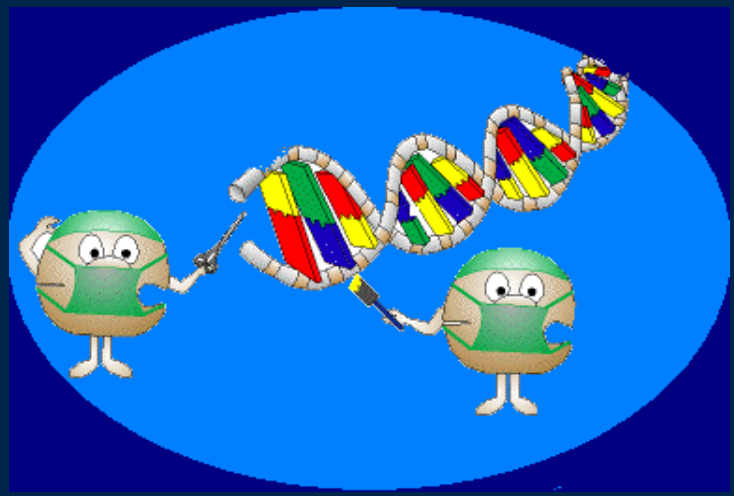
Genetics of Color Vision



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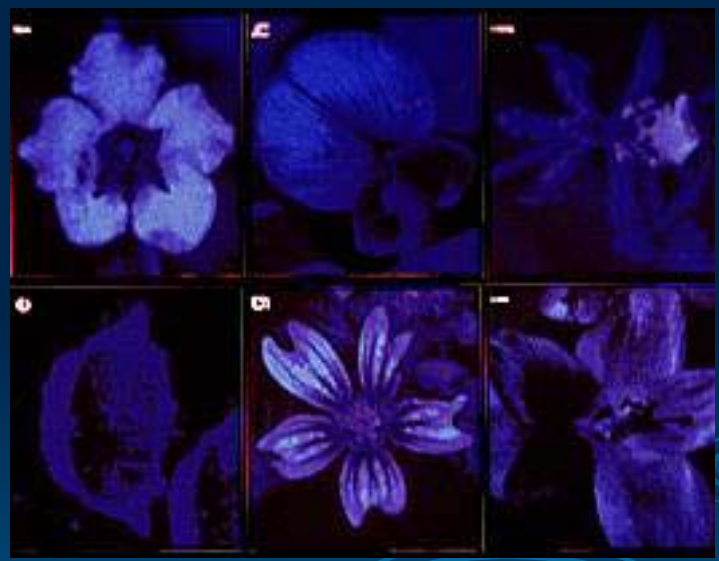
Introduction

- Species perceive colors differently

What Humans See

Without UV perception

What Bees See

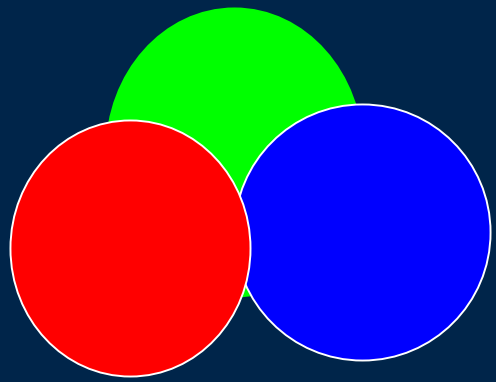


With UV perception

(http://gears.tucson.ars.ag.gov/ic/vision/bee-vision.html)

Background:
Steps in color perception

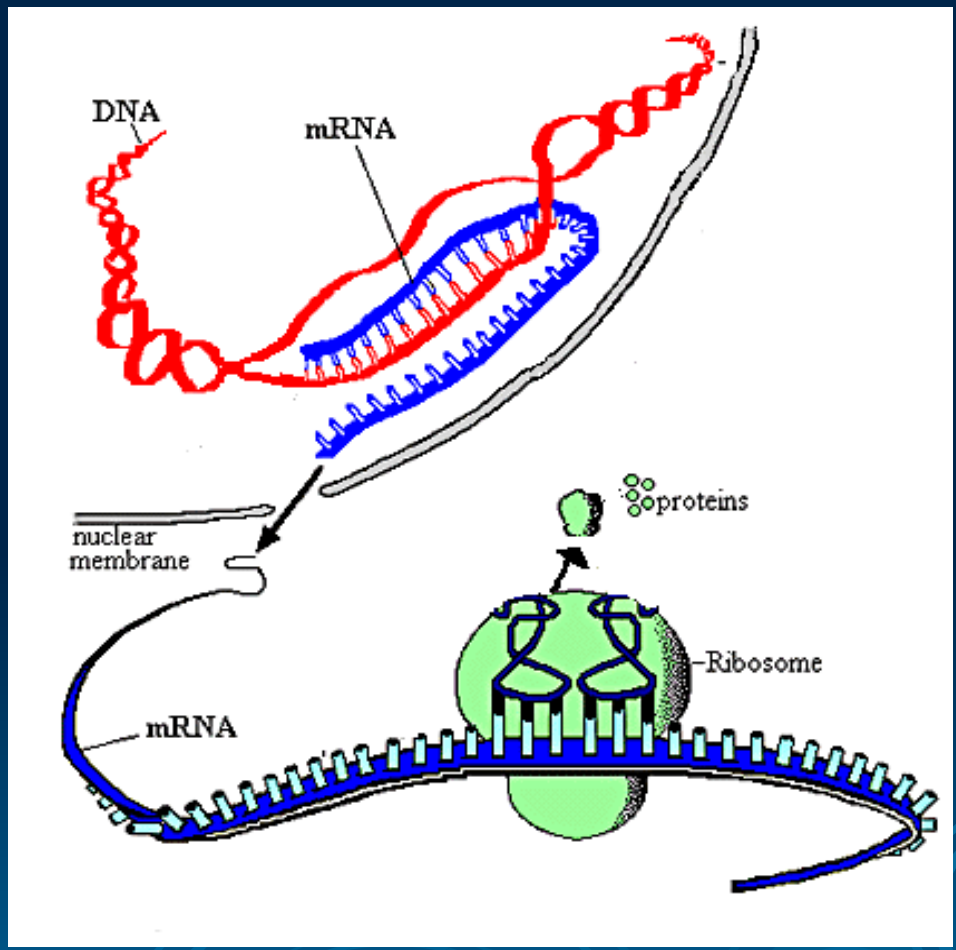
☼ What happens in the eye ☼



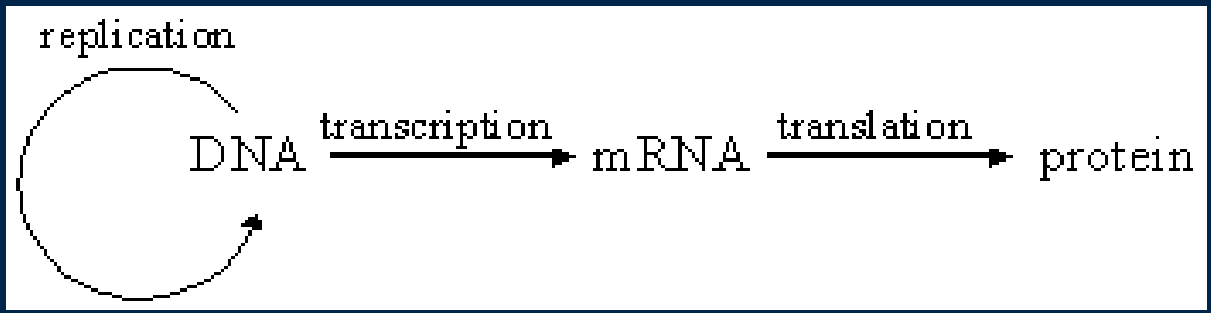
•Visual pigments in the rod and cone photoreceptor cell absorbs the light.

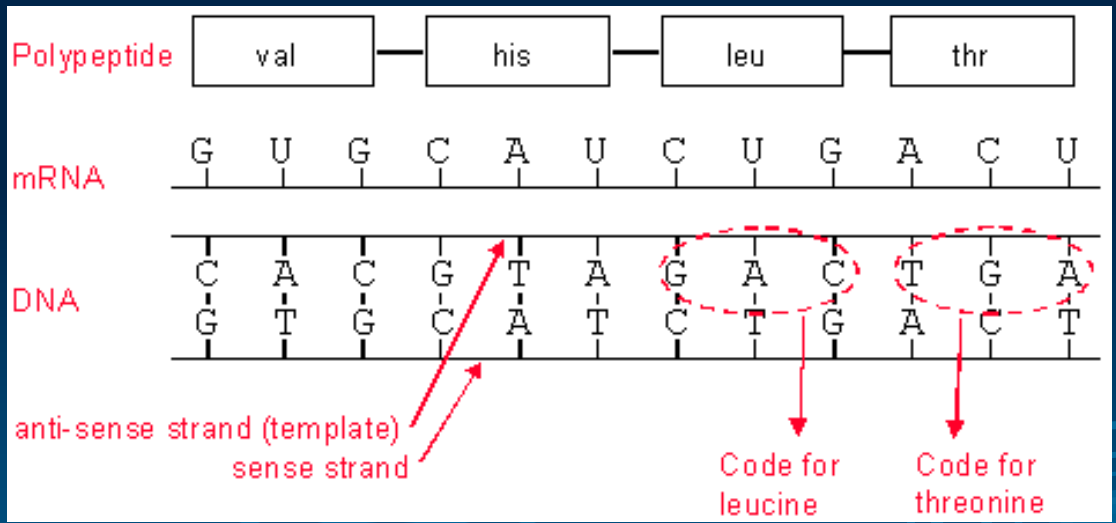
•Opsin and Rhodopsin genes code different proteins (visual pigments) in the photoreceptor cells that permit the perception of color.

From gene to protein



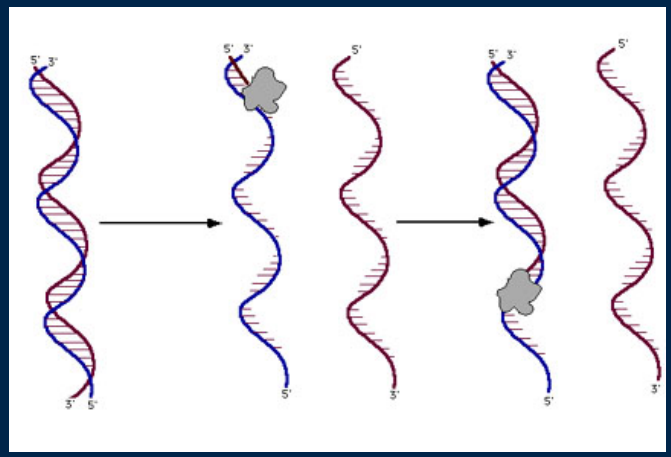
From gene to protein

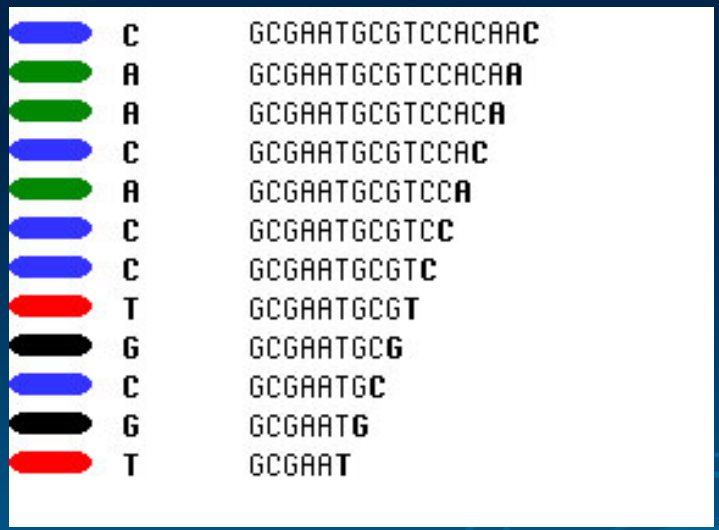




(http://faculty.clintoncc.suny.edu/faculty/Michael.Gregory/files/Bio%20101/Bio%20101%20Lectures/Protein%20Synthesis/protein.htm)

DNA sequencing





- Separate DNA strands
- Duplicate a DNA strand with fluorescence nucleotides
- At any one time point, different lengths of duplication are available
- Segments are separated in a gel
- Computerized reading of fluorescence and location

(http://seqcore.brcf.med.umich.edu/doc/educ/dnapr/sequencing.html)

Background
Literature review

Yokoyama (2000)

- Reviewed the molecular evolution of visual pigments.
- Concentrated on vertebrate species.
- Summarized the changes in light absorption from differences in amino acid positions

Yokoyama's Five Site Rule

- Amino acid differences at sites 180, 197, 277, 285, and 308 cause some of the major and minor differences in color vision.

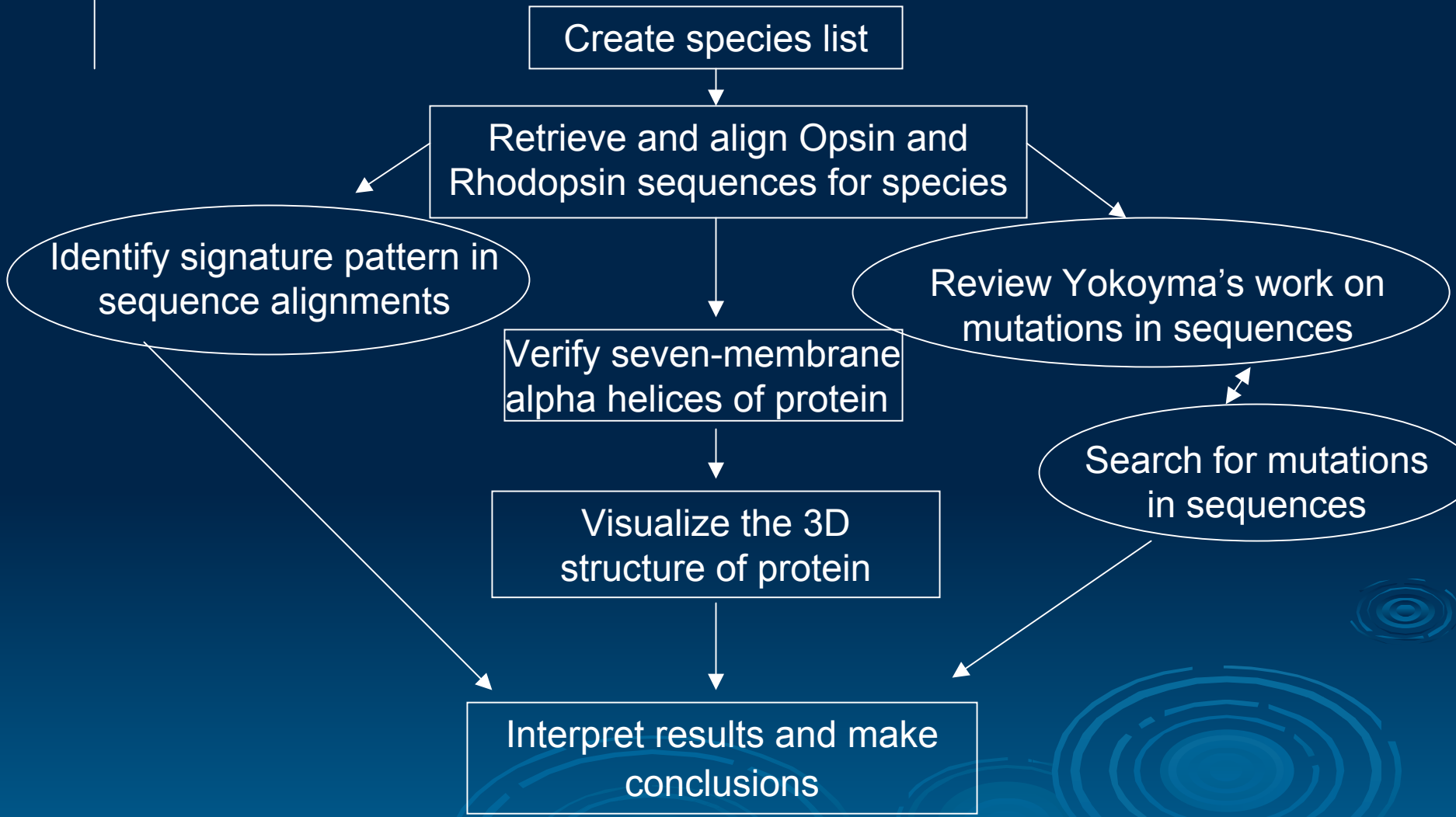
- This is based on the Cow and Human

Hypotheses

1) The identification of conserved regions in Rhodopsin and Opsin sequences can be used to locate specific amino acid positions that are critical for the formation and function of visual pigments.

2) The detection of amino acids that differ among species may help explain major and minor differences in color perception.

Objectives and activities



Species Considered

Eutheria	Domestic Mammals	Birds	Primates	Invertebrates
Mouse	Cat	Pigeon	Human	Butterfly
Rat	Dog	Chicken	Monkey	Fruit fly
Rabbit	Pig			Honey Bee
	Cow			

Examples of what species can see…

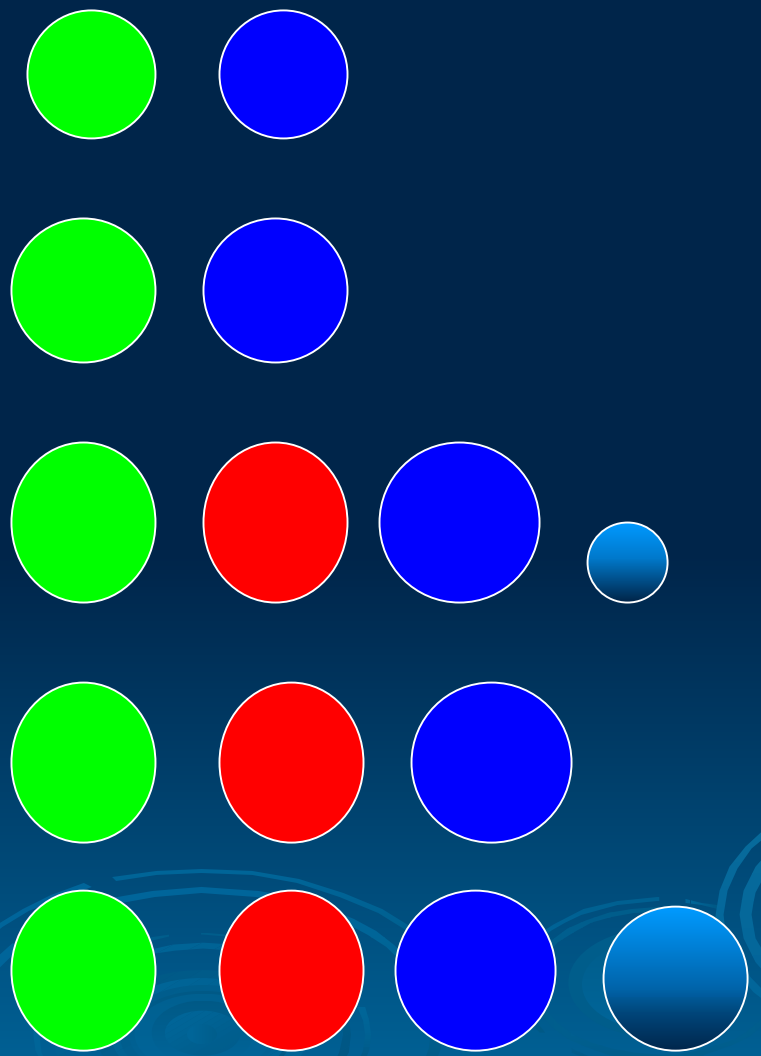
Rabbit -

Cow -

Chicken -

Human -

Butterfly -



Bioinformatics resources

Bioinformatics: Science that uses advanced computing techniques for management and analysis of biological data.

Tools	Databases
NDJINN	Genbank
View/edit	Prosite
ClustalW	PDBFINDER
DRAWTREE	
TMHMM	

Sequence alignment

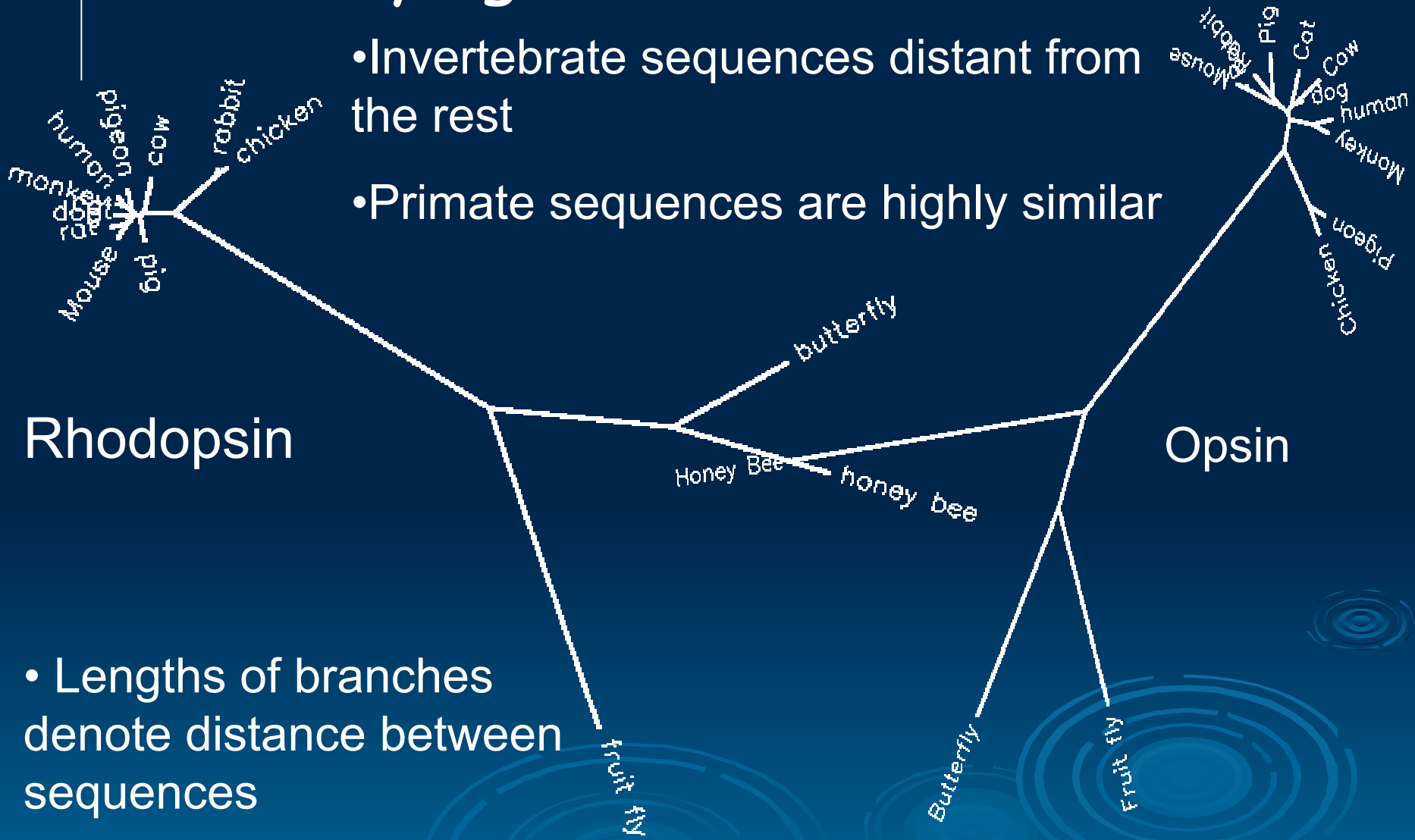
- *, :, .: degrees of site conservation. - denotes gap
- Signature pattern of Opsin (in red):

  [LIVMFWAC]-[PSGAC]-x(3)-[SAC]-**K**-[STALIMR]-
  [GSACPNV]-[STACP]-x(2)-[DENF]-[AP]-x(2)-[IY]

- Mutations that influence color perception (in violet)

Phylogentic Trees

- Invertebrate sequences distant from the rest
- Primate sequences are highly similar

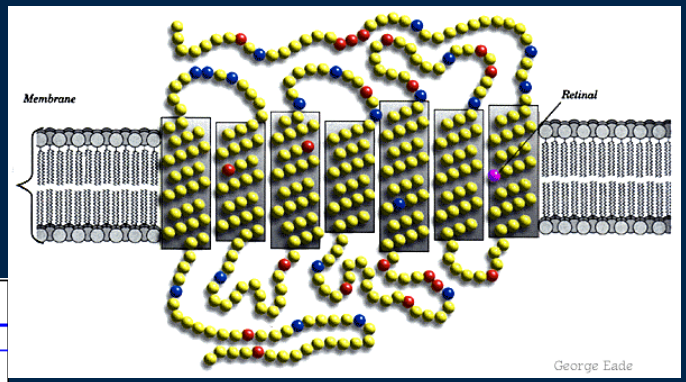


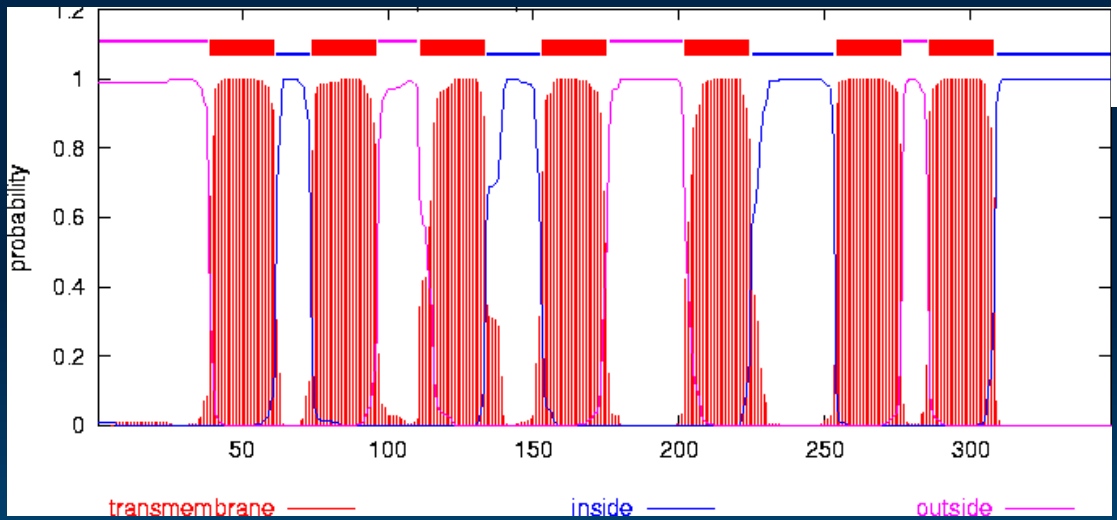
Rhodopsin

Opsin

- Lengths of branches denote distance between sequences

Prediction of the seven-transmembrane helices

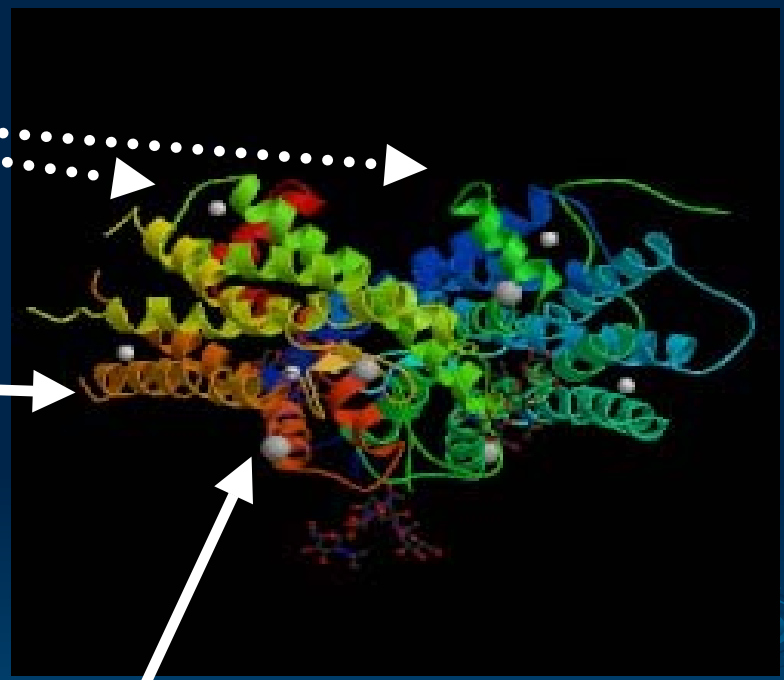




Predicted probability that a protein sequence region is inside (blue) or outside (purple) the cell or within (red) the disk membrane or transmembrane using TMHMM.

3D Structure of Rhodopsin protein

- Two chains each with a seven transmembrane sequence
- The seven helices of each seven-transmembrane protein that are located within the cell membrane connecting the outside with the inside



Circles: Zinc and mercury ions

Conclusions
(We were correct!!!!)

- Amino acid differences at specific locations are responsible for differences in light absorption and thus color perception.
- Mutations from one species can be used to formulate hypotheses about color perception differences in a wider range of species.

This material is available at
http://bighorn.animal.uiuc.edu/Biotut

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Questions ?