Color vision

- Introduction: What animals have color vision and why?
- How has color vision been measured behaviorally? (an example)
- The (general) physics of color
- The molecular basis of color vision
- How is color coded into sensory information in the visual system?
- Polarized light detection

Most mammals do not have extensive color vision

Except primates

Behavioral measures of color vision

Karl von Frisch

Apis mellifera

1. Train bees with sugar water on colored background

2. Test bees with variety of shades, one color

What the bee sees (no color vision)

What the bee sees (color vision)
Results:

Honey bees have sophisticated color vision detection

From Lehrer 1999

81% 19%

Blue contrast
Green contrast
Black and white

What exactly is color?
Light energy: part of the electromagnetic spectrum

Light of different wavelengths (λ) have different colors
Both wave and particle (photon)

The spectrum of sunlight received on the earth
(in photons m⁻² s⁻¹ nm⁻¹ (x10¹⁶))

How is color information transferred into neural information in an arthropod?

Eye
Ommatidia
Rhabdom
Retinular cells
Opsins = transmembrane proteins
Photopigments = molecules that undergo physical transformations when hit by a photon, allowing depolarization of axons

Location of photoreceptor cells in an insect eye
Photoreceptors: Opsin protein together with photosensitive molecule

Seven trans-membrane helices

Wavelength sensitivity can result from conformational differences in opsin and/or varying chromophores

Signal transduction: changing the energy of light into electrical energy

To have color vision, one must have more than one type of photoreceptor (at least two)

Reflectance curves of certain flowers and leaves

The ability to detect ultraviolet light

Human spectral sensitivity

Honey bee spectral sensitivity

Human's view.

Insect's view (simulated through UV filter.)
Flower colors on trichromatic plots for human and bee visual systems

Polarized light patterns in the sky

Organization of retinular cells allows for detection of polarized light

Arthropod visual neurons can be sensitive to specific planes of polarized light

(Cricket: Wehner 1989)