

UNIT LEARNING PACKS

# FOCUS IN ACTION

## **Grade 8 Science in Action**

Unit 3 - Light and Optical Systems

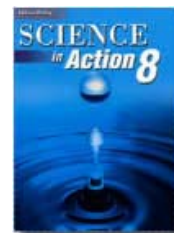
## 'Focus in Action' UNIT LEARNING PACKS

These booklets are designed to provide Grade 8 students with all the resources needed to review or reinforce concepts, covered in the Alberta Science Curriculum, and included in the Grade 8 Science Final Exam in June. There are circumstances in which **an entire unit** may be missed and covering the concepts from that unit (for the final exam) can be difficult. This can happen for a number of reasons:

- Students – new to the school – register throughout the year (from other provinces, school jurisdictions or countries)
- Students may be ill or have surgery and often can miss one or more units
- Students have extended holidays throughout the year
- Transfers from another school, who have completed the units in a different order

For additional support, students are directed to the **Edquest Middle School Science Website** or, Scienceman Resource ([www.scienceman.com/scienceinaction/pgs/hot\\_8u3.html](http://www.scienceman.com/scienceinaction/pgs/hot_8u3.html))

### ***Unit 3 – Light and Optical Systems***



- **Section 1 Notes**
- **Section 1 Quiz**
- **Section 2 Notes**
- **Section 2 Quiz**
- **Section 3 Notes**
- **Section 3 Quiz**
- **Section 4 Notes**
- **Section 4 Quiz**
- **Unit Summary**
- **Review Booklet**  
(Covered in class, prior to the Final Achievement Exam)
- **Unit 1 Test**
- **Answer Key for Section Quizzes and Unit Test**

#### **Light and Optics Module:**

<http://accept.la.asu.edu/PiN/mod/light/pattLightOptics.html>

Additional support will be provided, in the form of practice Achievement Test Questions, during the course review in June. Multiple Choice Questions and Numerical Response Questions will be reviewed, as these are the types that will make up the Science 8 Final Exam

Handouts and other activities, to reinforce the concepts covered in this Unit, will be made available based on need. If you require further information or resources, email Edquest directly: [edquest@gmail.com](mailto:edquest@gmail.com).

**Finding Solutions to Problems, instead of Making Excuses**

## Student Instructions for use of this Learning Pack

The purpose of this Learning Unit Pack is to provide you with the resources that will help you cover the material from the curriculum that will be tested on the Final Exam in June. Follow these steps to successfully complete this Unit Learning Pack:

**Step 1** – Read the **Topic Notes**

**Step 2** – Use a **highlighter** to identify the key words or phrases in the Topic Notes and reread the material again paying close attention to those words that you highlighted. If necessary, modify your highlights to make sure you understand the material in the notes.

**Step 3** – Complete the **Topic Quiz**

**Step 4** – Correct the Topic Quiz by **checking the answers** in the back of this Learning Pack.

**Step 5** – Using your **textbook** and the **completed quiz**, find the page where the question and correct answer can be found and write it next to the question number in your Learning Pack.

**Step 6** – **Repeat Steps 1-5** for each of the other Topics in this Unit.

**Step 7** – Look over the **Unit Outline** to review the **Key Concepts** once you have completed all of the Topics.

**Step 8** – Complete the **Unit Review**, using your **Learning Pack** and **Textbook**.

**Step 9** – **Highlight** those sections of the Review that you had difficulty with and review those sections with your teacher prior to taking the Unit Test.

**Step 10** – Take the **Unit Test** and correct it using the answer key provided in the back of the Learning Pack.

**Step 11** – You should now be ready to answer any questions on the **Final Exam** related to this Unit.

Anything you still do not understand should be discussed with your teacher. Congratulations on your **Independent Study**, and Good Luck on the Final Exam. I hope you have made good use of this resource. Please provide feedback to your teacher, so that this resource can be improved.

Additional support is available in the form of practice Achievement Test Questions. **Multiple Choice Questions** and **Numerical Response Questions** will be made available on request, as these are the types that will make up the **Science 8 Achievement Exam**.

Handouts and other activities, to reinforce the concepts covered in this Unit may be acquired by visiting the Edquest Middle School Science Resource Website

<http://www.edquest.ca>

**Light & Optics**

Links: <http://www.hazelwood.k12.mo.us/~grichert/sciweb/optics.htm>  
[http://dir.yahoo.com/Science/Physics/Light\\_and\\_Optics/](http://dir.yahoo.com/Science/Physics/Light_and_Optics/)  
<http://camillasenior.homestead.com/optics4.html>






# Unit 3 - Light and Optical Systems


## 1.0 Our knowledge about light and vision comes from explanations, inventions & investigations

**1.1 A Challenge of Light** ( pgs. 176-181 ) - Timeline History of Views about Light & Astronomy


Ancient Times

- [China] - used mirrors
- [Greece]
-  *Archimedes* - planned for the use mirrors in war
-  *Pythagoras* - thought light was beams of light coming from our eyes
-  *Euclid* - light was reflected  
- light travels in straight lines


1<sup>ST</sup> Century

-  *Ptolemy* – Light bends when it travels from air to glass


1000 AD (Middle Ages)

-  *Al-Haythem* – wrote a book to help explain optics, being the first to accurately describe how vision worked


1670

-  *Isaac Newton* – showed that white light is a mixture of different colors of light

1676

-  *Ole Romer* – determined the speed of light

1920's


-  *Albert A. Michelson* – was able to determine more accurately the speed of light

**Properties of Light**



- Light travels in straight lines
- Light can be reflected
- Light can be bent
- Light is a form of Energy

**1.2 Optical Devices** ( pgs. 182-186 ) - Timeline History of Optical Instruments


1300 AD

-  *Alessandra della Spina* – wore the 1<sup>st</sup> pair of eyeglasses



1595

-  *Zacharias Jansen* – built the 1<sup>st</sup> microscope 


17<sup>th</sup> Century

-  *Antonie van Leeuwenhoek* – credited with the discovery of cells using a very simple microscope

1600

-  *Galileo Galilei* – invented the **refracting** telescope
-  *Isaac Newton* invented the **reflecting** telescope

1854

-  *Ignatio Porro* – prism erecting system (simple binoculars)

1985

- 1<sup>st</sup> Endoscope used

1990

- Hubble Space Telescope* – named after Edwin Hubble – who's notion of an "expanding" universe formed the basis of **the Big Bang theory** <http://hubblesite.org/>

## Light and Optical Systems – Section 1 Quiz

### 1.1 The Challenge of light

1. **Archimedes'** plan to sink enemy war ships demonstrated his understanding of this principle of light

...

- A. Light travels in straight lines
- B. Light can be reflected
- C. Light can be bent
- D. Light is a form of energy

2. **Pythagoras'** thoughts about light were proven wrong because it was impossible to see ...

- A. the light beams
- B. dark objects
- C. in the dark
- D. shiny objects

3. When light is shone into a mirror, the angle of the incoming beam is equal to the angle of the outgoing beam. This understanding of light was suggested by ...

- A. Ptolemy
- B. Aristotle
- C. al-Haytham
- D. Euclid

4. **Sir Isaac Newton** is well known for many things. One thing that he showed was that white light is actually a mixture of different colors. He was able to demonstrate this by shining a light through ...

- A. prism
- B. water
- C. glass
- D. mirror

5. **Albert A Michelson** was able to accurately measure the speed of light by using mirrors on a mountain top. This was a refined measurement of the work of ...

- A. Albert Einstein
- B. Ole Romer
- C. Euclid
- D. Isaac Newton

### 1.2 Optical Devices

6. Any technology that uses light is called ...

- A. a reflecting telescope
- B. a refracting telescope
- C. an optical device
- D. a lens and mirror

7. **Antonie van Leeuwenhoek** used a simple microscope and discovered, what he called ...

- A. little animalcules
- B. tiny cells
- C. miniature vacuoles
- D. bacteria armies

8. **Microbiology** - the study of micro-organisms, began with the invention of these ...

- A. binoculars
- B. telescopes
- C. mirrors
- D. microscopes

9. In 1608 **Hans Lippershey** manufactured the very first telescope. This scientist used the discovery of the telescope to discover mountains and craters on the Moon, small objects circling Jupiter, and Venus had phases – just like the Moon. This scientist was ...

- A. Edwin Hubble
- B. Galileo Galilei
- C. Sir Isaac Newton
- D. Alessandro della Spina

10. The type of telescope that collects light from distant objects and focuses it in the eyepiece is called ...

- A. retracting
- B. reflecting
- C. refracting
- D. resisting

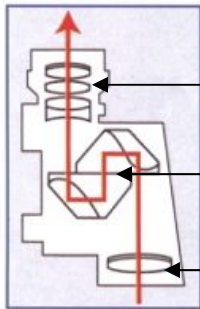
11. Binoculars are optical devices and are built using two of these types of prisms ...

- A. retracting
- B. reflecting
- C. refracting
- D. resisting

12. The properties of light include all of the following EXCEPT ...

- A. Light can go around a corner
- B. Light can bend
- C. Light can be reflected
- D. Light is a form of energy

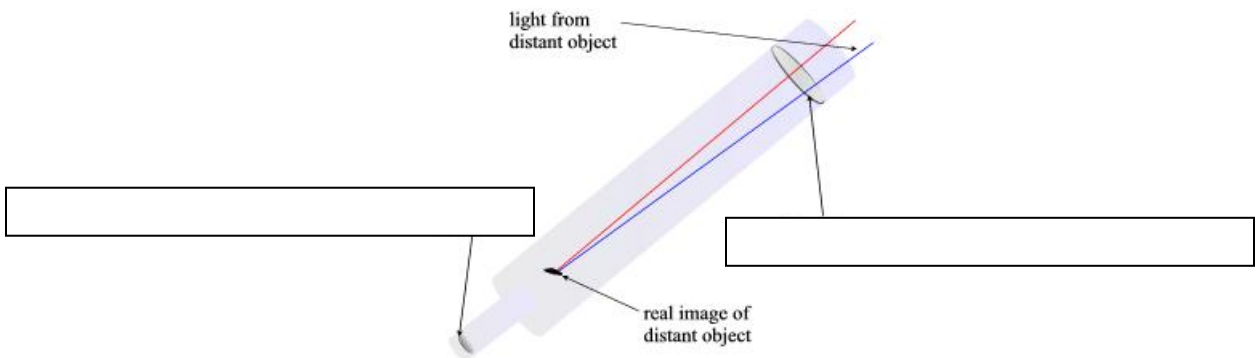
Label parts of the following: (*Illustration 1 – Binoculars* ..... *Illustration 2 – Refracting telescope*)



\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

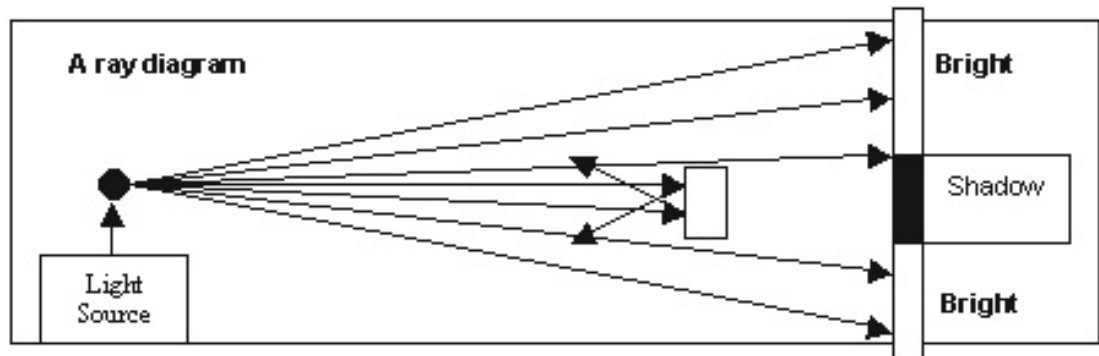


## 2.0 Light behaves in predictable ways.

### 2.1 Light Travels in Rays and Interacts with Materials ( pgs. 188-193 )

#### Ray Diagrams

'Light travels in straight lines.' Because of this principle, the ray model of light can help to explain certain properties of light. A ray is a straight line that represents the path of a beam of light. Ray diagrams can help to demonstrate brightness or intensity of light through changes in distance. The ray model helps to explain how shadows can be formed when an object blocks the ray of light.



#### Light Interacts with Materials

Light travels in straight lines until it strikes a surface.

The type of surface the light hits will determine how the light will continue.

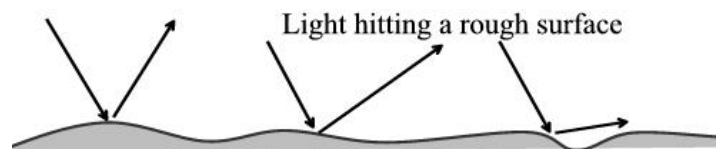
If a surface is **translucent**, light passes through it but is diffused so that one cannot see clearly the details of whatever is on the other side (*a frosted glass window is translucent*). If a surface is **transparent**, light passes through it nearly or wholly undiffused, so that one can see clearly the details of whatever is on the other side (*an ordinary glass window is transparent*). A surface that permits no light to pass through it is **opaque**; you can see nothing through it at all (*a door is opaque*).

**Luminous** objects give off light (they are light sources).

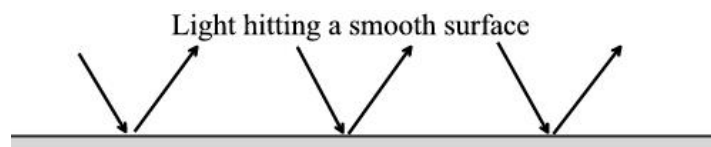
**Non-luminous** objects do not.

#### Types of Reflection

**Diffuse reflection** occurs **If light hits a rough or uneven surface, the light is scattered.**

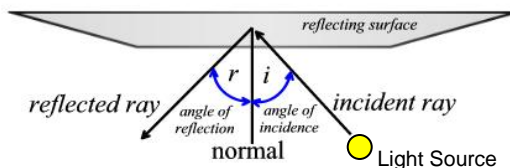


When light hits a smooth surface **regular reflection** occurs, **the light reflects at an opposite angle to the angle it hits.**



## 2.2 The Law of Reflection ( pgs. 194-196 )

Reflection is the process in which light strikes a surface and bounces back off that surface. How it bounces off the surface depends on the **Law of Reflection** and the type of surface it hits. Light coming from a light source is called an **incident ray** and the light that bounces off the surface is called a **reflected ray**. A line that is perpendicular ( $90^\circ$  with the surface) to the plane mirror is called the **normal line**. The angle between the incident ray and the normal line is called the **angle of incidence ( $i$ )**. The angle between the reflected ray and the normal line is called the **angle of reflection ( $r$ )**.



The Law of reflection states that:

**the angle of incidence equals the angle of reflection**

the incident ray, the normal line and the reflected ray all lie in the same **plane** (an imaginary flat surface)

Figure 2.12 p. 196

## 2.3 Reflecting Light with Curved Mirrors ( pgs. 197-199 )

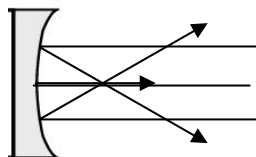
An image is formed in a mirror because light reflects off all points on the object being observed in all directions. The rays that reach your eye appear to be coming from a point behind the mirror. Because your brain knows that light travels in a straight line, it interprets the pattern of light that reaches your eye as an image of an object you are looking at.

This (EXCELLENT) site shows an **animation** of how an image is formed in a mirror.

<http://www.glenbrook.k12.il.us/gbssci/phys/Class/refln/u13l2a.html>

(Figure 2.13 in the Science in Action Textbook shows how an image in a mirror can be distorted.)

Mirrors that **cave in** are called **Concave mirrors**

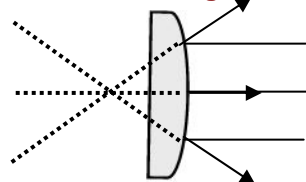


Concave mirrors form an image that appears to be closer than it actually is and can be useful because it can also reflect light from a large area

Focal point is in front of mirror

security devices, flashlights, telescopes,  
cosmetic mirrors and car headlights

Mirrors that **bulge out** are called **Convex mirrors**



Convex mirrors form images that appear much smaller and farther away than the object - but they can reflect light from a large area

Focal point is in behind mirror

rear-view mirrors and side mirrors on automobiles



**2.4 Transparent Substances Refract Light** ( pgs. 200-203 )

**Refraction** is the process in which light is bent, when it travels from one medium to another. Light bends because it changes speed when it moves through materials that have different densities. The bending of light makes the object's image appear to be in a different position than it really is.

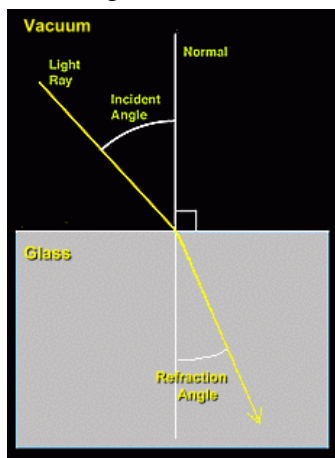


This site shows the angles of how a fish should be caught with a spear.  
(VERY Detailed Explanation)

<http://www.glenbrook.k12.il.us/gbssci/phys/Class/refln/u13l2a.html>

**Light travels slower in materials that are denser, because there are more particles.**

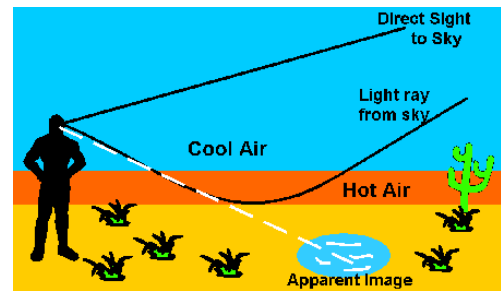
**How Light Refracts**



The **Law of Refraction** states that when light travels from one medium, to a more dense medium, the light will be bent **toward** the normal, and when it exits the denser medium into a less dense medium it will bend **away** from the normal. The new direction of light is called the **angle of refraction**.

**Mirage**

Refraction can also occur when light travels through air at different temperatures, because warm air is less dense than cold air. The refraction of light through air is called a **mirage**.



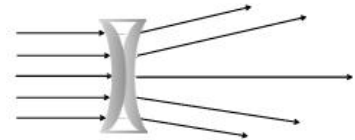
What happens when light strikes a surface?

Type of behavior	What happens to light striking a surface	Nature of surface	What else happens?
Absorption	Energy Transformation	rough, dark, opaque	some light is reflected
Reflection	Bounces off	smooth, shiny	some light is absorbed
Refraction	Travels through in a new direction	different transparent medium	some light is reflected

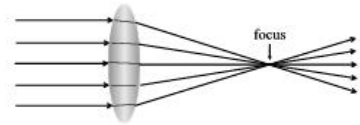
**2.5 Lenses Refract and Focus Light** ( pgs. 204-208 )

A **lens** is a curved piece of transparent material (glass/plastic).  
When light rays pass through it, the light is refracted, causing the rays to bend.

A **double concave lens** is thinner and flatter in the middle than the edges.  
Light passing through the thicker more curved areas of the lens will bend more than light passing through the thinner areas, causing the light to spread out or **diverge**.



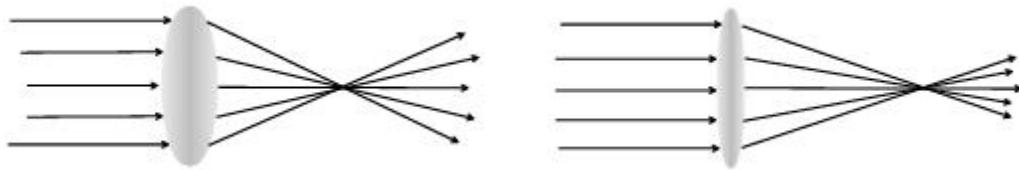
A **double convex lens** is thicker in the middle than around the edges.  
This causes the light to come together at a focal point, or **converge**.



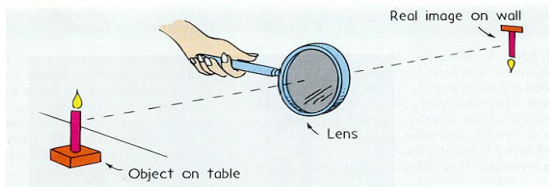
**Lenses and Mirrors**

Lenses are useful optical devices. Eyeglasses, have been made from lenses since the thirteenth century. A convex lens refracts the light rays from an object so they can be focused.

Different size lenses can converge the light rays at different distances, enabling corrections to be made to focal points.

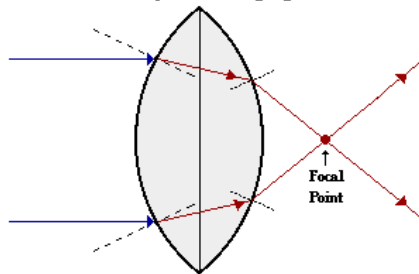


However, light from the left portion of the object is directed to the right and the light from the top is directed to the bottom. This **inverts** the image. Overhead projectors and film projectors do this.



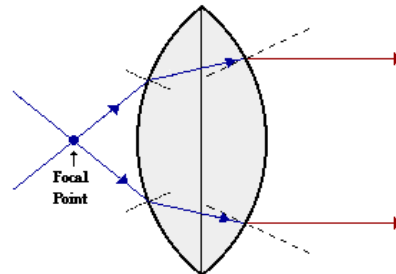
**Image Formation With A Convex Lens**

Refraction by a Converging Lens



Incident rays which travel parallel to the principal axis will refract through the lens and converge to a point.

Refraction by a Converging Lens



Incident rays which travel through the focal point will refract through the lens and travel parallel to the principal axis.

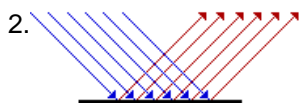
The formation of an image with a double convex lens depends on where the object is placed and the orientation of the light source.

## Light and Optical Systems – Section 2 Quiz

### 2.1 Light Travels in Rays and Interacts With Materials

1. When light travels, it does so in straight lines. What creates a **shadow**?

- A. The absence of a light source
- B. The bending of light
- C. The reflection of light
- D. The refraction of light



This illustration demonstrates how light travels and is referred to as a ...

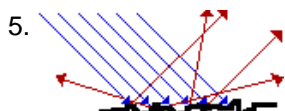
- A. light sketch
- B. light diagram
- C. ray sketch
- D. ray diagram

3. When light interacts with a substance, different things can happen to the light because of the type of material it is made of. Opaque materials do this to light ...

- A. refract
- B. transmit
- C. block
- D. diffuse

4. When a light bulb in a lamp receives electrical energy, it will produce light. The term that is used to indicate that the light source produces light is ...

- A. brilliant
- B. electricity
- C. luminous
- D. intensity



This illustration demonstrates a type of reflection referred to as ...

- A. regular
- B. crooked
- C. diffuse
- D. spectacular

### 2.2 The Law of Reflection

6. Reflection is the process in which light strikes a surface and bounces off that surface. The reflected ray will bounce back directly to the light source if it is lined up with the ...

- A. incident ray
- B. reflected ray
- C. normal line
- D. reflecting surface

7. To discover the laws of reflection it is necessary to use a ...

- A. ray box
- B. plane mirror
- C. reflective material
- D. normal line

8. In stating the law of reflection, that ***the angle of incidence equals the angle of reflection*** it is necessary to understand that this is a law because ...
- A. a scientist has stated it
  - B. this relationship happens most of the time
  - C. this relationship always happens
  - D. science is always accurate and precise
9. When you attempt to focus an image on a screen, using a concave mirror, but cannot, yet, you can see an image when you are looking into the same concave mirror, the image is called a ...
- A. convex distortion
  - B. concave image
  - C. virtual image
  - D. reflected distortion

### 2.3 Reflecting Light with Curved Mirrors

10.



***Funhouse mirrors*** distort the image you are looking at. The only practical purpose for mirrors of this type is for entertainment purposes

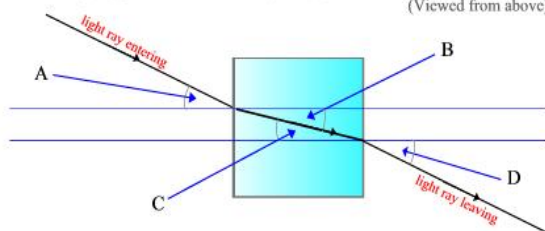
A mirror curved outward only once however, can have many practical applications and is called a ...

- A. bubble mirror
  - B. convex mirror
  - C. concave mirror
  - D. plane mirror
11. When parallel rays of light hit the surface of this type of mirror, they are reflected back to a focal point in front of the mirror. The type of mirror that does this is called a ...
- A. bubble mirror
  - B. convex mirror
  - C. concave mirror
  - D. plane mirror
12. Cosmetic mirrors, flashlights, reflecting telescopes, and the headlights in a car are all examples of practical applications for these type mirrors ...
- A. bubble mirror
  - B. convex mirror
  - C. concave mirror
  - D. plane mirror
13. If an object is placed far away from the focal point in a concave mirror, it will appear ...
- A. Upright and smaller
  - B. Upright and larger
  - C. Inverted and smaller
  - D. Inverted and larger
14. If an object is placed between the focal point in a concave mirror and the mirror itself, the image will appear ...
- A. Upright and smaller
  - B. Upright and larger
  - C. Inverted and smaller
  - D. Inverted and larger

### 2.4 Transparent Substances Refract light

15. Refraction is the bending of light when it travels from one medium to another. What direction does the light bend when it travels from a medium of greater density to one of lesser density?
- along the normal
  - along the perpendicular
  - towards the normal
  - away from the normal
16. When light is refracted, the angle of incidence increases and the angle of refraction ...
- depends on the intensity of the light
  - increases, depending on the material
  - decreases, but only by one half
  - increases by double
17. Mirages cause an illusion of a watery surface. This illusion is actually ...
- water drops reflecting the light
  - water drops refracting the light
  - the sky refracted by warm air
  - the sky reflected by warm air
18. When light strikes a surface and is absorbed, the light ...
- changes into another form of energy
  - bounces off in many different directions
  - travels through it in a different direction
  - happens only when it is a smooth shiny surface
19. During refraction, when the angle of incidence is doubled, the angle of refraction is ...
- also doubled
  - not necessarily doubled
  - decreased by the same amount
  - decreased by about half

20. Label the angles produced when a light ray goes through a refraction tank.  
(Viewed from above)



A is the angle of \_\_\_\_\_

B is the angle of \_\_\_\_\_

C is the angle of \_\_\_\_\_

D is the angle of \_\_\_\_\_

### 2.5 Lenses Refract and Focus Light

21. When light passing through a lens, the light is bent, causing the rays of light to diverge. The type of lens is a ...
- convex lens
  - concave lens
  - optic lens
  - diamond prism lens
22. When light rays pass through a convex, lens the image that is formed is ...
- diverted
  - converted
  - inverted
  - implied

### 3.0 Light is part of the Electromagnetic Spectrum and travels in waves. (\*\* Extension Material \*\*)

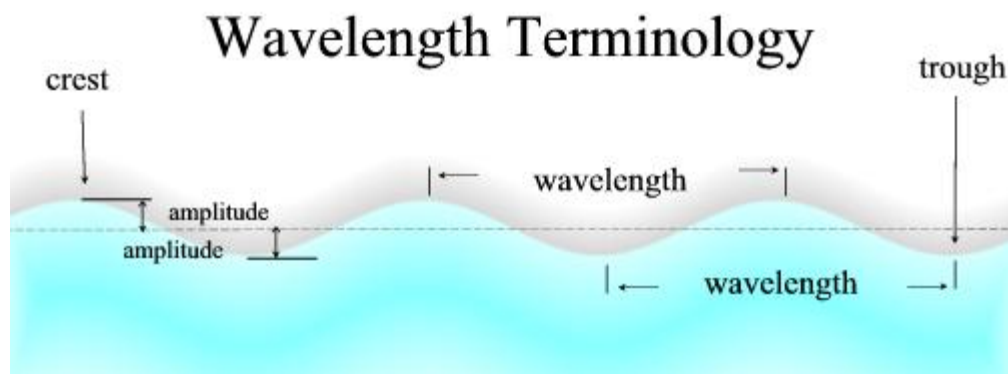
#### 3.1 The Wave Model of Light ( pgs. 212-215 )

The **wave model of light** pictures light traveling as a **wave**. It doesn't explain everything about how light behaves but it helps us visualize it. Thinking about light traveling in waves helps to explain unpredictable behavior, like when light curves around an opening. When light passes through a small opening, the waves spread out. If the wavelength is short, the waves spread out very little, whereas longer wavelengths spread out more. Wavelength is explored more in the labs for this topic.

#### Light Waves In Action

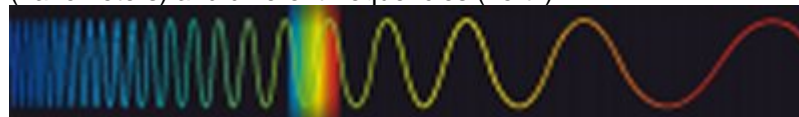
Sunsets can be explained using the wave model of light. As light waves from the sun travel through Earth's atmosphere, they strike particles of different sizes, including dust and other elements. The **longer wavelengths of the reds and oranges** tend to pass around these particles, whereas, the **shorter wavelengths of blue and violet**, strike the particles and reflect and scatter. At sunset, the light we see passes through about 700 kms of the Earth's atmosphere. There are many more particles in the atmosphere at this time of the day, due to the activity going on during the day - so many more blue and violet waves are reflected away. Red and orange are the vibrant colors we see at sunset.

When light passes through a small opening, it spreads out around each side of the opening. To explain this, Dutch scientist Christiaan Huygens (1629-1695) suggested that light travels in a wave, not as a stream of fast moving particles.



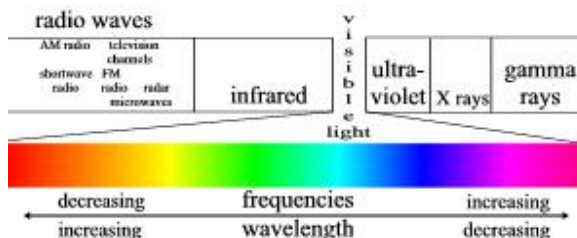
The high parts of the wave are called **crests**. The low parts of the wave are called **troughs**. The distance from crest to crest is called **wavelength** (the distance from one complete crest and one complete trough). The height of the crest or the depth of the trough from rest position is called the **amplitude**. The **Frequency** is the rate at which the crest and the trough move up and down. The number of cycles in a period of time - which is usually measured in **hertz**, or cycles per second.

Different colors on the electromagnetic spectrum have different wavelengths (nanometers) and different frequencies (hertz).



### 3.2 The Electromagnetic Spectrum ( pgs. 216-220 )

The sun is the most abundant source of direct natural light on the Earth. There are other forms of energy, invisible, that are also supplied by this source. The tiny band of visible light that we see is only part of the entire spectrum of light energy we receive. Called the electromagnetic spectrum, because the light waves, electrical and magnetic fields vibrate as they radiate to earth.



#### Applications Of Electromagnetic Radiation

Radiation is a natural part of our environment. Humans have always lived on earth in the presence of radiation. Natural radiation reaches earth from outer space and continuously radiates from the rocks, soil, and water on the earth. Background radiation is that which is naturally and inevitably present in our environment. Levels of this can vary greatly. People living in granite areas or on mineralized sands receive more terrestrial radiation than others, while people living or working at high altitudes receive more cosmic radiation. A lot of our natural exposure is due to radon, a gas, which seeps from the earth's crust and is present in the air we breathe.

Radiation is energy traveling through space. Sunshine is one of the most familiar forms of radiation. It delivers light, heat and suntans. We control its effect on us with sunglasses, shade, air conditioners, hats, clothes and sunscreen. There would be no life on earth without lots of sunlight, but we have increasingly recognized that too much of it on our persons is not a good thing. In fact it may be dangerous. So, we control our exposure to it. Sunshine consists of radiation in a range of wavelengths from long-wave infrared to shorter wavelength ultraviolet. Beyond ultraviolet are higher energy kinds of radiation which are used in medicine and which we all get in low doses from space, from the air, and from the earth. Collectively we can refer to these kinds of radiation as ion radiation. It can cause damage to matter, particularly living tissue. At high levels it is therefore dangerous, so it is necessary to control our exposure.

#### Radio Waves

If you could stretch the infrared wave out even further, so it became a few millimeters long, you could get radio waves. Radio waves are around us all the time. Radio waves have a longer wavelength and a lower frequency than visible light. Different types of radio waves have different uses. Signals from radio and television stations, cell phones and even distant stars pass through your body every day.

#### Remote Imaging Technologies

**LANDSAT** is a Canadian satellite that records how different parts of the light from the Sun reflect back to the satellite. It's most important use is for agriculture, monitoring crops for damage by disease, pests and drought.

**RADARSAT** is a Canadian telecommunications satellite, which, from time to time, sweeps the ground below it with radio waves, penetrating fog, haze, clouds and rain. Their reflection back to the satellite gives scientists information they can use in their studies of the Earth, monitoring ice floes, search possible sites for minerals, oil and natural gas, monitoring a flood, so that sandbagging efforts can be maximized where it is needed most.



**Microwaves** have the shortest wavelength and the highest frequency of the all the radio waves.

Microwaves have three characteristics that allow them to be used in cooking:

- they are reflected by metal;
- they pass through glass, paper, plastic, and similar materials;
- they are absorbed by foods.

Microwaves are used to detect speeding cars, to send telephone, satellite and television communications, and to treat muscle soreness. Industries use microwaves to dry and cure plywood, to cure rubber and resins, to raise bread and doughnuts, and to cook potato chips. But the most common consumer use of microwave energy is in microwave ovens. **Microwave ovens** have been regulated since 1971.

### Ultraviolet Radiation

Just beyond the **violet** part of the visible spectrum are wavelengths of about 200 nm., known as ultraviolet (UV) radiation. This radiation is very energetic. It causes tanning, but it can also do irreparable damage to us. *UV rays can damage the cornea of the eye (fogging which can lead to a slow loss of vision)*

In more recent years, more UV radiation is reaching us because the ozone layer in the atmosphere (which protects us from the damaging radiation by absorbing the UV rays) is being thinned. This thinning of the ozone layer is speeded-up by the use of aerosol sprays and Freon gas, which break up the ozone particles.

### Infrared Radiation

Red light has a wavelength of about 700 nanometers, but it could be stretched out to 100 nm, it would become heat radiation, or infrared radiation. It would become invisible to the eyes, but you could sense it with your skin. Anything that is warmer than its surroundings emit infrared rays.

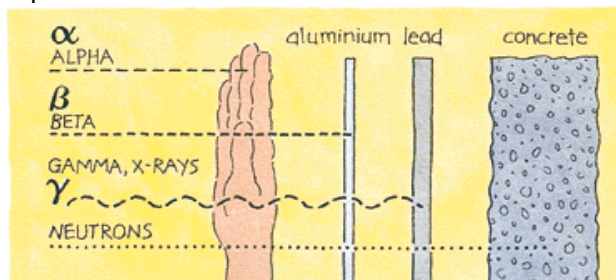
**Practical Applications** include:

- motion sensors
- burglar alarms
- heat lamps



### X-Rays

Even shorter wavelengths with higher frequencies are the X-rays. These waves pass through tissue (skin and muscle) and are absorbed by the bones. This radiation always stays in the bone and builds up over time. Therefore people who work as technicians taking the x-rays must protect themselves, by leaving the room where the xray is taken and also protect the patient's other areas of the body with lead vests to prevent over-exposure.



### Gamma Rays

Gamma rays have the shortest wavelength and the highest frequency of all the waves in the electromagnetic spectrum. Gamma rays result from nuclear reactions and can kill cells. This can be useful if the cells being destroyed are harmful - like cancerous cells. The cancerous growth of cells and tissue can be radiated, using gamma rays, and is known as **radiation therapy**.



**3.3 Producing Visible Light** ( pgs. 221-225 )

Simply stated, light is the form of energy you can see. This energy can be produced naturally by the sun or fire, or artificially by light-producing technologies, like batteries. Radiation is the wave like transfer of light from its source in all directions. Light is often called **radiant energy**. Light from the sun is formed by nuclear fusion.

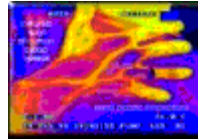
**The First Basic Principle of Light**

'Light is a form of energy' When light reaches a surface, it can be absorbed and transformed into other types of energy.

... into electrical energy    ... into thermal energy    ... into chemical energy



**Solar cells change light into electricity**



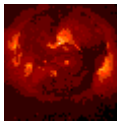




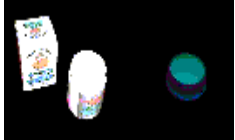

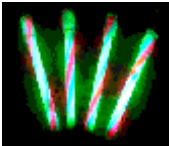
**Cameras change light into thermal images**



**Trees convert light energy into food (chemical energy)**

The amount of energy a surface receives depends on the intensity of the light. The more intense the light, the more light can be absorbed.

**Sources of Light**

Natural Light Sources		Artificial Light Sources	
Sun		<b>Incandescent</b> (heat causing a filament of metal to glow - visible light)	
Electrical energy ---» Thermal energy ---» Visible light energy			
Candles or Oil Lamps		<b>Florescent</b> (ultraviolet light is absorbed by fabric particles, which in turn emit some of the energy as light - glowing)	
Ultraviolet light ---» Energy absorbed ---» Visible light energy/particles energy			
Wood (fire)		<b>Phosphorescent</b> (light energy is stored and released later as visible light)paint	
Bioluminescence(light produced by living organisms)	 firefly light	<b>Chemiluminescent</b> (light energy released by chemical reactions)glow sticks <b>Chemiluminescence</b> Movies (Shockwave/Flash)	
UV Light Technologies Light and Color		Chemical energy ---» Visible light energy	

Other sources of Light Energy can come from the Earth's minerals including:  
**THERMOLUMINESCENCE** and **TRIBOLUMINESCENCE**

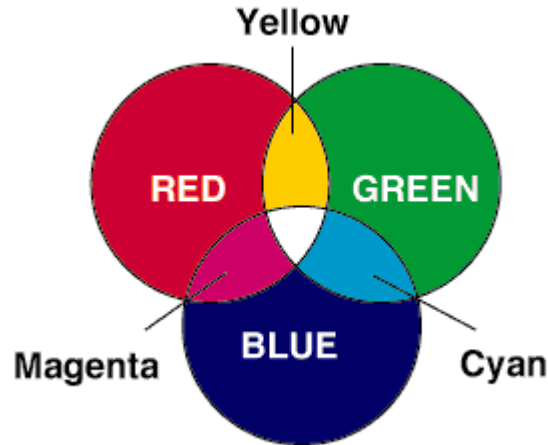
This subsection of **Section 2** is no longer part of the curriculum – Enrichment only

**3.4 The Colors of Light** ( pgs. 226-227 ) (Color is no longer in the required Curriculum – Extension)



The various colors of the **visible spectrum** have slightly different wavelengths and refract by a slightly different amount.

The **Primary colors** of the visible spectrum are **red, green and blue**.



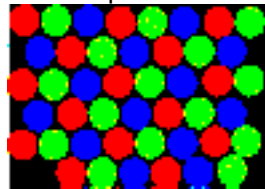
By mixing the correct intensities of the primary colors, you will observe white light.

Secondary colors are cyan, magenta and **yellow**.

The mixing of three colors of light to produce many different colors of light is called the **theory of color addition**.

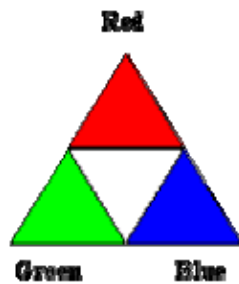
**Television**

Television puts this theory of color addition into practice.



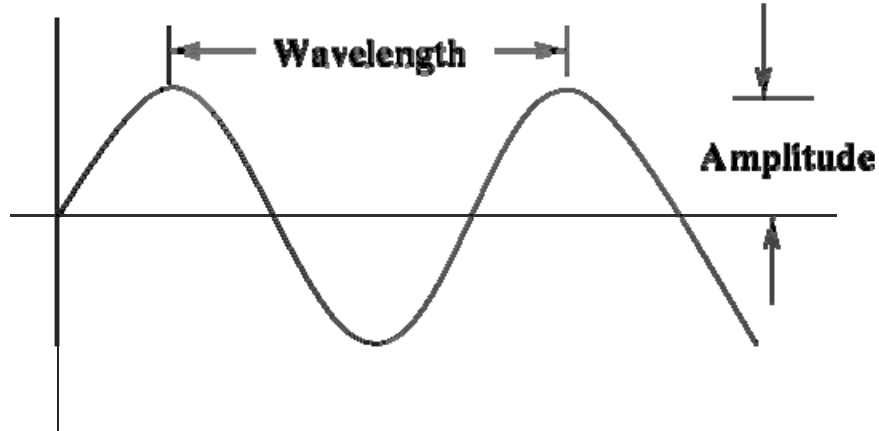
By changing the brightness of the dots that make up the screen many different colors can be produced.

The television works by fooling the eye into seeing colors that are not really there.

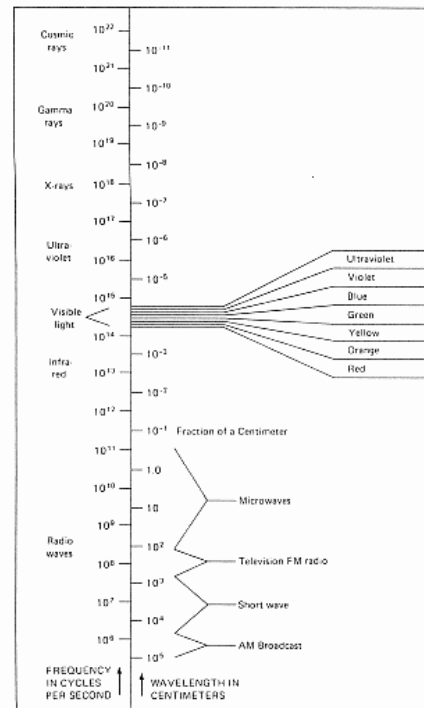


## Light and Optical Systems – Section 3 Quiz

### 3.1 The Wave Model of Light



- The highest point of the wave is called the crest. The lowest point is called the ...
  - trench
  - trough
  - valley
  - slope
- There are two ingredients in the atmosphere that are needed to make a rainbow appear. They are ...
  - heat and water
  - sunlight and raindrops
  - fog and warm air
  - sunlight and heat
- All waves have a wavelength. When a wavelength lengthens, the number of waves that are produced decreases. We can also say that this decreases as well
  - crest
  - trough
  - amplitude
  - frequency
- When sunlight is passed through a prism we are able to see the visible colors of ...
  - refraction
  - reflection
  - white light
  - the prism
- The visible light spectrum allows us to see all the colors of light, because each color has a different wavelength and frequency. The color that has the lowest frequency is ...
  - red
  - green
  - yellow
  - violet



**3.2 The Electromagnetic Spectrum**

6. The invisible spectrum has wavelengths that cover a very large range of electromagnetic radiation. This type of electromagnetic energy can burn your skin, even though most of it is absorbed by ozone in the Earth's atmosphere ...
- A. infrared**
  - B. microwave**
  - C. ultraviolet**
  - D. x-ray**
7. The only type of radiation which can penetrate solid material and concrete walls is ...
- A. microwaves**
  - B. x-rays**
  - C. infrared waves**
  - D. gamma rays**
8. Radar is an acronym for *radio detection and ranging*. These devices send out waves, which bounce off objects and return (obeying the law of reflection). Older radar devices used radio waves, whereas modern radar devices use ...
- A. microwaves**
  - B. ultraviolet waves**
  - C. infrared waves**
  - D. gamma rays**
9. Ultraviolet light can kill living cells in humans. If babies are born with a liver condition, which makes their skin yellow, they are placed under ultraviolet light to treat it. The skin condition is known as ...
- A. scurvy**
  - B. eczema**
  - C. jaundice**
  - D. atrophy**
10. Doctors use **MRI** (magnetic resonance imaging) machines to create pictures of the tissues inside the human body. The MRI machine uses these types of electromagnetic waves to produce images ...
- A. microwaves**
  - B. radio waves**
  - C. infrared waves**
  - D. X-rays**

**3.3 Producing Visible Light**

11. Thomas Edison was the first to design light bulbs in the late 1800's. They didn't last very long because he used this as the filament ...
- A. bamboo**
  - B. tungsten**
  - C. paper clip**
  - D. human hair**
12. A fluorescent light bulb is a glass tube that is filled with a small amount of gas, such as mercury vapour. The inside of the tube is coated with a white powder called ...
- A. fluorophor**
  - B. phosphor**
  - C. mercuricor**
  - D. incandescent**
13. Phosphorescence is slightly different from fluorescence. In phosphorescence, the energy that is used to produce the light is absorbed by the material and then given off later. These types of materials ...
- A. glow in the dark**
  - B. become natural light**
  - C. last longer than fluorescent light**
  - D. produce light and give off lots of heat**

14. Incandescent light bulbs produce 95% heat and only 5% visible light. Fluorescent light bulbs are much more efficient, because they produce 80% heat and ...
- A. 2 times as much light
  - B. 3 times as much light
  - C. 4 times as much light
  - D. 5 times as much light
15. When living organisms produce their own light it is called bioluminescence. The fire fly produces it's own light by using a light-producing organ on the under side of it's body, called a ...
- A. phosphortube
  - B. phosphorescent
  - C. phototube
  - D. photophore

Even though this subsection is not required, these questions will help you master the concept of color

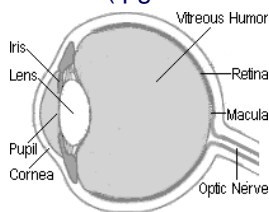
### 3.4 The Colors of Light

16. The **primary** colors of light are:
- A. red, yellow and blue
  - B. red, green and yellow
  - C. red, yellow and green
  - D. red, green and blue
17. The **secondary** colors of light are:
- A. cyan, green and yellow
  - B. cyan, magenta and orange
  - C. magenta, yellow and cyan
  - D. magenta, green and yellow
18. A television set puts the theory of color addition to practice. If you look closely at the screen, you will see that it is actually made up of rows of ...
- A. red, blue and yellow dots
  - B. blue, green and red dots
  - C. red, blue and yellow squares
  - D. blue, green and red squares

## 4.0 Eyes and Cameras capture images using the properties of light.

### 4.1 Image Formation in Eyes and Cameras ( pgs. 231-235)

There are many similarities between the human eye and the camera.



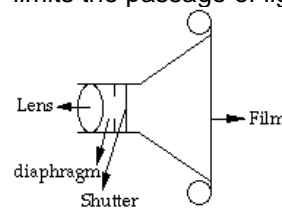
There is also a detailed color image of the eye in Science In Action (Figure 4.1, p. 231)

#### How Light Gets In

In order to adjust the amount of light that enters the eye and the camera, a special device opens and closes to let just the right amount of light in.

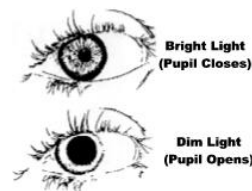
In the eye, the device (or part of the eye) that controls the amount of light entering is called the **iris** (the colored part of the eye), which changes the size of the **pupil** - in much the same way as the **diaphragm** controls the **aperture** (opening) of the camera lens. The natural adjustment in the size of the pupils is called the **iris reflex**, which is extremely rapid. This iris reflex action automatically adjusts the pupil when you go from a darkened area to a well-lit area, or, from a well-lit area to a darkened one.

In the camera, the **diaphragm** controls the **aperture** (opening) of the lens and the **shutter** limits the passage of light.



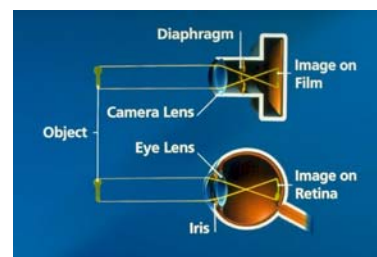
#### Parts of the Eye

<http://www.college-optometrists.org/public/eyeparts.htm>



#### When Light Gets Inside

In the eye, when the **photoreceptor cells** in the retina detect light (**rods** are highly sensitive to light and **cones** detect color), they produce small electrical impulses from the **retina** to the brain, by way of the **optic nerve**. The film at the back of the camera contains light sensitive chemicals, which change when light hits it. These chemicals form the image on the **film**.



The parts of a camera are housed in a rigid lightproof box, whereas layers of tissue hold the different parts of the eye together.

The eyeball contains fluids, called **humours**, which prevent the eyeball from collapsing and refract the light that enters the eye.

#### Focusing The Light

In a camera, if an object moves closer to the film, the lens must move away to keep the image in focus. In the human eye, the lens cannot move, so the **ciliary muscles** change the shape of the lens (by making the lens bulge in the middle if the image comes closer to you and stretch if the object is further away). This is done so that the eyeball isn't stretched. The process of changing the shape of the lens is called **accommodation**. As people become older, the lens stiffens and loses its' ability to change shape (doesn't bulge) and many people need to wear (convex lens) reading glasses, so that the images can be focused.

### Image Formation

The lens in the human eye is a convex lens, which focuses the light rays entering your eye to a point on your retina (a light sensitive area at the back of the eye). The image you see is formed on the retina. Some people however have eyes that are too long or too short.

If their eye is too long, the image forms in front of the retina - this is a condition called **Myopic, or near-sightedness** (they have trouble seeing distant objects).

If their eye is too short, the image forms behind the retina. This condition is called **Hyperopia or far-sightedness**. (objects that are close to them are difficult to see)



### Correcting Vision Problems With Lenses

Knowledge of how light behaves when it travels through **lenses** helps eye specialists correct vision problems. The shortest distance at which an object is in focus is called the **near point of the eye**. The longest distance is called the **far point of the eye**. On average, an adult has a near point of about 25 cm, whereas babies have a near point of only 7 cm. The far point is infinite (because you can see the stars).

### Laser Eye Surgery

Instead of wearing glasses many people are now opting to have an eye surgeon use a **laser** to correct a vision problem. The surgeon cuts a thin flap of tissue covering the eye, fold it over, then the cornea is reshaped with a laser. The reshaped cornea acts like a corrective lens, allowing the light to be bent so it will properly focus on the retina.

In 1966, Theodore H. Maiman, a physicist at Hughes Aircraft Company in California became the first person to use a process called ...

light **a**mplification by the **s**timulated **e**mmission of **r**adiation  
or **laser** light.

Incandescent lights give off many different colors and therefore have many different frequencies and wavelengths. The waves are jumbled and crests from one wavelength might overlap the trough of another, making the waves work against each other. This type of light is **incoherent**. Laser light is quite different. It gives off a single wavelength (frequency) of **coherent** light. Lasers have many useful **applications**:

- Scanners (bar codes in retail shops are scanned to give the price)
- Digitized data are read by a laser on a compact disk (CD)
- Lasers are used by law enforcement officers to detect the speed of vehicles.
- Laser light can be released in pulses or in a continuous beam. In either form, it is so powerful, that it can make precise cuts through metal and can also be used in surgery, as a scalpel - or, to instantly seal broken blood vessels, because it produces such intense heat.

### Night Vision Goggles

In night vision goggles, light is focused onto an image intensifier. Inside the intensifier, the light energy releases a stream of particles, which hit a phosphor-coated screen. These glow green and the person looking in the goggles can view a green image.





### Can you find your blind spot?

The point where the retina is attached to the optic nerve does not have any light sensitive cells. This point is known as the **blind spot**.

View this image at arm's length. Cover your right eye with your hand. Stare at **x**, slowly leaning closer to the image, until the dot disappears (when you reach your blind spot) and then reappears when you have passed your blind spot.



### 4.2 Other Eyes in the Animal Kingdom ( pgs. 236-238 )

<http://www.astc.org/exhibitions/eyes/introeyes.htm>

#### Camera Eyes

Eyes that have a cornea, a lens and a retina are called **camera eyes**. **Vertebrates** (animals with backbones) for the most part have camera eyes.



**Fish** have camera eyes with a perfectly round lens, which bulges out from the pupil, allowing it to see in practically every direction.

**Birds** have sharper vision than humans because they have five types of cones (humans have only 3), each sensitive to different wavelengths of light.

**Nocturnal animals** have eyes that collect as much light as possible because of their very large pupils. They also have a layer, called *tapetum lucidum*, inside their eye, which acts as a mirror. They also have many more rods than cones in their retina making their eyes more sensitive to low levels of light.

[http://www.ski.org/CWTyler\\_lab/Eyepage/index.html](http://www.ski.org/CWTyler_lab/Eyepage/index.html)

#### Compound Eyes

Insects and crustaceans have **compound eyes**. Each eye is made up of many smaller units called **ommatidium**. An ommatidium looks like a long tube with a lens on the outer surface, a focusing cone below it, and then a light sensitive cell below that.

The compound eye is great for spotting movement, but with so many lenses it is difficult to form a single **coherent** image. Instead it forms a **mosaic image** (much like a tv screen).



### 4.3 Image Storage and Transmission ( pgs. 239-244 )

Most information today is stored **digitally** (converted into numbers).

#### Stadium Images

The stadium image is made up of people holding different colored cards. Each card is assigned a seat based on the graphic representation of where the colors need to be to produce the correct effect.

This stadium image was one of many designed by college students from Caltech – even though their team was not in the **1961 Rose Bowl** – Read the story of how it stunned the world by clicking on the image



<http://www.museumofhoaxes.com/pranks/rosebowl.html>

#### Digital Images

Just as in the stadium image, a big picture made out of small colored squares, a digital image is a picture made up of smaller colored pieces called **pixels** (**picture elements**).

Each small pixel is assigned a place and is represented by a number. This long series of numbers can then be stored in the memory of a computer to be accessed at a later time.

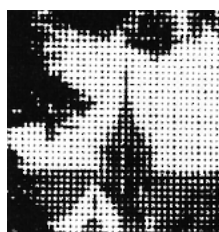
#### Coloring A Digital image

Once the individual pixels are in the correct order, each pixel is assigned a value, which corresponds to a specific color. When the picture gets reassembled, the computer reads the value of each pixel and makes that pixel the correct color.

#### Digital Image Quality

The quality of the digital image depends on the size of the pixels.

If the pixel is large you will see the image as a collection of small squares.



If the pixel is small you will not notice the squares.



The quality of the image is represented by its **resolution**. The more pixels there are in the image, the higher the resolution.

#### Capturing Digital Images

Scanners, digital video recorders, and digital cameras use a **charge-coupled device** (CCD) to capture the light. The CCD is a grid similar to graph paper. As the light enters each grid square it creates a small electrical charge, which is then converted into digital information and stored on a hard drive, compact disk or digital tape.

#### Transmitting Digital Images

Digital images can be sent over vast distances, without having to be processed. A powerful computer can convert the digital information very quickly. Digital imaging can also collect different parts of the electromagnetic spectrum, allowing infrared as well as visible images to be captured.

## Light and Optical Systems – Section 4 Quiz

Complete the comparison chart of the eye and the camera, using the illustrations/chart at the end of this quiz (5 marks)

### 4.1 Image Formation in Eyes and Cameras

1. The eye and the camera can be thought of as image-producing technologies. One (the eye) happens to be a **natural** technology, while the other (the camera) is a ...  
A. photo advancement  
B. film revolution  
C. artificial technology  
D. mechanical innovation
2. When making comparisons between the eye and the camera, different parts have similar functions. The hole in the human eye that lets light in is called the **pupil**, whereas the hole that lets light in the camera is called the ...  
A. diaphragm  
B. aperture  
C. shutter  
D. lens
3. The retina in the eye has a thin layer of cells that are light sensitive. These cells are called **photoreceptors**. There are two kinds of photoreceptor cells. The type that detect color are the ...  
A. rods  
B. cones  
C. pines  
D. iris
4. Surgeons use **laser surgery** to correct problems with vision. The doctor will use a laser to reshape this part of the eye ...  
A. iris  
B. pupil  
C. retina  
D. cornea
5. **Night vision** goggles or scopes are used to get images in the dark. A green image is formed on the screen because these glow green when light particles hit them ...  
A. photoreceptors  
B. phosphors  
C. photophors  
D. phosphates

### 4.2 Other Eyes in the Animal Kingdom

6. The human eye and most other vertebrates have eyes that can be compared to cameras. They are called camera eyes. Fish also have camera eyes, but instead of an **oval-shaped lens**, they have a ...  
A. convex lens  
B. concave lens  
C. flat lens  
D. round lens
7. Humans have **3 types of cones**, each sensing a different wavelength of light. Birds tend to have much sharper vision than humans because they have ...  
A. 4 types of cones  
B. 5 types of cones  
C. 6 types of cones  
D. 7 types of cones

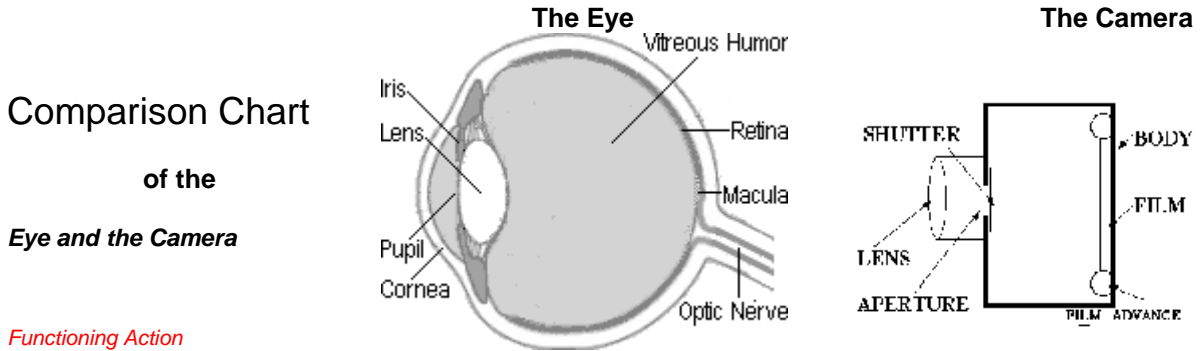
8. **Nocturnal** animals, such as cats and owls have very large pupils to allow them to collect as much light as possible. The purpose of the thin layer inside their eyes, called the **tapetum lucidum**, is to act as this inside their eye ...
- A. a magnifier
  - B. a mirror
  - C. a lens
  - D. a filter
9. An **ommatidia** is a long tube-like structure with a lens on the outer surface, a focusing cone below it and a light sensitive cell below that. Insect eyes have ommatidia facing in almost all directions because their eyes tend to have a ...
- A. round shape
  - B. flat shape
  - C. concave surface
  - D. convex surface
10. One drawback of the **compound eye** is that it has difficulty focusing a single, coherent sharp image. This is because of its ...
- A. round shape
  - B. oval shape
  - C. multiple lenses
  - D. 'mosaic' appearance

#### 4.3 Image Storage and Transmission

11. **Digital** information is stored by a computer converting the information into ...
- A. pictures
  - B. numbers
  - C. letters
  - D. symbols
12. The process of creating a big picture out of smaller pictures is similar to the process of digital imaging. The small elements that make up a picture are called **pixels**. The more pixels that make up a picture the higher the ...
- A. resolution
  - B. restoration
  - C. resolve
  - D. retention
13. CCD is a grid similar to a piece of graph paper. As light falls on a square of the grid, it creates a small amount of electricity in that square. This is then converted into digital information. **CCD** stands for ...
- A. Computer Charged Design
  - B. Capture Charge Device
  - C. Compact Charge Design
  - D. Charge Coupled Device
14. The greatest advantage to **digital imaging** is that the pictures don't have to be ...
- A. translated
  - B. recovered
  - C. processed
  - D. transmitted

**The Eye and the Camera have a lot in common.**

- They both have compound **lenses** - which are **converging lens** refracting the light to a focal point on the light sensitive layer to record an image.
  - To focus a camera you move the **lens** backward or forward.
  - The eye is focused by the **ciliary muscle**, which stretches the **lens**, changing its shape.
- To control how much light gets in.
  - The **iris** in your eye changes the size of the **pupil** - the dark spot in the center of your eye, which controls the amount of light that enters.
  - Cameras adjust to let different amounts of light in by using the **aperture** and the **shutter** controls how long the light is allowed to get through.
- The **retina** is like the **film** in a camera, covering the back of the eye.



*Functioning Action*

<b><i>The opening for light.</i></b>		
<b><i>Regulates the amount of light coming in.</i></b>		
<b><i>Focuses the refracted light.</i></b>		
<b><i>Light-sensitive layer that records images.</i></b>		

**Use these words to fill in the chart**

lens	shutter	film	retina
pupil	iris	lens	aperture

## REVIEW Outline

### Unit 3 – Light and Optical Systems

#### 1.0 Explanations, Inventions & Investigations about Light and Vision

- ❖ Scientific experiments to explain how light and vision work
- ❖ Optical devices – telescopes and microscopes – have led to astronomy and microbiology

#### 2.0 Light behaves in predictable ways

- ❖ Ray diagrams are used to describe light
- ❖ The Angle of Incidence equals the Angle of Reflection
- ❖ Concave mirrors converge light to a focal point (headlights)
- ❖ Convex mirrors diverge, or spread light out
- ❖ Refraction – light is bent when it passes to and from areas of different densities
- ❖ Concave and Convex lenses are optical devices that refract light to form images

#### 3.0 Electromagnetic Spectrum – Wave Theory

- ❖ Light has the properties of a wave
- ❖ Visible light has different wavelengths and forms the colors of the rainbow
- ❖ Electromagnetic spectrum also includes (invisible light) – radio waves, microwaves, infrared, ultraviolet, X-rays, gamma ray
- ❖ Radio waves carry the least energy – gamma rays the most energy
- ❖ Visible light can be produced naturally (bioluminescence, sunlight) & artificially (phosphorescence, incandescence and florescence)
- ❖ White light combines red light – green light – blue light

#### 4.0 Eyes and Cameras capture Images using Light Properties

- ❖ Similarities – designed to capture and focus light to form an image on a light-sensitive material
- ❖ Insects have compound eyes made of many tiny lenses
- ❖ Digital images are made by a computer, which converts the image to pixels (a set of numbers)

**1.0 Explanations, Inventions & Investigations about Light and Vision**

- Key Concepts
- Scientific experiments to explain how light and vision work
  - Optical devices – **telescopes** and **microscopes** – have lead to **astronomy** and **microbiology**

Outline a brief **Timeline History of Views about Light & Astronomy**

Ancient Times	
1 <sup>ST</sup> Century	
1000 AD (Middle Ages)	
1670	
1676	
1920's	



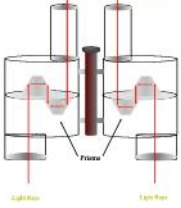
What are the four basic **properties of light**?

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

Outline a brief History of the **Invention of Optical Devices** <http://members.aol.com/WSRNet/D1/hist.htm>

1300 AD	
1595	
17 <sup>th</sup> Century	
1600	
1854	
1985	
1990	

Briefly outline the advantages of each Optical Device shown here

<b>Microscope</b>	<b>Telescope</b>	<b>Binocular</b>
		

**2.0 Light behaves in predictable ways.**

- Key Concepts
- Ray diagrams are used to describe light
  - The **Angle of Incidence** equals the **Angle of Reflection**
  - **Concave** mirrors **converge** light to a focal point (headlights)
  - **Convex** mirrors **diverge**, or spread light out
  - **Refraction** – light is bent when it passes to and from areas of different densities
  - **Concave and Convex lenses** are **optical devices** that refract light to form **images**

Use a **ray diagram** to show how light causes a **shadow**.

Explain the difference between **transparent**, **translucent** and **opaque** materials.

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What is meant by **luminous**?

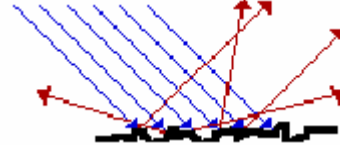
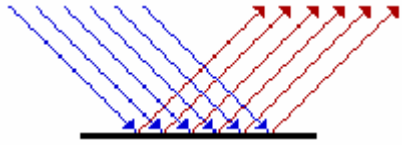
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What is meant by **non-luminous**?

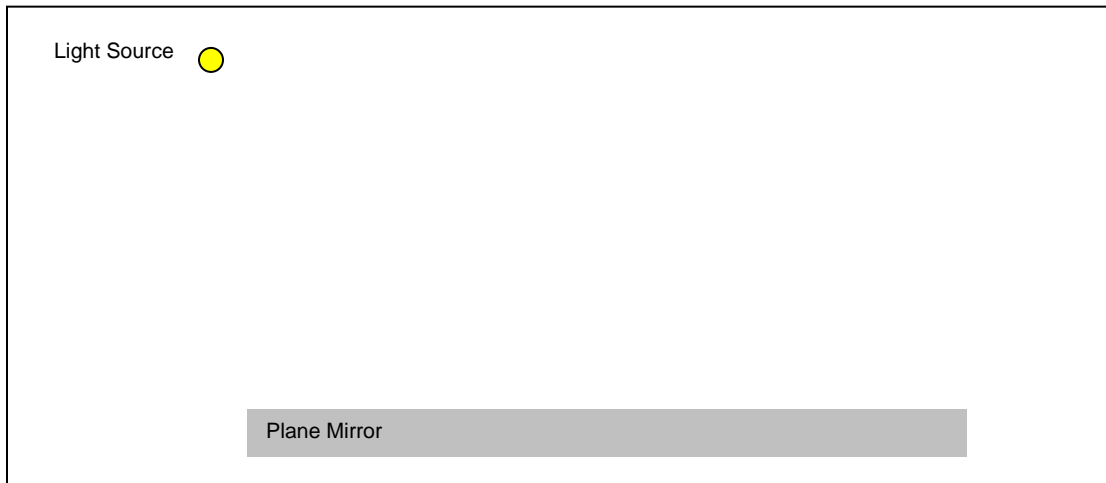
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Identify each of the following types of reflection



Illustrate the **Law of Reflection** and complete the statement below the illustration






The **Law of Reflection** states that \_\_\_\_\_

Illustrate with **ray diagrams** what happens when light strikes each of the following

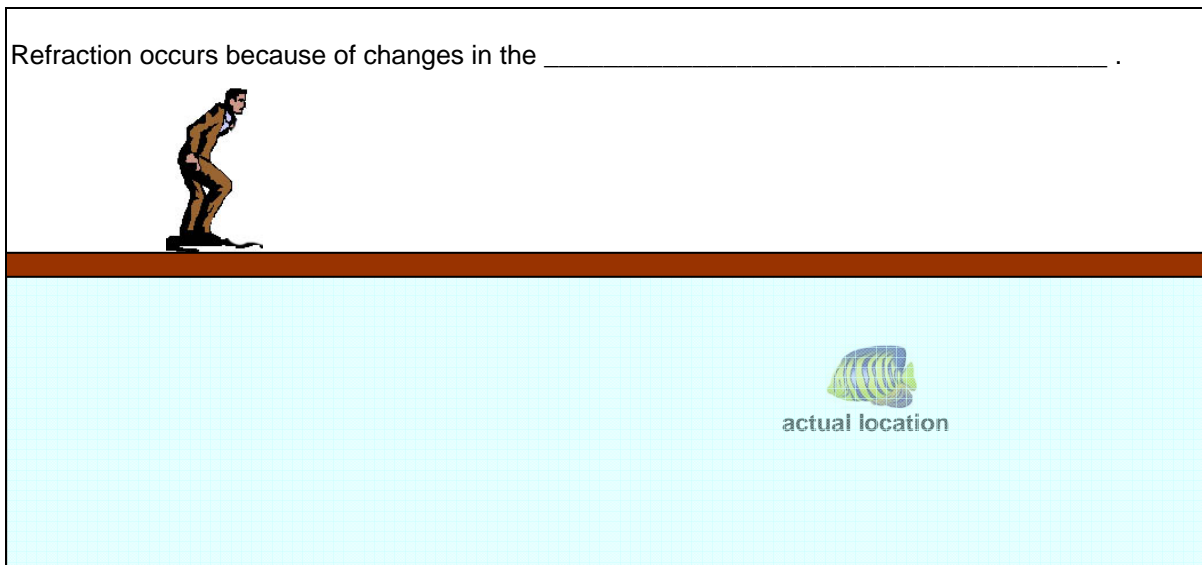
Concave Mirrors (p.197)	Convex Mirrors (p. 199)

Illustrate how an image is formed in a concave mirror

Concave Mirror Images (p.198)		
Object far from focal point	Object at focal point	Object between focal point and mirror
		

Illustrate the **Law of Refraction** and complete the statement

Refraction occurs because of changes in the \_\_\_\_\_ .



The **Law of Refraction** states that \_\_\_\_\_

\_\_\_\_\_

What is a **'Mirage'** and what causes it? \_\_\_\_\_

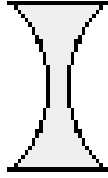
\_\_\_\_\_

\_\_\_\_\_

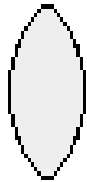
\_\_\_\_\_

**Lenses** refract light – Illustrate what happens to light passing through each lens and describe it below.

**Concave Lens**



**Convex Lens**



**Image Formation with a Convex lens** (p.208)

Object far from focal point	
Object near focal point	
Object between focal point and lens	

**3.0 Electromagnetic Spectrum – Wave Theory**

**Key Concepts**

- Light has the properties of a **wave**
- **Visible light** has different wavelengths and forms the colors of the rainbow
- Electromagnetic spectrum also includes (**invisible** light) – radio waves, microwaves, infrared, ultraviolet, X-rays, gamma ray
- Radio waves carry the least energy – gamma rays the most energy
- Visible light can be produced naturally (**bioluminescence, sunlight**) & artificially (**phosphorescence, incandescence** and **fluorescence**)
- White light combines red light – green light – blue light

Briefly explain the wave model of light? (Use the **wavelength** terminology provided)

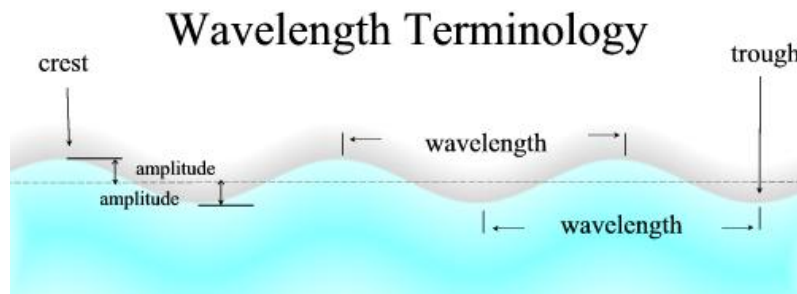
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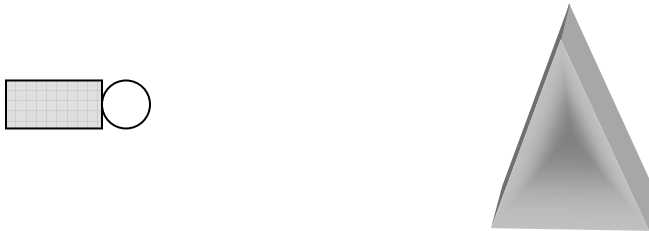
What is the mathematical relationship between the **speed**, **wavelength** and **frequency** of a wave?

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Illustrate (with colors) what happens to white light when it is passed through a **prism**?



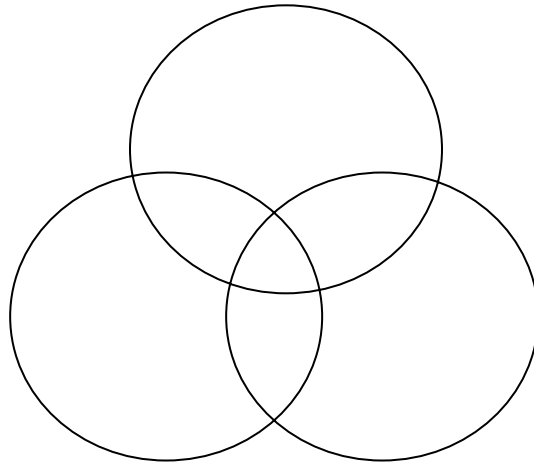
The **electromagnetic spectrum** shows us what different forms of energy are available to us. Use the table to illustrate and describe various uses of each form of electromagnetic energy.

Radio waves	Microwaves	Infrared waves	Ultraviolet Light (UV)	X-Rays	Gamma Radiation
<b>Practical Applications of Electromagnetic Radiation</b>					
	Radar Gun				

Sources of Light (pgs. 222-225) Identify the sources and give examples of each

Artificial Sources of Light	Natural Sources of Light

Identify the colors when added together produce white light?  
(by coloring the appropriate parts of the circles below)



What are the **Primary** colors of light?

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What are the **secondary** colors of light?

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What is the **Theory of Color Addition**?

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Briefly explain how a **television** works.

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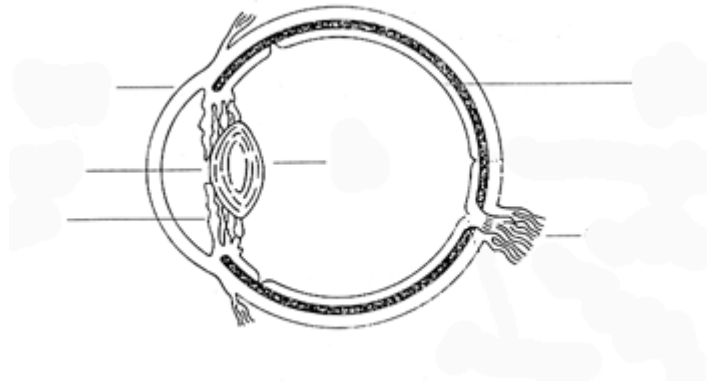
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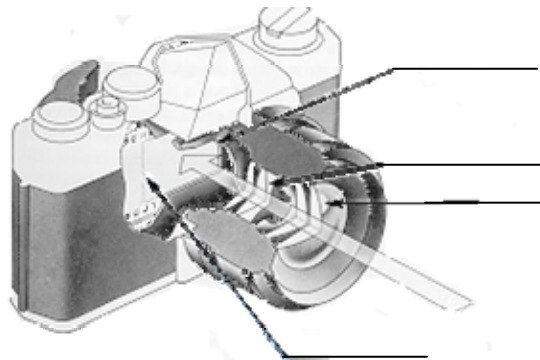
#### 4.0 Eyes and Cameras capture Images using Light Properties

- Key Concepts
- Similarities – designed to capture and focus light to form an image on a light-sensitive material
  - Insects have **compound eyes** made of many tiny lenses
  - Digital images are made by a computer, which converts the image to **pixels** (a set of numbers)

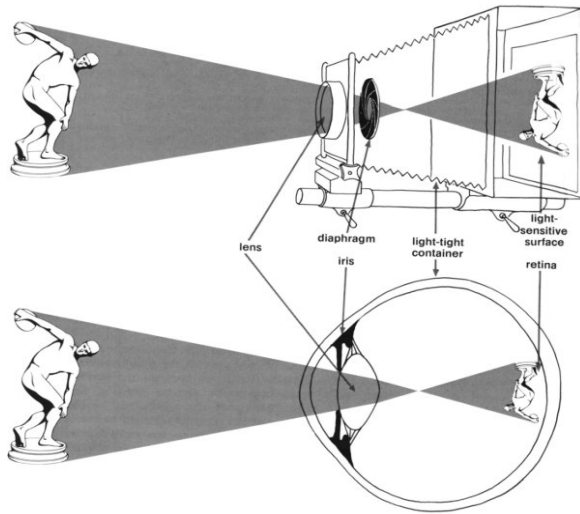
Label the parts of the eye



Label the parts of a camera



Explain how the eye and the camera are similar in what they do and how they do it.  
 (Use this illustration to help in your explanation)




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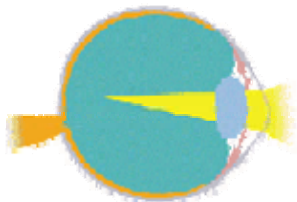
What is the function of the **ciliary muscles** in the eye?

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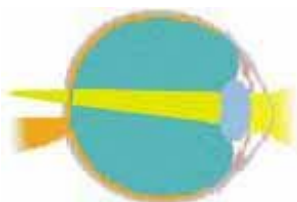
Illustrate with ray diagrams how vision problems can be corrected with lenses.

Normal Vision (Image formation)



Myopia

**Nearsightedness (Myopia)** corrected with Lens



Hyperopia

**Farsightedness (Hyperopia)** corrected with Lens

Explain how **night vision goggles** work.

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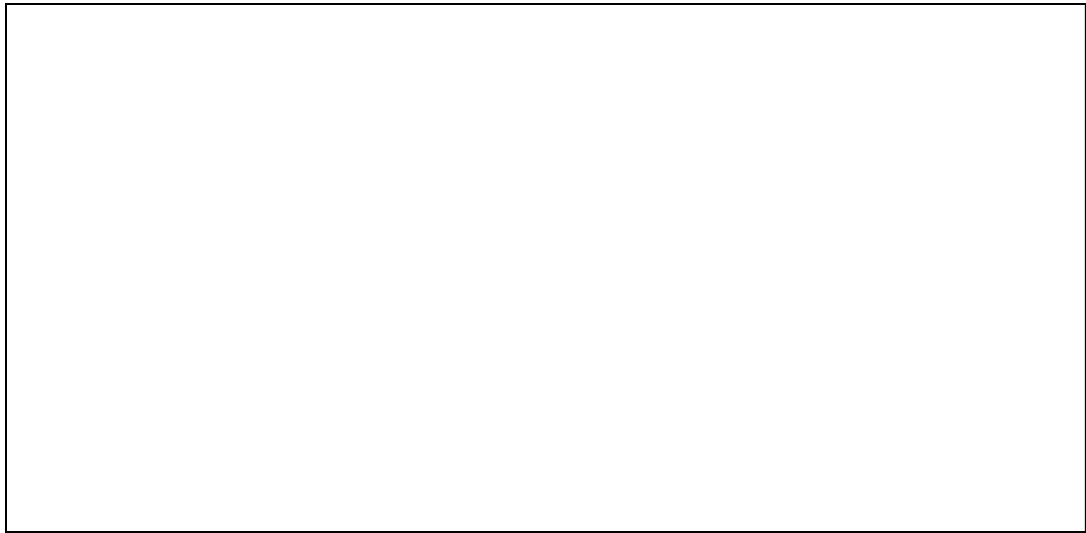
How can you find your **Blind Spot**? \_\_\_\_\_

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In what situation would it be useful to know where your **Blind Spot** is?

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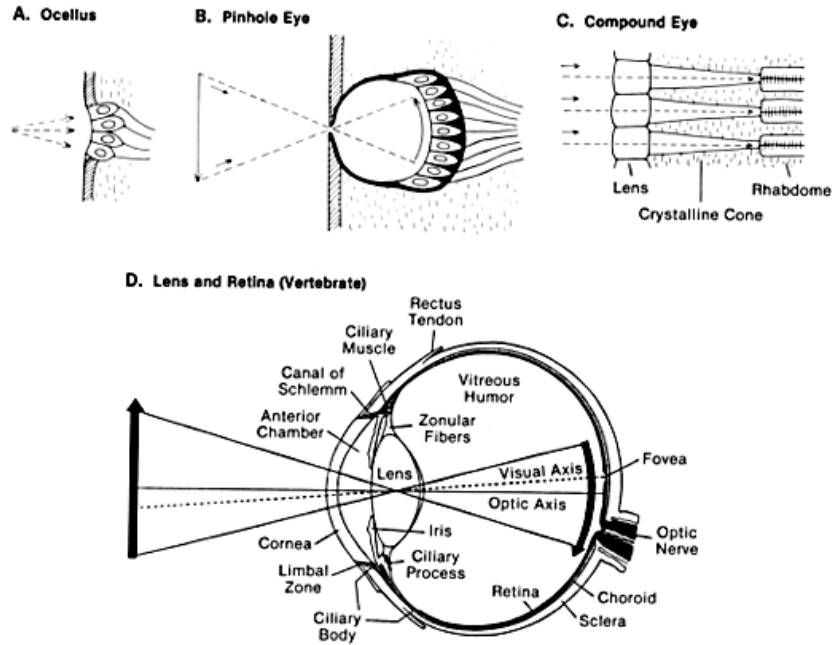
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Identify some Advantages and Disadvantages of each type and which animals would have a particular type.

### Types of eyes in the animal kingdom



Type of Eye	Advantage	Disadvantage	Animals

How is a **stadium image** made?

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What are **pixels** and **resolution**?

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## Light and Optical Systems Unit Test

### 1.1 The Challenge of light

1. **Pythagoras'** thoughts about light were proven wrong because it was impossible to see ...

- A.the light beams**
- B.dark objects**
- C.in the dark**
- D.shiny objects**

2. **Sir Isaac Newton** is well known for many things. One thing that he showed was that white light is actually a mixture of different colors. He was able to demonstrate this by shining a light through ...

- A.prism**
- B.water**
- C.glass**
- D.mirror**

3. **Albert A Michelson** was able to accurately measure the speed of light by using mirrors on a mountain top. This was a refined measurement of the work of ...

- A.Albert Einstein**
- B.Ole Romer**
- C.Euclid**
- D.Isaac Newton**

### 1.2 Optical Devices

4. Any technology that uses light is called ...

- A.a reflecting telescope**
- B.a refracting telescope**
- C.an optical device**
- D.a lens and mirror**

5. **Microbiology** - the study of micro-organisms, began with the invention of these ...

- A.binoculars**
- B.telescopes**
- C.mirrors**
- D.microscopes**

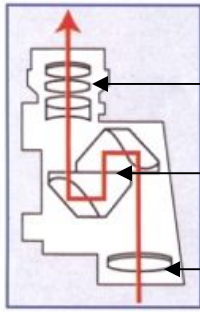
6. The type of telescope that collects light from distant objects and focuses it in the eyepiece is called ...

- A.retracting**
- B.reflecting**
- C.refracting**
- D.resisting**

7. Binoculars are optical devices and are built using two of these types of prisms ...

- A.retracting**
- B.reflecting**
- C.refracting**
- D.resisting**

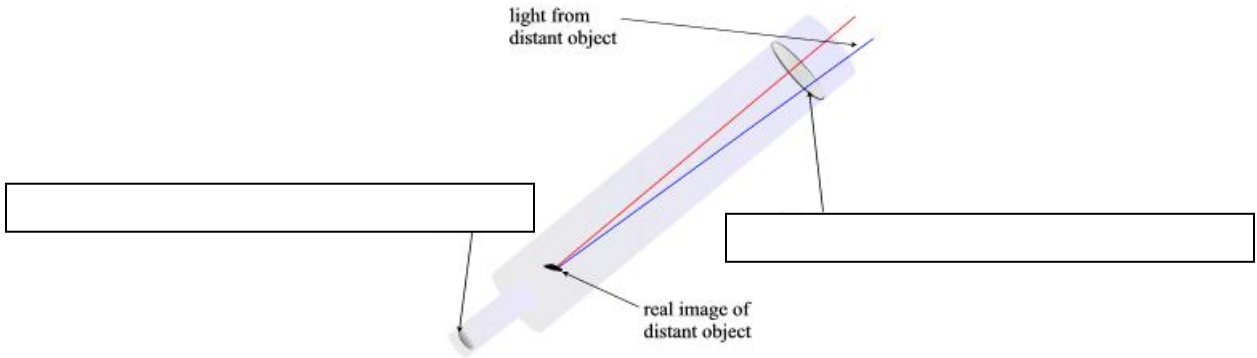
Label parts of the following: (*Illustration 1 – Binoculars* ..... *Illustration 2 – Refracting telescope*)



\_\_\_\_\_

\_\_\_\_\_

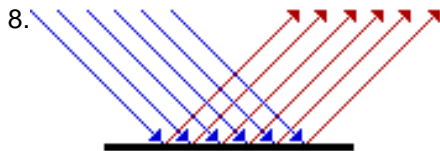
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\_\_\_\_\_

**2.1 Light Travels in Rays and Interacts With Materials**

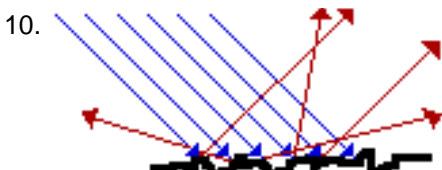


This illustration demonstrates how light travels and is referred to as a ...

- A. light sketch
- B. light diagram
- C. ray sketch
- D. ray diagram

9. When a light bulb in a lamp receives electrical energy, it will produce light. The term that is used to indicate that the light source produces light is ...

- A. brilliant
- B. electricity
- C. luminous
- D. intensity



This illustration demonstrates a type of reflection referred to as ...

- A. regular
- B. crooked
- C. diffuse
- D. spectacular

**2.2 The Law of Reflection**

11. Reflection is the process in which light strikes a surface and bounces off that surface. The reflected ray will bounce back directly to the light source if it is lined up with the ...
- A. incident ray**
  - B. reflected ray**
  - C. normal line**
  - D. reflecting surface**
12. In stating the law of reflection, that *the angle of incidence equals the angle of reflection* it is necessary to understand that this is a law because ...
- A. a scientist has stated it**
  - B. this relationship always happens**
  - C. science is always accurate and precise**
  - D. this relationship happens most of the time**
13. When you attempt to focus an image on a screen, using a concave mirror, but cannot, yet, you can see an image when you are looking into the same concave mirror, the image is called a ...
- A. virtual image**
  - B. concave image**
  - C. convex distortion**
  - D. reflected distortion**

**2.3 Reflecting Light with Curved Mirrors**

14. When parallel rays of light hit the surface of this type of mirror, they are reflected back to a focal point in front of the mirror. The type of mirror that does this is called a ...
- A. bubble mirror**
  - B. convex mirror**
  - C. concave mirror**
  - D. plane mirror**
15. Cosmetic mirrors, flashlights, reflecting telescopes, and the headlights in a car are all examples of practical applications for these type mirrors ...
- A. plane mirror**
  - B. bubble mirror**
  - C. convex mirror**
  - D. concave mirror**
16. If an object is placed between the focal point in a concave mirror and the mirror itself, the image will appear ...
- A. Upright and smaller**
  - B. Upright and larger**
  - C. Inverted and smaller**
  - D. Inverted and larger**

**2.4 Transparent Substances Refract light**

17. Refraction is the bending of light when it travels from one medium to another. What direction does the light bend when it travels from a medium of greater density to one of lesser density?
- A. along the normal**
  - B. along the perpendicular**
  - C. towards the normal**
  - D. away from the normal**

18. Mirages cause an illusion of a watery surface. This illusion is actually ...

- A. water drops reflecting the light
- B. water drops refracting the light
- C. the sky refracted by warm air
- D. the sky reflected by warm air

19. During refraction, when the angle of incidence is doubled, the angle of refraction is ...

- A. also doubled
- B. not necessarily doubled
- C. decreased by the same amount
- D. decreased by about half

### 2.5 Lenses Refract and Focus Light

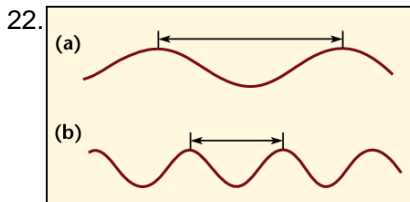
20. When light passing through a lens, the light is bent, causing the rays of light to diverge. The type of lens is a ...

- A. convex lens
- B. concave lens
- C. optic lens
- D. diamond prism lens

21. When light rays pass through a convex lens the image that is formed is ...

- A. diverted
- B. converted
- C. inverted
- D. implied

### 3.1 The Wave Model of Light



The arrows a) and b) -identified in the illustration- indicate the ...

- A. crest
- B. rest position
- C. amplitude
- D. wavelength

23. As frequency increases, this will happen to the wavelength ...

- A. they get longer and less frequent
- B. they get longer and more frequent
- C. they get shorter and less frequent
- D. they get shorter and more frequent

24. White light is refracted through a device that breaks it up into all the visible colors that make up white light. The device that does this is called a ...

- A. refractor dish
- B. refractor lens
- C. prism
- D. light source

**3.2 The Electromagnetic Spectrum**

25. The only type of radiation which can penetrate solid material and concrete walls is ...
- A. x-rays**
  - B. gamma rays**
  - C. infrared waves**
  - D. microwaves**
26. **Radar** is an acronym for *radio detection and ranging*. These devices send out waves, which bounce off objects and return (obeying the law of reflection). Older radar devices used radio waves, whereas modern radar devices use ...
- A. microwaves**
  - B. ultraviolet waves**
  - C. infrared waves**
  - D. gamma rays**

**3.3 Producing Visible Light**

27. Phosphorescence is slightly different from fluorescence. In phosphorescence, the energy that is used to produce the light is absorbed by the material and then given off later. These types of materials ...
- A. glow in the dark**
  - B. become natural light**
  - C. last longer than fluorescent light**
  - D. produce light and give off lots of heat**
28. Incandescent light bulbs produce 95% heat and only 5% visible light. Fluorescent light bulbs are much more efficient, because they produce 80% heat and ...
- A. 2 times as much light**
  - B. 3 times as much light**
  - C. 4 times as much light**
  - D. 5 times as much light**

**3.4 The Colors of Light**

29. The **primary** colors of light are:
- A. red, yellow and blue**
  - B. red, green and yellow**
  - C. red, yellow and green**
  - D. red, green and blue**
30. A television set puts the theory of color addition to practice. If you look closely at the screen, you will see that it is actually made up of rows of ...
- A. red, blue and yellow dots**
  - B. blue, green and red dots**
  - C. red, blue and yellow squares**
  - D. blue, green and red squares**

**4.1 Image Formation in Eyes and Cameras**

31. The eye and the camera can be thought of as image-producing technologies. One (the eye) happens to be a *natural* technology, while the other (the camera) is a ...
- A. photo advancement**
  - B. film revolution**
  - C. artificial technology**
  - D. mechanical innovation**

32. The retina in the eye has a thin layer of cells that are light sensitive. These cells are called **photoreceptors**. There are two kinds of photoreceptor cells. The type that detect color are the ...
- A. rods
  - B. cones
  - C. pines
  - D. iris
33. **Night vision** goggles or scopes are used to get images in the dark. A green image is formed on the screen because these glow green when light particles hit them ...
- A. photoreceptors
  - B. phosphors
  - C. photophors
  - D. phosphates

#### 4.2 Other Eyes in the Animal Kingdom

34. Humans have **3 types of cones**, each sensing a different wavelength of light. Birds tend to have much sharper vision than humans because they have ...
- A. 4 types of cones
  - B. 5 types of cones
  - C. 6 types of cones
  - D. 7 types of cones
35. **Nocturnal** animals, such as cats and owls have very large pupils to allow them to collect as much light as possible. The purpose of the thin layer inside their eyes, called the **tapetum lucidum**, is to act as this inside their eye ...
- A. a magnifier
  - B. a mirror
  - C. a lens
  - D. a filter
36. An **ommatidia** is a long tube-like structure with a lens on the outer surface, a focusing cone below it and a light sensitive cell below that. Insect eyes have ommatidia facing in almost all directions because their eyes tend to have a ...
- A. round shape
  - B. flat shape
  - C. concave surface
  - D. convex surface

#### 4.3 Image Storage and Transmission

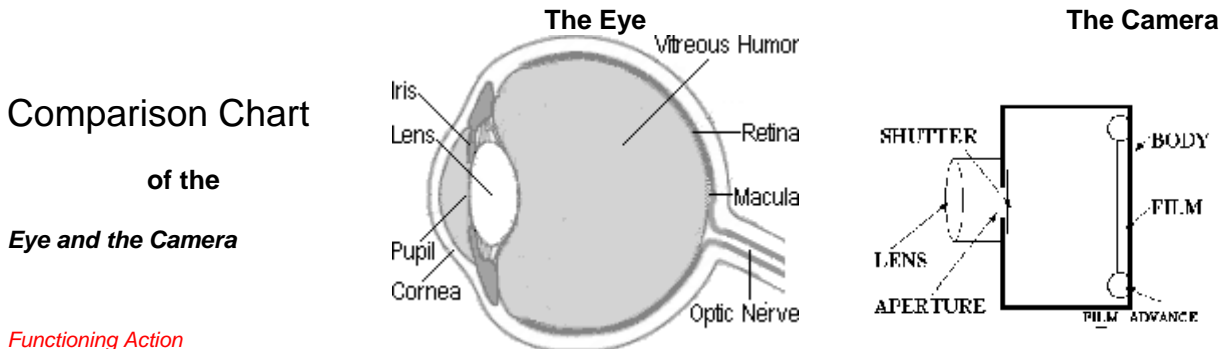
37. **Digital** information is stored by a computer converting the information into ...
- A. pictures
  - B. numbers
  - C. letters
  - D. symbols
38. CCD is a grid similar to a piece of graph paper. As light falls on a square of the grid, it creates a small amount of electricity in that square. This is then converted into digital information. **CCD** stands for ...
- A. Computer Charged Design
  - B. Capture Charge Device
  - C. Compact Charge Design
  - D. Charge Coupled Device

39. The greatest advantage to **digital imaging** is that the pictures don't have to be ...

- A. translated
- B. recovered
- C. processed
- D. transmitted

40. The **Eye** and the **Camera** have a lot in common.

- They both have compound **lenses** - which are **converging lens** refracting the light to a focal point on the light sensitive layer to record an image.
  - To focus a camera you move the **lens** backward or forward.
  - The eye is focused by the **ciliary muscle**, which stretches the **lens**, changing its shape.
- To control how much light gets in.
  - The **iris** in your eye changes the size of the **pupil** - the dark spot in the center of your eye, which controls the amount of light that enters.
  - Cameras adjust to let different amounts of light in by using the **aperture** and the **shutter** controls how long the light is allowed to get through.
- The **retina** is like the **film** in a camera, covering the back of the eye.



<b>The opening for light.</b>		
<b>Regulates the amount of light coming in.</b>		
<b>Focuses the refracted light.</b>		
<b>Light-sensitive layer that records images.</b>		

shutter	film	
iris	lens	aperture



### Light and Optical Systems Section Quiz Answer Keys

Section 1 Quiz		Section 2 Quiz		Section 3 Quiz		Section 4 Quiz	
1	<b>B</b>	1	<b>A OR B</b>	6	<b>C</b>	1	<b>C</b>
2	<b>C</b>	2	<b>D</b>	7	<b>D</b>	2	<b>B</b>
3	<b>D</b>	3	<b>A OR C</b>	8	<b>A</b>	3	<b>B</b>
4	<b>A</b>	4	<b>C</b>	9	<b>C</b>	4	<b>D</b>
5	<b>B</b>	5	<b>C</b>	10	<b>B</b>	5	<b>B</b>
6	<b>C</b>	6	<b>C</b>	11	<b>A</b>	6	<b>D</b>
7	<b>A</b>	7	<b>B</b>	12	<b>B</b>	7	<b>B</b>
8	<b>D</b>	8	<b>C</b>	13	<b>A</b>	8	<b>B</b>
9	<b>B</b>	9	<b>C</b>	14	<b>C</b>	9	<b>D</b>
10	<b>C</b>	10	<b>B</b>	15	<b>D</b>	10	<b>C</b>
11	<b>B</b>	11	<b>C</b>	16	<b>D</b>	11	<b>B</b>
12	<b>A</b>	12	<b>C</b>	17	<b>C</b>	12	<b>A</b>
<i>Bonus</i>  Eyepiece lens Reflective prisms Objective lens  Eyepiece lens Objective lens		13	<b>C</b>	18	<b>B</b>	13	<b>D</b>
		14	<b>B</b>			14	<b>C</b>
		15	<b>D</b>	<b>Eye and Camera Comparison Chart</b>  pupil – aperture iris - shutter lens – lens retina - film			
		16	<b>B</b>				
		17	<b>C</b>				
		18	<b>A</b>				
		19	<b>B</b>				
		20	INCIDENCE REFRACTION  INCIDENCE REFRACTION				
		21	<b>B</b>				
		22	<b>C</b>				
Double Convex Converging (Focal Point)							

### Light and Optical Systems Unit Test Answer Key

1	<b>C</b>	9	<b>C</b>	17	<b>D</b>	25	<b>B</b>	33	<b>B</b>	<b>40</b>  <table border="1" style="margin: auto;"> <tr><td></td><td>APERTURE</td></tr> <tr><td>IRIS</td><td>SHUTTER</td></tr> <tr><td>LENS</td><td></td></tr> <tr><td></td><td>FILM</td></tr> </table>		APERTURE	IRIS	SHUTTER	LENS			FILM
	APERTURE																	
IRIS	SHUTTER																	
LENS																		
	FILM																	
2	<b>A</b>	10	<b>C</b>	18	<b>C</b>	26	<b>A</b>	34	<b>B</b>									
3	<b>B</b>	11	<b>C</b>	19	<b>B</b>	27	<b>A</b>	35	<b>B</b>									
4	<b>C</b>	12	<b>B</b>	20	<b>B</b>	28	<b>C</b>	36	<b>D</b>									
5	<b>D</b>	13	<b>A</b>	21	<b>C</b>	29	<b>D</b>	37	<b>B</b>									
6	<b>C</b>	14	<b>C</b>	22	<b>D</b>	30	<b>B</b>	38	<b>D</b>									
7	<b>B</b>	15	<b>D</b>	23	<b>D</b>	31	<b>C</b>	39	<b>C</b>									
8	<b>D</b>	16	<b>B</b>	24	<b>C</b>	32	<b>B</b>											