NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

A Trip to the Eye Doctor

by
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Part I – Pre-Exam

"Samantha," called a voice from the front of the optometrist's office.

Samantha looked up. Jason, the optometrist assistant, was calling her name.

Samantha smiled as she walked over to meet him.

"It's good to see you again," Jason said. "Let's get you back and get started on some of the pre-exam tests. Dr. Thompson is with another patient but will be ready to see you soon."

Jason led Samantha through a hall back to the pre-exam room. Machines designed to test different aspects of vision were lined up across the room.

"Let's have you start here with the visual field test, Samantha" said Jason. "Do you remember this test from last year's exam?"

"Yes," Samantha replied. She sat down at the machine, placed her face in the forehead and chin rests and stared through the opening in the machine to a light on the inside.

"Okay Samantha," Jason began. "I want you to keep your eyes focused on the light inside the machine. Every so often, you'll notice lights flashing in areas of your peripheral vision. Each time you do, I want you to click this button letting me know that you saw the flashing lights."

Questions

(Please note: You may need to use your text or online resources to answer some of the questions in this case study.)

1. What is central vision, and where is Samantha's central vision focused during the visual field test?

2. On which part of the retina are the light rays from the object in Samantha's central vision landing?

3. What is peripheral vision, and on which part(s) of the retina are the light rays from the objects in Samantha's peripheral vision landing?

As she finished up the visual field test, Samantha was curious about what she was being examined for. "Jason, I took an A&P class in college and we did a unit on eyes," she began. "Now that I understand better the anatomy of the eye, I'm curious about what this test is looking for."

"That's great, I loved that class!" Jason replied. "This particular test looks to see if there are any blind spots, or areas where you've lost the ability to see, in your peripheral vision. You would think it would be obvious if you had a blind spot, but often they develop slowly over time and people don't notice them. Your brain is also very good at filling in missing visual information, so sometimes people lose an extensive amount of their peripheral vision and don't even notice! That's why we specifically test for it here, so that if there is a problem with vision loss we can treat it before it progresses."

"We talked about the physiological blind spot that is in the peripheral field of vision in my A&P class," said Samantha. "Isn't it normal to have a blind spot?"

"Everyone has the physiological blind spot," Jason explained. "That is normal. But developing other blind spots in addition to that one is not normal."

"What causes other blind spots to develop?" asked Samantha.

"There are a lot of things that can do it, but the most common is a disease called glaucoma. Here's a model of the eye, which you probably are familiar with," Jason began. "Glaucoma develops when there is increased pressure in the anterior chamber of the eye due to a buildup of aqueous humor."

Questions

4. What structure in the eye is responsible for the physiological blind spot, and why does it cause it?

5. Label the eye model (Figure 1) with the following: *anterior chamber, posterior chamber, vitreous humor, aqueous humor, retina, lens, pupil, cornea, ciliary body, scleral venous sinus (canal of Schlemm),* and *optic nerve.*

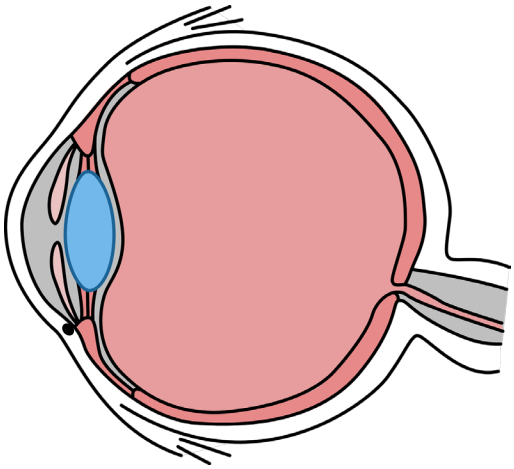

Figure 1. Sagital section of the eye.

6. What are the roles of aqueous humor?

7. Glaucoma is caused by an increase in pressure in the anterior chamber. This may happen when aqueous humor builds up in this chamber. Explain how problems with the ciliary body or the canal of Schlemm could lead to development of glaucoma.

8. How does the increase in pressure in the anterior chamber affect the optic nerve and peripheral vision?

"Samantha," said Jason, "your peripheral vision looks good and I'm going to have you move over to the next machine, our tonometer. This one is going to shoot a little puff of air into your eye, which will temporarily flatten the cornea. How much your cornea flattens in response to the puff of air will give us information about the intraocular pressure, or the pressure inside the eye."

"Ugh! The puff of air usually makes me blink and I have to get shot several times to get the needed measurements," complained Samantha. She sat down in the chair and once again placed her face in the chin and forehead rests.

Questions

9. Intraocular pressure (pressure within the eye) needs to be kept within a certain range. Why is pressure inside of the eye necessary for proper vision?

10. Fill-in-the-blanks. If the cornea flattens less-than-normal in response to the puff of air, this would indicate that intraocular pressure is _____ (above normal/below normal). If the cornea flattens more-than-normal in response to the puff of air, this would indicate that intraocular pressure is _____ (above normal/below normal).

11. Both the visual field test and tonometry can provide information about the development of glaucoma. Which of these tests would be able to catch glaucoma in earlier stages? Explain your answer.

Part II – Visual Acuity

Following the pre-exam, Jason took Samantha back to the exam room where Dr. Thompson was waiting. Dr. Thompson asked Samantha to sit in the exam chair, and had her complete the visual acuity test using the Snellen chart. Upon finishing Dr. Thompson said, "Samantha, the good news is, it looks like your vision has stabilized. I know that you don't see well without correction, but you are still 20/500, which is the same as what you were last year. Your vision hasn't gotten any worse at least. And since it has stabilized we could maybe talk about LASIK surgery, which could possibly get you back to 20/20 vision without your glasses."

Questions

1. Explain what it means to have 20/500 vision.

2. Explain what it means to have 20/20 vision. What does having 20/15 vision mean?

"That is good news!" Samantha exclaimed. "I finished graduate school last year, and I haven't had so much reading and computer work to do; it's been a lot easier on my eyes. Could that help explain why my vision hasn't gotten any worse?"

"Yes!" replied Dr. Thompson. "Normally, the eye should be almost perfectly spherical. When you do a lot of reading or other work that requires focus on close objects, the lens of the eye has to change shape. It actually starts to bulge into the posterior chamber. This bulging increases pressure in the posterior chamber and over time that can start to stretch the eye out and cause it to become longer. Usually nearsightedness, or myopia, is caused by an eyeball that has become too long."

Question

3. Based on the description given by Dr. Thompson, which eye in Figure 2 below is currently accommodating for viewing a close object, Eye A or Eye B? Explain your answer.

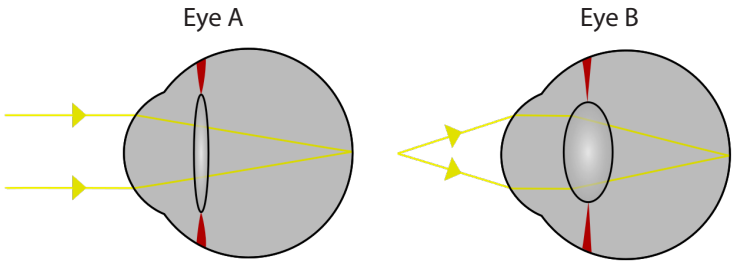

Figure 2. Lens accommodation. *Credit:* Wikimedia Commons, CC BY-SA 2.5, <https://commons.wikimedia.org/wiki/File:Focus_in_an_eye.svg>.

"Why does an eye that has become too long cause distant vision to be blurry?" Samantha asked.

"Light rays are bent, or refracted, when they pass through curved surfaces. Here's a diagram that shows how this works, Samantha." Dr. Thompson handed her Figure 3:

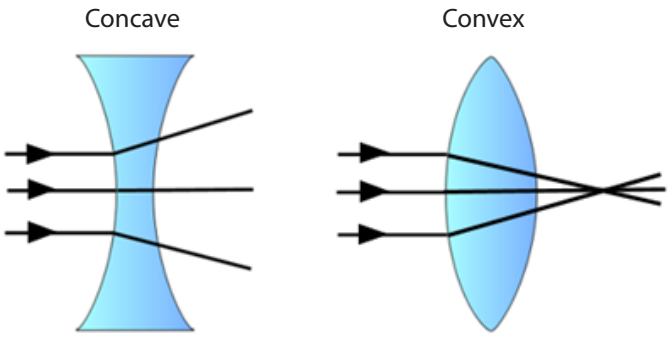

Figure 3. Light rays as they pass through concave (left) and convex (right) surfaces.

Questions

4. According to Figure 3, how does a concave surface differ from a convex surface?

5. Does a concave surface cause light rays to converge or diverge? What about a convex surface?

6. When all of the light rays come together at a single point, this is known as a focal point. Which type of surface causes light rays to converge at a focal point, concave or convex? Label the focal point on Figure 3.

7. Now return to Figure 1. Based on the shape, which structure(s) in the eye would bend light rays that pass through? Would the structure(s) cause light rays to converge or diverge?

Part III – Refractive Correction

Questions

1. Look closely at the diagram of an eye with normal vision (emmetropia) represented in Figure 4. On what structure of the eye does the focal point need to occur for normal vision, and why does it need to occur here?

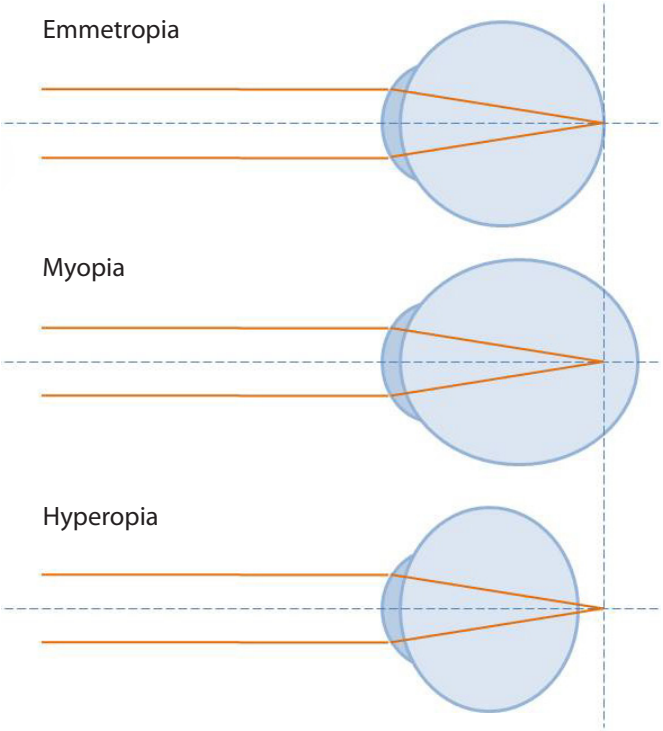

Figure 4. Refractive disorders of the eye. *Credit:* Philos2000, CC BY-SA 4.0, <https://commons.wikimedia.org/wiki/File:Refractive_Errors_of_the_Eye.jpg>.

2. According to Figure 4, where is the focal point in myopia, and why has it moved from where it should be found normally?

3. Examine Figure 3 again. What happens to light rays as they continue past the focal point? Draw the light rays as they move past the focal point in the myopic eye represented in Figure 4.

4. Explain why distance vision is blurry in myopia.

5. The longer the eyeball becomes, the further in front of the retina the focal point moves. Explain why Samantha's vision has gotten progressively worse over time, by summarizing what you've learned so far.

6. Myopia is treated by glasses with concave lenses. Explain how this could move the focal point back into the correct position on the retina.

7. What is hyperopia?

8. According to Figure 4, where is the focal point with hyperopia, and what seems to be responsible for the focal point being in this place?

9. Explain why close vision is blurry with hyperopia.

10. Why are glasses with convex lenses used to correct hyperopia?

"So I think I get it," Samantha said. "Because my eyeballs are too long, the focal point is in front of my retina! And the light rays that are hitting my retina are diverged. Is LASIK a surgery to shorten my eyeballs?"

"No, it's a lot simpler than that," replied Dr. Thompson. "We can correct your vision simply by reshaping the cornea. That will allow us to move the focal point back onto your retina where it needs to be. So we would be working with just the surface of the eye, and it really is a very simple procedure."

Questions

11. The more convex a surface is, the stronger it converges light rays. Rank the corneas (A–C in Figure 5) from most convex to least convex.

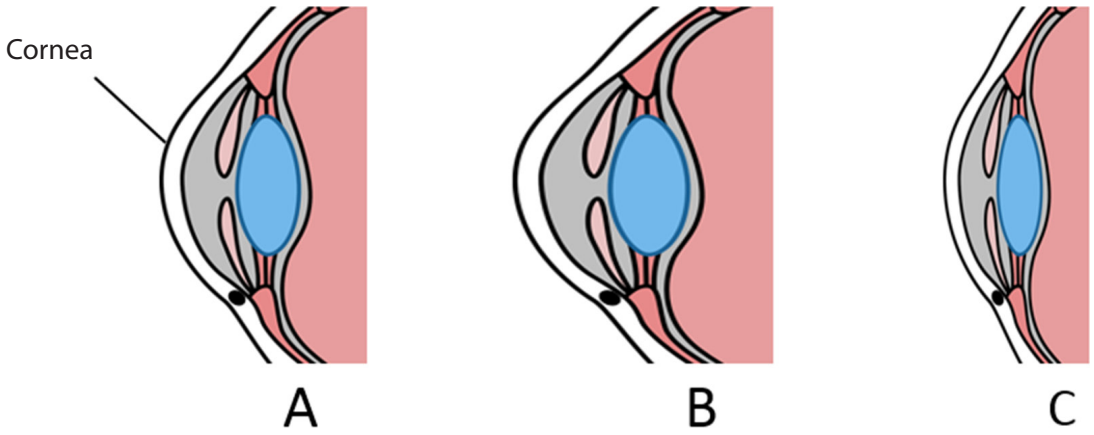

Figure 5. Corneas of varying convexity.

12. Which of the corneas in Figure 5 would bend light rays to a focal point in the shortest distance? Explain your answer.

13. Which of the corneas in Figure 5 would bend light rays to a focal point in the longest distance? Explain your answer.

14. Based on what you've learned would LASIK need to make Samantha's cornea more convex or less convex? Explain your answer.

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