Biophysics Seminar

(Mechanics of motor proteins and the cytoskeleton)

Chapter 7

Structure of Cytoskeletal Filaments

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Outline

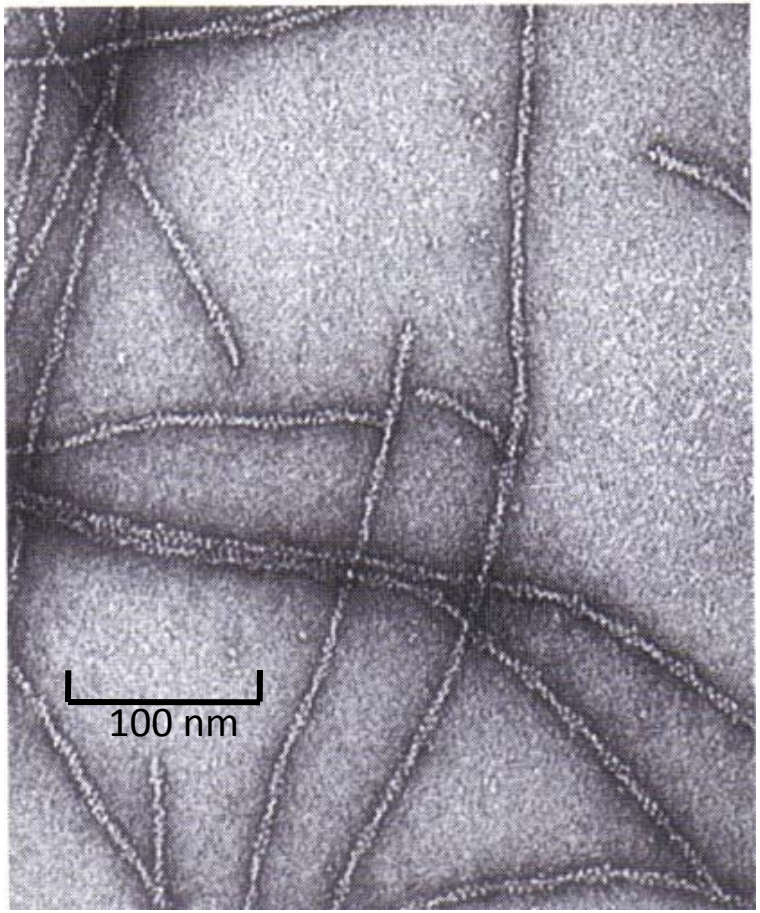
- Introduction
- Structure of subunits
- Families of cytoskeletal proteins

❑ Introduction

Three major classes of cytoskeletal filaments:

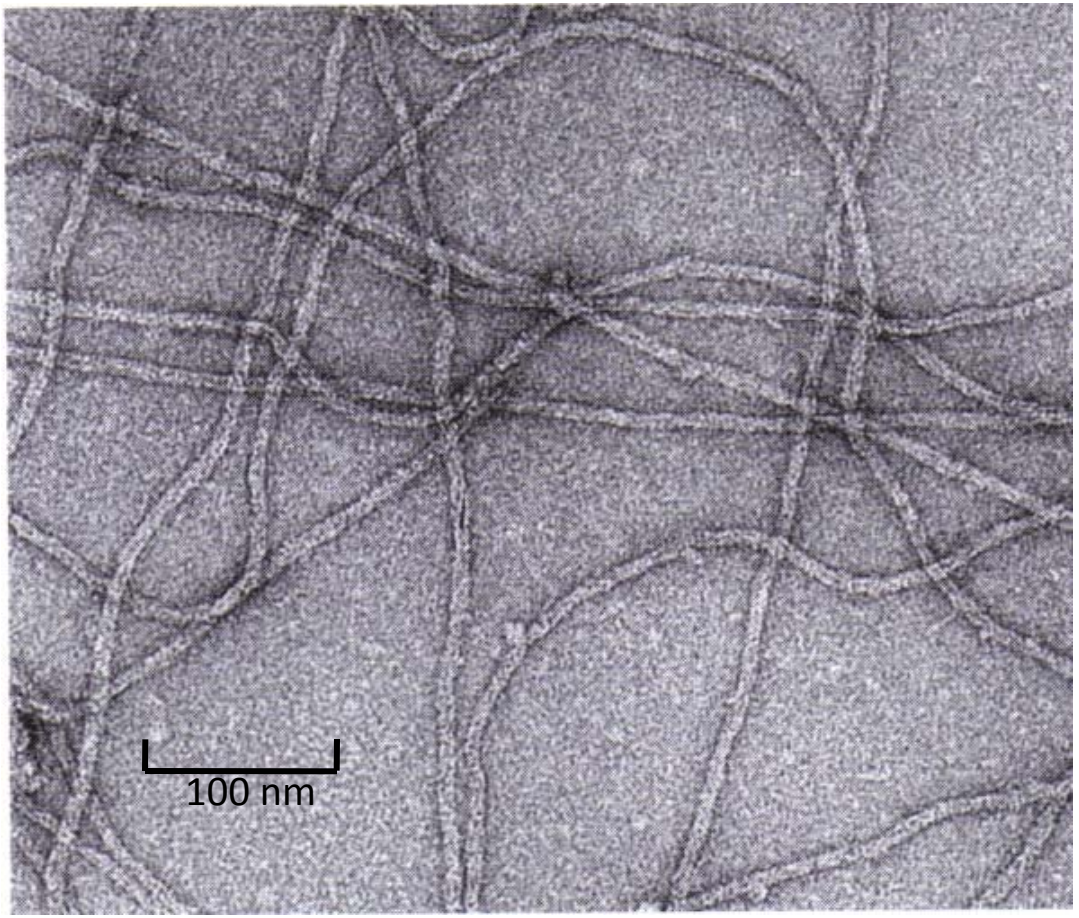
- Actin filaments (microfilaments) → Cable-like
- Intermediate filaments → Rope-like
- Microtubules → Pipe-like

Actin filaments:

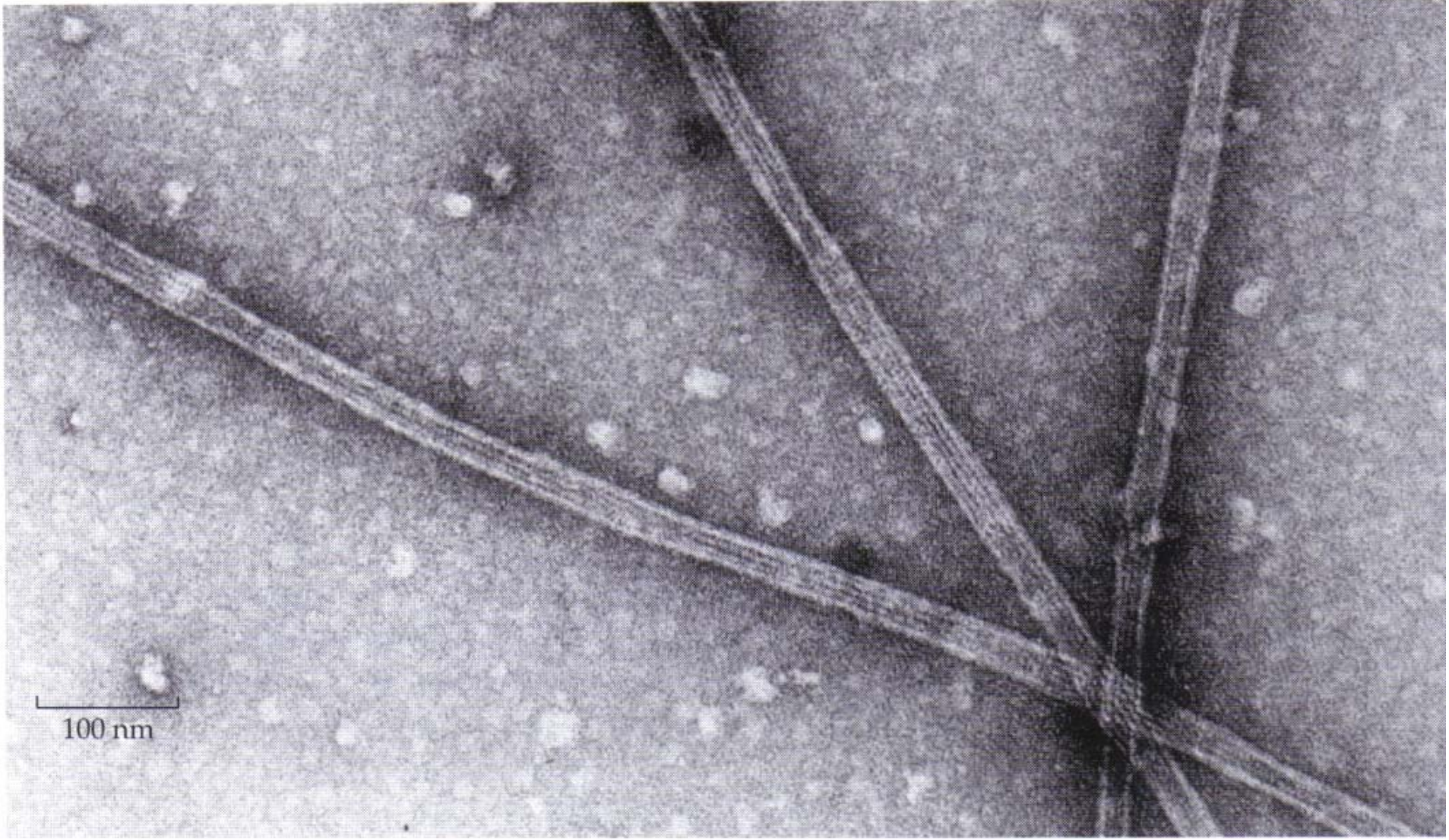


- Diameter: ~ 6nm
- Characteristic helical repeat period: 36nm (Apparent period).

Intermediate filaments:



- Diameter: ~ 10 nm
- have greater curvature, indicating that they are more flexible



Microtubules:

- Diameter: ~ 25nm

Table 7.1 Properties of the cytoskeletal proteins and filaments

Material	Molecular mass of subunits (kDa)	Number of protofilaments Average	Range[a]	Diameter (nm)	Cross-sectional area (nm^2)[b]
Actin	45	2	2	6	19
Tubulin	50	1–3	9–17	25	200
Intermediate filaments	40–180	8	6–10	~10	~60
Coiled coil	—	2	2	2	1.9

[a] Tubulin (Wade and Chretien, 1993); intermediate filaments (Heins et al., 1993).

[b] Assuming a density of 1.2 nm^3 per 1 kDa of protein, or a volume per amino acid of 0.14 nm^3.

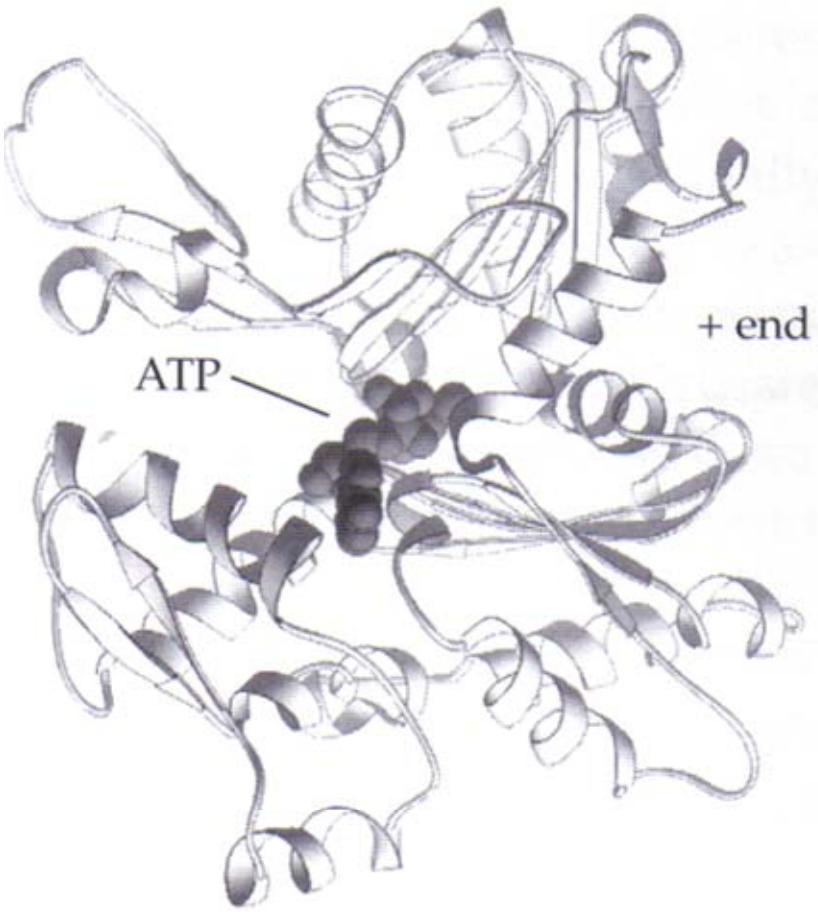
❑ Structure of subunits

- Actin filaments → Actin monomer
- Intermediate filaments → Intermediate filament dime
- Microtubules → αβ tubulin heterodimer

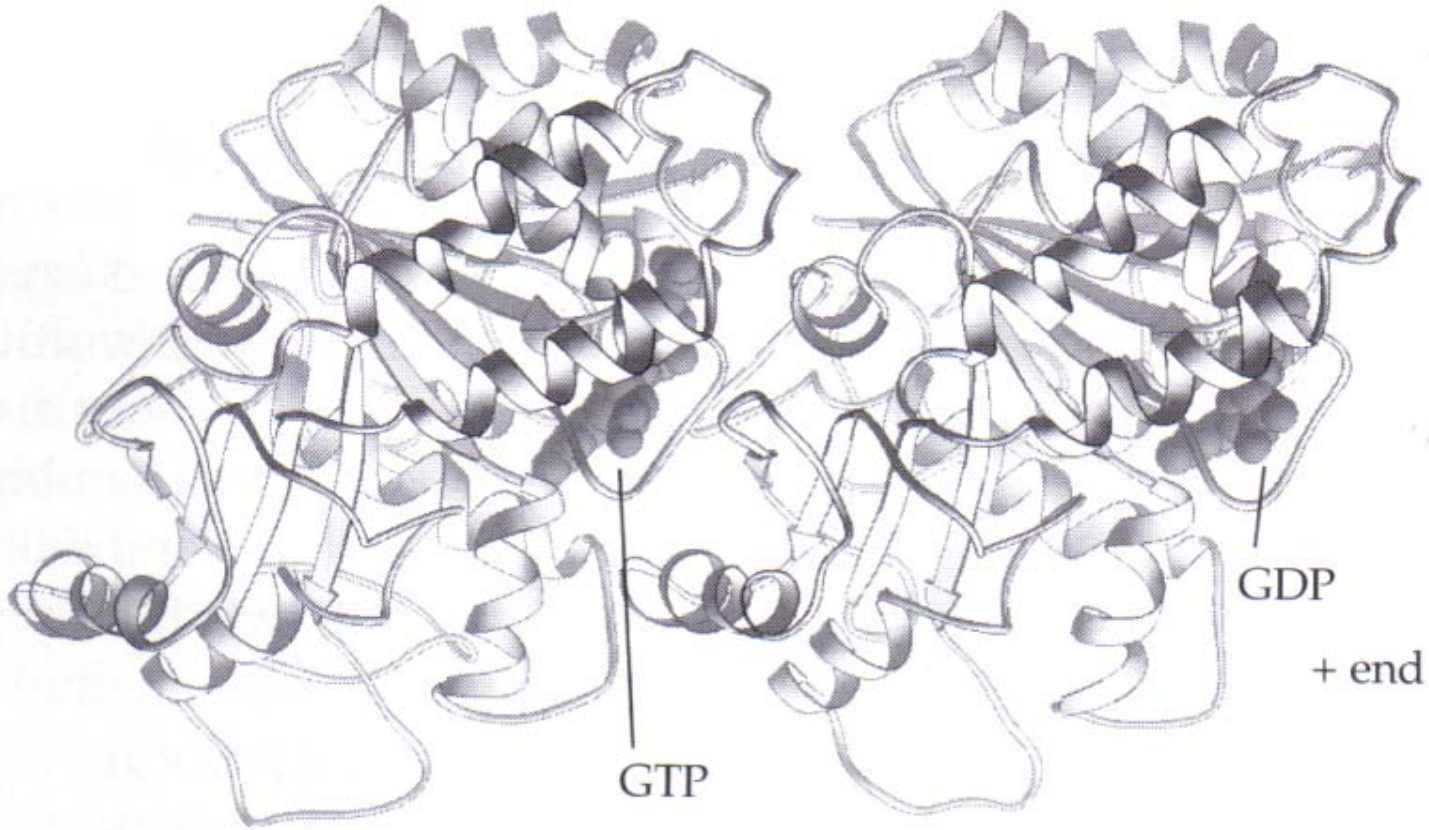
Structure of actin:

The structure of the actin monomer from skeletal muscle, elucidated by x-ray crystallography

- A globular protein
- Contains a deep cleft

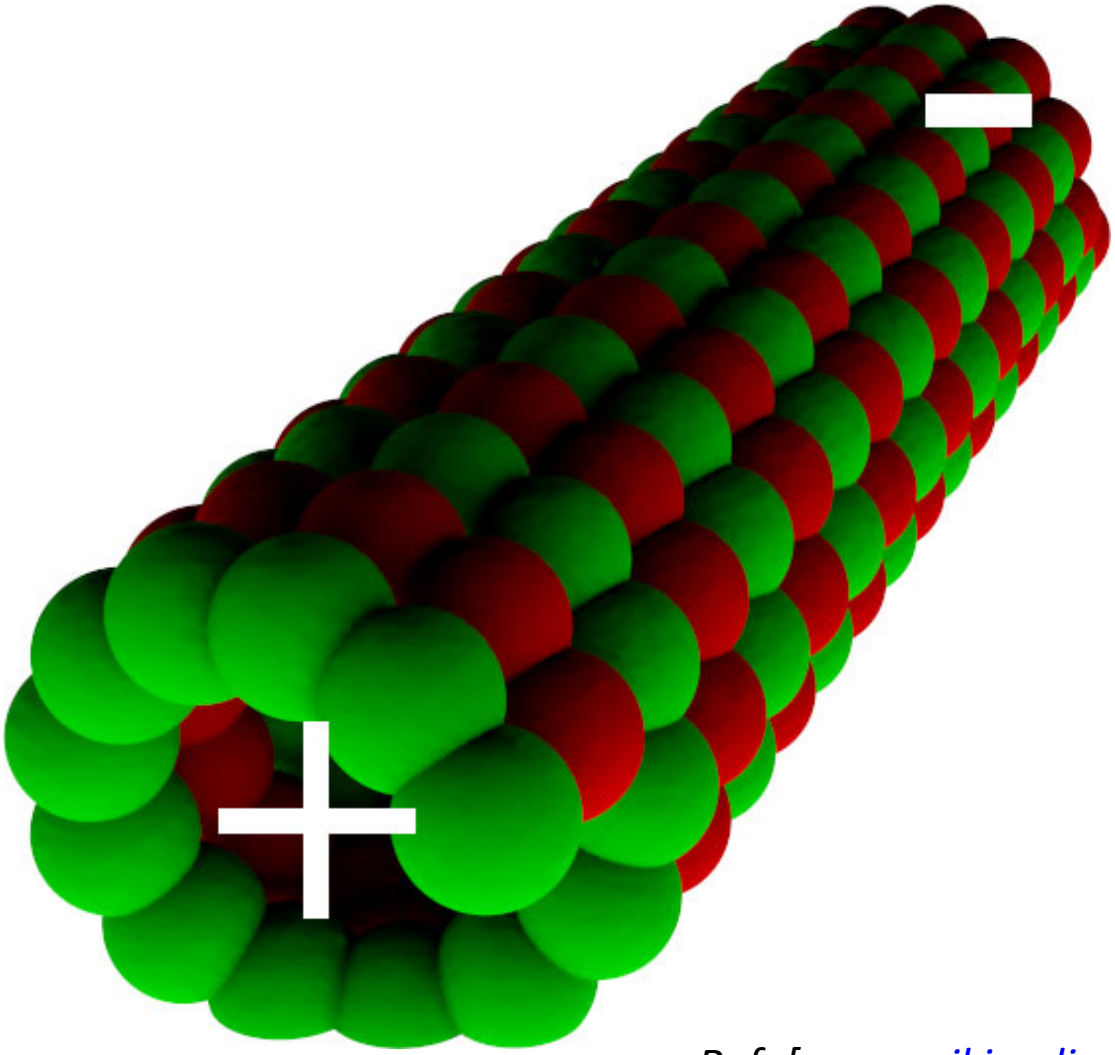


Structure of tubulin:



The structure of the αβ–tubulin dimer from brain determined by electron microscopy

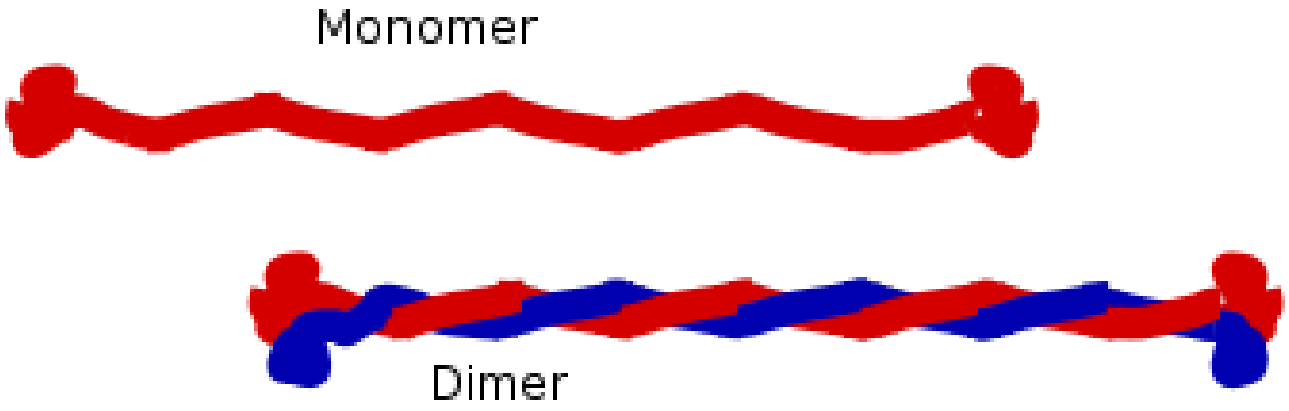
- The tubulin dimer is also globular.
- It has translational symmetry



Ref. [www.wikipedia.com]

Structure of intermediate filaments:

- Intermediate filament proteins are highly elongated.
- Each monomer is a long α-helix
- They do not bind nucleotides.



Ref. [www.wikipedia.com]

❑ Families of cytoskeletal proteins

What do we actually mean with "**actin**", "**tubulin**", and "**intermediate**" family proteins?

Sources of protein variation:

I. Genetic polymorphism of individuals within one species

The nucleotide sequence of a particular gene may vary from individual to individual. As a consequence, the encoded protein may vary in amino acid sequence. They do the same thing but they are not necessarily composed of the same things.

II. Genetic variations between species

Individuals from different species have similar organization of their genes. The genes are called orthologous and the encoded proteins are called orthologues proteins. When they have both the same organization and function between species, they are called homologues.

III. Gene duplication within individuals

When one species has two or more different genes located at different positions, but are very similar to each other, then the corresponding proteins are called isoforms or paralogues.

Actin:

- Over a dozen classes of proteins
- Actin related proteins (Arps)
  - Arp1 (at the core of the dynactin complex)
  - Arp2
  - Arp3

Tubulin:

- α, β, γ, δ, and ε

Intermediate Filament Proteins:

- More structurally diverse than actin and tubulin
- Keratin
- Vimentin
- Desmin
- Lamin

Thank you