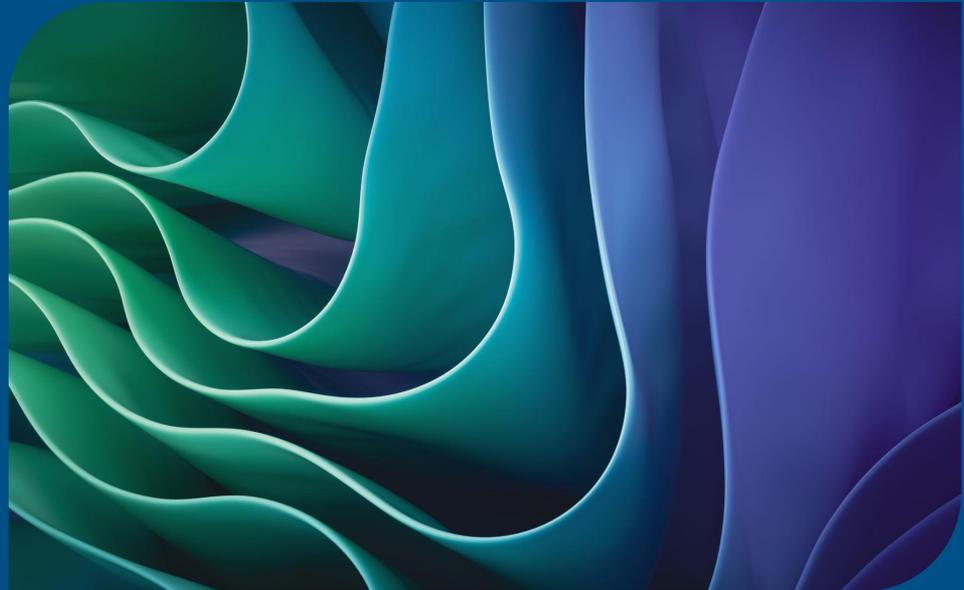
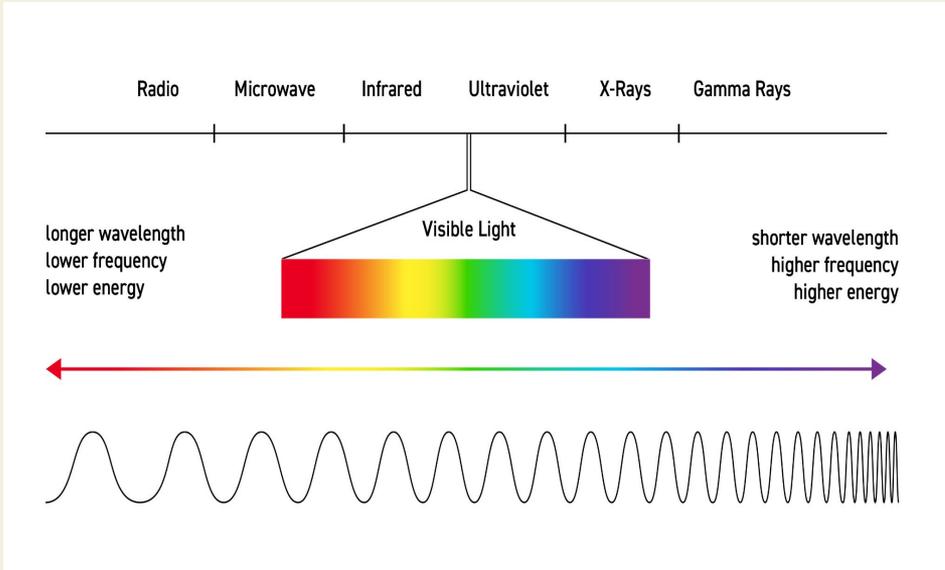


Visual Communication

Chapter 5 of *Principles of Animal
Communication*



1. **Light: An Overview**
2. **The ARTS Diagram & Detectability**
3. **Eye Structure**
4. **Function & Visual Processing**
5. **Conclusion**



National Institute of Standards and Technology

- Visible light = $\sim 300\text{--}800\text{ nm}$
- Infrared light:
 - Weakens over distance
 - Variable
- UV light:
 - Can cause tissue damage
- Visible light:
 - Waves reflect and travel directly to receiver
 - No harm to receiver
 - Transparent in water

“Only in the range of visible light can electromagnetic radiation interact constructively with organic matter to facilitate visual communication”

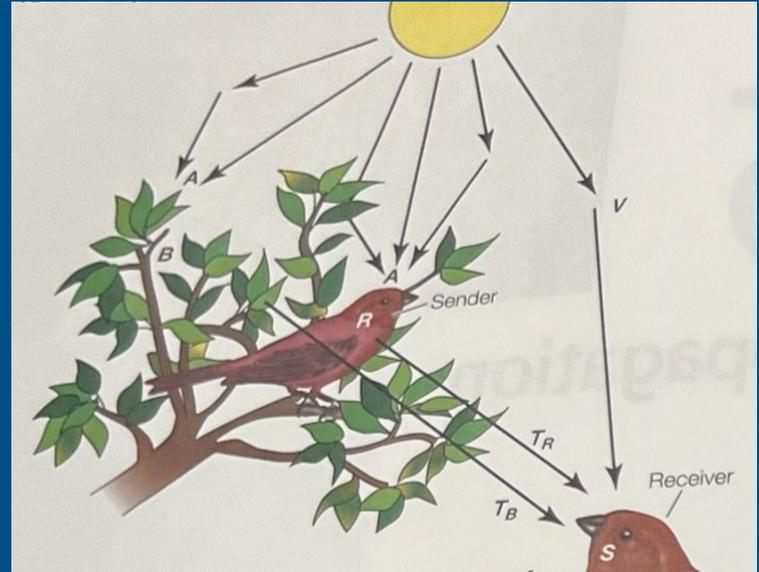
– Bradley, *Principles of Animal Communication*

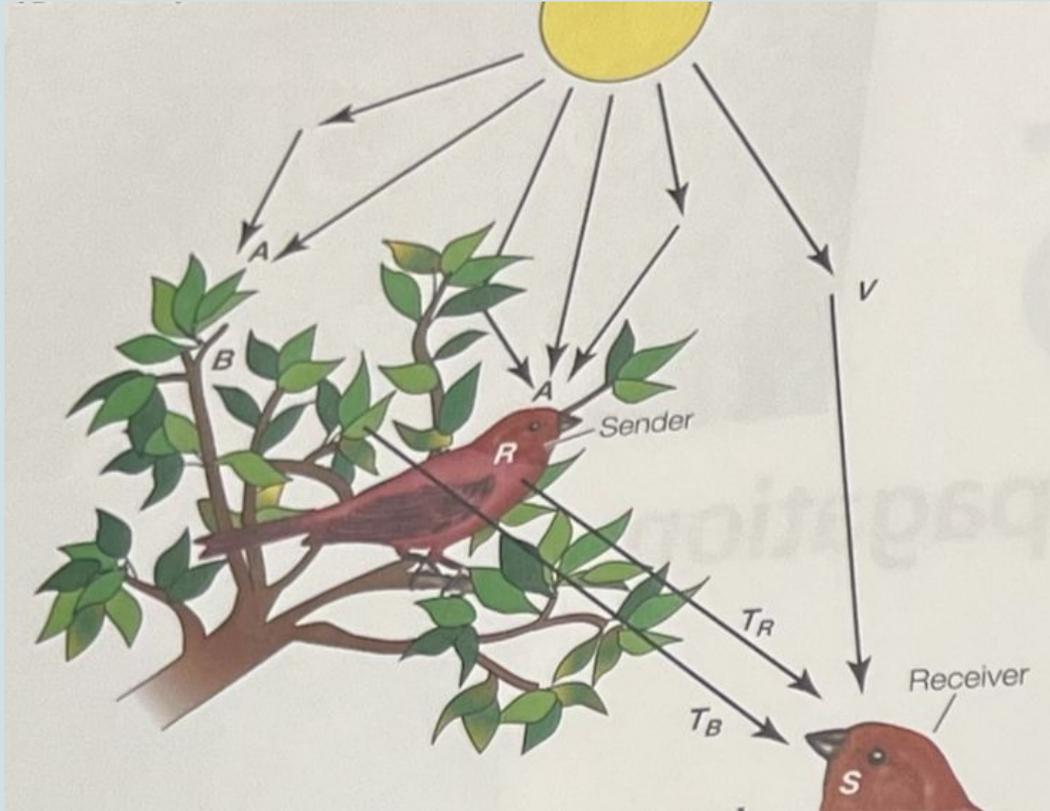
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The ARTS Diagram

A: ambient light spectrum
R: reflected light spectrum
T: transmission spectrum
S: color sensitivity

**B* = background



Chapter 5, pg. 154 in *Principles of Animal Communication*

Ambient light spectrum

The spectrum of visible light available for the sender and the background to reflect. Dependent on time of day, weather, medium, and habitat.

Reflected light spectrum

Describes the **brightness, hue, and saturation** of the light signal from the sender.

Transmission spectrum

Specifies how much the light beam **attenuates** over time – dependent on the distance between sender and receiver, the **medium** through which the signal travels, **scatter**, and blockage.

Sensitivity

Based on the sensitivity of the receiver's visual receptors, measured using **wavelength absorption curves**.

Background

- The background light spectrum influences how the sender's body is perceived
- A sender may increase or decrease their conspicuousness depending on background noise

Contrast Strategies



Brightness contrast

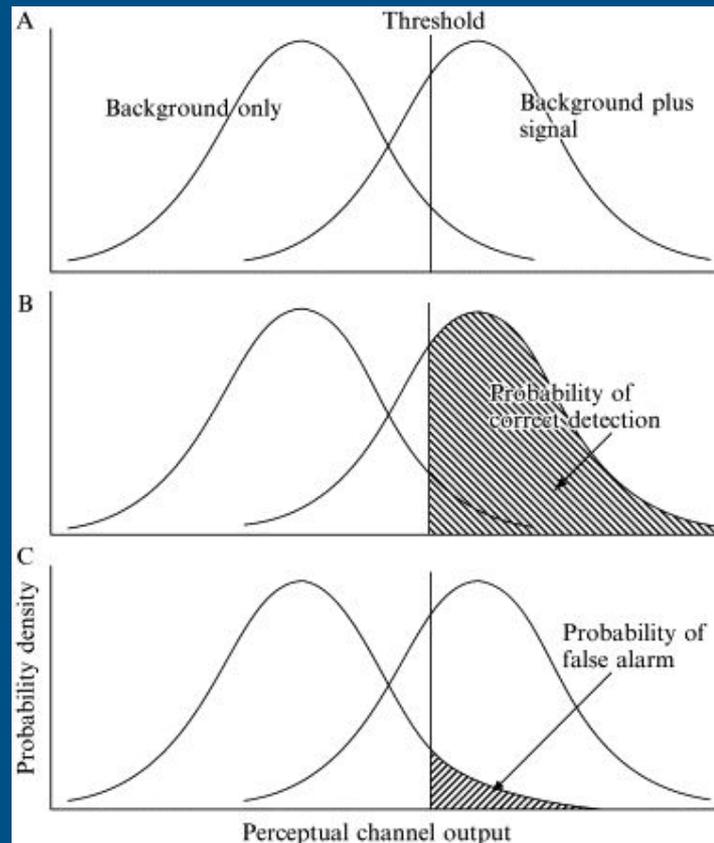
Pattern contrast



Motion contrast

Detectability

- Depends on ARTS and apparent object size
- Constrained by receiver **resolving power**, background noise, and contrast
- **Contrast threshold** quantifies constraints



Wiley, 2006

A: ambient light spectrum
R: reflected light spectrum
T: transmission spectrum
S: color sensitivity

B = background

In practice...

**Total receiver catch of the
SIGNAL = $A \times R \times T \times S$**

**Total receiver catch of the
BACKGROUND = $A \times B \times T \times S$**

Animals navigate the difference between these in
visual signalling.

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Eye Structure

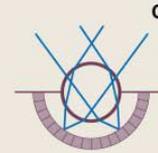
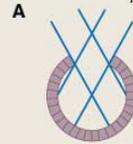
“The design of an animal’s eye and its resulting acuity reflect its visual needs”
 – Chapter 5, *Principles of Animal Communication*

We will focus on the **camera-lens eye**, which nearly all vertebrates use.

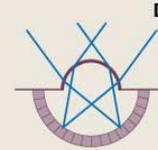
Chambered eyes



Nautilus



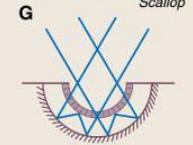
Octopus



Red-tailed hawk



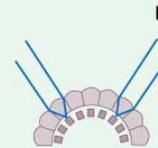
Scallop



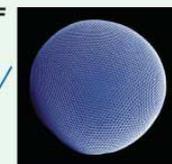
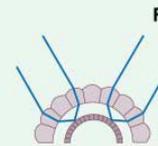
Compound eyes



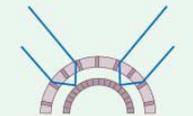
Sea fan



Dragonfly



Krill eye

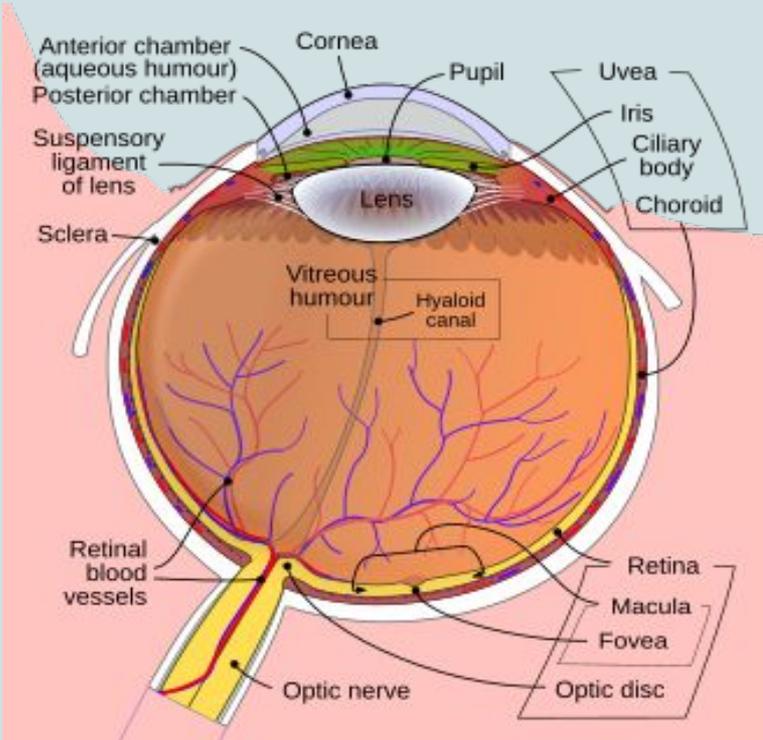


H



Lobster

Parts of the camera-lens eye



Wikipedia

Lens

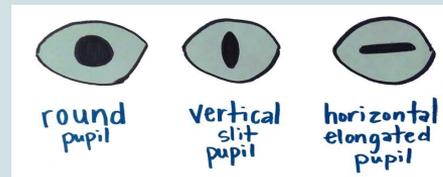
Cornea or hard lens refracts light onto retina

Focusing (**accommodation**)

Iris & Pupil

Controls how much light enters the eye

Round versus **slit** pupil tradeoffs



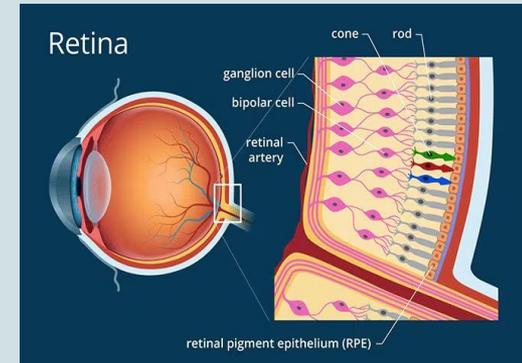
Outdoor Education

Retina

Made up of packed **photoreceptor cells** which contain the pigment **rhodopsin**

Rod receptor cells are highly light sensitive in low light

Cone receptor cells are useful in bright-light environments



ResearchGate

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Resolution

- Determines image quality
- Impacted by...
 - **Scattering**
 - Aberration (**chromatic** and **spherical**)
 - **Diffraction**
- Increasing resolution entails tradeoffs
 - **Area centralis & fovea**

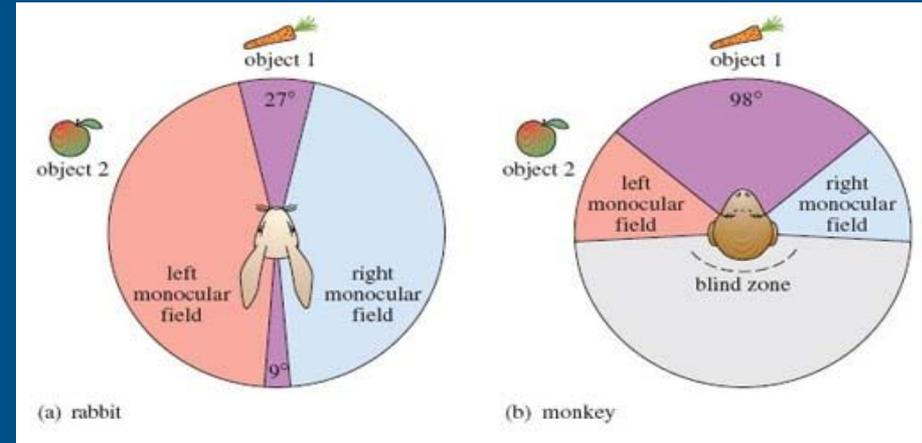
Sensitivity

- # photons / receptor / second
- Impacted by...
 - Pupil diameter
 - Angle of light reception
 - Photon absorption

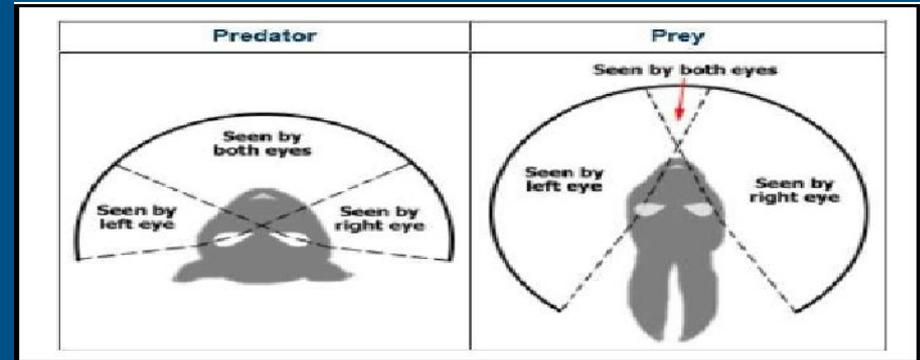


Field of view

- **Monocular vision**
 - Each eye independent
 - Small overlap
 - Dominant in prey
- **Binocular vision**
 - Lots of overlap
 - Large blindspot
 - Dominant in predators



Open University



ResearchGate

Visual processing

Color vision

Modifications to rhodopsin and **chromatically opponent ganglion cells** impact color vision and discrimination

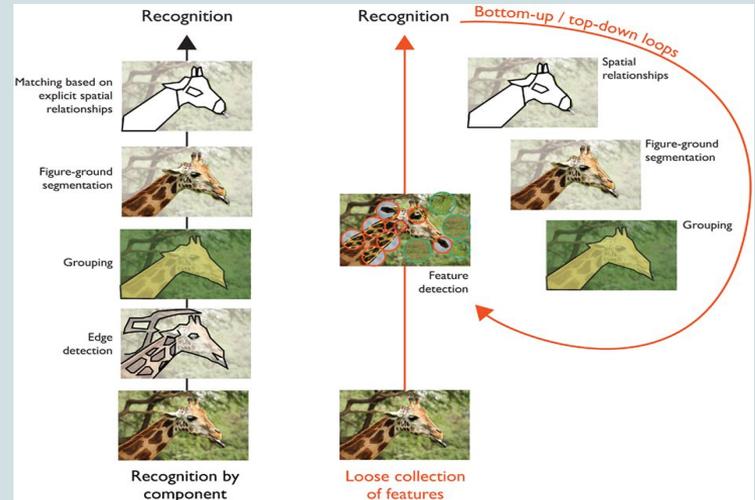
Four kinds of animal: **monochromats, dichromats, trichromats,** and **tetrachromats**



Feature detection

Object recognition starts with edge detection, then sensing of outlines, then color and detail recognition

Feature detectors are specialized neurons that help sense certain kinds of motion



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“Most of the properties of visual receptors are determined by the environment, lifestyle, and diet of the animal... Tradeoffs largely determine the optics and wiring of the visual system, and therefore the opportunity to use the visual modality for communication.”

— Bradley, *Principles of Animal Communication*

Thank you!

... any questions?

