

Teaching Workshop: Color Vision in Primates and Other Mammals

Carrie C. Veilleux & Amber Heard-Booth

Anthropology Department, University of Texas at Austin

Trichromatic Color Vision

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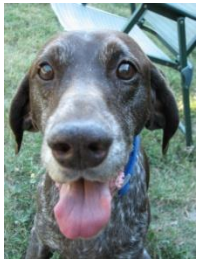
Dichromatic Color Vision

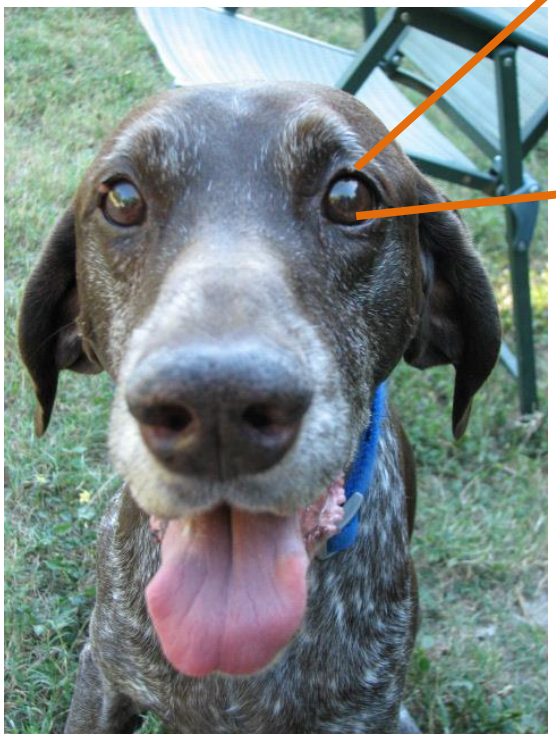
Trichromat

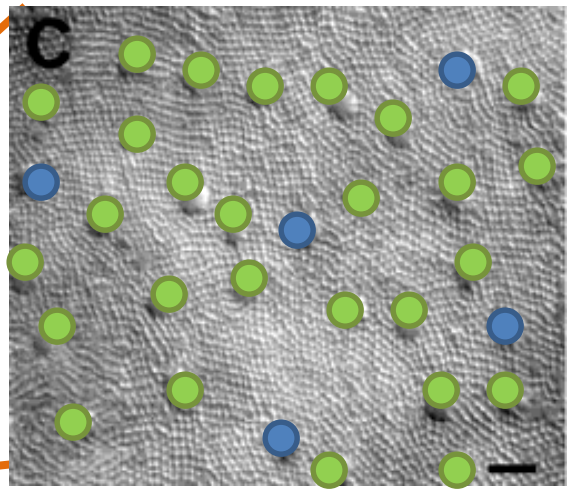
Dichromat



http://www.colblindor.com/coblis-color-blindness-simulator/

How does this work?

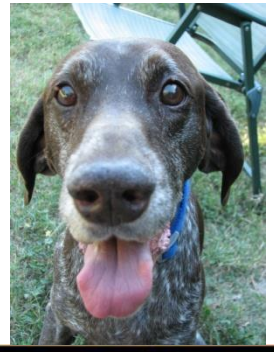




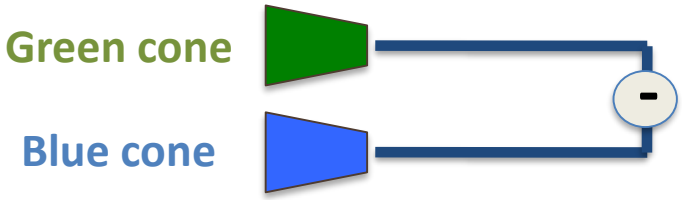
Dichromats have 2 types of color-detecting cells in the retinas in their eyes:

Blue-sensitive cones

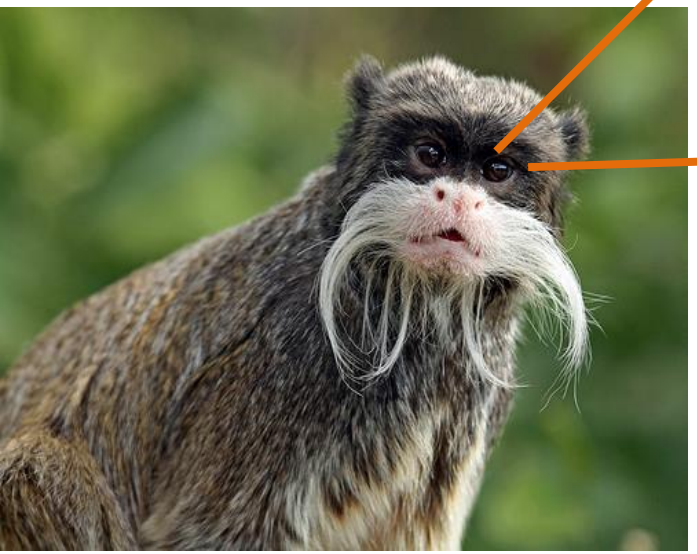
Yellow/green-sensitive cones

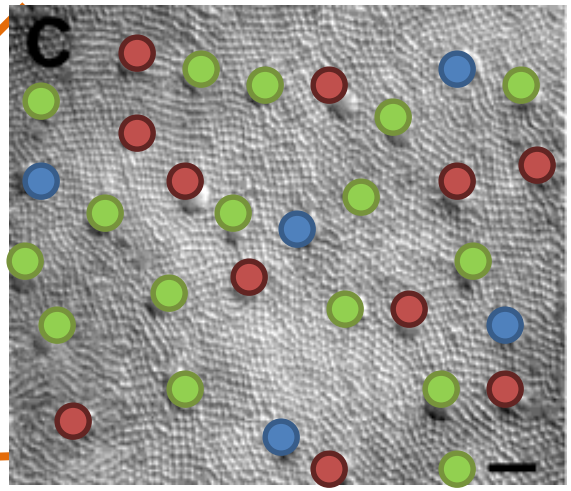


Dichromat



How does this work?





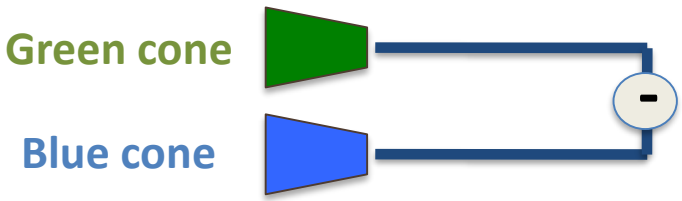
Trichromats have **3** types of color-detecting cells in the retinas in their eyes:

Blue-sensitive cones

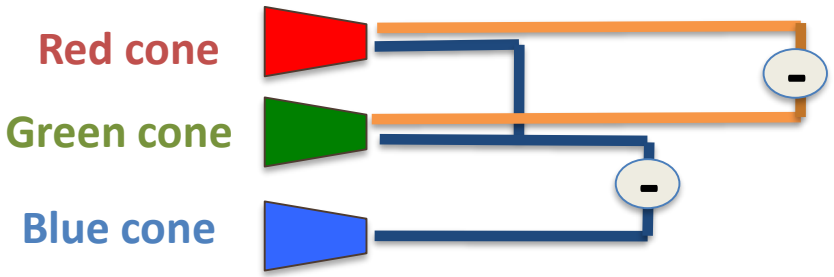
Yellow/green-sensitive cones

Red-sensitive cones

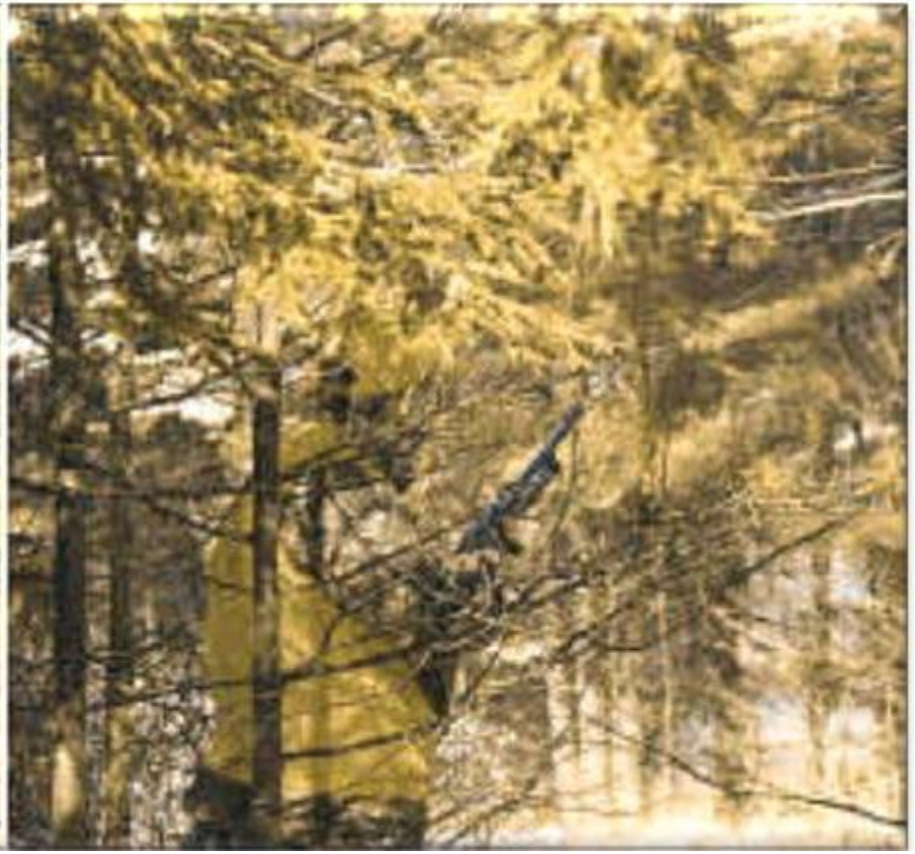
Dichromat

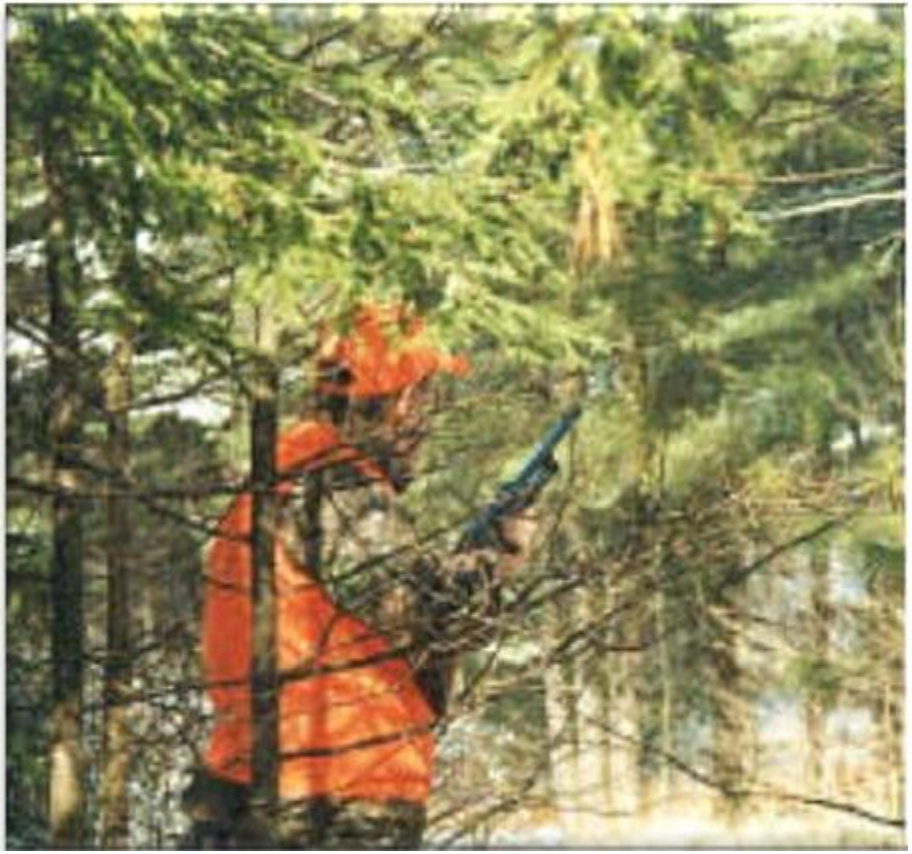


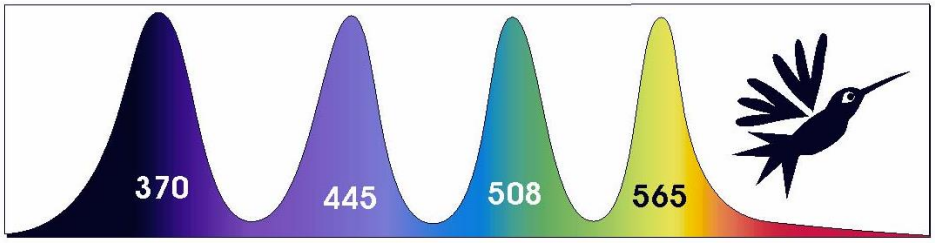
Trichromat



Most mammals are dichromats



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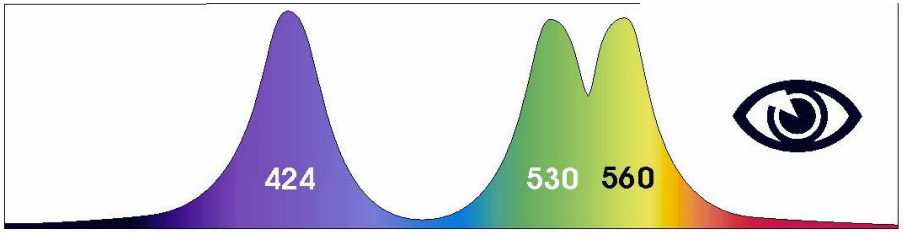
508
565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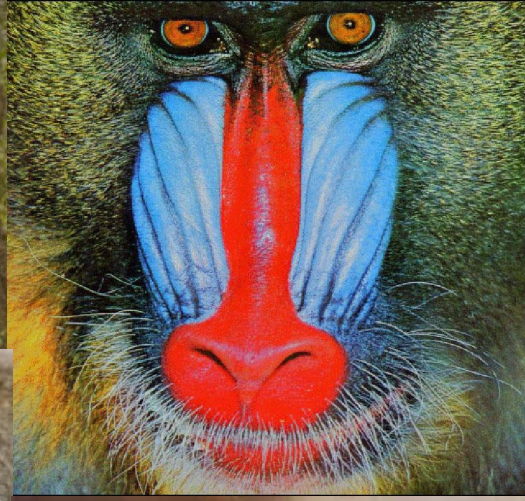
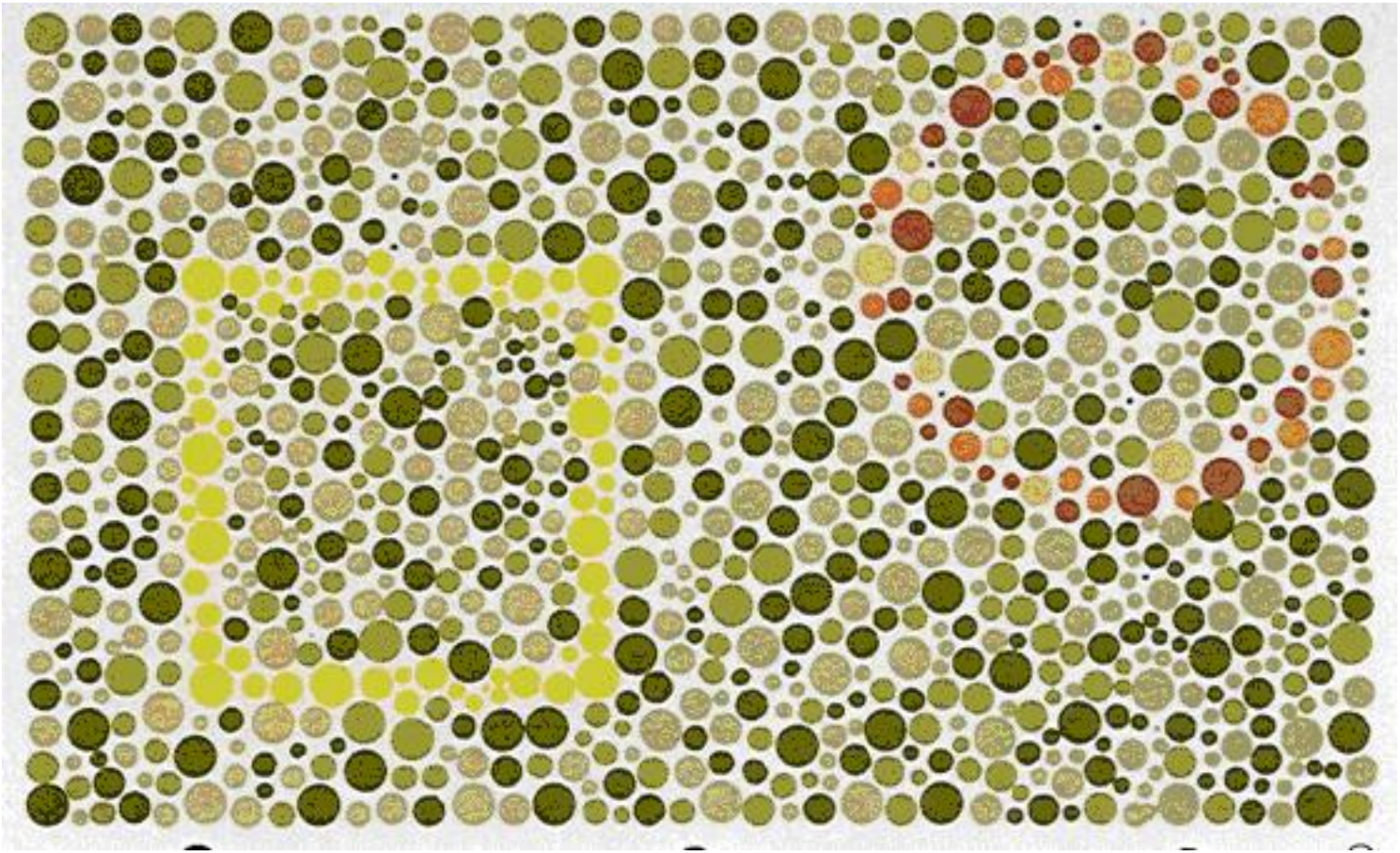




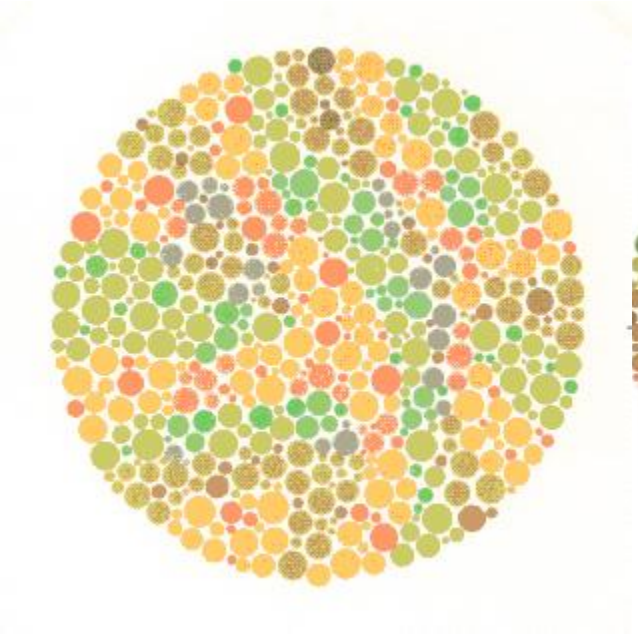
Many primates are trichromats



Dichromats see a square

Trichromats see a square and a circle

Dichromatic animals and people can actually detect camouflaged objects better than trichromats



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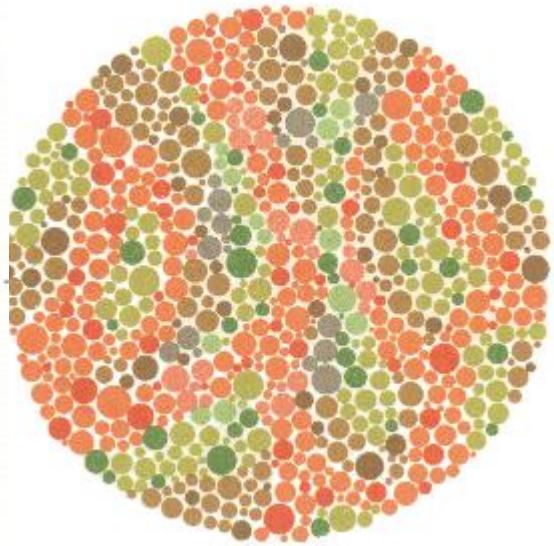

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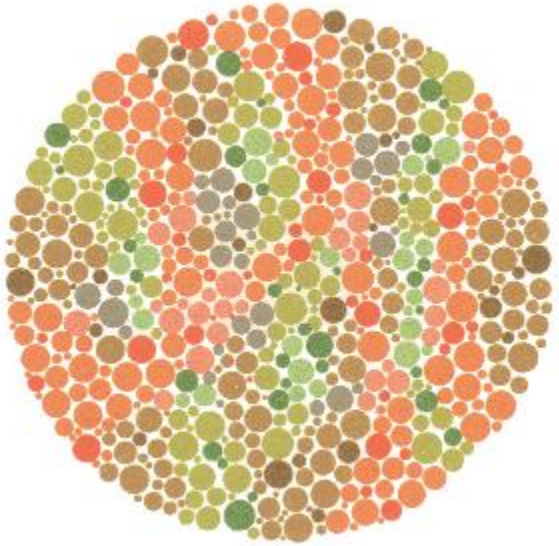
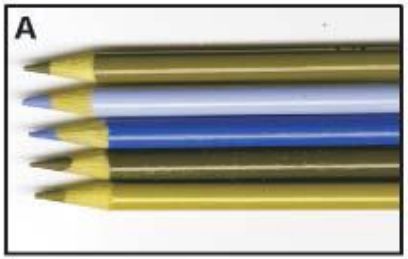


45

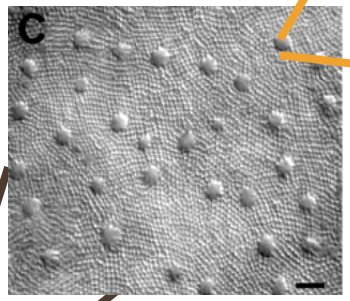
Find the ripe tomato.

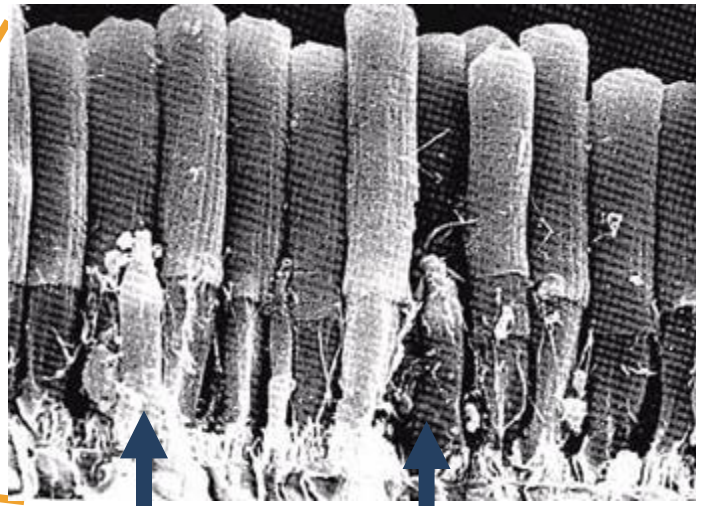
Find the pink-stained cell.



Find the red pencil.

Physiology of Color Vision





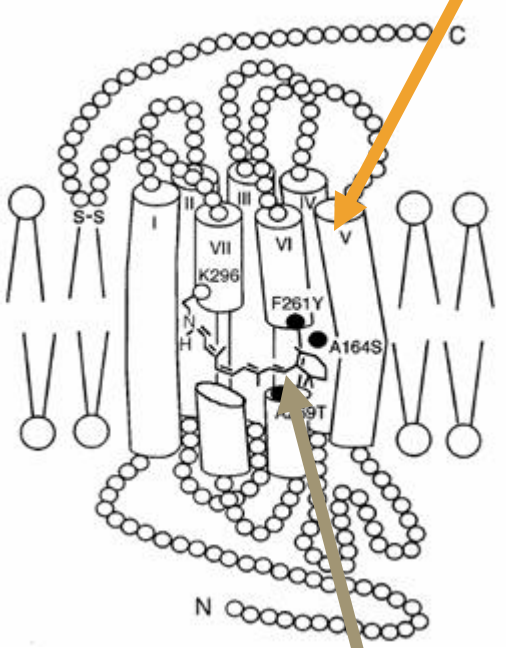
Cone photoreceptors

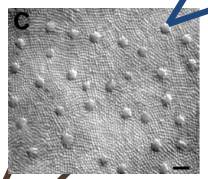
Physiology of Color Vision

Photopigment

Opsin protein

chromophore

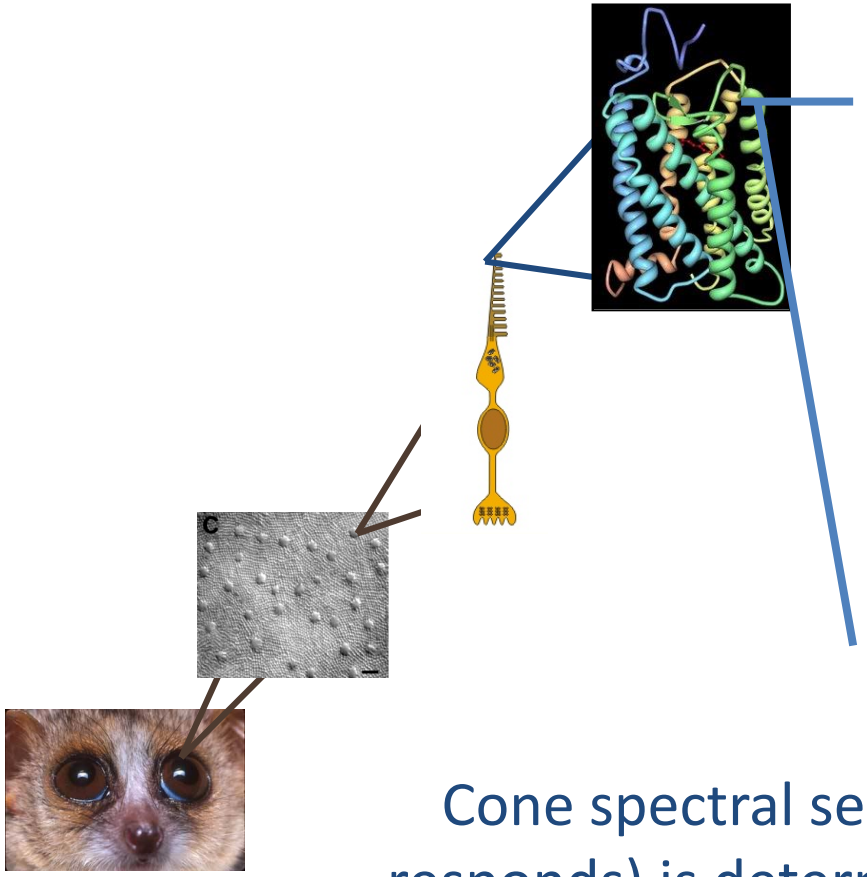


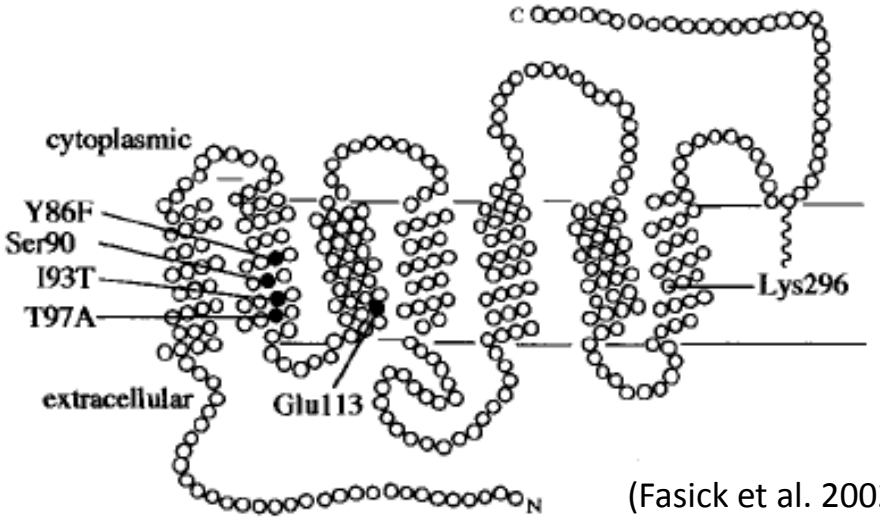


opsin protein

chromophore (11-*cis* retinal)

Physiology of Color Vision





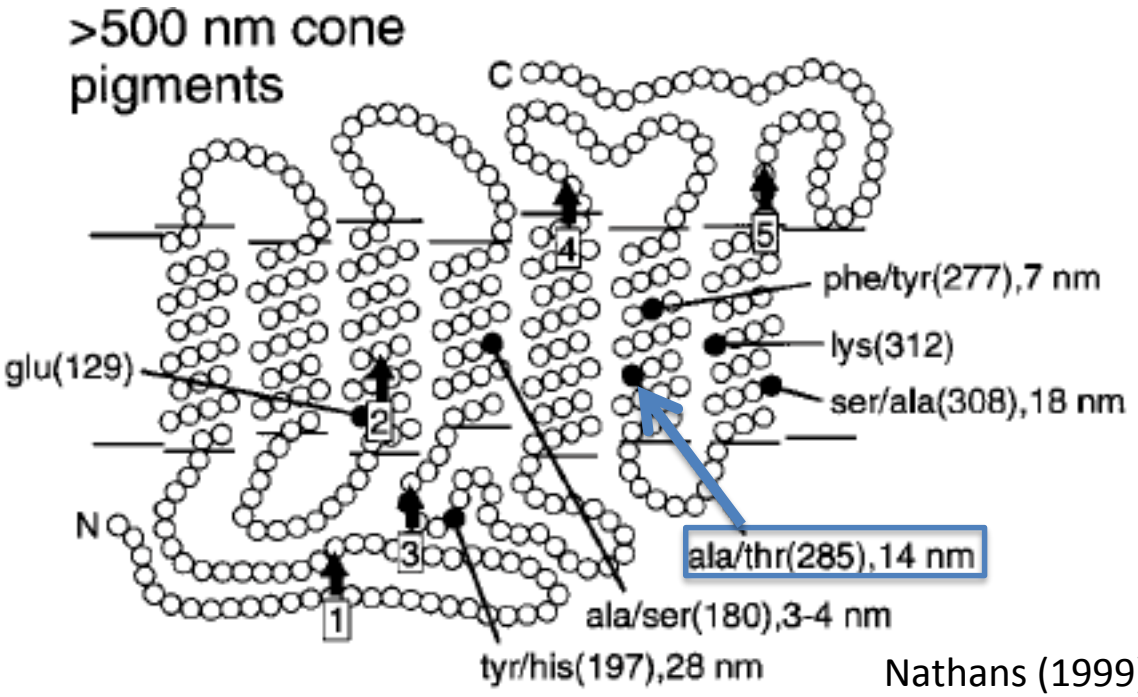
(Fasick et al. 2002)

Cone spectral sensitivity (color of light to which it responds) is determined by structure of opsin protein (amino acid sequence of protein).

Amino acid sequence is determined by **opsin genes.**

Physiology of Color Vision

So, changes in the DNA sequence of an opsin gene can lead to differences in the spectral sensitivity of cones ("critical tuning sites").

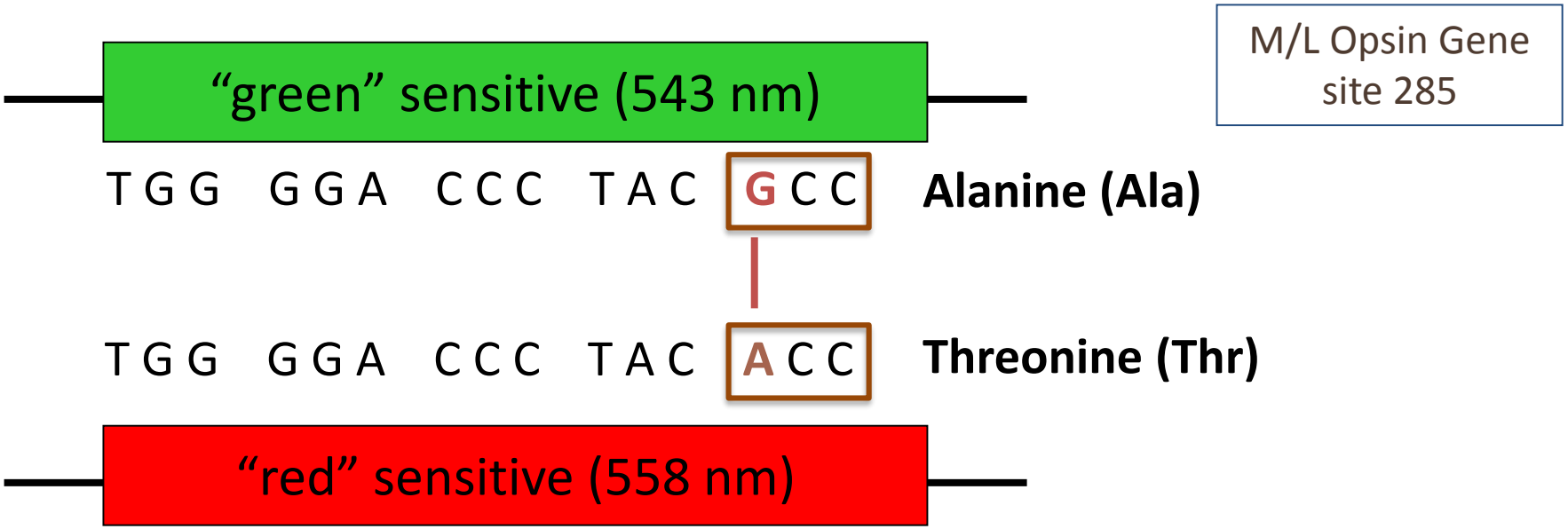


critical tuning sites of the M/L opsin gene

Nathans (1999)

Physiology of Color Vision

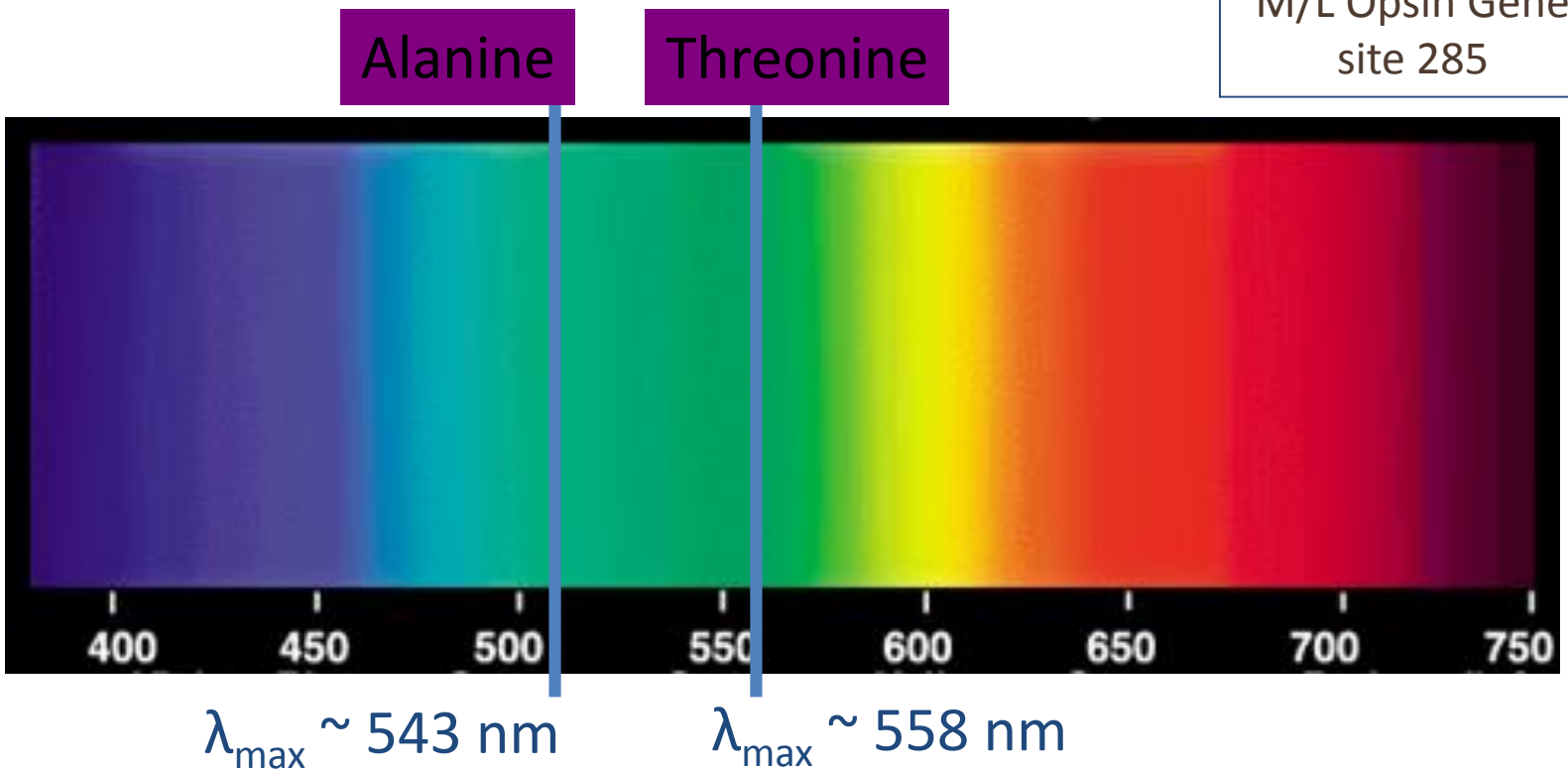
So, changes in the DNA sequence of an opsin gene can lead to differences in the spectral sensitivity of cones ("critical tuning sites").



Physiology of Color Vision

So, changes in the DNA sequence of an opsin gene can lead to differences in the spectral sensitivity of cones ("critical tuning sites").

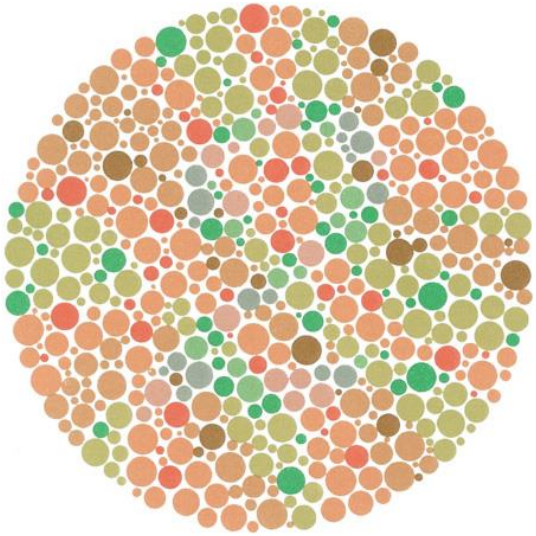
M/L Opsin Gene site 285



Physiology of Color Vision

The number of cone types with different spectral sensitivities determines the type of **color vision** an animal has.

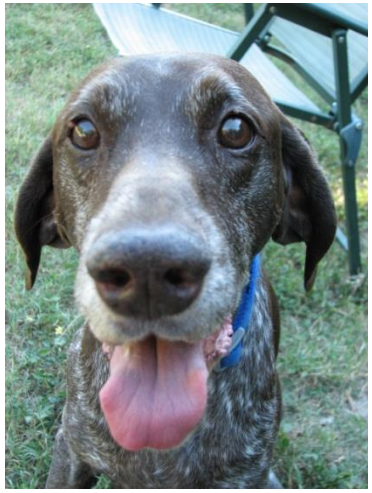
Color vision = ability to discriminate light of different spectral qualities independent of intensity



For color vision, need:

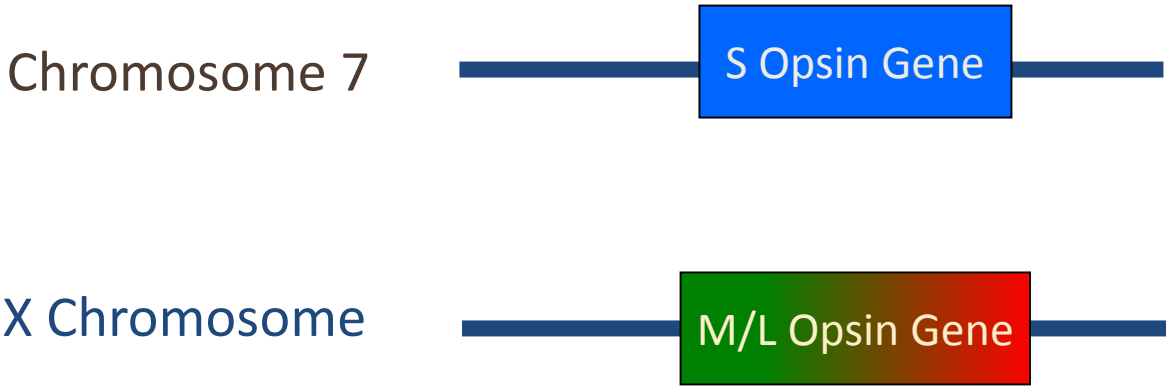
1) 2+ cone types
2) Neural mechanisms to compare cone outputs

Physiology of Color Vision



Color vision and primate opsin genes:

Dichromacy (ancestral mammal condition)



Physiology of Color Vision

Color vision and primate opsin genes:

Polymorphic trichromacy (NWM & lemurs)

Chromosome 7 — S Opsin Gene

X Chromosome — M/L Opsin Gene

M/L Opsin Gene

Multiple alleles with different spectral sensitivities (2-5 alleles!)

Physiology of Color Vision

Color vision and primate opsin genes:

Polymorphic trichromacy (NWM & lemurs)

Male

Ch. 7 — S Opsin

Ch. X — any allele

DICHROMAT

Homozygous Female

Ch. 7 — S Opsin

Ch. X — 543nm allele

Ch. X — 543nm allele

DICHROMAT

Heterozygous Female

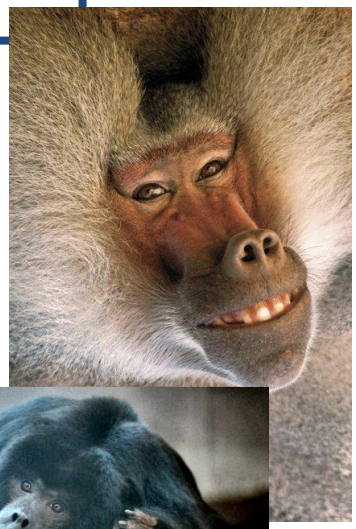
Ch. 7 — S Opsin

Ch. X — 543nm allele

Ch. X — 563nm allele

TRICHROMAT

Physiology of Color Vision



Color vision and primate opsin genes:

<u>Routine trichromacy (catarrhines & *Alouatta*)</u>

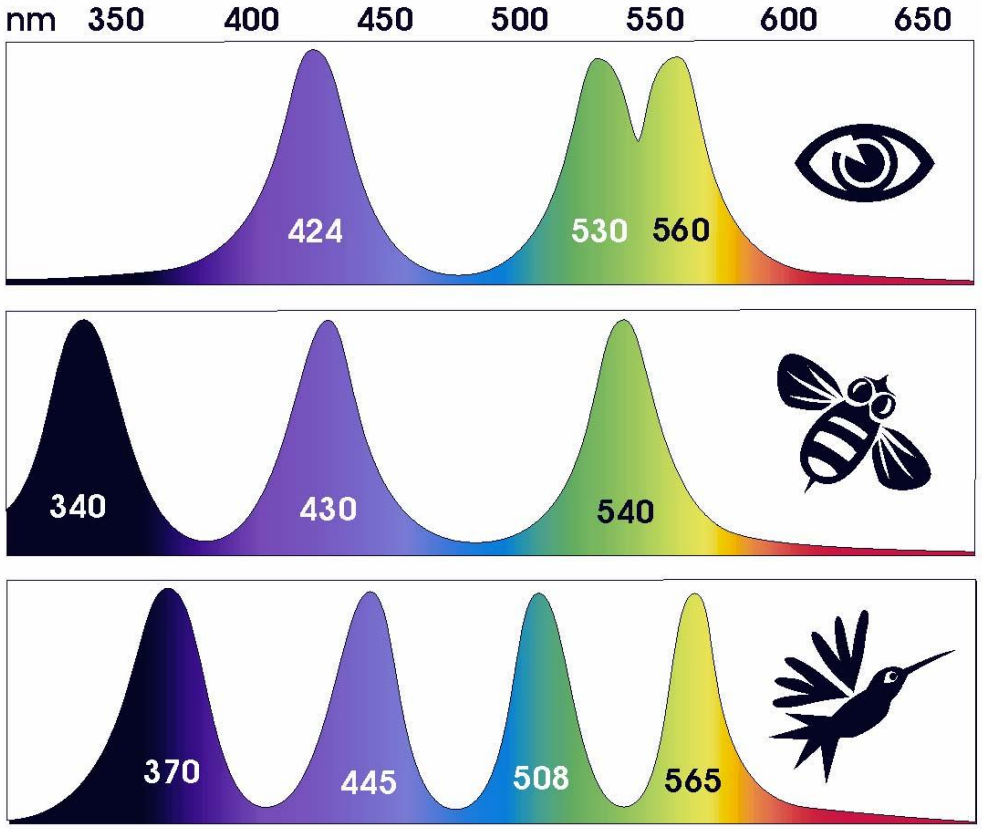
Duplication of M/L opsin gene leading to divergent L and M opsin genes.

Routine trichromacy evolved independently in catarrhines and howlers.

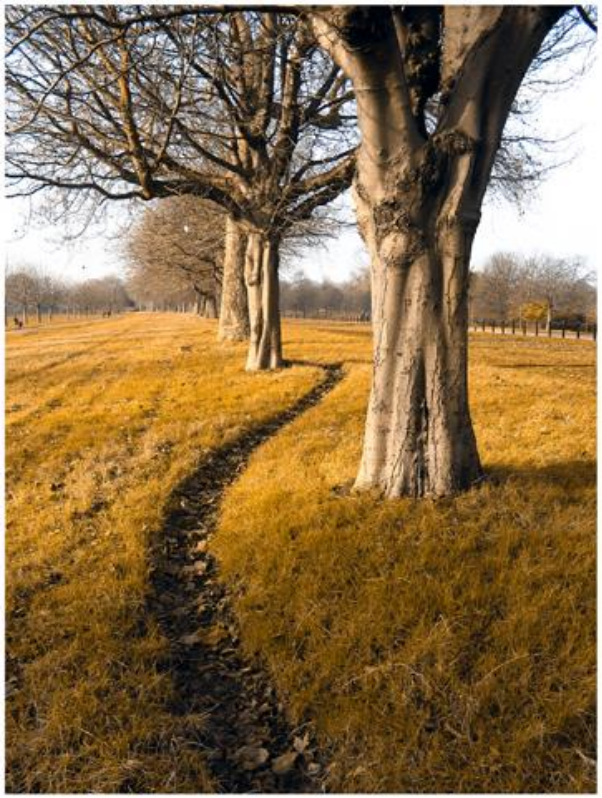
Primates are unique among placental mammals in having trichromatic color vision …

BUT

primate color vision is not impressive compared to other vertebrates!



Why be a trichromat?



Search Activity: Why be a trichromat?

Based on an experiment done in marmoset monkeys

Some individuals were dichromats, some individuals were trichromats

Monkeys foraged for orange or green Kix cereal in green wood shavings

Search Activity for Humans

Activity Goals:

1. Explore differences in color recognition among different people
2. Identify possible benefits of having trichromatic color vision for primates
3. Explore the effects of red-green colorblindness in humans