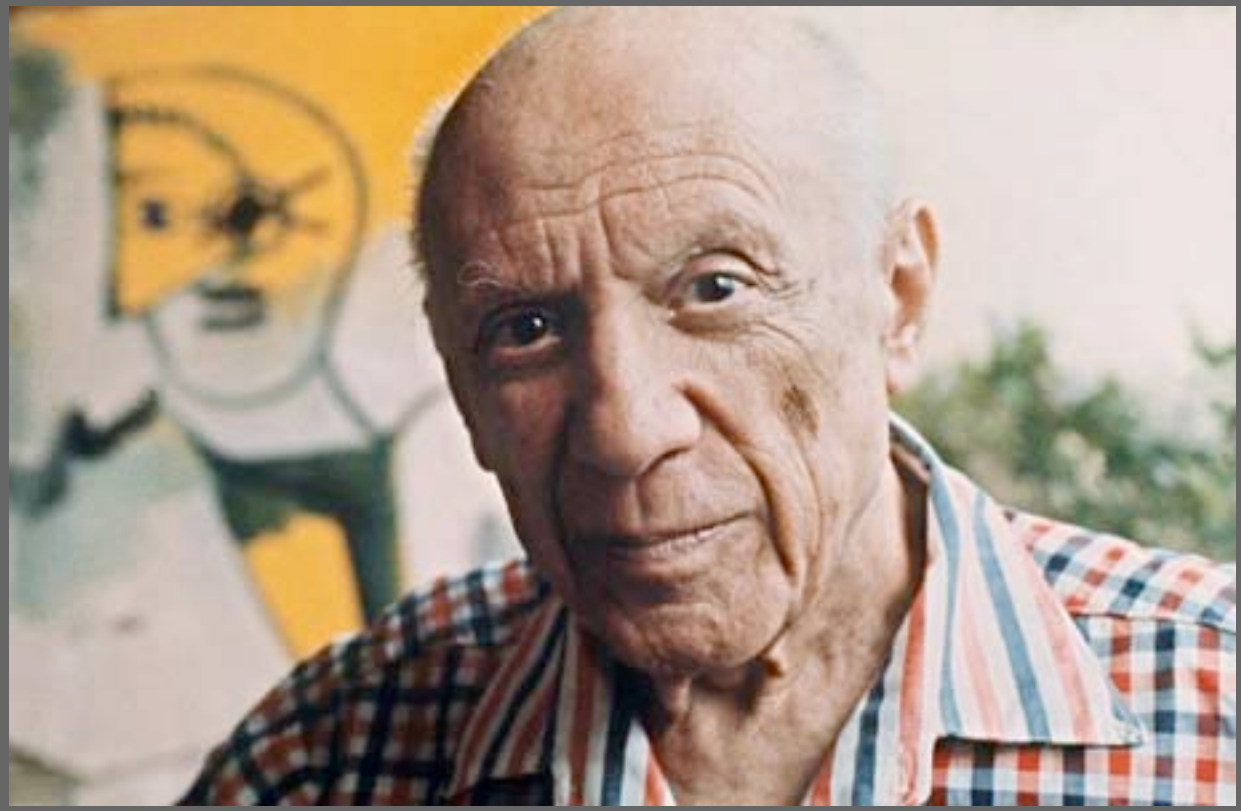
What is a face, really? Its own photo? Its make-up?
Or is it a face as painted by such or such painter?
That which is in front? Inside? Behind? And the rest?
Doesn't everyone look at himself in his own particular way?
Deformations simply do not exist.

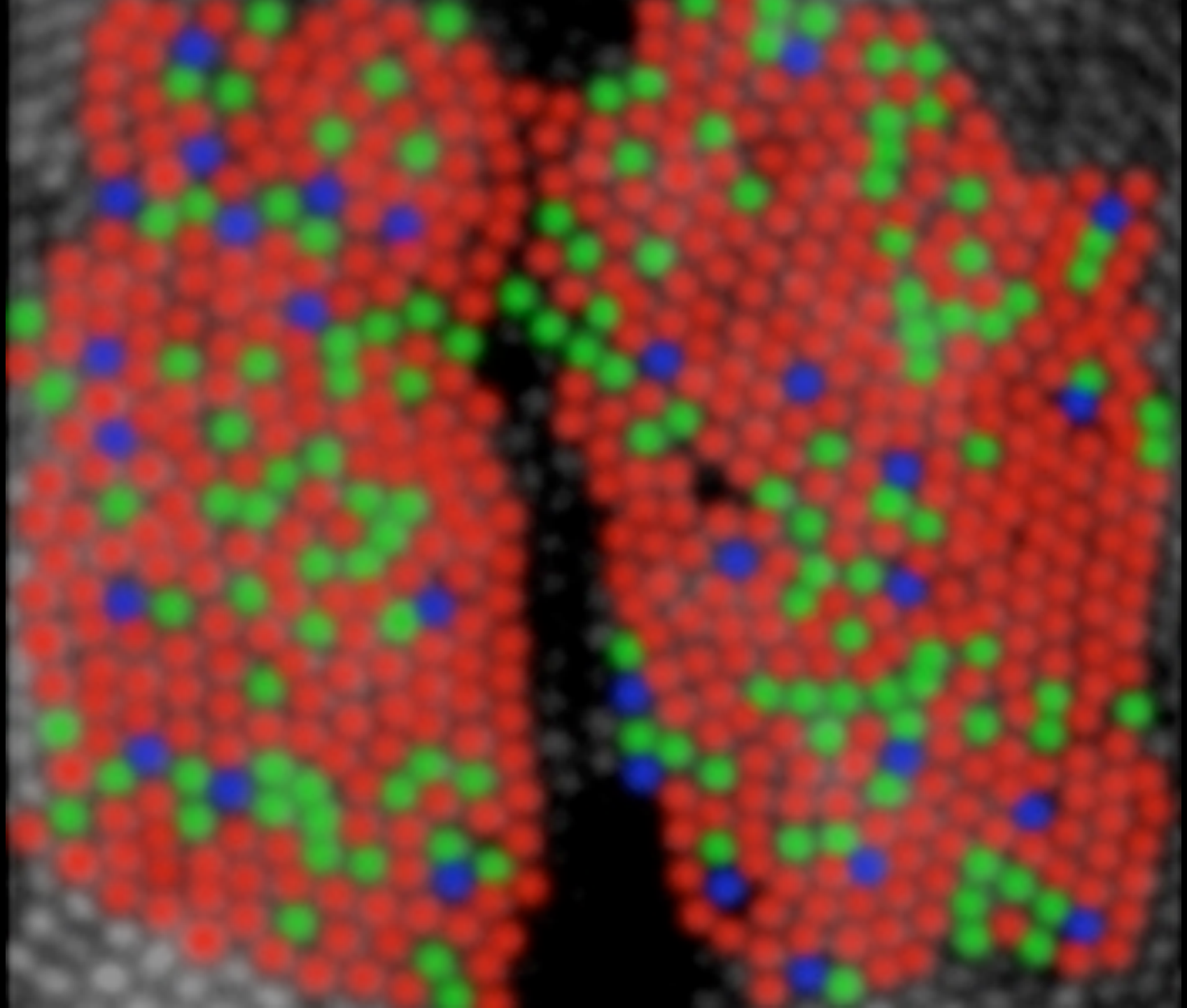
Pablo Picasso



Richard Feynman (1918-1988)

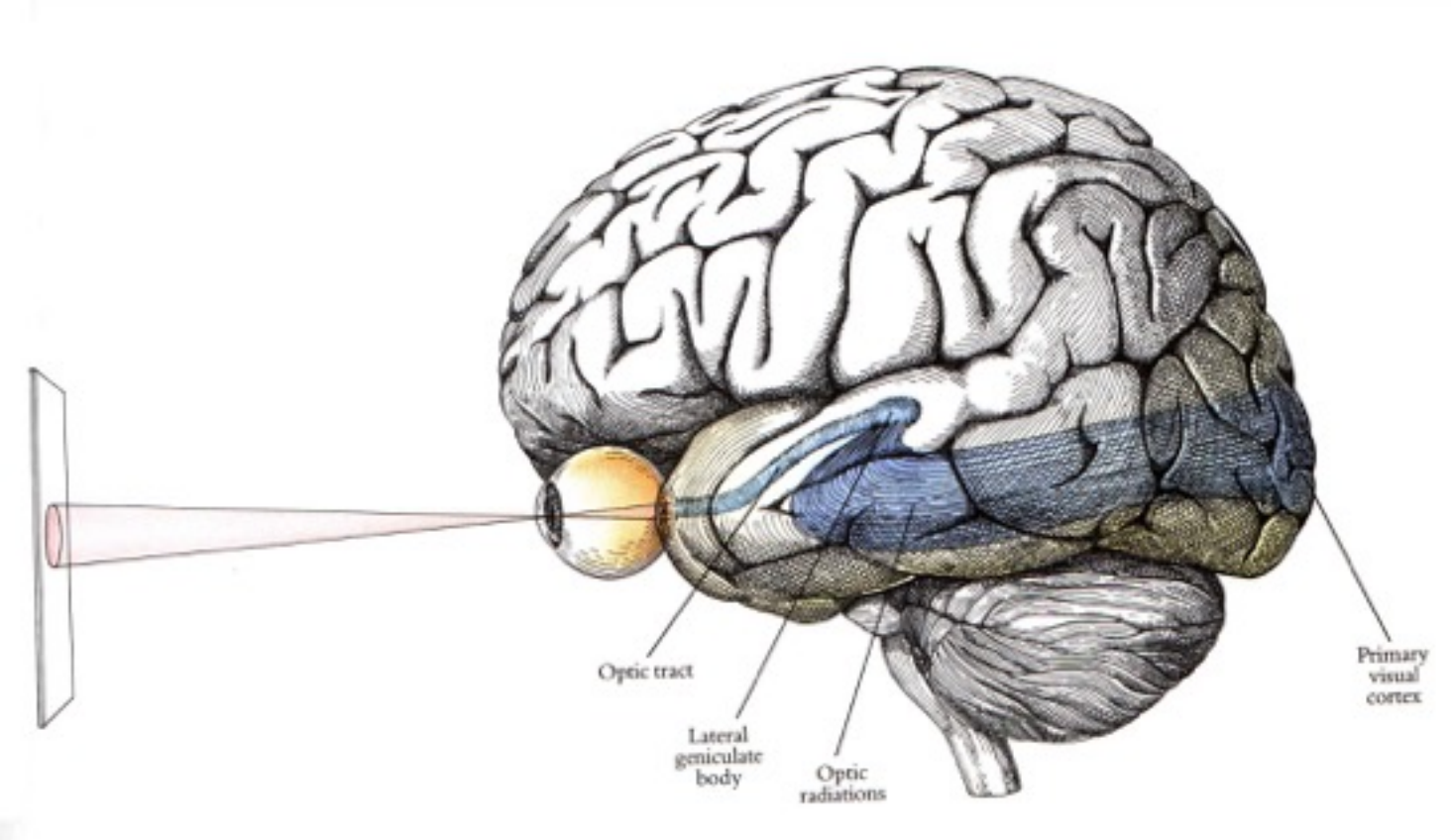
Described by one of his colleagues, Freeman Dyson, as "half genius, half buffoon", He later revised this to "all genius, all buffoon"

http://www.youtube.com/watch?v=1qQQXTMih1A



Blue

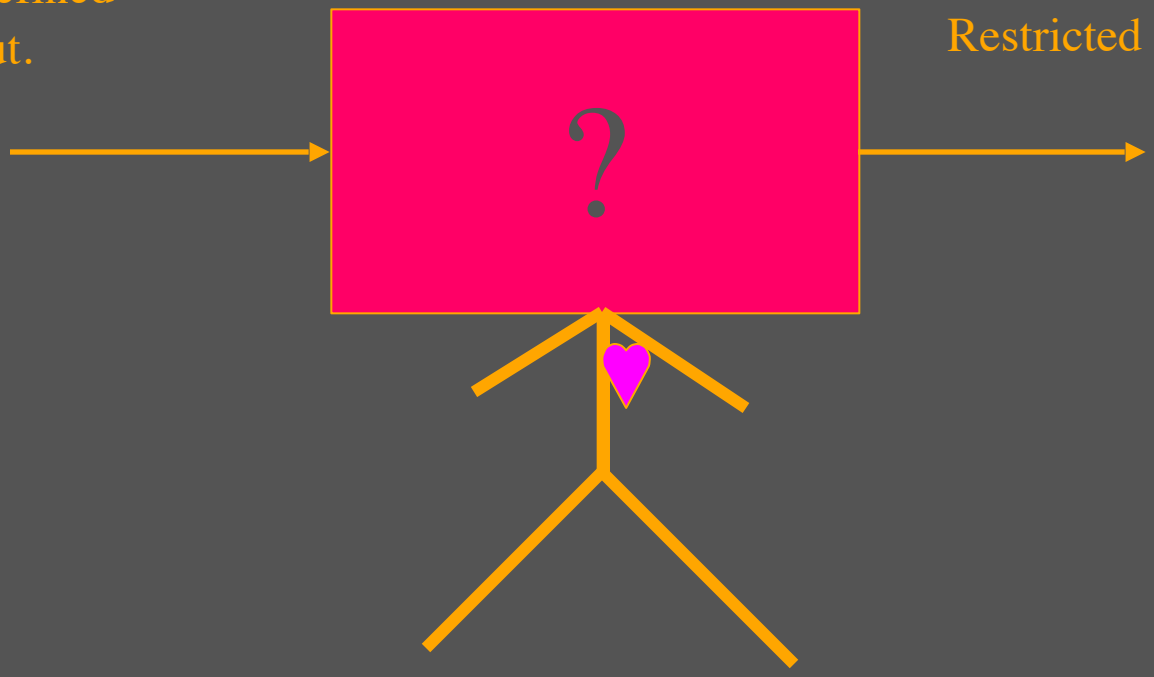
The Visual System
A physiologists view



The Visual System:
A psychologist's view

Psychophysics

Absolutely defined stimulus input.

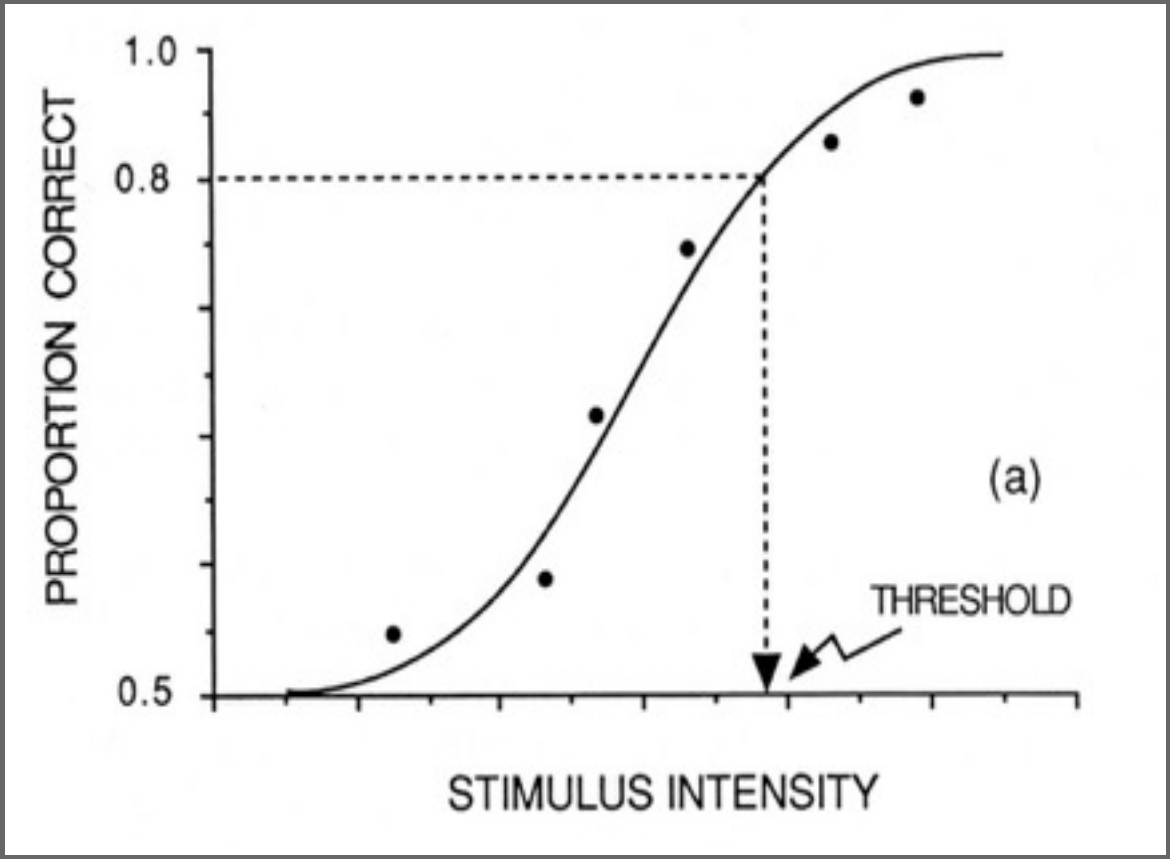


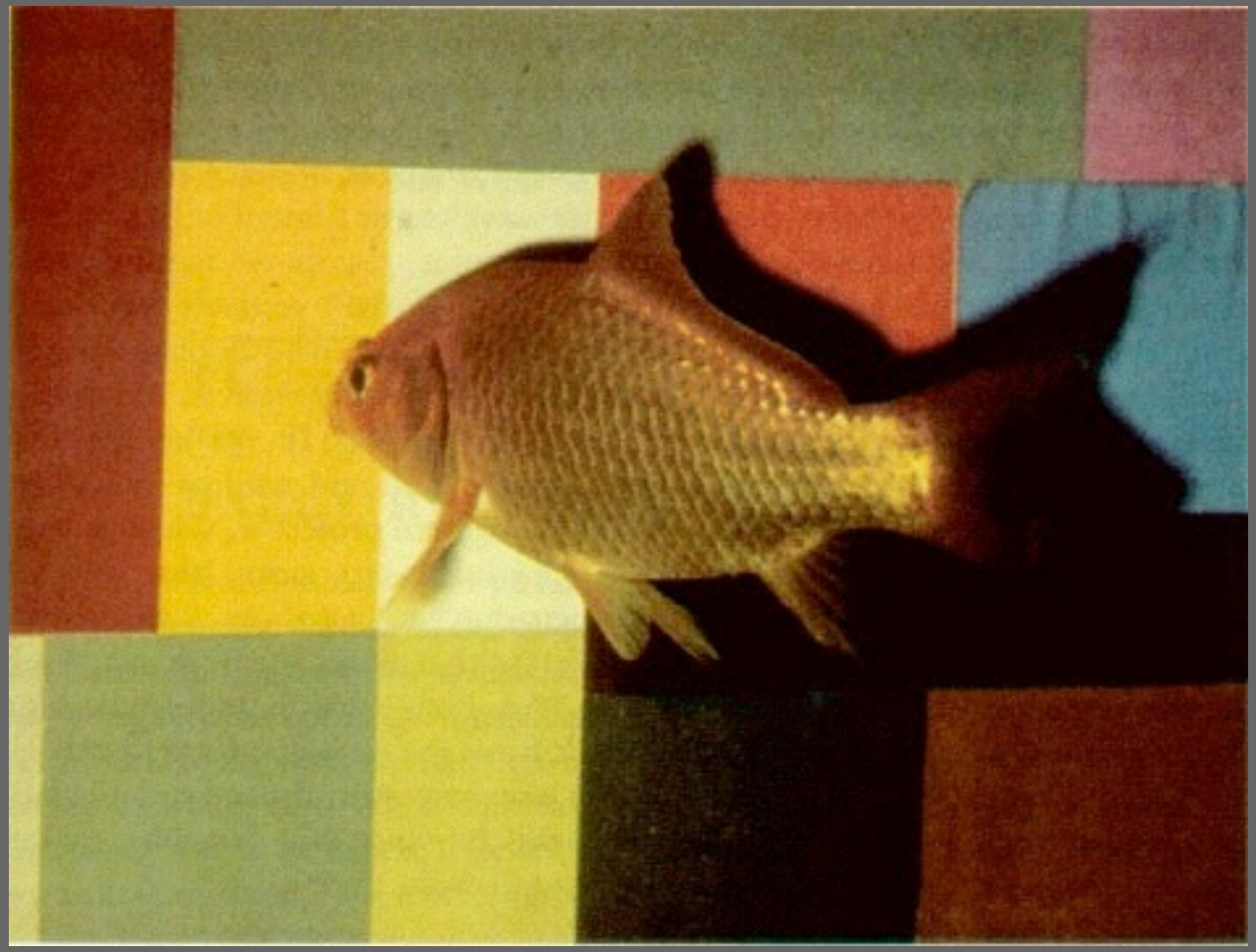
Restricted output

Psychophysics
The system for measuring behaviour

- The behavioural response to a given input-stimulus
- Treat the system in question as a ‘black box’
- Must know (without question) the input
- Must restrict the output (e.g. binary yes/no response)

A psychometric function





The power of observation

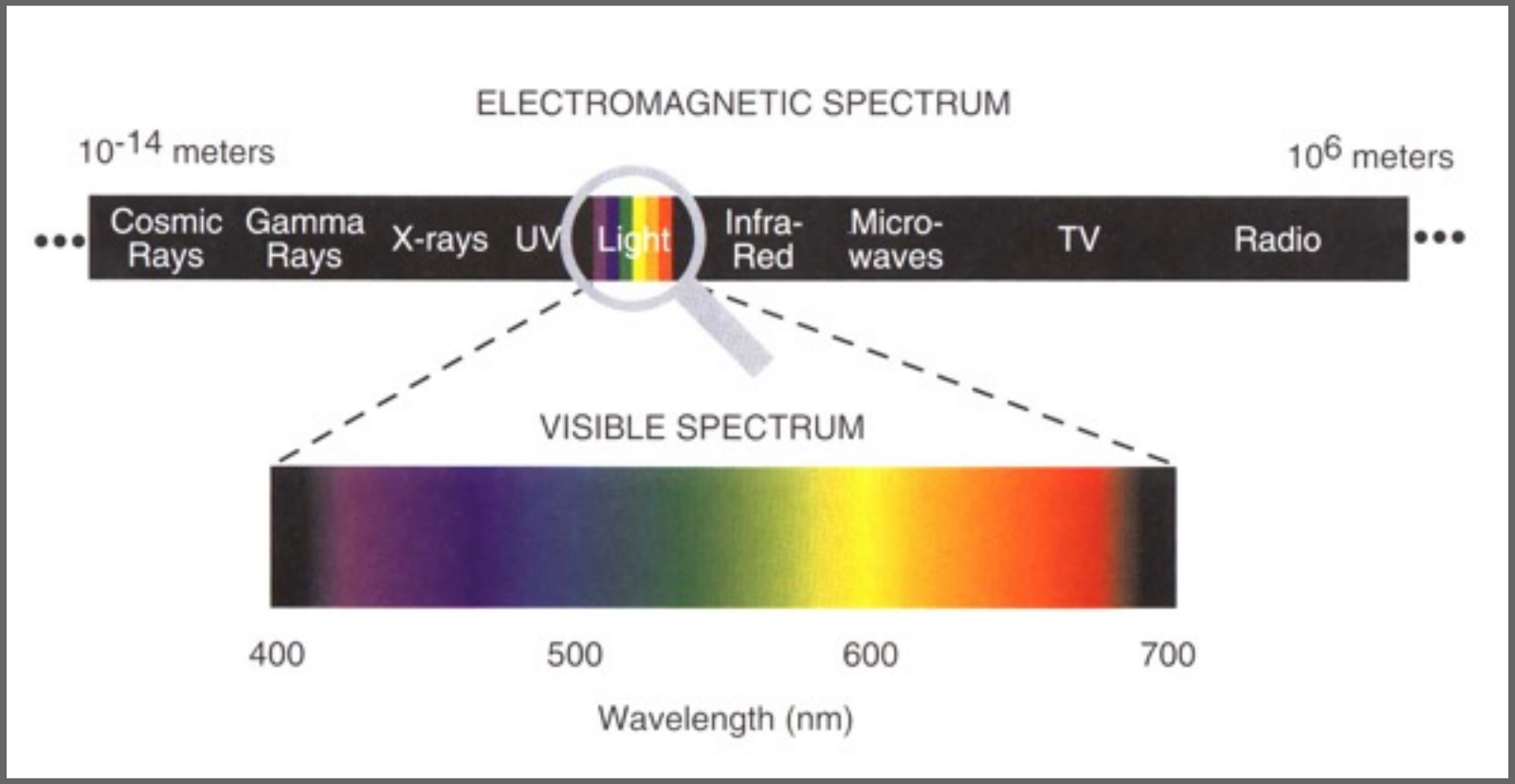
- The first two stages of vision deduced on the basis of almost pure phenomenology
  - Isaac Newton (1643-1727)
  - Thomas Young (1773-1829)
  - Hermann von Helmholtz (1821-1894)
  - Ewald Hering (1834-1918)

The physical nature of light

- Newton(1671) - “The Light of the Sun consists of Rays differently Refrangible*”
  - Showed that white light was made up of the sum of all different visible colours
  - Turned the way of thinking upside down and allowed the problem to be defined

*able to be refracted

Physics of light

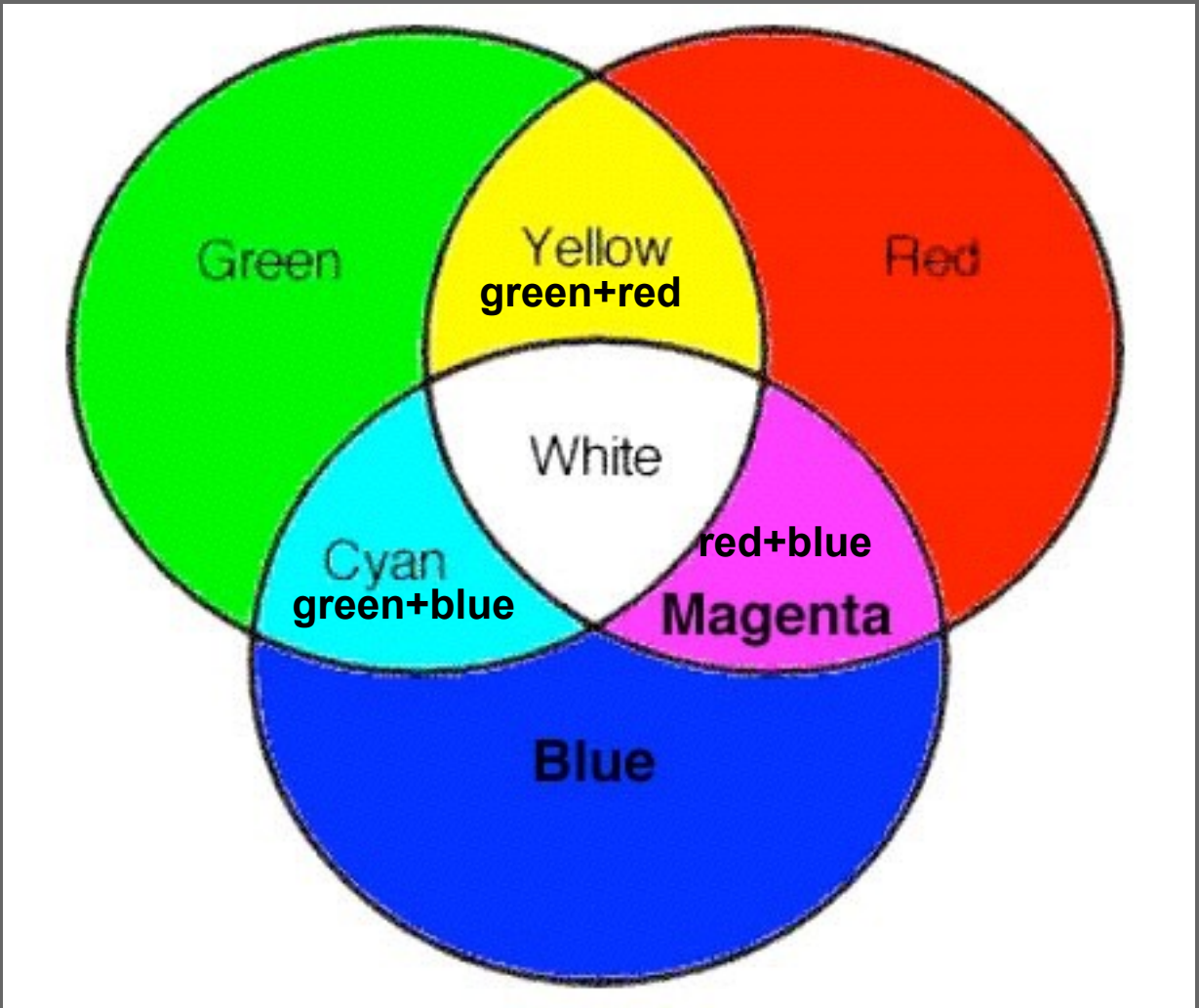


Young & Helmholtz

- "As it is almost impossible to conceive each sensitive point of the retina to contain an infinite number of particles, each capable of vibrating in perfect unison with every possible undulation, it becomes necessary to suppose the number limited; for instance to the three principal colours red, yellow and blue, and that each of the particles is capable of being put in motion more or less forcibly by undulations differing less or more from perfect unison. Each sensitive filament of the nerve may consist of three portions, one for each principal colour".
  (Young, 1802; in MacAdam 1970)

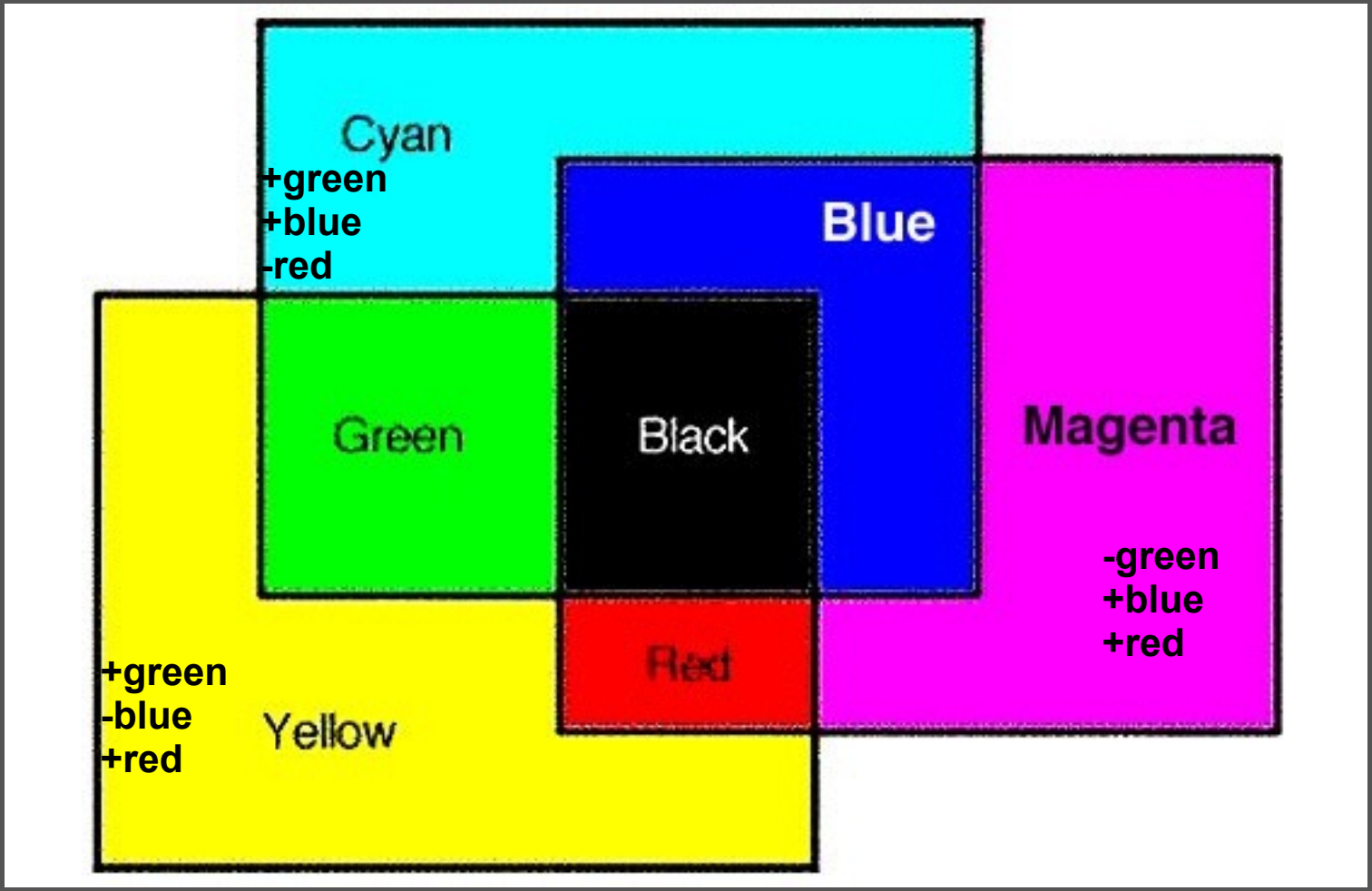
Physics of light

Additive colour mixing - light



Physics of light

Subtractive colour mixing - pigments



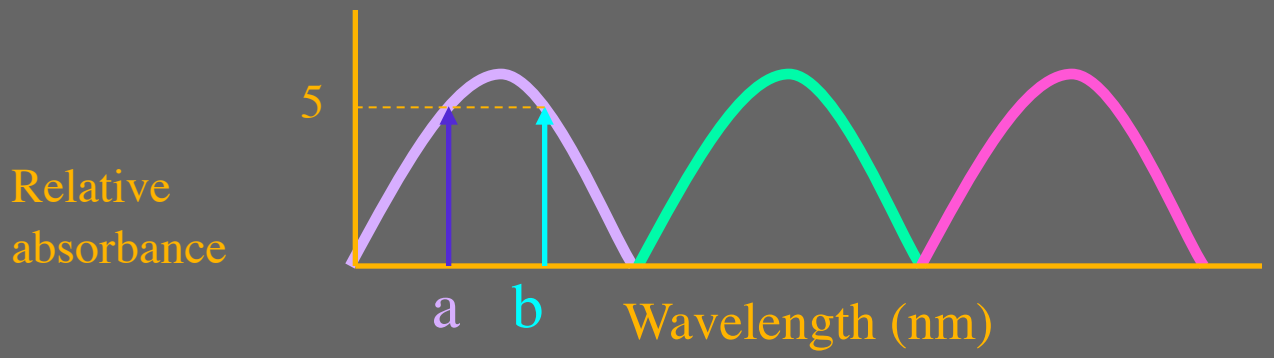
Principal of Univariance

- The output elicited by the absorption of a photon of light will be the same whatever the wavelength of the incident light
  - Photoreceptor output only signals how many photons are absorbed, nothing more

William A.H. Rushton, 1901-1980

Trichromacy

Three non-overlapping photopigments



R(a) = R(b) = 5

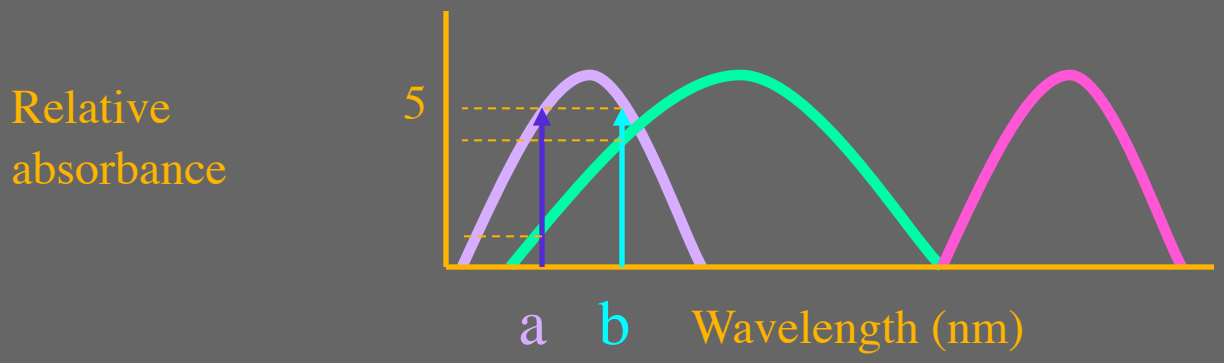
Cannot discriminate between a and b.

The response also changes with the intensity of a and b.

Within a single photopigment sensitivity band, the wavelength of the photon absorbed can never be signalled by the output.

Trichromacy

Two overlapping photopigments



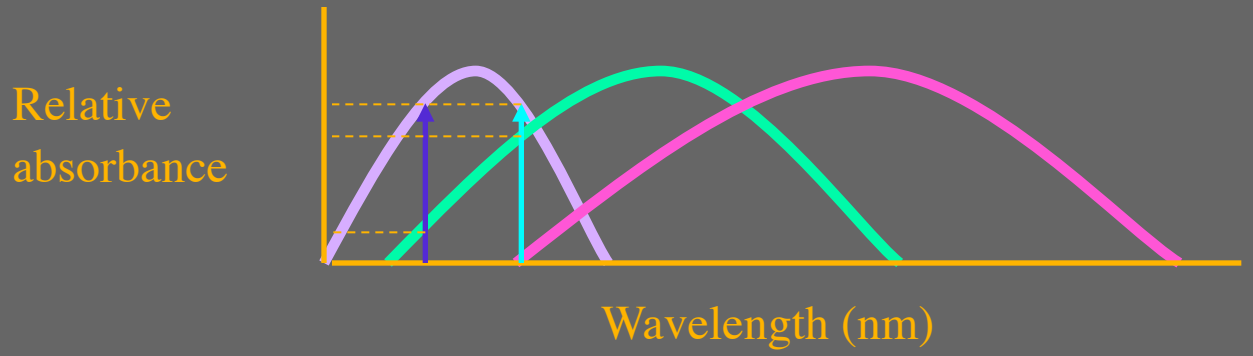
R(a) = 5,1

R(b) = 5,4

a and b can be discriminated between if both receptor types are compared

Trichromacy

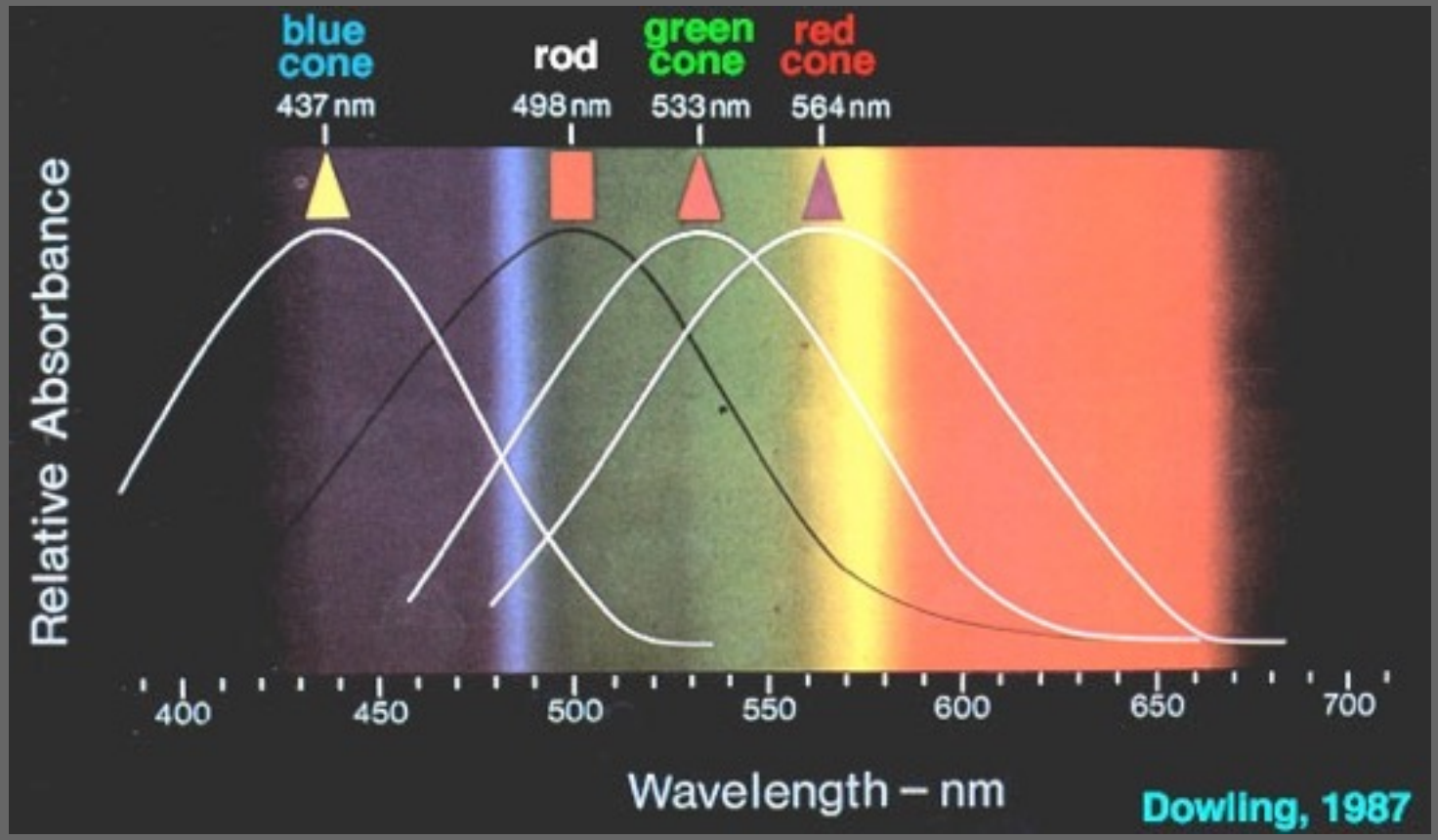
Three overlapping photopigments



R(a) = 5,1

R(b) = 5,4

Trichromacy



Trichromacy

- Overlapping spectral sensitivities are essential for discrimination of different lights
  - The calculation of ratios is fundamental throughout the system

The first stage of vision

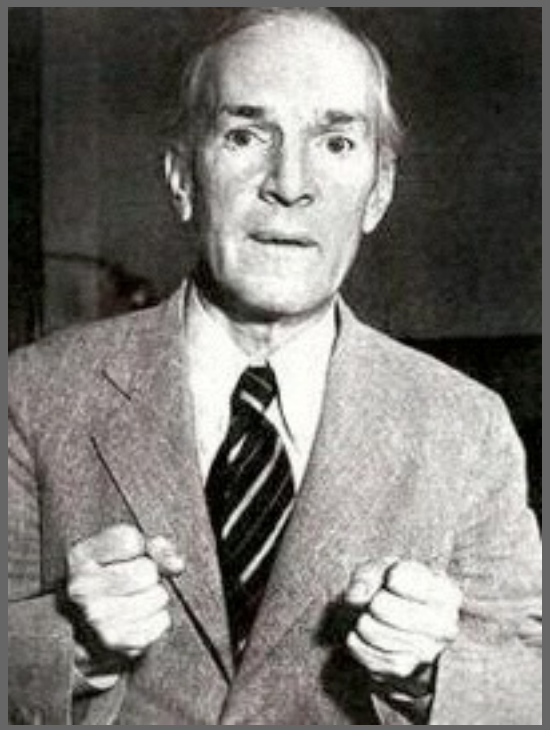
- A graded output (potential) in either long, medium or short wavelength bands
- This is spatially two-dimensional
- The third dimension is time
  - (x,y,z,t) is reduced to (x,y,t)
- Maximally fragmented in space and time

Reality?

- We see all visible colours and lights from just three photopigments.
- Our internal world is maximally fragmented (atomic) at the photoreceptor level of processing.
- This was deduced simple by examination, introspection and deduction.
- Relatively simple observations reveal a great deal about the underlying system.

"It is difficult to get a man to understand something when his salary depends on him not understanding it"

Upton Sinclair 1878-1968



Cited in *An Inconvenient Truth* and *Food, Inc*.