

AVIAN VISION, NAVIGATION, AND ORIENTATION

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USFWS Conference on Wind Power



Hazards to Birds



Wind Turbines



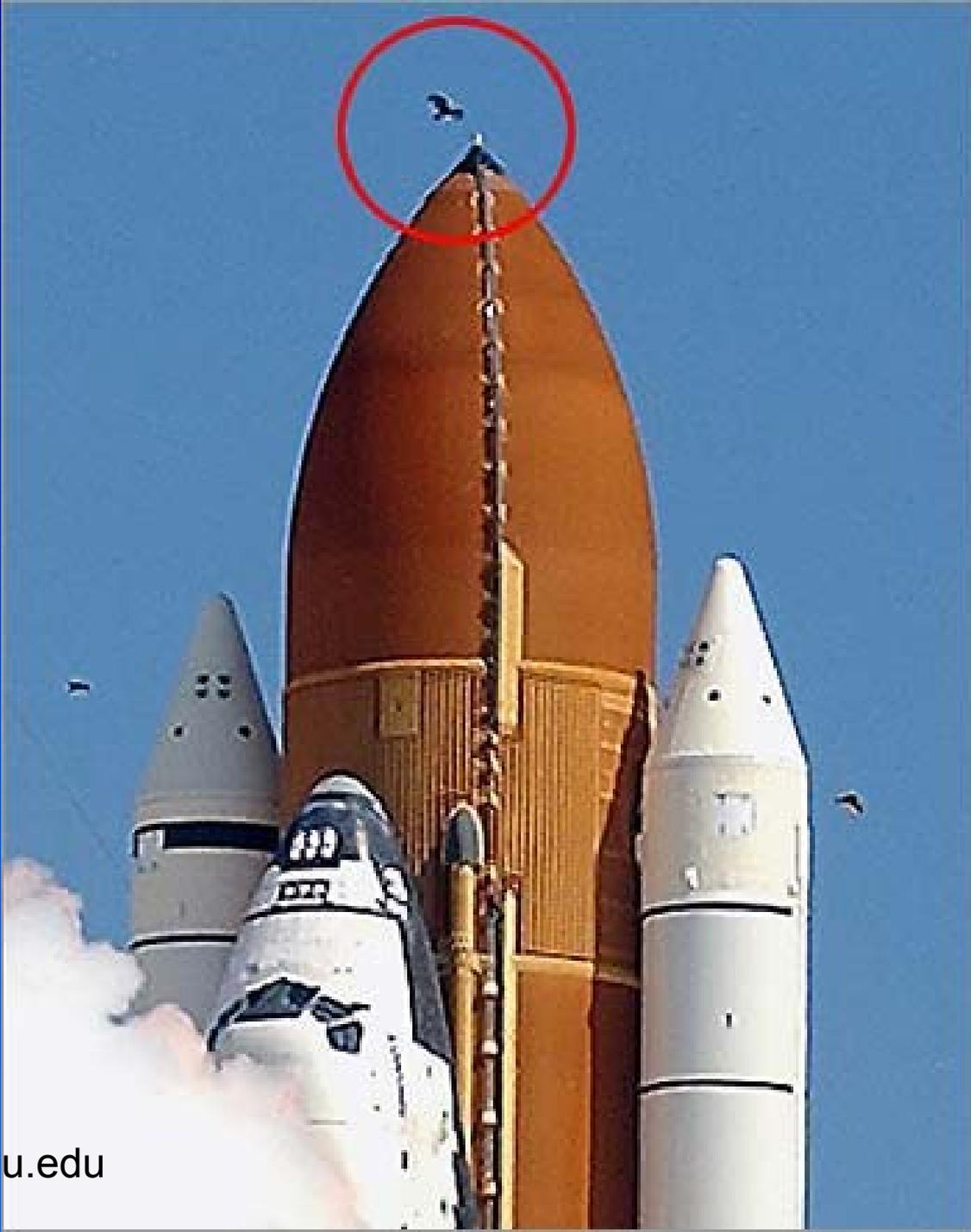
Denmark



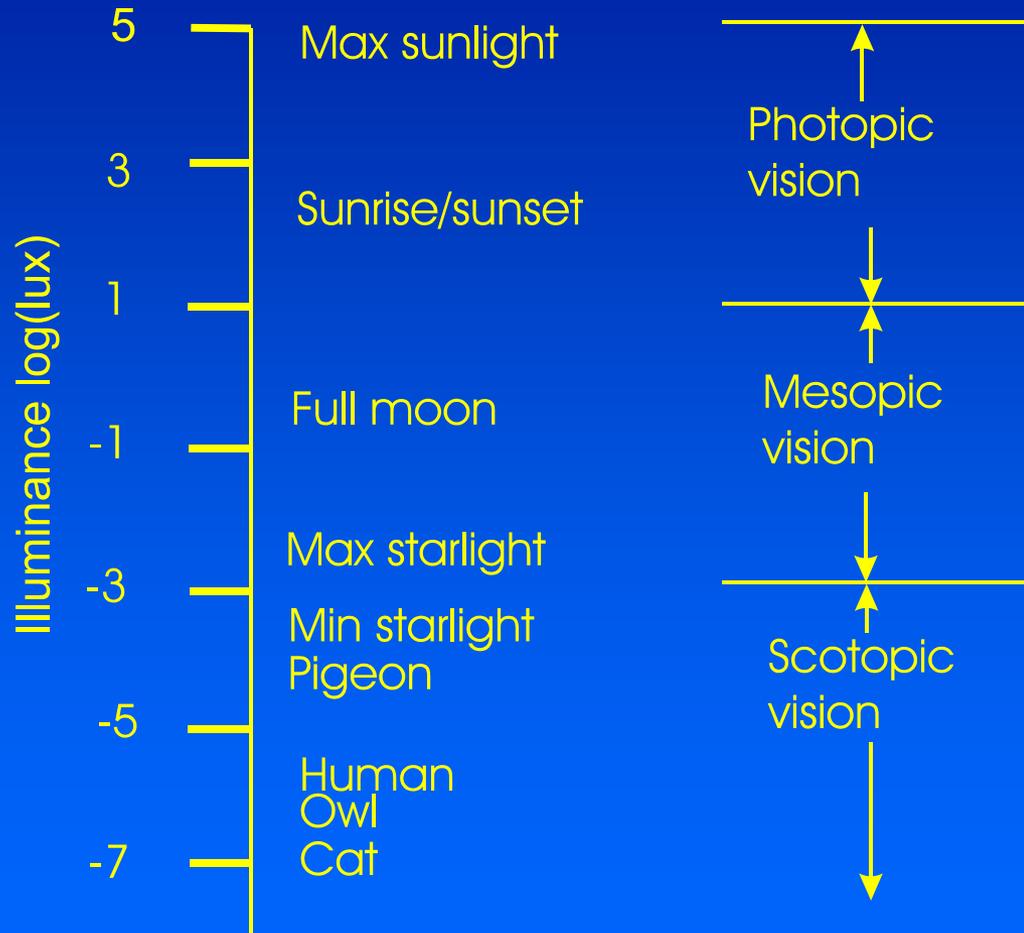
France

Power Transmission Lines

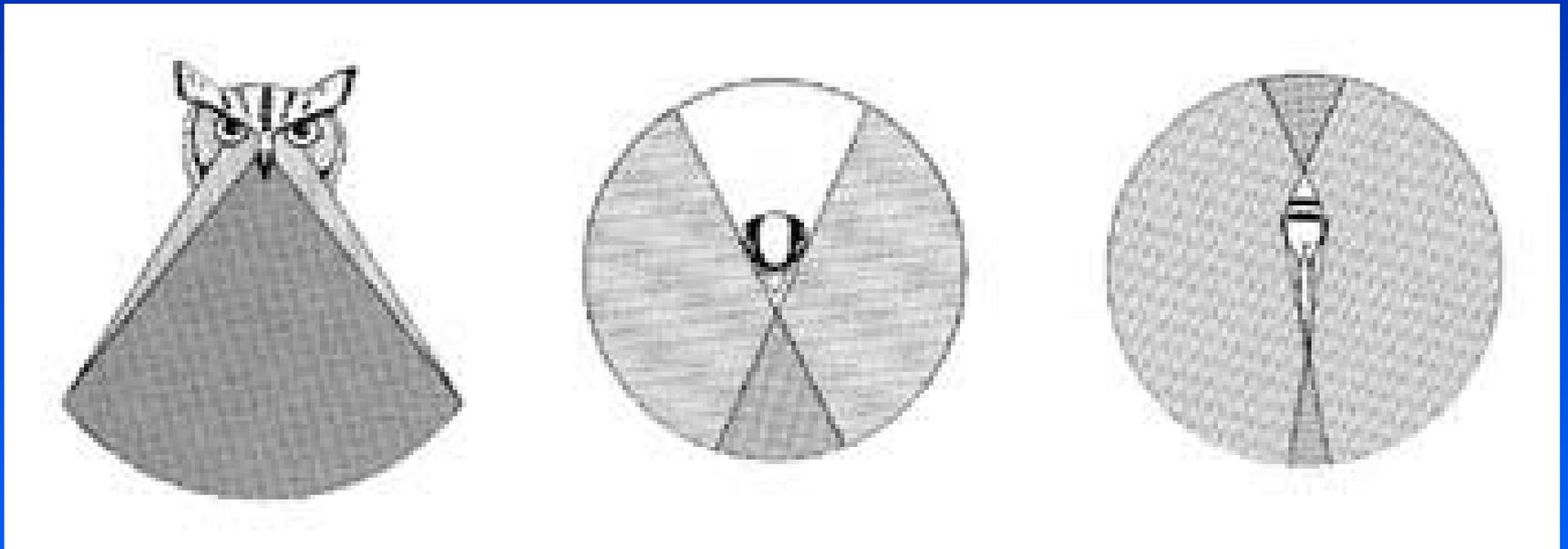




Intensity Thresholds



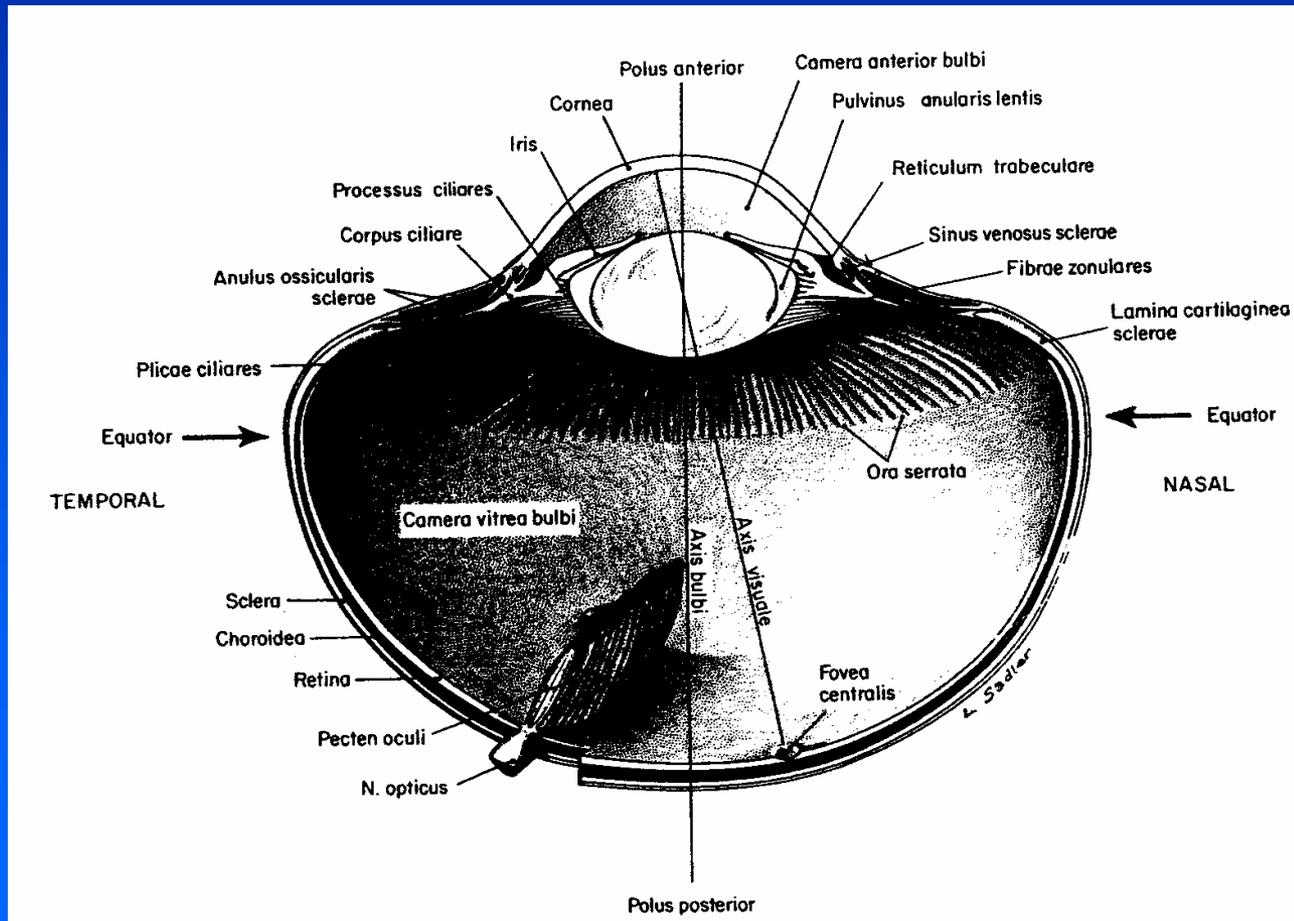
Fields of View



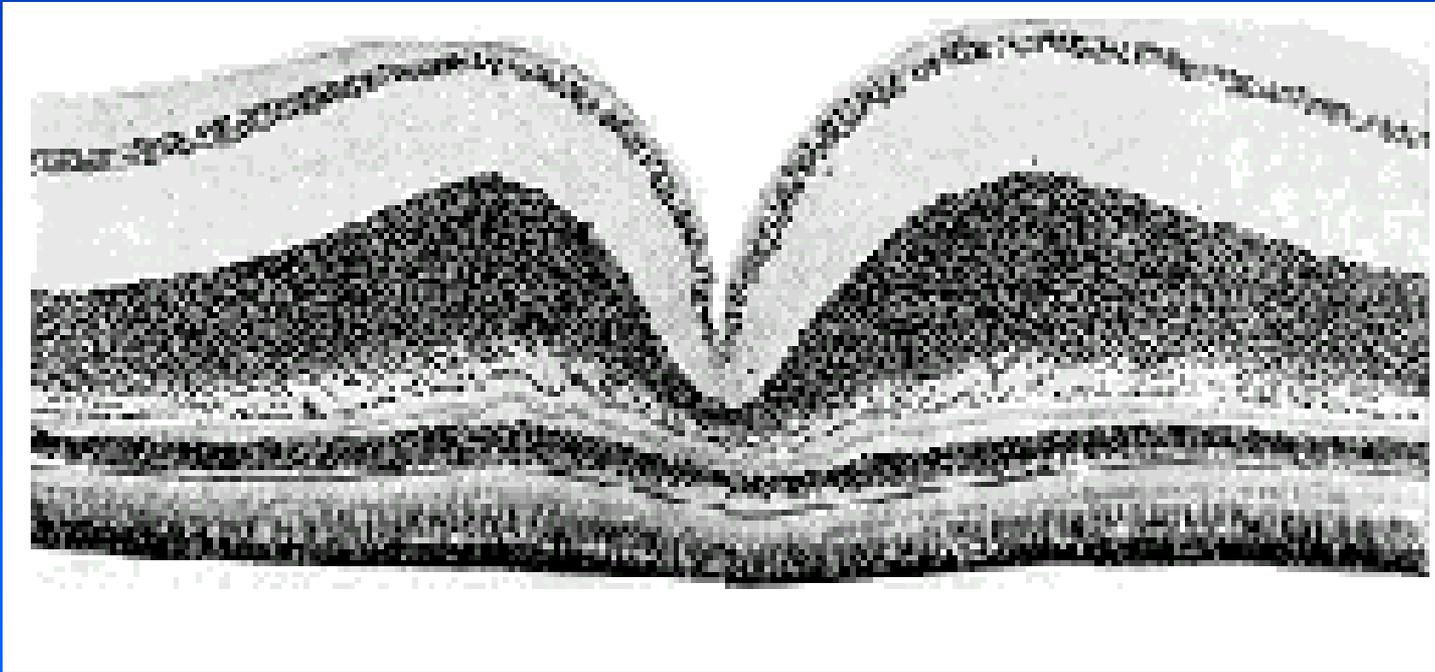
Stereoscopic Vision

	Total	Binocular	Blind
Mallard	360°	16°	0°
Pigeon	316°	22°	44°
Starling	286°	36°	74°
Shearwater	285°	11°	75°
Tawny Owl	201°	48°	159°
Human	200°	140°	160°

Avian Eye

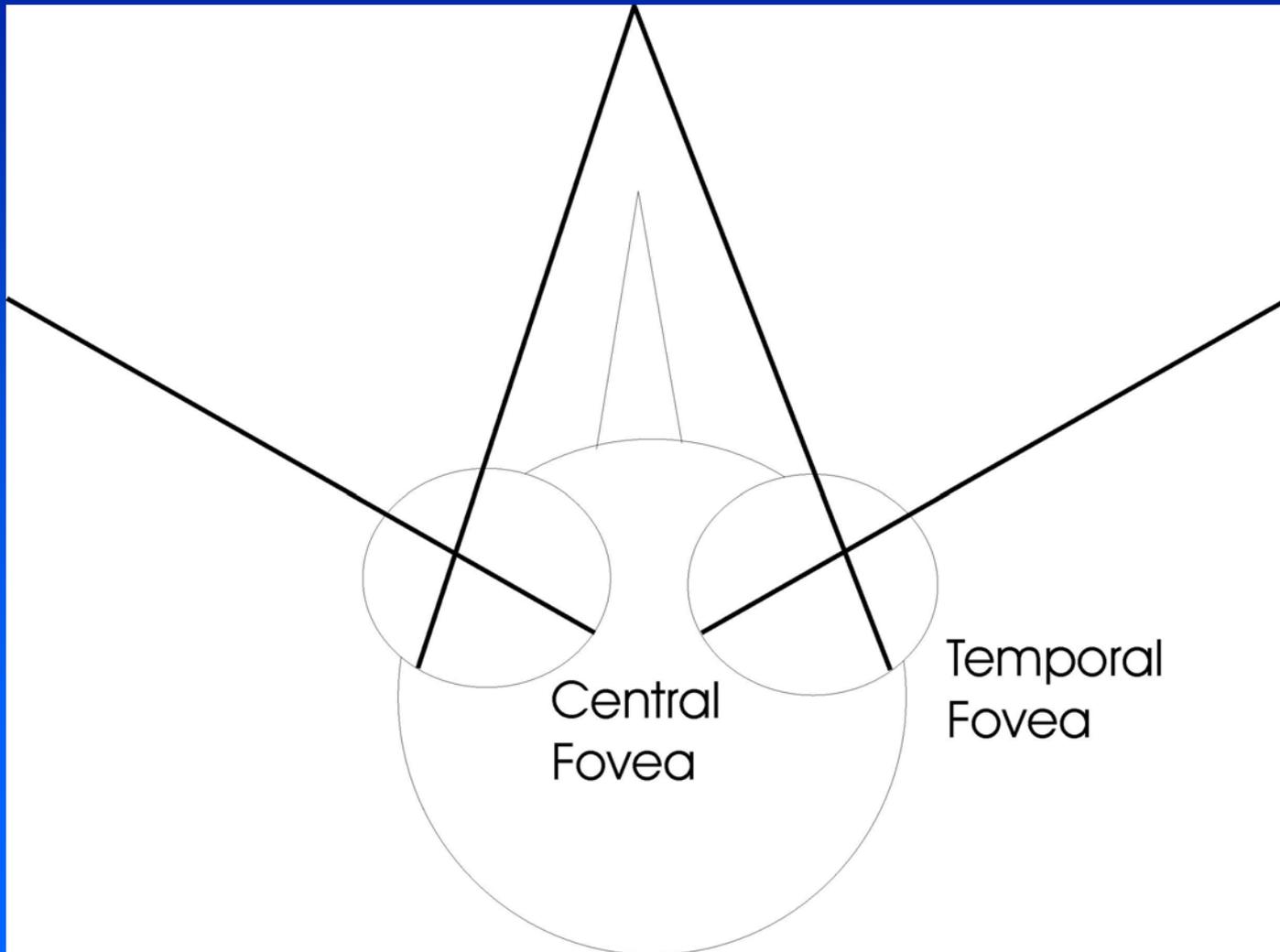


Central Fovea



Arctic Tern

Visual Fovea



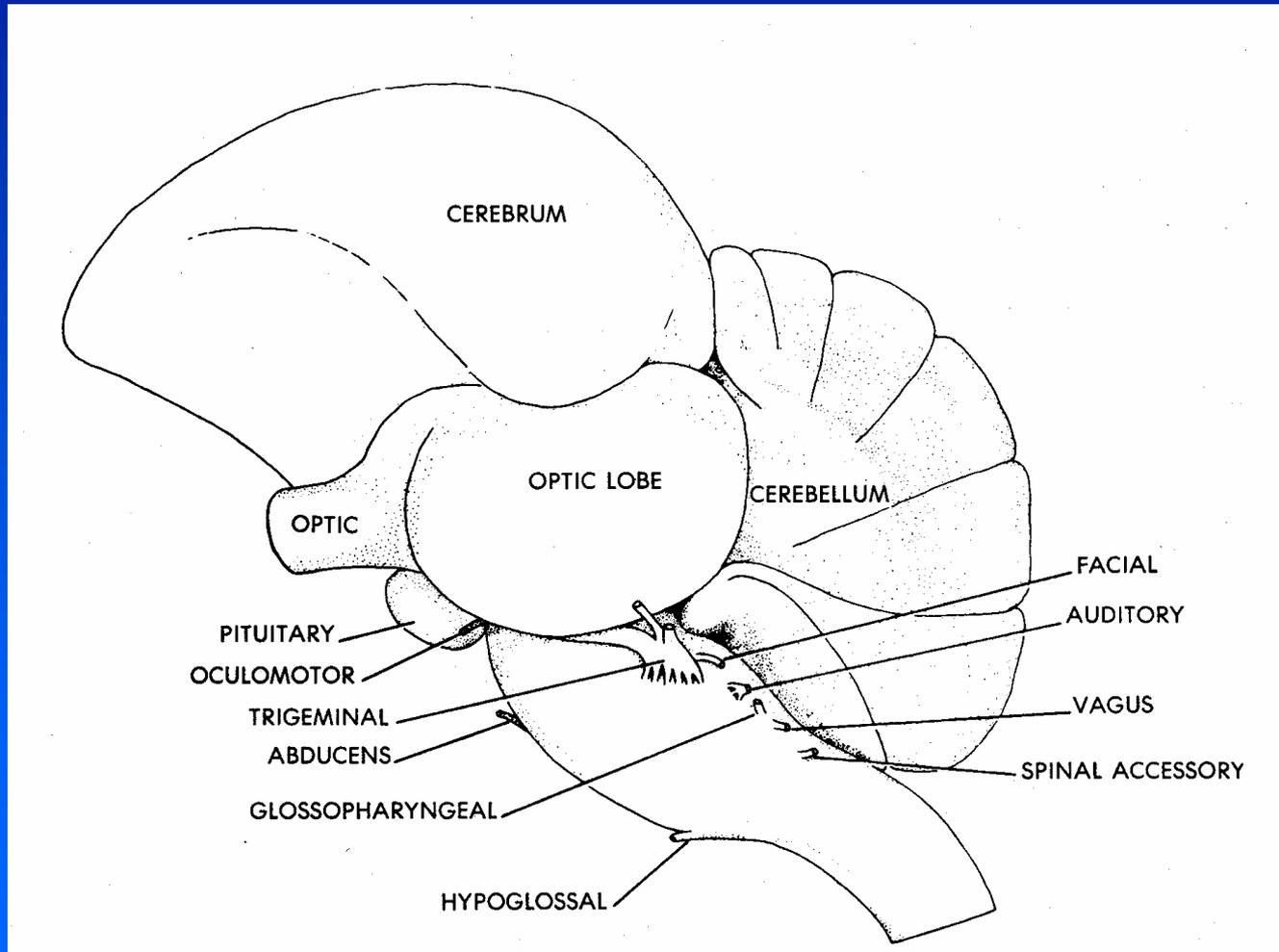
Fovea

- Central Fovea
 - Greatest visual acuity
 - Greatest density of ganglion cells
 - Used to fixate object
- Temporal Fovea
 - Binocular vision
 - Depth perception in raptors
 - Not present in all birds

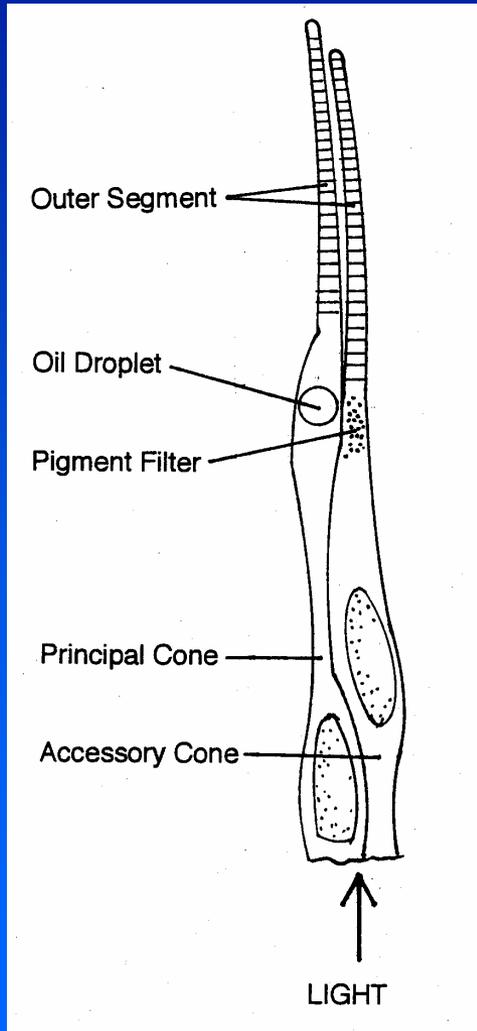
Pigeon Brain



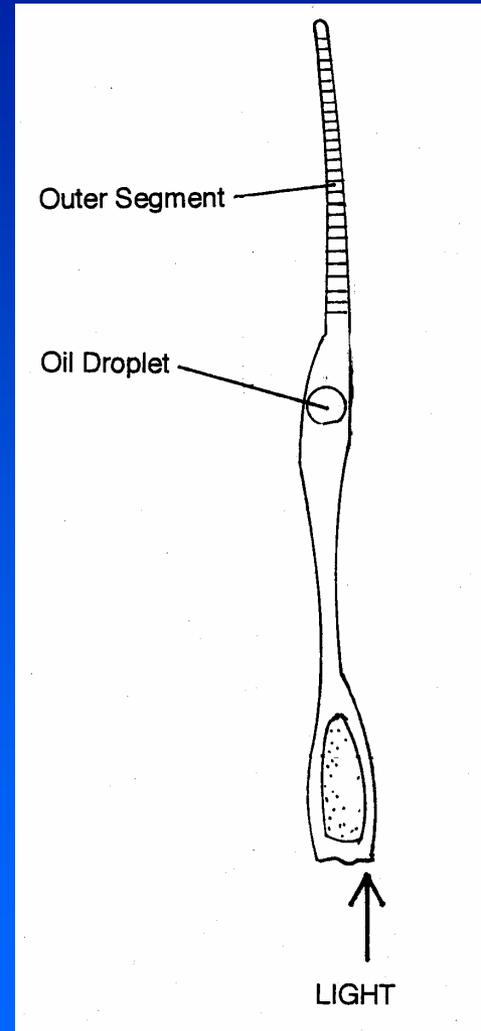
Visual System



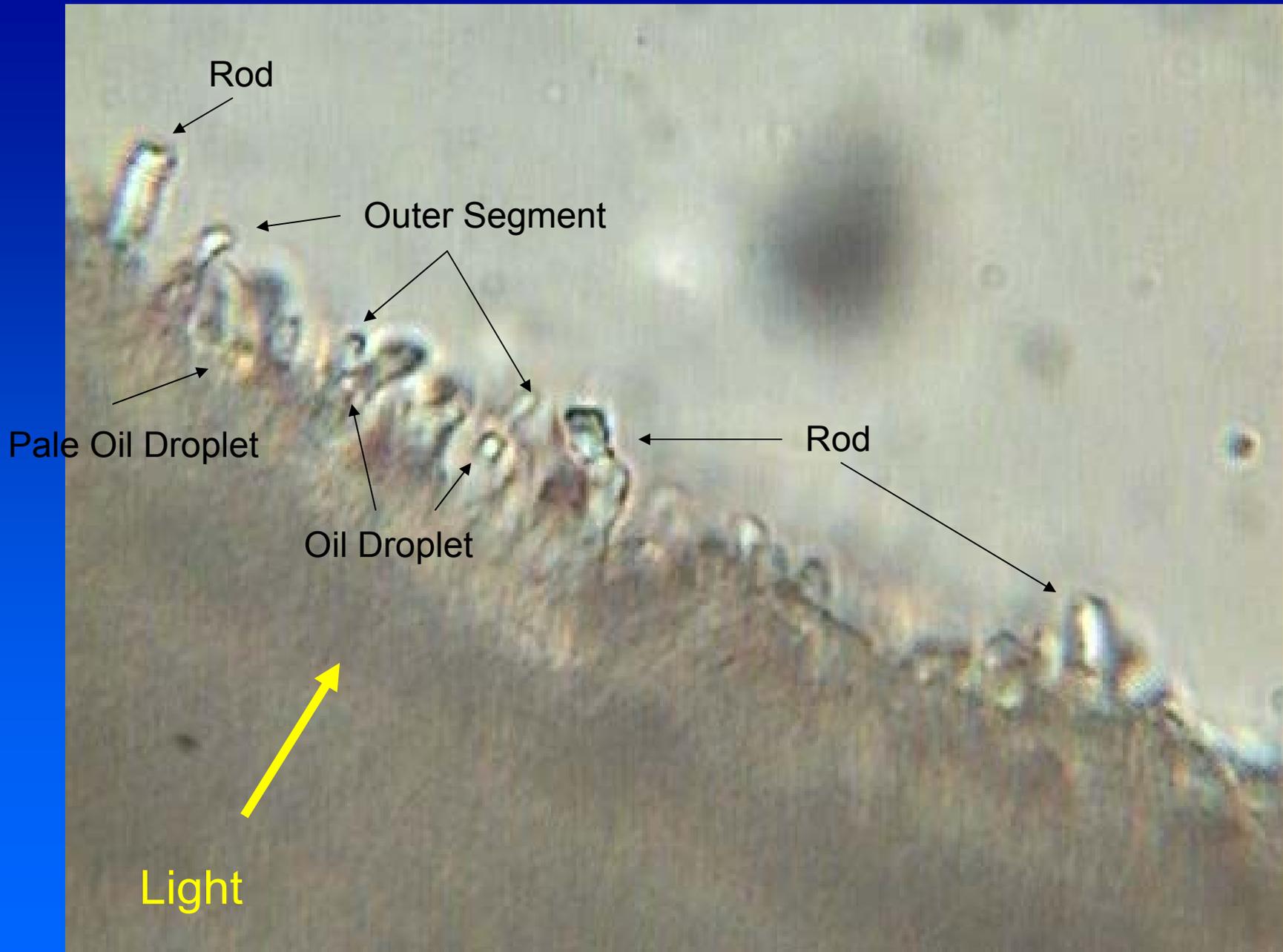
Cone Photoreceptors



Double Cone



Single Cone



Red-winged Blackbird male

Avian Visual Pigments

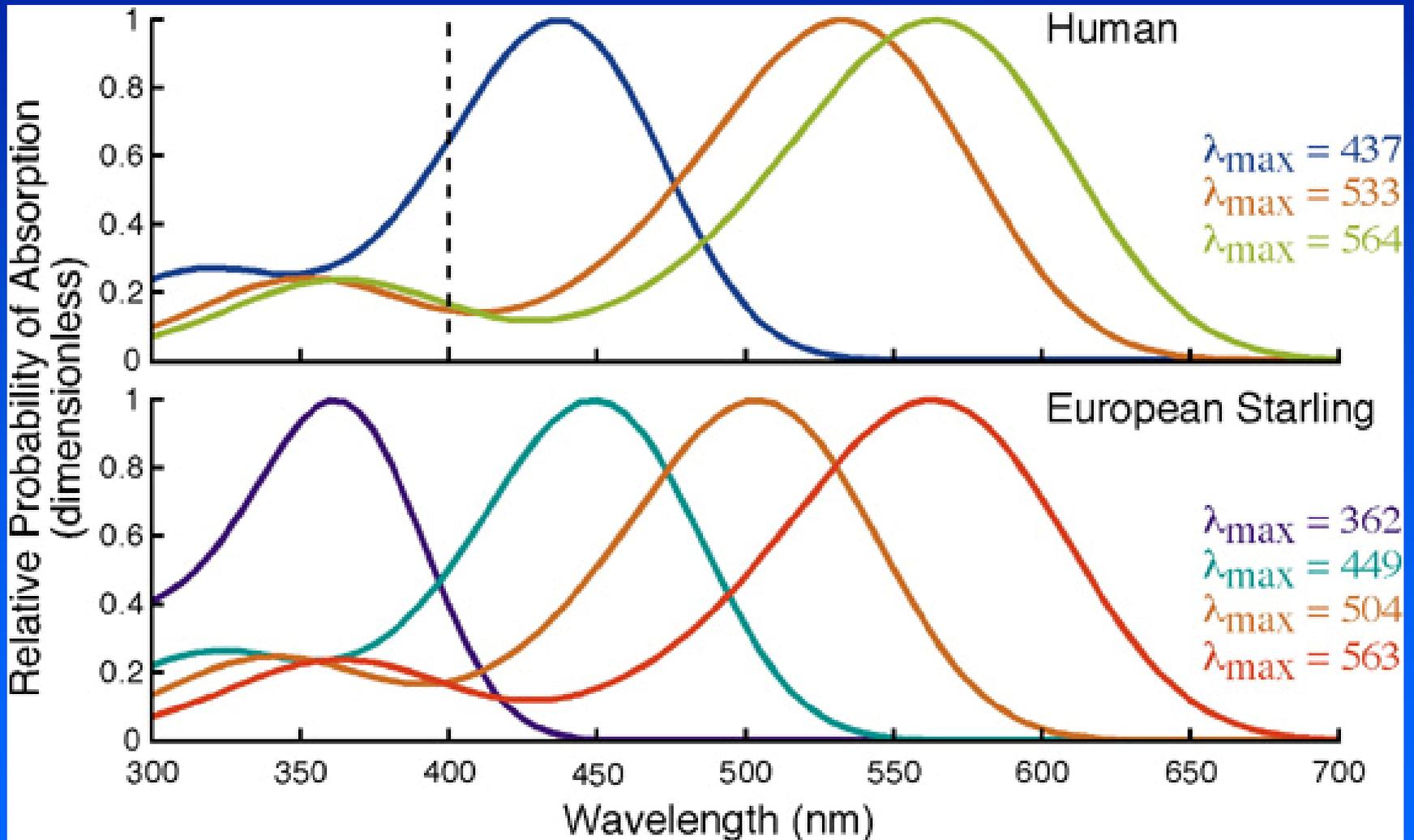
- Long wavelength sensitive (560-570 nm)
- Medium wavelength sensitive (500-510 nm)
- Short wavelength sensitive (445-450 nm)
- Violet sensitive (400-420 nm)
- Ultraviolet sensitive (369-373 nm)

- Rod (501-509 nm)

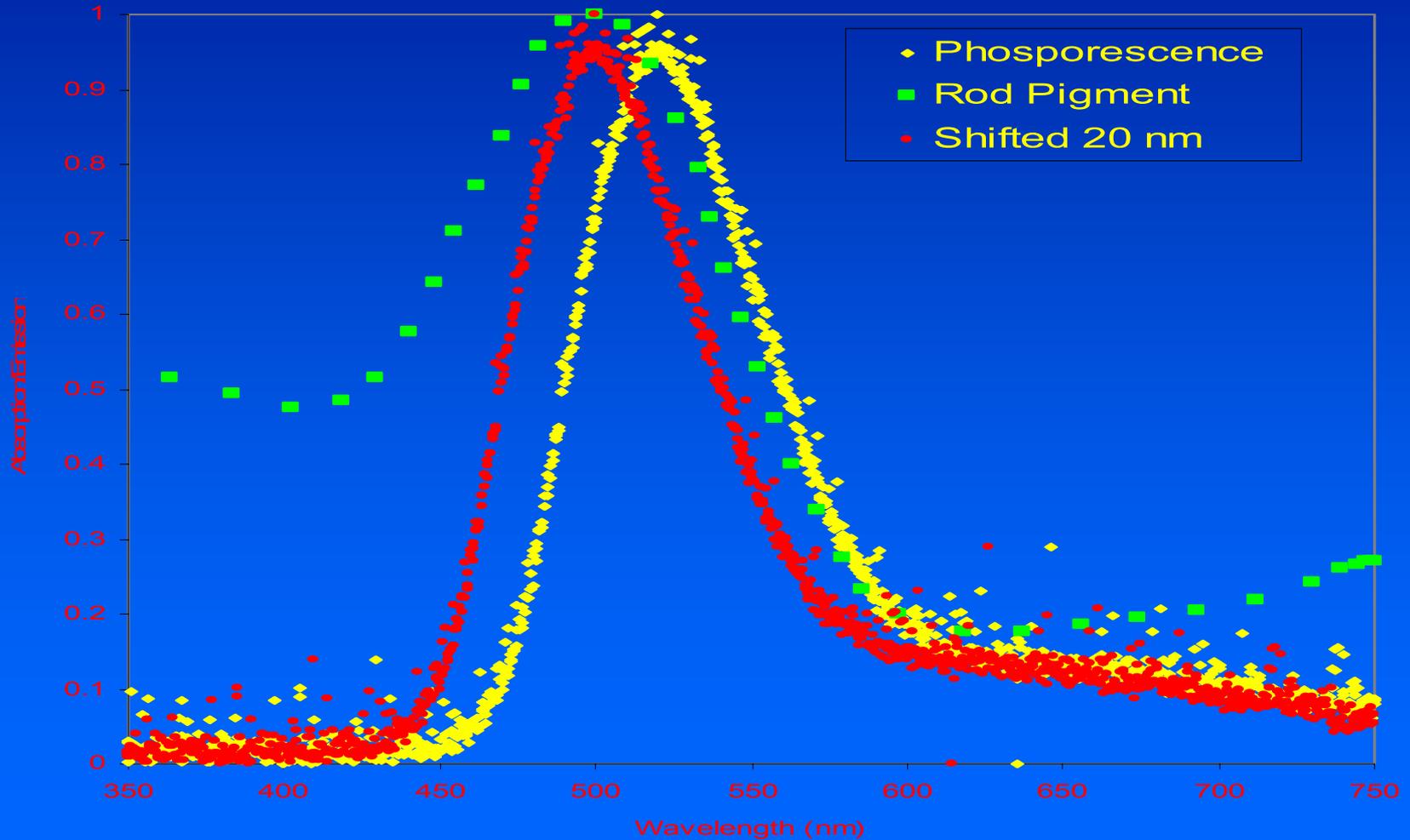
Cone Visual Pigments

	UVS	VS	SWS	MWS	LWS
Non-passerines		X	X	X	X
Rheidae	X		X	X	X
Laridae	X		X	X	X
Psittaciformes	X		X	X	X
Passeriformes	X		X	X	X
Tyrannidae		X	X	X	X
Corvidae		X	X	X	X

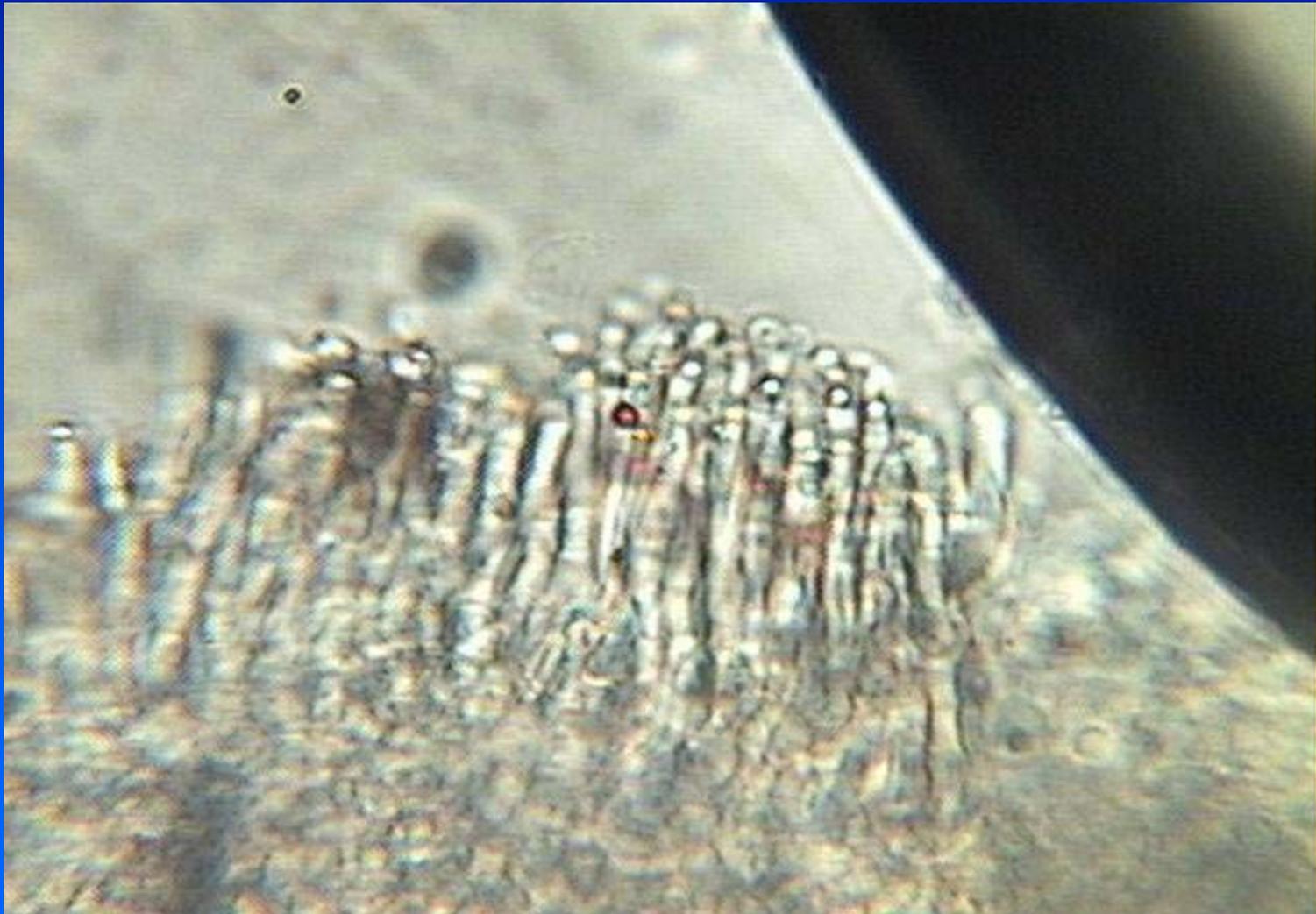
Human vs Starling



Need to Match Stimulus to Sensitivity

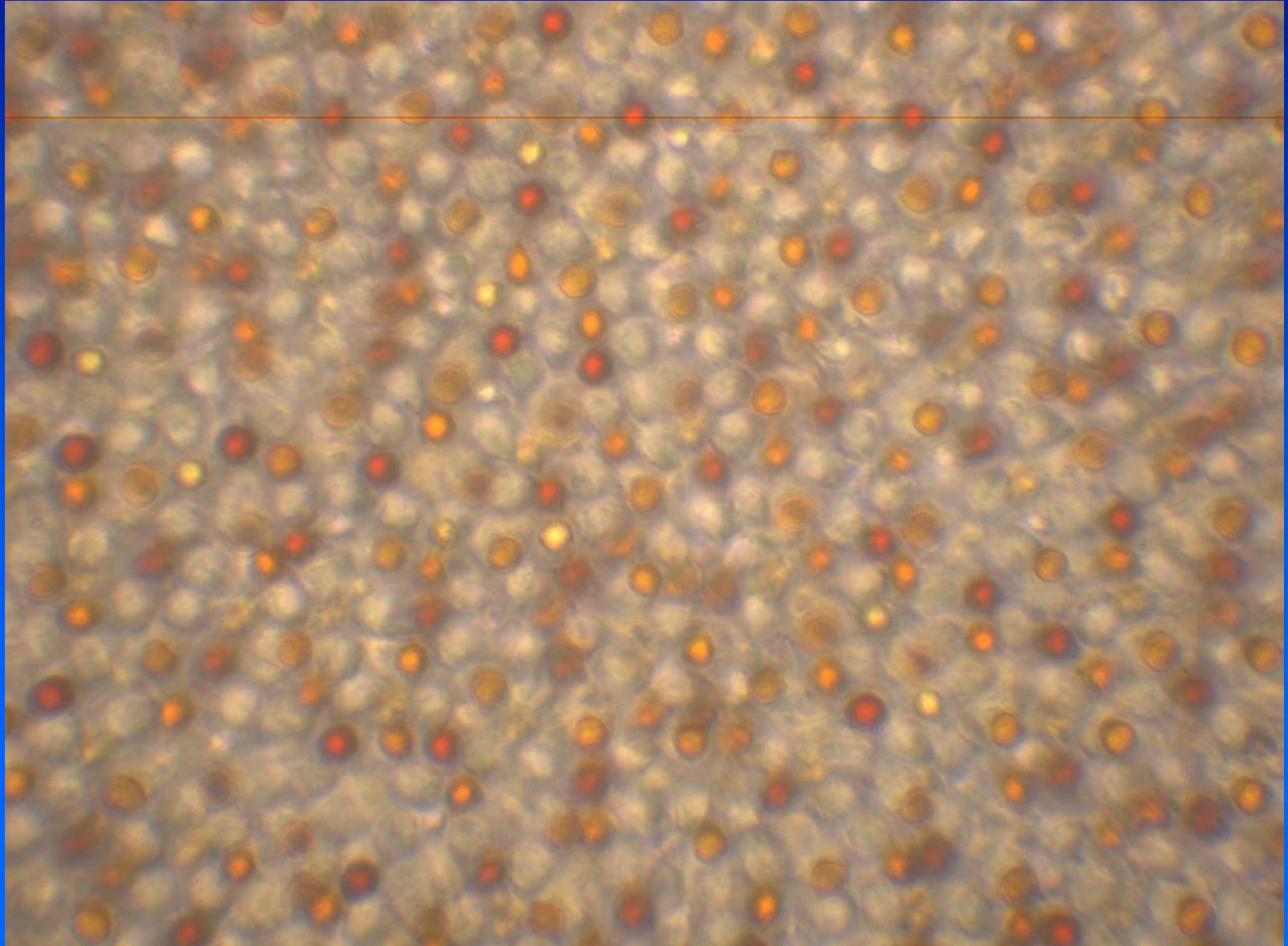


Retinal Photoreceptors

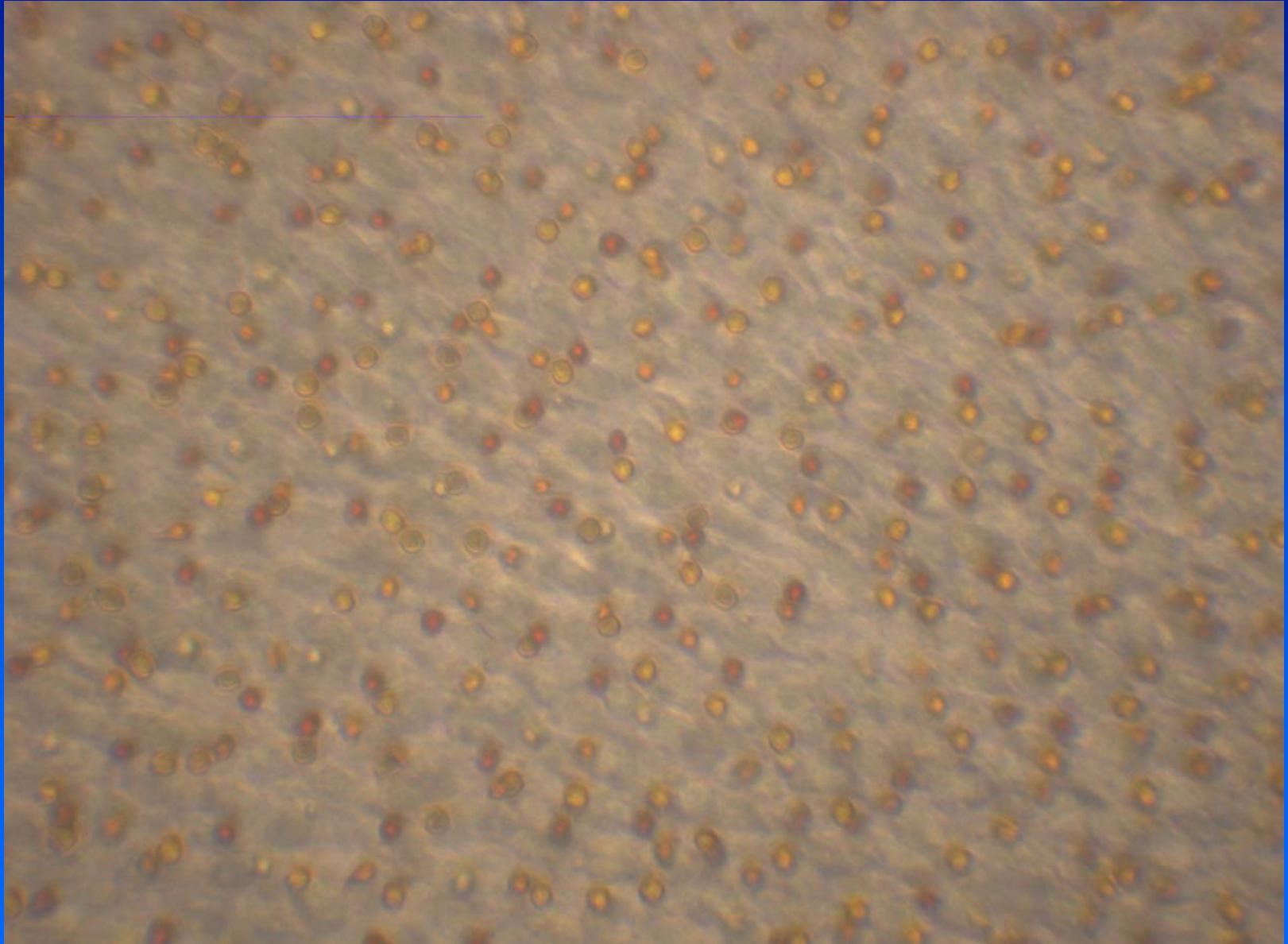


Red-winged Blackbird male

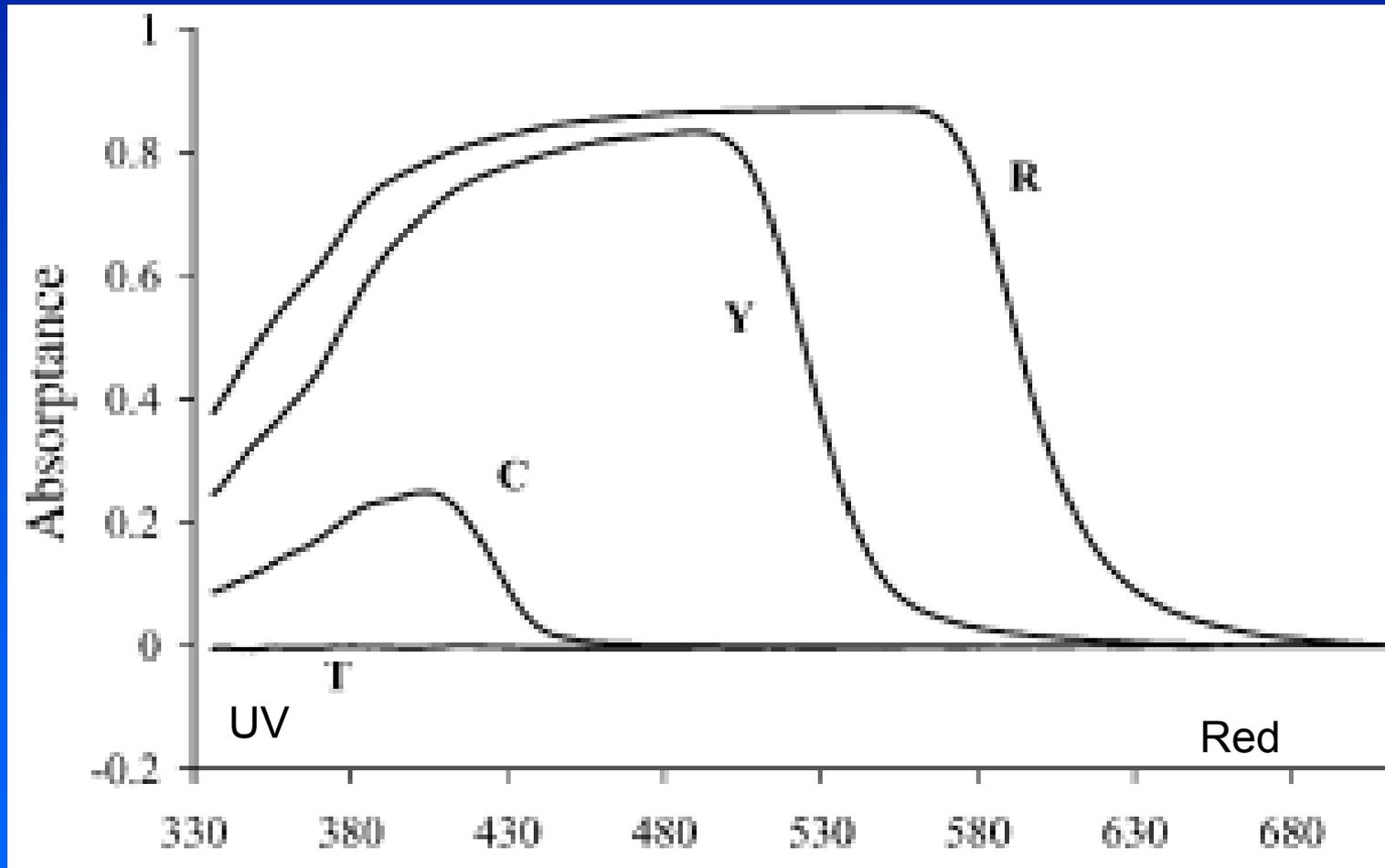
Canada Goose Peripheral Retina



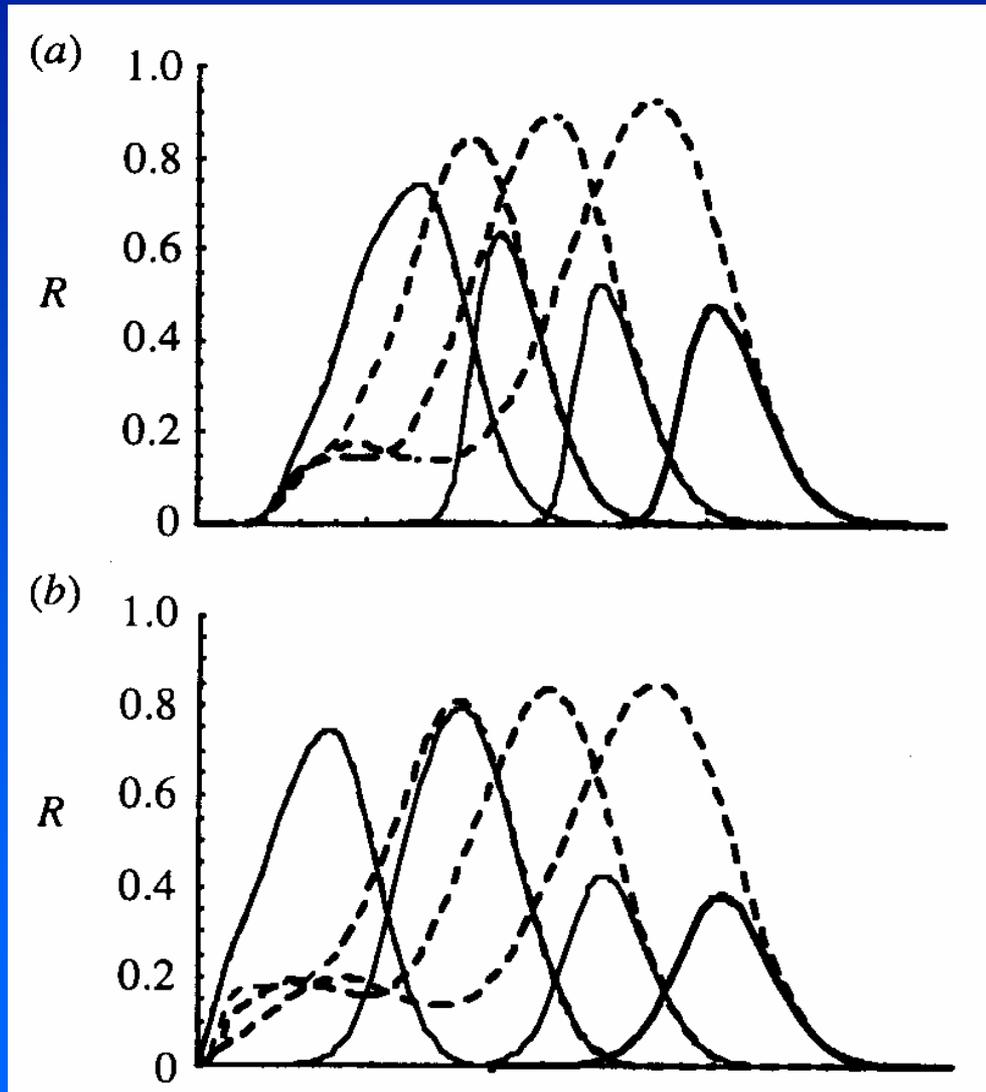
Canada Goose Central Retina



Oil Droplet Function

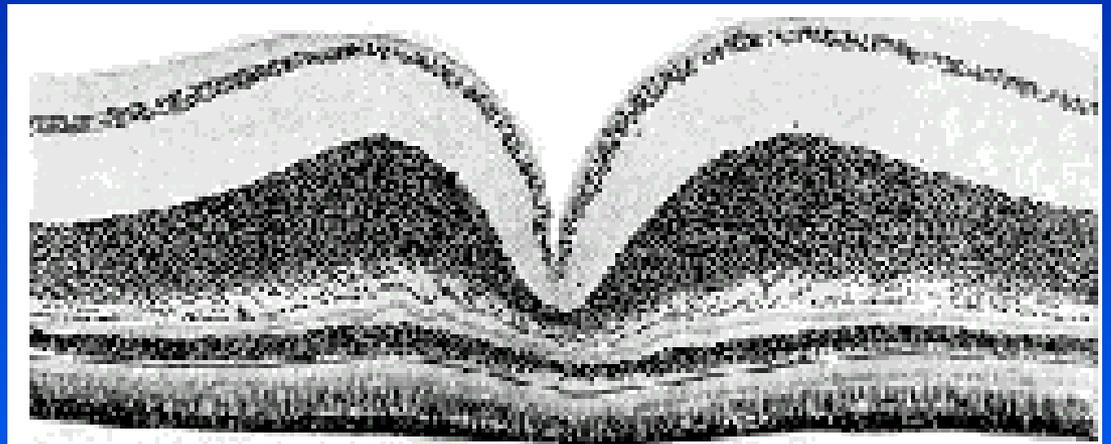


Spectral Tuning



Avian Retina

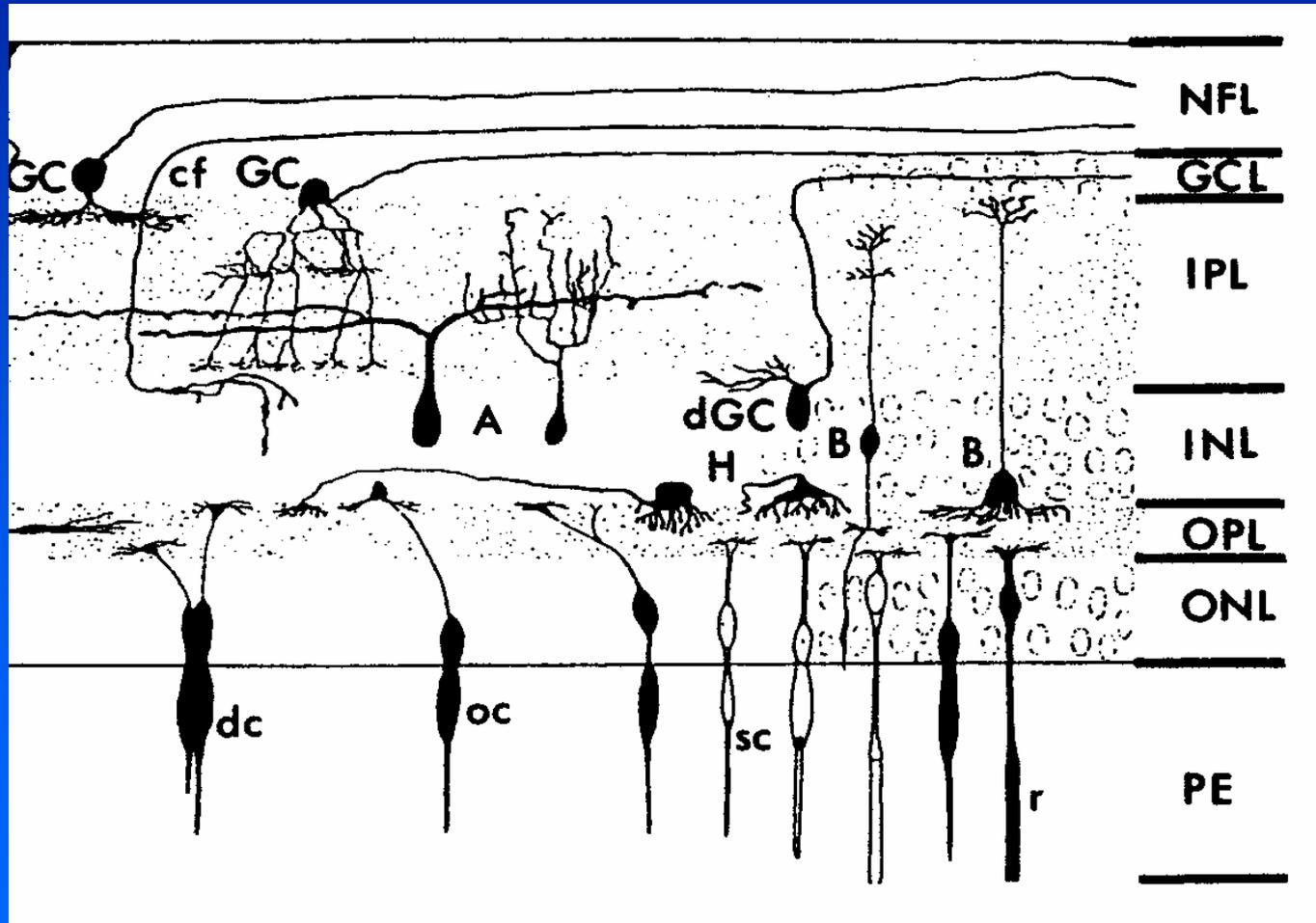
Arctic Tern



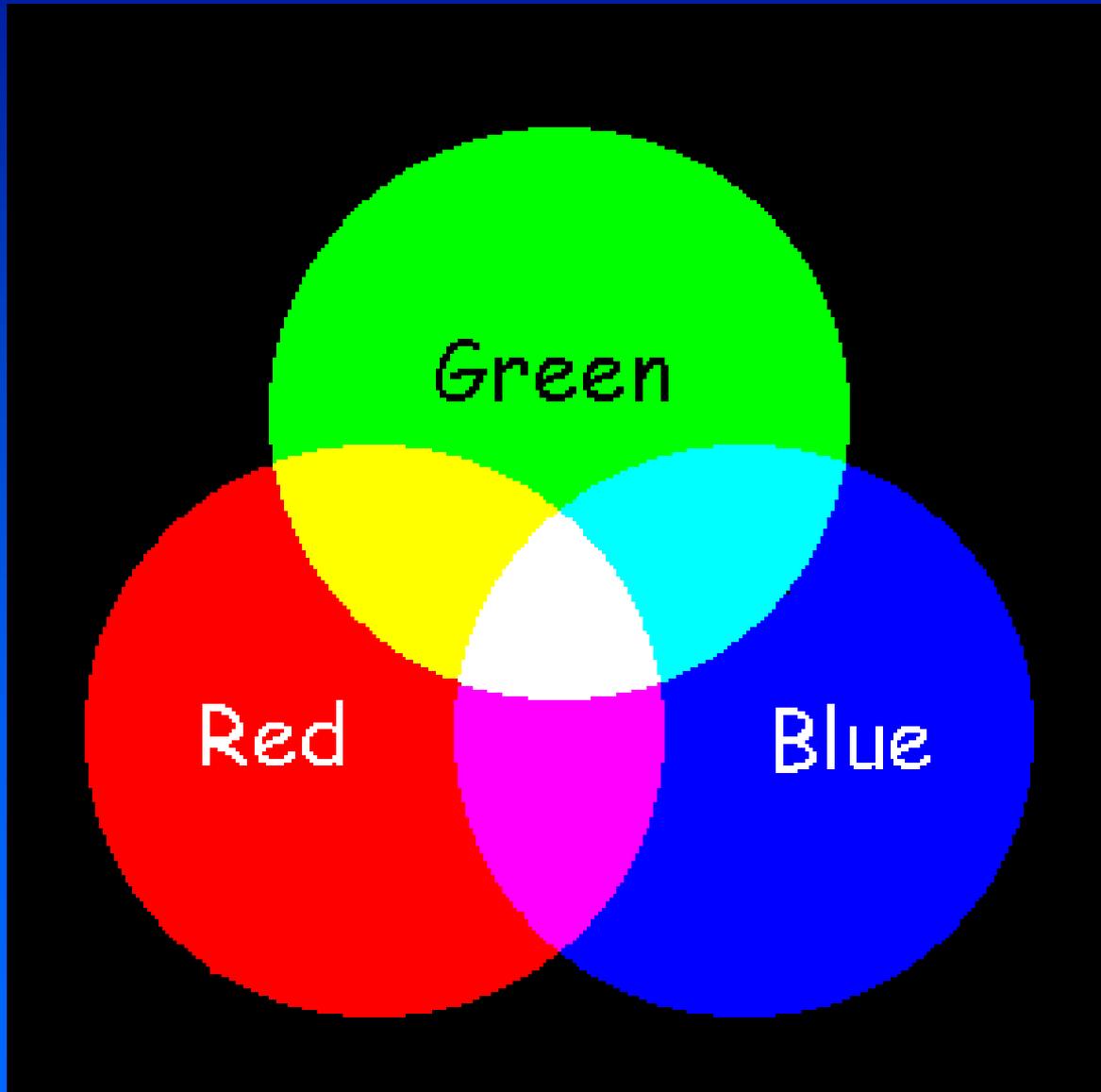
Human



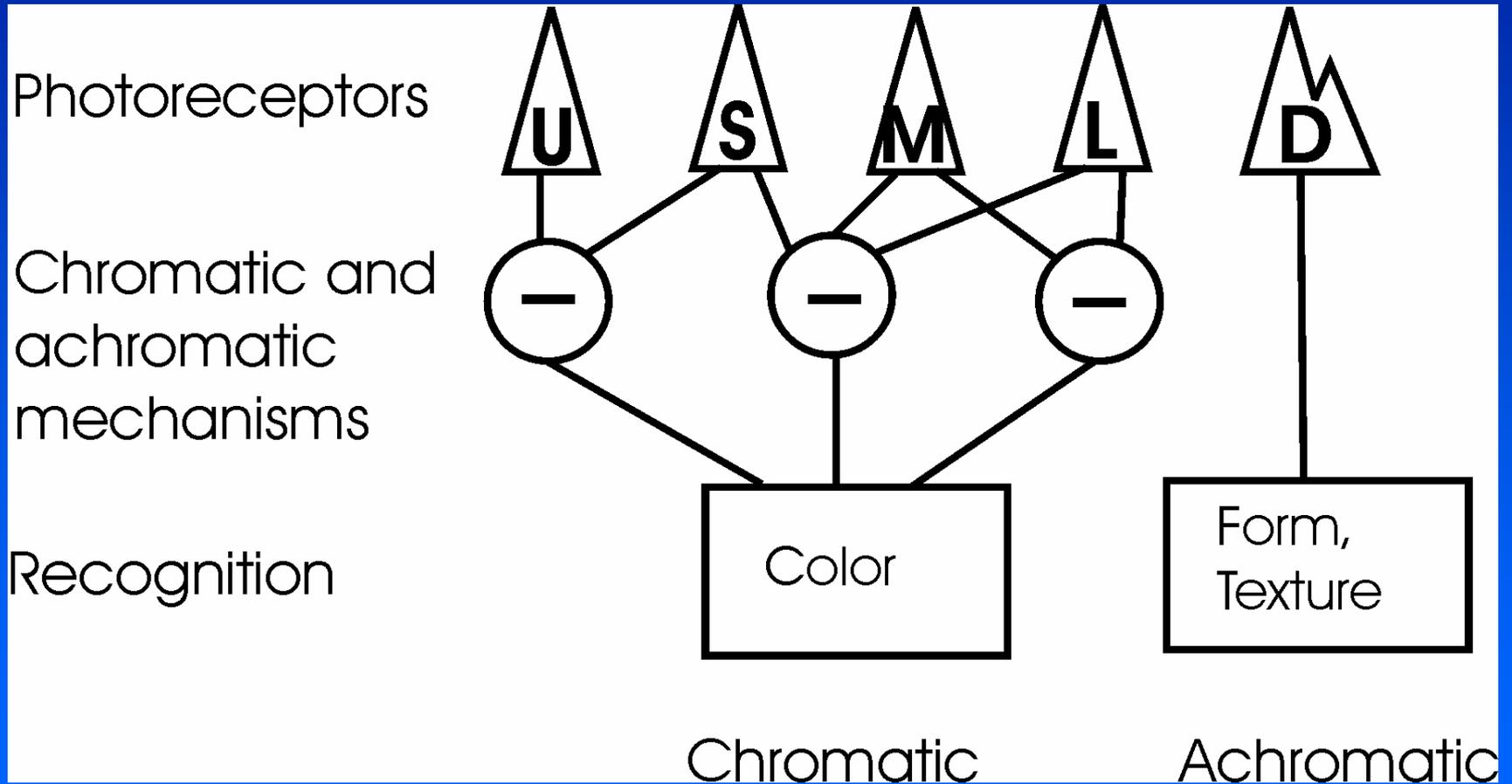
Avian Retinal Cells



Composite Colors



Avian Color Computation



Lateral Inhibition

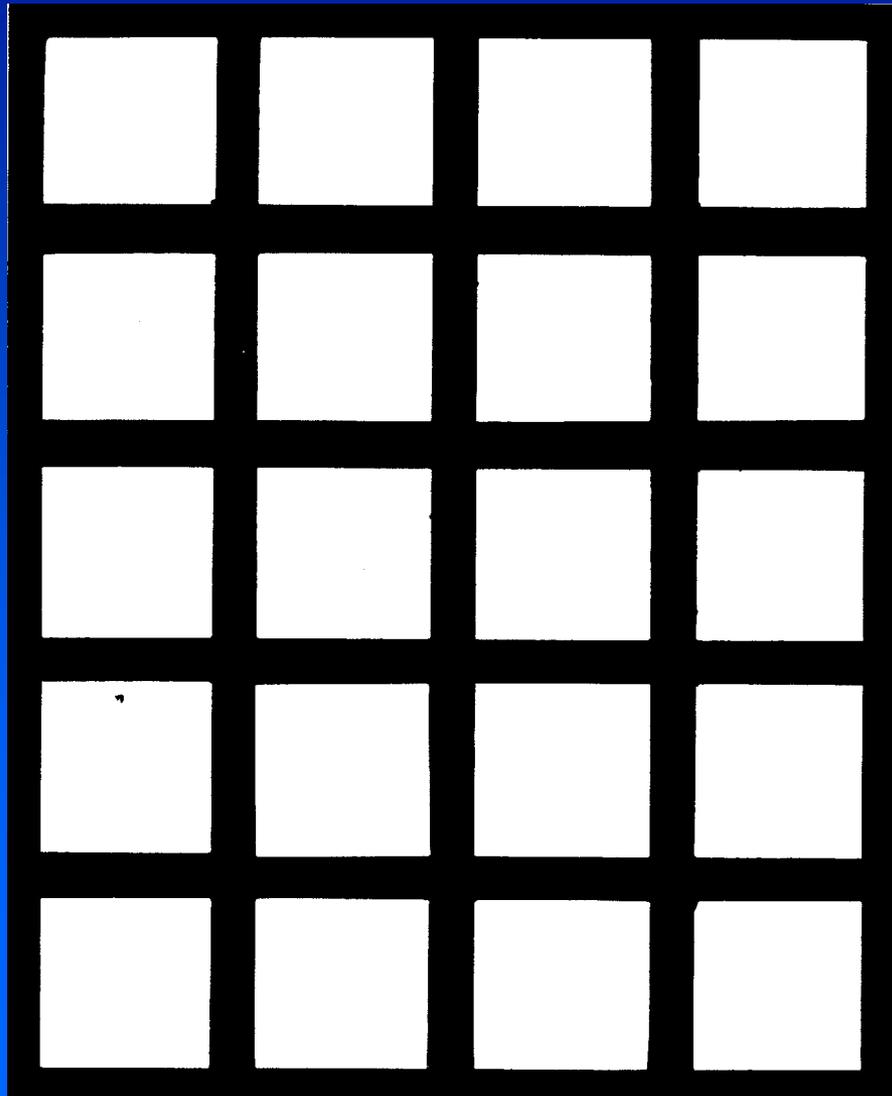
Center-on, surround-off
Enhances points of light



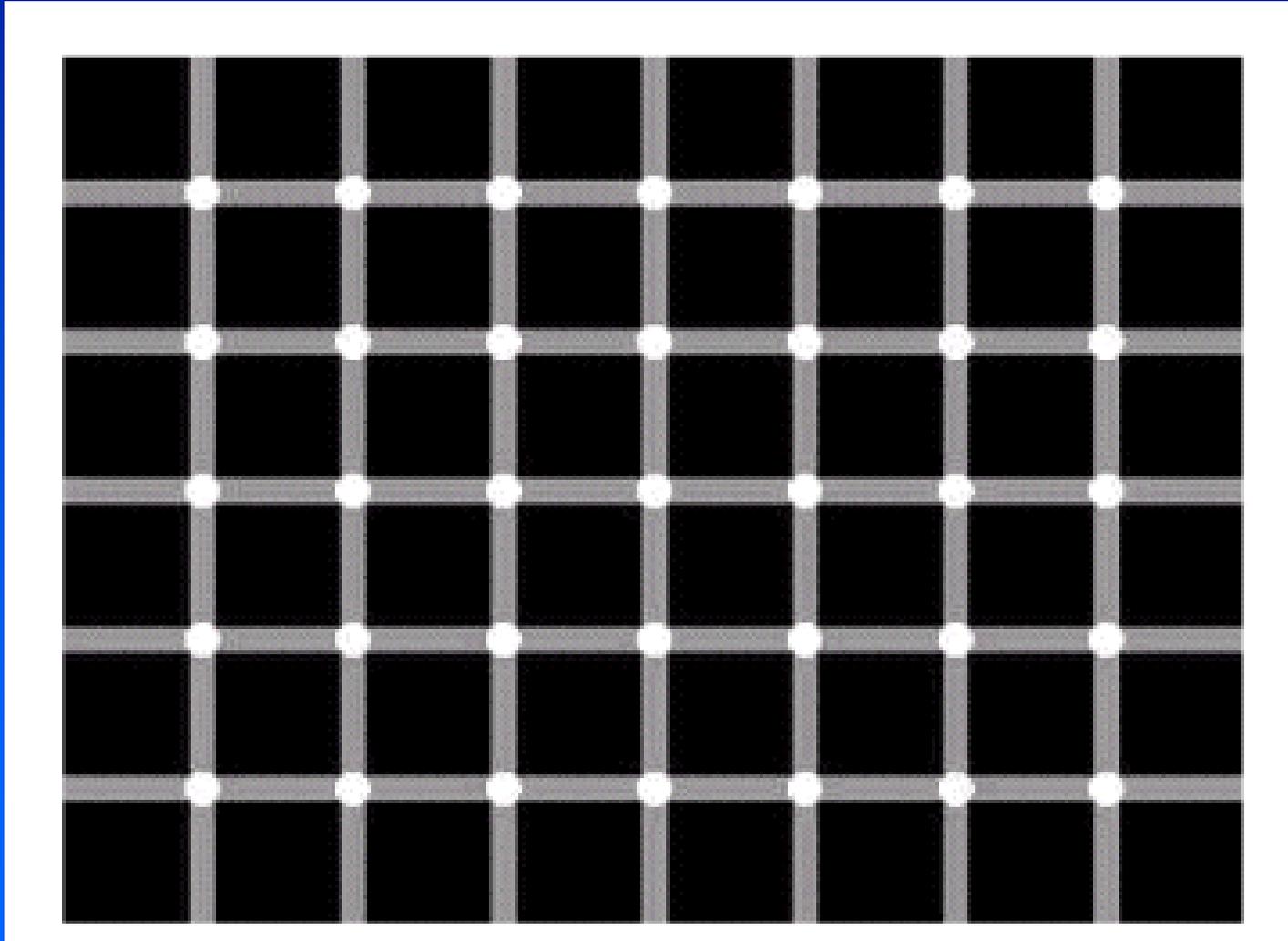
Center-off, surround-on
Enhances points of dark



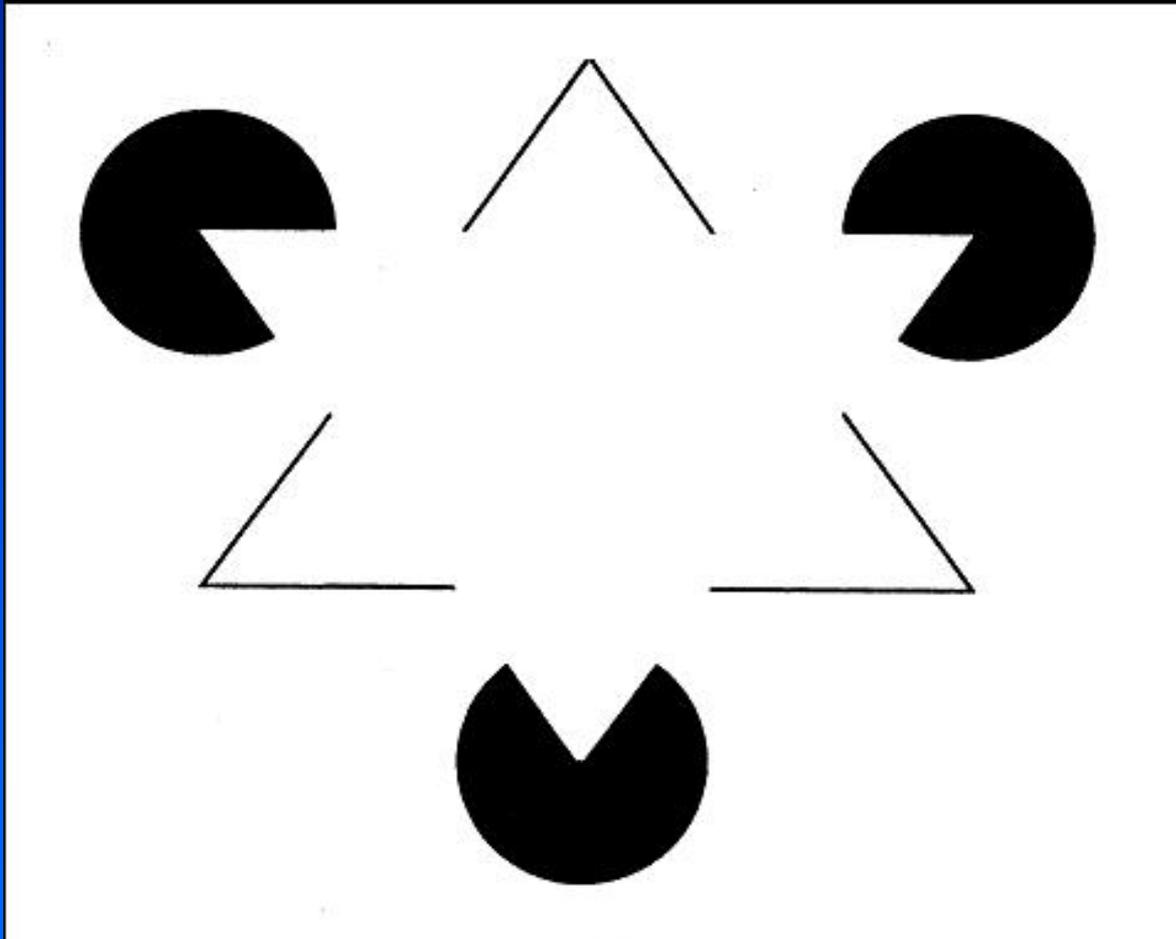
Optical Illusions



How Many Black Dots?



Occluded Edges



Recognize Occluded Objects

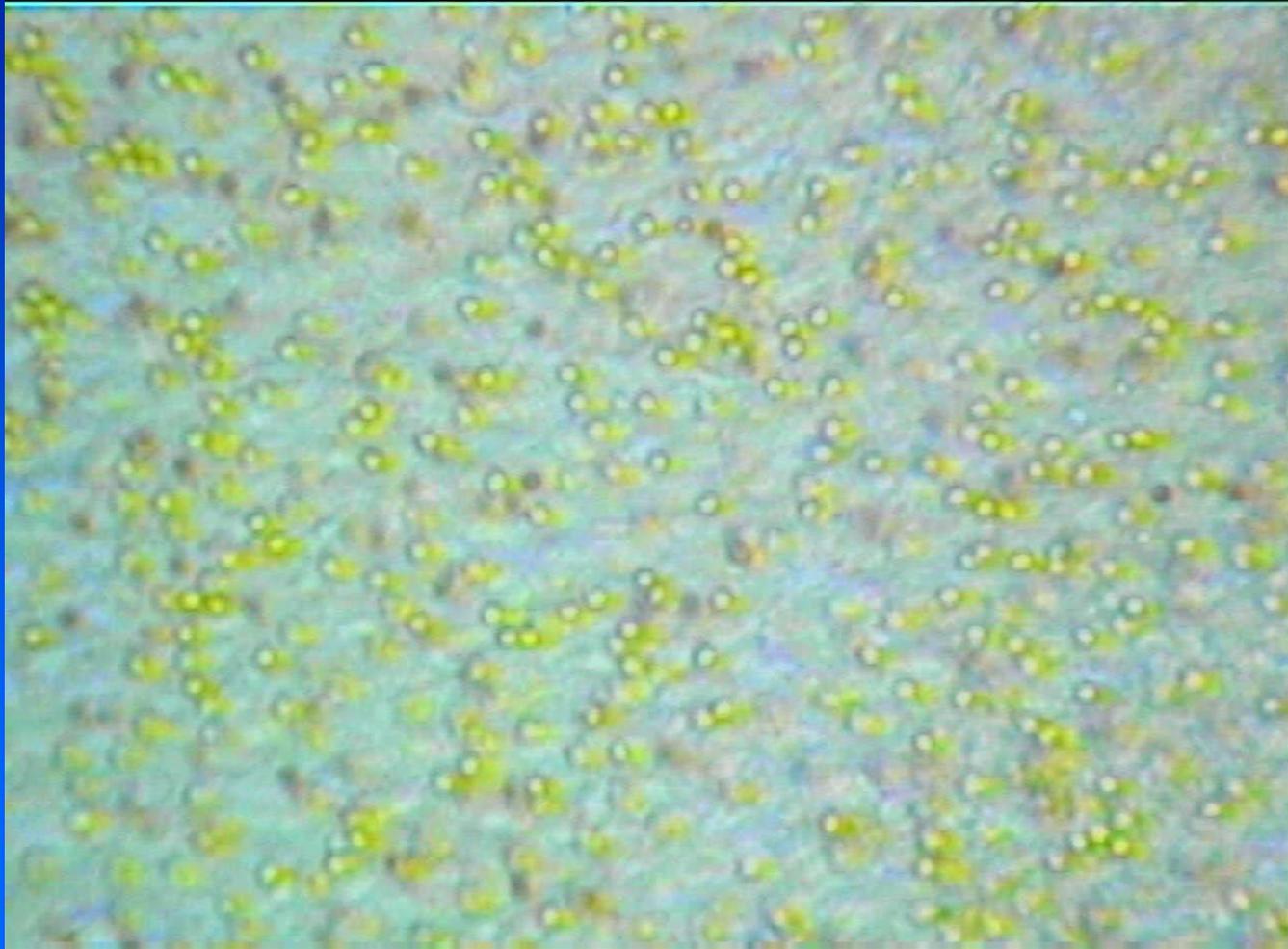


Wolbach Farms, Sudbury

Flicker (Movement) Detection

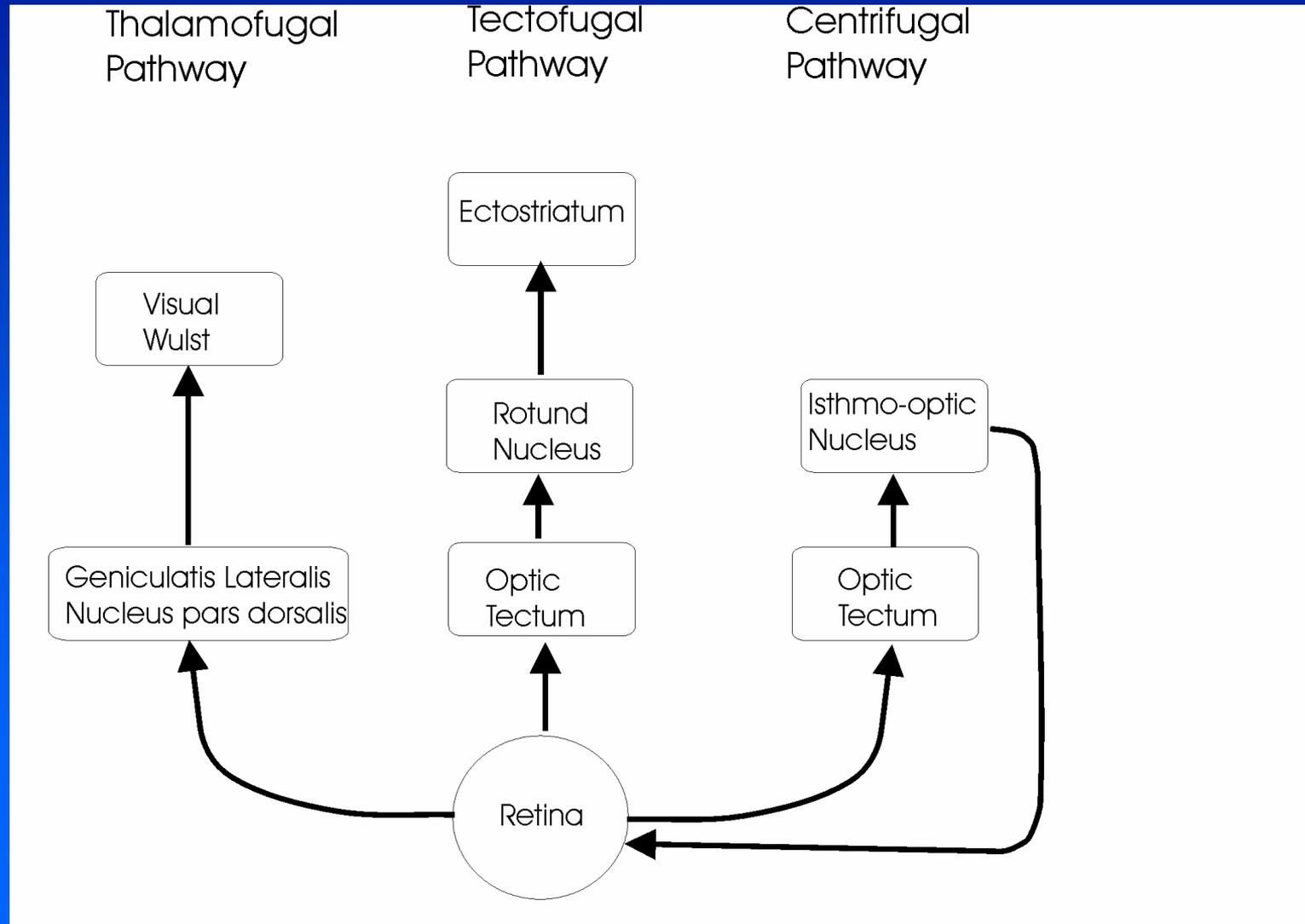
- Double cones?
- Retinal ganglion cells
 - ON
 - OFF
 - ON/OFF
- Tectofugal Pathway
 - Optic tectum
 - Rotund nucleus

Peripheral Retina



Red-winged Blackbird, female, peripheral

Visual Pathways



Tectofugal Pathway

- Involved in most or all visual processing
- Specialized for detecting movement
 - Stimulated by local movement
 - Inhibited by whole field movement
- Collision avoidance
- Involved in color vision

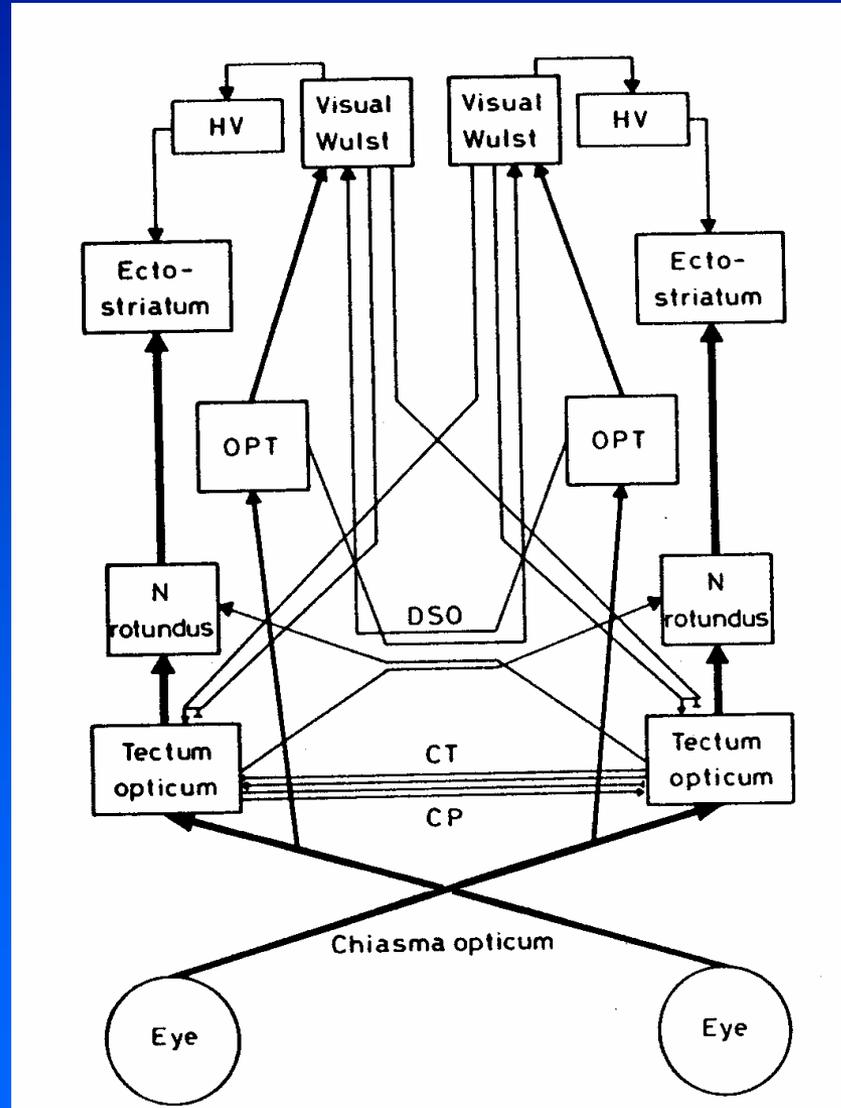
Thalamofugal Pathway

- Stereoscopic vision (raptors)
- Somatosensory-somatomotor mapping in Wulst

Centrifugal Pathway

- Closed loop from the retina to the brain and back to the retina
- Viewing nearby objects
- Visually guided pecking
- Feedback improves discrimination
- Switching attention from ventral to dorsal retina

Connections Between Pathways



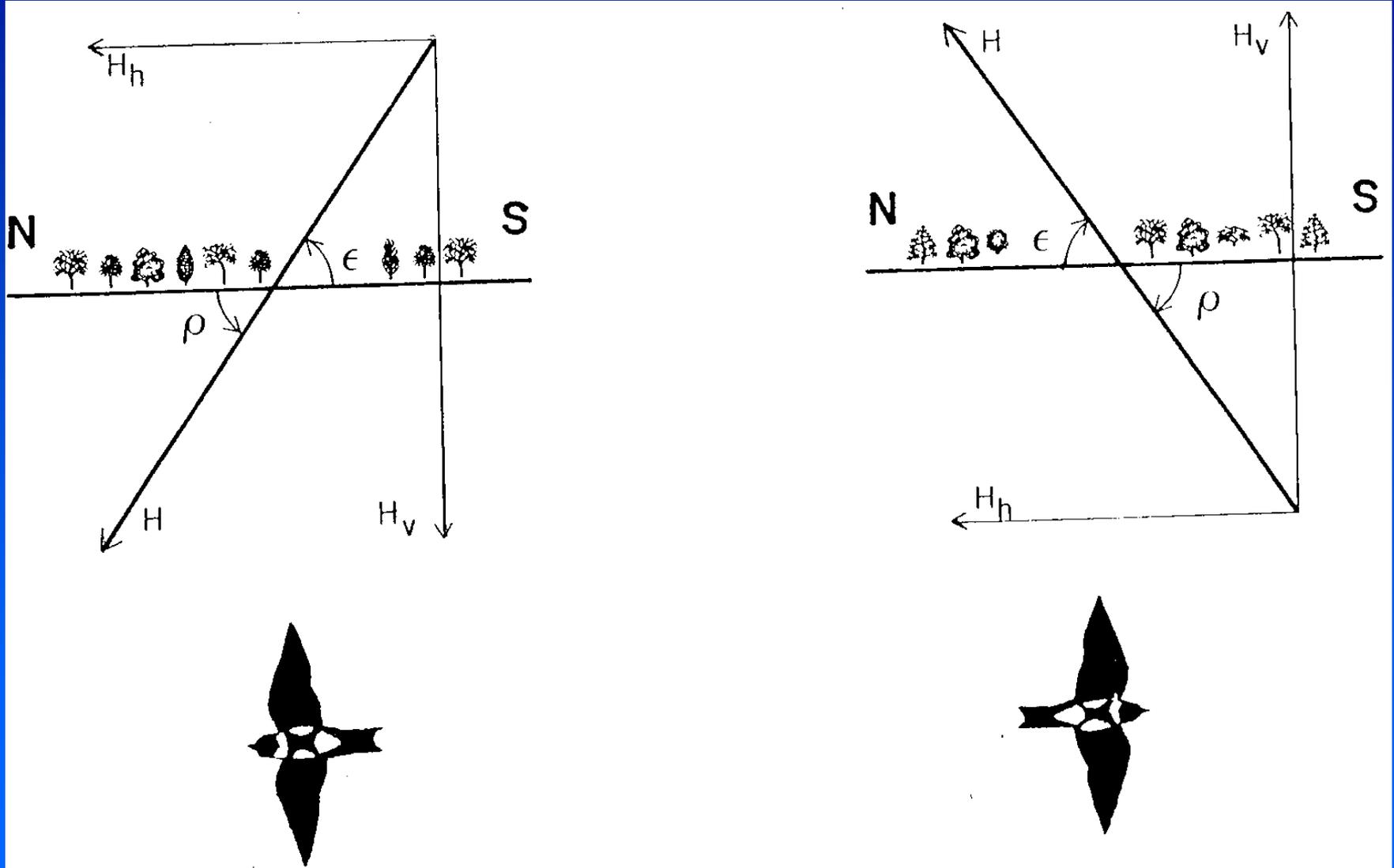
Object Recognition



Non-visual Influences of Light

- Photoperiod synchronization
- Migratory orientation
 - Magnetic compass system wavelength sensitive
 - Magnetic “map” unaffected by light

Avian Magnetic Compass



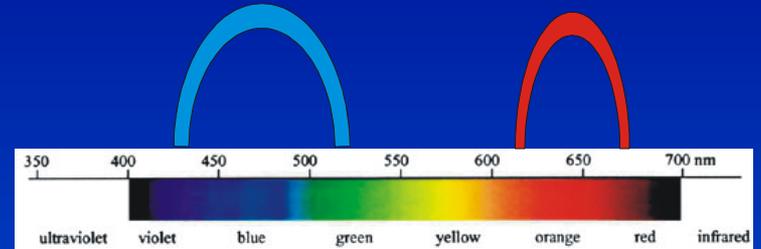
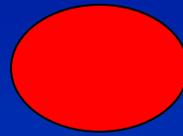
Avian Magnetic Compass

- Light dependent
- Wavelength sensitive
 - Short wavelengths (blue) result in normal orientation
 - Long wavelengths (red) result in disorientation or random orientation
 - Might not be the same for all species
- Located in the retina

Species Comparison

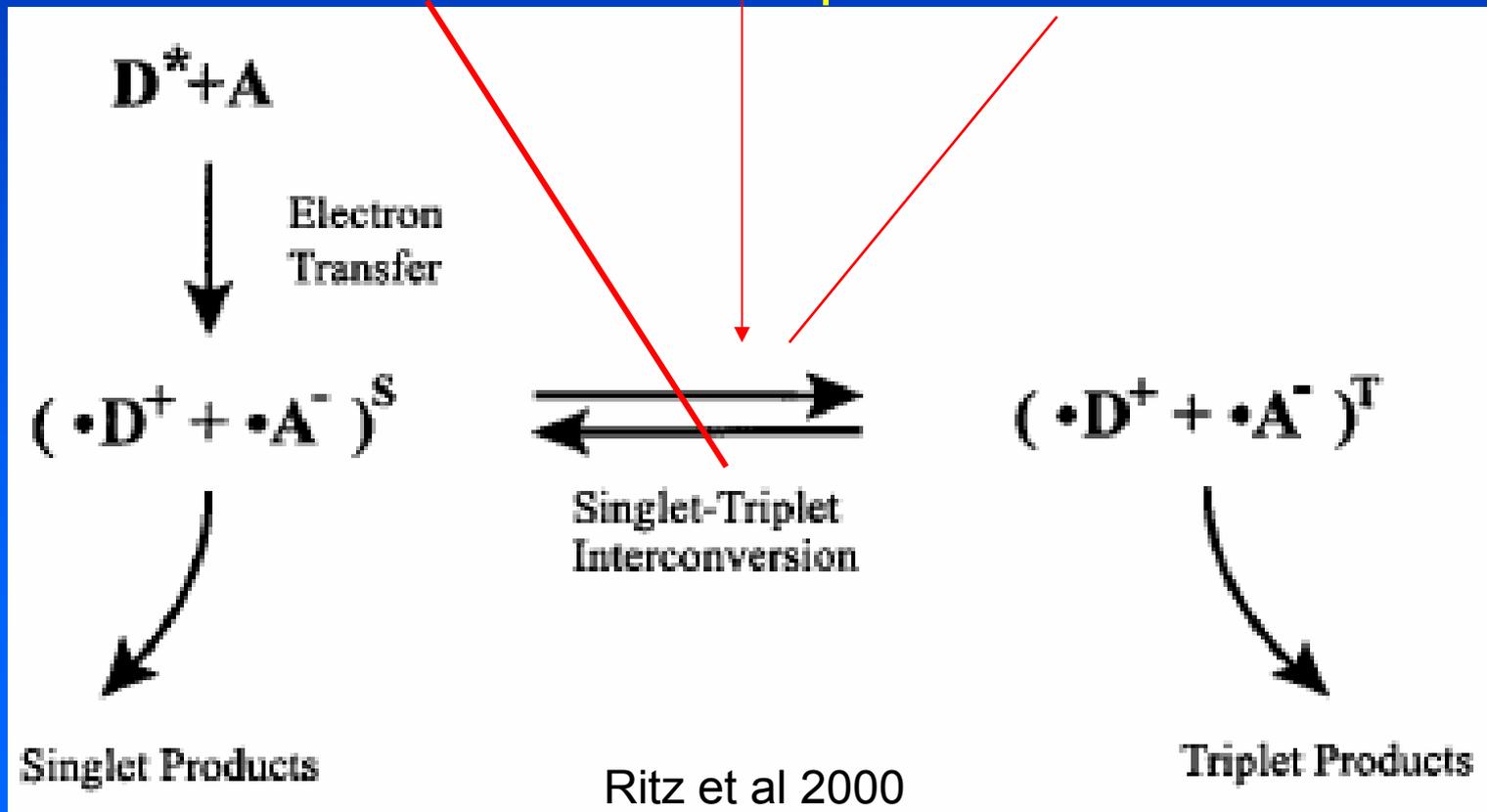
	Red	Orange- Yellow	Green	Blue
Pigeon	Disorient			Normal
European Robin	Disorient	Disorient	Normal	Normal
Australia Silvereye			Normal	Normal
Bobolink	Disorient	Bimodal Rotated	Disorient	Normal

Mechanism of Disorientation



Inhibition

Spectral Mismatch



Summary

- Avian vision encompasses a wider range of wavelengths, with better color resolution, than human vision
- Avian night vision is less sensitive than human (except nocturnal birds)
- Avian contrast sensitivity is poorer than human
- Avian visual acuity is better than human
- Avian vision is sensitive to whole field movement and movement of small objects against a non-moving background
- Birds perceive at least some of the same optical illusions as humans
- Red illumination results in disorientation of magnetic compass

QUESTIONS?