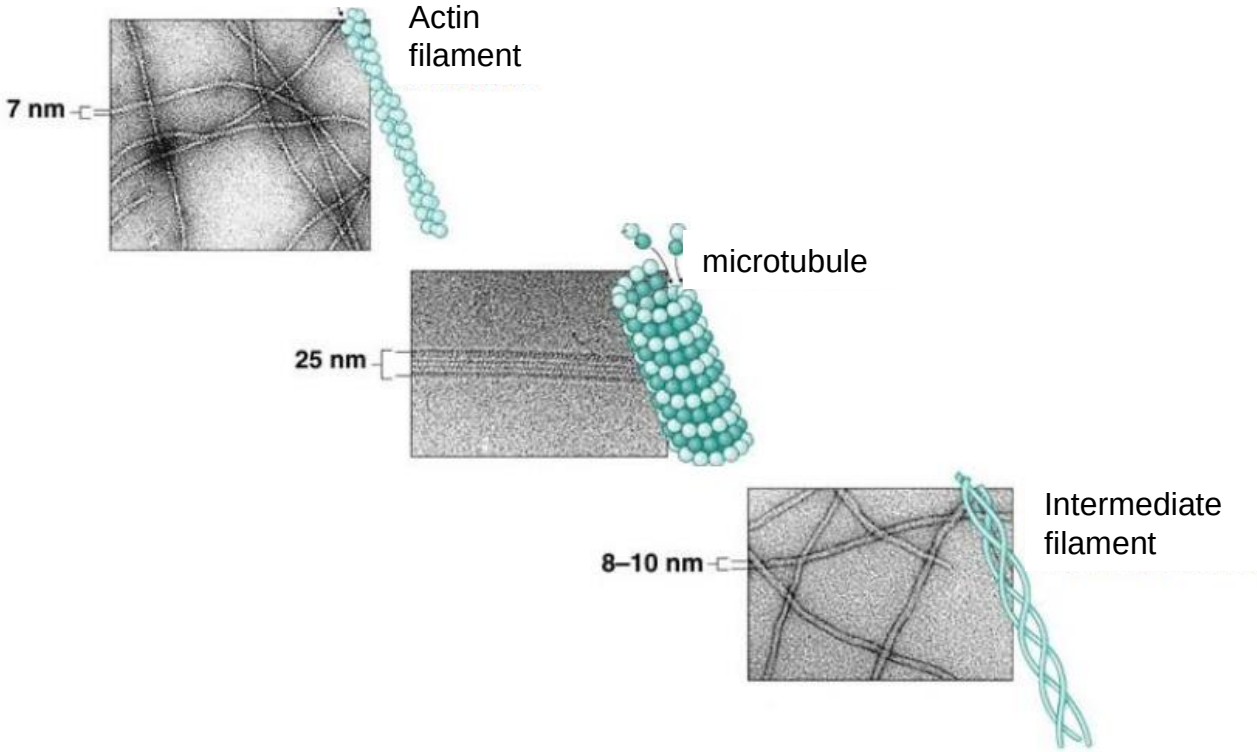
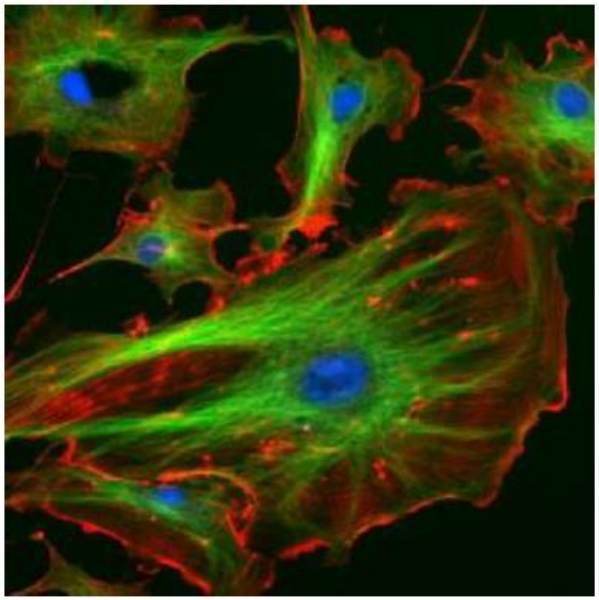
Basics about cellular biology

Stéphane Avril
IMWS
TU Wien
stephane.avril@tuwien.ac.at

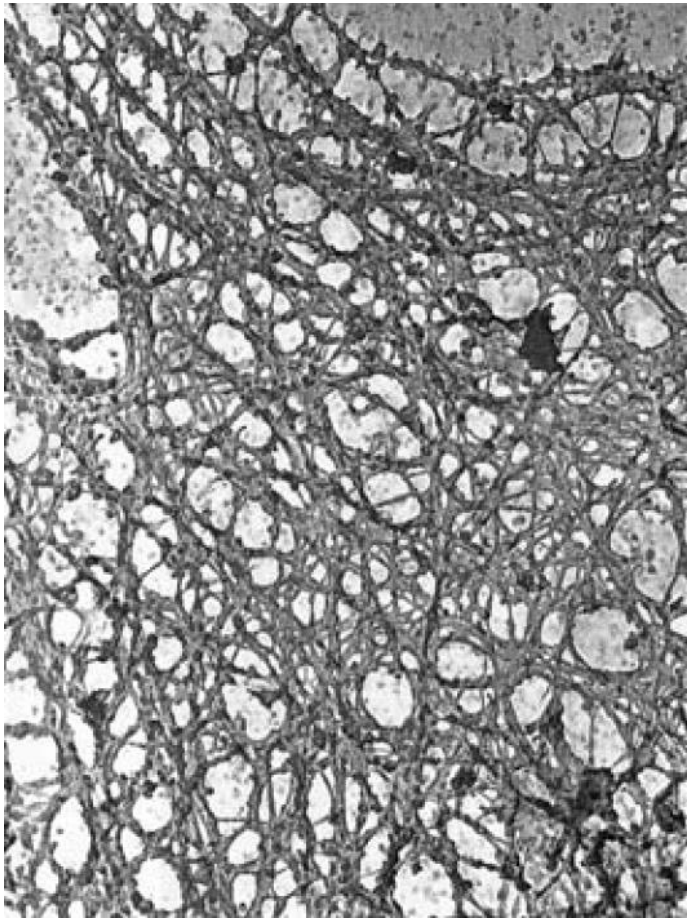
For the structure

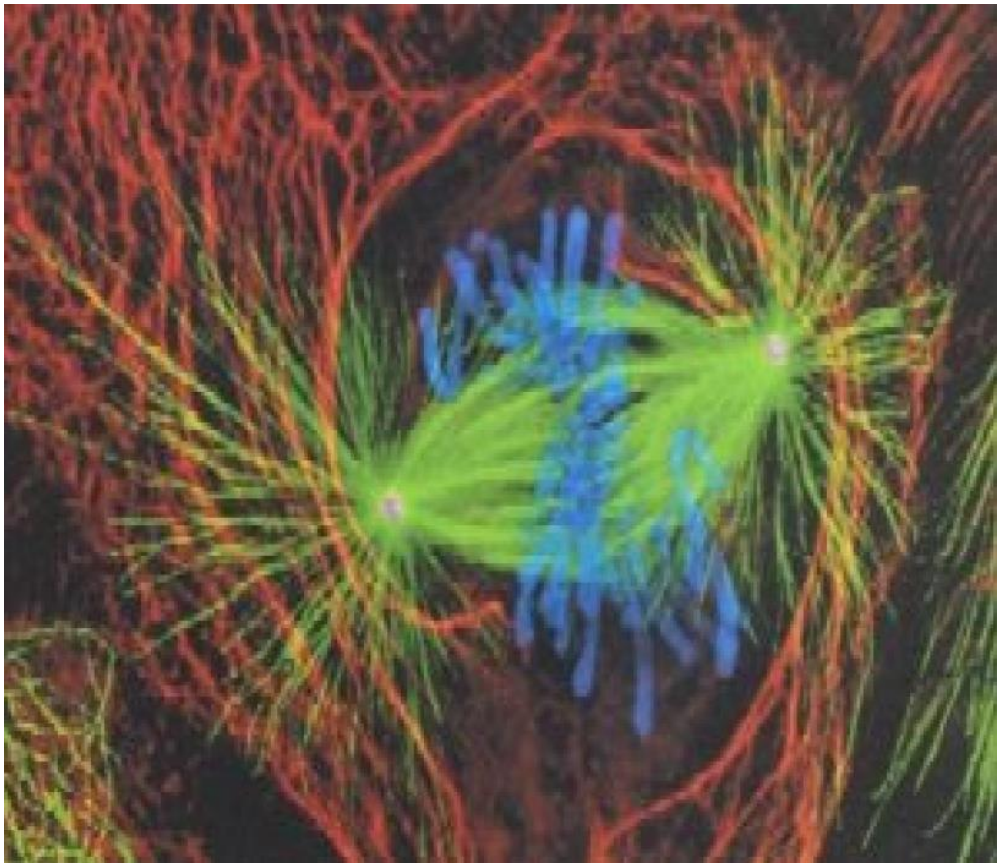
The **cytoskeleton** is a complex, dynamic network of interlinking protein filaments present in the cytoplasm of all cells, including bacteria and archaea. It extends from the cell nucleus to the cell membrane and is composed of similar proteins in the various organisms.
In eukaryotes, it is composed of three main components, microfilaments, intermediate filaments and microtubules, and these are all capable of rapid growth or disassembly dependent on the cell's requirements





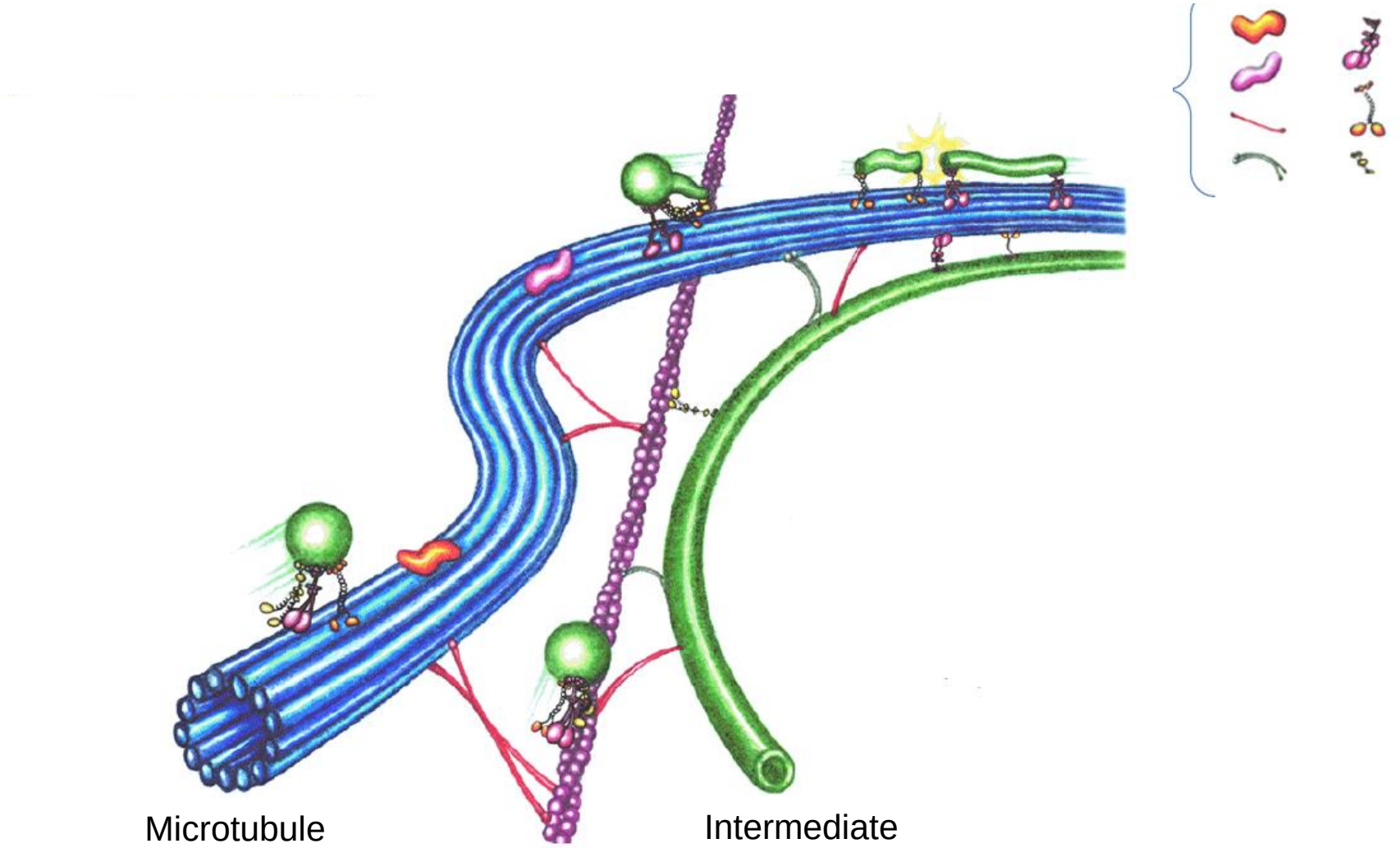
In blue, the nucleus. In green, microtubules, In red, the actin filaments,





Polymers organized in networks, beams or ropes depending on the roles they fill.(bridging proteins, connection, depolymerizing proteins, anchoring proteins ...)

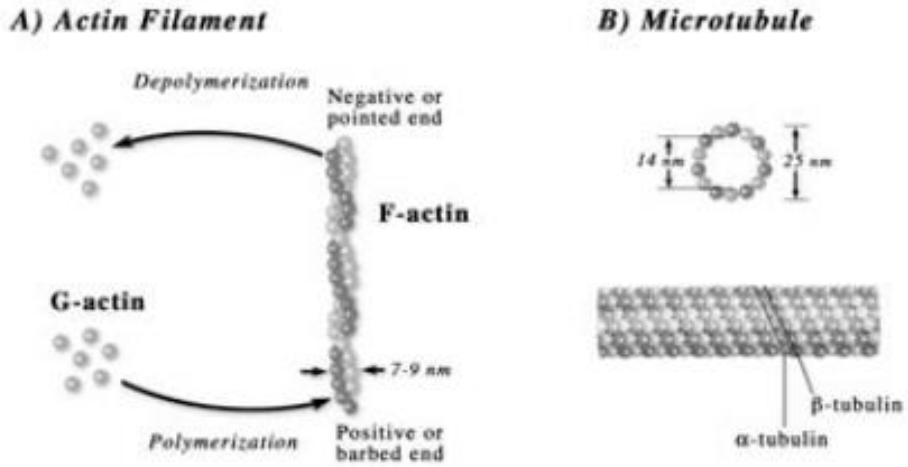
High level of organization

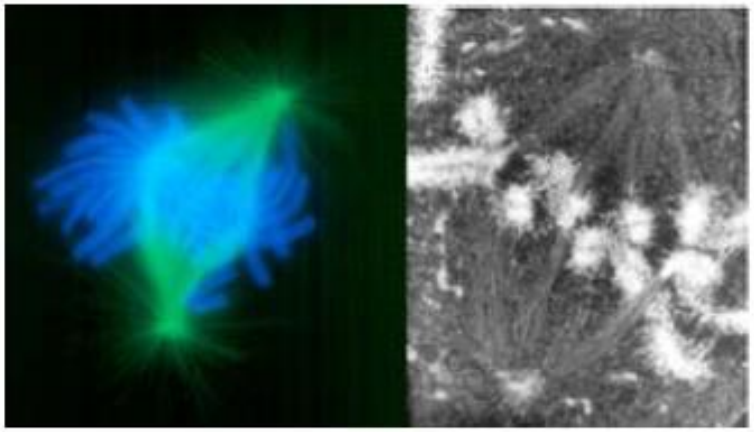


Microtubule

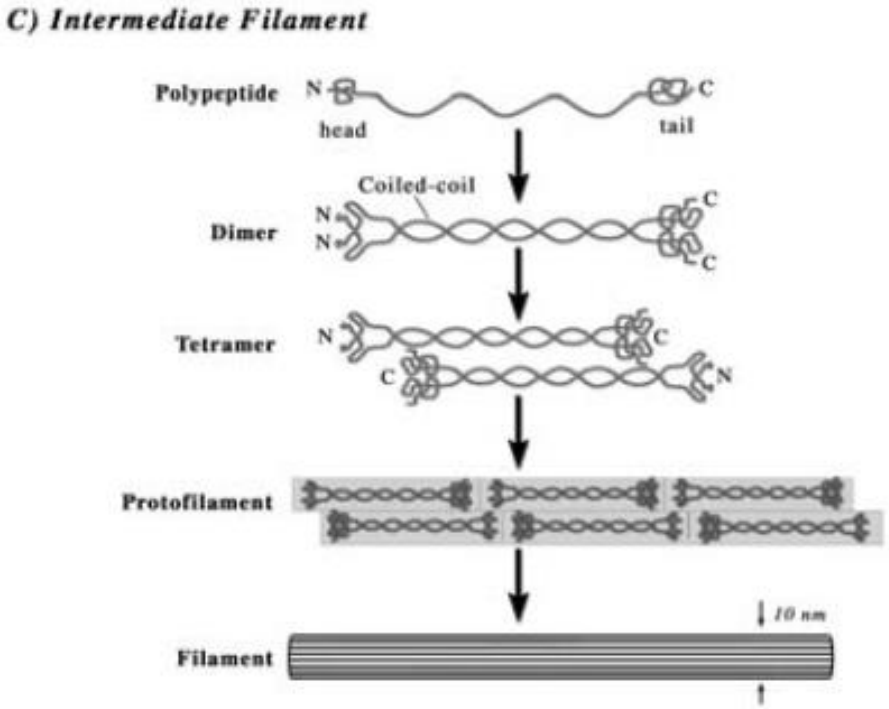
Actine filament

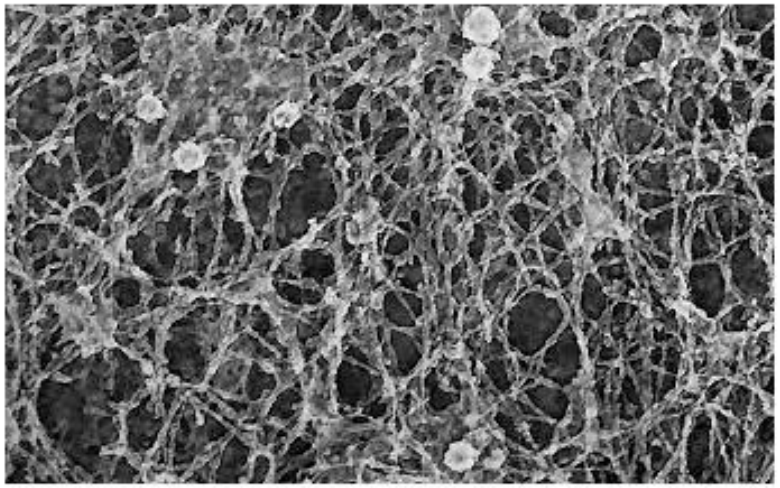
Intermediate filament



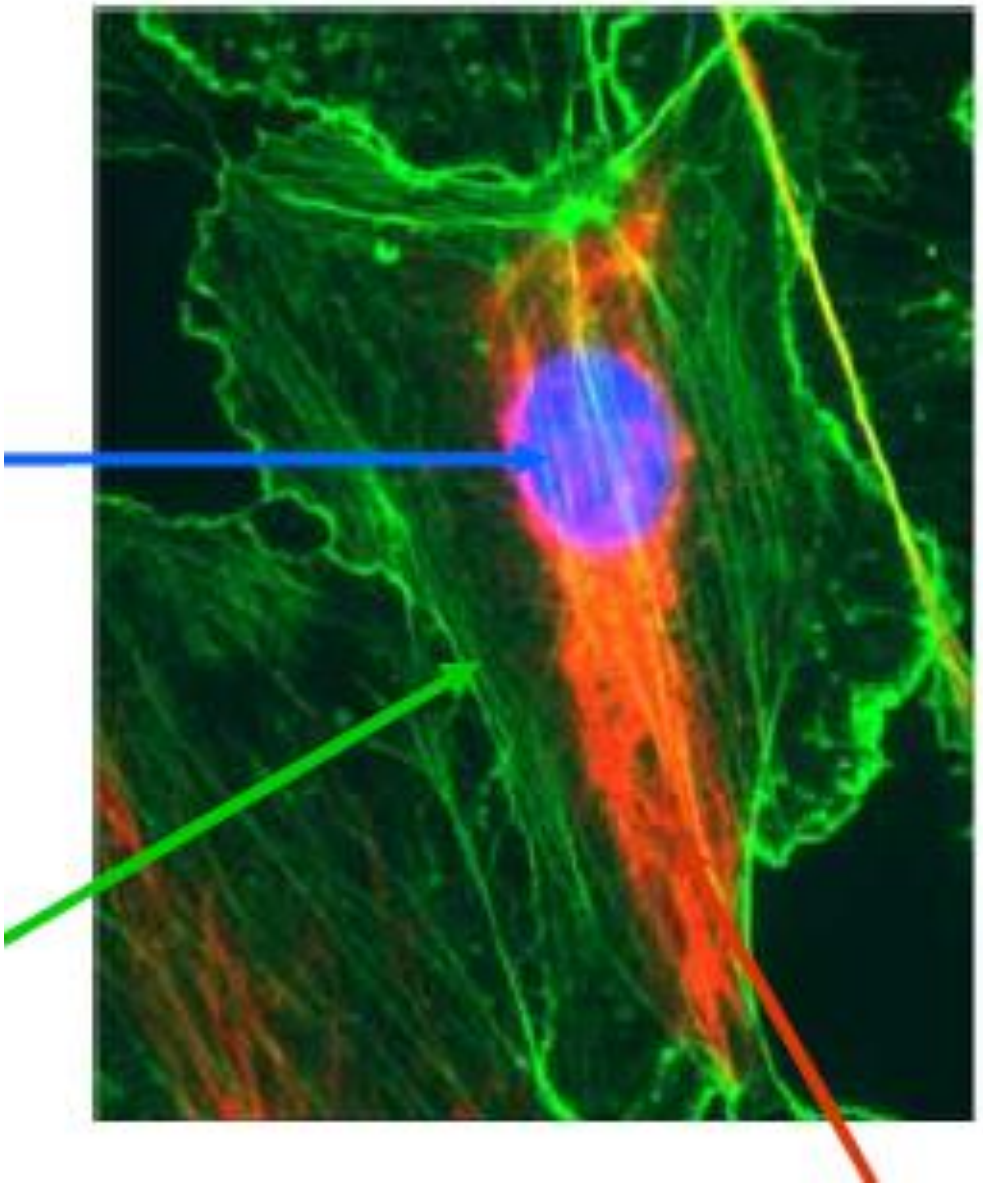


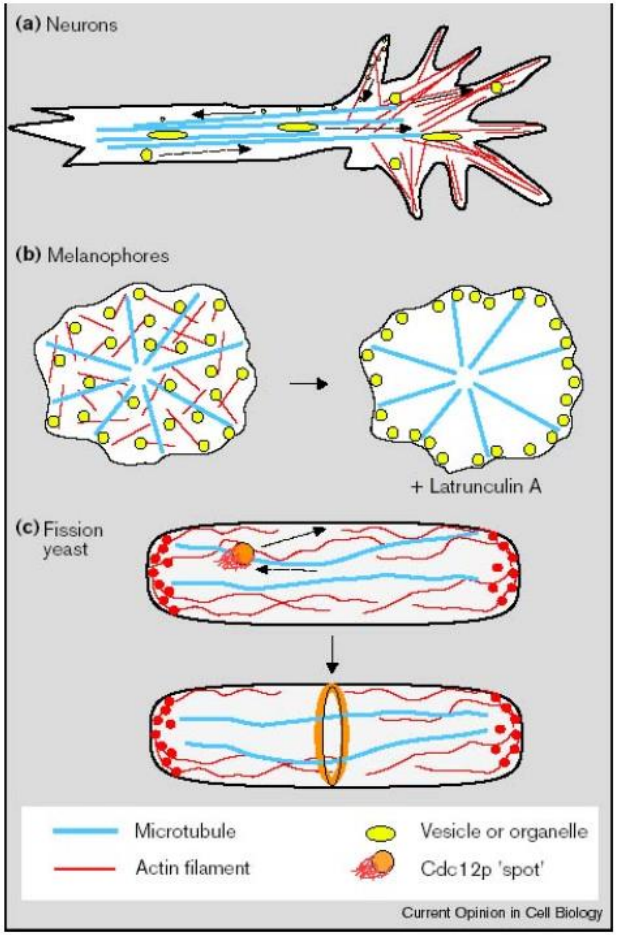
[Reproduced from C. Rieder, http://www.wadsworth.org/BMS/SCBlinks/WEB_MIT2/res_mit.htm]

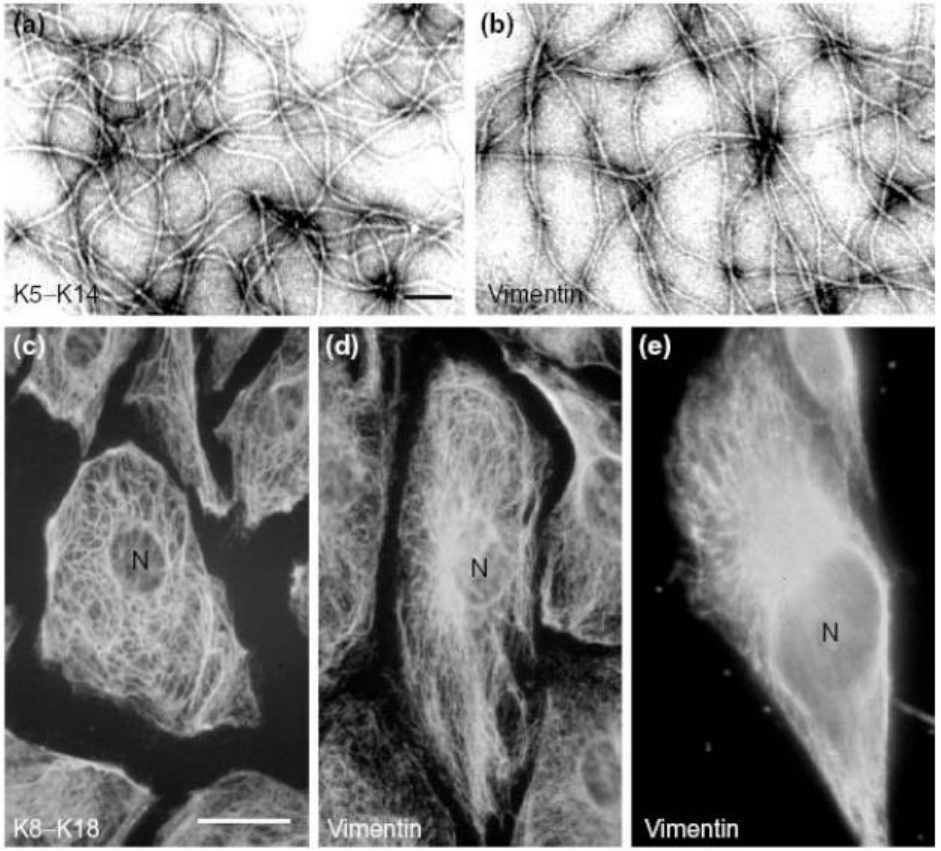




J. Hartiwick


NUCLEUS
MICROFILAMENTS
INTERMEDIATE FILAMENTS

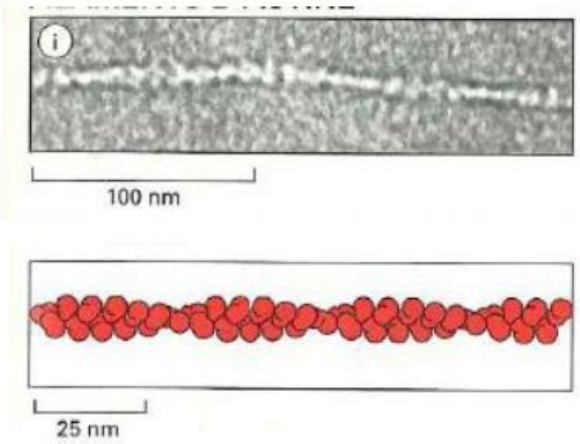


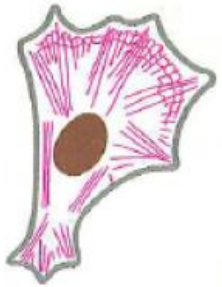


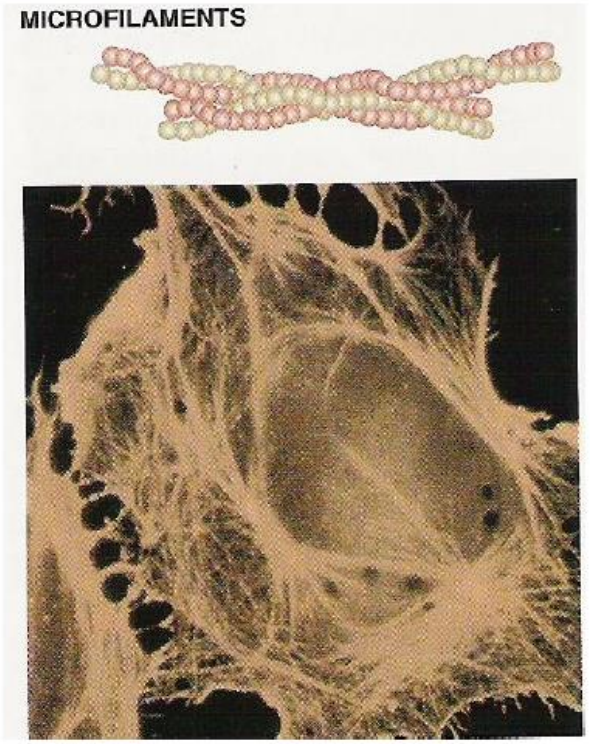
microtubules

Intermediate filaments

Microfilaments or actin filaments: 2-stranded helical polymers.
Flexible structures of 5-9 nm diameter, 17 µm long.

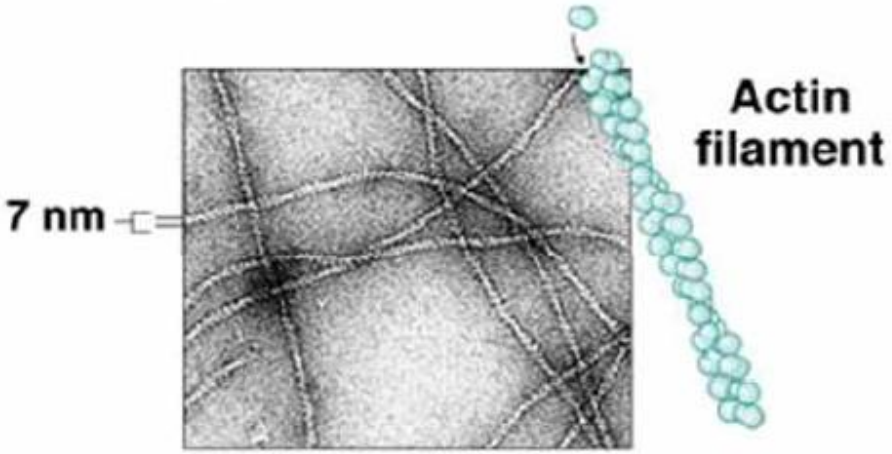


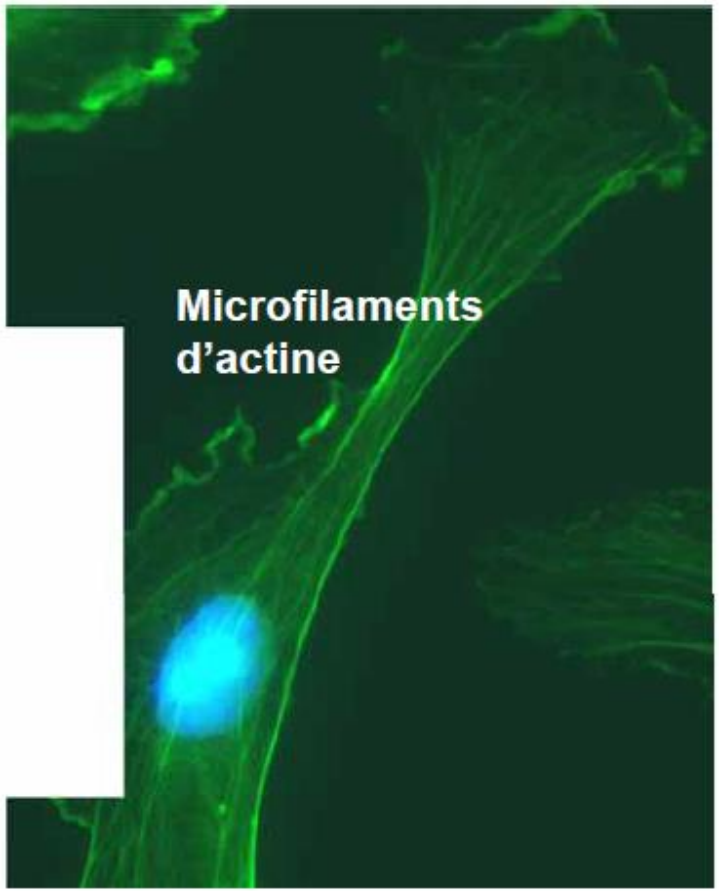




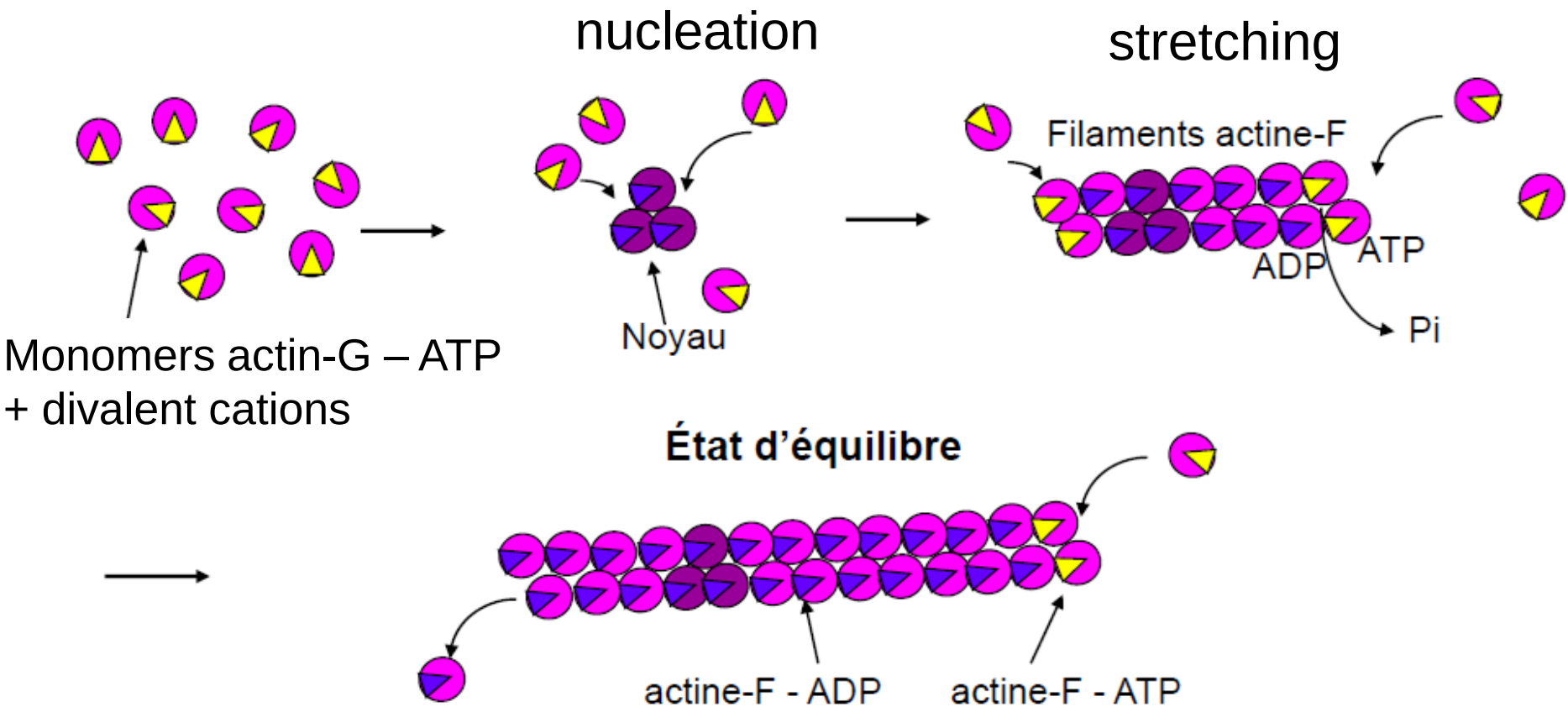
They are oriented (asymmetry of actin monomers and their propeller assembly): one of the extremities (+) polymerized much faster than the other (-)
➔ polarized filaments.

STRUCTURE OF MICROFILAMENTS



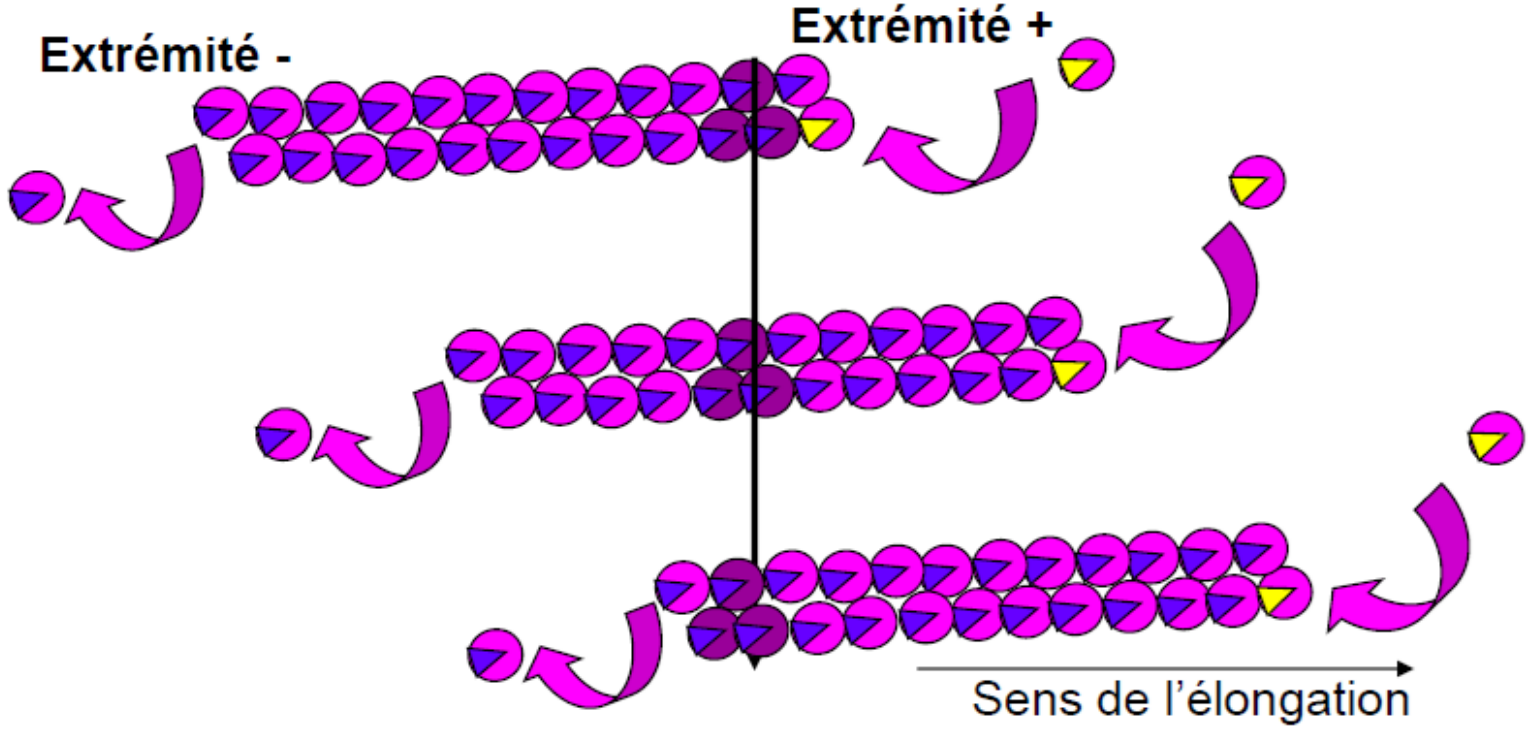


POLYMERIZATION OF ACTIN FILAMENTS

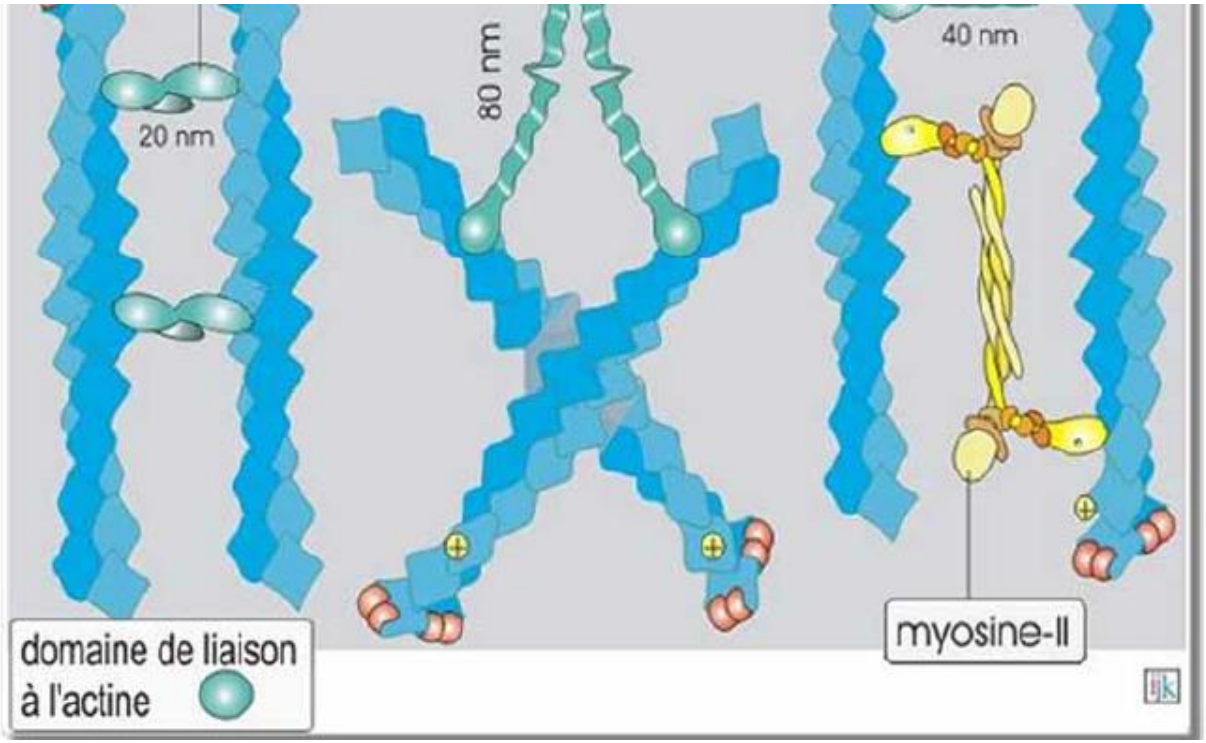


treadmilling

Cc- (0,8µM)> C actine-G > Cc+ (0,1µM)

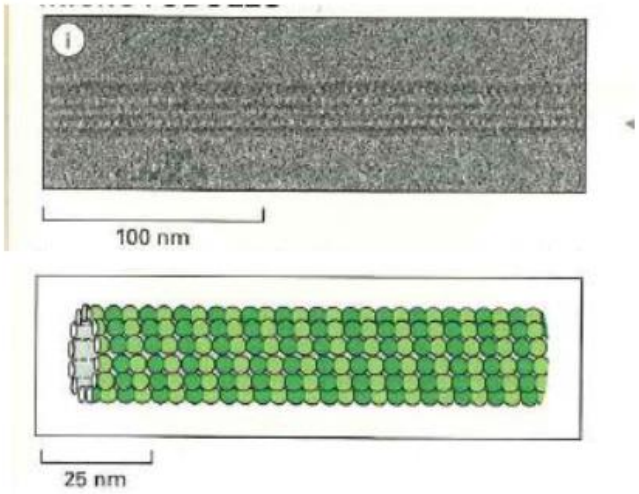


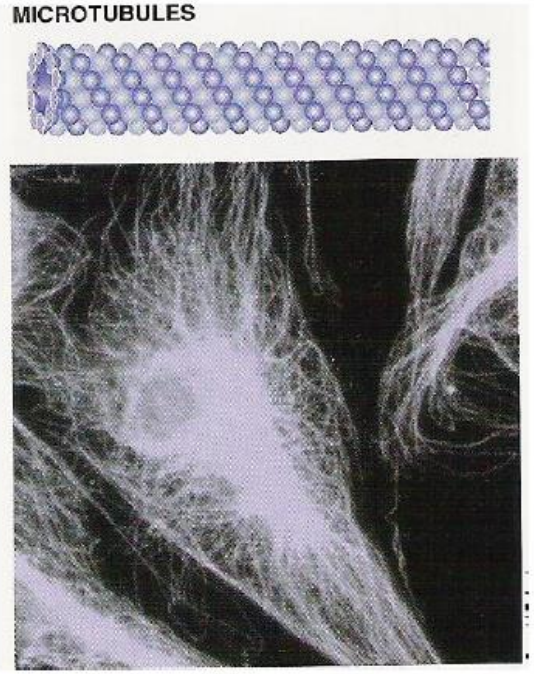
STRUCTURE OF ACTIN FILAMENTS IN THE CELL



Microtubules: long hollow cylinders made up of several tubulin filaments (usually 13). Each filament consists of two tubulin (α and β).

➔ External 25 nm, several mm long.

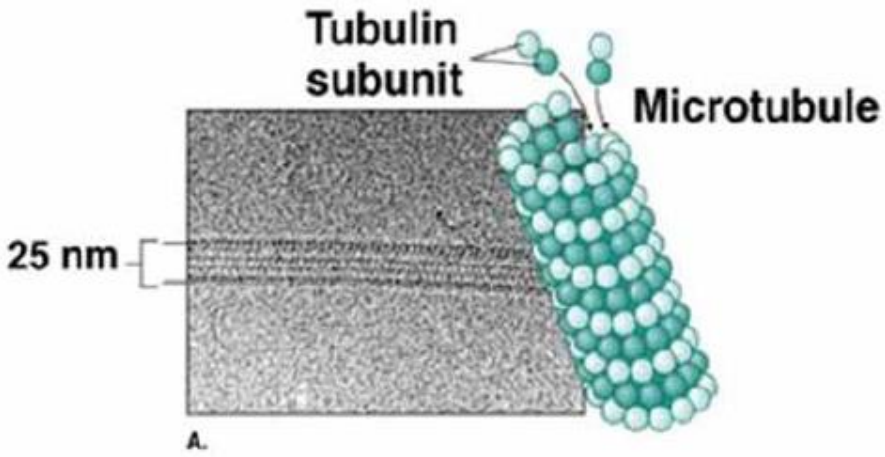


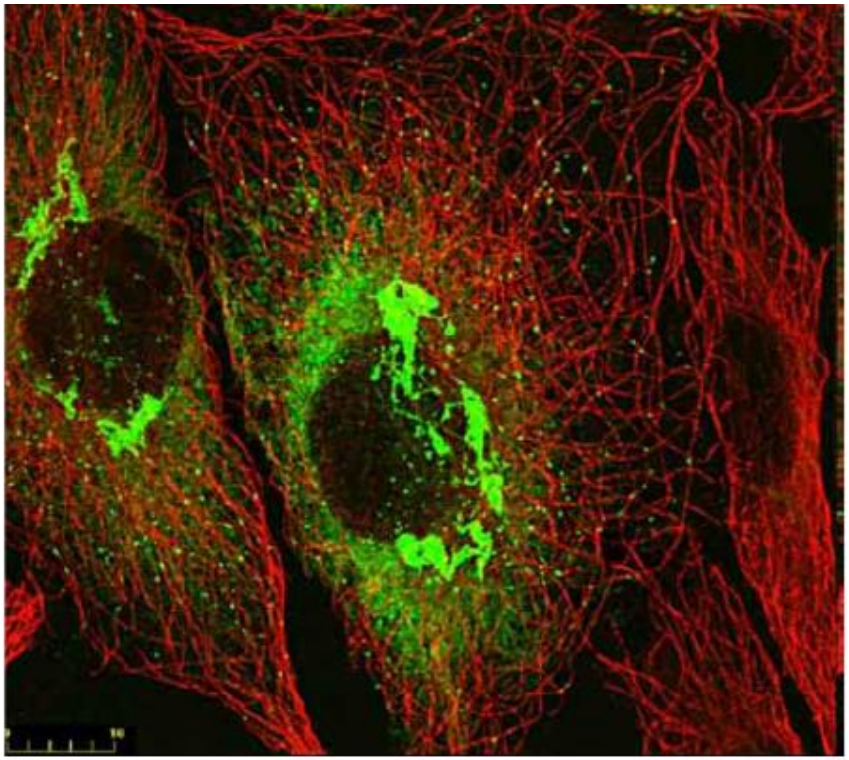


One of their end attached to the centrosome (organizer center of microtubules).
Polarized filaments.
The most rigid constituents of the cytoskeleton.

Dynamic instability that can lead to a very brutal shortening of a microtube, which can be at the origin of an important force.

STRUCTURE OF MICROTUBULES

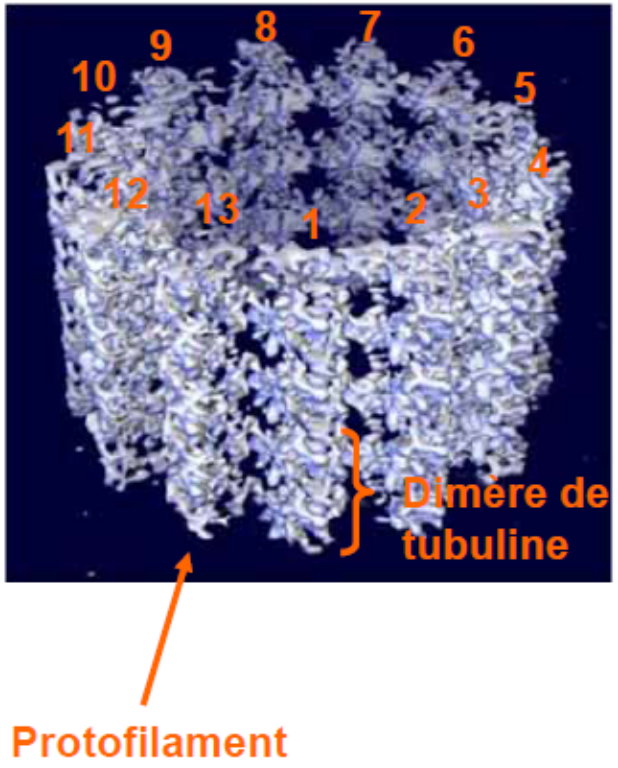




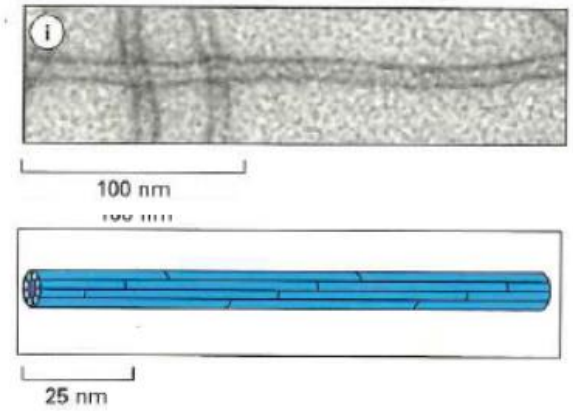
Laboratoire de génomique fonctionnelle, Montpellier
© Vincent Hombureger-CNRS

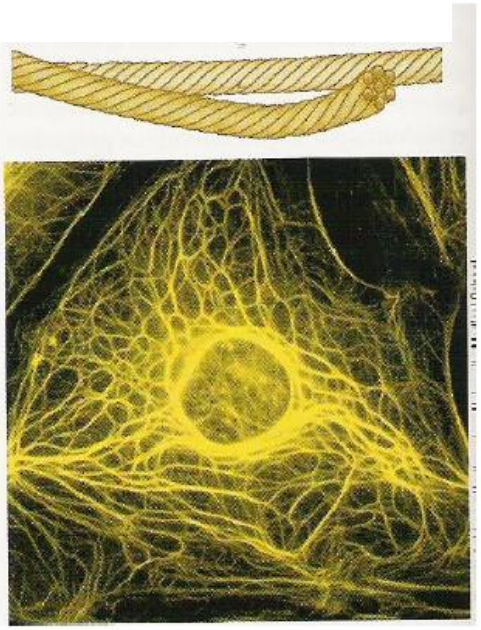
STRUCTURE OF MICROTUBULES

They are hollow cylindrical fibers obtained by assembling 13 protofilaments which are composed of tubuline dimers stacked together



Intermediate filaments: rope fibers of 10 nm diameter approx. Intermediate size between microfilaments and microtubules.

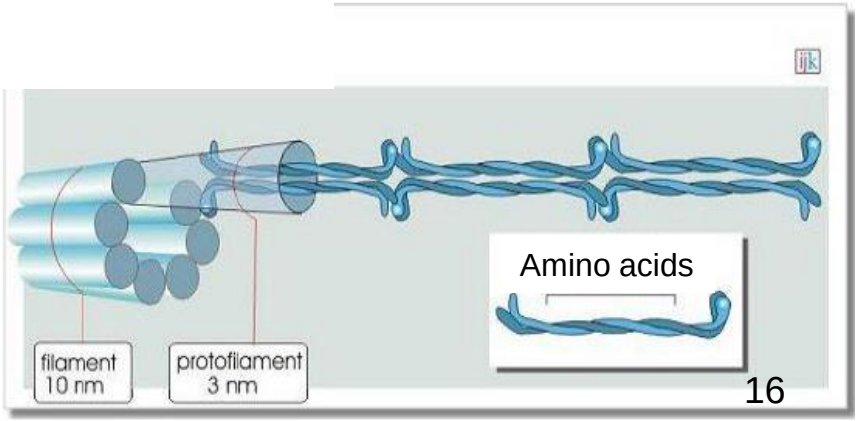




The least dynamic elements of the cytoskeleton.
The most resistant (important for the non-polarized nucleus structure).
Allow the anchorage of the organelles.

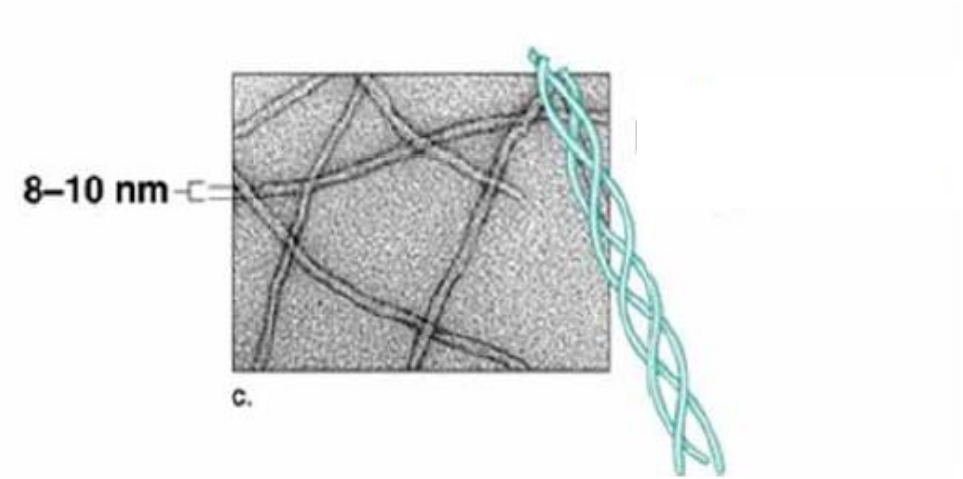
Different types :

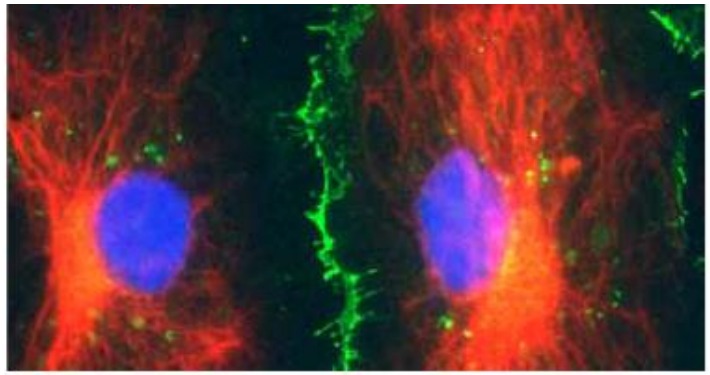
- keratin (epidermal cells, hair, hair, nails ...)
- Desmin (muscle cells)
- Lamin (nuclear lamina)



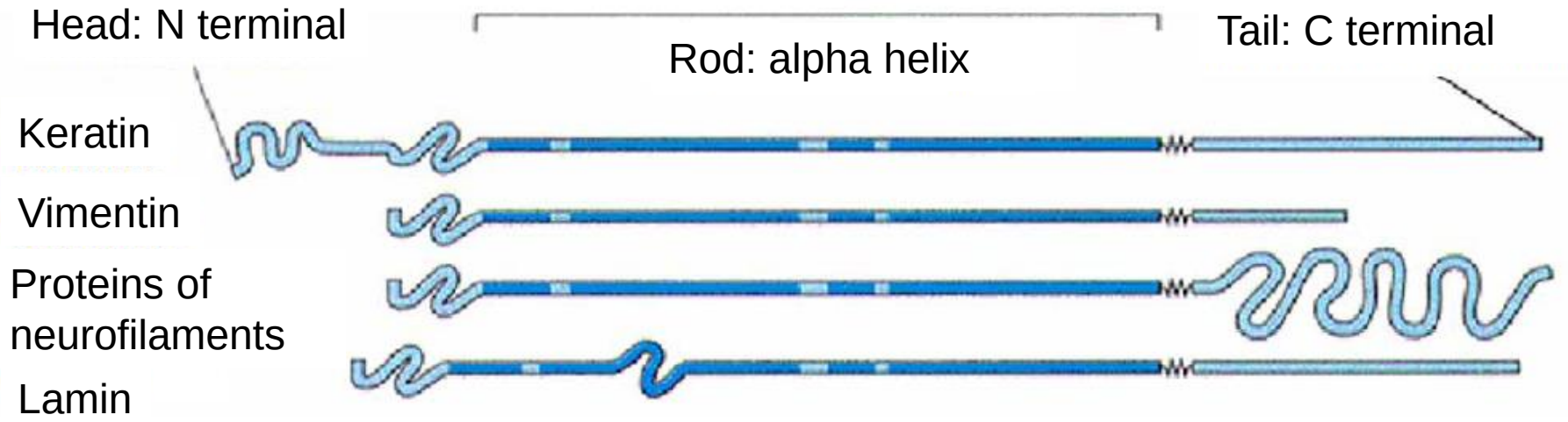
STRUCTURE OF INTERMEDIATE FILAMENTS

Intermediate filaments of 10nm: fibers composed of different proteins



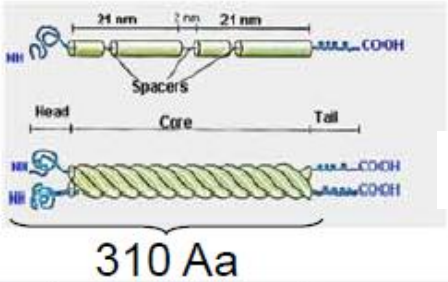


MONOMERS COMPOSING INTERMEDIATE FILAMENTS



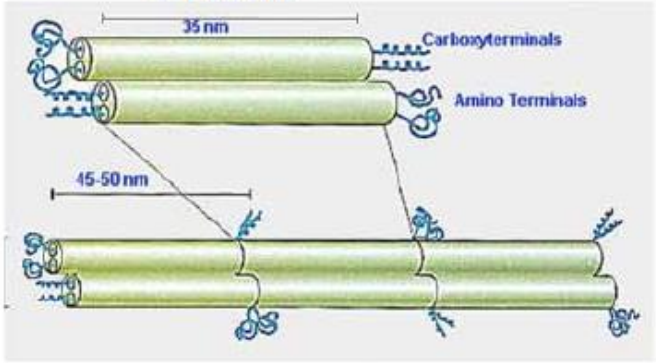
The monomer is at least 45nm long, and very thin (2-3nm)
Spontaneous assembling, no polarity

ASSEMBLING OF INTERMEDIATE FILAMENTS



Monomer

Coiled coil dimer



Antiparallel tetramer = base of intermediate filament

Several tetramers making a protofilament of 3nm diameter

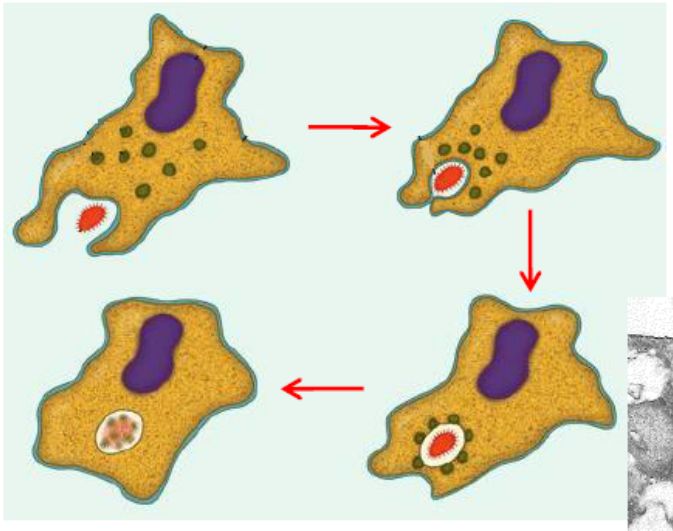
Protofibril made of several protofilaments

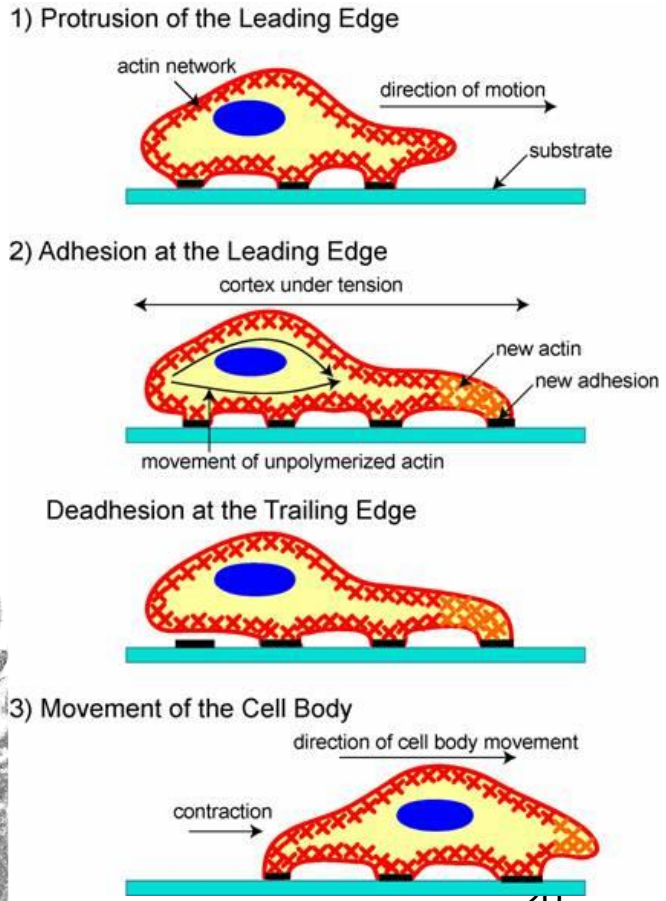
Intermediate filament: helix made of 8 teramers: 10nm diameter

Function of the cytoskeleton

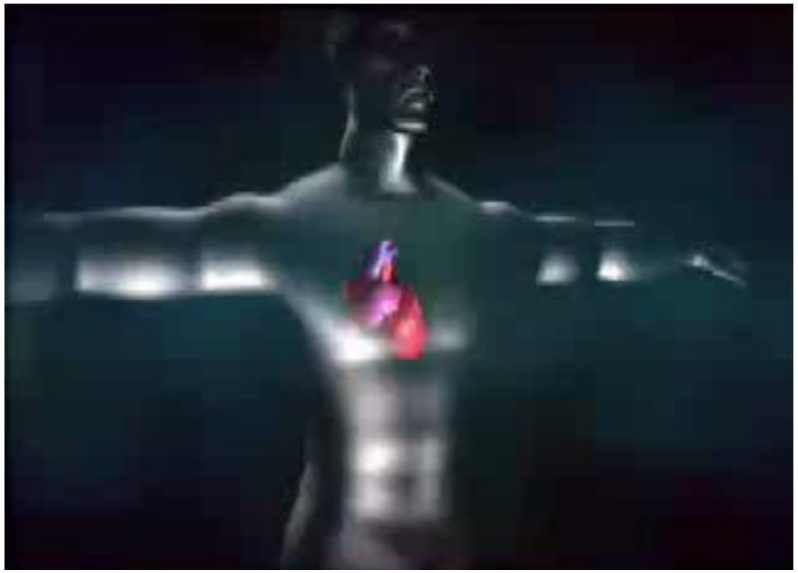
Structural role:
- Regulation of the shape of the cell.
- Maintenance of the internal structure, cellular compartments.
- anchoring to neighboring cell membranes.

Cellular movement:
- Migration cell.
- Formation of pseudopods for phagocytosis.

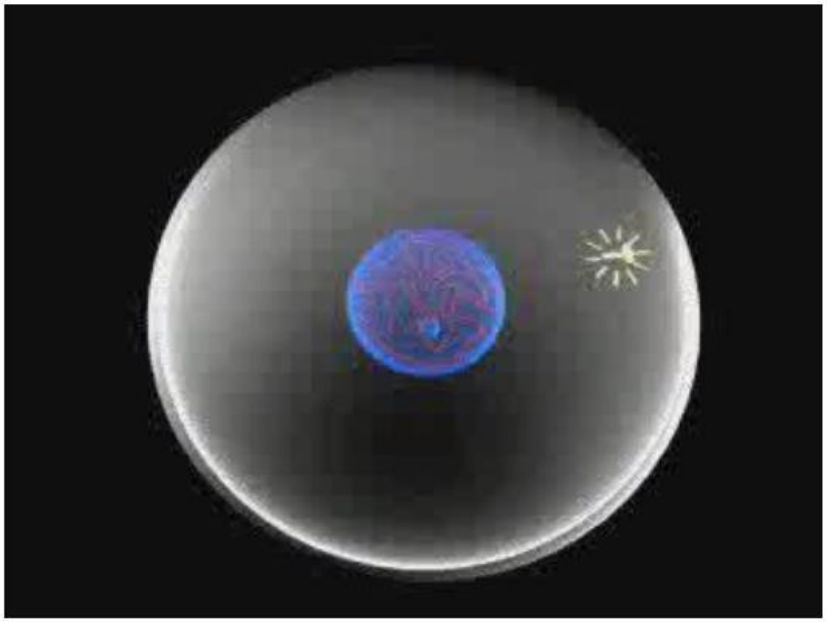




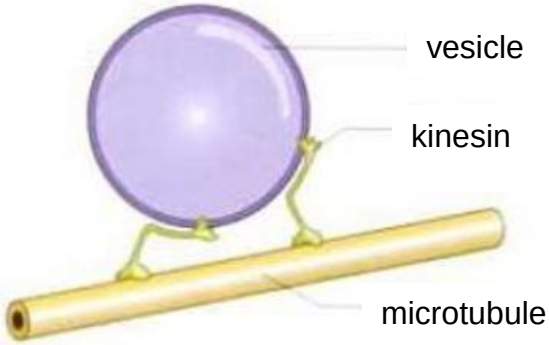
- Contraction of muscle cells

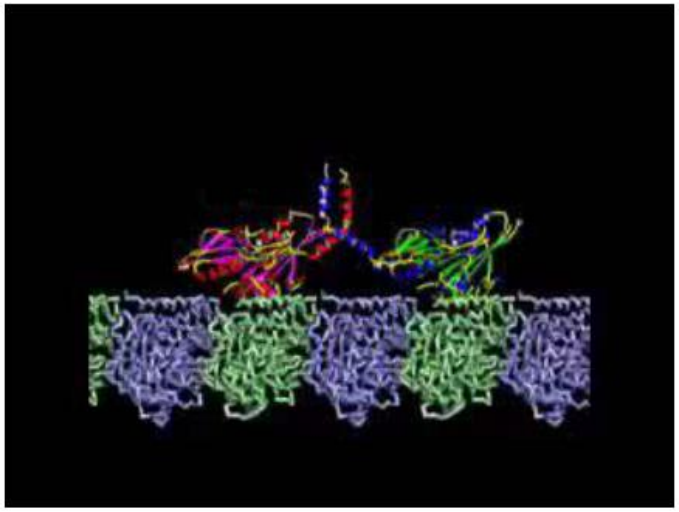


- Intracellular transport
  separation of chromosomes during mitosis



- Transport of cytoplasmic vesicles

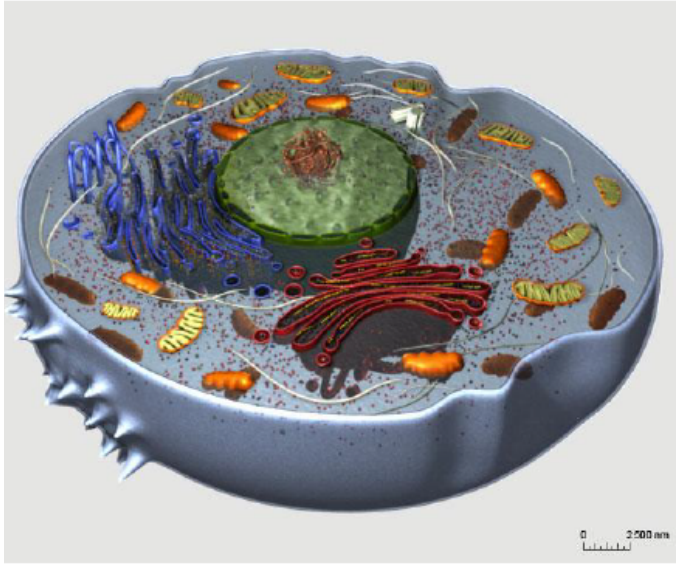




In general, all cells have the same organisms, but according to their role in the body (of their specialization), they are more or less developed (more or less apparent).

Examples:

Pancreatic cells: production of digestive enzymes
➔ large Golgi apparatus



Lymphocytes B: Antibody production
➔ large endoplasmic reticulum

Hepatic cells: Detexification of blood
➔ large piroxysomas

Leukocyte cells: elimination of microorganisms
➔ large lysosomes

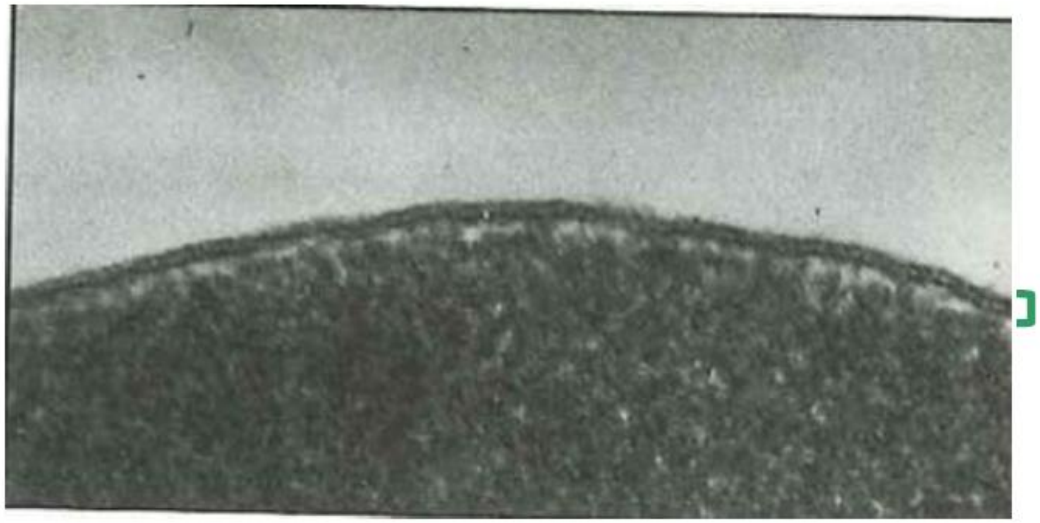
Muscle cells: contraction of muscle
➔ developed cytoskeleton (actin and myosin)

Nerve cells: transport of neurotransmitter vesicles
➔ developed cytoskeleton (tubulin)

The cell membrane

Envelope that acts as a selective barrier between cytoplasm and extracellular medium.

Without plasmic membrane, the cell could not maintain its ordered chemical system integrity.



Cell membrane

5 or 6 nm thick

Composition: lipids and proteins

The lipid bilayer

3 main types of membrane lipids:

- Phospholipids (the most numerous)
- Cholesterol
- Glycolipids

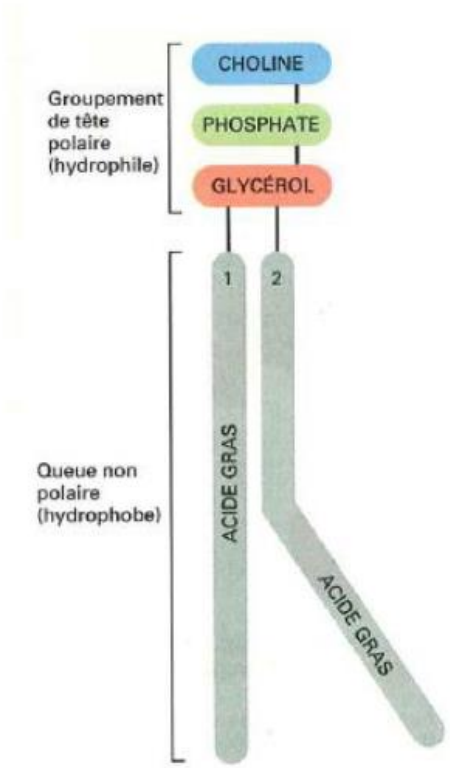
Structure of lipids :

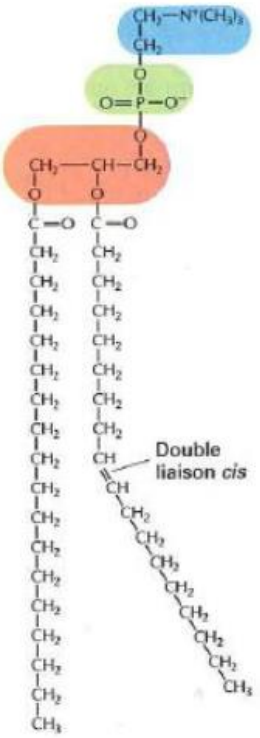
Polar head

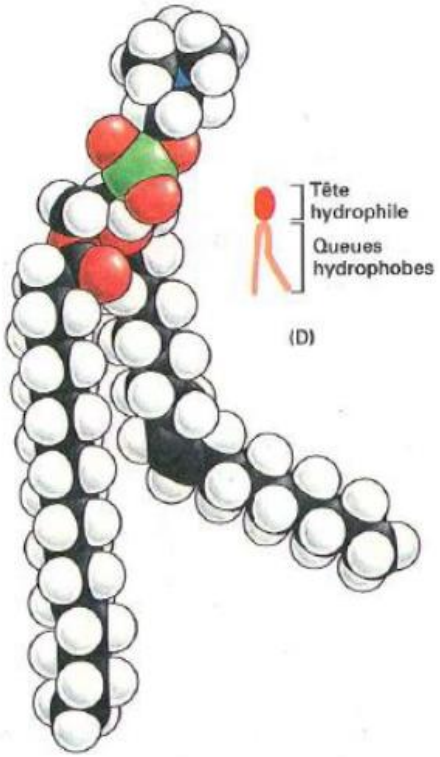
hydrophilic

2 hydrocarbon tails
Fatty acid

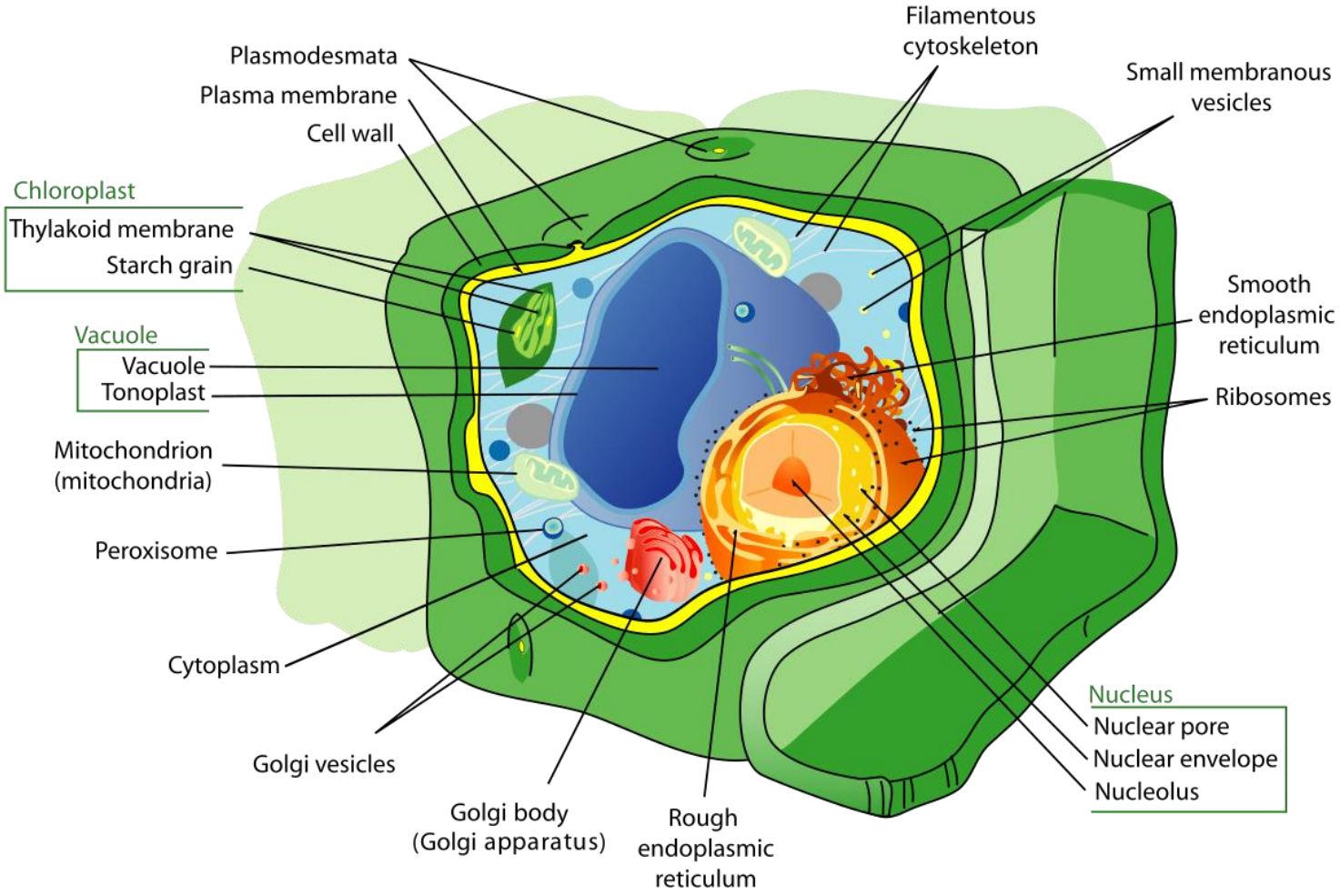
hydrophobic







Structure of plant eukaryote cell



Plastids are found in plants and algae.

The best known are **chloroplasts**, in the cells of photosynthetic organisms, which convert light energy into chemical energy used to make sugars from carbon dioxide.

They also have their own genome.

In plants, algae and fungi, the cell is surrounded by a **pectocellulosic cell wall** which provides the body with a skeleton. Deposits of compounds such as suberin or lignin modulate the physicochemical properties of the wall, making it more solid or more impermeable.

Layout

I. Definition and general presentation of the cell.

II. The main cellular structures.

III. The origin of cells.

IV. The different cellular organizations.

V. Cellular homeostasis.

VI. Structure of the eukaryotic cell:

1. Animal:

a. The organelles.

b. The membrane.

2. Plants.

VII. Genetic information.

DNA = Deoxyribonucleic acid

phosphate

Sugar
desoxyribose

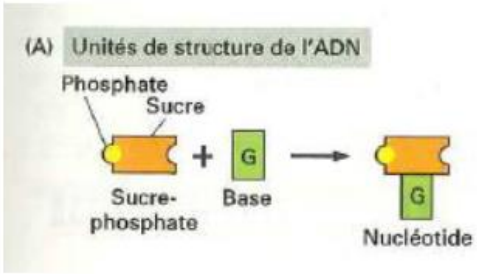
base

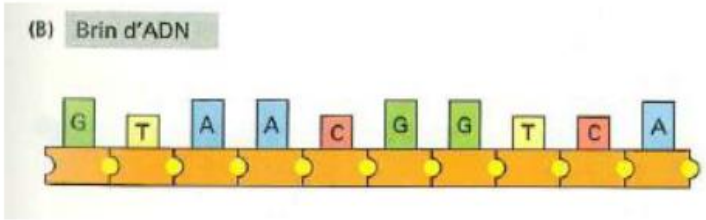
A= Adénine
T= Thymine
C= Cytosine
G= Guanine

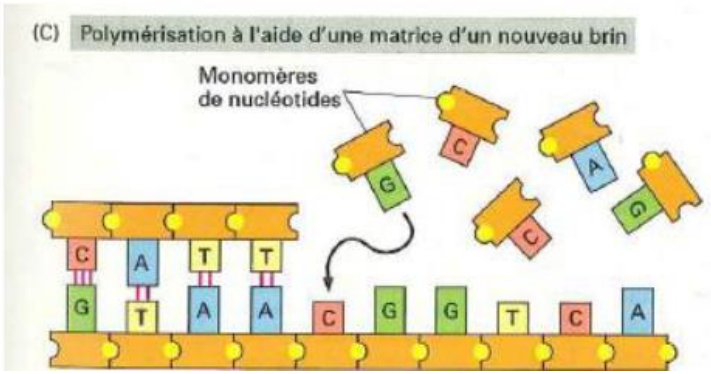
Unité de base

Brin d'ADN

Double brin d'ADN

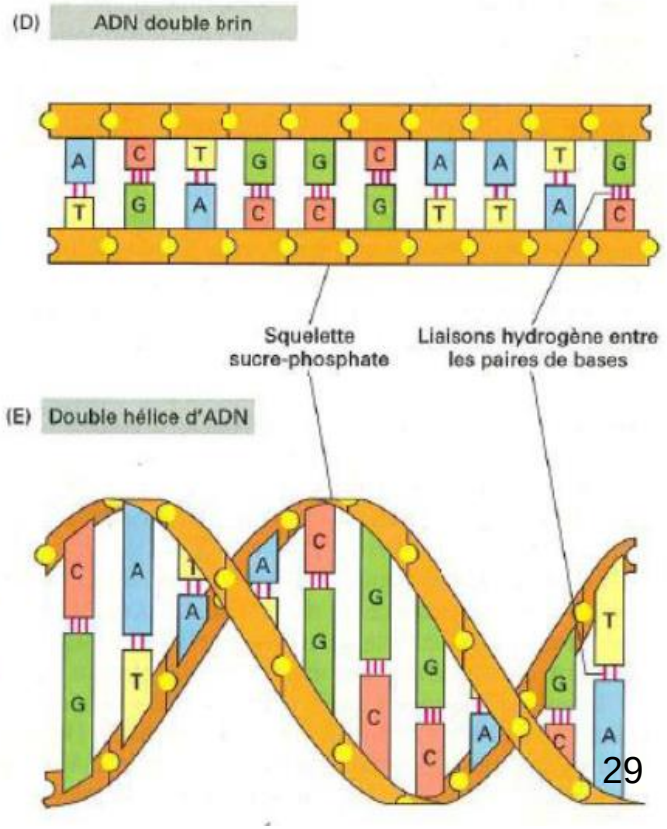






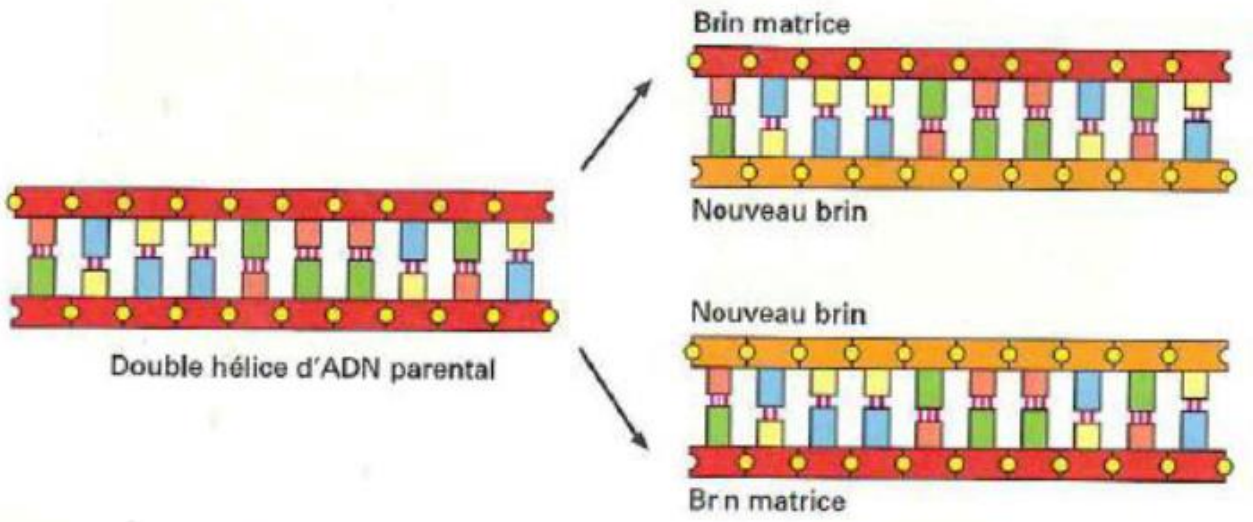
Double brin d'ADN

Double hélice d'ADN

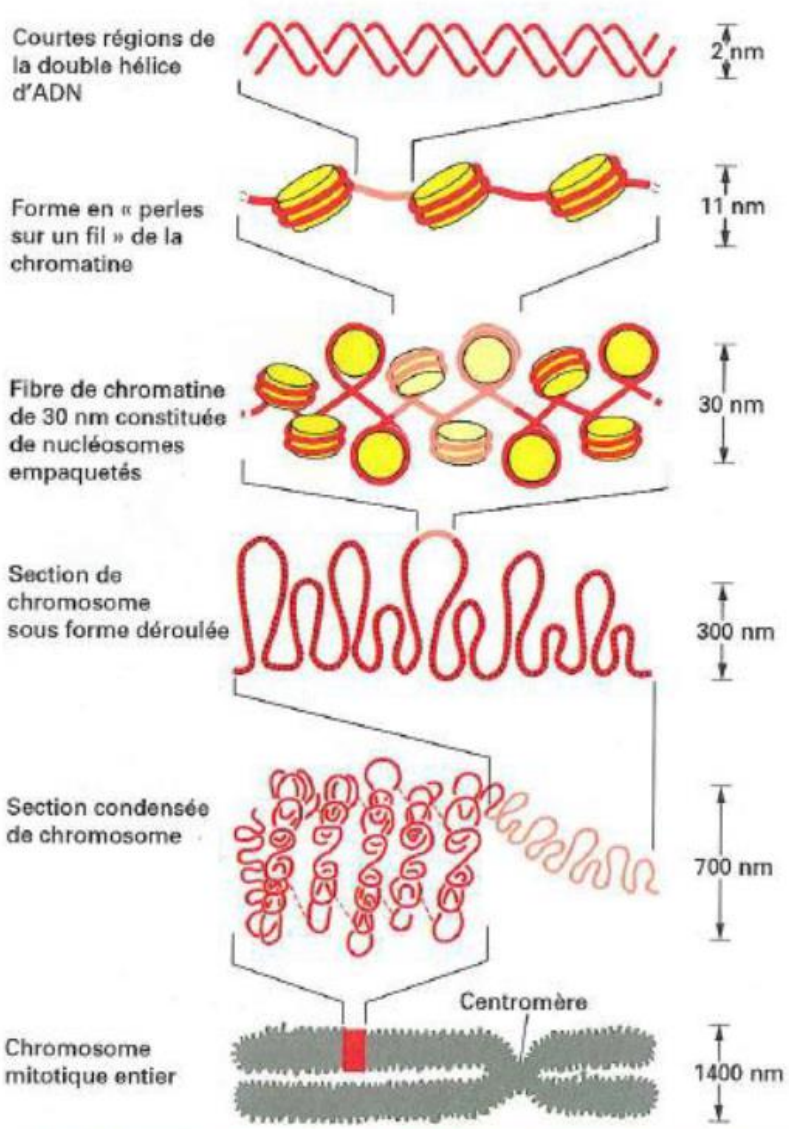


- Duplication of genetic information by reppling DNA:

➔ polymerization using a matrix.



Each cell contains 2 m of DNA. The nucleus measures 6 µm diameter
➔ compaction of the DNA with proteins



RÉSULTAT NET : CHAQUE MOLÉCULE D'ADN A ÉTÉ EMPAQUETÉE DANS UN CHROMOSOME MITOTIQUE QUI EST 10 000 FOIS PLUS COURT QUE SA LONGUEUR DÉROULÉE

23 pairs of chromosomes

22 paires de chromosomes homologues

1 paire de chromosomes sexuels
XX ou XY.