LESSON 5 - THE OPTICS OF THE EYE

Overview:
By dissecting a mammalian eye, students will learn how the lens in the eye focuses light to form an image of an object. They will also learn the main parts of the eye and the function of each part. If mammalian eyes are not available for dissection, an online virtual dissection is provided as an alternative.

Suggested Timeline: 1.5 hours

Materials for dissection:
- The Optics of the Eye – Discovery Through Dissection (Teacher Support Material)
- The Optics of the Eye – Discovery Through Dissection (Student Handout)

The following materials per group of 2 students:
- cow eyes (fresh from a butcher shop is preferred to preserved – try to get eyes with the muscles and fat still attached)
- scalpel
- dissecting scissors
- dissecting pan
- paper towel

Materials for virtual dissection:
- The Optics of the Eye – Discovery Through Virtual Dissection (Student Handout)
- computer with speakers (1 per student)

Method:

OPTION A - If mammalian eyes are available for dissection:
1. Have students complete the vocabulary list for the eye (student handout).
2. Familiarize students with the set-up for the lab and lab safety protocol.
3. With a partner, have students complete the dissection, filling in answers to procedural questions along the way.
4. Have students hand in their lab handout for evaluation.

OPTION B - If mammalian eyes are not available for dissection:
1. Have students complete the vocabulary list for the eye (student handout).
2. Working on computers, have students complete the virtual dissection of a cow's eye. Students must answer questions in the handout along the way.
3. Have students hand in their lab handout for evaluation.

Evaluation:
Student grade on lab.

The Optics of the Eye – Discovery Through Dissection
Teacher Solutions

Procedure and Observations:

3. a) a clear plastic bottle, a clear page protector
   b) the white plastic of a food storage container
4. a fabric binder, the wall of your house
6. see given diagram on student handout
8. a) should not be easy to remove the muscle; the muscle must be firmly attached to the eye so that it can securely move it around
   b) for protection, cushioning
9. a) sclera
   b) vitreous humor
10. should circle biconvex lens
11. a) increases size of printing
    b) magnifying glass
12. Example: Notice that the lens can currently be seen through clearly. In some people, especially the elderly, the lens can become cloudy which is called a cataract. This creates areas on the lens that light can pass through but cannot be seen through clearly, or areas that completely block the light and therefore cause blind spots in a person's vision.

Conclusion:

- The cow's eye is like the human eye because it shares almost all of its structures (since both human and cow are mammals).
- The cow's eye is unlike the human eye because it is larger and has a tapetum.
- Flow chart: Light enters the eye through the cornea then passes through the jelly-like aqueous humor and enters the opening in the iris called the pupil. The light is focused by the flexible and clear structure called the lens which is called a biconvex lens because of its shape. The lens can be seen through clearly and is therefore transparent. The light focuses on the special layer at the back of the eye called the tapetum which is made up of light-detecting cells called rods and cones. The information is sent to the brain through a bundle of nerve fibers called the optic nerve.

Student Handout

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Name: _____ Date: _____ Period: _____

The Optics of the Eye – Discovery Through Dissection

VOCABULARY: (16 x 0.5 mark each = 8 marks)

cornea –

transparent –

translucent –

opaque –

aqueous humor –

vitreous humor –

lens –

retina –

→ cones –

→ rods –

iris –

pupil –

sclera –

Student Handout

optic nerve –

blind spot –

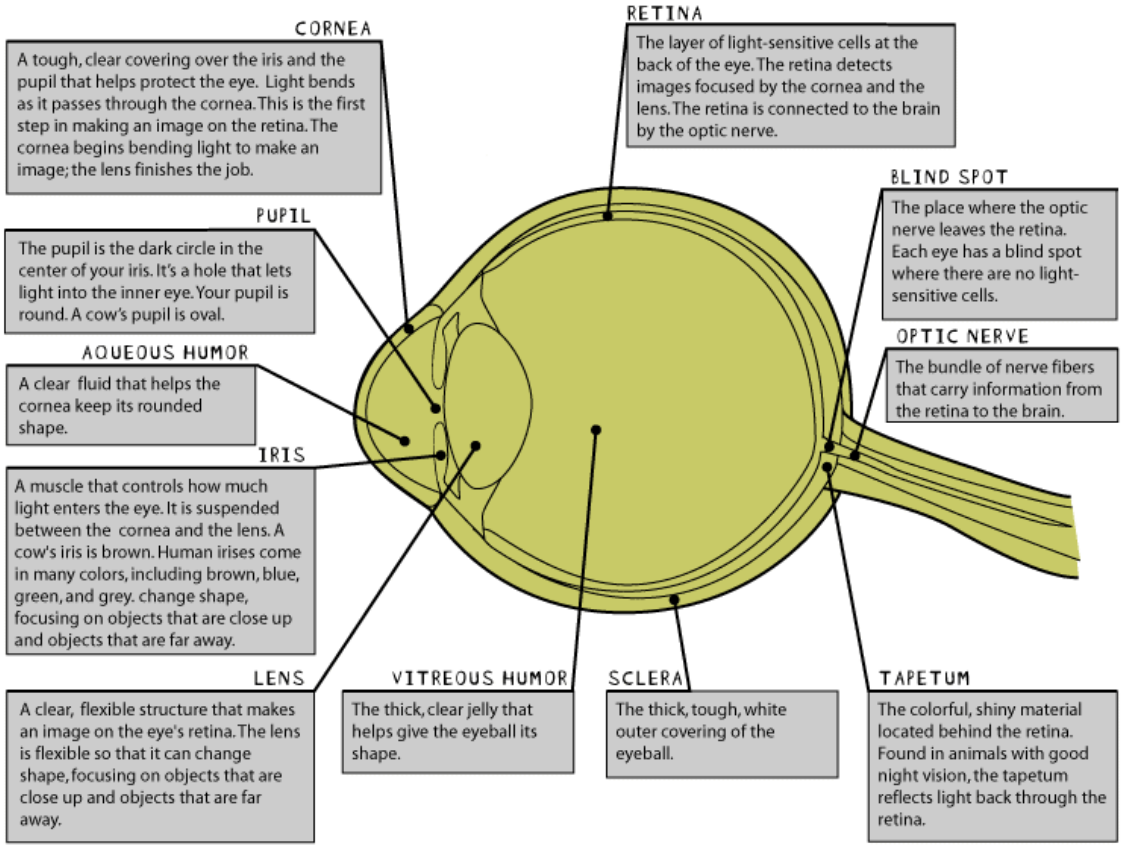
tapetum –

Student Handout

BACKGROUND:

"Optics" from the Greek "optikes" originally referred to the study of the eye and vision, but today refers to the study of all phenomena related to light. So far, you have investigated how light reflects and refracts and have investigated how plane mirrors make images. In this section, you will focus on the geometric optics of the lens of the mammalian eye which deals with the formation of images by reflection and refraction. You will also learn about how different materials affect the formation of images.

The cow's eye is ideal for dissection since it is very similar to the human eye but much larger, and is readily available. The following diagram of the cow's eye can be used as a guide during your dissection.



MATERIALS: (per 2 students)

- cow's eye (fresh is preferred to preserved)
- scalpel
- dissecting scissors
- forceps (tweezers)
- dissecting pan
- paper towel
- latex gloves

Student Handout

PROCEDURE AND OBSERVATIONS:

1. Put on your latex gloves. Line your dissecting pan with a piece of wet paper towel.
2. Place the cow's eye and your other materials in the dissecting pan and return to your work area.
3. Examine the outside of the eye. First find the **cornea**. When the cow was alive, the cornea was **transparent** or clear, allowing light to pass through it and objects to be seen clearly through it. The cornea may be cloudy, or **translucent** since the cow has died. Translucent materials allow light through, but objects cannot be seen clearly through them.
   a) Another example of a transparent material is a window pane in your house. Provide two more examples of transparent materials.

      _____

      ___ 3

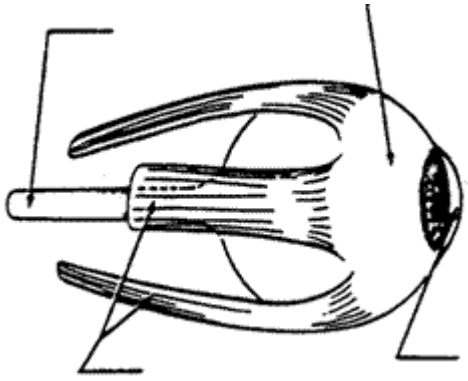
   b) Another example of a translucent material is frosted glass on a shower door. Provide one more example of a translucent material.

      _____

4. Next, find the **sclera** or white of the eye. The sclera is **opaque** or does not allow light to pass through it. Another example of an opaque material is a wooden door. Provide two more examples of opaque materials.

   _____ ___ 2

5. Using the diagram above, see how many more parts of the outside of the eye you can identify. See if you can look through the cornea to find the **iris** and the **pupil**. Find the **optic nerve** where it exits the back of the eye. Notice that yellow fat surrounds part of the back of the eye.
6. Label the following diagram of the eye. Draw in the places where you found fat.



___ 5

7. Using your scissors and forceps, remove as much fat from the eye as possible. Leave the optic nerve in place.

8. Try to pull some of the eye muscle away from the sclera.
   a) Is it easy to remove the muscle? _____ Why do you think that this is so?

   _____

   _____

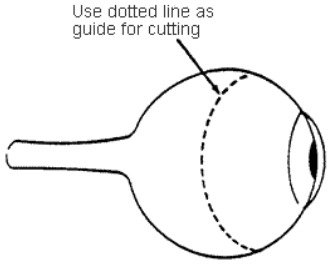
   3

   b) Why might there be so much fat around the eye? _____

   _____

   2

9. Use your scissors to cut along the dotted line as shown below.

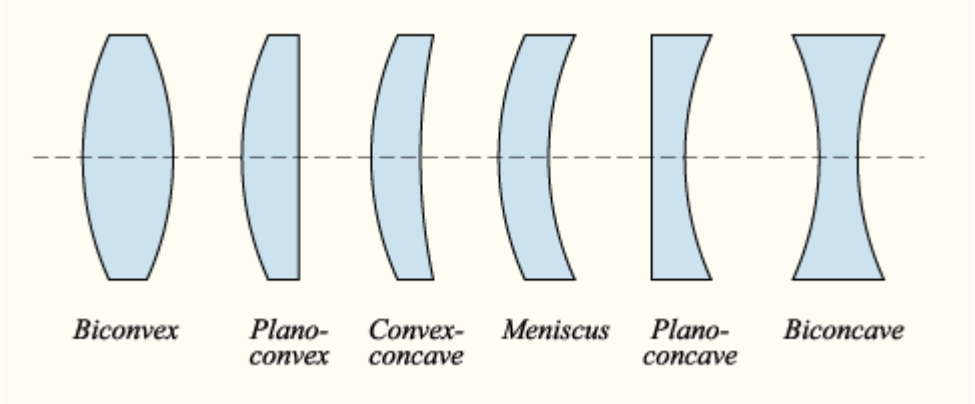


   a) What structure did you cut through to cut the eye in half? _____

   b) What is the clear, jelly-like liquid that oozes out of the eye? _____

   2

10. Once the eye is cut in half, locate the **pupil**, **retina** and **lens.** Use your forceps to remove the lens to examine it. The lens is soft on the outside and hard in the middle. Muscles attached to the lens will move it to change its shape so that the cow can focus on objects at different distances. Look at the lens from the side then examine the pictures below of different types of lenses. Circle the type of lens that is the cow's eye.



1

11. Using your forceps, hold the lens a few inches over some printing on a page.
    a) Look at the printing through the lens and slowly move the lens away from the page. What does the lens do to the size of the printing?

    _____ /2

    b) What object have you used before that uses this same type of lens?

    _____

12. Notice that the lens is currently **transparent**. In some people, especially the elderly, a **cataract** can develop wherein the lens becomes cloudy. This creates **translucent** and sometimes even **opaque** areas in the person's vision. Using the definitions of transparent, translucent and opaque, rewrite the last three sentences in your own words. /3

    _____

    _____

    _____

    _____

    _____

13. Examine the inside of the back half of the eyeball. You should be able to see some blood vessels that are part of a fleshy film. The film is the **retina**. The retina is made up of cells that can detect light. **Rods** are cells of the retina that are used in detecting dim light. **Cones** are cells of the retina that are used in detecting bright light and colours. The light that passes through the lens of the eye lands on the retina and forms an image of what we see.

14. Use your finger to push the retina around. The retina is attached to the back of the eye at just one spot. This is the place where the nerves of all of the cells of the retina come together. The bundle of nerves that exits the back of the eye and sends the image to the brain is called the **optic nerve.**

15. The spot where the retina is attached to the back of the eye is called the **blind spot**. There are no light sensitive cells here, so you cannot see a picture of anything that lands here. You do not usually notice this blind spot since your brain will 'fill it in'. For a cool experiment to do at home, follow this link to find your blind spot!
    http://homepage.eircom.net/~kogrange/4th_ys_blindspot.html

16. With your fingers, turn the eye inside out. Find the shiny blue-green coloured stuff that covers the back of the eye. This is the **tapetum**. It reflects light back through the retina to improve the cow's vision in low light. When light shines on a cow's eye at night, its eye appears to be blue-green due to light reflecting from the tapetum. Humans do not have a tapetum.

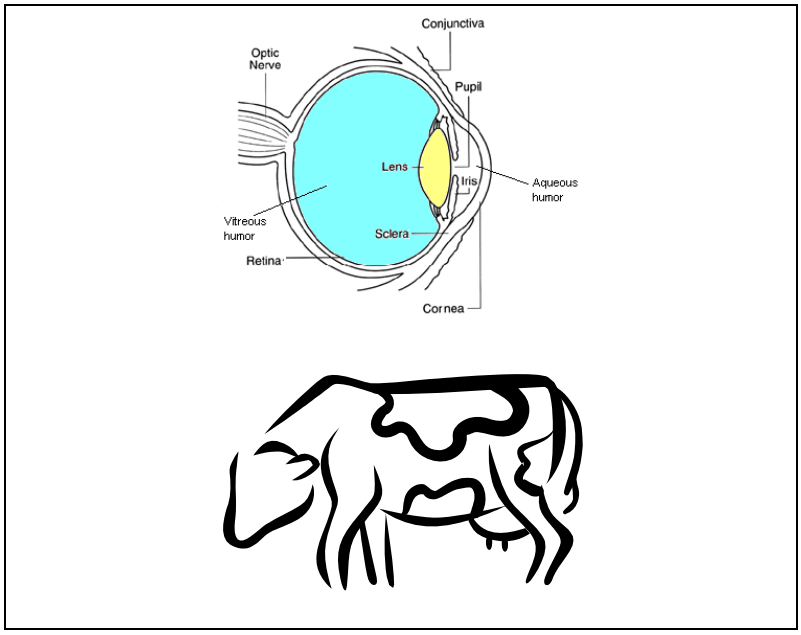
Student Handout

17. You are now finished your dissection. Wash and dry all of your tools thoroughly and return them to the designated area. Wrap your dissected eye in wet paper towel and discard. Wipe down the area on which you were dissecting your eye and dry.

CONCLUSION:

To sum up the important information learned in this lab activity, complete the following chart by filling in the circles and blanks.

Student Handout



1. The cow's eye is like the human eye because _____

   _____

2. The cow's eye is unlike the human eye because _____

   _____

light enters the eye through the

( )

then passes through the jelly-like

(aqueous humor)

and enters through the opening in the **iris** called the

( )

Student Handout

The light is focused by the flexible and clear structure called the

lens

which is called a _____lens because of its shape. The lens can be seen through clearly and is therefore _____.

The light focuses on the special layer on the back of the eye called the

which is made up of special light-detecting cells called **rods** and **cones.**

The information is sent to the brain through a bundle of nerve fibers called the

Student Handout

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Name: _____ Date: _____ Period: _____

The Optics of the Eye – Discovery Through A Virtual Dissection

8

VOCABULARY: (16 x 0.5 mark each = 8 marks)

cornea –

transparent –

translucent –

opaque –

aqueous humor –

vitreous humor –

lens –

retina –

→ cones –

→ rods –

iris –

pupil –

sclera –

Student Handout

optic nerve –

blind spot –

tapetum –

Student Handout

BACKGROUND:

"Optics" from the Greek "optikes" originally referred to the study of the eye and vision, but today refers to the study of all phenomena related to light. So far, you have investigated how light reflects and refracts and have investigated how plane mirrors make images. In this section, you will focus on the geometric optics of the lens of the mammalian eye which deals with the formation of images by reflection and refraction. You will also learn about how different materials affect the formation of images.

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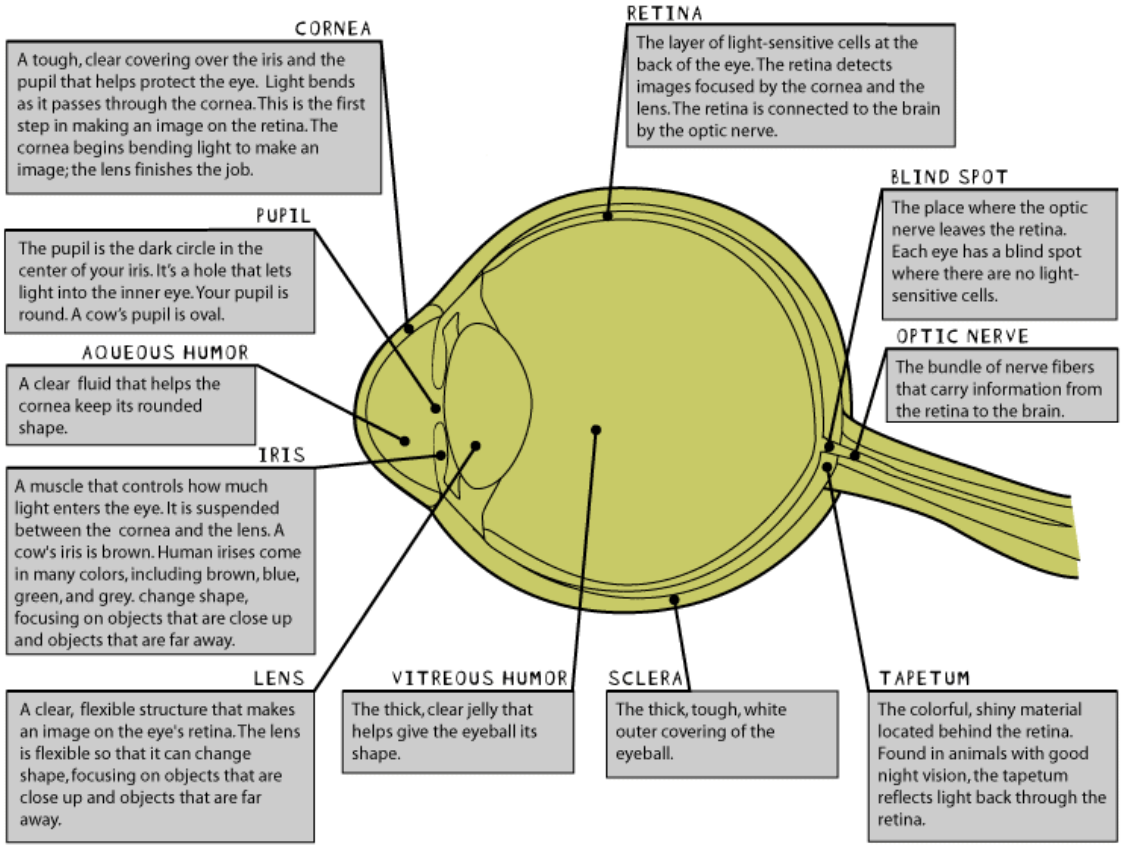


Student Handout

PROCEDURE AND OBSERVATIONS:

Access the following website: http://www.ebioinfogen.com/virtual.htm on a computer with sound. As you watch the videos for each step of the virtual dissection, answer the questions that go along with each step.

Step 1 (2 marks)

a) Why are cow eyes used for dissection?_____

_____

b) What is the main difference between human eyes and cow eyes? _____

_____

Step 2 (1 mark)

How many more muscles does a human eye have than a cow's eye? _____

Step 3 (1 mark)

The purpose of the fat is to _____ the eye.

Step 4 (6 marks)

The **cornea** of the eye is a protective, clear layer through which light first enters the eye. When the cornea is cut open, a liquid called the _____ comes out. List the two functions of this structure:

1.

2.

When the cow was alive, the cornea was **transparent** or clear, allowing light to pass through it and objects to be seen clearly through it. The cornea may be cloudy or **translucent** since the cow has died. Translucent materials allow light through, but objects cannot be seen clearly through them.

a) Another example of a transparent material is a window pane in your house. Provide two more examples of transparent materials.

_____

b) Another example of a translucent material is frosted glass on a shower door. Provide one more example of a translucent material.

_____

Step 5 (1 mark)
The white, tough part of the eye is called the _____.

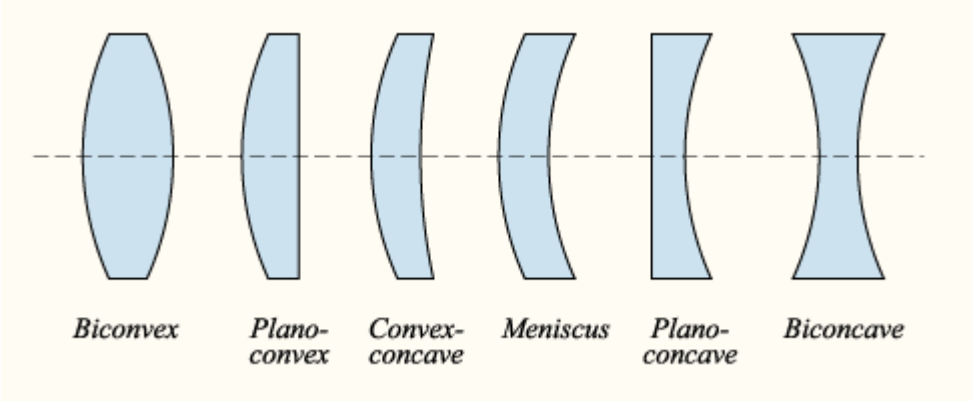
Step 6 (4 marks)
The part of the eye that gives the eye its colour is called the _____. It also contains the _____, the black dot (an opening) in your eye, that lets in light.

A major difference between a cow's eye and a human's eye is that the iris in a cow' eye is _____ whereas the iris in a human's eye is _____.

Step 7 (1 mark)
The _____ is the jelly-like substance that surrounds the lens.

Step 8 (5 marks)
The lens' job is to _____.

The lens is soft on the outside and hard in the middle. Muscles attached to the lens will move it to change its shape so that the cow can focus on objects at different distances. Look at the lens from the side (in the diagram on in the video), then examine the pictures below of different types of lenses. Circle the type of lens that is the cow's eye.



Notice that the lens is currently **transparent**. In some people, especially the elderly, a **cataract** can develop wherein the lens becomes cloudy. This creates **translucent** and sometimes even **opaque** areas in the person's vision.

Using the definitions of transparent, translucent and opaque, rewrite the last three sentences in your own words.

_____

_____

_____

_____

_____

Step 9 (1 mark)
The lens acts as a(n) _____.

Step 10 (2 marks)
The **retina** lays flat on the back of the eye. The retina detects light. It has _____ cells which allow us to see colour and _____ cells which detect whether or not there is light.

Step 11 (2 marks)
At the point where the retina connects to the back of the eye, no image can be focused. This is called your _____ spot. (For a fun activity to find your blind spot, go to http://homepage.eircom.net/~kogrange/4th_ys_blindspot.html)

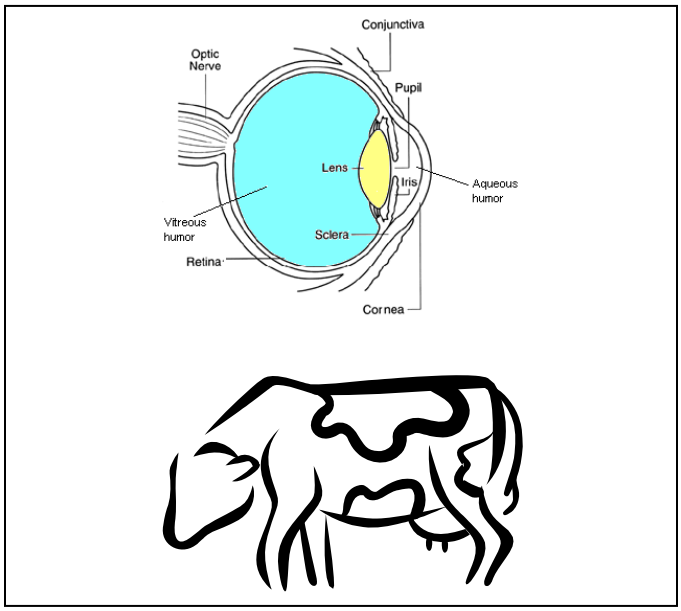
The retina sends images to the brain through a nerve that exits the back of the eye. This nerve is called the _____ nerve.

Step 12 (1mark)
Your brain receives information from the cells of the _____ (through the **optic nerve**) and turns that information into a picture of the world.

Step 13 (1mark)
Light comes into the cow's eye and bounces off the _____ at the back of the eye. This makes cows' eyes 'glow' when light is shone at them at night. Human eyes do not have a tapetum.

CONCLUSION:
To sum up the important information learned in this lab activity, complete the following chart by filling in the circles and blanks.

Student Handout



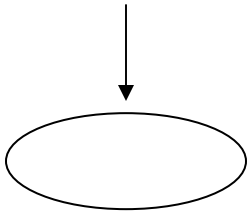
The cow's eye is like the human eye because _____

_____

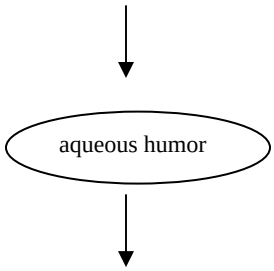
The cow's eye is unlike the human eye because _____

_____

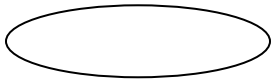
light enters the eye through the



then passes through the jelly-like



and enters through the opening in the **iris** called the



Student Handout

The light is focused by the flexible and clear structure called the

lens

which is called a _____lens because of its shape. The lens can be seen through clearly and is therefore _____.

The light focuses on the special layer on the back of the eye called the

_____

which is made up of special light-detecting cells called **rods** and **cones.**

The information is sent to the brain through a bundle of nerve fibers called the

_____

8