Part 1: Light and the eye

- Light is a stimulus for vision
  - Seeing involves a stimulus (light) and a mechanism (the visual system)

- Vision is based on visible light, a band of energy within the electromagnetic spectrum

- Electromagnetic spectrum-- a continuum of electromagnetic energy produced by electrical charges that is radiated as waves

The Electromagnetic Spectrum

Visible light

- Only a small part of the electromagnetic spectrum
- We can detect light between 400 - 700 nm
  - (nm = 1 billionth of a metre)

Light-- the stimulus for vision

- Can regard light as a wave or as a particle

  - Properties used depend on the circumstances

The Structure of the Eye

a) Non-optical components

b) Optical components

- Cornea

Pupil size depends on

- Light level
- Age
- Autonomic nervous system-- fear, excitement, etc.

b) Optical Components

- Cornea
• Aqueous
• Iris/pupil

c) Neural Components
  • Retina
    – Contains photoreceptors, collector cells, retinal ganglion cells

Part 3: The Eye as an Optical System
• Need to get a focused image on the retina
  – Pattern of light on the retina is the retinal image

The Eye and Camera
• Both are optical devices designed to record visual images on light sensitive material
  – Camera: film
  – Eye: photoreceptors
• Similar aperture control but different focusing mechanism
• But the eye does much more!
  – Recodes image
  – Extracts biologically meaningful information
  – Transmits info to brain for
    • interpretation
    • reaction

Refraction-- the basis of optics

The Eye as an Optical System
• Cornea is the main focusing element
  – Consequence of refractive index differences between air and cornea.

• Lens provides the fine focus component
• They both refract light rays into the eye

The Focussing Power of the Eye
• Power of a lens system is expressed in diopters.

  1 Diopter = 1 ÷ focal length (in metres)

• FL of cornea = .02 m, so power = 1 ÷ .02 = 50 D
• FL of lens = .08 m, so power = 1 ÷ .08 = approx. 12 D
Focussing -- Accommodation
In humans, fine focussing is controlled through changing the shape of the lens.

Accommodation
- Changing the lens shape is controlled by the ciliary muscles

Object-Lens Distance
- The spot at which a convex lens brings light to a point depends on the degree of divergence of the light arriving at the lens
- Close objects are focussed further from the lens
- Far objects are focussed closer to the lens

Near and Far Points
- Far point
  - Normally at optical infinity
- Near point - closest distance that an object can still be kept in focus.
  - Will change with age

The Emmetropic Eye
- The “normal” eye can bring an image into clear focus on the retina with no optical correction
- Correct refraction produces focussed images on the retina
  - Far point
    - at optical infinity
  - Near point
    - fairly close to eye

Part 4: Eye Disorders and Diseases
- Disorders at the level of the eye prevent information being transmitted to the higher centres for processing
  - Optical disorders interfere with the generation of a proximal stimulus
  - Retinal disorders interfere with the transduction process

When the Eye Goes Wrong
- Optical
  - Refractive errors
    - spherical - hyperopia, myopia, presbyopia
    - cylindrical – astigmatism
  - Cataract
– Corneal and vitreous opacities

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35  Refractive Errors

36  Hyperopia

37  Hyperopia

38

39  Refractive Error and Optical Power
  • Convex lenses increase the power of an optical system (They have positive power)

40  Myopia

41  Myopia Correction

42  Refractive Error and Optical Power
  • Concave lenses decrease the power of an optical system (They have negative power)

43  Myopia
  • Number of diopters of lens power needed to correct myopic vision for different far points
    – far point of 10 cm = severe myopia
    – far point of 100 cm = mild myopia

44  Astigmatism
  • Cylindrical error
  • Cornea is lemon, rather than orange shaped
    – Radius of curvature is different in different meridia

45  Astigmatism

46  Astigmatic Correction

47  Presbyopia
  • Increasing hyperopia with age
  • Results from loss of accommodation of the lens
• Eye becomes a “fixed-focus” system

• Corrected with appropriate spectacle correction (sometimes bifocals)

Presbyopic Correction

Your Spectacle Prescription

When the Eye Goes Wrong

• Optical
  – Refractive error
  – Cataract

Cataract

Cataract Vision

Cataracts

• Opacity of the lens prevents clear vision

• Typically occurs later in life, but even seen in infants

• Corrected by removing lens and using either spectacle correction or intraocular lens implants

Cataract Surgery

Intraocular Lens Implant

Eye Charts

Blindness

• Visual acuity of 20/200 or worse

• Visual field of 20° or less

Blindness

• Visual acuity of 20/200 or worse

• Visual field of 20° or less

• A “blind” person does not necessarily have no useful vision

When the eye goes wrong

• The clinical conditions described are only a sample of the kinds of things that can go
wrong with the eye

- Important to remember that each disorder produces a different kind of visual impairment, so that the visual experiences of low vision or "blind" individuals may be quite different