Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.

Enduring understanding 4.C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Essential knowledge 4.C.1: Variation in molecular units provides cells with a wider range of functions.

a. Variations within molecular classes provide cells and organisms with a wider range of functions. [See also 2.B.1, 3.A.1, 4.A.1, 4.A.2]

To foster student understanding of this concept, instructors can choose an illustrative example such as:

-Different types of phospholipids in cell membranes

-Different types of hemoglobin

-Molecular diversity of antibodies in response to an antigen

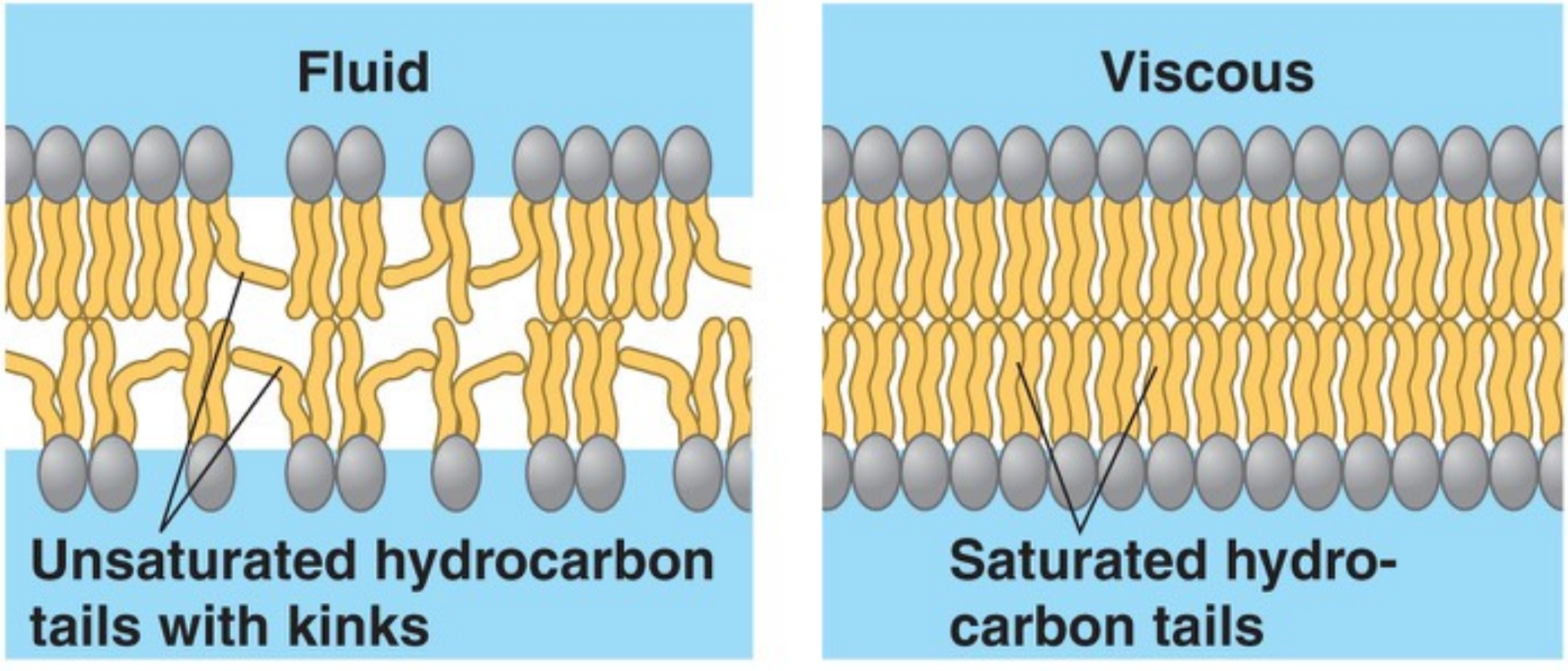
-Chlorophylls

-MHC proteins

Diversity in Phospholipids

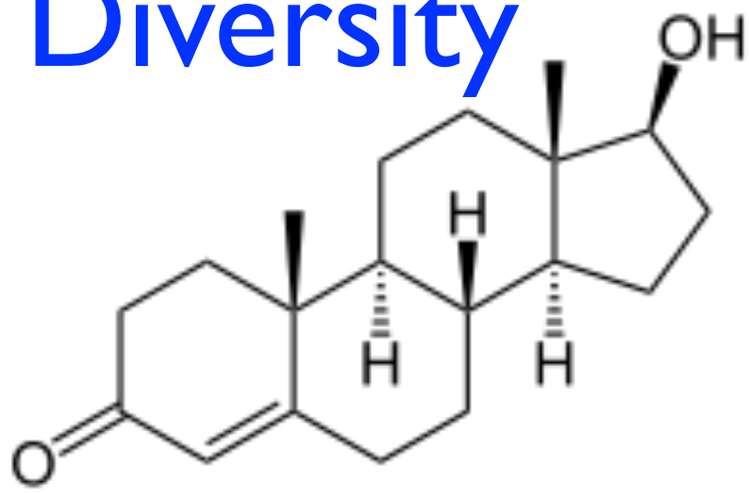
- The type of fatty acid tails in the phospholipids also effect fluidity
  - The more unsaturated fatty acids, the more fluid the membrane
  - The more saturated fatty acids, the less fluid the membrane

- Membrane fluidity is important because it effects membrane permeability

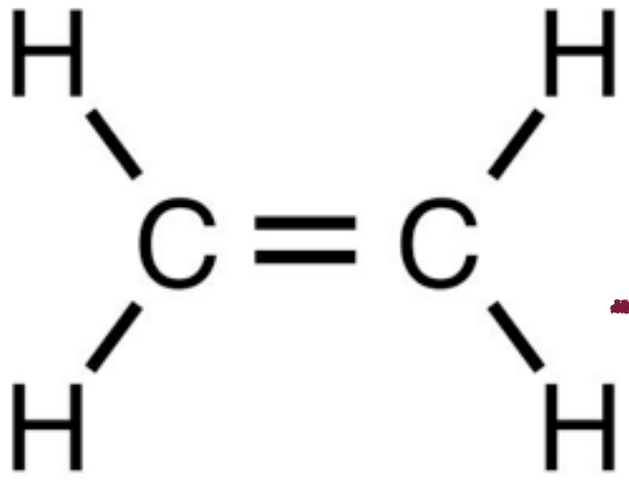


Chemical Messengers Exhibit Diversity
ex. Hormones

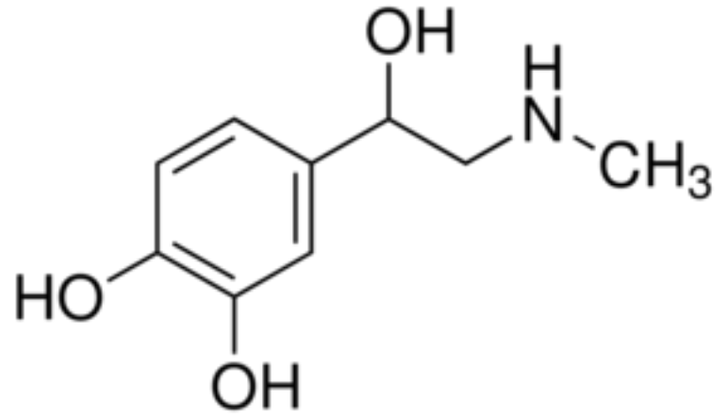
Insulin
-very large



Testosterone
-lipid soluble

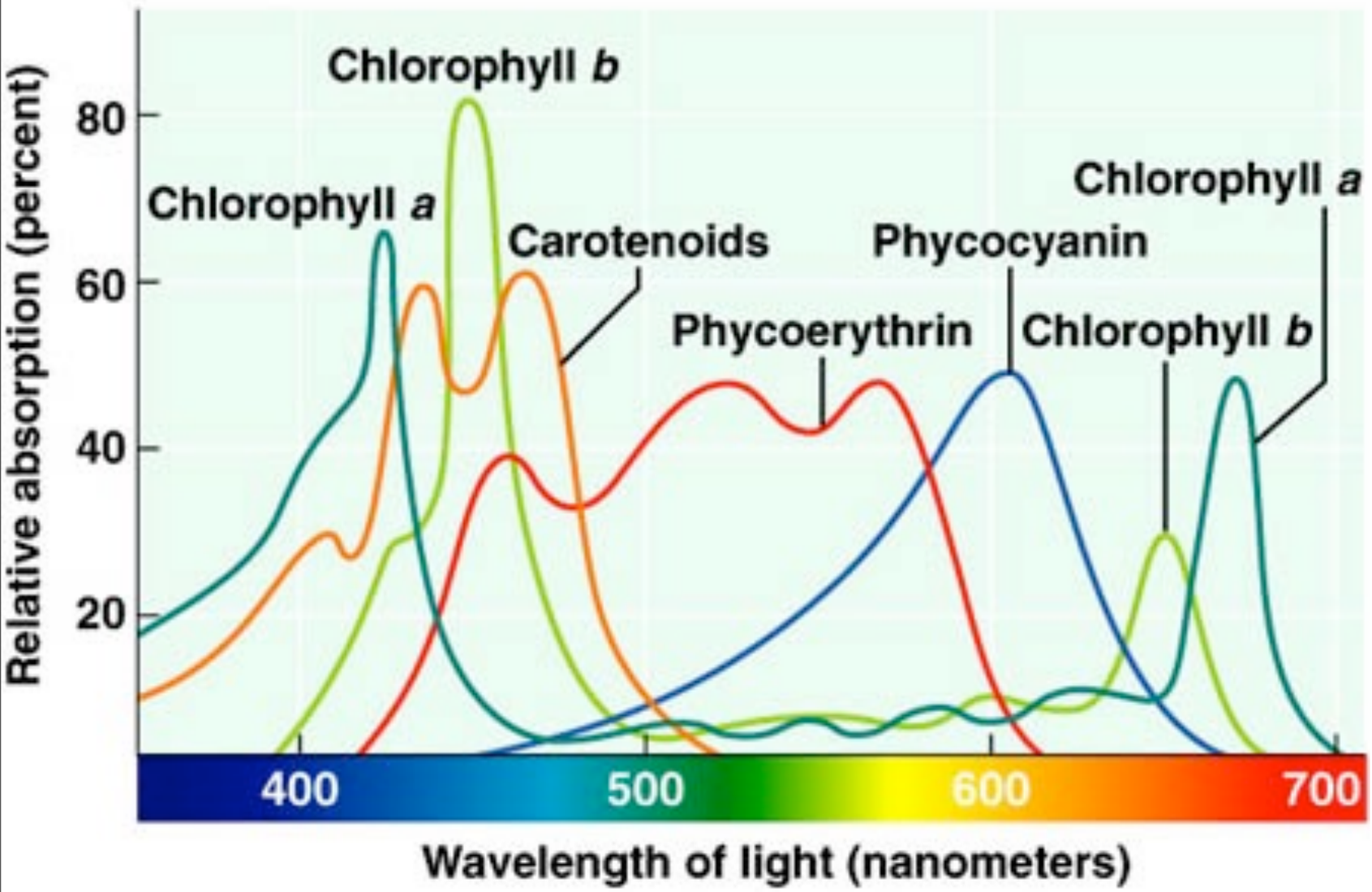


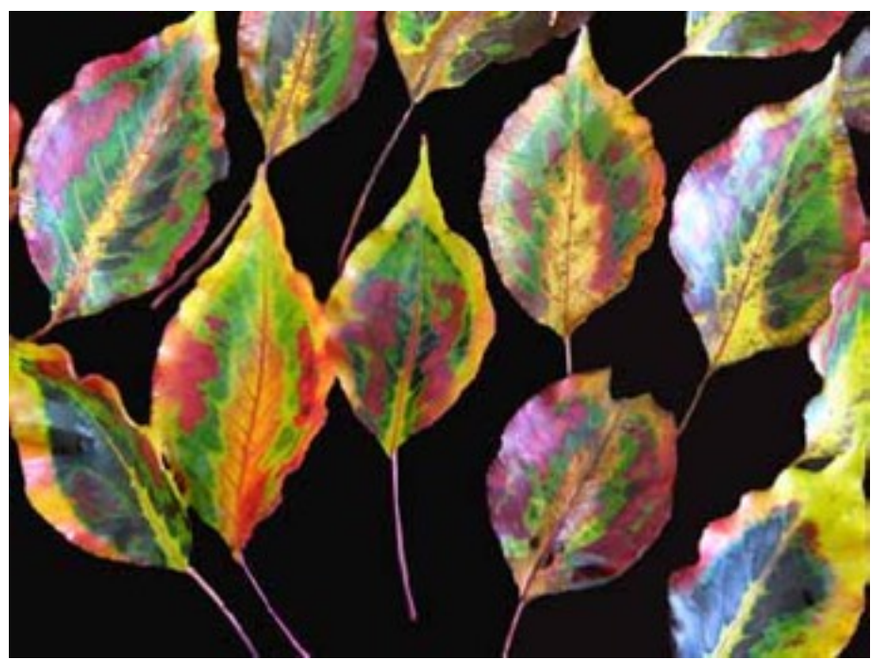
Ethylene
-very small



Epinephrine
-water soluble

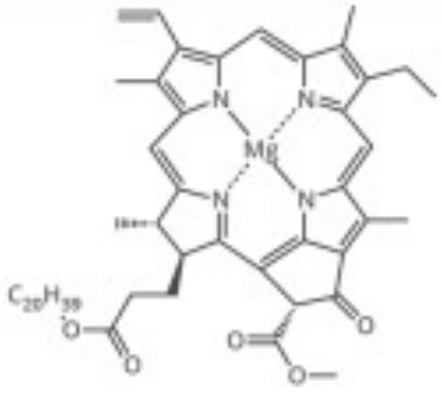
Diversity Among Photosynthetic Pigments





THE CHEMISTRY OF THE COLOURS OF AUTUMN LEAVES

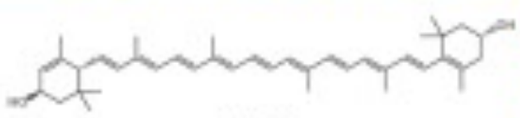
CHLOROPHYLL



CHLOROPHYLL A
A type of porphyrin

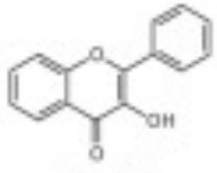
Chlorophyll is the chemical that gives plant leaves their green colour. Plants require warm temperatures and sunlight to produce chlorophyll - in autumn, the amount produced begins to decrease, and the existing chlorophyll is slowly broken down, diminishing the green colour of the leaves.

CAROTENOIDS & FLAVONOIDS

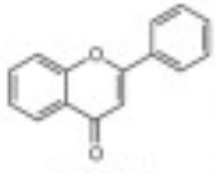


LUTEIN
A type of carotenoid

Carotenoids and flavonoid pigments are always present in leaves, but as chlorophyll is broken down in the autumn their colours come to the fore. Xanthophylls, a subclass of carotenoids, are responsible for the yellows of autumn leaves. One of the major xanthophylls, lutein, is also the compound that contributes towards the yellow colour of egg yolks.



FLAVONOL
(general structure)



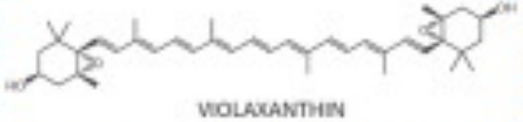
FLAVONE
(general structure)

CAROTENOIDS

ß-CAROTENE
A type of carotenoid

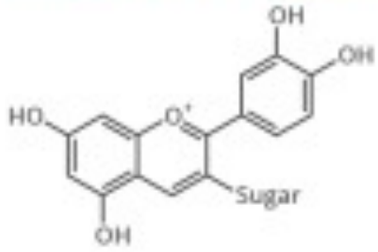
Carotenoids can also contribute orange colours. Beta-carotene is one of the most common carotenoids in plants, and absorbs green and blue light strongly, reflecting red and yellow light and causing its orange appearance. It is also responsible for the orange colouration of carrots.

Carotenoids in leaves start degrading at the same time as chlorophyll, but they do so at a much slower rate; beta-carotene is amongst the most stable, and some fallen leaves can still contain measurable amounts.



VIOLAXANTHIN
A type of carotenoid

ANTHOCYANINS & CAROTENOIDS



ANTHOCYANINS
(general structure)

Unlike the carotenoids, anthocyanin synthesis is kick-started by the onset of autumn - as sugar concentration in the leaves increases, sunlight initiates anthocyanin production. The purpose they serve isn't clear, but it's been suggested that they help protect the leaves from excess light, prolonging the amount of time before they fall.

LYCOPENE
A type of carotenoid

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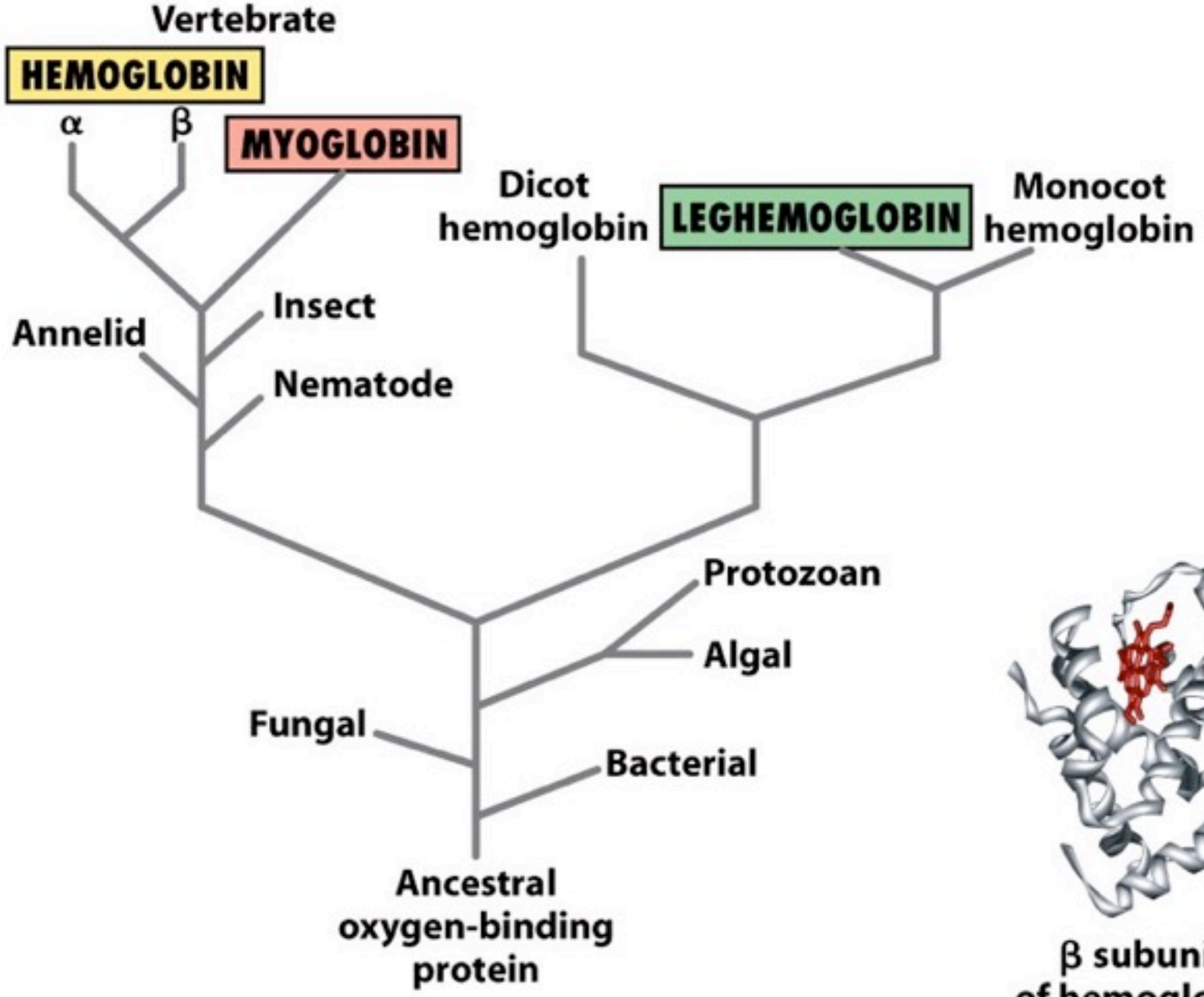
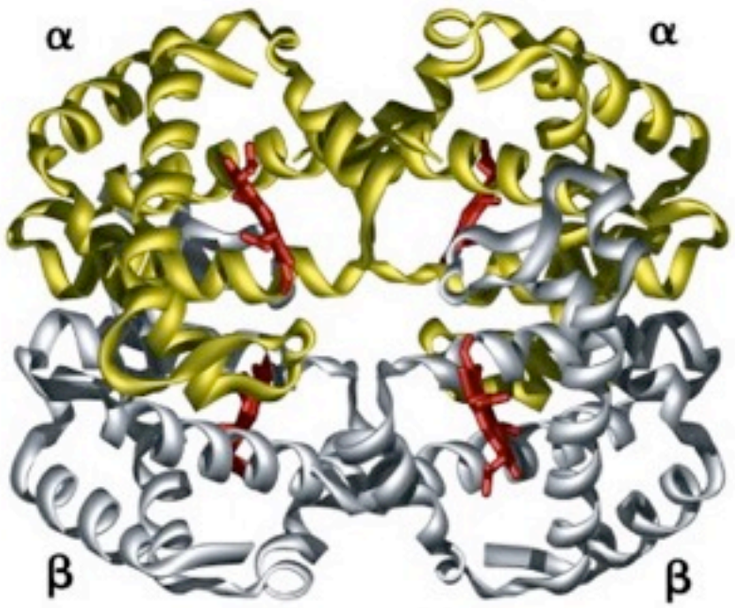
Shared under a Creative Commons Attribution-NonCommercial-NoDerivatives licence. Leaf designed by Peter Silk from the Noun Project.

Diversity of Oxygen Binding Proteins





Hemoglobin

β subunit of hemoglobin

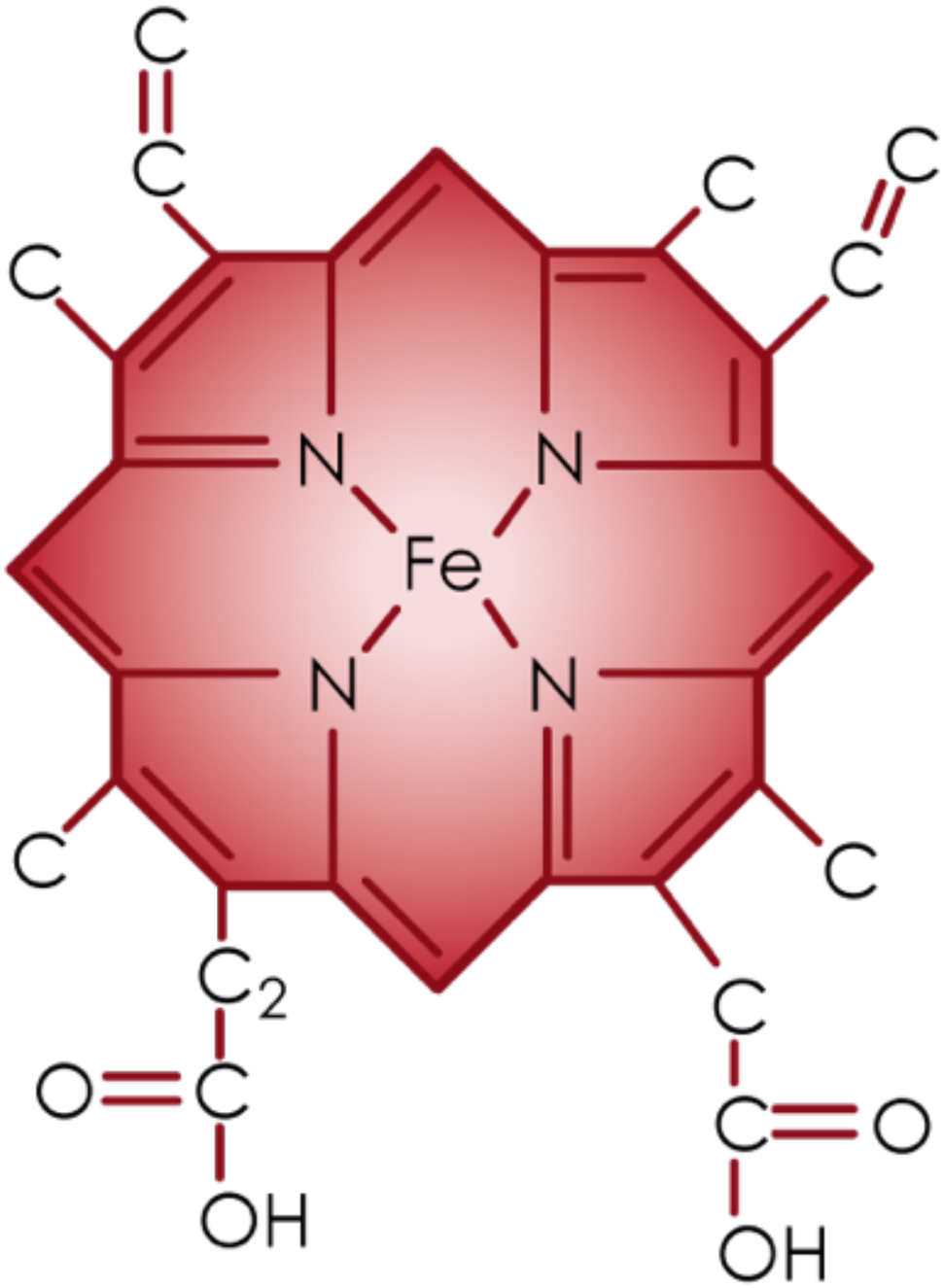
Myoglobin

Leghemoglobin

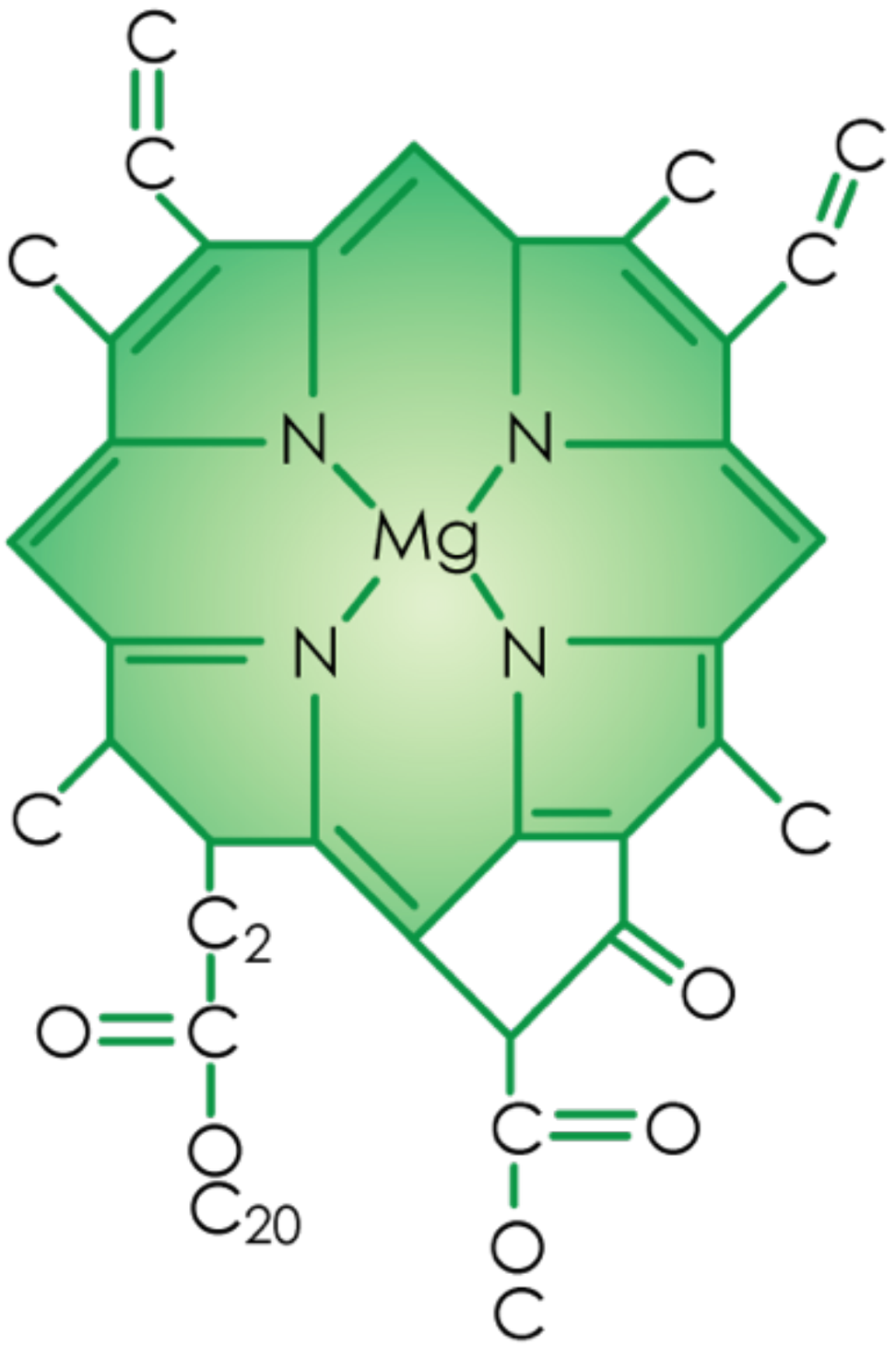
Structure Dictates Function

	Primary Structure	Secondary and Tertiary Structures	Quaternary Structure	Function	Red Blood Cell Shape
Normal hemoglobin	1 Val 2 His 3 Leu 4 Thr 5 Pro 6 Glu 7 Glu	β subunit	Normal hemoglobin α β α β	Molecules do not associate with one another; each carries oxygen.	10 μm
Sickle-cell hemoglobin	1 Val 2 His 3 Leu 4 Thr 5 Pro 6 Val 7 Glu	Exposed hydrophobic region β subunit	Sickle-cell hemoglobin α β α β	Molecules crystallize into a fiber; capacity to carry oxygen is reduced.	10 μm

Molecular Homology?



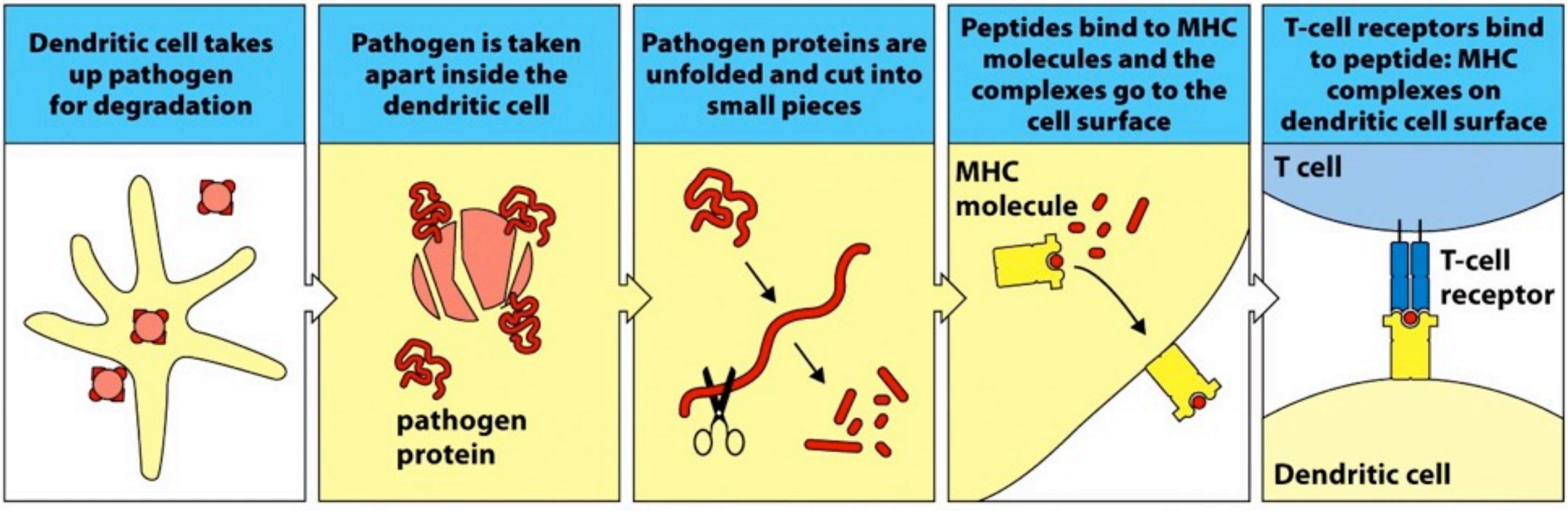
Human Blood
Hemoglobin



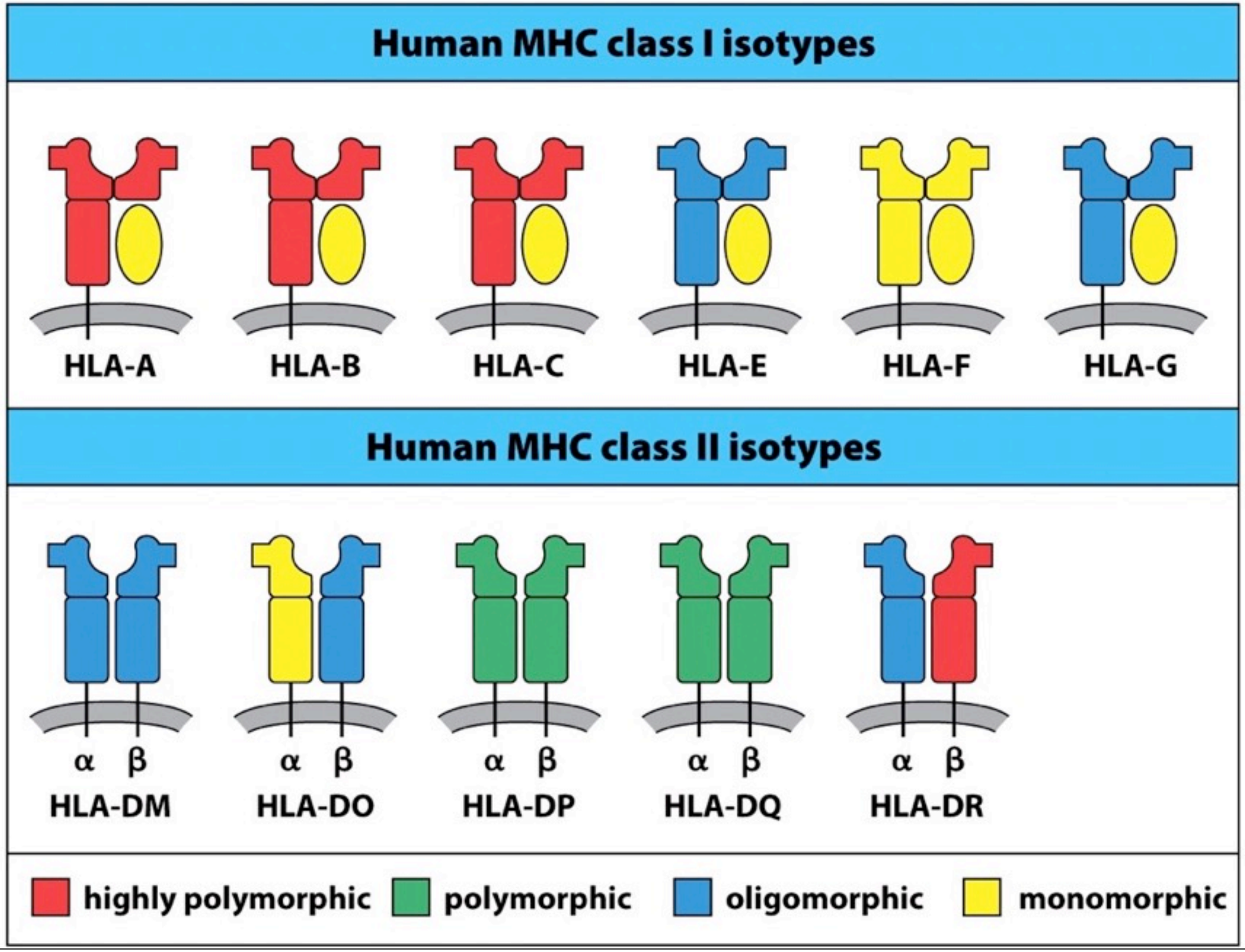
Plant Chlorophyll

MHC Diversity

In vertebrates, growing evidence suggests that genetic diversity is particularly important at the level of the major histocompatibility complex (MHC). MHC variants influence many important biological traits, including immune recognition (see below), susceptibility to infectious and autoimmune diseases, individual odours, mating preferences, kin recognition, cooperation and pregnancy outcome.



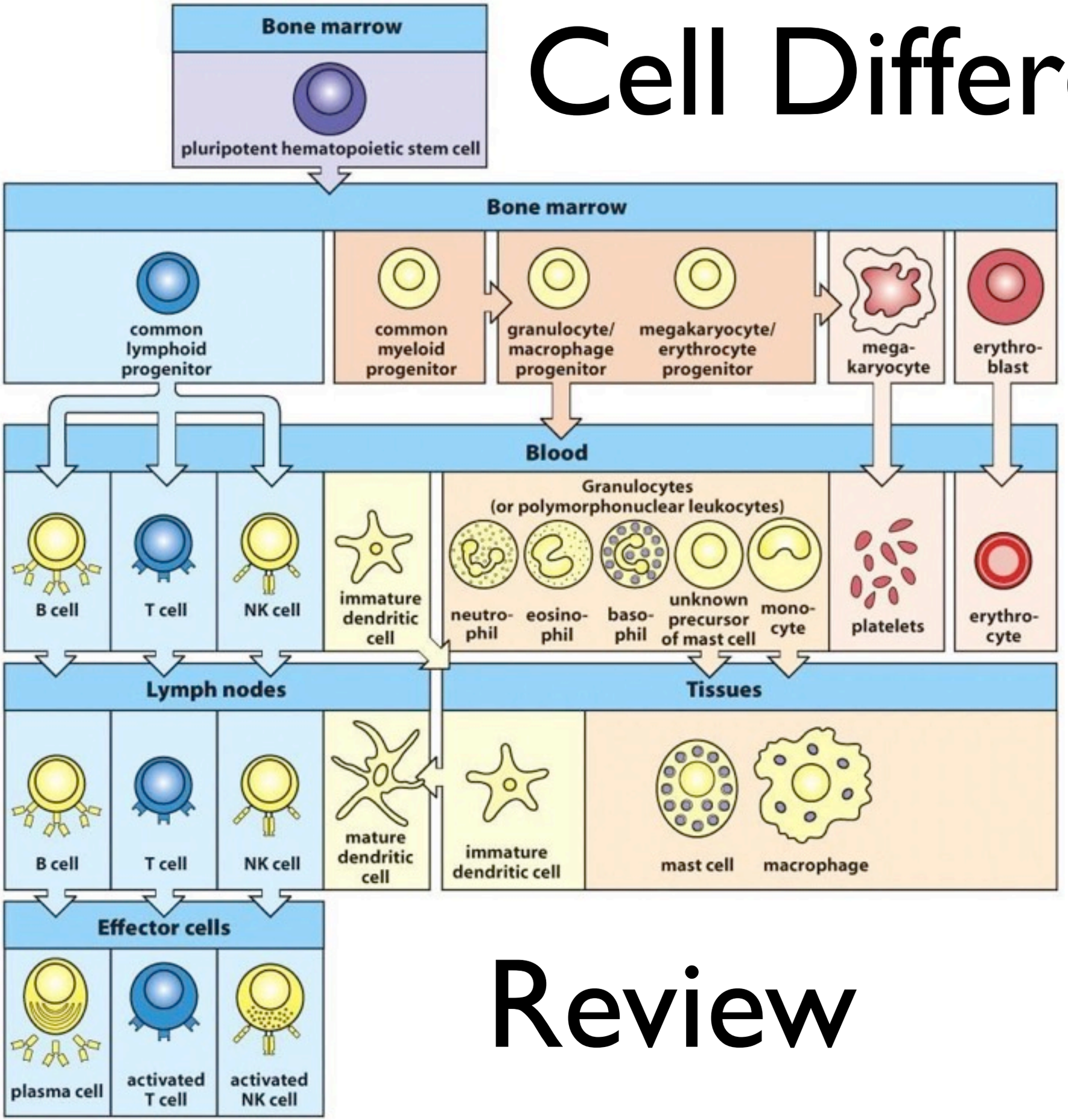
Structure Dictates Function



Structure and function

The MHC consists of a group of closely linked genes that constitute the most important genetic component of the mammalian immune system. The MHC encodes cell-surface glycoproteins that bind antigens derived from pathogens or parasites and present them to T-lymphocytes which trigger the appropriate immune response. Two major groups of MHC genes can be distinguished. MHC class I genes play an essential role in the immune defense against intracellular pathogens by binding peptides mainly derived from viral proteins and cancer infected cells. They are expressed on the surface of all nucleated somatic cells. In contrast, MHC class II genes are predominantly involved in monitoring the extracellular environment by presenting peptides mainly derived from parasites to the T-cells (e.g. bacteria, nematodes, cestodes). They are primarily expressed on antigen-presenting cells of the immune system, such as B cells and macrophages.

Cell Differentiation



Review

The actual cue used in MHC-based mate choice is thought to be based on odour which allows to distinguish MHC-identity. Peptides/MHC complexes that are not retained at the cell surface but instead are released into the extracellular space might appear in the urine and other body secretions and be used for interindividual communication. In mammals, the vomeronasal organ is essential in odour-based social recognition by detecting pheromones and other chemosignals that carry information about gender, sexual and social status, dominance hierarchies, and individualities, but it has been difficult to define the molecular nature of these chemosignals. Recent studies provided evidence that MHC class I peptides serve as chemosensory signals in the vomeronasal organ by which individual MHC genotype diversity can be used as a relatedness marker and may influence social behaviour.

After you read and understand the last slide... watch the video below! The entire video is worthwhile and applicable to the class but pay particular attention minutes 40 to 47.

GOOGLE: PBS Nova Evolution Ep 5 Why Sex

OR

COPY PASTE THE LINK BELOW

https://www.bing.com/videos/search?q=pbs+evolution+series+why+sex&&view=detail&mid=7316C0DDE0C145BC1210731 6C0DDE0C145BC1210&FORM=VRDGAR

Minutes 42:10 to 43:15...INTERESTING???
MHC MOLECULES AT WORK????

Essential knowledge 4.C.1: Variation in molecular units provides cells with a wider range of functions.

b. Multiple copies of alleles or genes (gene duplication) may provide new phenotypes. [See also 3.A.4, 3.C.1]

Evidence of student learning is a demonstrated understanding of each of the following:

1. A heterozygote may be a more advantageous genotype than a homozygote under particular conditions, since with two different alleles, the organism has two forms of proteins that may provide functional resilience in response to environmental stresses.

2. Gene duplication creates a situation in which one copy of the gene maintains its original function, while the duplicate may evolve a new function.

To foster student understanding of this concept, instructors can choose an illustrative example such as:

-The antifreeze gene in fish

Time to Revisit: MHC Diversity

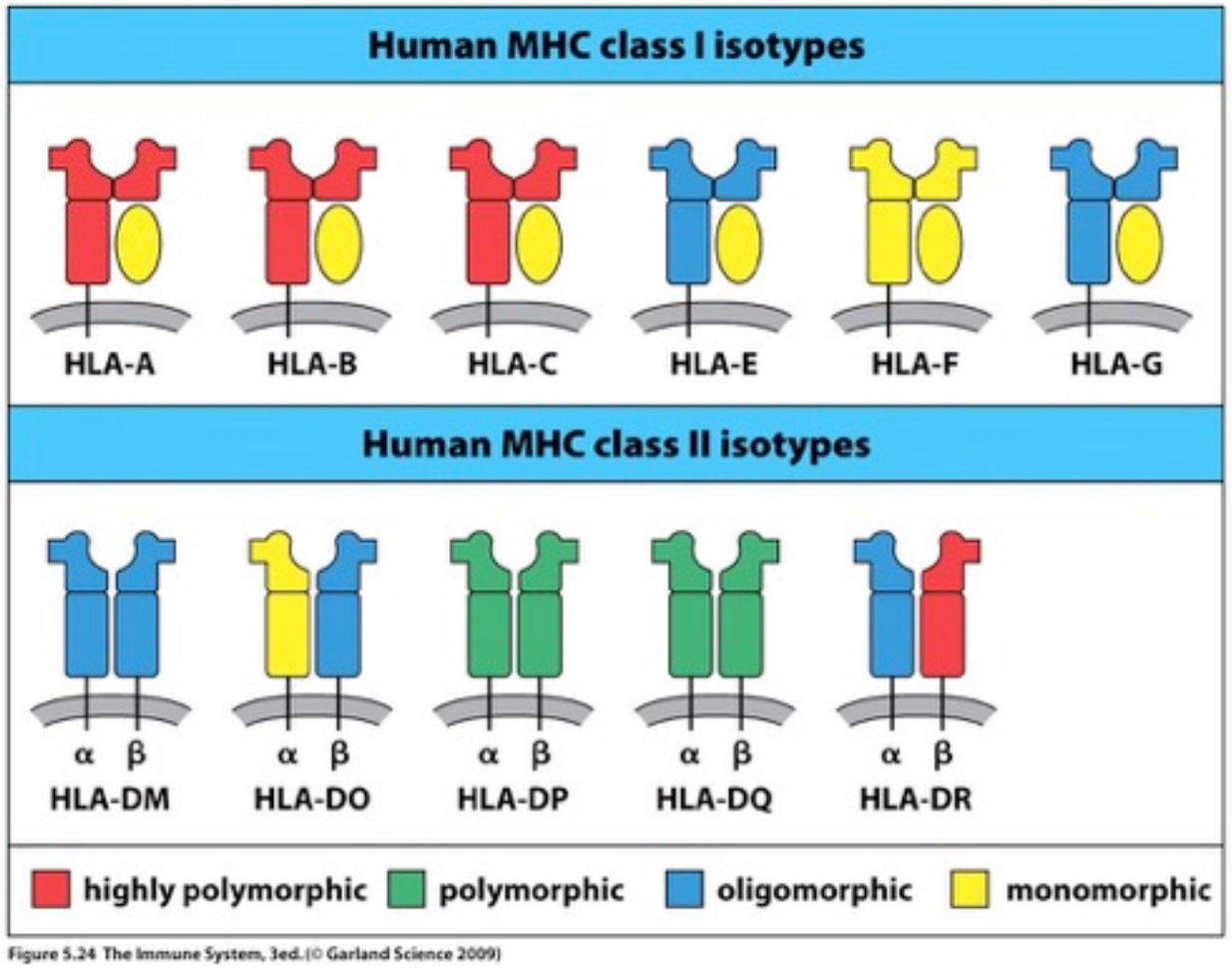


Figure 5.24 The Immune System, 3ed. (© Garland Science 2009)

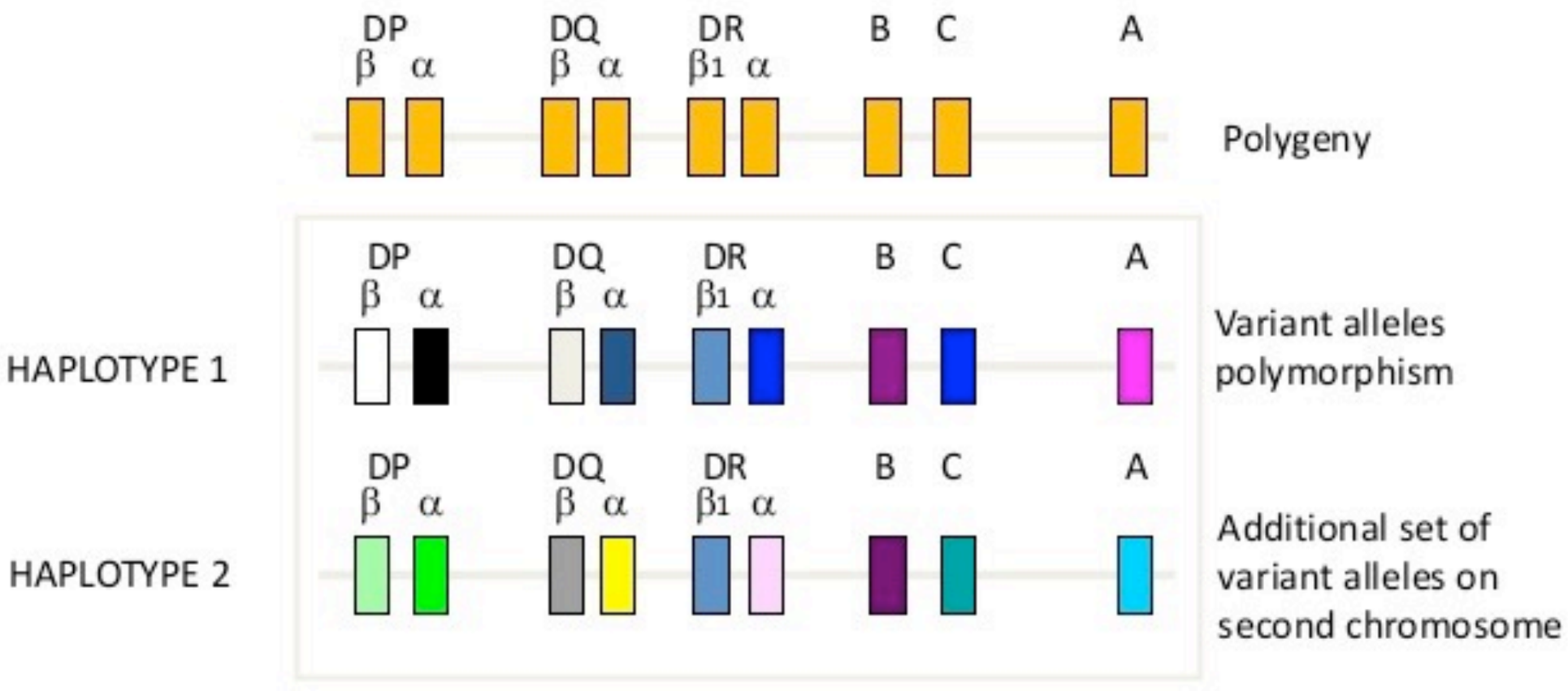
Selection mechanisms

Two main types of balancing selection ('*heterozygote advantage hypothesis*' and '*frequency-dependence selection*') have been suggested as important in retaining high levels of genetic diversity at the MHC in humans and vertebrates

Heterozygote Advantage

In evaluating the evolutionary potential of '*heterozygote advantage*' mechanism a clear distinction between '*dominance*' (heterozygote advantage in a broad sense) and '*overdominance*' (heterozygote superiority) is necessary. The term '*dominance*' refers to heterozygotes that are as resistant as the most resistant homozygote (if the allele A is associated with resistance, then the genotype AB is as resistant as AA (AB = AA)). In this case the heterozygote advantage could be due to masking of susceptible alleles. '*Overdominance*' seems to be the more efficient '*heterozygote advantage*' mechanism promoting MHC diversity. In this case, heterozygotes are expected to have higher fitness than either parental homozygotes especially if confronted with multiple species or strains of pathogens or parasites (the genotype AB has a higher fitness than AA (AB>AA) and BB (AB>BB)). The assumption is based on the theoretical background that heterozygous individuals should be able to detect and present a wider range of pathogen-driven antigens due to a larger number of different MHC molecules, hence increasing the relative fitness of MHC heterozygotes compared with homozygotes

Diversity of MHC molecules in the individual



MHC molecules are CODOMINANTLY expressed
Two of each of the six types of MHC molecule are expressed

Genes in the MHC are tightly LINKED and usually inherited in a unit called an MHC HAPLOTYPE

Polymorphism in biology and zoology is the occurrence of two or more clearly different morphs or forms, also referred to as alternative phenotypes, in the population of a species. In order to be classified as such, morphs must occupy the same habitat at the same time and belong to a panmictic population (one with random mating).

The Source of Information on MHC diversity within this Powerpoint can be found below,
a link to the entire article is also included

The importance of immune gene variability (MHC) in evolutionary ecology and conservation

- Simone Sommer Frontiers in Zoology20052:16

DOI: 10.1186/1742-9994-2-16

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Published: 20 October 2005

http://frontiersinzoology.biomedcentral.com/articles/10.1186/1742-9994-2-16

Learning Objectives:

LO 4.22 The student is able to construct explanations based on evidence of how variation in molecular units provides cells with a wider range of functions. [See SP 6.2]