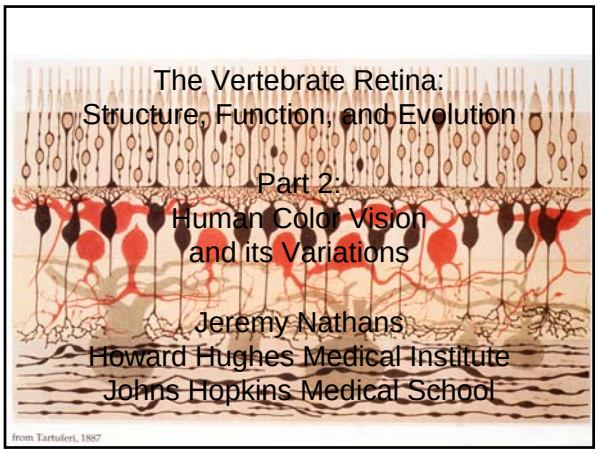
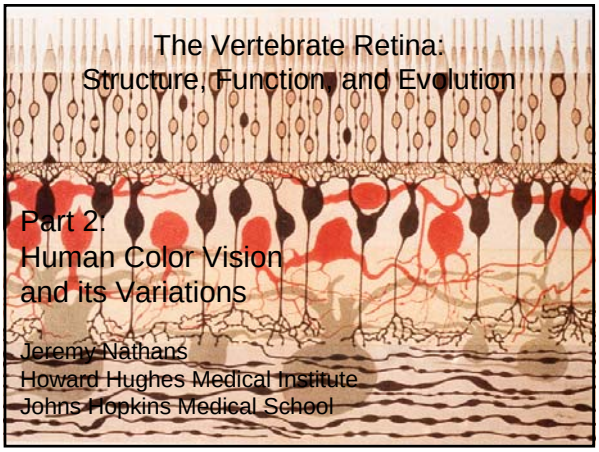

The Vertebrate Retina:
Structure, Function, and Evolution
Part 2:
Human Color Vision
and its Variations
Jeremy Nathans
Howard Hughes Medical Institute
Johns Hopkins Medical School
from Tartuferi, 1887


The Vertebrate Retina:
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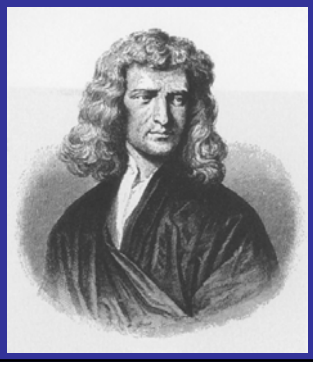
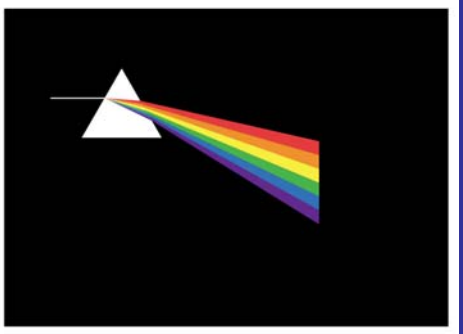
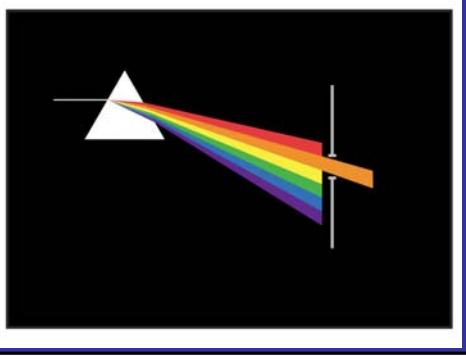
Isaac Newton



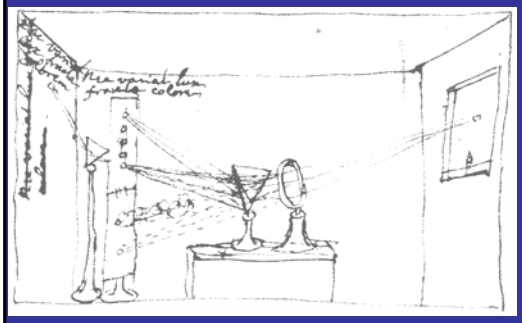
Newton's experiment: 1



Newton's experiment: 2



Newton's sketch



Newton's experiment: 3

"May not the harmony and discord of Colours arise from the proportions of the Vibrations propagated through the fibres of the optick Nerves into the Brain, as the harmony and discord of Sounds arise from the proportions of the Vibrations of the Air?"

- Isaac Newton (Opticks, 1704)

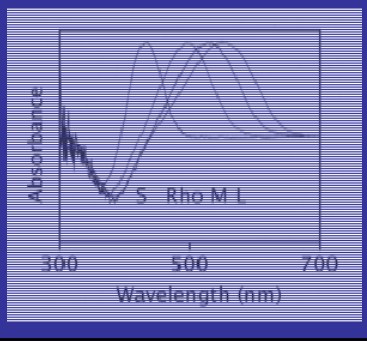
Thomas Young

"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 particle is capable of being put in motion more or less forcibly by undulations differing less or more from perfect unison."

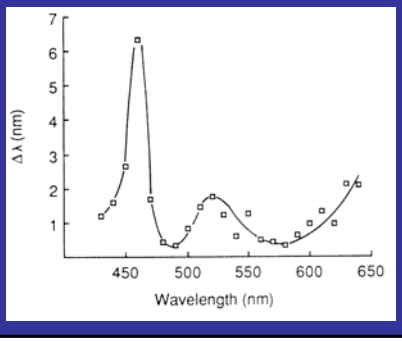
- Thomas Young (Bakerian Lecture, 1802)

Hermann von Hemholtz (left), James Clerk Maxwell (right)

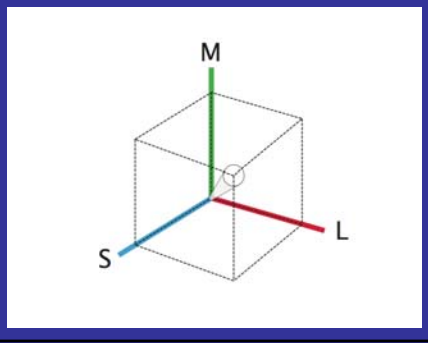
Absorbance spectra of human rod and cone visual pigments



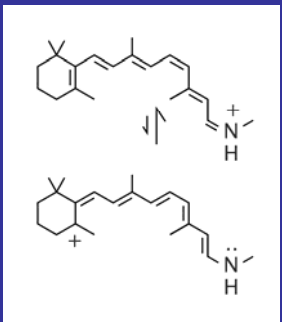
Chromatic discrimination at different wavelengths



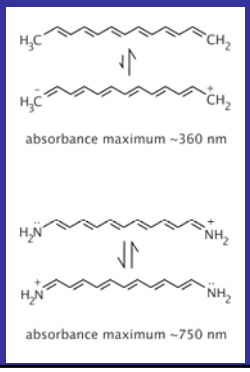
Maxwell's 3-dimensional color space

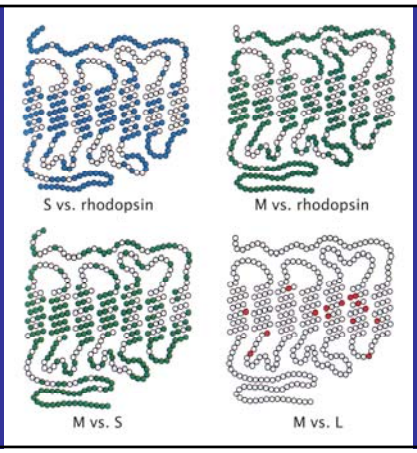


Resonance delocalizes pi-electrons in 11-cis retinal

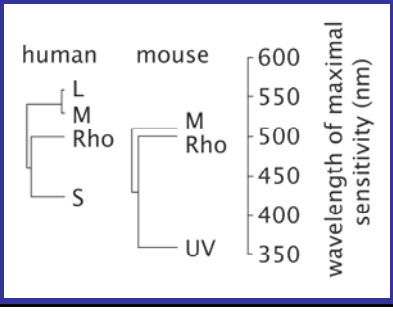


A polyene and a cyanine

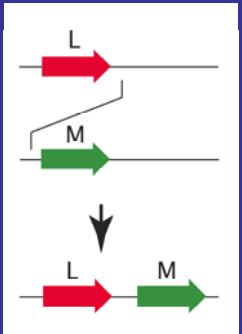




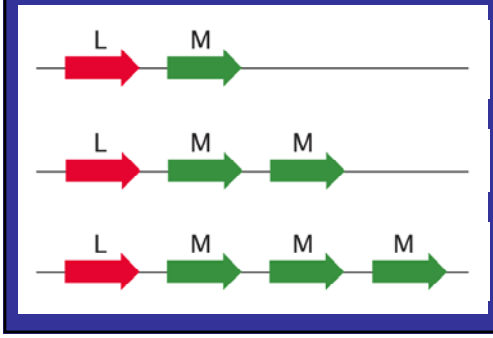
Sequence divergence among human and mouse rod and cone pigments



An ancient gene duplication



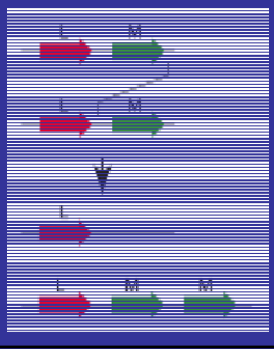
L and M pigment gene arrays in human trichromats



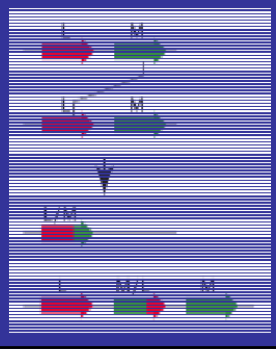
John Dalton

How the world looks to trichromats and dichromats

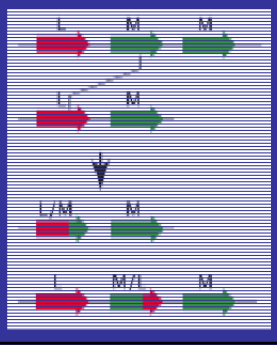
Unequal homologous recombination: 1



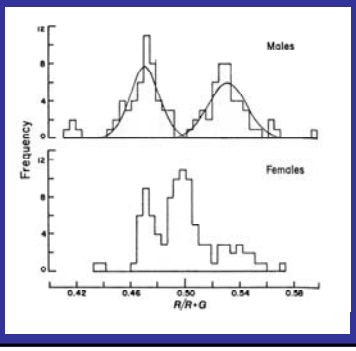
Unequal homologous recombination: 2



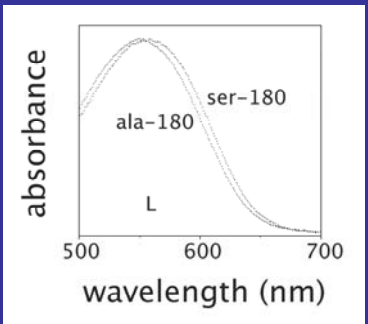
Unequal homologous recombination: 3



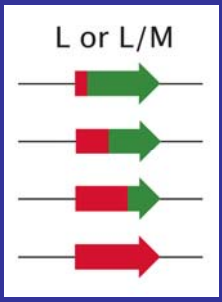
Subtly different color matches among “normal” trichromats



L pigment polymorphism: alanine(180) vs. serine(180)



L and L/M hybrid pigments in "single gene" dichromats



Spectral sensitivity of L and M cones in the living human eye