotation the slow phase would be to the left and quick phases to the right. Rotation of the head to the left would decrease the activity of the right horizontal canal. This would slow the slow phase and generate a less frequent quick phase.
c) An effort to look in the direction of the slow phase.	Nope. A lesion of the left horizontal canal would produce an imbalance. The right side would generate more activity and one would sense that one was rotating to the right. As in a real rightward rotation the slow phase would be to the left and quick phases to the right. An effort to look in the direction of the slow phase, that is to the left, and in the opposite direction one felt one was turning, would extend the slow phase and generate a less frequent quick phase.
d) An effort to look in the direction opposite to the slow phase.	**Correct!** A lesion of the left horizontal canal would produce an imbalance. The right side would generate more activity and one would sense that one was rotating to the right. As in a real rightward rotation the slow phase would be to the left. The frequency of saccades increase when you look in the direction of the quick phase (i.e. in the direction that you sense you are rotating). This is because saccades interrupt the slow phase more often.
e) None of the above.	Nope. Hint: A lesion of the left horizontal canal would produce an imbalance. The right side would generate more activity and one would sense that one was rotating to the right. As in a real rightward rotation the slow phase would be to the left.

Problem 4: Suppose the PPRF is damaged so that the burst it generates is at a lower frequency than normal. What effect do you think this damage will have on a saccade?

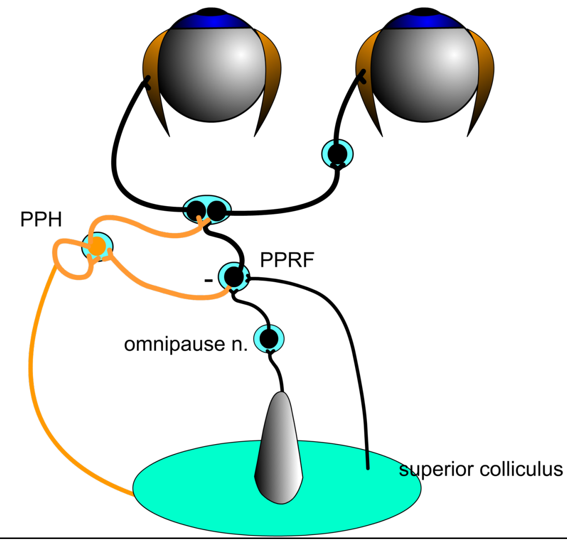
This would produce

a) faster saccades of a normal size.	
b) saccades of normal speed but of a smaller size.	
c) slower saccades of a smaller size.	
d) slower saccades of a larger size.	
e) slower saccades of a normal size.	

Problem 4: Suppose the PPRF is damaged so that the burst it generates is at a lower frequency than normal. What effect do you think this damage will have on a saccade?

This would produce

Answer

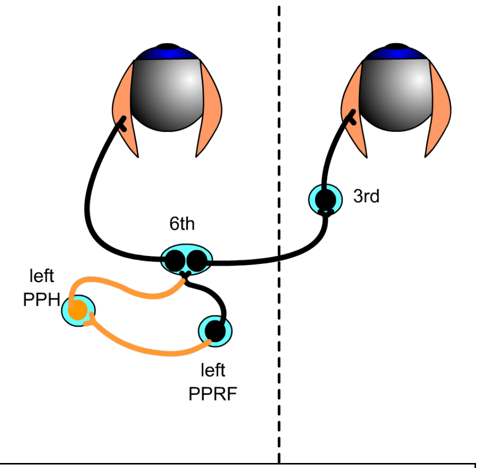


a) faster saccades of a normal size.	No. There is no good reason for the saccade to be faster.
b) saccades of normal speed but of a smaller size.	No. The lower frequency burst will contract the muscle less and generate a slower speed.
c) slower saccades of a smaller size.	No. Hint. Look at the diagram and think about what stops the saccade.
d) slower saccades of a larger size.	No. Hint. Look at the diagram and think about what stops the saccade.
e) slower saccades of a normal size.	**Correct!** A damaged PPRF will generate a slow saccade. The PPH will feed back to the superior colliculus (SC) a slowly changing eye position. This will slowly move the hill in the SC. When the hill reaches the center, the correct eye position, the pause neurons will be activated, the PPRF burst stops and so would the saccade at the same correct position. This is an excellent example of the power of feedback loops.

Problem 5: Suppose the saccade size in only one eye needs to be changed because only the left lateral rectus has become weaker. Suggest what the saccade circuit that we learnt needs to be modified to allow this.

a) Change the sensitivity of the right PPRF for saccades to the right and the left PPRF for saccades to the left.	
b) Change the sensitivity of the right PPRF for saccades to the left and the left PPRF for saccades to the right.	
c) Change the sensitivity of the right PPRF for saccades of the left eye and the left PPRF for saccades of the right eye.	
d) Change the sensitivity of the right PPRF for saccades of the right eye and the left PPRF for saccades of the left eye.	
e) Create two populations of burst neurons, one that goes to the motor neurons of the left eye and the other to the right. Change the sensitivity of one of these two populations of burst neurons.	

Problem 5: Suppose the saccade size in only one eye needs to be changed because only the left lateral rectus has become weaker. Suggest what the saccade circuit that we learnt needs to be modified to allow this.



Answer

a) Change the sensitivity of the right PPRF for saccades to the right and the left PPRF for saccades to the left.	No. The left PPRF generates saccades to the left, in both eyes.
b) Change the sensitivity of the right PPRF for saccades to the left and the left PPRF for saccades to the right.	No. The left PPRF generates saccades to the left, in both eyes.
c) Change the sensitivity of the right PPRF for saccades of the left eye and the left PPRF for saccades of the right eye.	No. The left PPRF generates saccades to the left, in both eyes.
d) Change the sensitivity of the right PPRF for saccades of the right eye and the left PPRF for saccades of the left eye.	No. The left PPRF generates saccades to the left, in both eyes.
e) Create two populations of burst neurons, one that goes to the motor neurons of the left eye and the other to the right. Change the sensitivity of one of these two populations of burst neurons.	**Correct.** One way of solving this problem is to have PPRF burst neurons for each eye. The saccadic error is presumably detected by the cerebellum, which somehow makes a selective adjustment to one population or the other. In this case the left PPRF would increase the signal only to the motor neurons of the left lateral rectus. It appears that monocular adjustments are harder than binocular.

Problem 6: Myasthenia gravis is an autoimmune disease in which circulating antibodies block acetylcholine receptors at the post-synaptic neuromuscular junction. The hallmark of myasthenia gravis is muscle fatigability which is often first noticed in the eye muscles. The patient is most likely to first sense an impairment of which eye movement system?

a) VOR	
b) Saccades	
c) Vergence	
d) OKR	
e) Pursuit	

Problem 6: Myasthenia gravis is an autoimmune disease in which circulating antibodies block acetylcholine receptors at the post-synaptic neuromuscular junction. The hallmark of myasthenia gravis is muscle fatigability which is often first noticed in the eye muscles. The patient is most likely to first sense an impairment of which eye movement system?

Answer

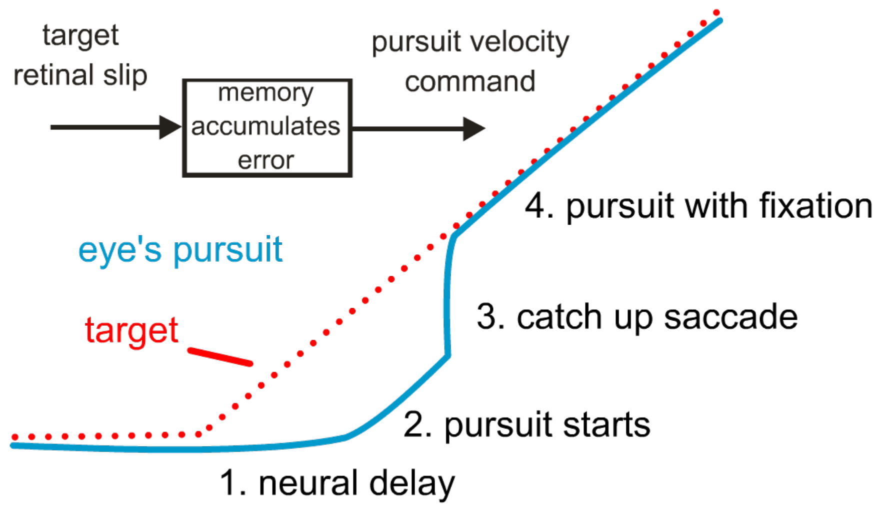
a) VOR	No. Normally, the eye rotation is not precisely equal to your head rotation. The result is a small slip of the background on the retina. Vision seems to tolerate this. An increase in this retina slip is not likely to be noticed.
b) Saccades	No. Patients are not likely to notice slightly slower and smaller saccades. More than one saccade will be required to reach the target. This occurs normally in large saccades and is not something that you notice. Also, the brief burst of action potentials is less susceptible to fatigue than a prolonged activation.
c) Vergence	**Yes.** Double vision, i.e. seeing two faces when there is only one, is something patients with myasthenia gravis first notice. The eye muscles are tonically active when fixating a face. Tonic activity is more likely to cause muscle fatigue than a brief movement. A small change in the tonic activity will cause the eye to point in a different direction.
d) OKR	No. Normally, even with the help of the OKR the eye rotation is not precisely equal to your head rotation. The result is a small slip of the background on the retina. Vision seems to tolerate this. An increase in this retina slip is not likely to be noticed.
e) Pursuit	No. Normally the eye's pursuit is slower than the object's motion. Saccades are automatically used to catch up to the object. A somewhat slower pursuit would not be noticed.

Problem 7: What drives pursuit eye movements?

a) Retinal slip	
b) Short term memory	
c) Both a and b are true.	

Problem 7: What drives pursuit eye movements?

Answer



a) Retinal slip	Correct. In phase 1, the eye is stationary while the target is moving. The initial retinal slip is the error signal that starts the pursuit system. But that is not the complete story.
b) Short term memory	Correct. In phase 4, if pursuit is perfect, there is no retinal slip. Both the object and the eye are moving together. So, there is no error signal. So, what signal keeps the eyes moving at the correct speed?
c) Both a and b are true.	**Correct.** In phase 1, the eye is still while the target is moving. The initial retinal slip of the target is the error signal that starts the pursuit system. Short term memory accumulates the error making the pursuit command larger and larger until it is large enough to make retinal slip zero. In phase 4, when pursuit is perfect, there is no retinal slip of the target. Both the target object and the eye are moving together. So, there is no error signal. The pursuit continues based a short-term memory of the accumulated error.

Problem 8: Pick the correct situation in which the following occurs. The image of the room or other backgrounds slips on your entire retina but you sense no self-motion. This occurs when you

a) make saccades to look around the room.	
b) pursue a moving object, e.g. a tennis ball during a tennis match.	
c) pursue a moving light in a completely dark room.	
d) look at a stationary room while you turn your head.	
e) look at a stationary light in a dark room while you turn your head.	

Problem 8: Pick the correct situation in which the following occurs. The image of the room or other backgrounds slips on your entire retina but you sense no self-motion. This occurs when you

Answer

a) make saccades to look around the room.	**Yes.** When you make saccades to look around the room, the image of the room slips on the entire retina. The same occurs when you pursue a moving object, e.g. a tennis ball during a tennis match. In both cases the room or court does not seem to move (at least normally), presumably because the efference copy drive estimate of how much things in the world should move matches how much they really move.
b) pursue a moving object, e.g. a tennis ball during a tennis match.	Yes. When you pursue a tennis ball, the image of the court in the background slips on the retina. The same as when you make a saccade. In both cases the room or court does not seem to move (at least normally), presumably because the efference copy drive estimate of how much things in the world should move matches how much they really move.
c) pursue a moving light in a completely dark room.	No. No image slip occurs here.
d) look at a stationary room while you turn your head.	No. No image slip occurs here. The VOR should keep your eyes stationary in the room.
e) look at a stationary light in a dark room while you turn your head.	No. No image slip occurs here. The VOR should keep your eyes stationary with respect to the light.

Problem 9: Pick the correct situation in which the following occurs. The whole visual image is stationary on the eye but you sense motion of the image. This occurs when you

a) make saccades to look from one image to another.	
b) pursue a moving image, e.g. a tennis ball during a tennis match.	
c) look at a stationary image while you turn your head.	
d) pursue an imagined moving image in a completely dark room.	
e) look at a stationary red dot while an image moves from side to side.	

Problem 9: Pick the correct situation in which the following occurs. The whole visual image is stationary on the eye but you sense motion of the image. This occurs when you

Answer

a) make saccades to look from one image to another.	No. You would not sense motion of the image here.
b) pursue a moving image, e.g. a tennis ball during a tennis match.	Yes and No. When you pursue a tennis ball, the image of the court in the background slips on the retina. But you sense that it is stationary. On the other hand, the ball's image during pursuit is stationary on the retina but you do sense that it is moving.
c) look at a stationary image while you turn your head.	No. You would not sense motion of the image here.
d) pursue a moving image in a completely dark room.	**Yes.** The image is stationary on the retina, but we clearly sense that it is moving. Because the room is in the dark, you do not see the image of the room moving on the retina.
e) look at a stationary red dot while an image moves from side to side.	No. The whole visual image is not stationary on the eye.

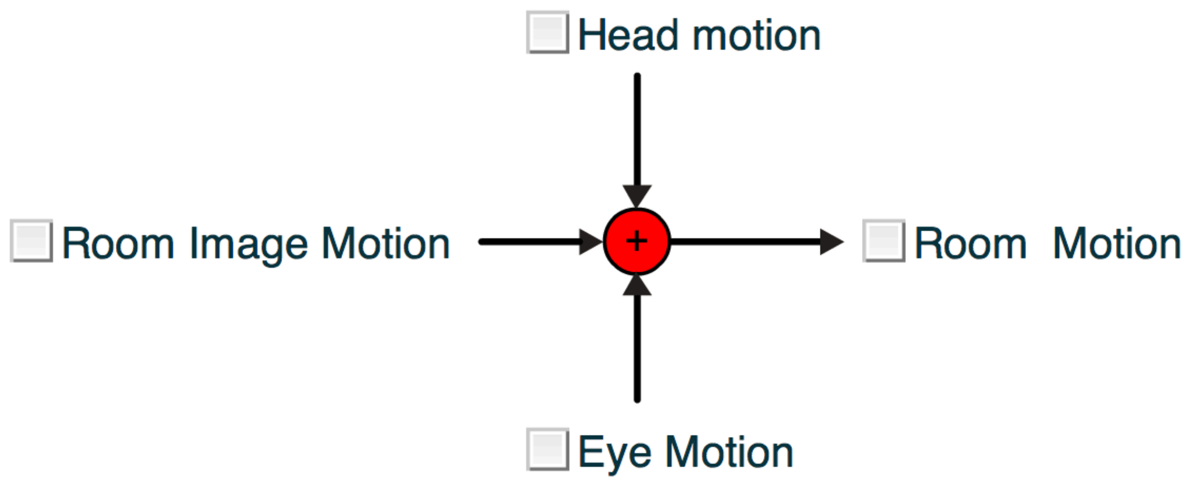
Problem 10: Pick the correct situation in which the following occurs. The image of an object is stationary on the eye while the eye is moving, and you sense no motion of the object. This occurs when you

a) pursue a moving image in a completely dark room.	
b) look at a stationary red dot while an image moves from side to side.	
c) look at a stationary image while you turn your head.	
d) make saccades to look from one image to another.	
e) pursue a moving image, e.g. a tennis ball during a tennis match.	

Problem 10: Pick the correct situation in which the following occurs. The image of an object is stationary on the eye while the eye is moving, and you sense no motion of the object. This occurs when you

a) pursue a moving image in a completely dark room.	No. You would sense motion of the image here.
b) look at a stationary red dot while an image moves from side to side.	No. You would sense the motion of the image.
c) look at a stationary image while you turn your head.	**Yes.** The VOR senses the head motion and turns the eye in the opposite direction. By doing so the image would remain stationary on the retina.
d) make saccades to look from one image to another.	No. The image would move on the retina.
e) pursue a moving image, e.g. a tennis ball during a tennis match.	No. You would sense that the tennis ball is moving.

Problem 11: What are good criteria that the brain might use for sensing that an object is indeed moving?
Case 1. Do you sense that the room is still or moving during saccades? Check the boxes in which motion is present or sensed in this situation.



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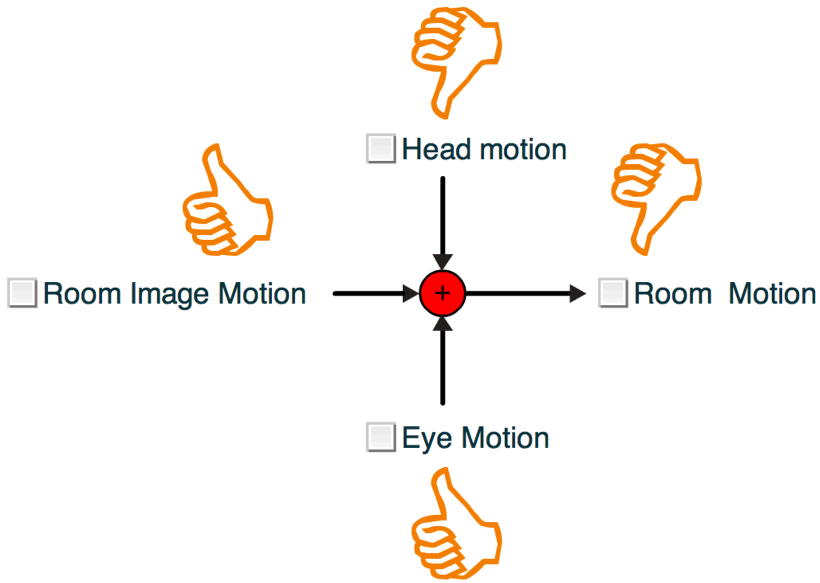


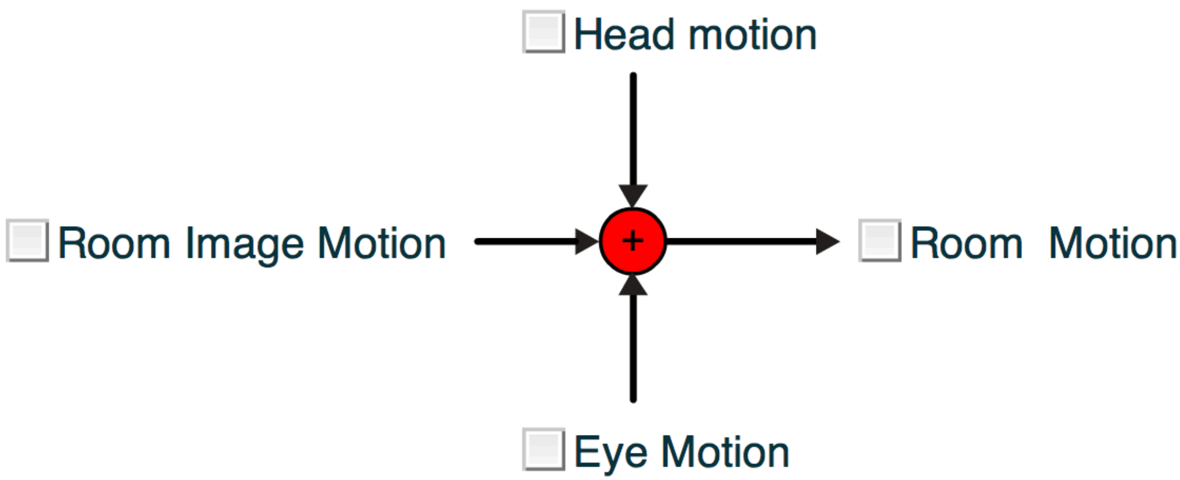
Answer

The room does not seem to move (at least normally) presumably because the efference copy drive estimate of how much things in the world are displaced by your eye movements matches how much they really are displaced (as measured by the retinal slip of the room).

The motion sensed by retinal slip is cancelled by the efference copy sense of eye motion and the room is sensed to be stationary.

Problem 12: What are good criteria that the brain might use for sensing that an object is indeed moving?

Case 2. When you track a ball with pursuit eye movements does the room appear to be moving or stationary? Check the boxes in which motion is present or sensed in this situation.



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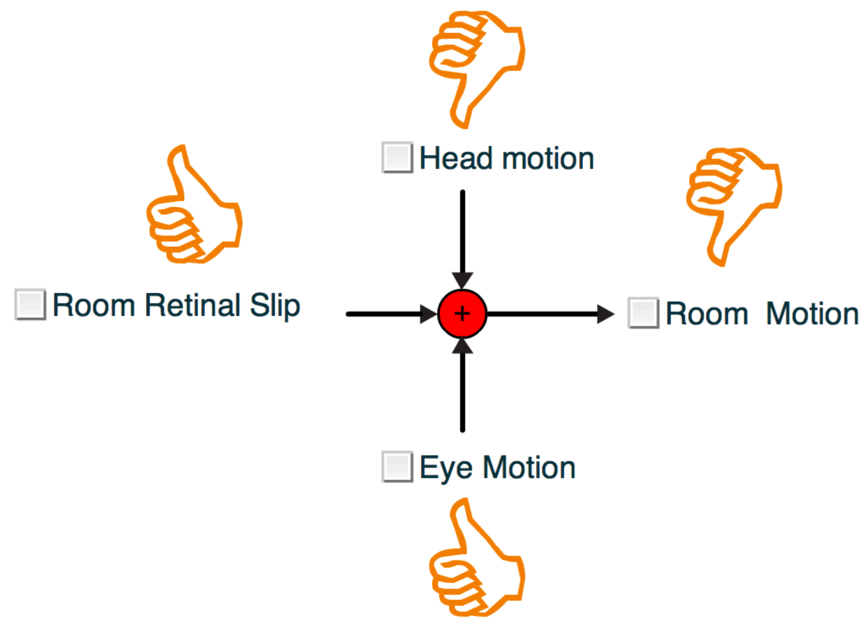
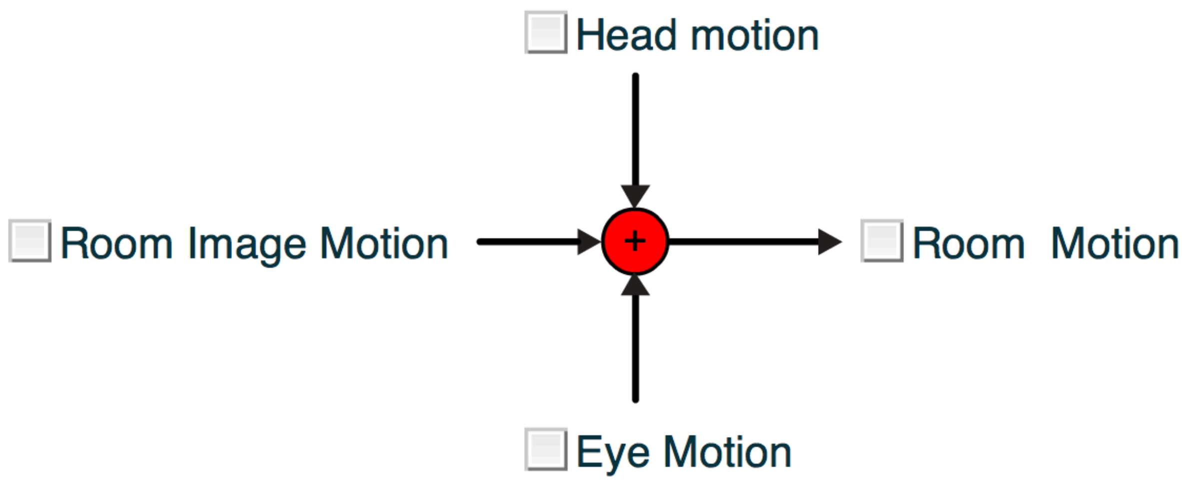


Answer

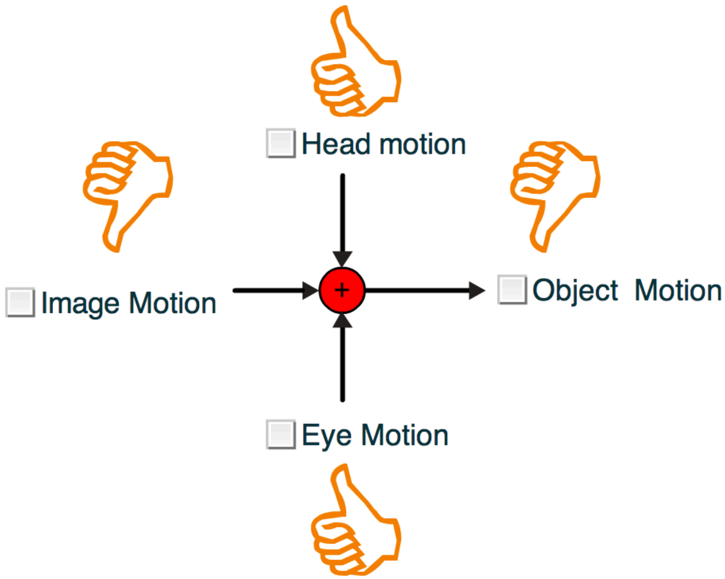
The image of the room is moving on the retina because of pursuit but we clearly sense that it is still.

Here there is motion of the room sensed by retinal slip but efference copy generated by the pursuit command tells us that the eye is moving and thus that the room must be still.

Problem 13: What are good criteria that the brain might use for sensing that an object is indeed moving?
Case 3. What happens when you look at a stationary object while you turn your head? Check the boxes in which motion is present or sensed in this situation.



Problem 13: What are good criteria that the brain might use for sensing that an object is indeed moving? **Case 3.** What happens when you look at a stationary object while you turn your head? Check the boxes in which motion is present or sensed in this situation.



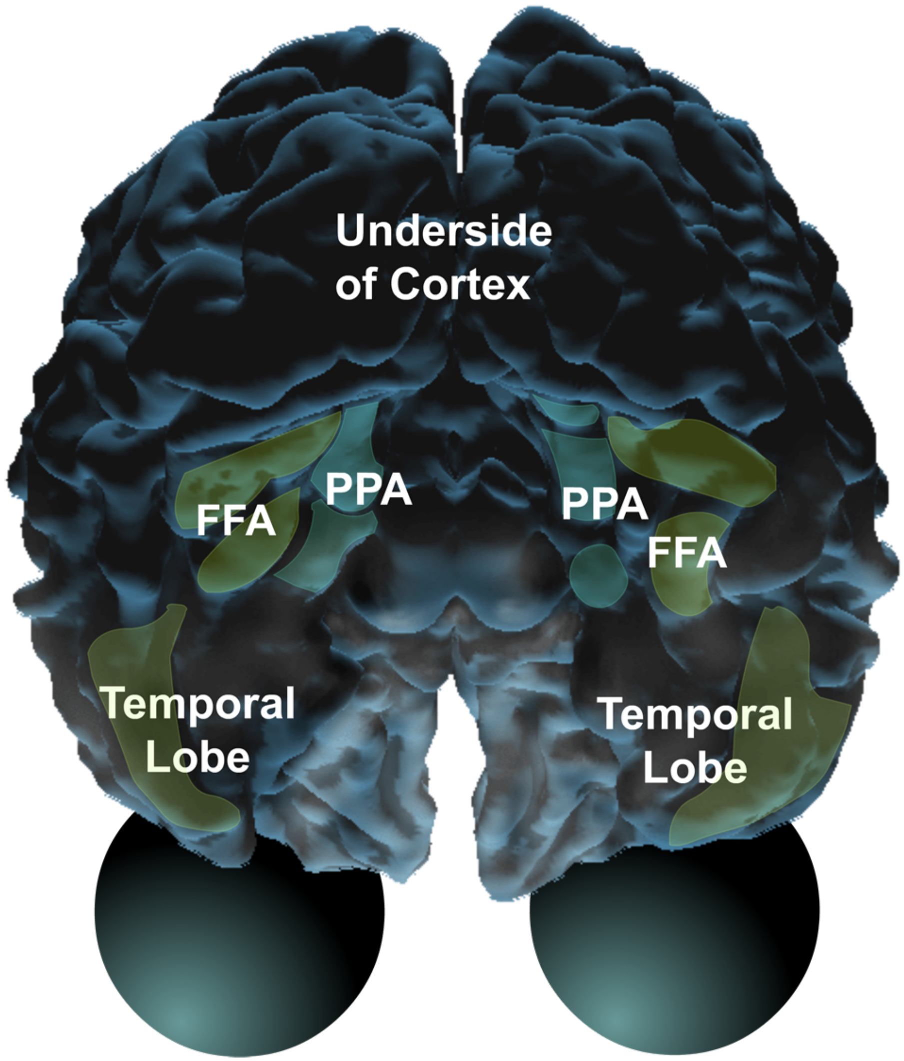
Answer

The image of an object is stationary on the eye while the eye is moving, and you sense no motion.

When your VOR is working correctly, the eye turns in the opposite direction to the head's turn and thus keeps the image stationary on the retina.

Here the efference copy from the VOR command to turn the eyes is cancelled by the sense of head motion, resulting in signal that the object is still.

Chapter 12: Memory

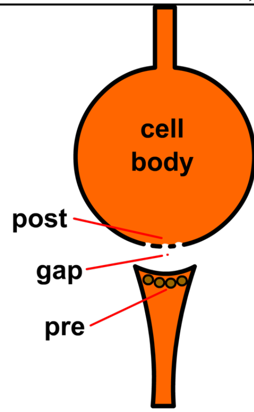
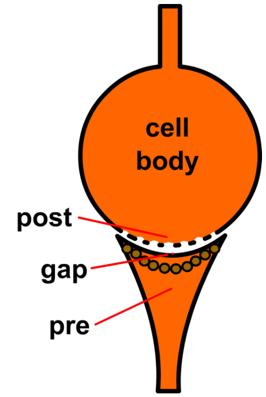


Problem 1: Where does a synapse change when it becomes stronger?

a) pre-synaptic axon terminal	
b) post-synaptic receptor	
c) the gap between	
d) All of the above	

Problem 1: Where does a synapse change when it becomes stronger?

Answer

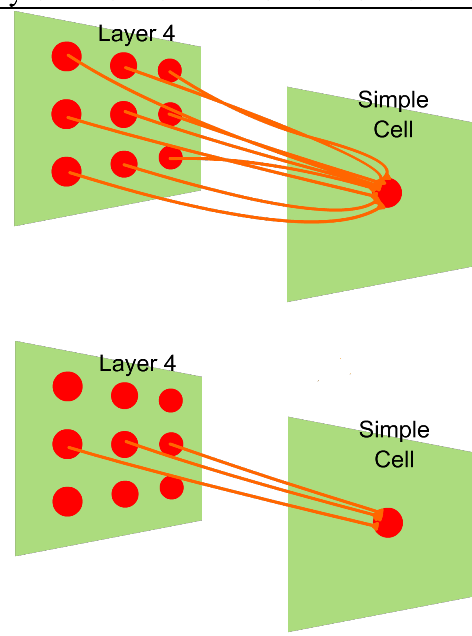
a) pre-synaptic axon terminal	This is true, but it is not the complete story.
b) post-synaptic receptor	This is true, but it is not the complete story.
c) the gap between	This is true, but it is not the complete story.
d) All of the above	 **Yes!** All these factors can make a synapse stronger. a) More pre-synaptic vesicles would be able to release more transmitter. b) The post-synaptic receptor becomes enlarged, e.g.: more sites and/or each site becomes more sensitive. c) Transmission in the gap is enhanced, e.g.: closer contact or the transmitter stays around longer. 

Problem 2: Where might the memory of a line with a horizontal orientation first form?

a) In retinal ganglion cells	
b) In LGN cells	
c) In V1 layer 4 cells	
d) In V1 simple cells	
e) In the synapses to V1 simple cells	

Problem 2: Where might the memory of a line with a horizontal orientation first form?

Answer

a) In retinal ganglion cells	No. Retinal ganglion cells have circular surround receptive fields which are not tuned to horizontal lines.
b) In LGN cells	No. LGN cells have circular surround receptive fields. These are not tuned to horizontal lines.
c) In V1 layer 4 cells	No. V1 layer 4 cells have circular surround receptive fields. These are not tuned to horizontal lines.
d) In V1 simple cells	Yes. Some V1 simple cells do fire selectively to horizontal lines. But this is not where the memory of a horizontal line first forms.
e) In the synapses to V1 simple cells	 **Correct.** The particular connections formed on this cell give it its selectivity to a horizontal line. Its memory lies in which synapses it receives from layer 4. At birth, simple cells are not tuned to a particular orientation. They fire equally for all orientations. Most inputs from the LGN do not favor any particular orientation selectivity (not yet tuned). With practice (repeated exposure to lines of a particular orientation), the unnecessary connections are pruned out. Losing connections in your brain can often be a good thing!

Problem 3: What type of memory is the memory of a horizontal line?

a) Short Term Working	
b) Long term: Procedural	
c) Long term: Declarative	

Problem 3: What type of memory is the memory of a horizontal line?

Answer

a) Short Term Working	Initially it is. But what does it become?
b) Long term: Procedural	**Correct.** This is a good example of procedural memory. Repeated exposure to horizontal lines is required to learn the correct connections for perceiving horizontal lines.
c) Long term: Declarative	No. Declarative memories do not require **repeated** exposure but those of horizontal lines do.

Problem 4: If you were riding a bike and felt you were falling to the right. Would you compensate by

a) leaning to the left?	
b) turning the wheel to the right?	

Problem 4: If you were riding a bike and felt you were falling to the right. Would you compensate by

Answer

a) leaning to the left?	No. Leaning left would compound the problem and cause a fall. Surprisingly, many experienced cyclists choose this answer even though, when riding, they turn the wheel to the right without thinking.
b) turning the wheel to the right?	**Yes.** Leaning left would compound the problem and cause a fall.

Problem 5: Surprisingly, many experienced cyclists choose "leaning to the left" as the answer even though, when riding, they turn the wheel to the right without thinking. Why?

a) The memory of the skills required to ride a cycle resides in procedural memory.	
b) These skills are learned implicitly, without the person's being aware of the particular motor reflexes that are being generated.	
c) The memory of the skills required to ride a cycle resides in declarative memory.	
d) One is conscious of procedural memories.	
e) Both a) and b) are true.	
f) Both c) and d) are true.	

Problem 5: Surprisingly, many experienced cyclists choose "leaning to the left" as the answer even though, when riding, they turn the wheel to the right without thinking. Why?

Answer

a) The memory of the skills required to ride a cycle resides in procedural memory.	Yes, this is procedural. But this is not quite the complete answer.
b) These skills are learned implicitly, without the person's being aware of the particular motor reflexes that are being generated.	True. But what type of memory does that require?
c) The memory of the skills required to ride a cycle resides in declarative memory.	No. Declarative memories are the representations of objects and events.
d) One is conscious of procedural memories.	No. One is conscious of declarative memories, such as what a bike is used for.
e) Both a) and b) are true.	**Correct.** These procedural memories are in the strength of the connection from your balance sensors to your arm and leg muscles. You sense you are falling and your arms turn in the correct direction to maintain your balance. You are not conscious of what the strength of these numerous connections are.
f) Both c) and d) are true.	No.

Problem 6: What type of memory does the ability to read involve?

a) Declarative memories	
b) Working memories	
c) Procedural memories	
d) All 3 types of memories	

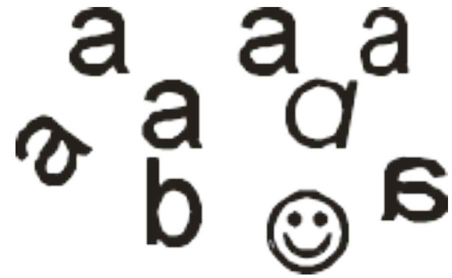
Problem 6: What type of memory does the ability to read involve?

Answer

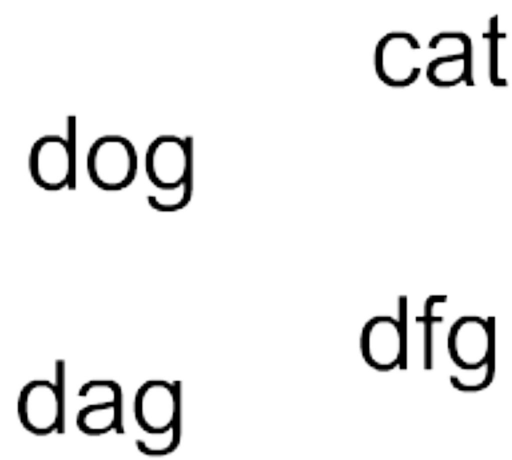
a) Declarative memories	You are correct, understanding the meaning of the words you read, and not just seeing a bunch of letters, is certainly important for reading. But there are other correct answers.
b) Working memories	Yes, you are correct. As you read, your fovea points to a word and then jumps to the next word. You read one word at a time, sometimes skipping words. You need to store all these words in working memory to figure out what a particular word combination and word order mean. But there is another correct answer as well.
c) Procedural memories	Yes, reading requires procedural memory. Perceiving letters and words is an extension of the process that tunes simple cells for lines of particular orientations. And as any child knows this requires lots of practice.
d) All 3 types of memories	**Correct,** reading involves all 3 types of memories. 1) Declarative memory: remember the meaning of words. 2) Working memory to understand a sentence. Remember that you do not see a sentence at once but saccade from word to word. You need to store all these words in working memory to figure out what this particular word combination and word order mean. 3) Procedural memory: Distinguishing and recognizing letters and words takes lots of practice.

What aspects of reading are reflexive? One can imagine that learning to read involves the following steps.

Step 1: Recognizing letters from non-letters and from each other.



Step 2. Recognizing words from non-words and from each other.



Step 3. Quickly recognizing groups of words as phrases.

Learning to read groups of words as phrases

Aoccdrnig to research at an Elingsh University, it doesn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht the frist and lsat ltteer is at the rghit pclae. The rset can be a toatl mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae we do not raed ervey lteter by it slef but the wrod as a wlohe.

Problem 7: In classical conditioning, would you expect any changes at the synapse from the teacher (the puff)?

a) No, because synaptic strength normally has a maximum.	
b) No, because the synapse from the puff has not been recently activated.	

Problem 7: In classical conditioning, would you expect any changes at the synapse from the teacher (the puff)?

Answer

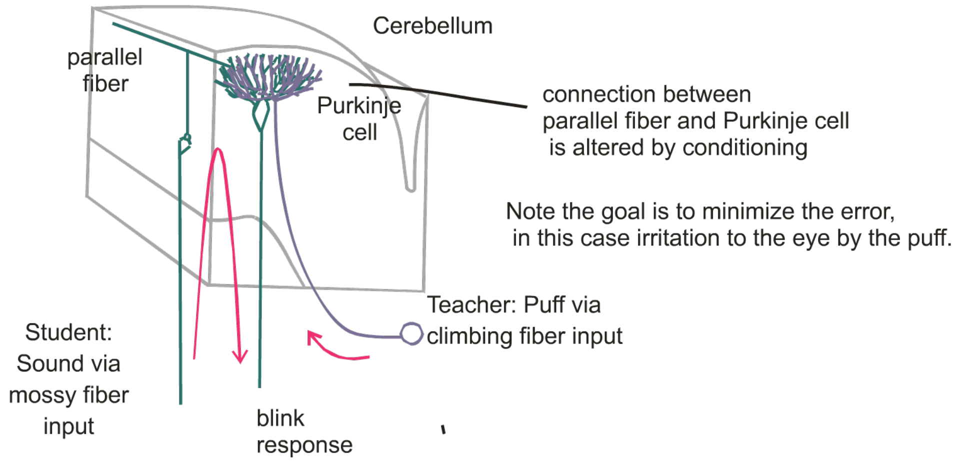
a) No, because synaptic strength normally has a maximum.	**Correct.** The puff is the teacher and its synapse to the blink is always activated because it is a strong synapse. One might expect that this synapse is strengthened whenever that from the sound input occurs. But a synapse can be over strengthened to such an extent that even a small input will produce activity. This can lead to epilepsy (spontaneous activity with no input). To prevent this, synapses normally have a maximum.
b) No, because the synapse from the puff has not been recently activated.	No.

Problem 8: In the cerebellar circuit for conditioning a blink reflex to a sound

a) the "student" input is sound via the climbing fiber.	
b) the "teacher" input is puff via the mossy fibers.	
c) the connection between the parallel fiber and the purkinje cell is altered by conditioning.	
d) the error is the sound.	

Problem 8: In the cerebellar circuit for conditioning a blink reflex to a sound

Answer



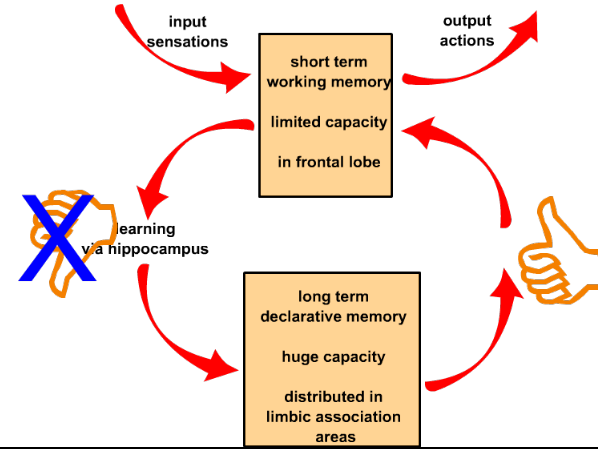
a) the "student" input is sound via the climbing fiber.	No. The sound is the student input, but it arrives via the mossy fiber.
b) the "teacher" input is puff via the mossy fibers.	No. The puff is the teacher, but it arrives via the climbing fiber.
c) the connection between the parallel fiber and the purkinje cell is altered by simultaneous activity of both.	Correct.
d) the error is the sound.	No. The error is the irritation produced by the puff.

Problem 9: H.M. can [there may be more than one]?

recognize the notes he made while reading yesterday.	
remember the characters in the new TV soap opera.	
learn to read words that are mirrored.	
remember what he had for breakfast.	
remember his name.	
learn new sport skills, like golf.	
remember his childhood books.	
remember himself in the mirror.	
remember the way to his new house.	
carry on a normal conversation.	

Problem 9: H.M. can [there may be more than one]?

Answer



recognize the notes he made while reading yesterday.	No, he reads the notes he made the day before and does not remember having written them. When he rereads these notes, it is hard for him to imagine that he has written such insightful notes.
remember the characters in the new TV soap opera.	No, characters that appeared the day before are completely new to him. He has difficulty remembering the faces of the characters from scene to scene.
learn to read words that are mirrored.	**Yes,** this requires procedural memory which HM retains.
remember what he had for breakfast.	No, HM cannot consolidate short term memories into long-term memories. HM cannot remember what happened just before. HM feels like continuously waking up from a dream.
remember his name.	**Yes,** this comes from his long-term memories which he has retained.
learn new sport skills, like golf.	**Yes,** these are procedural memories. But he cannot remember that he played golf yesterday.
remember his childhood books.	**Yes,** these are from his long-term memories.
remember himself in the mirror.	No, HM only remembers himself as a young man.
remember the way to his new house.	No, HM cannot consolidate new long-term memories. At home he needs to ask where the bathroom is.
carry on a normal conversation.	**Yes,** his short-term memory is good enough to allow him normal conversation.

Problem 10: fMRI experiments show that the hippocampus is activated during remembering.

a) Some suggest that this demonstrates that the hippocampus is involved not only in memory consolidation but also memory retrieval.	
b) Others suggest that when the old memories are remembered, they can again form new long-term members.	
c) Both may be true.	

Problem 10: fMRI experiments show that the hippocampus is activated during remembering.

Answer

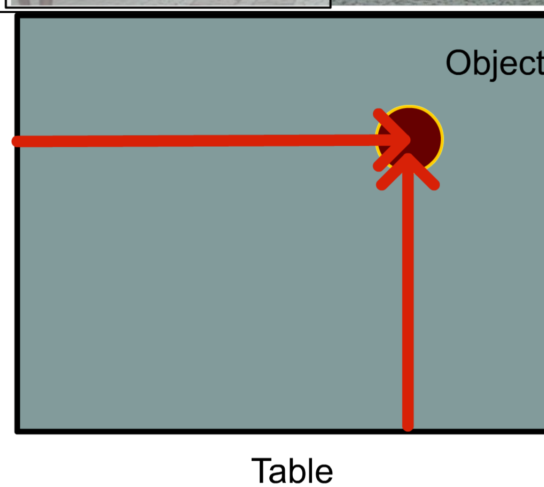
a) Some suggest that this demonstrates that the hippocampus is involved not only in memory consolidation but also memory retrieval.	Yes. This may be true but there is another possibility.
b) Others suggest that when the old memories are remembered, they can again form new long-term memories.	Indeed, this may be the route by which one strengthens old associations and forms new ones. This may be how our memories are tuned and refined. As with procedural memory this would also make our long-term memory labile and susceptible to interference from other new memories or practice. It has in fact been recently demonstrated that when the old memories are rehearsed, they again become particularly susceptible to disruption by the learning of other new memories. But there may be another possibility
c) Both may be true.	**Yes,** both may indeed be true. It would in fact be hard to distinguish between these two possibilities from these fMRI experimental results.

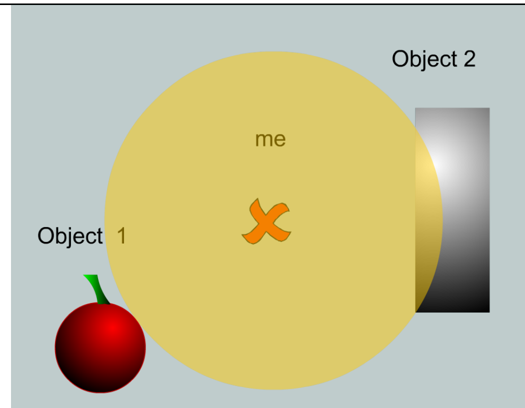
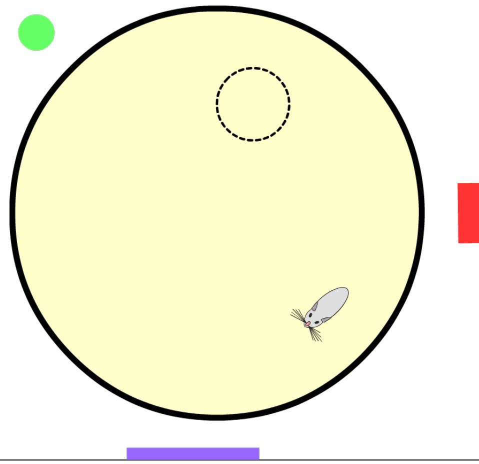
Problem 11: The following is **not** an example of an allocentric representation.

a) remembering the way home by means of a sequence of spatial landmarks	
b) patients with a right PTO lesion who neglect buildings along a street on their left side	
c) remembering where the sugar bowl is on the table of your kitchen	
d) a simple forward movement changes only your own remembered location with respect to the room	
e) remembering your location using hippocampal Place cells	

Problem 11: The following is **not** an example of an allocentric representation.

Answer

a) remembering the way home by means of a sequence of spatial landmarks.	No. This **is** an example of an allocentric representation. You remember the relative location of a landmark with respect to the next one.
b) patients with a right PTO lesion who neglect buildings along a street on their left side.	 **Yes.** This is an example of an **egocentric** representation. The patient would neglect houses on that patient's left. If the patient turned around, houses on the opposite side of the street (but still in the patient's left) would be neglected.
c) remembering where the sugar bowl is on the table of your kitchen.	 No. This is an example of an allocentric representation. An allocentric representation gives you the location of one object with respect to some other object, such as a sugar bowl in terms of its location on a table or a feature of a face in terms of its location on the face.

d) a simple forward movement changes only your own remembered location with respect to the room.		No. This is an example of an allocentric representation. For an allocentric representation, you re-code your position on the map of the room and the position of all the other objects stay fixed.
e) remembering your location using hippocampal Place cells.		No. This is an example of an allocentric representation. The firing rate of rat's hippocampal Place cells is independent of how the platform is reached (i.e. from which direction). Place cells thus code the platform location in a form that is view independent (i.e. independent of which way the rat is placed).

Congratulations! You now have a basic understanding of how your senses work.