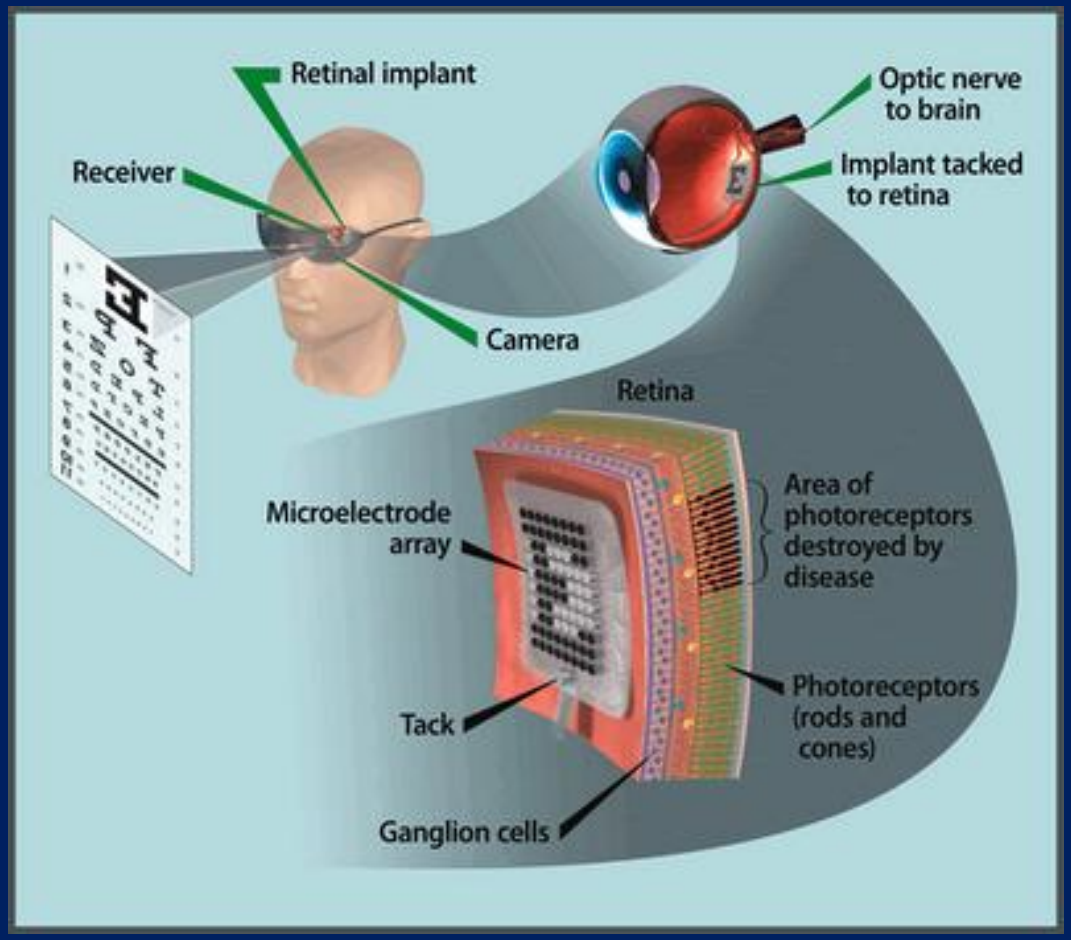
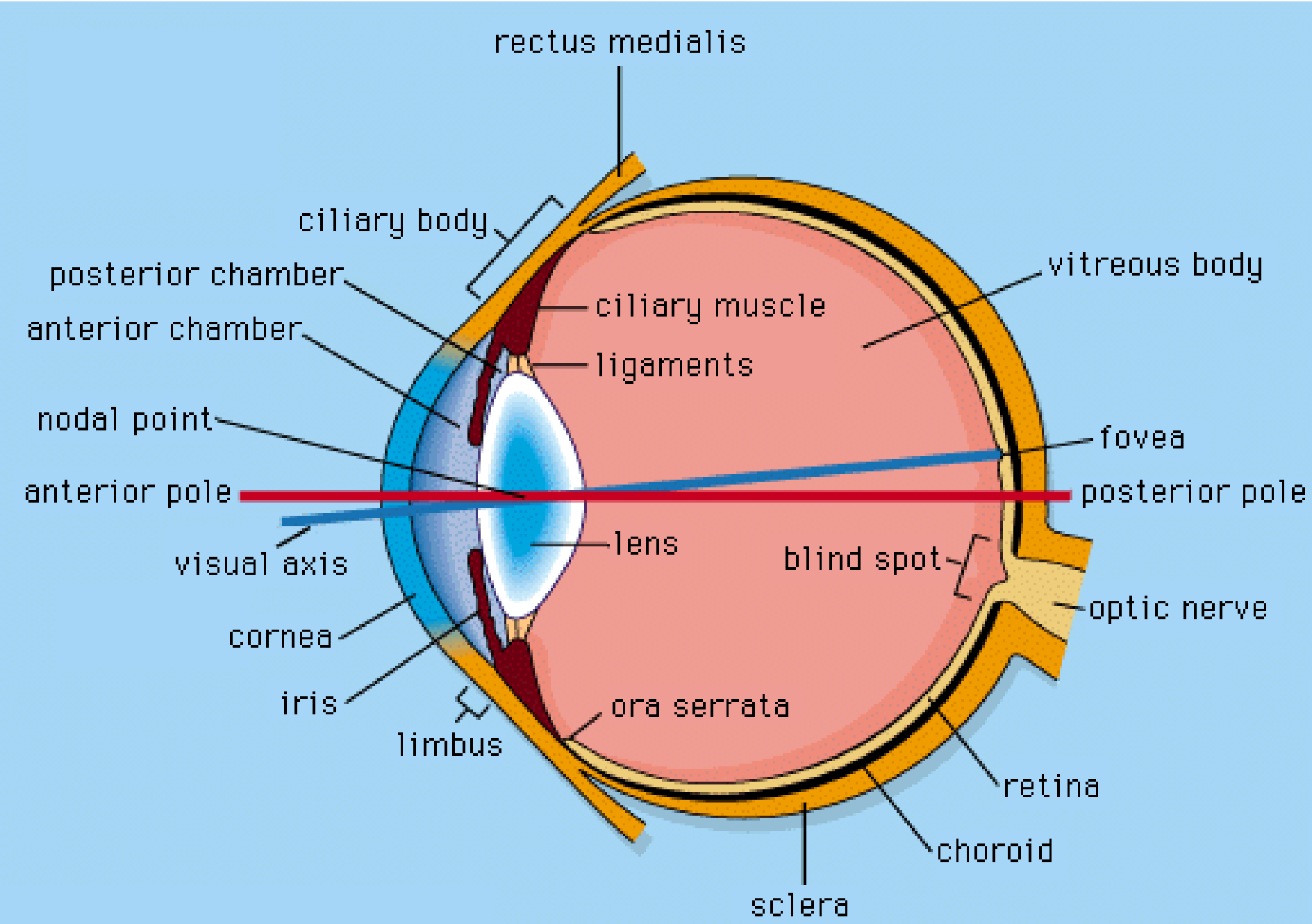
Elements of Visual Perception



Dr A S Jalal

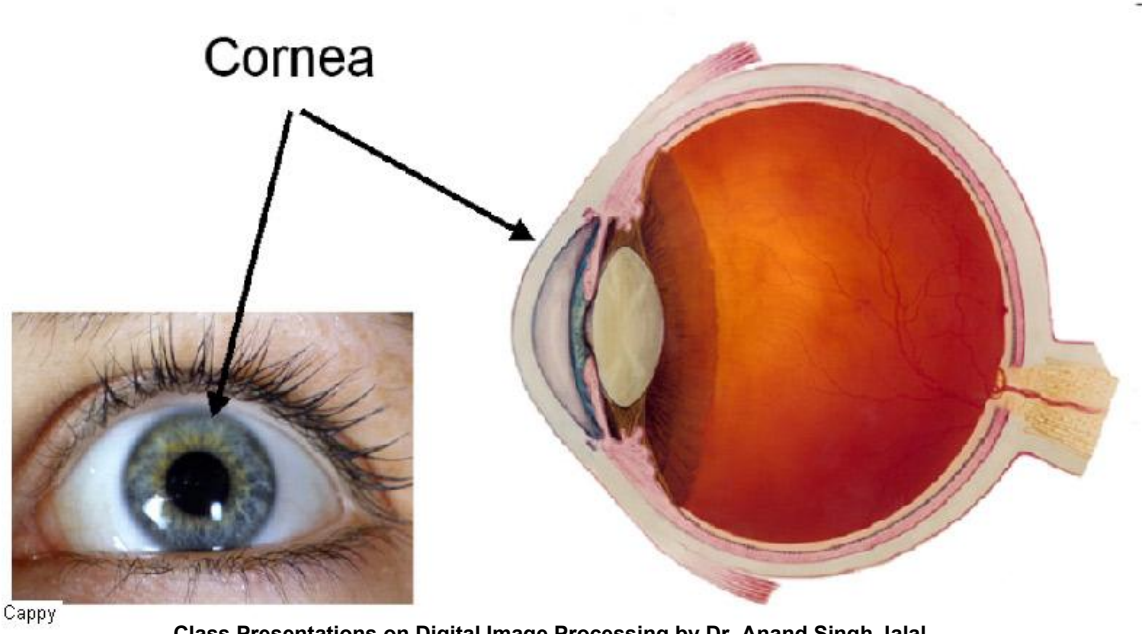
Structure (anatomy) of the human eye

- The cornea and sclera outer cover
- The choroid
  - Ciliary body
  - Iris diaphragm
  - Lens
- The retina
  - Cones vision (photopic/bright-light vision): centered at fovea, highly sensitive to color
  - Rods (scotopic/dim-light vision): general view
  - Blind spot



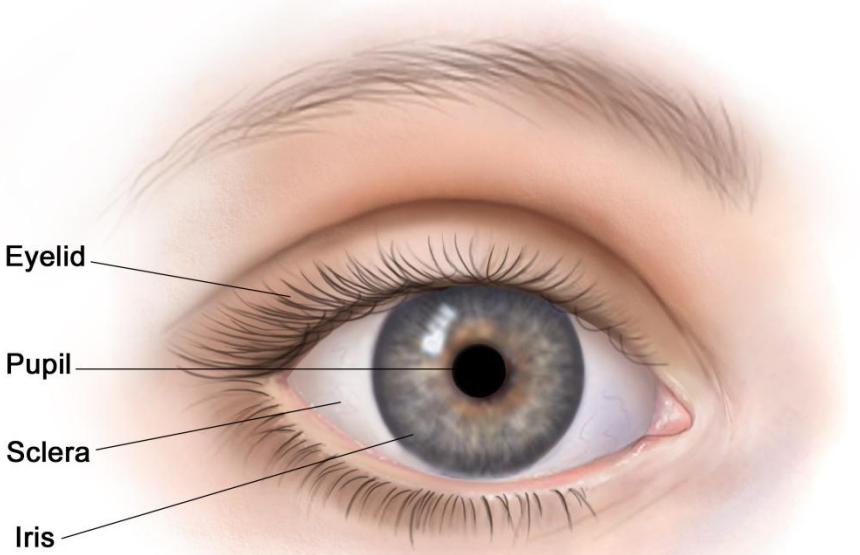
Structure of the human eye …

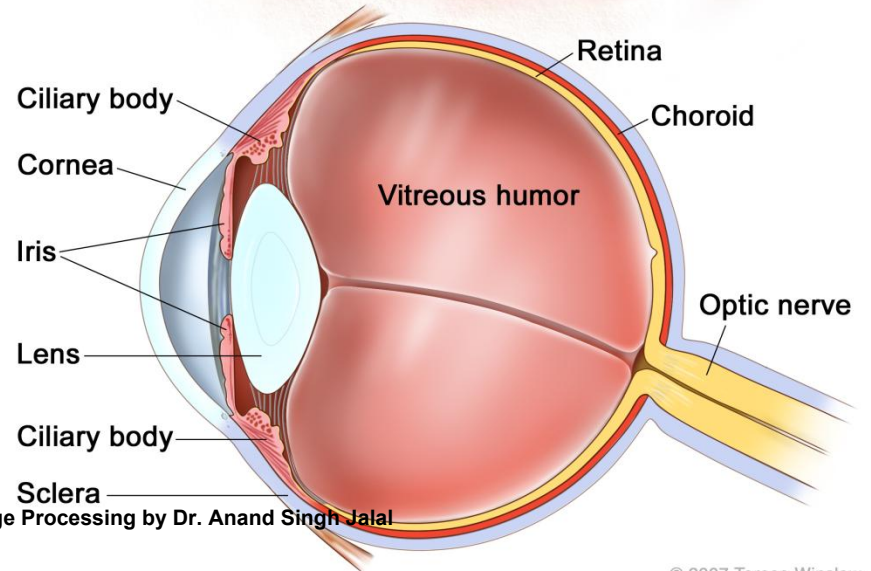
- **Cornea**
  - Tough & Transparent tissue
  - Covers the frontal surface of the eye



Structure of the human eye …

- **Sclera**
  - Continuous with cornea
  - Opaque membrane
  - Encloses the remainder of the optic globe





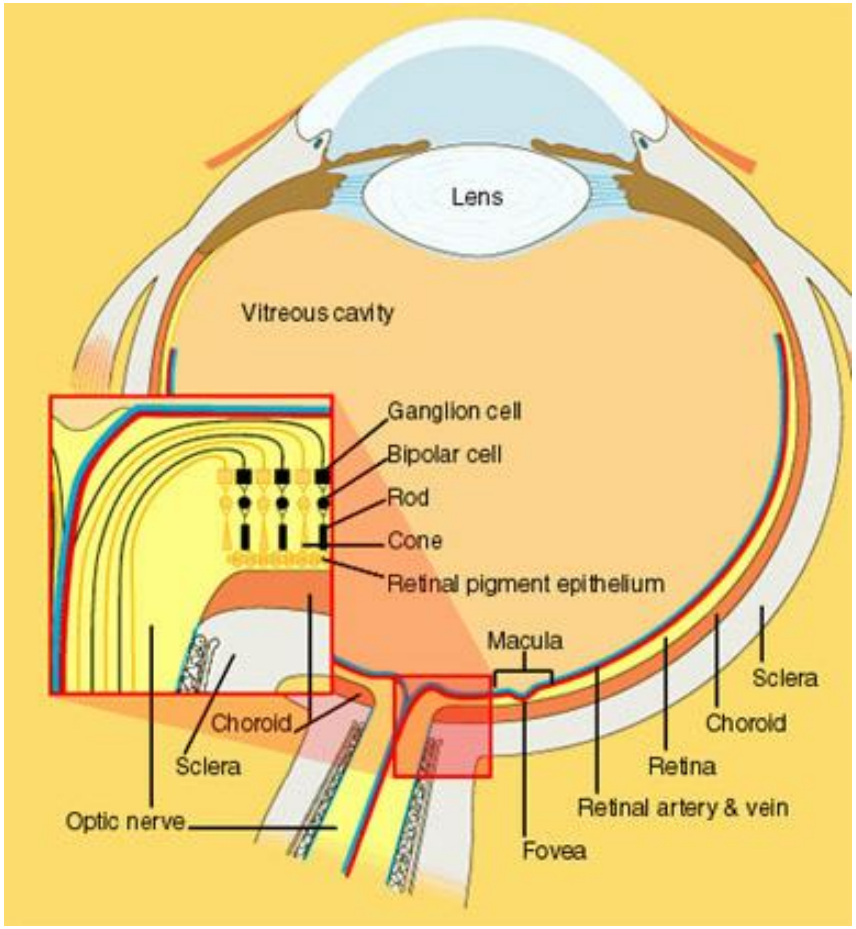
Structure of the human eye …

- **Choroid**
  - The choroid contains blood vessels for eye nutrition and is heavily pigmented to reduce extraneous light entrance and backscatter.
  - It is divided into the ciliary body and the iris diaphragm, which controls the amount of light that enters the pupil (2 mm ~ 8 mm).

- **The lens is made up of fibrous cells and is suspended by fibers that attach it to the ciliary body.**
- **It is slightly yellow and absorbs approx. 8% of the visible light spectrum.**

Structure of the human eye …

- **Retina**
  - Light from an object is imaged on the retina
  - The retina lines the entire posterior portion.
  - Discrete light receptors are distributed over the surface of the retina:
    - cones (6-7 million per eye) and
    - rods (75-150 million per eye)



Structure of the human eye …

- **Cones**
  - Cones provide color vision and respond to higher levels of illumination
  - The density of the cones is higher in the fovea
  - Each one is connected to its own nerve end.
  - Cone vision is called *photopic* (or bright-light vision).
  - **Muscles controlling the eye rotate the eye ball until the image of an object of interest falls on the fovea.**

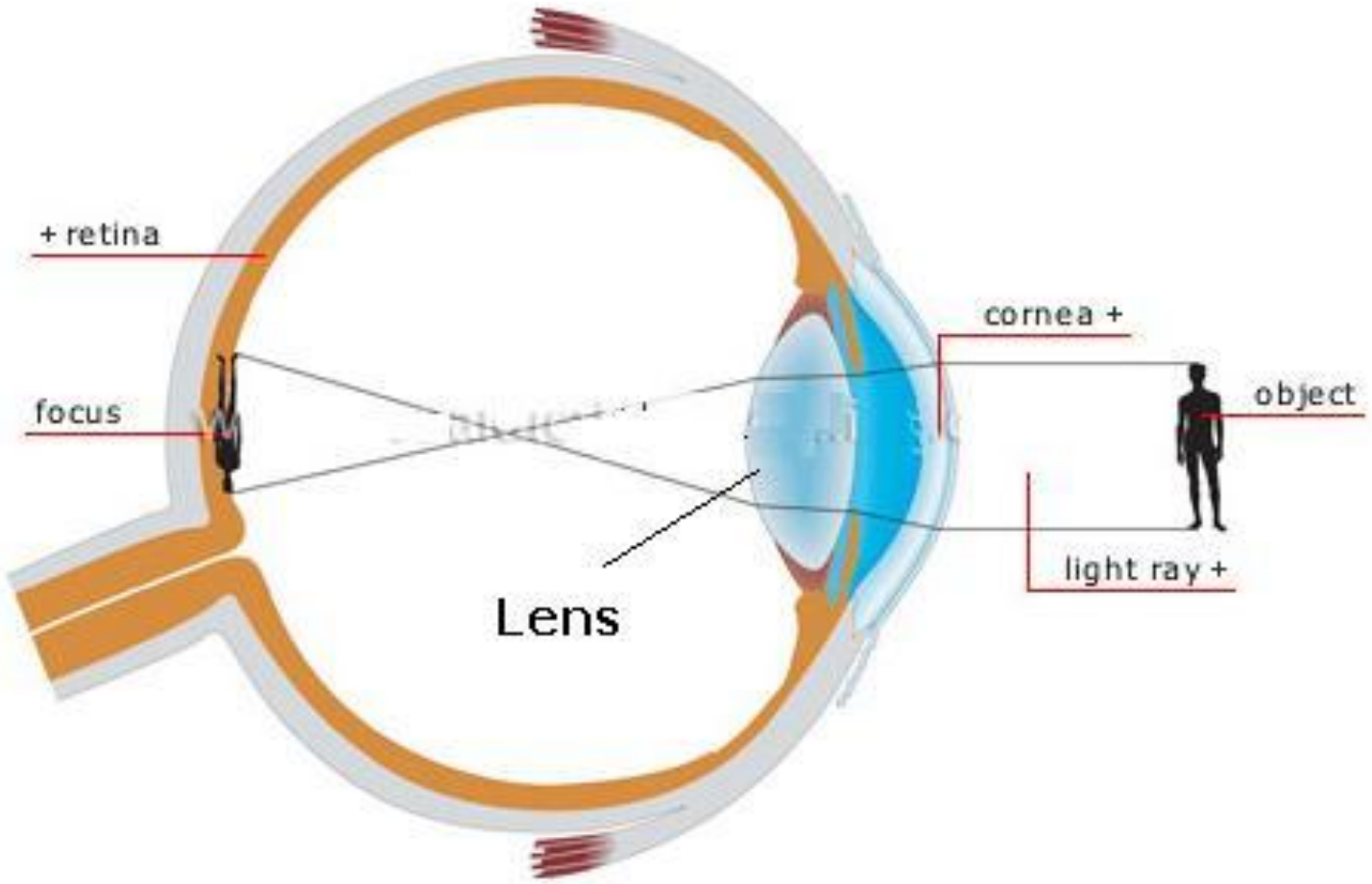
Structure of the human eye …

- **Rods**
  - Rods are distributed over the retinal surface
  - Rods give a general, overall picture of the field of view and are not involved in color vision.
  - Rods are important for black and white vision in dim light
  - Discriminate between different shades of darks and light
  - Rods provide visual response called Scotopic Vision
  - **Objects seen by moon light appear as colourless forms because only rods are stimulated.**

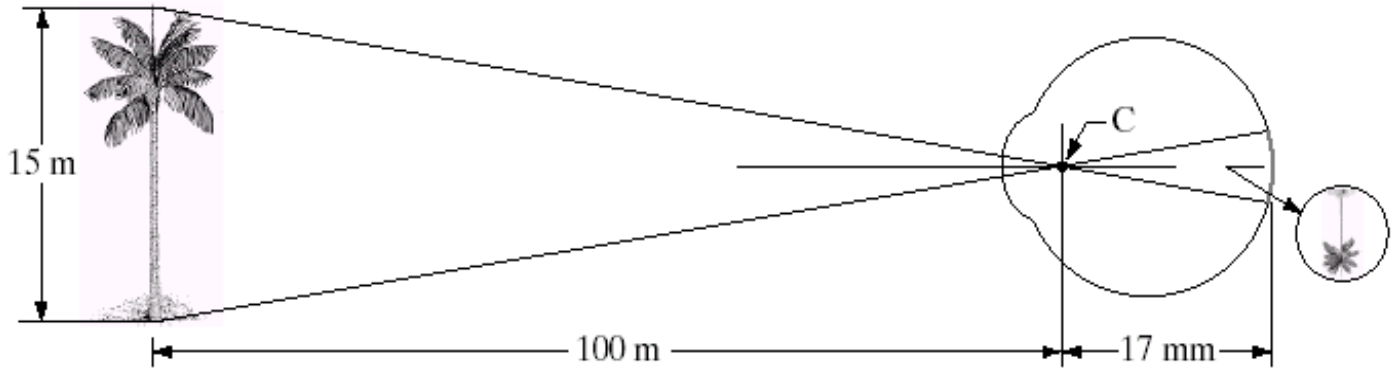
Image Formation in the Eye

- **The eye lens (as compared to an optical lens) is flexible.**
- **It gets controlled by the fibers of the ciliary body and to focus on distant objects it gets flatter (and vice versa).**
- Distance between the center of the lens and the retina (*focal length*):
  - varies from 17 mm to 14 mm (refractive power of lens goes from minimum to maximum).
- Objects farther than 3 m use minimum refractive lens powers (Focal Length 17 mm) and vice versa.

Image Formation in the Eye



Graphical representation of the eye looking at a palm tree. Point *C* is the optical center of the lens.



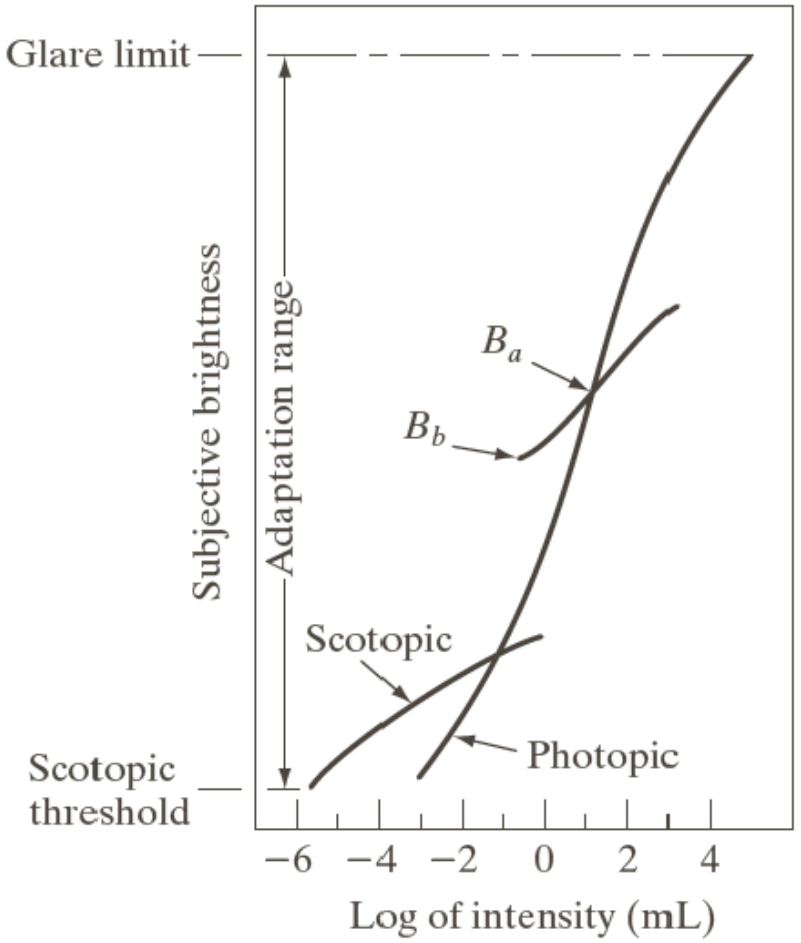
Size of retinal image (h) **15 / 100 = h / 17**

h = 2.55 mm

- Retinal image reflected primarily in the fovea
- Perception takes place by relative excitation of light receptors
- Receptors transform radiant energy into electrical impulses which are decoded by the brain

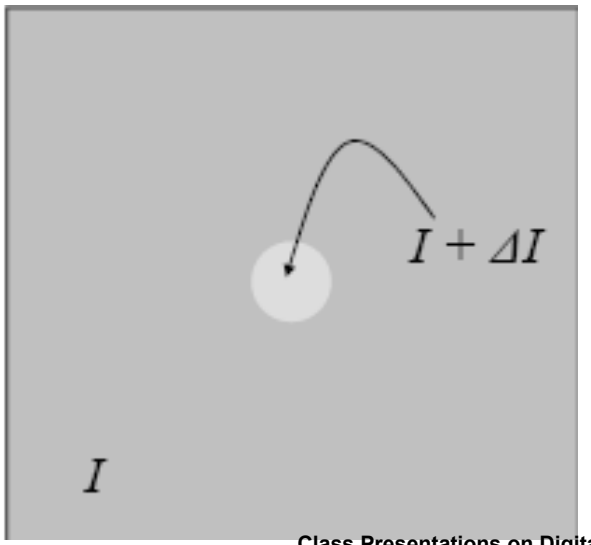
Visual Phenomena: Brightness adaptation

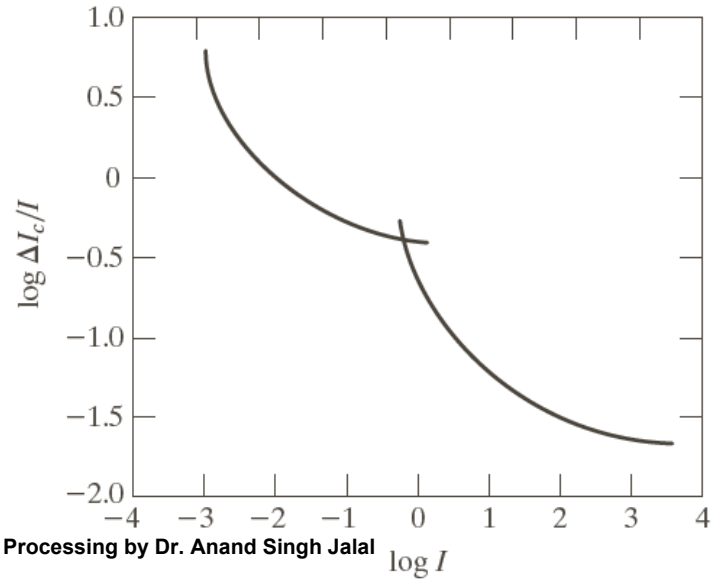
- Dynamic range of human visual system
  - $10^{-6} \sim 10^{4}$
- Cannot accomplish this range **simultaneously**
- The current sensitivity level of the visual system is called the **brightness adaptation level**



Brightness discrimination

- **Weber ratio** (the experiment) $\Delta I_c/I$
  - I: the background illumination
  - ΔI_c : the increment of illumination
  - Small Weber ratio indicates good discrimination
  - Larger Weber ratio indicates poor discrimination

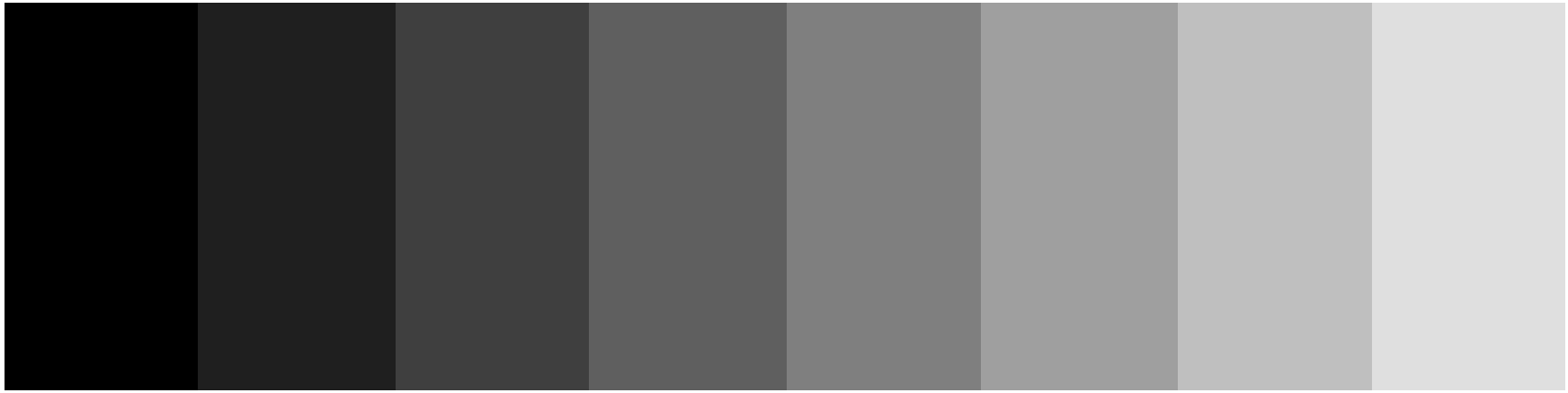




Psychovisual effects

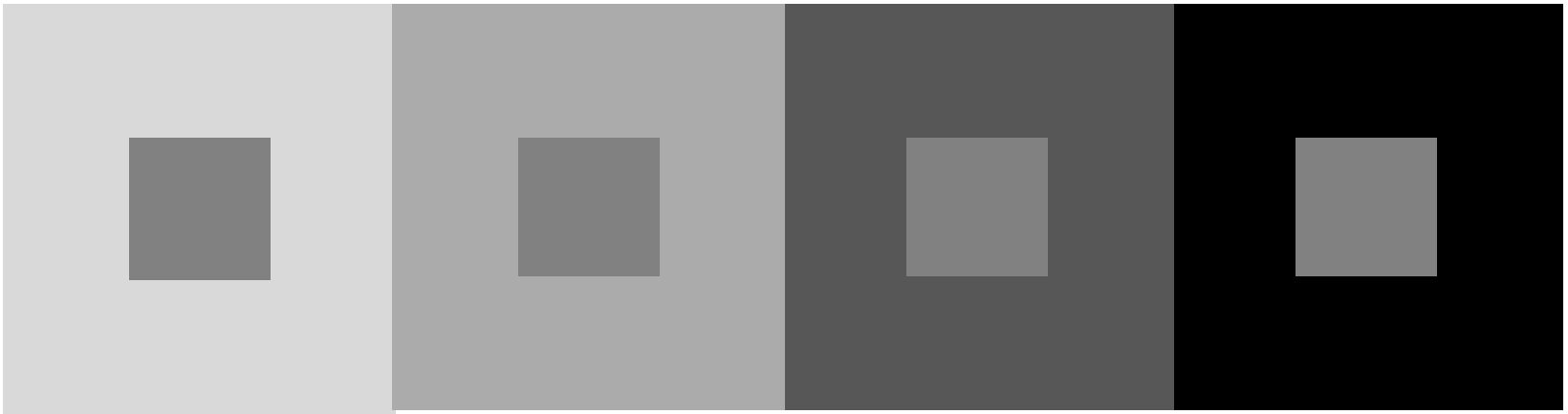
- The perceived brightness is not a simple function of intensity
  - **Mach band pattern**
    - The visual system tends to undershoot or overshoot around the boundary of regions of different intensities
  - **Simultaneous contrast**
    - A region's perceived brightness does not depend simply on its intensity.
  - **Optical illusion**
    - Eye fills in nonexisting information or wrongly perceives geometrical properties of objects

Psychovisual effects : Mach band pattern



- The Mach band effect is illustrated in the figure above.
- The intensity is uniform over the width of each bar.
- However, the visual appearance is that each strip is darker at its right side than its left.

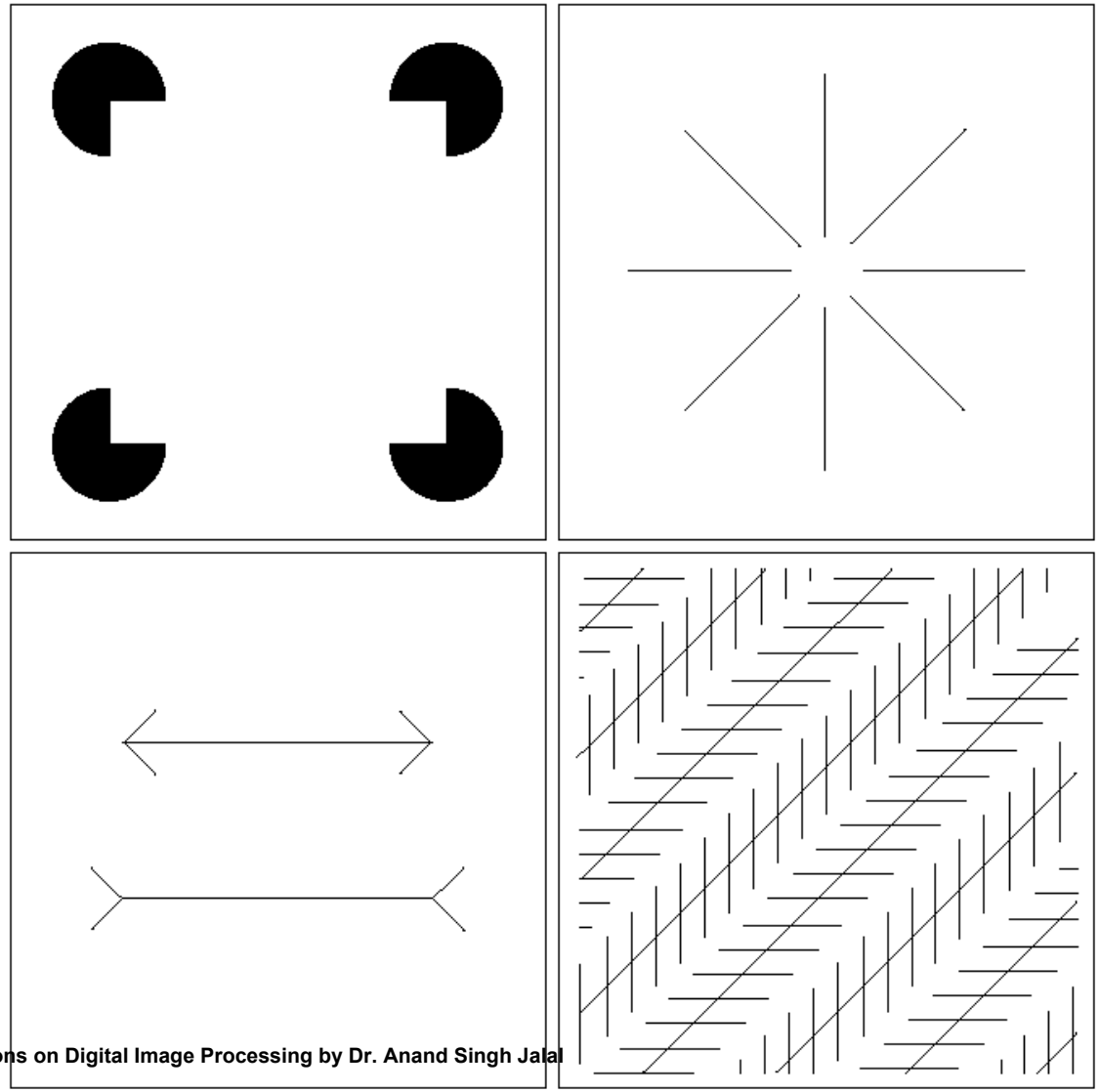
Psychovisual effects :Simultaneous contrast



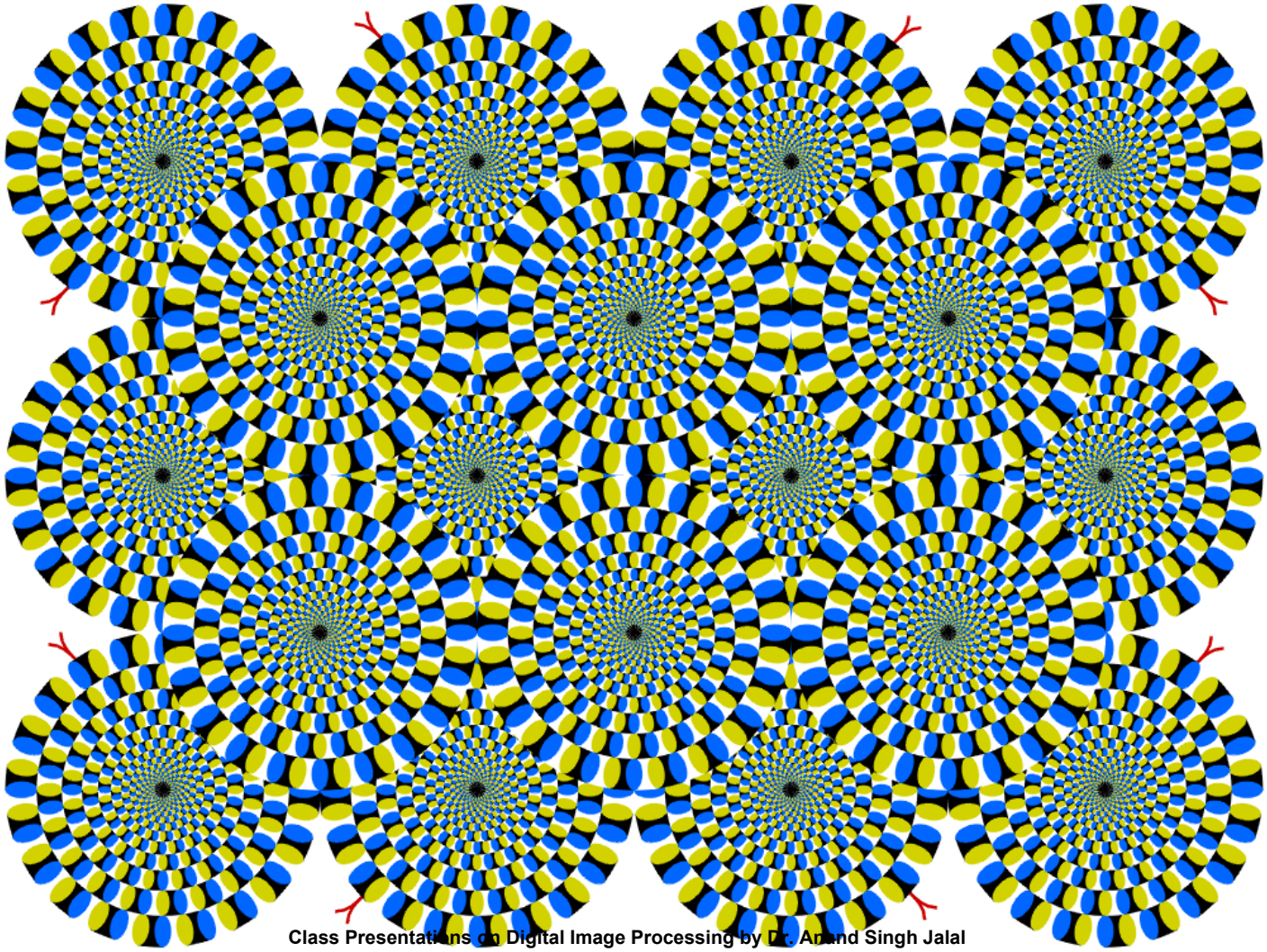
- The simultaneous contrast phenomenon is illustrated above.
- The small squares in each image are the same intensity.
- Because of the different background intensities, the small squares do not appear equally bright.

Psychovisual effects :Optical illusion

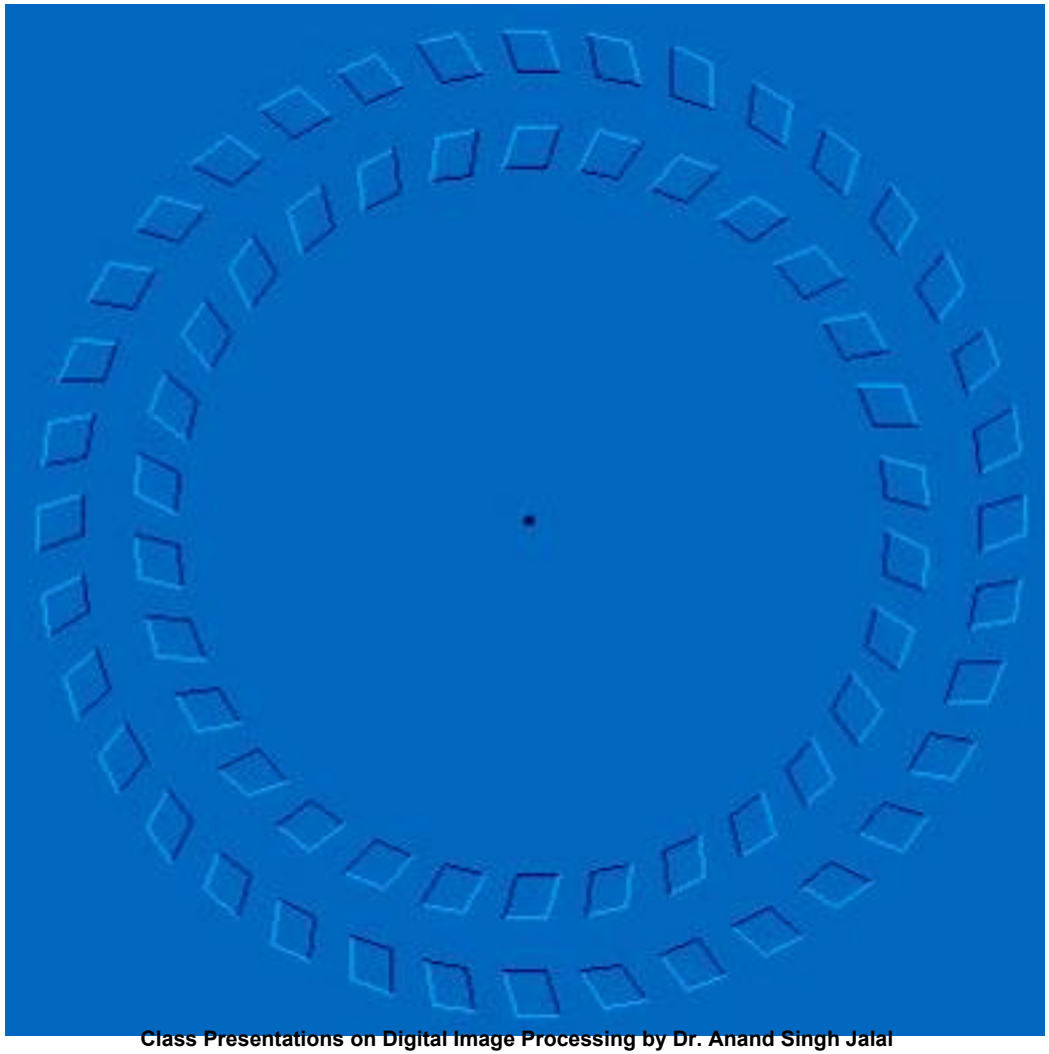
- Eye fills in non existing information or wrongly perceives geometrical properties of an object



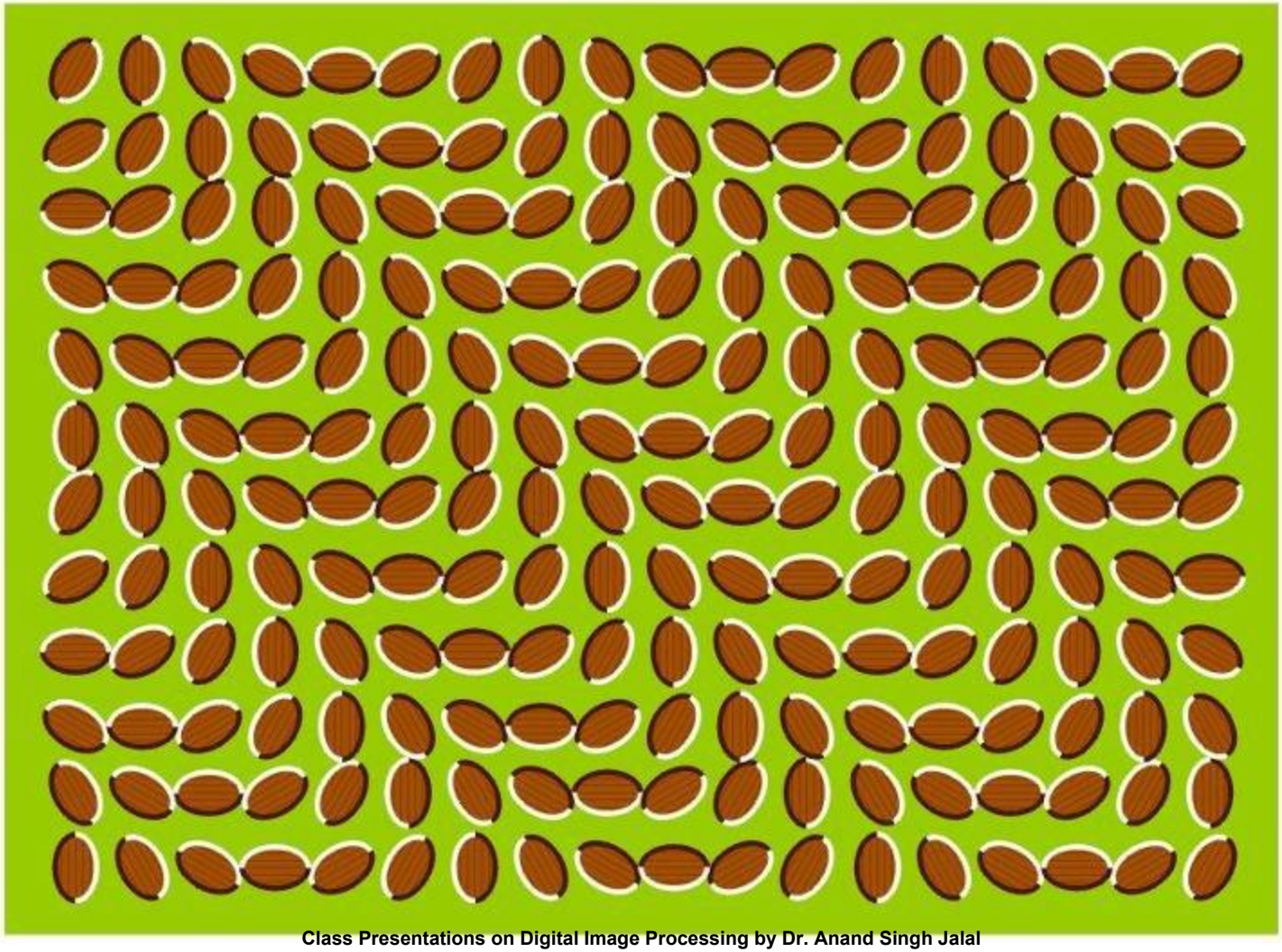
Psychovisual effects :Optical illusion …



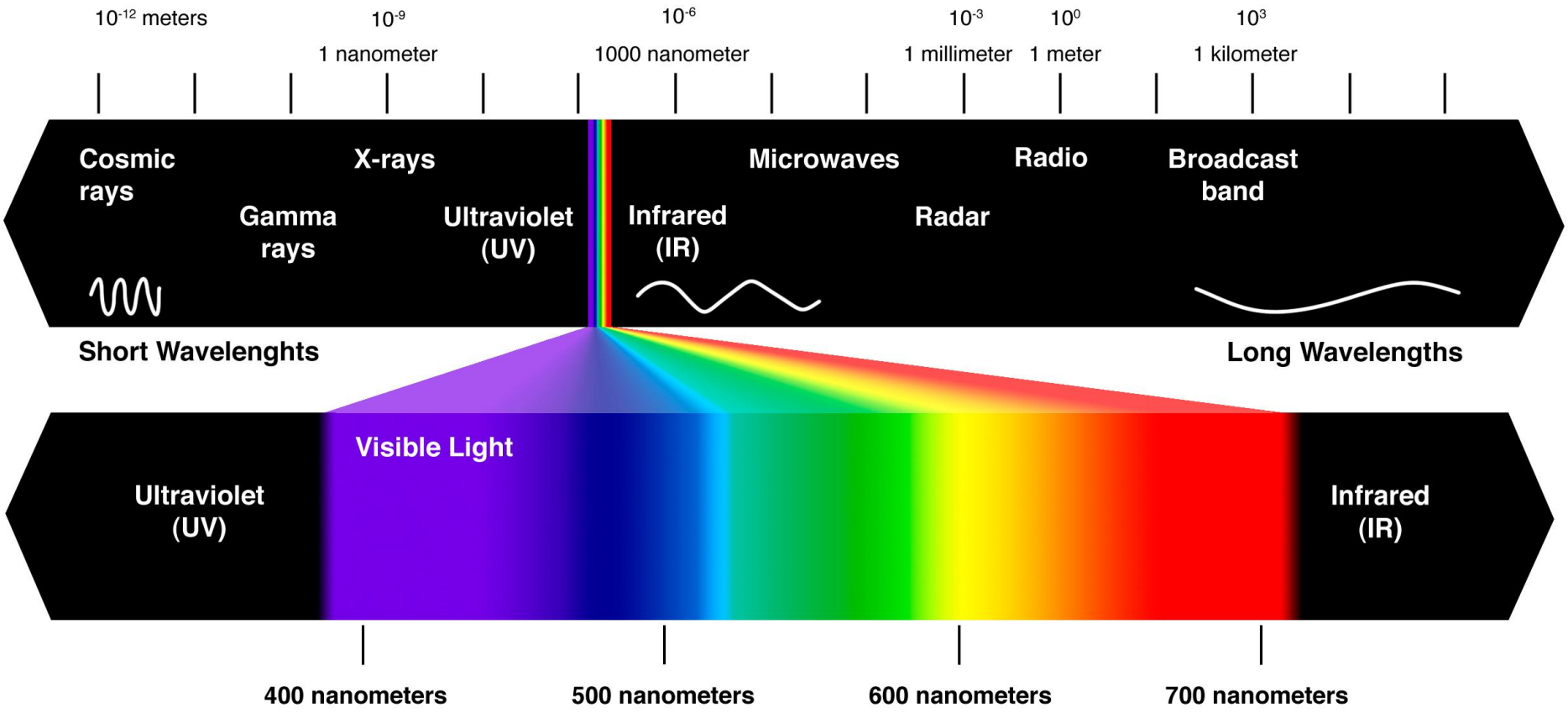
Psychovisual effects :Optical illusion …



Psychovisual effects :Optical illusion …

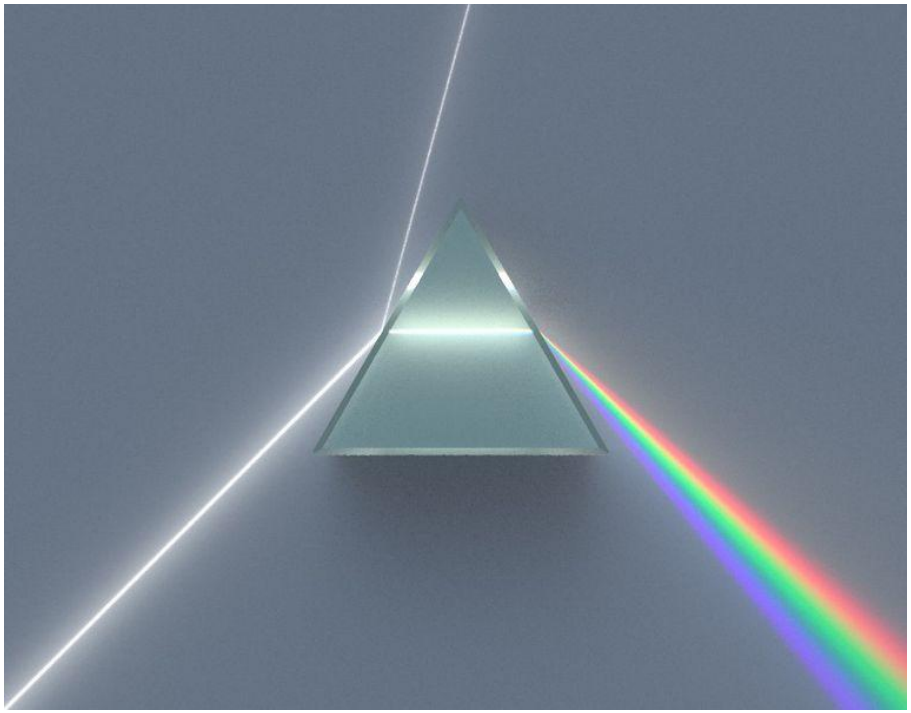


Electromagnetic spectrum

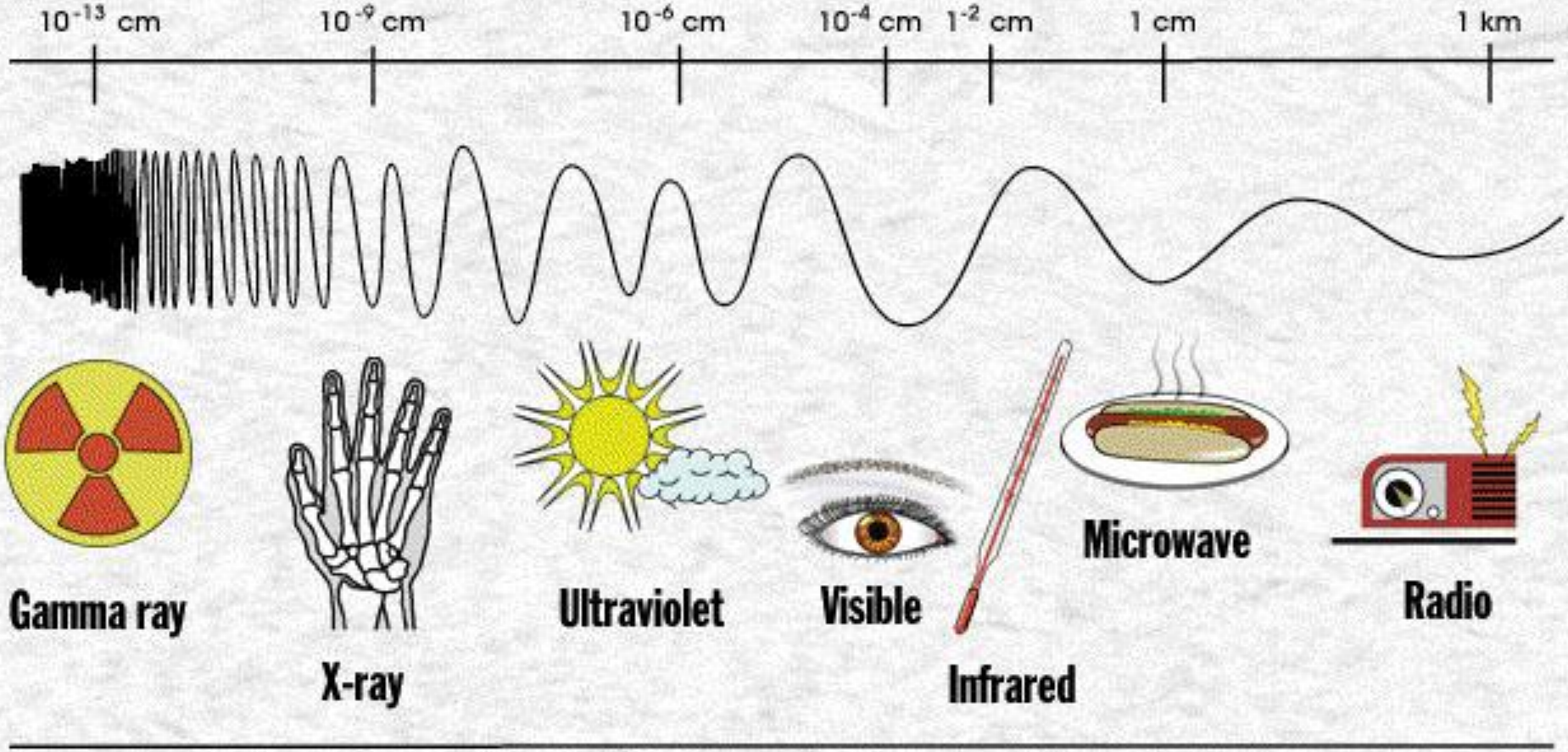


Spectrum of Colors

Sir Isaac Newton



The Electromagnetic Spectrum



Electromagnetic spectrum

- Speed = frequency x wavelength
- i.e $\lambda = c/\nu$
- Speed of light is 3×10^8 m/sec.
- The energy E, of the various components of the electromagnetic spectrum is given as:

$E = h\nu$ where h is Planck's constant

Chromatic Light

- **Radiance**
  - Total amount of energy that flows from the light source
  - Measured in Watts (W)
- **Luminance**
  - Measures the amount of energy an observer perceives from a light source.
  - Measured in lumens (lm)
- **Brightness**
  - Subjective descriptor – practically impossible to measure.
  - It embodies the notion of intensity.
  - Key factor in describing colour sensation.

Any Questions ?