Operating Microscope- Neurosurgery

Presented By:

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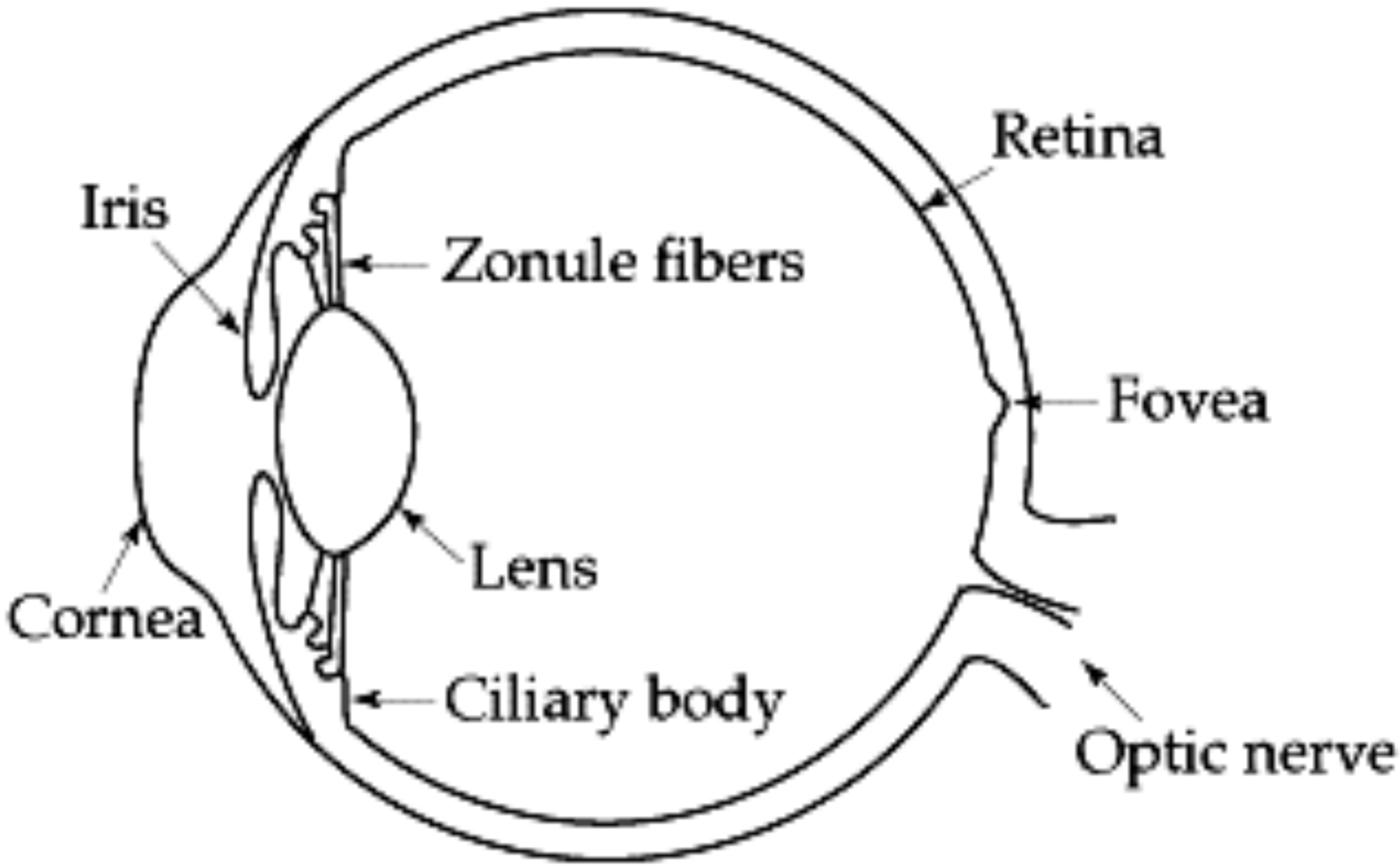
How human Eye works

- A human eyeball is like a simple camera!
  - **Sclera**: outer walls, hard, like a light-tight box.
  - **Choroid**: black in color and prevents any internal reflection of any stray light.
  - **Cornea and crystalline lens (eyelens)**: the two lens system.
  - **Retina:** at the back of eyeball, like the film.
  - **Iris**: like diaphragms or stop in a camera.
  - **Pupil**: camera aperture which controls amount of light.
  - **Eyelid**: lens cover.

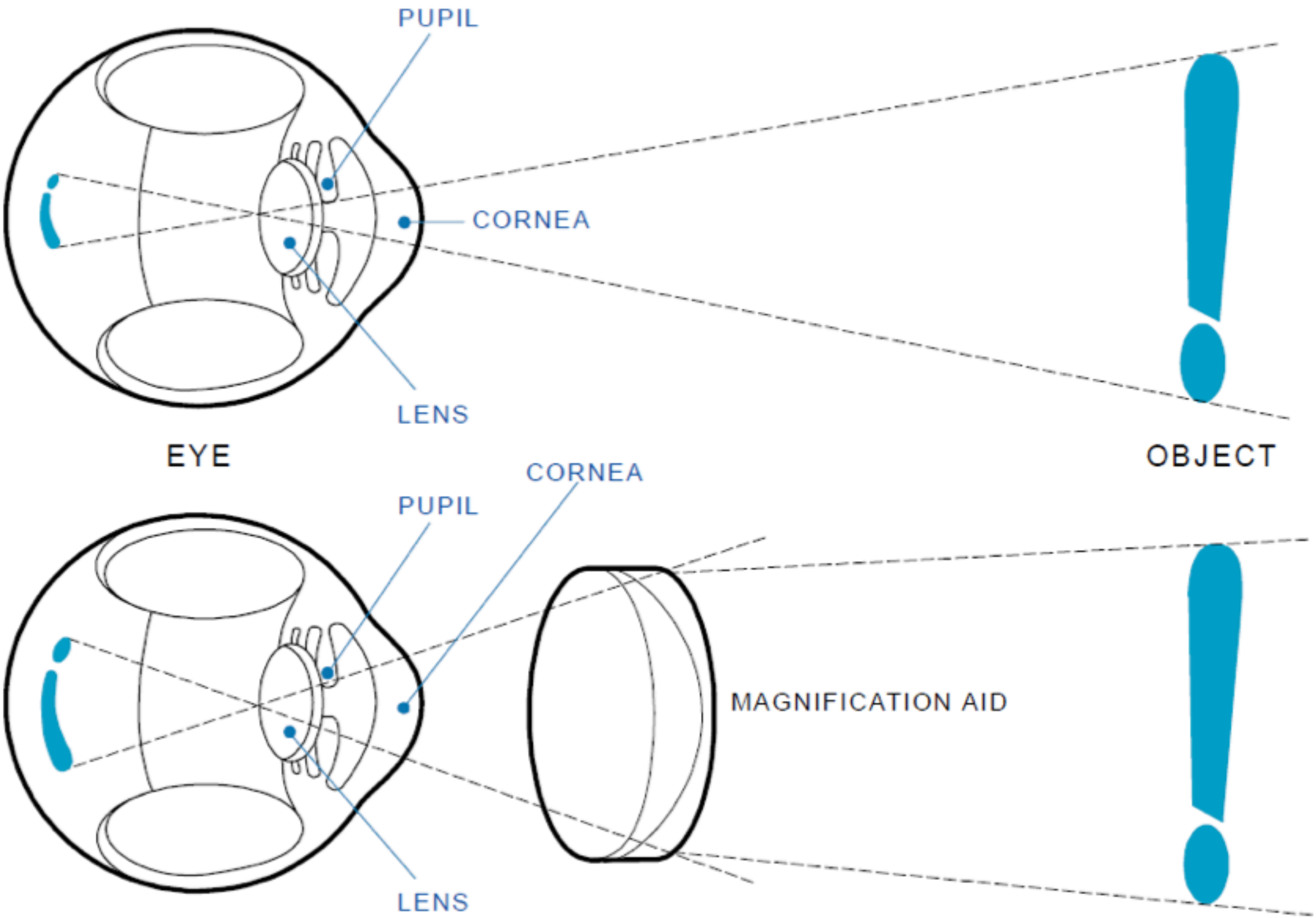


Sclera (The white/non-transparent tissue surrounding the cornea)

Focusing

- The cornea and eyelens form a compound lens system, producing a real inverted image on the retina.
- The optic nerve, transmits visual information from the retina to the brain.
- Located in the posterior part of the brain, the occipital lobe houses the central visual processing center.
- The eye has a limited depth of field. We cannot see things close and far at the same time.

Magnification in eye (optical aid)

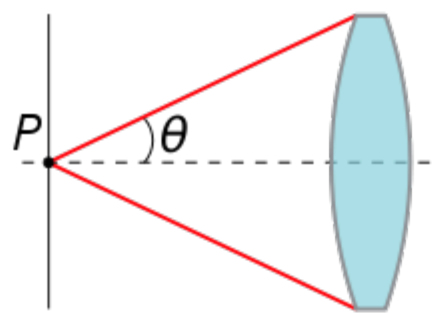


Some Definitions

- Numerical Aperture
- Refractive Index
- Focal length
- Magnification
- Resolution
- Interference
- Absorption
- Reflection
- Refraction
- Diffraction
- Dispersion

Numerical Aperture

- It is a dimensionless number that characterizes the range of angles over which the system can accept or emit light.
- In Microscopy it is commonly used to describe the acceptance cone of an objective (and hence its light-gathering ability and resolution).
- In endoscopy it is used in fiber optics, in which it describes the cone of light accepted into the fiber or exiting it.



The numerical aperture with respect to a point *P* depends on the half-angle *θ* of the maximum cone of light that can enter or exit the lens.

Refractive Index

- Refractive index is the measurement of how hard it is for light to travel through a media. The higher the number the harder it is.

- The refractive index of a medium is

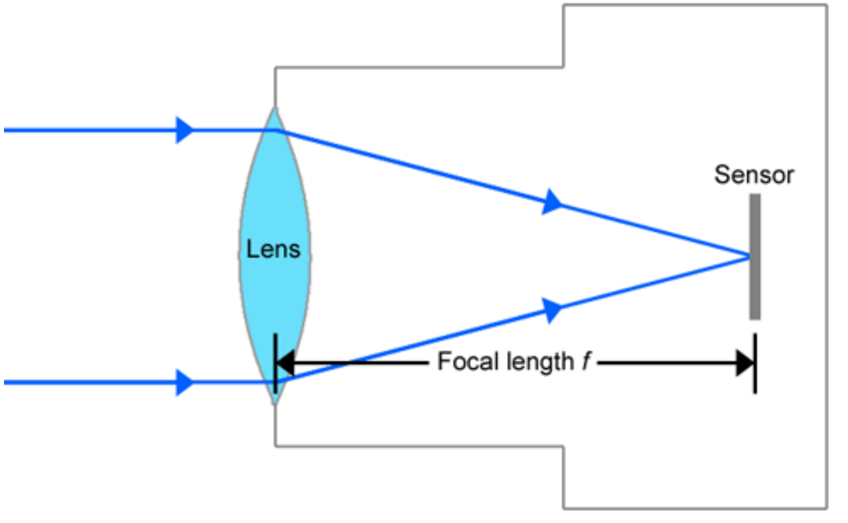
$$\eta = \frac{c}{v}$$

where c is the speed of light in vacuum, and v is the speed in the medium.

- Note that $\eta > 1$.

Focal Length

- The focal length of a lens determines its angle of view.
- Wide angle lenses have short focal lengths, while telephoto lenses have longer corresponding focal lengths.
- A zoom lens is one where the photographer can vary the focal length within a pre-defined range.

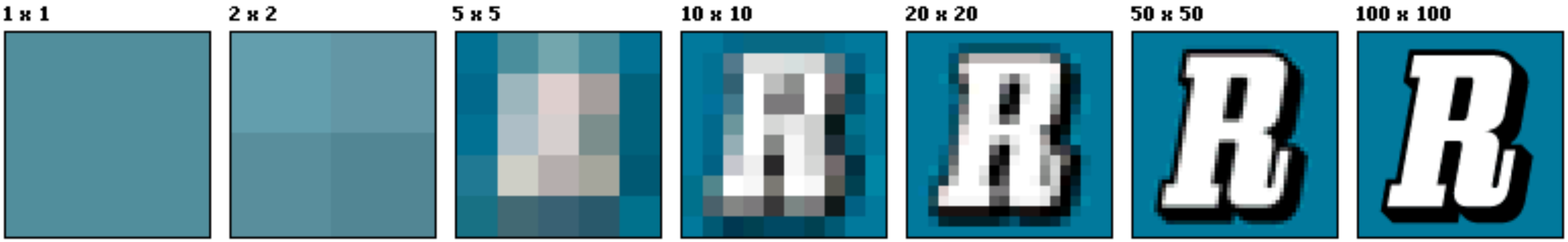


Magnification

- Magnification is the process of enlarging something only in appearance.
- This enlargement is quantified by a calculated number also called "magnification".
- It makes a small object appear as a much larger object at a comfortable distance for viewing.

Resolution

- **Image resolution** is an umbrella term that describes the detail an image holds.
- An image that is 2048 pixels in width and 1536 pixels in height has a total of 2048×1536 = 3,145,728 pixels or 3.1 megapixels.



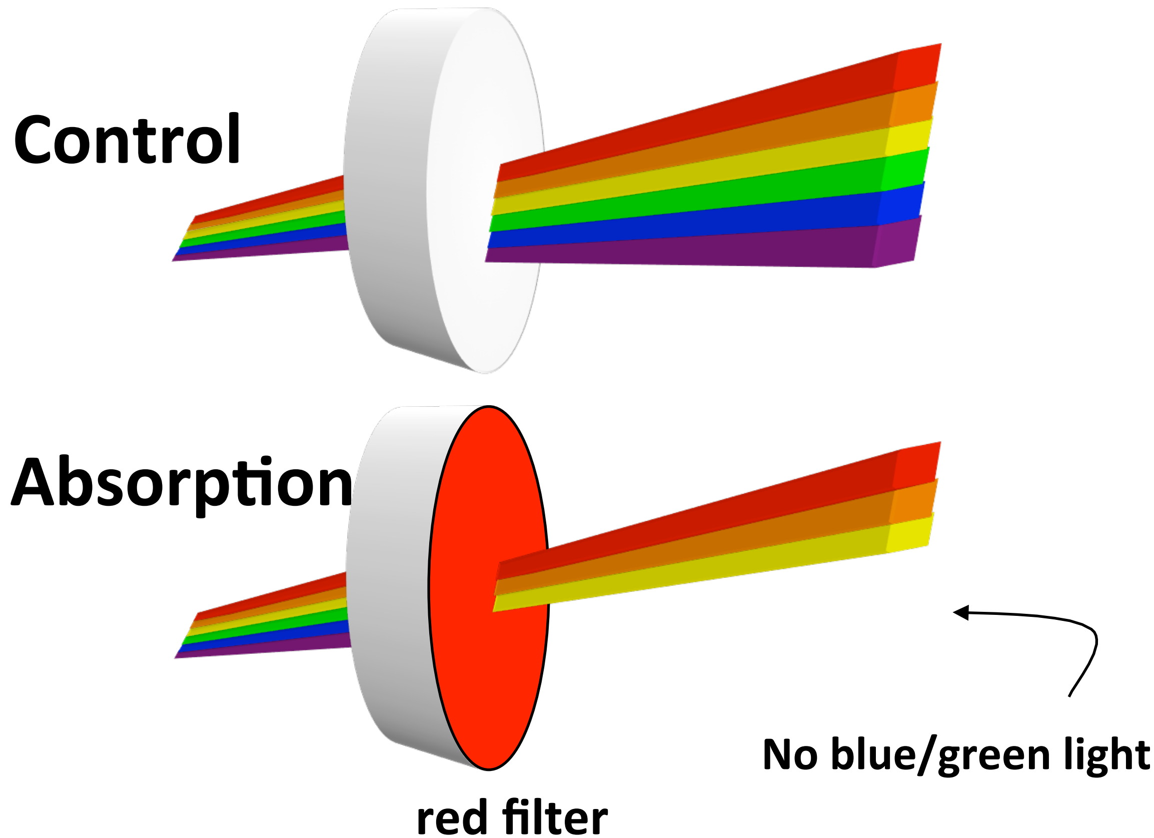
Spatial resolution

- The measure of how closely lines can be resolved in an image is called spatial resolution, and it depends on properties of the system creating the image, not just the pixel resolution in pixels per inch (ppi).
- The spatial resolution of computer monitors is generally 72 to 100 lines per inch.

Image at left has a higher *pixel count* than the one to the right, but is still of worse spatial resolution.

Absorption

When light passes through an object the intensity is reduced depending upon the color absorbed. Thus the selective absorption of white light produces colored light.

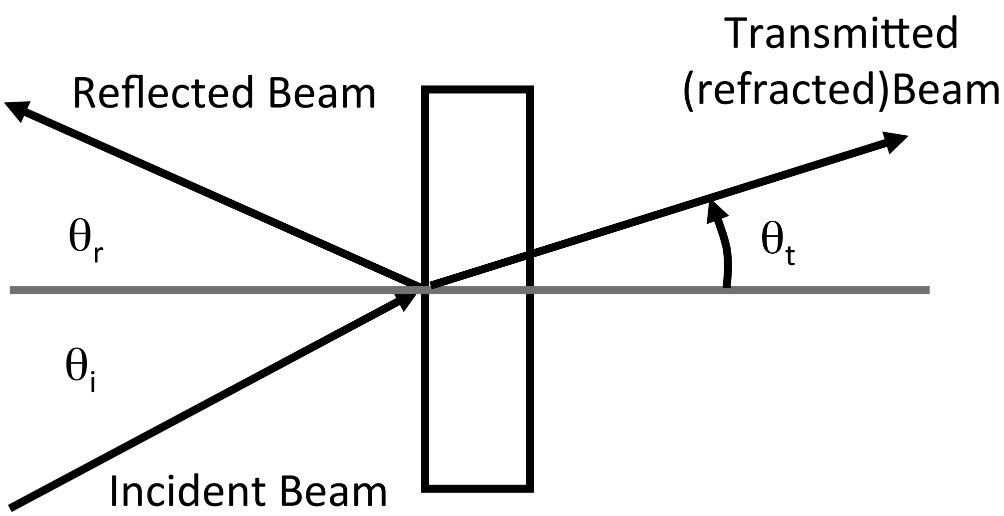


A **red filter** will only allow red light to pass through it - it will **absorb blue** and **green**.

Reflection and Refraction

Reflection - Reflection is defined as Bouncing back of light from a reflective surface due to *absorption* of light of a particular wavelength by the surface and reflecting the remaining wavelength.

Refraction - Direction change of a ray of light passing from one transparent medium to another with different optical density.

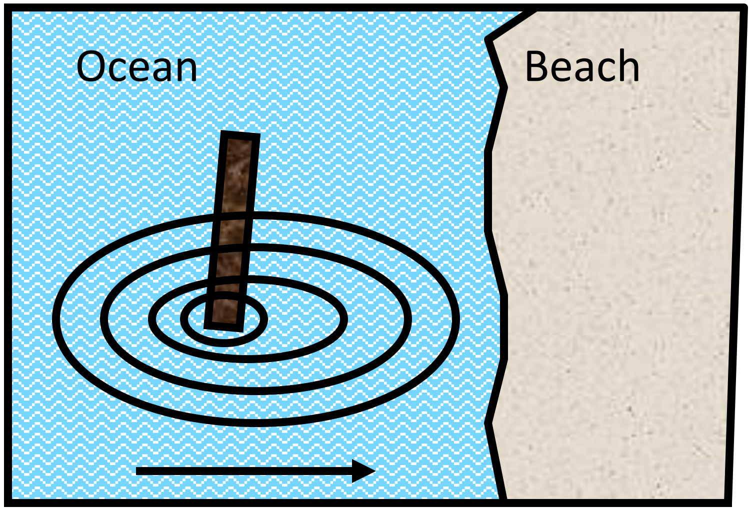


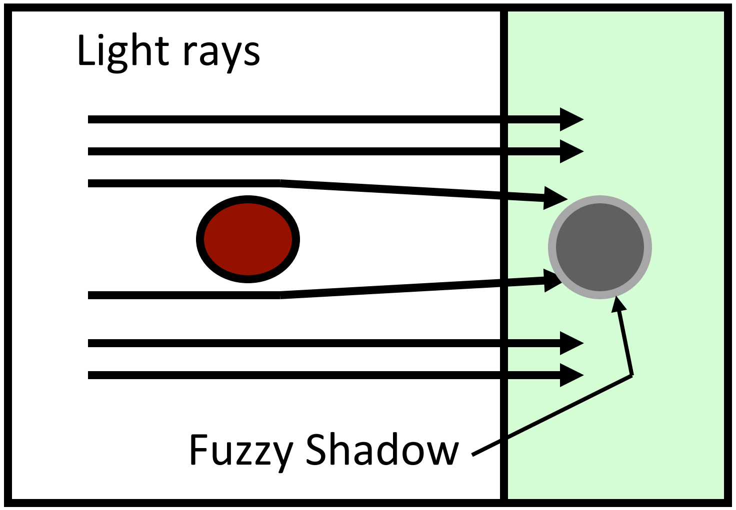
- **Snell's Law**: The angle of reflection ($Ø_r$) is equal to the angle of incidence ($Ø_i$) regardless of the surface material
- The angle of the transmitted (refracted) beam ($Ø_t$) is dependent upon the composition of the material

The velocity of light in a material of refractive index n is c/n

Diffraction of Light

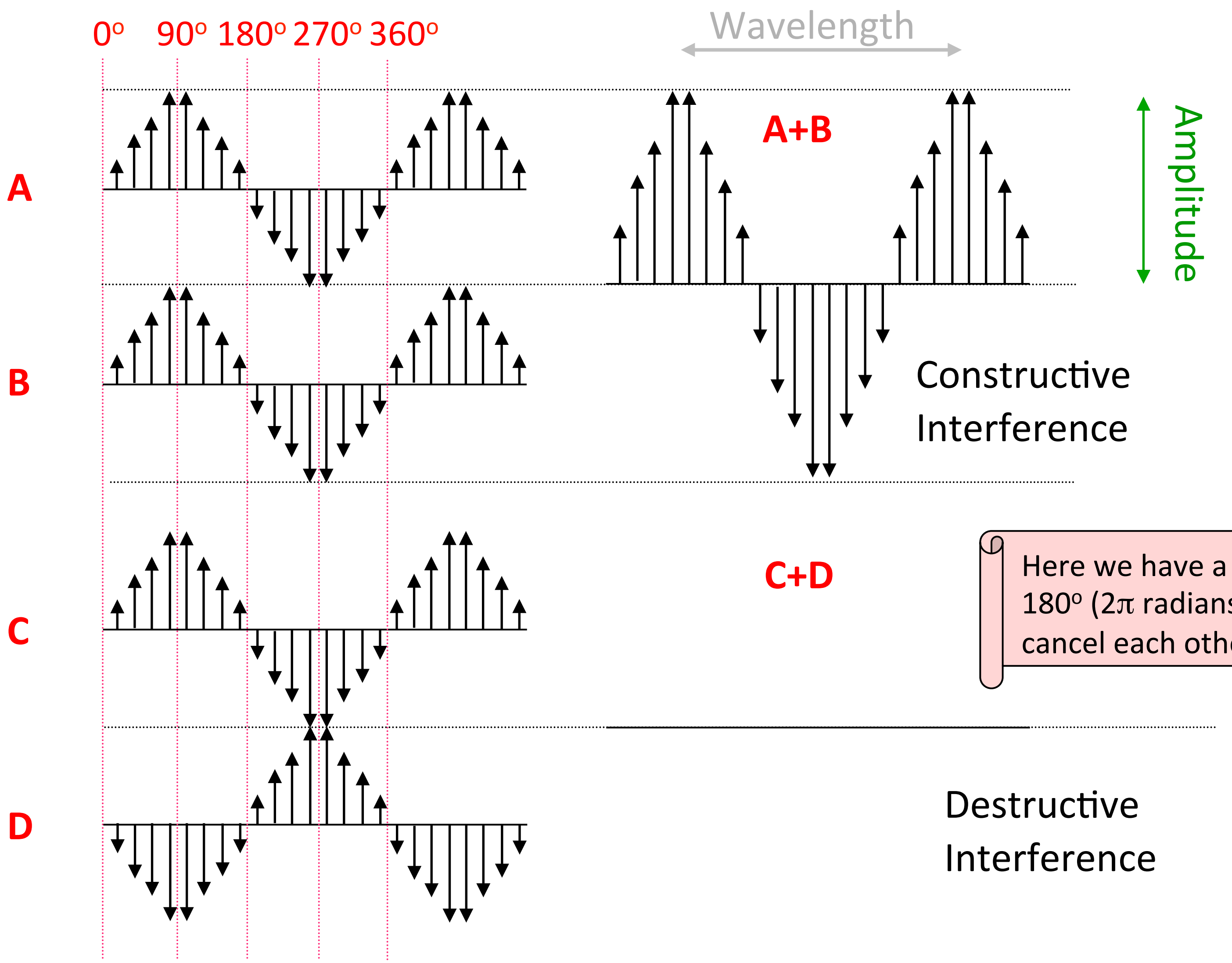
Diffraction is the ability of light waves to bend around obstacles placed in their path.





Water waves easily bend around obstacles, but light waves also bend, as evidenced by the lack of a sharp shadow on the wall.

Interference

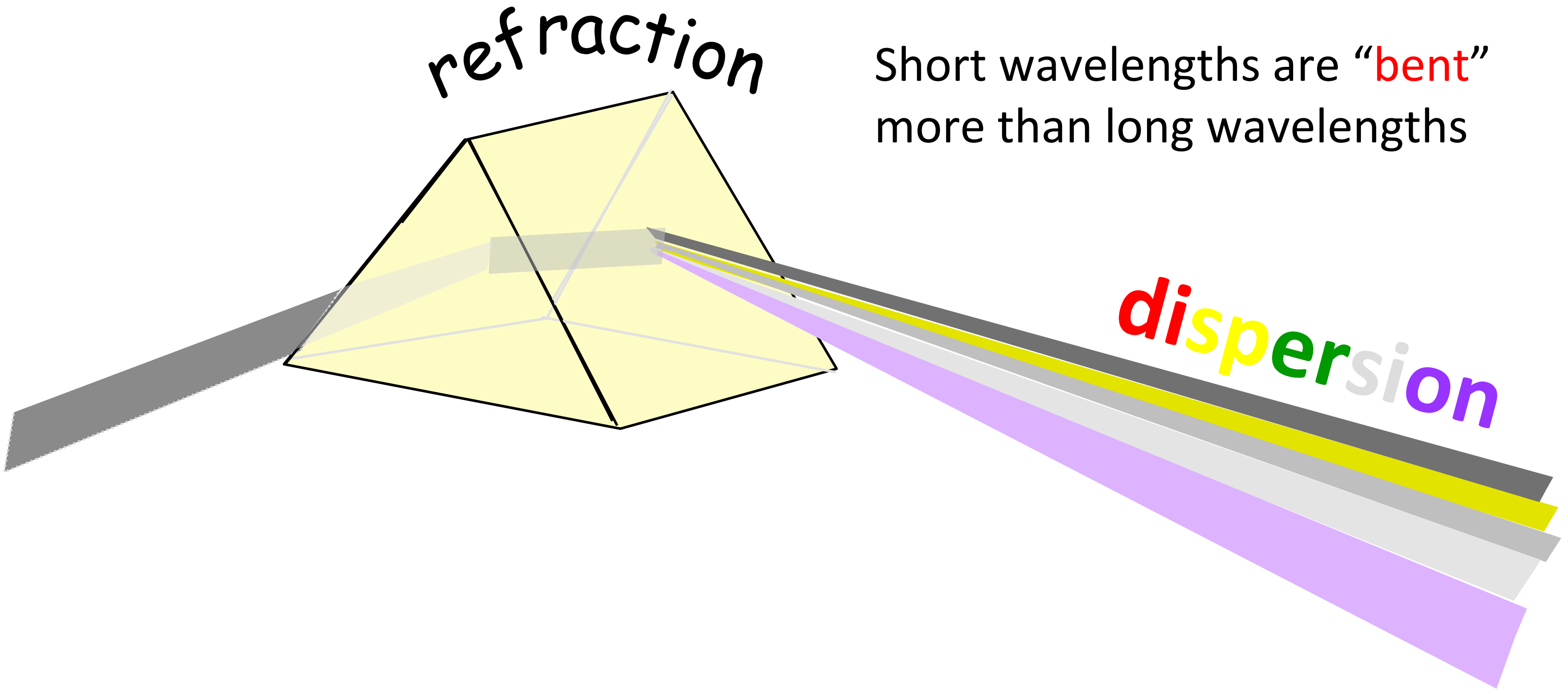


The frequency does not change, but the amplitude is doubled

Here we have a phase difference of 180º (2π radians) so the waves cancel each other out

Dispersion

- Separation of light into its constituent wavelengths when entering a transparent medium - the change of refractive index with wavelength, such as the spectrum produced by a prism or a rainbow.
- Light is “bent” and the resultant colors separate (dispersion).
- Red is least refracted, violet most refracted.



Short wavelengths are “bent” more than long wavelengths

Aberration

Aberration is an imperfection in image formation by an optical system.

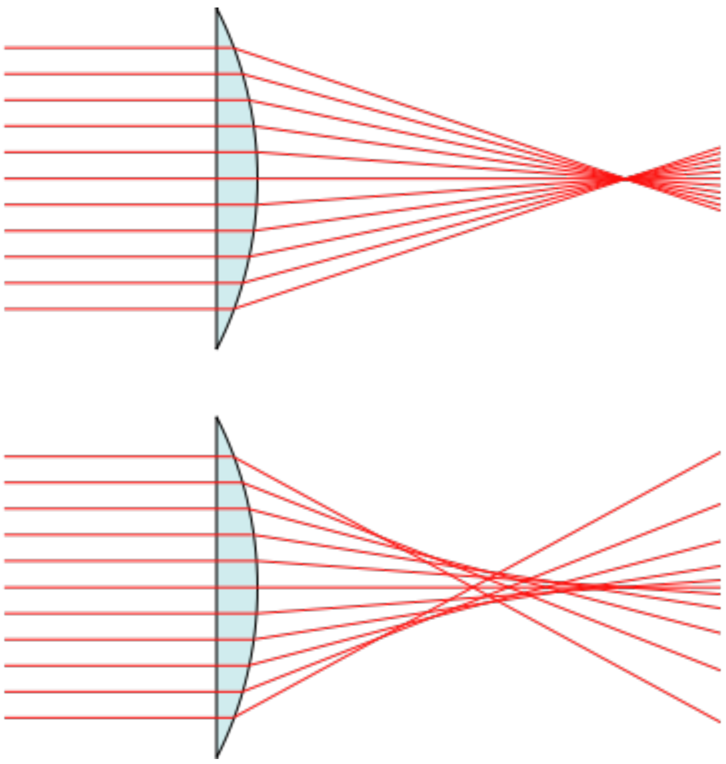
It is mainly of two types:

Spherical aberration, which occurs when light rays strike a lens or mirror near its edge.

Chromatic aberration, caused by differences in refractive index for different wavelengths of light.

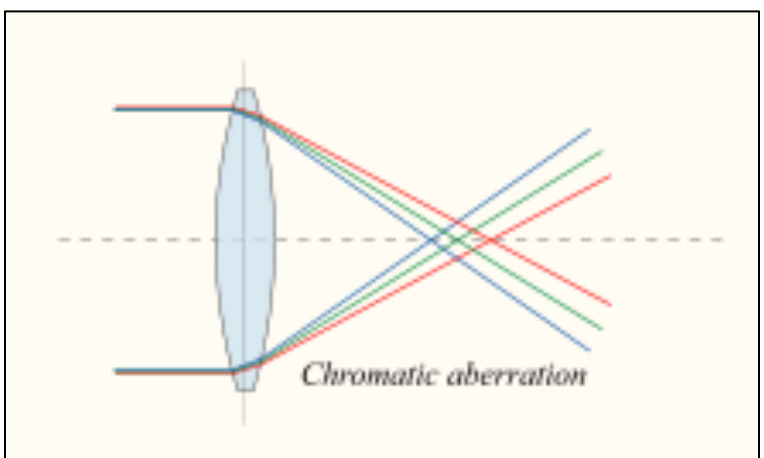
Spherical aberration

- Spherical aberration occurs when light rays strike a lens or mirror near its edge.
- A perfect lens (top) focuses all incoming rays to a point on the optic axis.
- A real lens (bottom) with spherical surfaces suffers from spherical aberration.



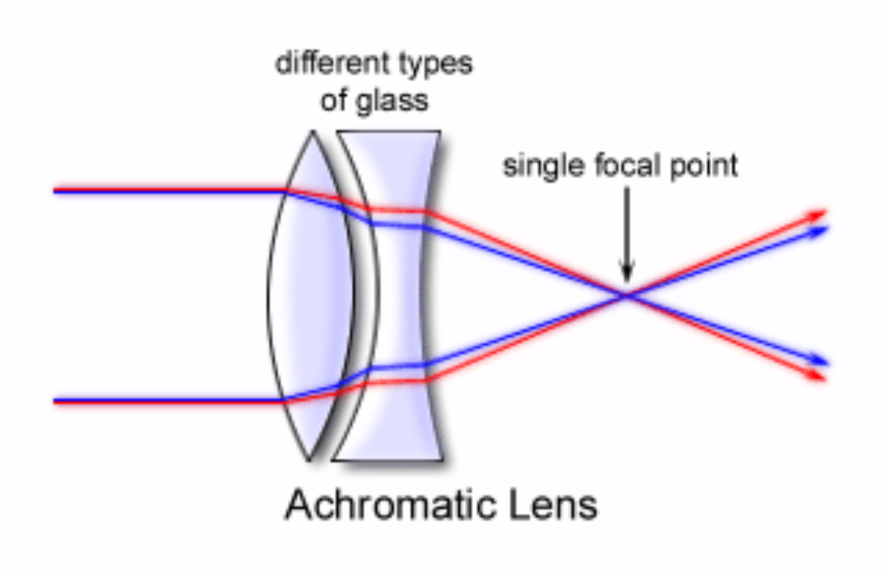
Chromatic aberration

- It is a type of distortion in which there is a failure of a lens to focus all colors to the same convergence point.
- It occurs because lenses have a different refractive index for different wavelengths of light (the dispersion of the lens).



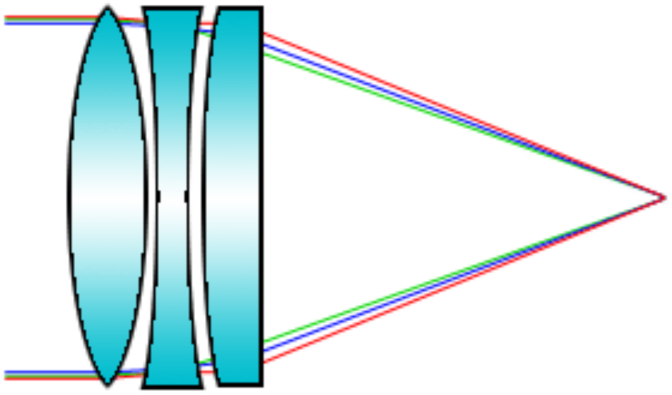
Achromatic lens

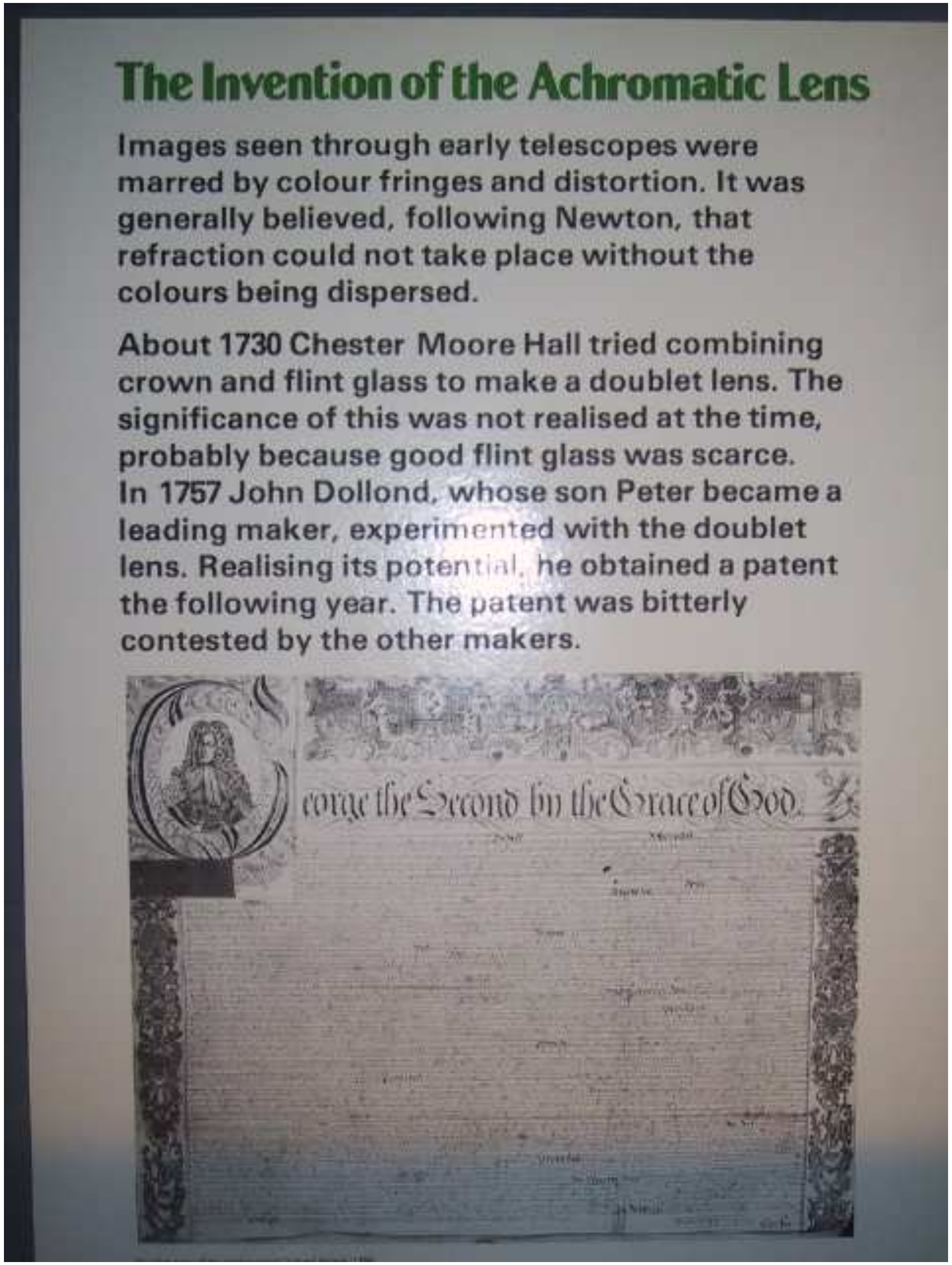
- An **achromatic lens** or **achromat** is a lens that is designed to limit the effects of chromatic and spherical aberration.
- The most common type of achromat is the **achromatic doublet**, which is composed of two individual lenses made from glasses with different amounts of dispersion.
- one element is a negative (concave), which has relatively high dispersion, and the other is a positive (convex) , which has lower dispersion.



Apochromatic lens

- Apochromatic lens is a lens that has better correction of chromatic and spherical aberration than the much more common achromat lenses.
- The Apochromatic lens is usually of three elements and brings light of three different frequencies to a common focus



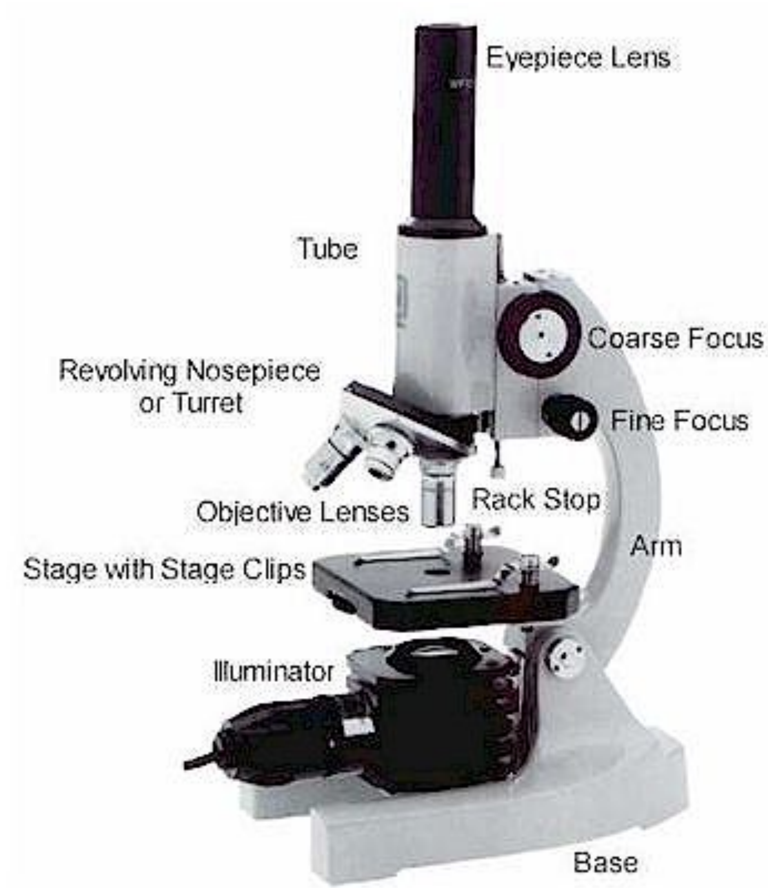


The famous patent of 1758

- **George Bass** was the lens-maker that actually made the lenses, but he did not divulge the secret until over 20 years later to **John Dollond** who copied the idea in 1757 and patented the achromatic lens in 1758.

What is Microscope?

- A **microscope** (from the Ancient Greek: micro meaning ‘small’ and scope meaning ‘to aim at’ or "see") is an instrument used to see objects that are too small for the naked eye.



Simple Microscope

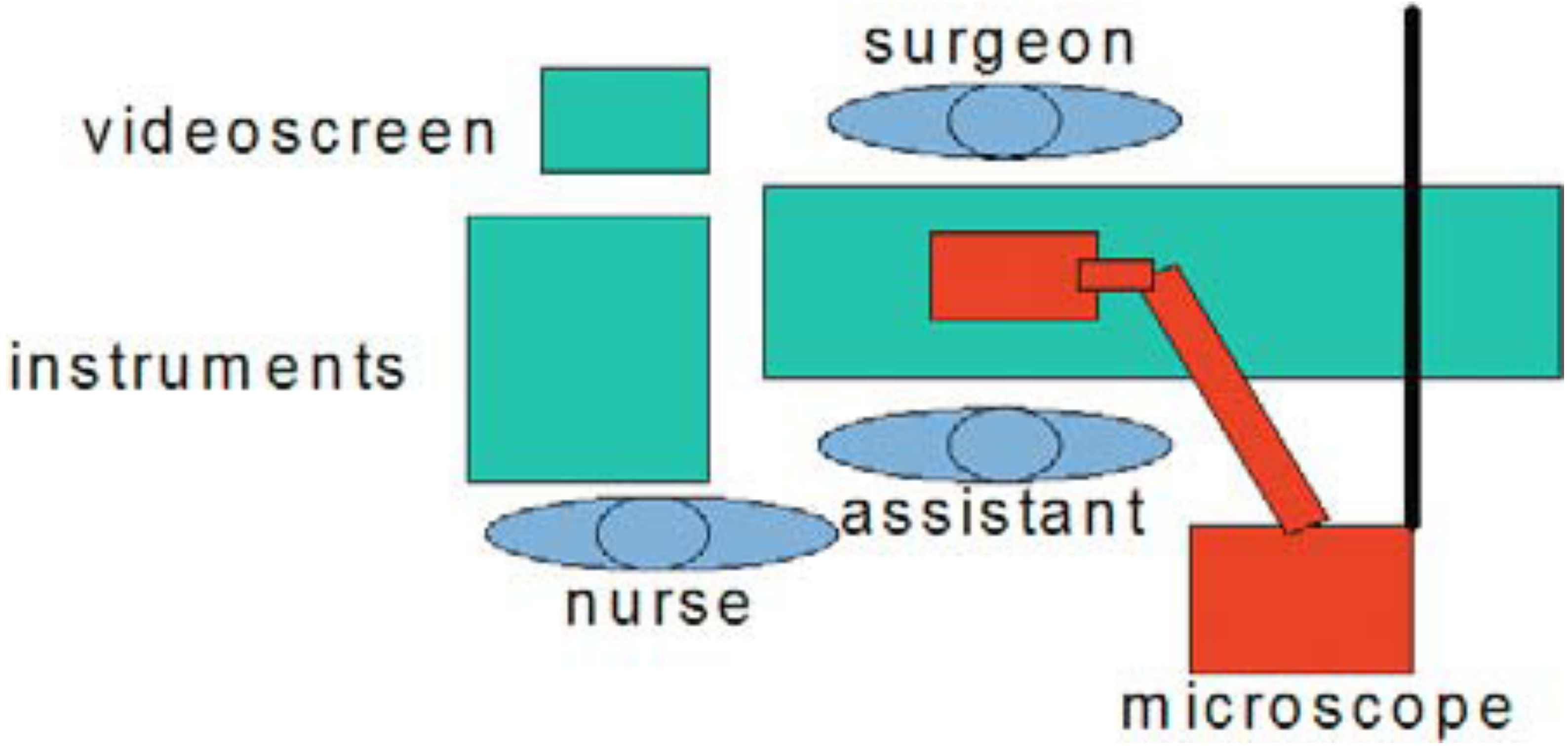
Microscope types

- acoustic microscope
- binocular microscope
- compound microscope
- dark field microscope
- electron microscope
- fluorescence microscope
- light microscope
- operating microscope
- phase microscope (phase-contrast microscope)
- scanning electron microscope (SEM)
- simple microscope
- slit lamp microscope
- stereoscopic microscope
- transmission electron microscope
- x-ray microscope

Operating Microscope

- A Operating microscope is the one that is used in delicate surgical procedures.
- It is a **stereoscopic microscope** i.e. modified version of binocular microscope to give a three-dimensional view of the specimen.
- The standing type of operating microscope has a motorized zoom system that quickly changes the magnification.
- Basic function is to provide clear vision and lighting in addition to magnification.
- It is also called, **surgical microscope**.

Example of a standard setup in the operating room



History

Year	Milestones
1590	Zacharias and Hans (Dutch opticians) aligned two lenses in a sliding tube and invented the compound microscope.
1848	Carl Zeiss opened a microscope workshop in Germany.
1893	Concept of stereopsis utilizing binocular microscope was introduced by Zeiss
1921	Carl Nylen, a Swedish otolaryngologist constructed and used the world's first surgical monocular microscope on humans.
1957	Theodore Kurze became the first neurosurgeon to use an operating microscope to operate on 8^{th} cranial nerve.
1958	RMP Donaghy established the world's first microsurgery research and training laboratory in Burlington.
1960	Jacobson and Suarez, working in the same laboratory, performed a successful small vessel anastomose using the microscope.

History cont…

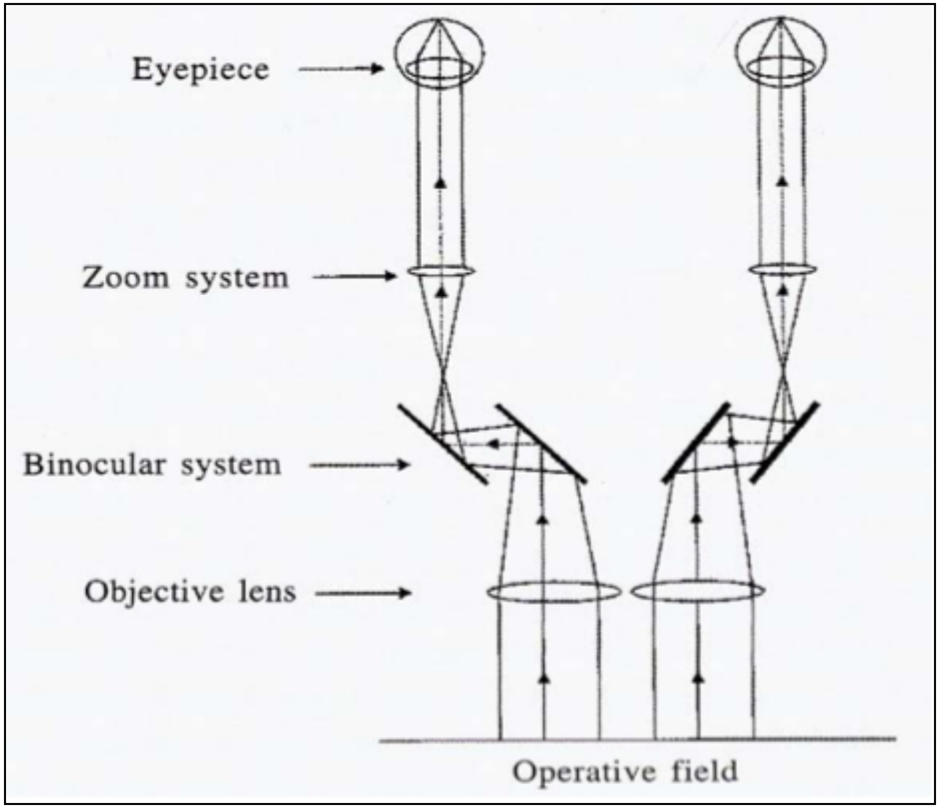
Year	Milestones
1962	Then by collaborating with Hans Littman of Zeiss Corporation , Jacobson and Suarez designed, stereoscopic microscope utilizing the beam splitter technology to allow second surgeon to assist.
1966	MG Yasagril attended this training facility of Donaghy and returned to Zurich.
1967	Yasagril also established a training laboratory in Zurich and performed the first superficial temporal artery to middle cerebral artery anastomosis under the microscope.
1970	Since the middle of the 1970s microsurgery pioneers such as Caspar, Yasargil, and Williams performed various microsurgical procedures with the aid of a microscope. Since then, surgical microscopes have become an integral part of neurosurgery.

Stereoscopic vision

- Different images are sent to the two eyes from different angles so that a stereo effect is achieved.
- Stereoscopic vision thus gives depth to 3D objects or provides depth perception to the surgeon.
- Stereoscopic perspective is thus the most useful function of the surgical microscope.
- Even when assisted with magnification loupes, the eyes are unable to maintain stereoscopic vision in such a narrow space.
- The operating microscope allows stereoscopic vision in small spaces by reducing the necessary interpupillary distance required for binocular vision.

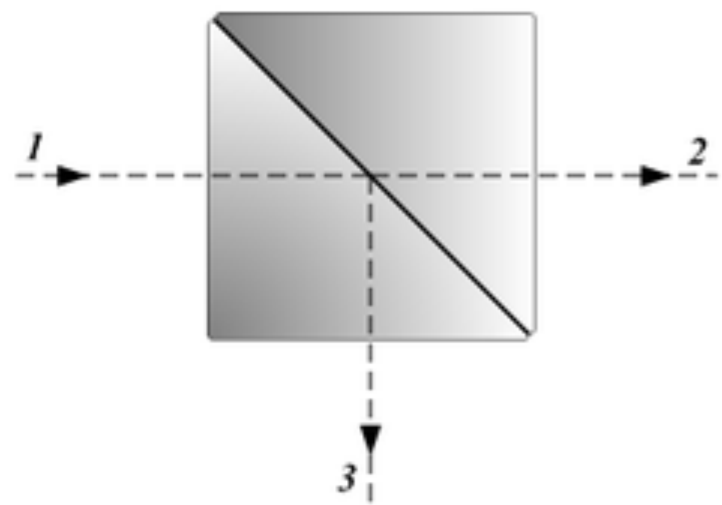
Stereoscopic vision cont...

- The distance between the anterior lenses of the binocular tube of the microscope is only 16 mm, whereas the average interpupillary distance is around 60 mm.
- This means that light reflected from deep basal structures towards the operating microscope during surgical procedures, will result in a stereoscopic image when only a 16 mm image enters the microscope aided eye.



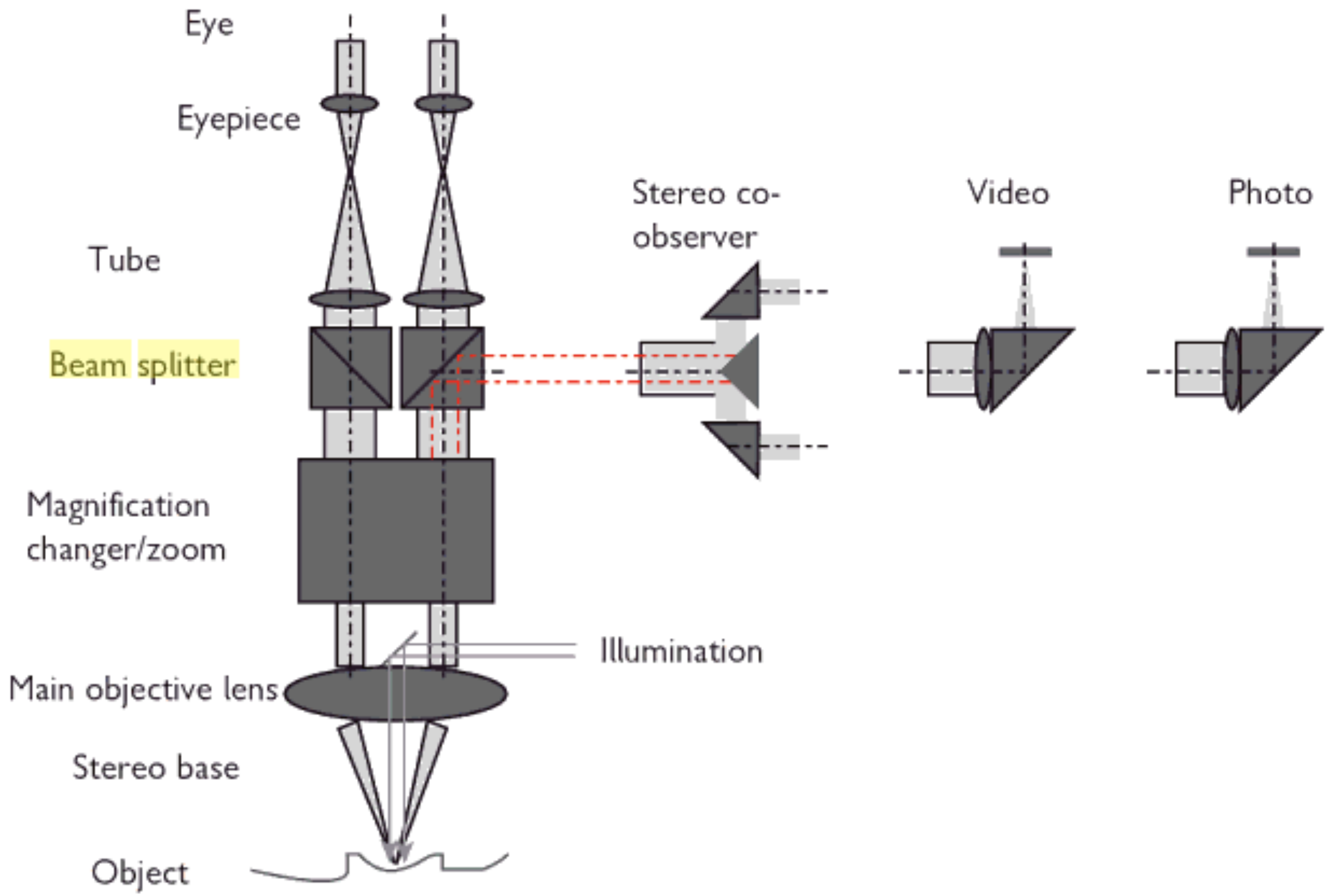
Beam Splitter

- A **beam splitter** is an optical device for separating incident beam of light into two or more beams.
- It directs the imaging beam to the eyepiece and to the camera simultaneously.
- In its most common form, a cube, it is made from two triangular glass prisms which are glued together at their base using polyester, epoxy, or urethane-based adhesives.



1 - Incident light
2 - 50% Transmitted light
3 - 50% Reflected light

Beam Splitter Mechanism



Zeiss Surgical microscope

Components of Operating Microscope

- Main Objective Lens
- Magnification Changer
- Illumination system
- Suspension system
- Braking System
- Video systems and Documentation

Main Objective lens

- Primary image from the operative field enters the microscope body through objective lens.
- The focal length varies from 200 to 400 mm depending on working distance required.
- In deep operative field e.g. in trans-sphenoidal pituitary surgery, 300-400 mm lens can be used.
- Objective lens with a focal length of 300, 350, or 400 mm. These lenses are available separately, however, the newer microscope models allow for variable adaptation of the focal length.

Magnification changer

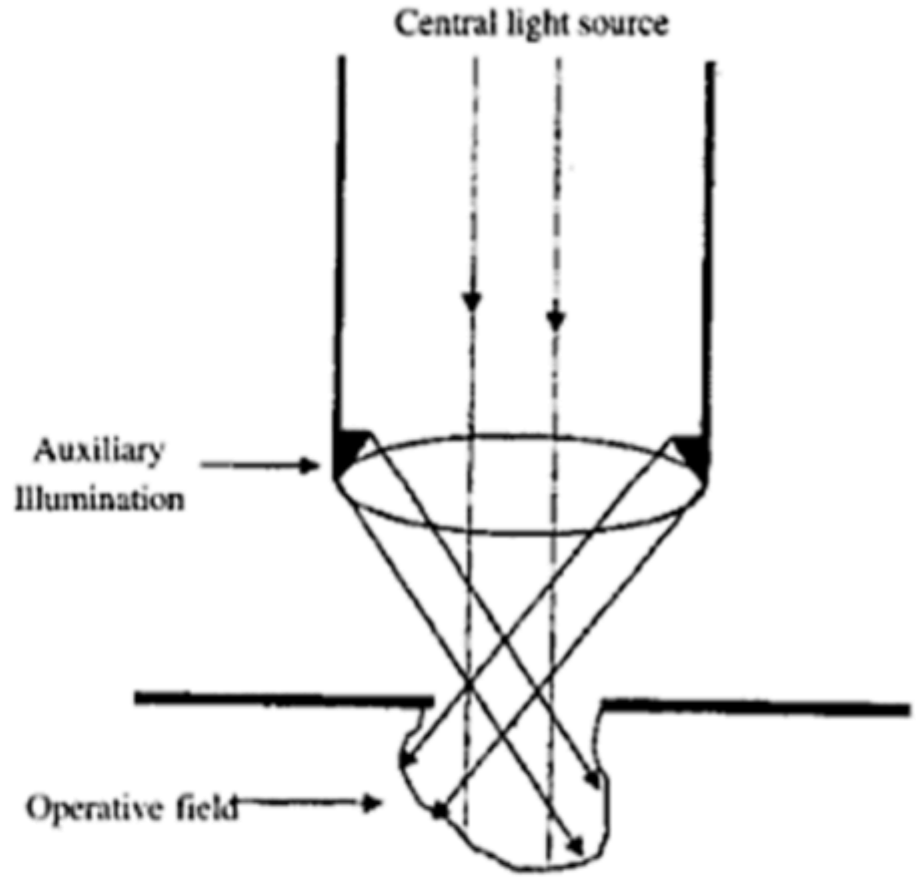
- Magnification power of a microscope is calculated by multiplying the individual magnification produced by the objective lens and eyepiece individually.
- Magnification changer is a lens system placed between the objective and the binocular system comprising microprocessor controlled lenses which allow continuous adjustment of magnification.
- Modern microscope models allow for independent correction of zoom, focus, and magnification by the surgeon as well as by the assistant.

Illumination System

- Earlier microscopes used integrated light sources such s tungsten and halogen bulbs that generated lot of heat and made prolonged surgery problematic.
- Development of fiber optics enabled the use of remote illumination source.
- Automatic adjustment of light collimation in modern microscopes allows appropriate illumination as magnification is changed.
- Xenon light source is the best possible light source with the highest intensity and the longest life span.

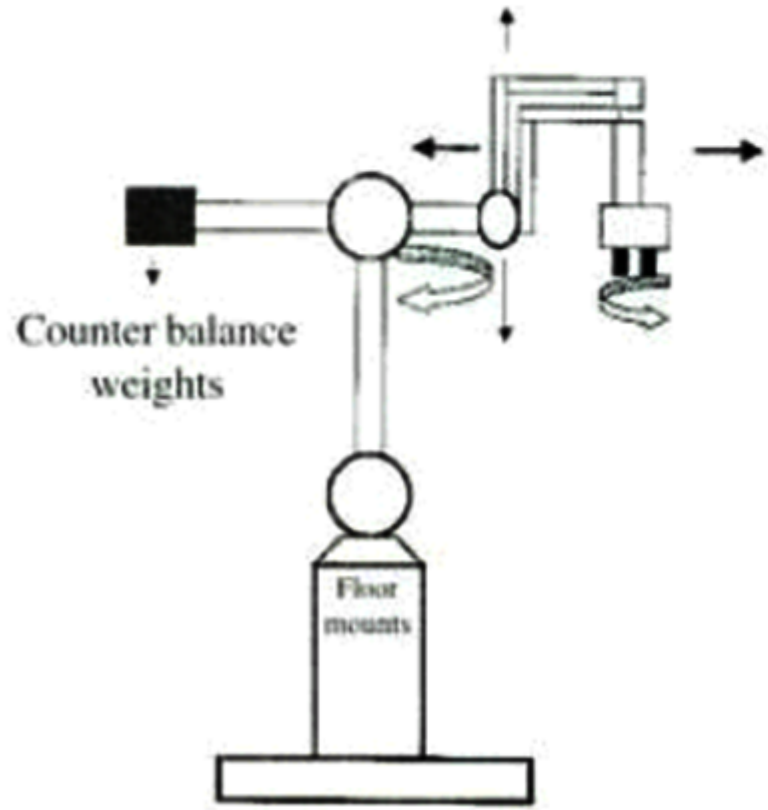
Auxiliary illumination

The present generation OPMI neuromicroscope from Zeiss contains an auxiliary illumination system used to decrease shadowing when changing the viewing angle.



Microscope Suspension

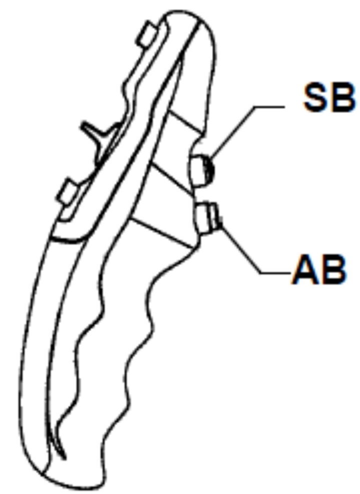
- The counterweight-balanced microscope was designed by Yasargil, and copied by many manufacturers.
- This creates an essentially weightless suspension of the microscope optics.



Freedom of movement by counterweight- balance

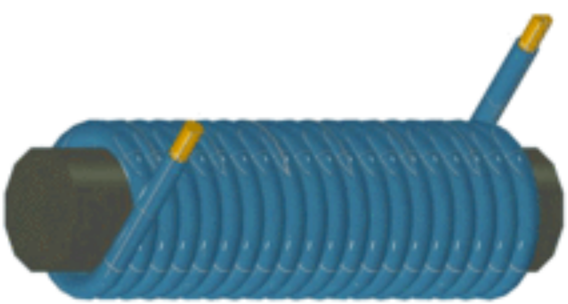
Locking Mechanism

- The microscope is locked to a defined position using magnetic brakes.
- Surgeon can press the brake release buttons (AB) to unlock all magnetic brakes.
- By Keeping the brake release buttons (AB) pressed the microscope can be moved into the working position required using the handgrips.
- When surgeon let go of the brake release buttons (AB), all magnetic brakes are locked.

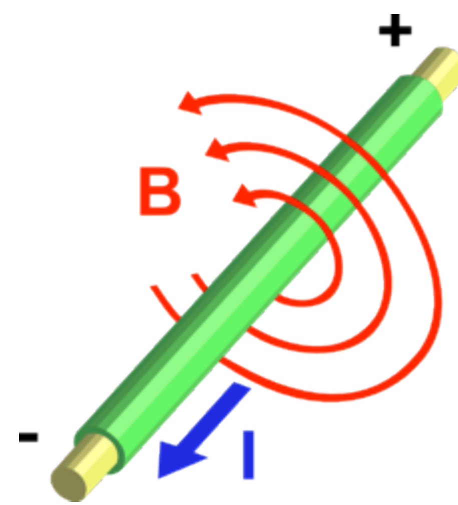


Electromagnetic Brakes

- Electromagnetic brakes (also called electro-mechanical brakes or EM brakes) slow or stop motion using electromagnetic force to apply mechanical resistance (friction).
- An electromagnet is a type of magnet in which the magnetic field is produced by the flow of electric current.



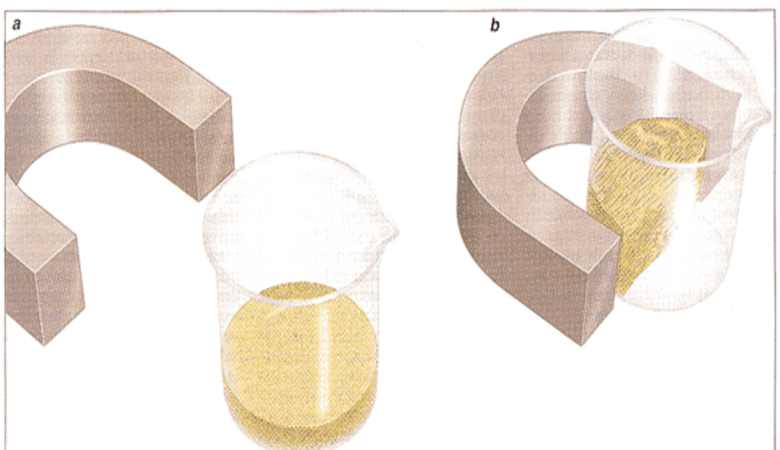
A simple electromagnet consisting of a coil of insulated wire wrapped around an iron core.

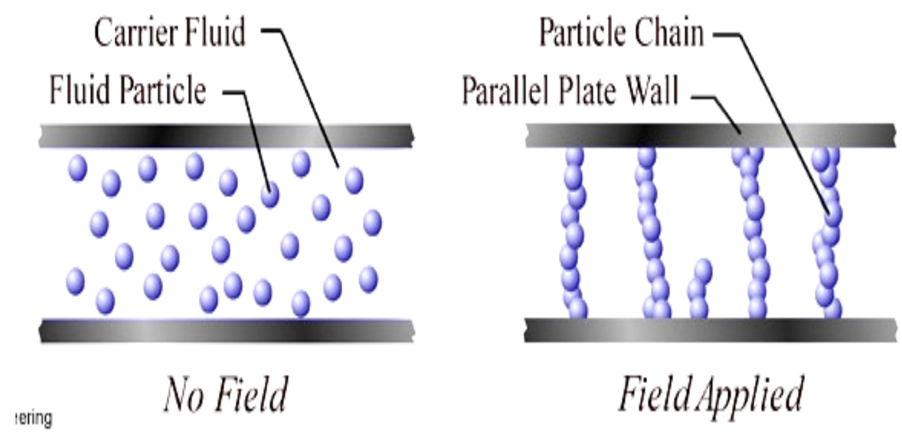


Current (I) through a wire produces a magnetic field (B).

MAGNETORHEOLOGICAL BRAKES

- MR fluids are dispersions of Particles made of a soft magnetic material in a carrier oil.
- Tiny Iron Particles align with Magnetic Field.
- Fluid turns pasty and feels very stiff.
- Reverts to liquid when Magnetic Field is removed.





Video Technology and Documentation

- Documentation for medical as well as for scientific reasons has become easier with the use of microsurgery.
- It allows direct coupling to the video system (chip-camera, video screen, video recorder) to the microscope.
- This enables the surgeon to document the significant steps of an operation.
- To achieve the best quality, 3-chip digital cameras as well as a professional video-recording system (e.g., Betacam) can be used.
- For rapid documentation of intraoperative findings, a video color printer can be helpful.

Microscope Handling

Usually the draping of the microscope is done by the scrub nurse and the operating room technician. There are several key points which are important during draping for comfortable use of the microscope:

- The handlebars should be covered tightly with the drape, allowing proper handling without slipping of the drape or unwanted accidental activation of the controls.
- The draping starts with the optical lens, which has a tight-fitting ring around it leaving the lens open for maximum optical quality.
- While the optical unit around the lens remains sterile, the lens itself is uncovered and thereby unsterile.

Know your microscope and some of its trivial failures. Service of the microscope is important. The light source should be exchanged regularly. Once the light source died during an intraoperative aneurysm rupture!

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