

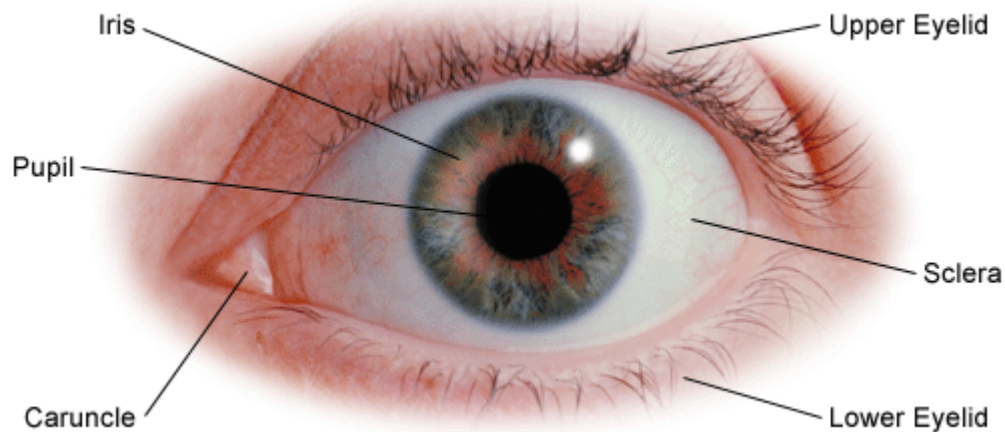
How to Prepare for ASNT NDT Level-III Examination

ASNT NDT Level-III

Visual and Optical Testing

Document No : ASNT/VT/Level-III Rev:0 Date:25 April 2011

Note: Visual and Optical Testing NDT Level-III is **2 Hours** paper and having the **90 questions** and all the Questions carrying the equal marks.



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VT - Visual and Optical Testing

Length: 2 hours Questions: 90

- Fundamentals
 - Vision and light
 - Ambient conditions
 - Test object characteristics
- Equipment Accessories
 - Magnifiers/microscopes
 - Mirrors
 - Dimensional
 - Borescopes
 - Video systems
 - Machine vision
 - Replication
 - Temperature indicating devices and materials
 - Chemical aids
 - Surface comparators
 - Lasers
- Applications and Requirements
 - Raw materials
 - Primary process materials
 - Joining processes
 - Fabricated components
 - In-service materials
 - Coatings
 - Other applications
 - Requirements
- Variables Affecting Results of interpretation/ Evaluations
 - Equipment including type and intensity of light
 - Material including the variations of surface finish
 - Discontinuity
 - Determination of dimensions (ie: depth, width, length, etc.)
 - Sampling/scanning
 - Process for reporting visual discontinuities
 - Personnel (human factors)
- Documentation
- Safety

VT - Visual and Optical Testing

Reference Books and Catalog Number

Sr.No.	Book Title and Author	Catalog Number
1	Level III Study Guide: Visual and Optical Testing	2263
2	Supplement to SNT-TC-1A: VT (Q & A Book)	2034A
3	NDT Handbook: Volume 8, Visual and Optical Testing	133
4	ASM Handbook Vol. 17, NDE and QC	105
5	Materials and Processes for NDT Technology	2250
6	NDT Handbook: Volume 10, NDT Overview of VT	135

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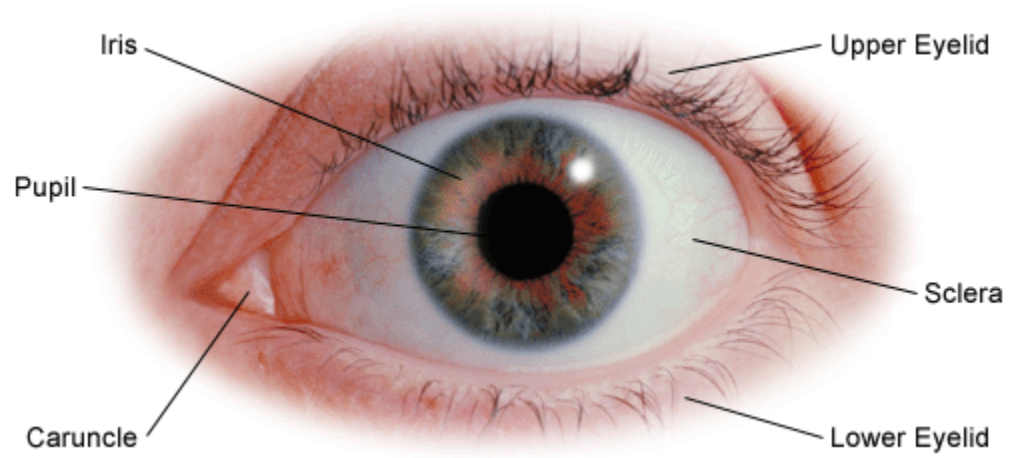
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VT - Visual and Optical Testing

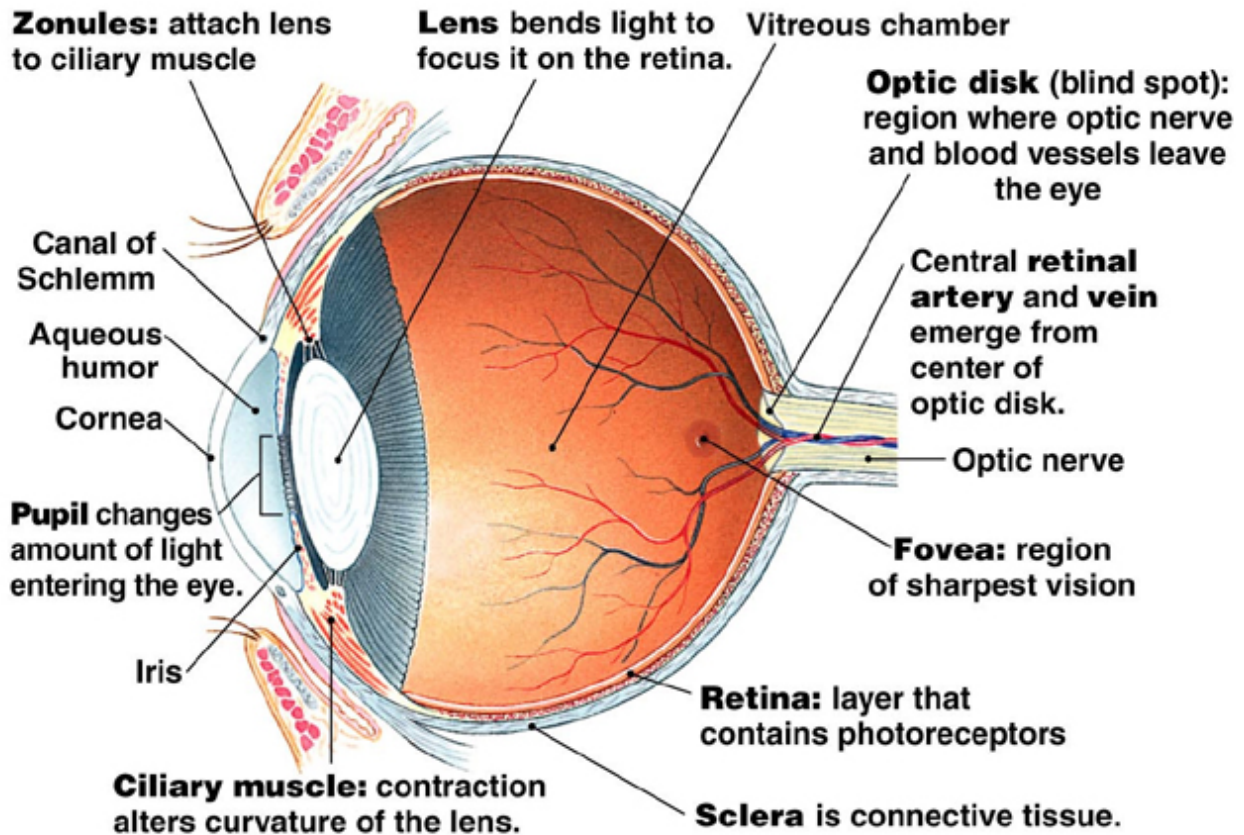
VISION

What is Eye or our Eye (Front view)



Our Eye (Side view)

(a) Sagittal section of the eye



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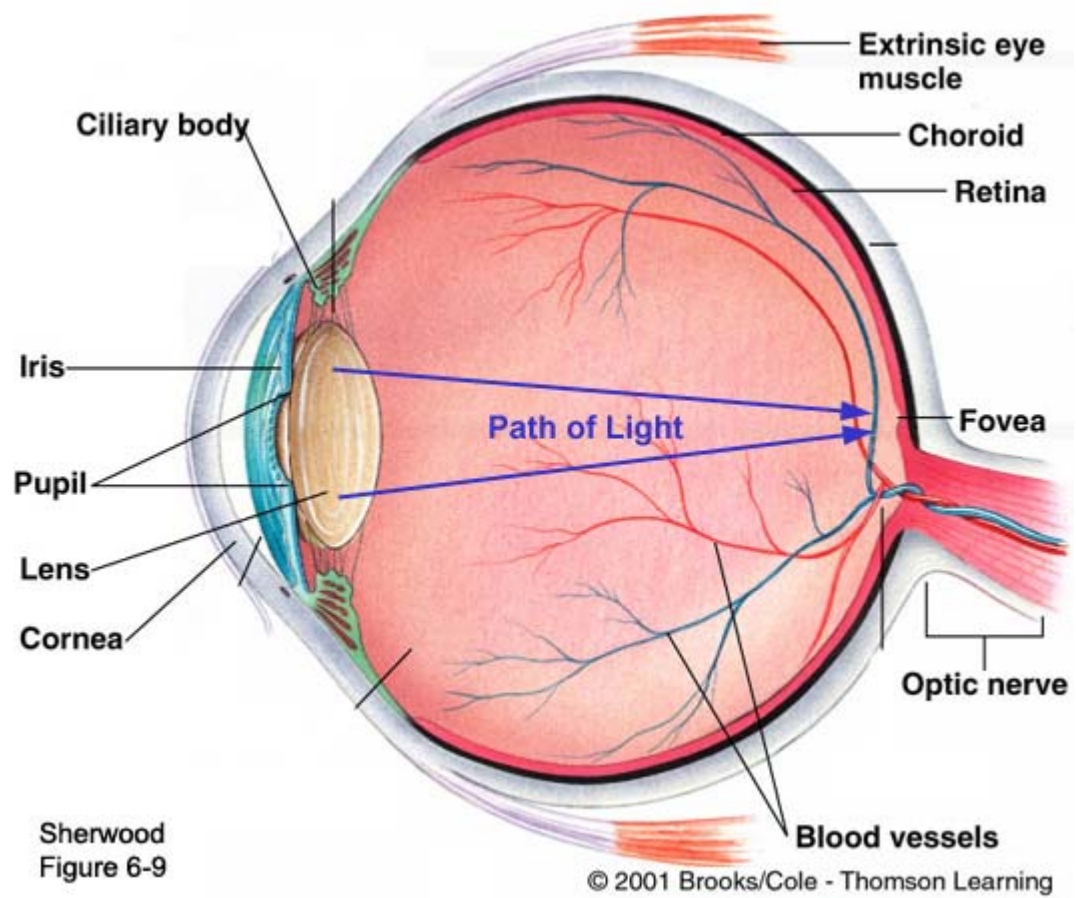
Fig. 10-28

The **aqueous humor** is a thick watery substance filling the space between the lens and the cornea. It is not to be confused with vitreous humor, which is contained within the larger cavity of the eye.

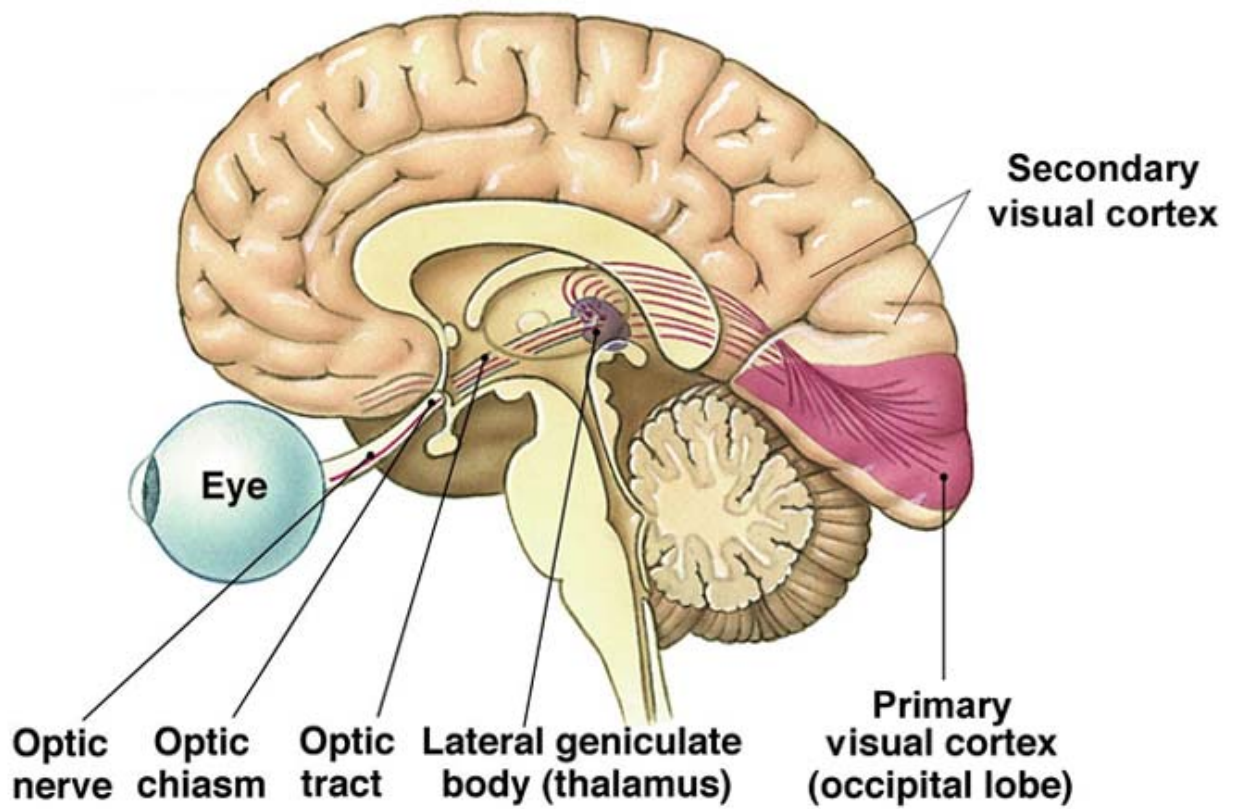
Structure/Function of the eye

1. Lens
 - a. Refraction and accommodation by the lens
 - b. Nearsightedness and farsightedness
2. Iris
3. Retina
 - a. Structure and function of rods and cones
 - 1) Color vision
 - b. Fovea is packed with cones
 - 1) Dysfunction: Macular degeneration

a. Refraction and accommodation by the lens



Optic Nerves

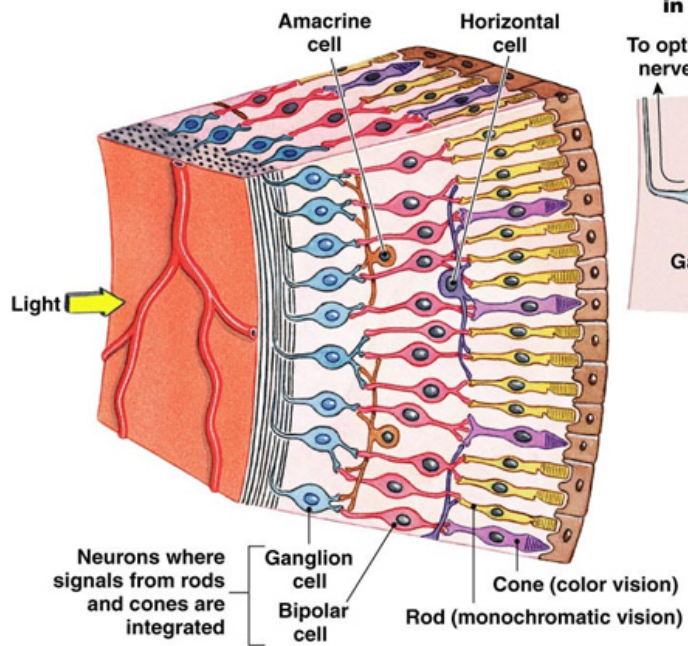


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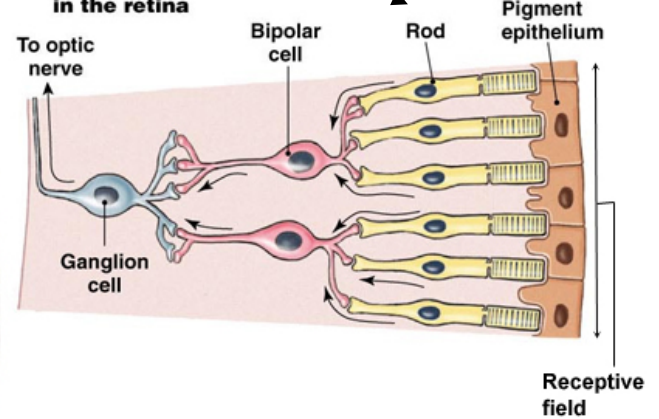
Figure 10-29

Structure and function of rods and cones

(d) Organization of the retina



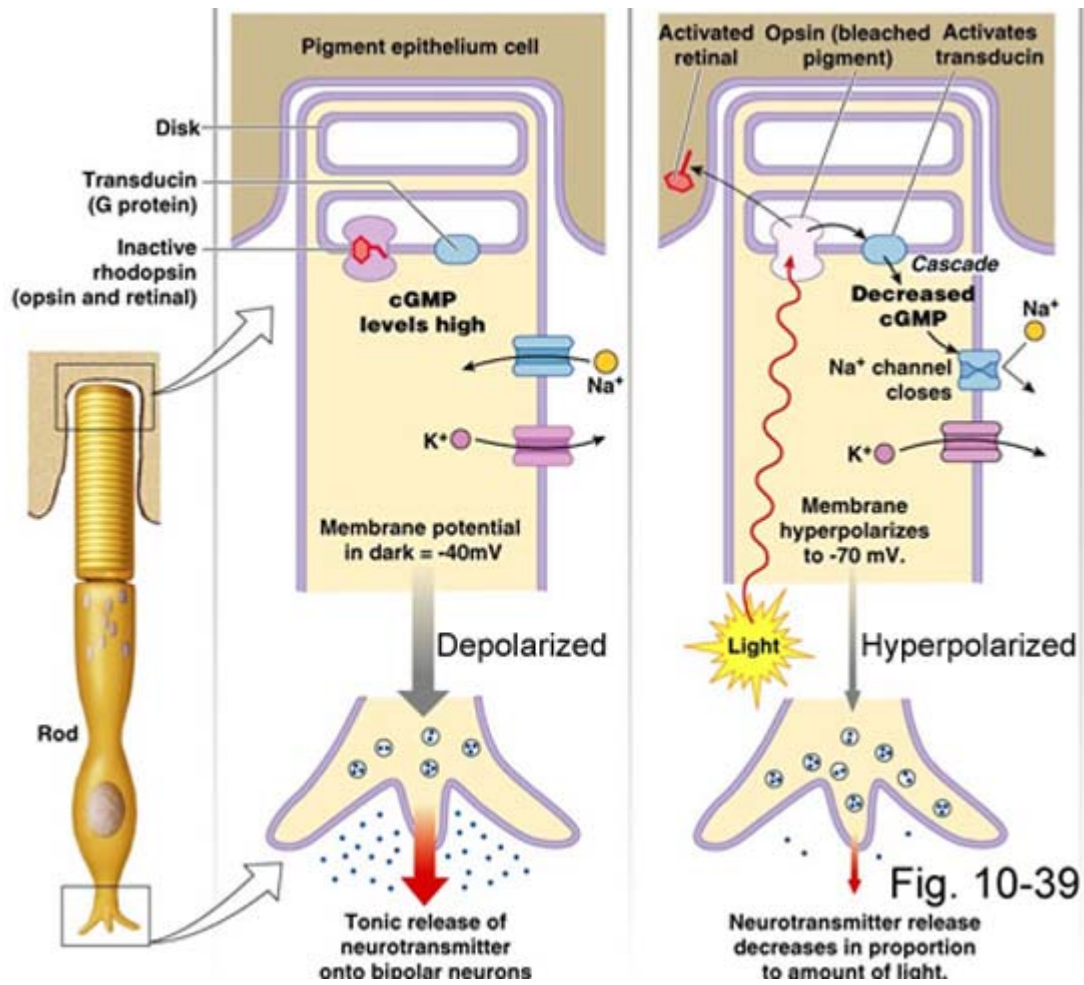
(e) Convergence in the retina



RODS

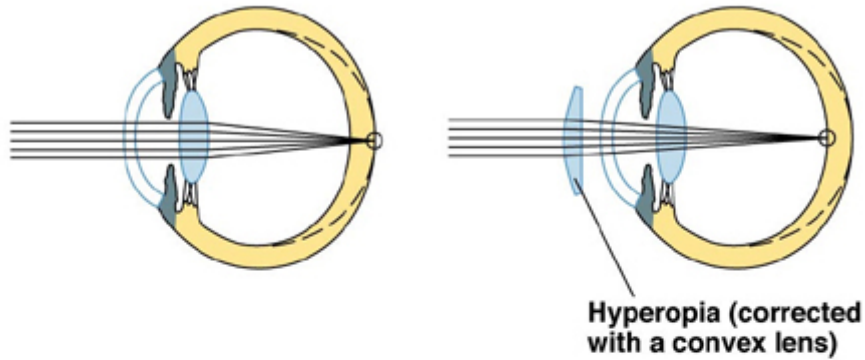
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Fig. 10-35

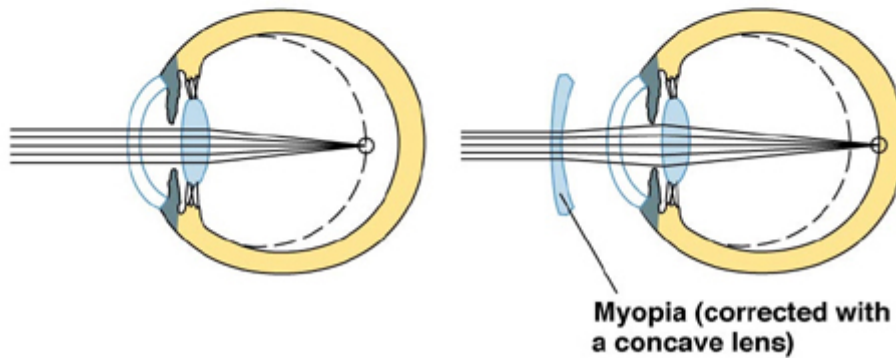


Nearsightedness

(a) Hyperopia, or far-sightedness, occurs when the focal point falls behind the retina.



(b) Myopia, or near-sightedness, occurs when the focal point falls in front of the retina.



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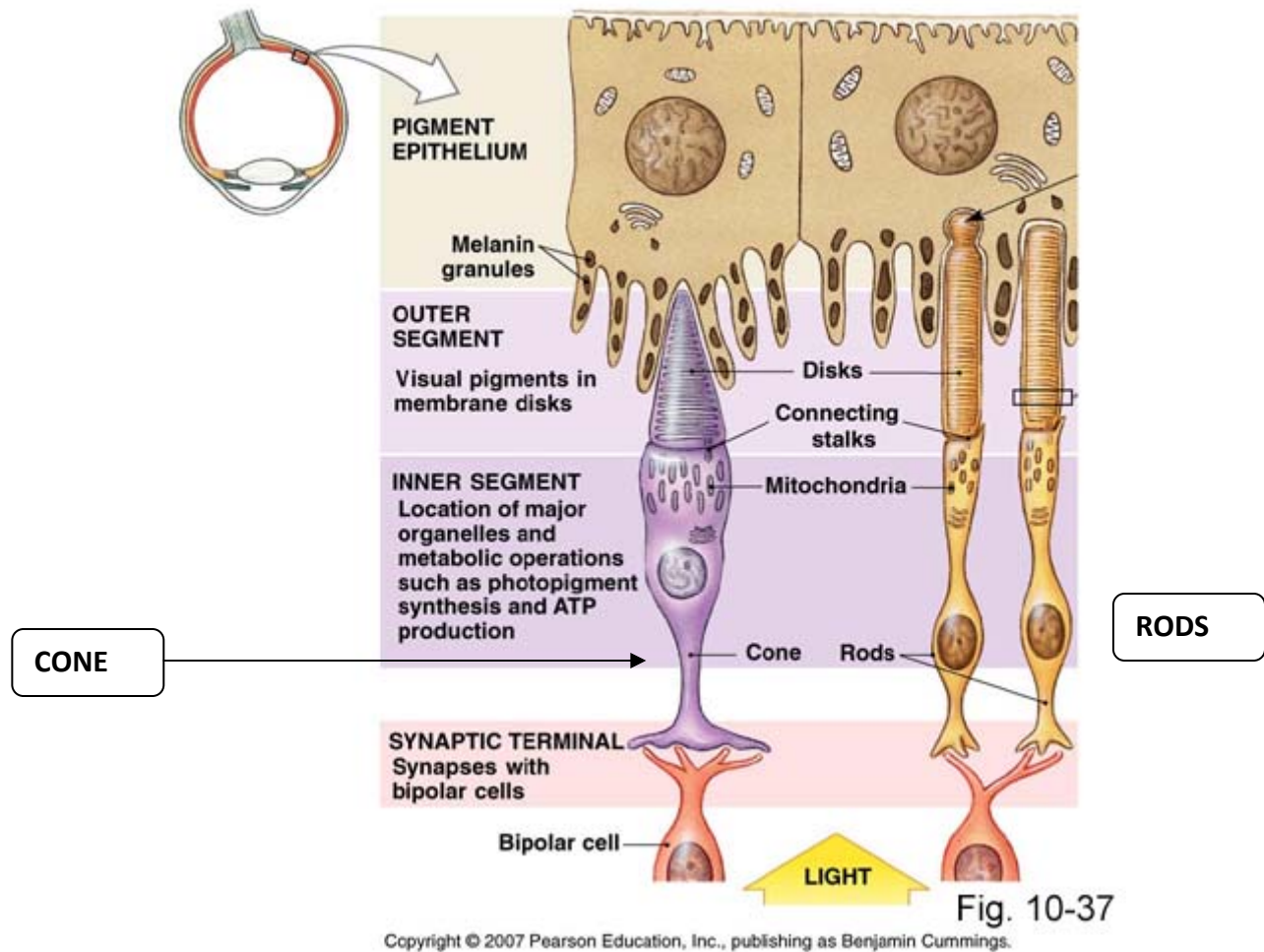
3. Retina

a. Structure and function of **rods** and **cones**

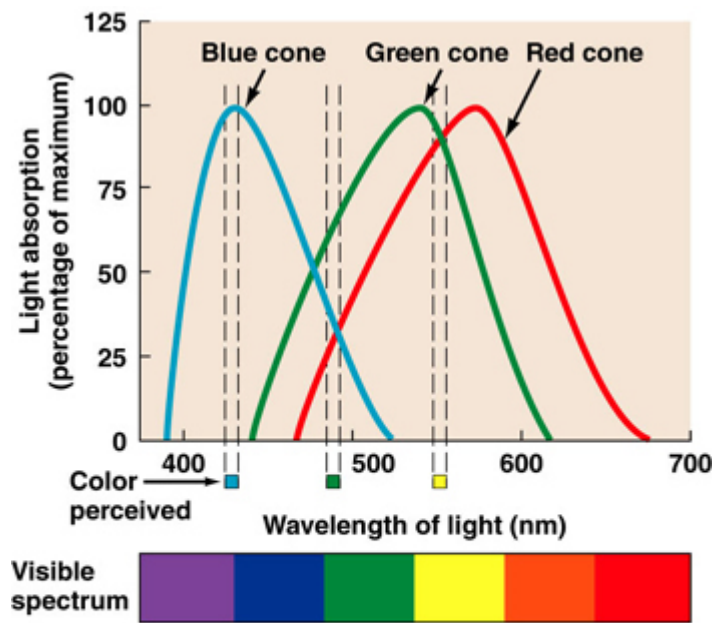
1) **Color vision**

b. Fovea is packed with cones

1) Dysfunction: Macular degeneration



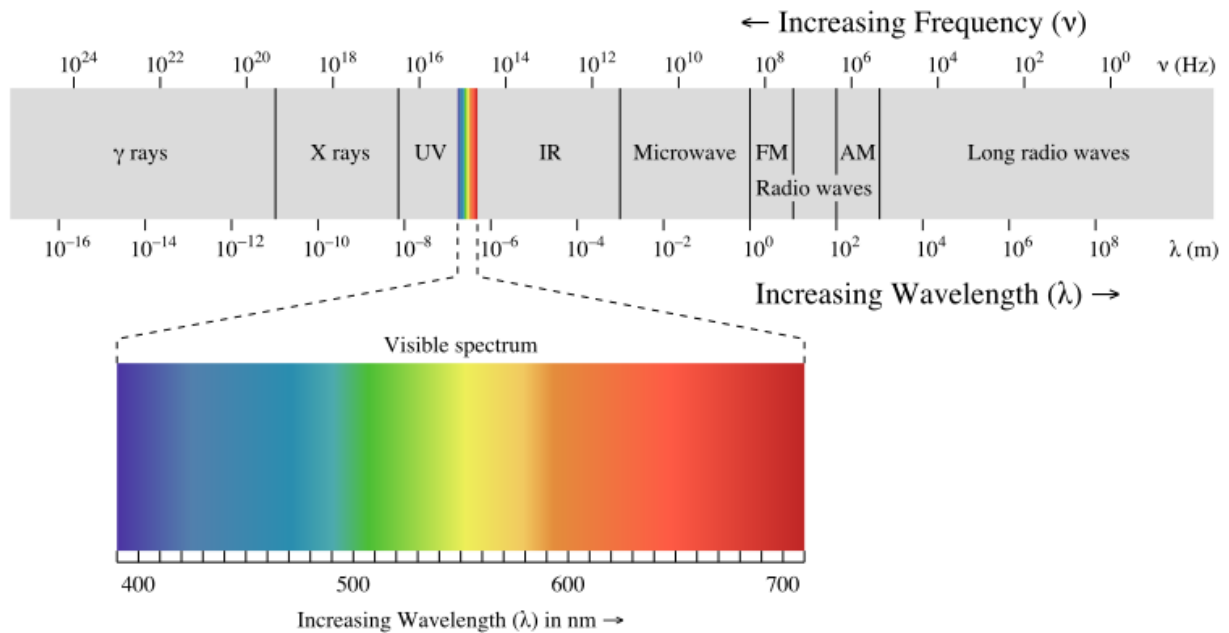
1) Color vision



Light

Light or **visible light** is the portion of electromagnetic radiation that is visible to the human eye, responsible for the sense of sight. Visible light has a wavelength in a range from about 380 or 400 nanometers to about 760 or 780 nm, with a frequency range of about 405 THz to 790 THz. In physics, the term light often comprises the adjacent radiation regions of infrared (at lower frequencies) and ultraviolet (at higher), not visible to the human eye.

Electromagnetic spectrum



Refraction-with-soda (Coca cola) - straw



Refraction of Light:

Refraction is the bending of light rays when passing through a surface between one transparent material and another. It is described by **Snell's Law**:

$$n_1 \sin \theta_1 = n_2 \sin \theta_2 .$$

where θ_1 is the angle between the ray and the surface normal in the first medium, θ_2 is the angle between the ray and the surface normal in the second medium, and n_1 and n_2 are the indices of refraction, $n = 1$ in a vacuum and $n > 1$ in a transparent substance.

When a beam of light crosses the boundary between a vacuum and another medium, or between two different media, the wavelength of the light changes, but the frequency remains constant. If the beam of light is not orthogonal (or rather normal) to the boundary, the change in wavelength results in a change in the direction of the beam. This change of direction is known as refraction.

What gives rainbows their curved shape? Why rainbows looked in Curved shape?



Sunlight that shines into a raindrop leaves that raindrop at an angle of 138 degrees from the path that the light traveled before it entered the drop. Light and raindrops work together to create a ring of colored light opposite the sun.

We see part of that ring as the curved arc of a rainbow. Here's how it works: the sunlight that shines into a raindrop leaves that raindrop at an angle of 138 degrees from the path that the light traveled before it entered the drop. That's the "rainbow angle," discovered by **Descartes** in the year 1637. (June 8, 1637: René Descartes (1596 - 1650) is a name of Scientist who discover this effect, He was born in Place: a Haye, at Netherland, Descartes was born in La Haye en Touraine (now Descartes), Indre-et-Loire, France.)

He is credited as the father of **analytical geometry**.



René Descartes (1596 - 1650)

If the light left at 180 degrees, it'd head straight back toward the sun. As it is, the light is traveling in a direction somewhat back toward the sun, which is why you always see rainbows when the sun is behind you.

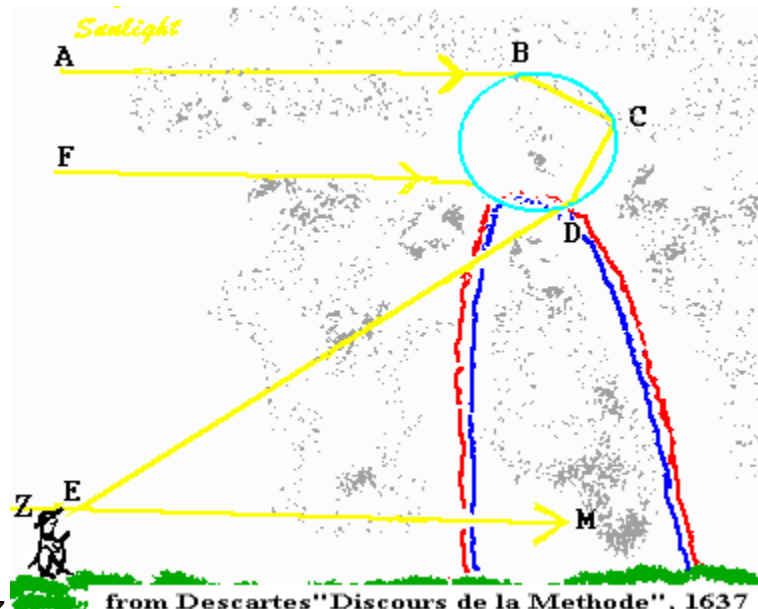
The sunlight emerges from many raindrops at once. The combined effect is a mosaic of light, spread out in an arc in the sky. But that's not the end of the story. When sky conditions and your vantage point are perfect, the rain and sun work together in this way to create a complete ring of light – a circle rainbow. You'll never see this from Earth's surface because your horizon gets in the way.

What makes the bow?

A question like this calls for a proper physical answer. We will discuss the formation of a rainbow by raindrops. It is a problem in optics that was first clearly discussed by [Rene Descartes](#) in 1637. An interesting historical account of this is to be found in Carl Boyer's book, *The Rainbow From Myth to Mathematics*. Descartes simplified the study of the rainbow by reducing it to a study of one water droplet and how it interacts with light falling upon it.

He writes: "*Considering that this bow appears not only in the sky, but also in the air near us, whenever there are drops of water illuminated by the sun, as we can see in certain fountains, I readily decided that it arose only from the way in which the rays of light act on these drops and pass from them to our eyes. Further, knowing that the drops are round, as has been formerly proved, and seeing that whether they are larger or smaller, the appearance of the bow is not changed in any way, I had the idea of making a very large one, so that I could examine it better.*"

Descarte describes how he held up a large sphere in the sunlight and looked at the sunlight reflected in it. He wrote "*I found that if the sunlight came, for example, from the part of the sky*"

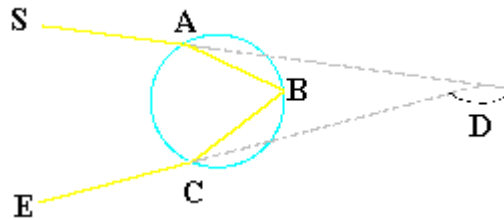


which is marked AFZ from Descartes "Discours de la Methode", 1637

and my eye was at the point E, when I put the globe in position BCD, its part D appeared all red, and much more brilliant than the rest of it; and that whether I approached it or receded from it, or put it on my right or my left, or even turned it round about my head, provided that the line DE always made an angle of about forty-two degrees with the line EM, which we are to think of as drawn from the center of the sun to the eye, the part D appeared always similarly red; but that as soon as I made this angle DEM even a little larger, the red color disappeared; and if I made the angle a little smaller, the color did not disappear all at once, but divided itself first as if into two parts, less brilliant, and in which I could see yellow, blue, and other colors ... When I examined more particularly, in the globe BCD, what it was which made the part D appear red, I found that it was the rays of the sun which, coming from A to B, bend on entering the water at the point B, and to pass to C, where they are reflected to D, and bending there again as they pass out of the water, proceed to the point ".

This quotation illustrates how the shape of the rainbow is explained. To simplify the analysis, consider the path of a ray of monochromatic light through a single spherical raindrop. Imagine how light is refracted as it enters the raindrop, then how it is reflected by the internal, curved, mirror-like surface of the raindrop, and finally how it is refracted as it emerges from the drop. If we then apply the results for a single raindrop to a whole collection of raindrops in the sky, we can visualize the shape of the bow.

The traditional diagram to illustrate this is shown here as adapted from Humphreys,



Physics of the Air.

It represents the path of one light ray incident on a water droplet from the direction SA. As the light beam enters the surface of the drop at A, it is bent ([refracted](#)) a little and strikes the inside wall of the drop at B, where it is reflected back to C. As it emerges from the drop it is refracted (bent) again into the direction CE. The angle D represents a measure of the deviation of the emergent ray from its original direction. Descartes calculated this deviation for a ray of red light to be about $180 - 42$ or 138 degrees.

The ray drawn here is significant because it represents the ray that has the smallest angle of deviation of all the rays incident upon the raindrop. It is called the *Descarte* or *rainbow ray* and much of the sunlight as it is refracted and reflected through the raindrop is focused along this ray. Thus the reflected light is diffuse and weaker except near the direction of this rainbow ray. **It is this concentration of rays near the minimum deviation that gives rise to the arc of rainbow.**

The sun is so far away that we can, to a good approximation, assume that sunlight can be represented by a set of parallel rays all falling on the water globule and being refracted, reflected internally, and refracted again on emergence from the droplet in a manner like the figure. Descartes writes

*I took my pen and made an accurate calculation of the paths of the rays which fall on the different points of a globe of water to determine at which angles, after two refractions and one or two reflections they will come to the eye, and I then found that after one reflection and two refractions there are **many more rays** which can be seen at an angle of from forty-one to forty-two degrees than at any smaller angle; and that there are none which can be seen at a larger angle" (the angle he is referring to is $180 - D$).*

A [typical raindrop](#) is spherical and therefore its effect on sunlight is symmetrical about an axis through the center of the drop and the source of light (in this case the sun). Because of this symmetry, the two-dimensional illustration of the figure serves us well and the complete picture can be visualized by rotating the two dimensional illustration about the axis of symmetry. The symmetry of the focusing effect of each drop is such that whenever we view a raindrop along the line of sight defined by the *rainbow ray*, we will see a bright spot of reflected/refracted sunlight. Referring to the figure, we see that the *rainbow ray* for red light makes an angle of 42 degrees between the direction of the incident sunlight and the line of sight. Therefore, as long as the raindrop is viewed along a line of sight that makes this angle with the direction of incident light, we will see a brightening. The rainbow is thus a circle of angular radius 42 degrees, centered on the anti solar point, as shown schematically.

We don't see a full circle because the earth gets in the way. The lower the sun is to the horizon, the more of the circle we see -right at sunset, we would see a full semicircle of the rainbow with

the top of the arch 42 degrees above the horizon. The higher the sun is in the sky, the smaller is the arch of the rainbow above the horizon.

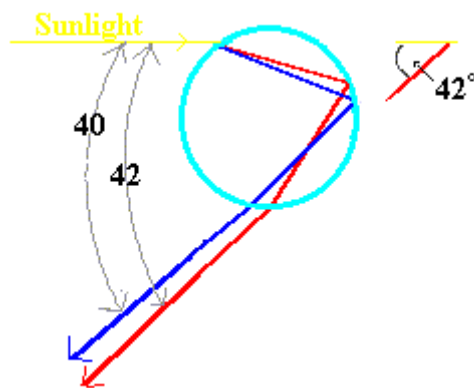
What makes the colors in the rainbow?

The traditional description of the rainbow is that it is made up of seven colors - red, orange, yellow, green, blue, indigo, and violet. Actually, the rainbow is a whole continuum of colors from red to violet and even beyond the colors that the eye can see.

The colors of the rainbow arise from two basic facts:

- Sunlight is made up of the whole range of colors that the eye can detect. The range of sunlight colors, *when combined*, looks white to the eye. This property of sunlight was first demonstrated by Sir Isaac Newton in 1666.
- Light of different colors is refracted by different amounts when it passes from one medium (air, for example) into another (water or glass, for example).

Descartes and Willebrord Snell had determined how a ray of light is bent, or refracted, as it traverses regions of different densities, such as air and water. When the light paths through a raindrop are traced for red and blue light, one finds that the angle of deviation is different for the two colors because blue light is bent or refracted more than is the red light.



This implies that when we see a rainbow and its band of colors we are looking at light refracted and reflected from *different raindrops*, some viewed at an angle of 42 degrees; some, at an angle of 40 degrees, and some in between. This is illustrated in [this drawing](#), adapted from Johnson's *Physical Meteorology*. This rainbow of two colors would have a width of almost 2 degrees (about four times larger than the angular size as the full moon). Note that even though blue light is refracted more than red light in a single drop, we see the blue light on the inner part of the arc because we are looking along a different line of sight that has a smaller angle (40 degrees) for the blue.

Magnifiers

Aspheric Hand Magnifiers: Hand magnifiers facilitate many of the tasks we perform at work and in our private lives that require detailed, precise vision. [Carl Zeiss](#) (is the name of manufacturing company, involved in Magnifiers and Microscopes') offers a range of five different hand magnifiers for this purpose.



Hand Held Magnifiers



VisuLook classic



VisuLook style



VisuLight M



VsiuLight S



Pocket magnifiers **Hand Magnifiers from Carl Zeiss**

It is primarily the design of an optical system that determines whether you really do see better when you use it. The **VisuLook classic** product series contains hand magnifiers featuring high-quality, aspheric lenses which come standard with a hard protective coating. They can be optionally ordered with a broadband antireflection coating (Super ET).

The **VisuLook style** product line from Carl Zeiss contains three hand magnifiers with a modern design. Their aspheric lens makes them ideal for tasks at work or hobbies that require exact vision. Their standard hard coating makes them insensitive and versatile.

VisuLight – good light for easier reading

Reading can be twice as difficult in poor light: the worse the contrast, the less you see.

The VisuLight illuminated pocket and stand magnifiers make up for missing light. One special benefit is their homogenous LED illumination which guarantees low power consumption and a long service life.

Pocket magnifiers - what could be more convenient?

Doing high precision work or having to recognize even the finest detail - this is the kind of visual task that you can be confronted with in everyday life. With its aplanatic-achromatic pocket magnifiers, Carl Zeiss offers you optical systems that can fit into practically any pocket and - depending on the model - provide magnification of 3x to 10x over the entire field of view - and all without distortion or chromatic aberrations.

Your [→eyecare professional](#) will be pleased to help you select the right magnifier for your special requirements.

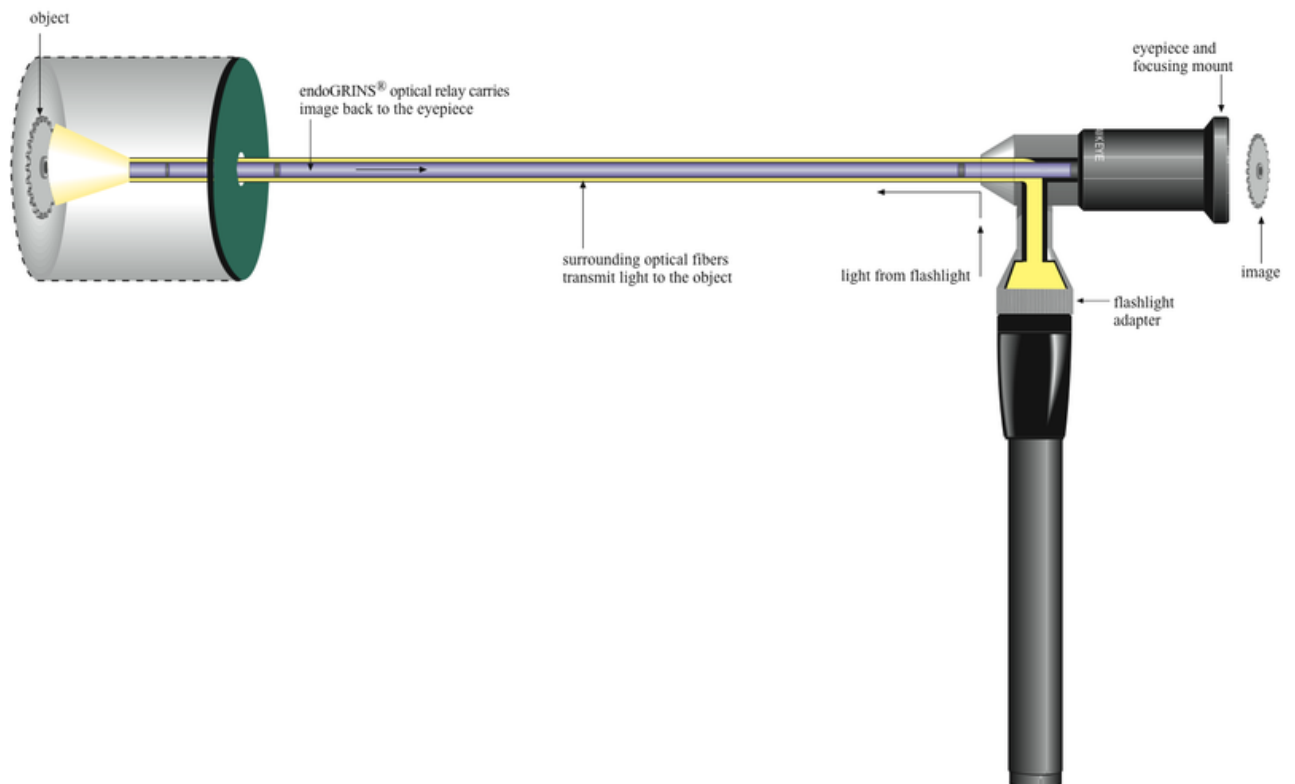
Magnifiers



Bausch & Lomb Make

Borescopes

Rigid borescopes



Flexible borescopes:

Video borescopes