The Extracellular Matrices
Part II.

2. Elastin fibers.
3. Proteoglycans (PG) and glycosaminoglycans (GAG).
4. Cell-adhesion molecules (CAM).

Elastin fibers

- **A network of randomly coiled macromolecules. No periodicity. Highly extensible chains.**
- **Rubber-like elasticity is complicated by hydrophobic bonding effects.**
- **Interaction of hydrophobic (nonpolar) AA with water leads to hydrophobic bonding. Primarily entropic, not energetic, bonding between molecules. It forces nonpolar macromolecules, such as elastin, to adopt a compact, rather then extended, shape in hydrated tissue.**
- **Stretching of elastin fibers leads to large entropy loss due to reduction in chain configurations and increased "ordering" of water molecules against nonpolar AA. Spontaneous retraction.**
- **Elastic ligament of neck. Blood vessel wall.**

The Hydrophobic bond

$$\Delta G = \Delta H - T\Delta S$$

Equilibrium when $\Delta G = 0$. G is Gibbs' free energy, the enthalpy is H = E + PV, T is absolute temperature and S is the entropy. The process goes spontaneously from left to right when $\Delta G < 0$. Find the position of thermodynamic equilibrium for a well-known example of insolubility:

$$CH_4 \text{ in benzene} \rightarrow CH_4 \text{ in } H_2O$$

The experimental data show (all units in calories per mol): $\Delta G = \Delta H - T\Delta S$

$$+2600 = -2800 - 298(-18)$$

$$+2600 = -2800 + 5400$$

<u>Conclusion</u>: Insolubility of paraffin in water due to entropy loss, not to enthalpy change! (Kauzmann)

Historical models of cell membrane structure

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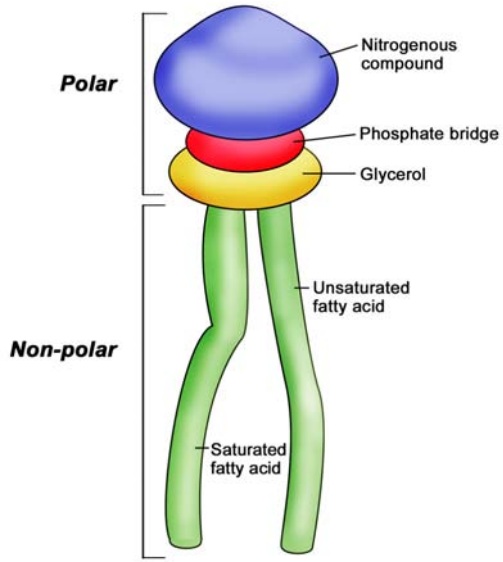
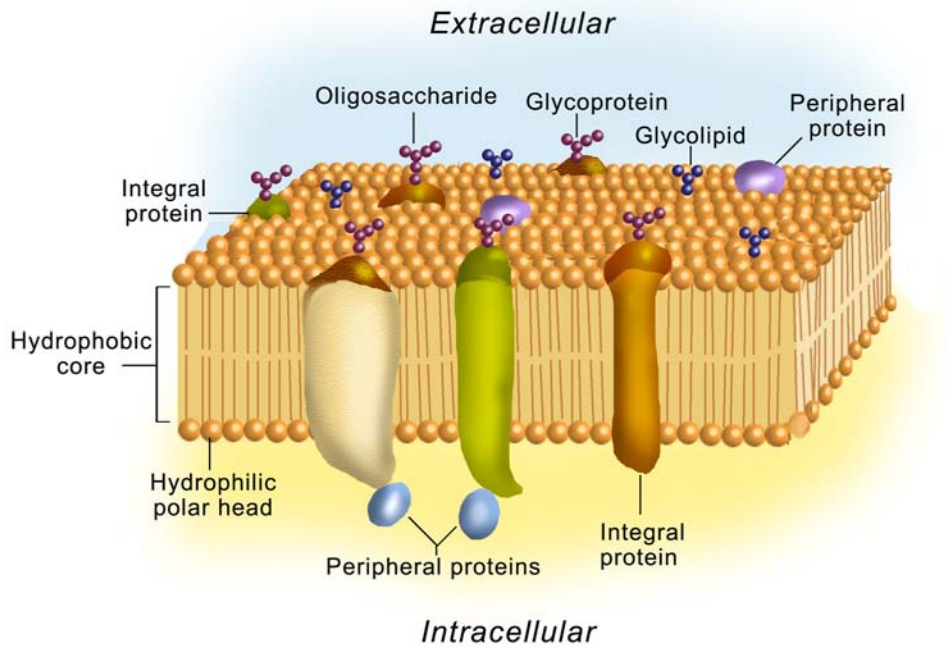
Cell membrane showing bilayer structure





Elastin fibers in the relaxed aorta.

Elastin macromolecules are random coils tied together to form a 3-dimensional (insoluble) network.

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Macromolecules coil upon themselves due to high content of nonpolar (hydrophobic) amino acids that mediate withdrawal from polar medium (aqueous buffer) and promote bonding within chains. These networks stretch extensively like all rubbers.

Proteoglycans (PGs) and glycosaminoglycans (GAGs)

- **A proteoglycan is a polypeptide chain (proteo) with polysaccharide (glycan or GAG) side chains.**
- **Primary structure modeled as an alternating copolymer of two different glucose-like units, one of them an acidic sugar-like molecule, the other an amino sugar with a negatively charged sulfate group (except hyaluronic acid that is not sulfated).**
- **Electrostatic interactions between charged groups in GAG side chains of PG responsible for about 50% of stiffness of articular cartilage (Grodzinsky et al.).**

Proteoglycans (PGs) and glycosaminoglycans (GAGs)

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Glycosamino-glycans

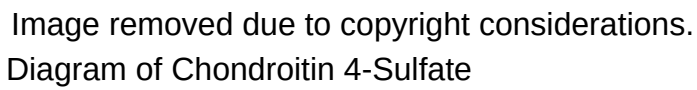
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Diagram of Chondroitin 4-Sulfate

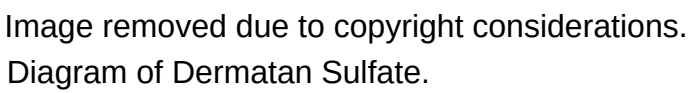
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Diagram of Dermatan Sulfate.

disaccharide repeat unit

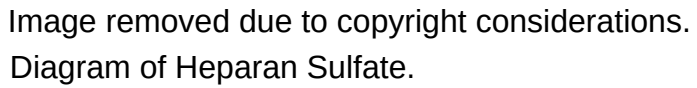
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Diagram of Heparan Sulfate.

Proteoglycans and glycosaminoglycans

repeat unit of chondroitin 6-sulfate

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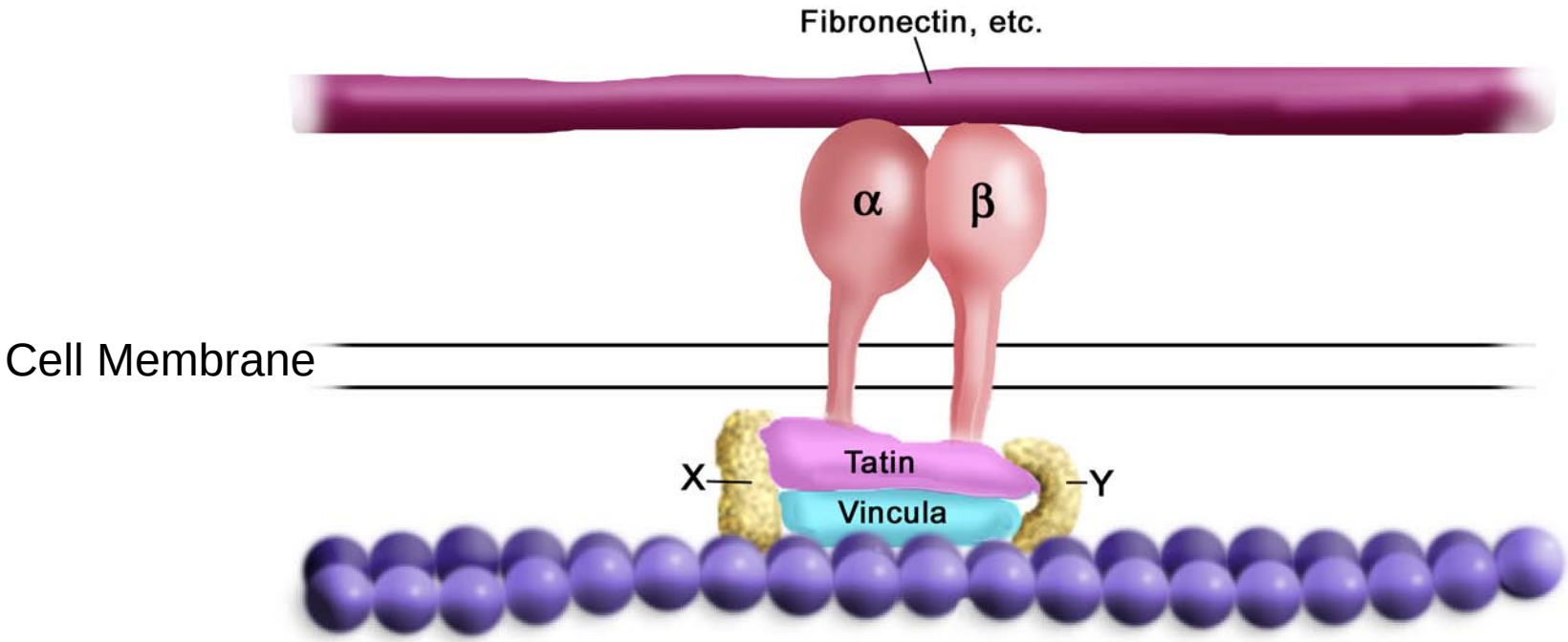
a proteoglycan

Cell-adhesion molecules

- **Cell-matrix interactions involve binding of transmembrane proteins (integrins) on specific sites (ligands) in ECM molecules such as fibronectin, laminin and collagen. Example: integrins of contractile fibroblasts bind to fibronectin molecules that are attached to collagen fibers (fibronexus).**
- **Integrins connect with proteins in the cell cytoplasm and a signal is transmitted to or from the nucleus.**

An integrin “connects” the interior of the cell (cytoplasm) with the ECM outside it



After Hynes, 1990.

Bilayer structure of cell membrane viewed by electron microscopy

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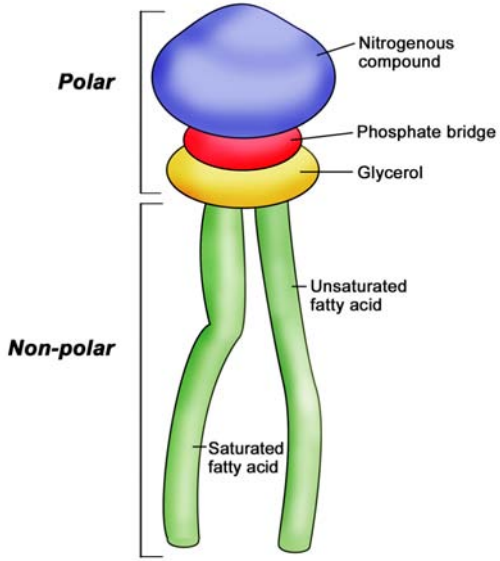
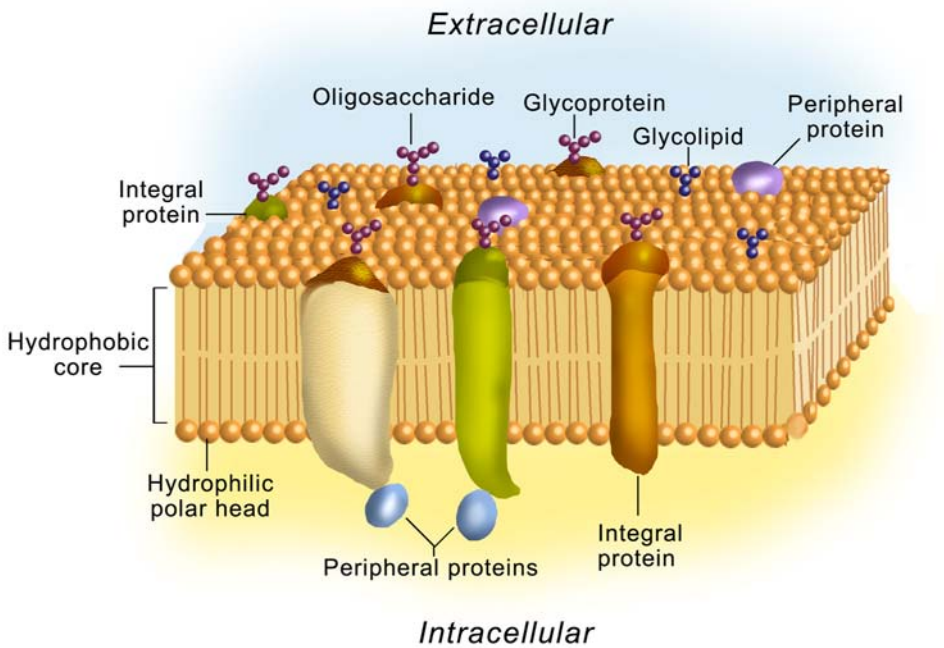


Phospholipid molecule

Cell membrane showing cell surface receptors (integrins)



Cells pull matrix (thin silicone film), causing buckling (Harris et al.)

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Location of fibronectin binding sites (Hynes, 1990)