

Lecture 4

The Cell Surface Is Coated with Carbohydrate

Lipids and proteins in the outer layer of the plasma membrane have **sugars covalently attached** to them.

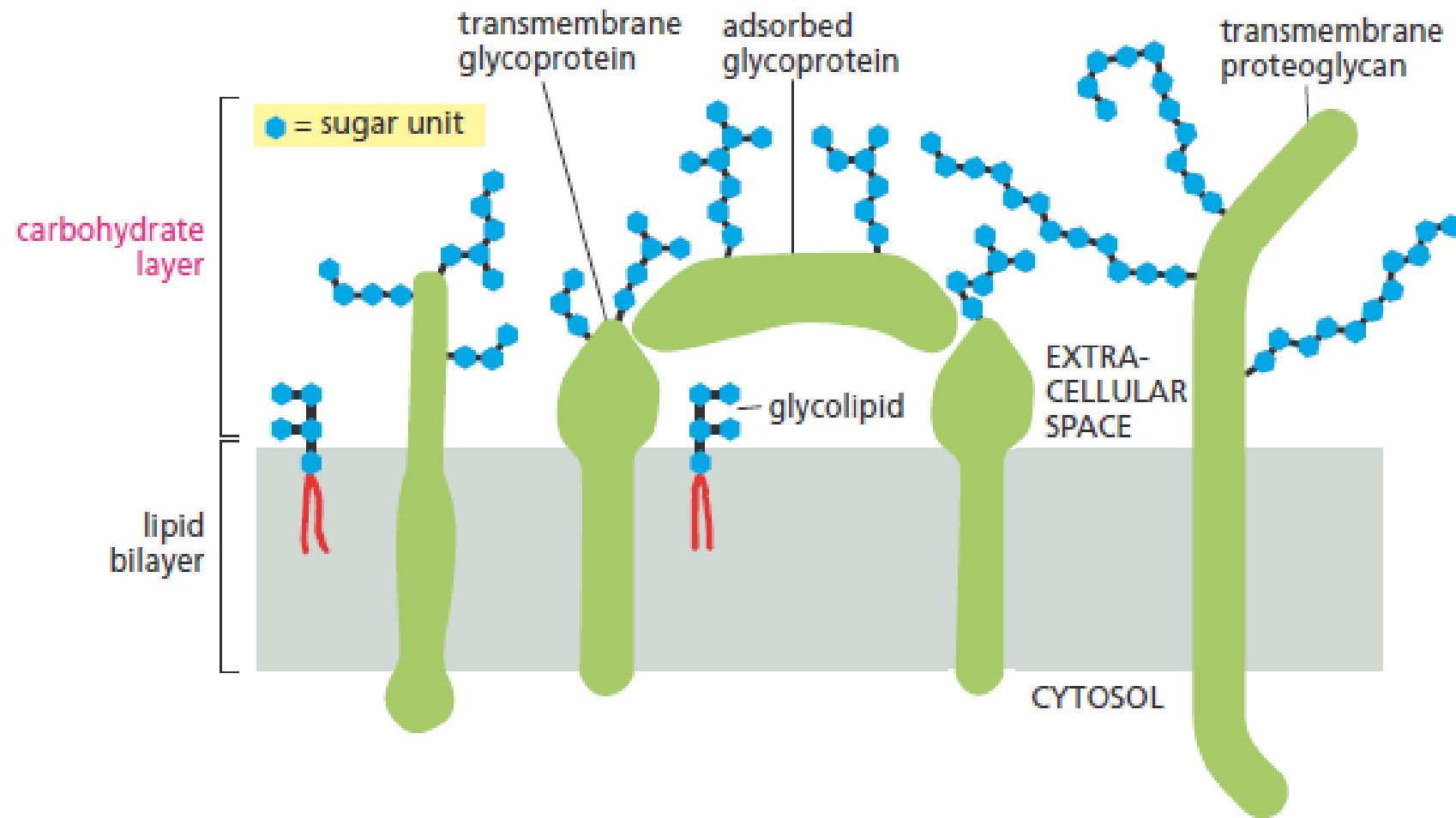
Common monosaccharides associated with membranes are: **glucose, galactose, fructose** and **mannose**.

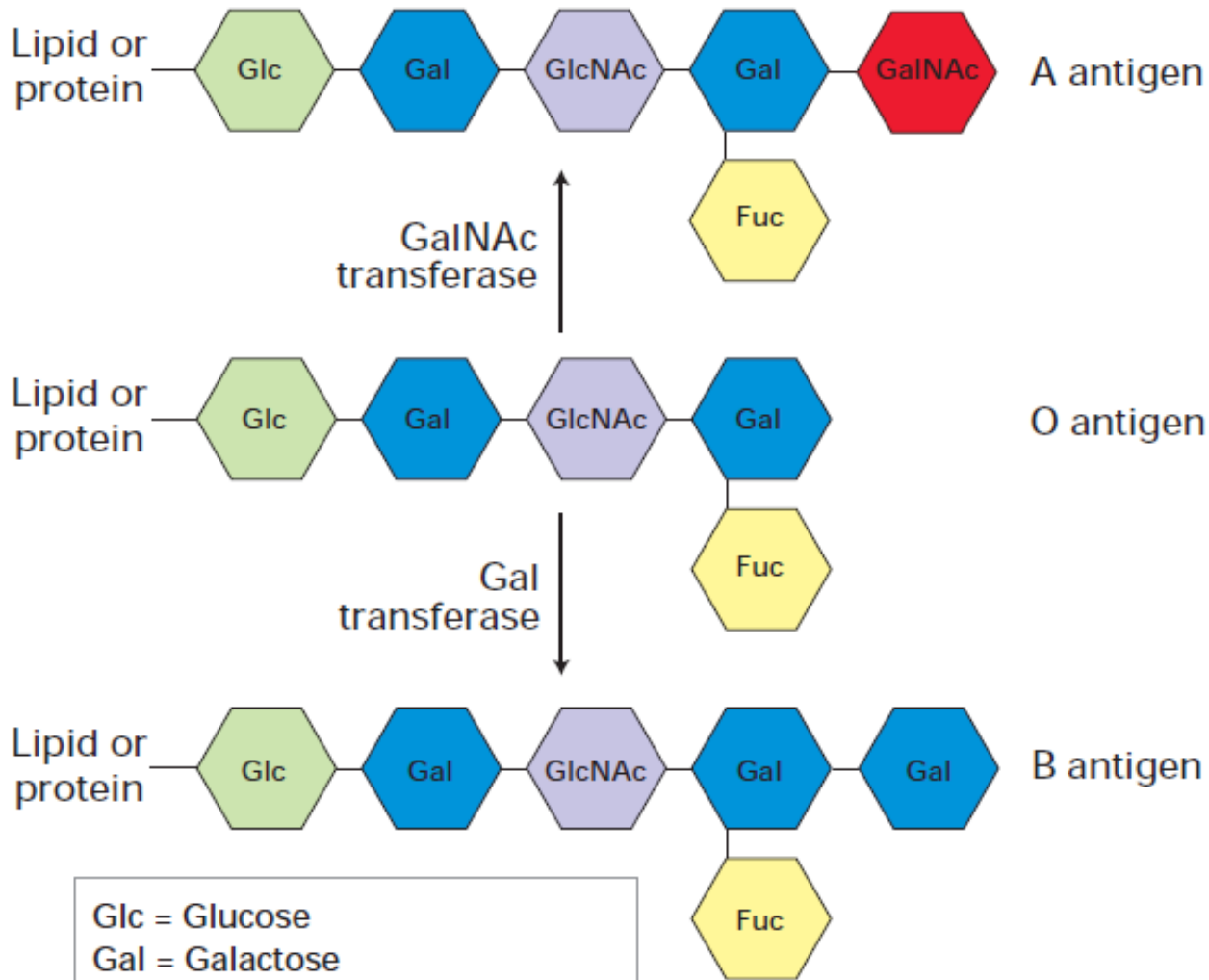
The great majority of these proteins have **short chains of sugars, called oligosaccharides**, linked to them; they are called **glycoproteins**.

Other membrane proteins, the **proteoglycans**, contain one or more long polysaccharide chains.

All of the carbohydrate on the glycoproteins, proteoglycans, and glycolipids is located on the outside of the plasma membrane, where it forms a sugar coating called the **carbohydrate layer or glycocalyx**.

- This layer of carbohydrate helps protect the cell surface from **mechanical damage**.
- As the oligosaccharides and polysaccharides adsorb water, they also give the cell a **slimy surface**, which helps motile cells such as white blood cells squeeze through narrow spaces and prevents blood cells from sticking to one another or to the walls of blood vessels.
- Important in cell-cell recognition

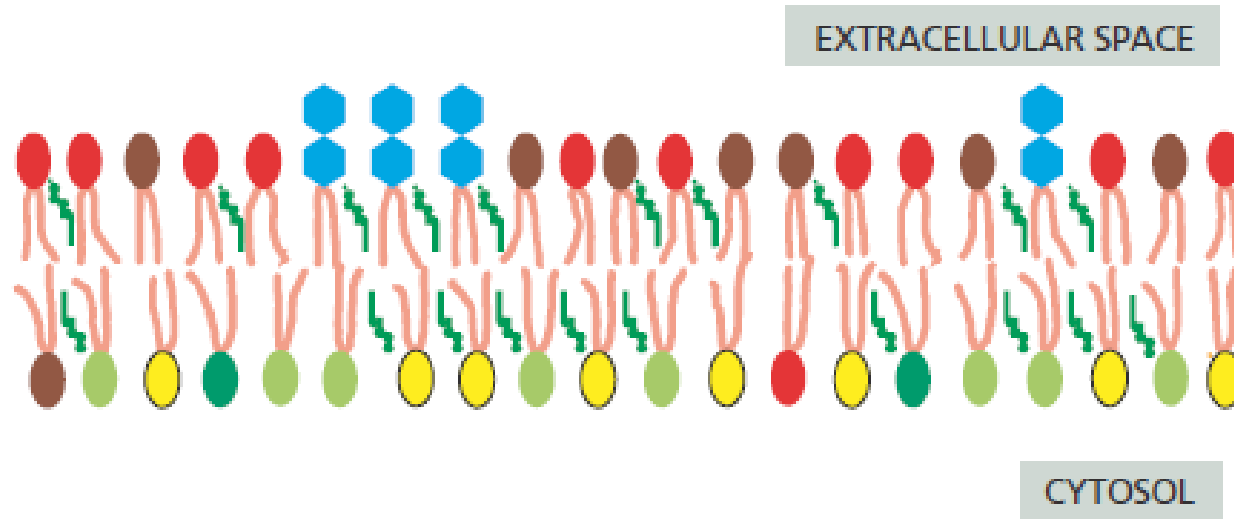




The **ABO** blood group antigens are **distinct polysachharides** found mainly on glycoproteins on the **RBC membrane**.

The polysachharides are constructed in the ER and Golgi apparatus by **glycosyl transferases**.

Individuals express **different glycosyl transferases**.



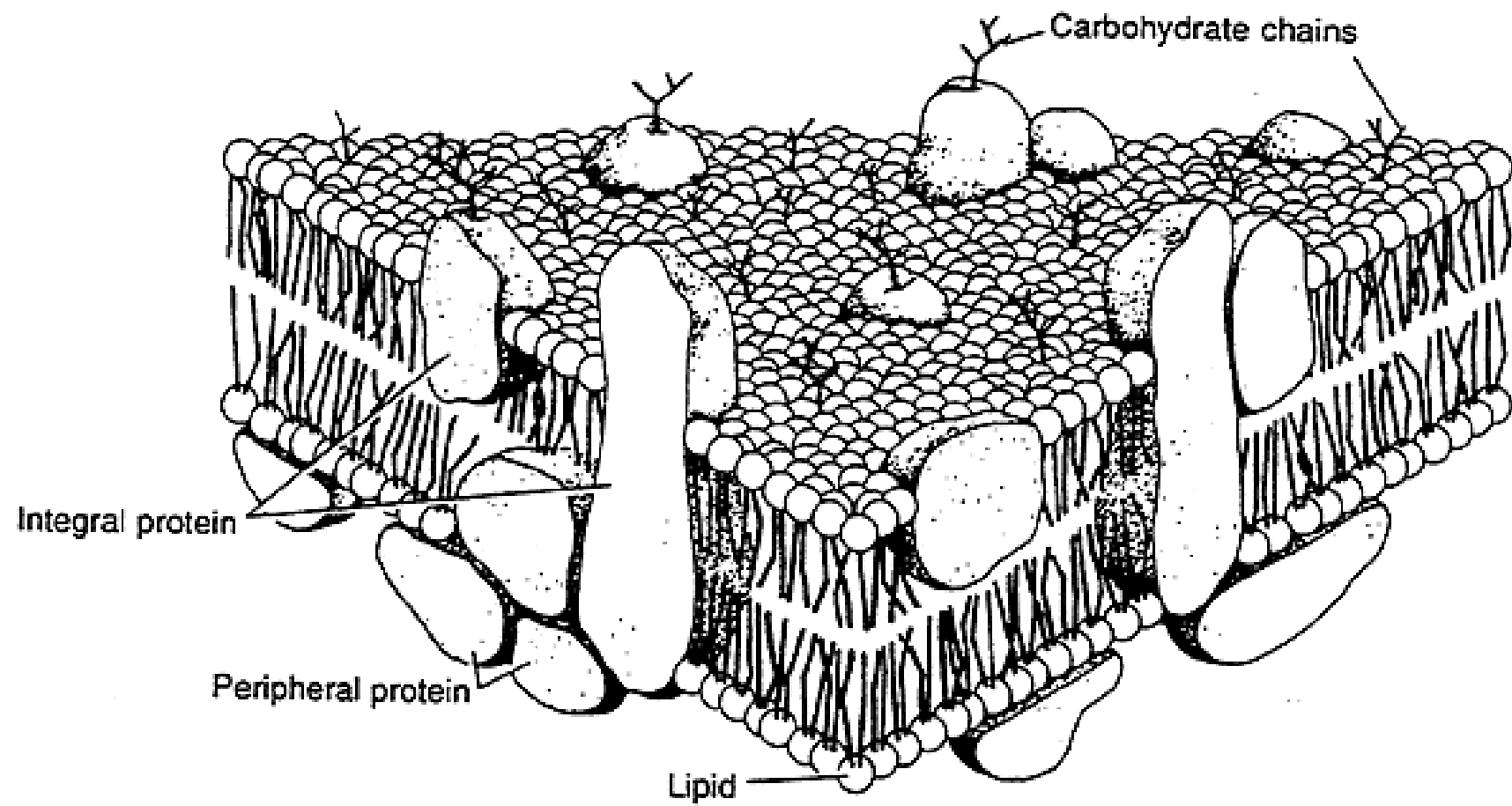
Phospholipids and glycolipids are distributed asymmetrically in the lipid bilayer of a eukaryotic plasma membrane.

Phosphatidylcholine (*red*) and sphingomyelin (*brown*) are concentrated in the noncytosolic monolayer, whereas phosphatidylserine (*light green*), and phosphatidylethanolamine (*yellow*) are found mainly on the cytosolic side.

In addition to these phospholipids, phosphatidylinositols (*dark green*), a minor constituent of the plasma membrane, are shown in the cytosolic monolayer, where they participate in cell signaling.

Glycolipids are drawn with hexagonal *blue* head groups to represent sugars; these are found exclusively in the noncytosolic monolayer of the membrane.

Within the bilayer, cholesterol (*green*) is distributed almost equally in both monolayers.





Three Types of Filaments Compose the Cytoskeleton

Distinguished on the bases of

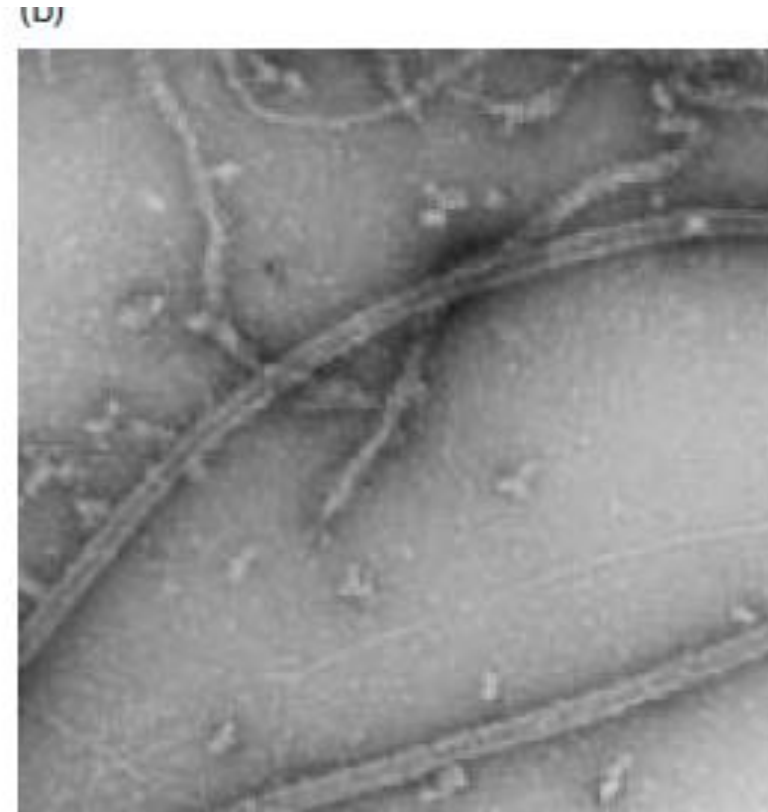
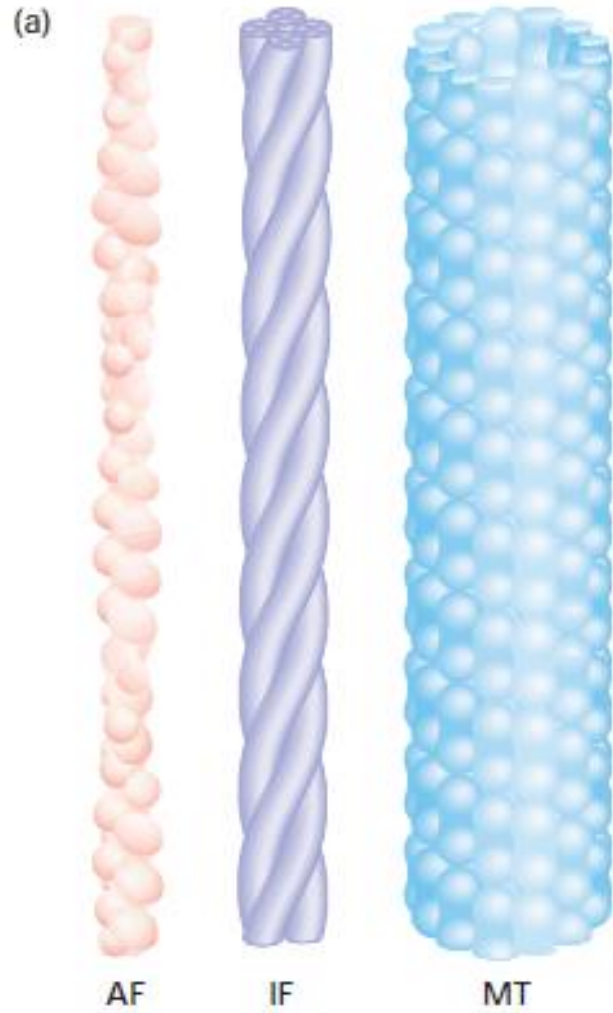
- their diameter,
- type of subunit, and
- subunit arrangement

Actin filaments, also called **microfilaments**, are 8–9 nm in diameter and have a twisted two-stranded structure.

Microtubules are hollow tube-like structures, 24 nm in diameter, whose walls are formed by adjacent protofilaments.

Intermediate filaments (IFs) have the structure of a 10-nm-diameter rope.

Three Types of Filaments Compose the Cytoskeleton



Three Types of Filaments Compose the Cytoskeleton

Each type of cytoskeletal filament is a **polymer of protein subunits**

Monomeric **actin** subunits assemble into microfilaments;

Dimeric subunits composed of **α and β -tubulin** polymerize into microtubules.

Unlike microfilaments and microtubules, which are assembled from one or two proteins, intermediate filaments are assembled from a large diverse family of proteins.

The most common intermediate filaments, found in the nucleus, are composed of ***lamins***.

Intermediate filaments constructed from other proteins are expressed preferentially in certain tissues:

for example, *keratin*-containing filaments in epithelial cells,
desmin-containing filaments in muscle cells, and
Vimentin containing filaments in mesenchymal cells.

Three Types of Filaments Compose the Cytoskeleton

TABLE 5-4 Protein Subunits in Cytoskeletal Filaments

Protein Subunits	MW	Expression	Function
MICROFILAMENTS			
Actin	42,000	Fungi, plant, animal	Structural support, motility
MreB	36,000	Rod-shaped bacteria	Width control
MICROTUBULES			
Tubulin (α and β)	58,000	Fungi, plant, animal	Structural support, motility, cell polarity
FtsZ	58,000	Bacteria	Cell division
INTERMEDIATE FILAMENTS			
Lamins	Various	Plant, animal	Support for nuclear membrane
Desmin, keratin, vimentin, others	Various	Animal	Cell adhesion
OTHER			
MSP	50,000	Nematode sperm	Motility

Cytoskeletal Filaments Are Organized into Bundles and Networks

bundles and *networks*, are the most common arrangements of cytoskeletal filaments in a cell.

Structurally, bundles differ from networks mainly in the organization of the filaments.

In bundles, the filaments are closely packed in parallel arrays.

In a network, the filaments crisscross, often at right angles, and are loosely packed.

Networks can be further subdivided.

One type, associated with the nuclear and plasma membranes, is planar (two-dimensional), like a net or a web;

the other type, present within the cell, is three-dimensional, giving the cytosol gel-like properties.

In all bundles and networks, the filaments are held together by various cross-linking proteins

Actin

Actin is the most abundant intracellular protein in most eukaryotic cells.

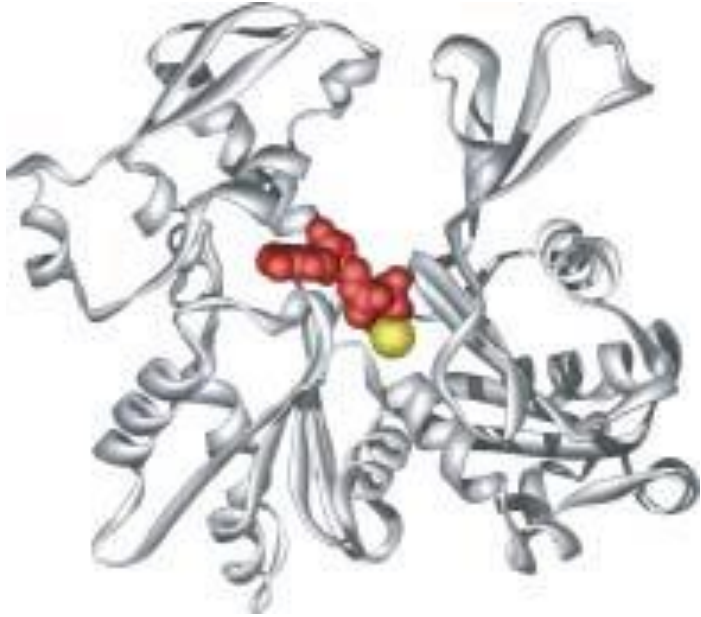
In muscle cells, for example, actin comprises 10 percent by weight of the total cell protein; even in non muscle cells, actin makes up 1–5 percent of the cellular protein.

To grasp how much actin cells contain, consider a typical liver cell, which has 2×10^4 insulin receptor molecules but approximately 5×10^8 or half a billion, actin molecules.

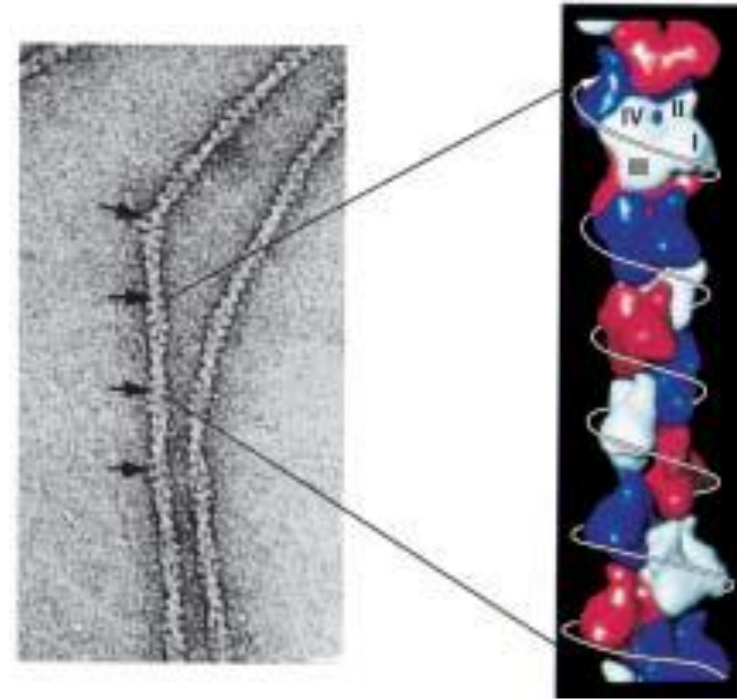
Actin exists as a **globular monomer called *G-actin*** and as a **filamentous polymer called *F-actin***, which is a linear chain of G-actin subunits.

(The microfilaments visualized in a cell by electron microscopy are F-actin filaments plus any bound proteins.)

Globular and Filamentous actin



ATP (red) binds at the bottom of the cleft and contacts both lobes (the yellow ball represents Mg₂)

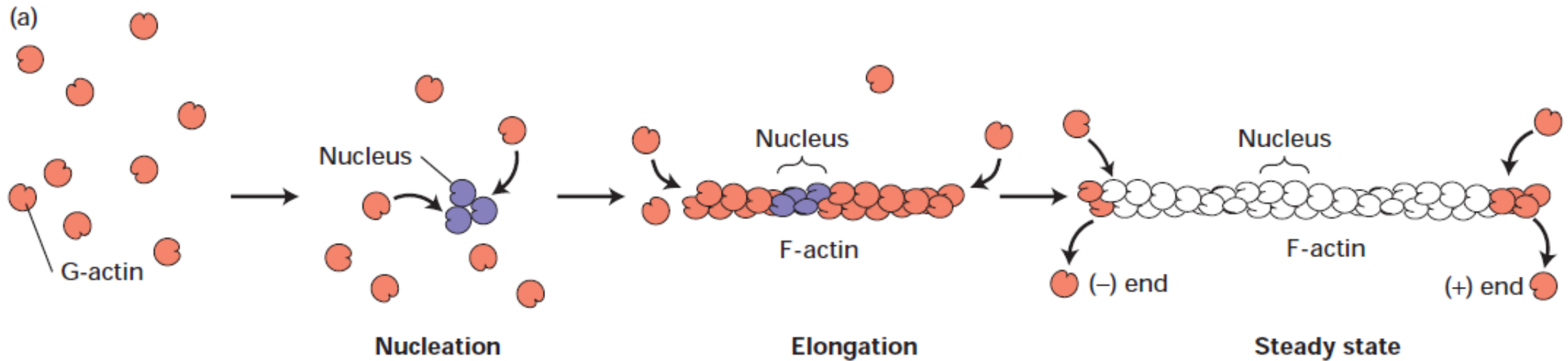


The ATP-binding cleft is oriented in the same direction (*top*) in all actin subunits in the filament. The end of a filament with an exposed binding cleft is designated the (-)end; the opposite end is the (+) end.

The Dynamics of Actin Assembly

Property of self assembly

Microfilaments in a cell are constantly shrinking or growing in length, and bundles and meshworks of microfilaments are continually forming and dissolving.



A red blood cell must squeeze through narrow blood capillaries without rupturing its membrane. The strength and flexibility of the erythrocyte plasma membrane depend on a dense cytoskeletal network that underlies the entire membrane and is attached to it at many points.

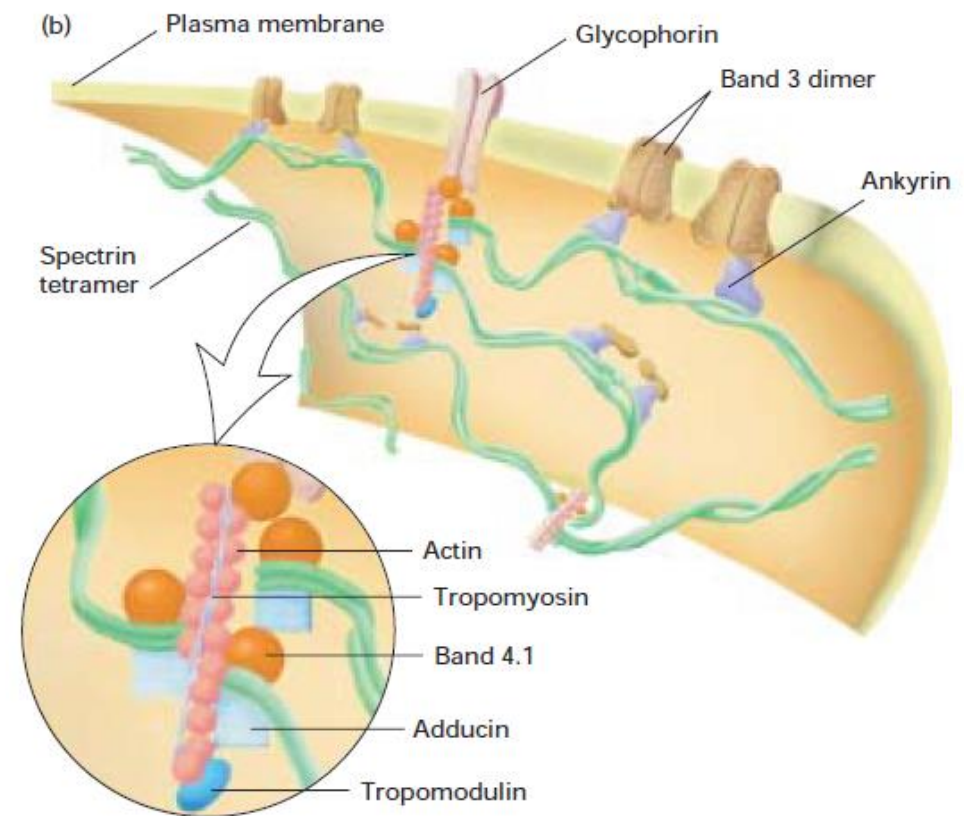
The primary component of the erythrocyte cytoskeleton is *spectrin*, a 200-nm-long fibrous protein.

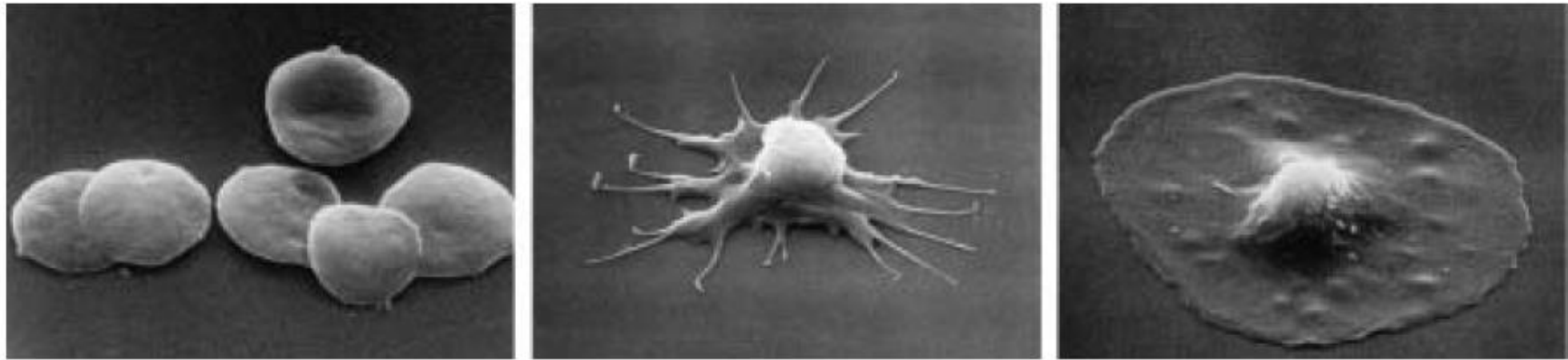
The entire cytoskeleton is arranged in a spoke-and-hub network. Each spoke is composed of a single spectrin molecule, which extends from two hubs and cross-links them.

Each hub comprises a short (14-subunit) actin filament plus adducin, tropomyosin, and tropomodulin.

The last two proteins strengthen the network by preventing the actin filament from depolymerizing.

Six or seven spokes radiate from each hub, suggesting that six or seven spectrin molecules are bound to the same actin filament.





Platelets change shape during blood clotting

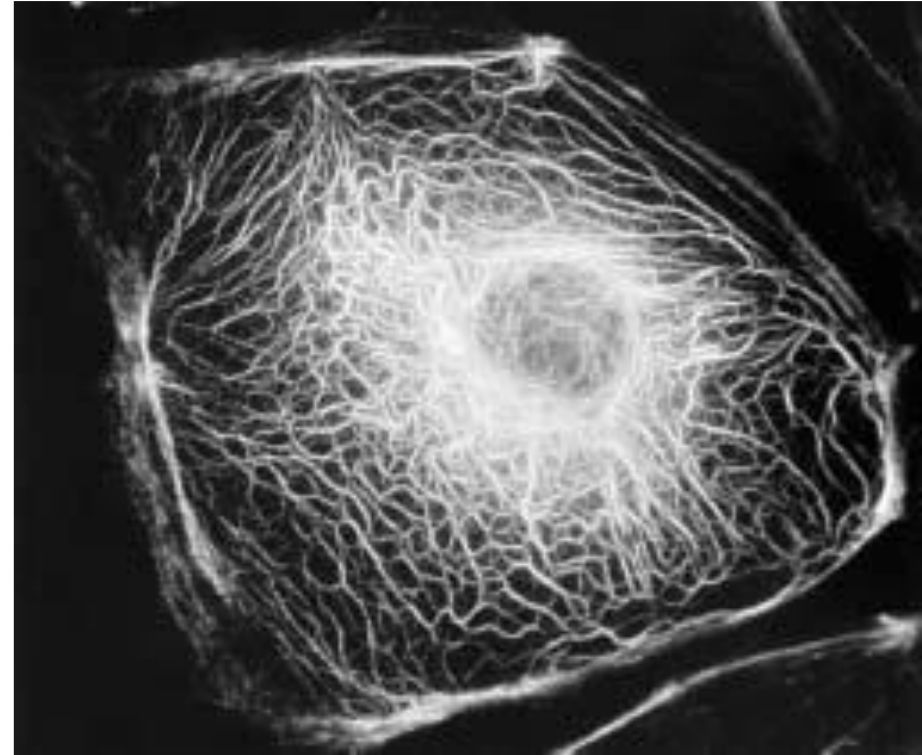
Intermediate Filaments Support the Nuclear Membrane and Help Connect Cells into Tissues

Intermediate filaments typically crisscross the cytosol, forming an internal framework that stretches from the nuclear envelope to the plasma membrane

A network of intermediate filaments is located adjacent to some cellular membranes, where it provides mechanical support.

For example, lamin A and lamin C filaments form an orthogonal lattice that is associated with lamin B.

The entire supporting structure, called the **nuclear lamina**, is anchored to the inner nuclear membrane by prenyl anchors on lamin B.



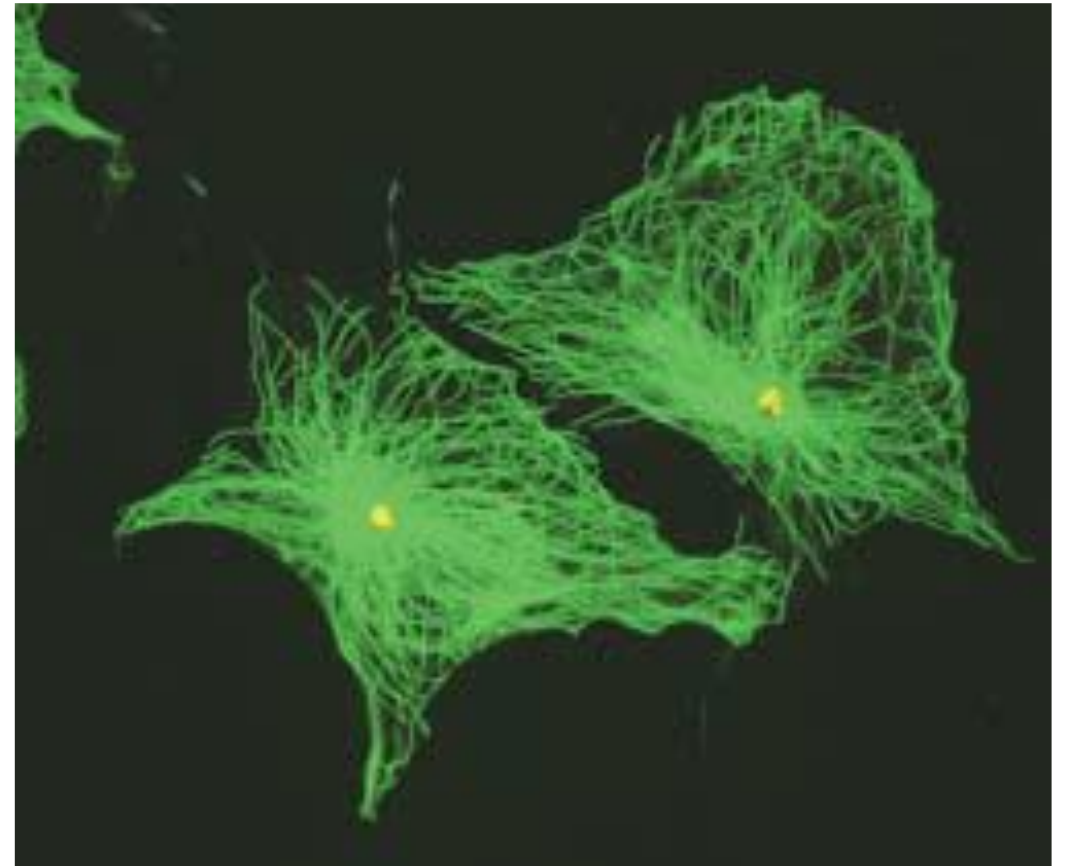
Microtubules Radiate from Centrosomes and Organize Certain Subcellular Structures

Like microfilaments and intermediate filaments, microtubules are not randomly distributed in cells. Rather, microtubules radiate from the **centrosome**, which is the primary **microtubule-organizing center (MTOC)** in animal cells

The two ends of a microtubule differ in their dynamic properties and are commonly designated as the (-) and (+) ends.

For this reason, microtubules can have two distinct orientations relative to one another and to other cell structures.

In many nondividing animal cells, the MTOC is located at the center of the cell near the nucleus, and the radiating microtubules are all oriented with their (-) ends directed toward the cell periphery.



Bacterial counterparts

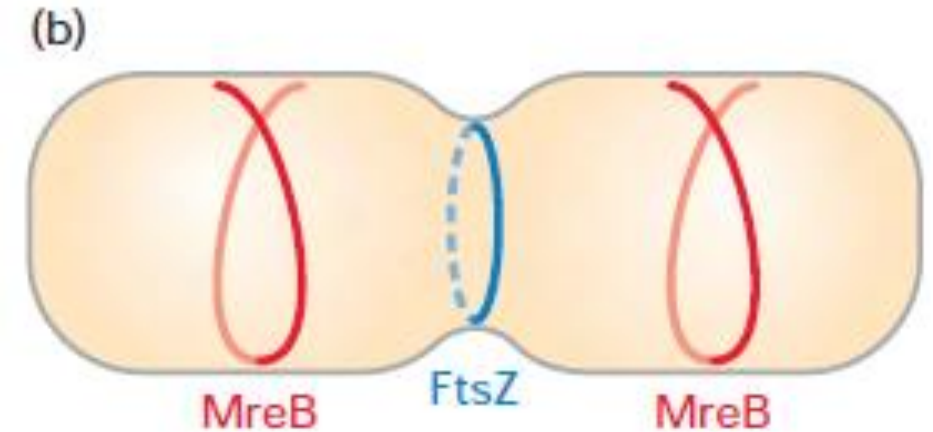
The simple bacterial cytoskeleton controls cell length, width, and the site of cell division.

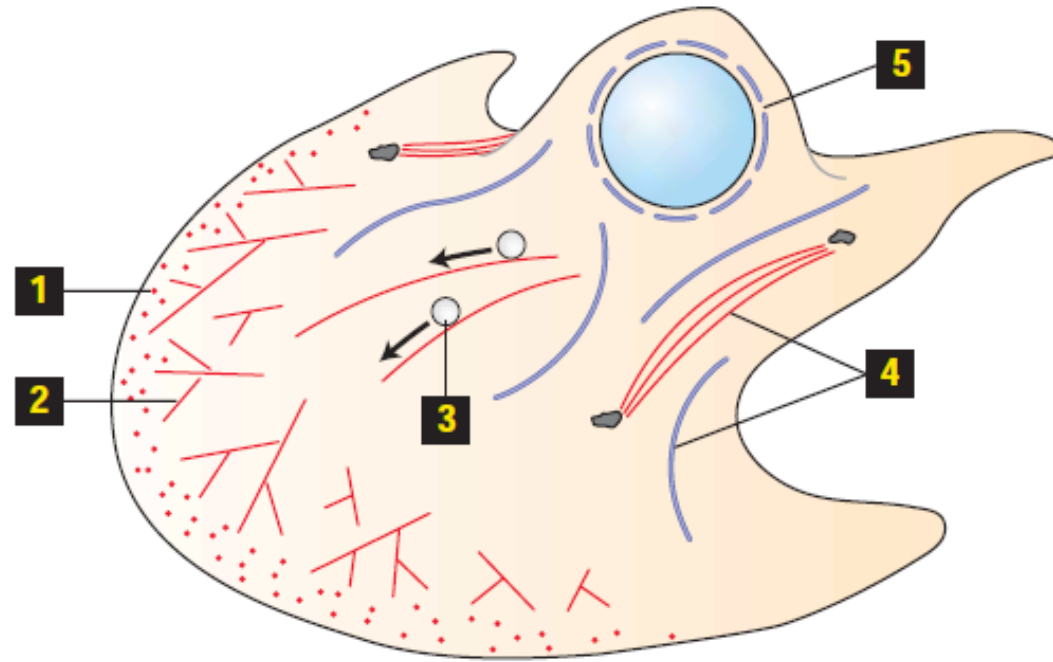
The FtsZ protein, a bacterial homolog of tubulin, is localized around the neck of dividing bacterial cells, suggesting that FtsZ participates in cell division.

The results of biochemical experiments with purified FtsZ demonstrate that it can polymerize into protofilaments, but these protofilaments do not assemble into intact microtubules.

Another bacterial protein, MreB, has been found to be similar to actin in atomic structure and filament structure—strong evidence that actin evolved from MreB.

MreB controls the width of rodshaped bacteria.





	CYTOSKELETAL COMPONENT	CELL FUNCTION
1	Actin dynamics	Membrane extension
2	Filament networks: bundles	Cell structure
3	Myosin motors	Contractility and vesicle transport
4	Actin bundles and intermediate filaments	Cell adhesion
5	Lamin network	Nuclear structure

