

Chapter 8 Muscles and Movement

Large Complexes of Proteins

Structure and Function

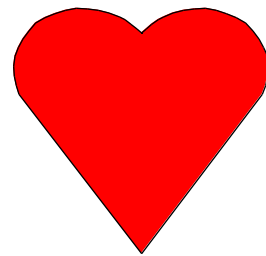
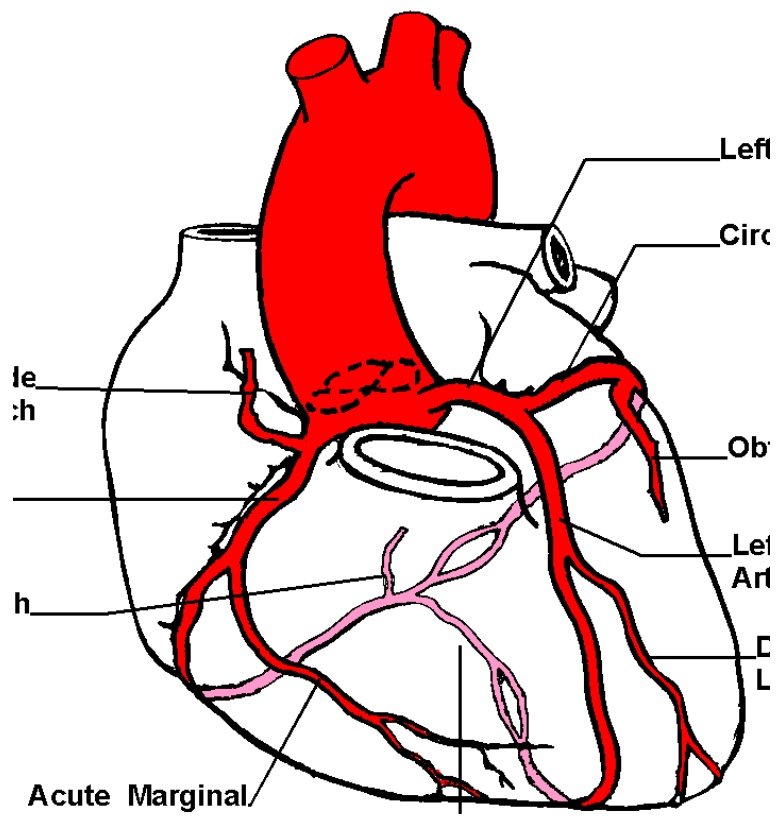
Energy Transduction

Myosin, Actin, Tropomyosin,

Tubulin

Chapter 9 Carbohydrates

Happy Valentine's Day!!!



Heart shape?

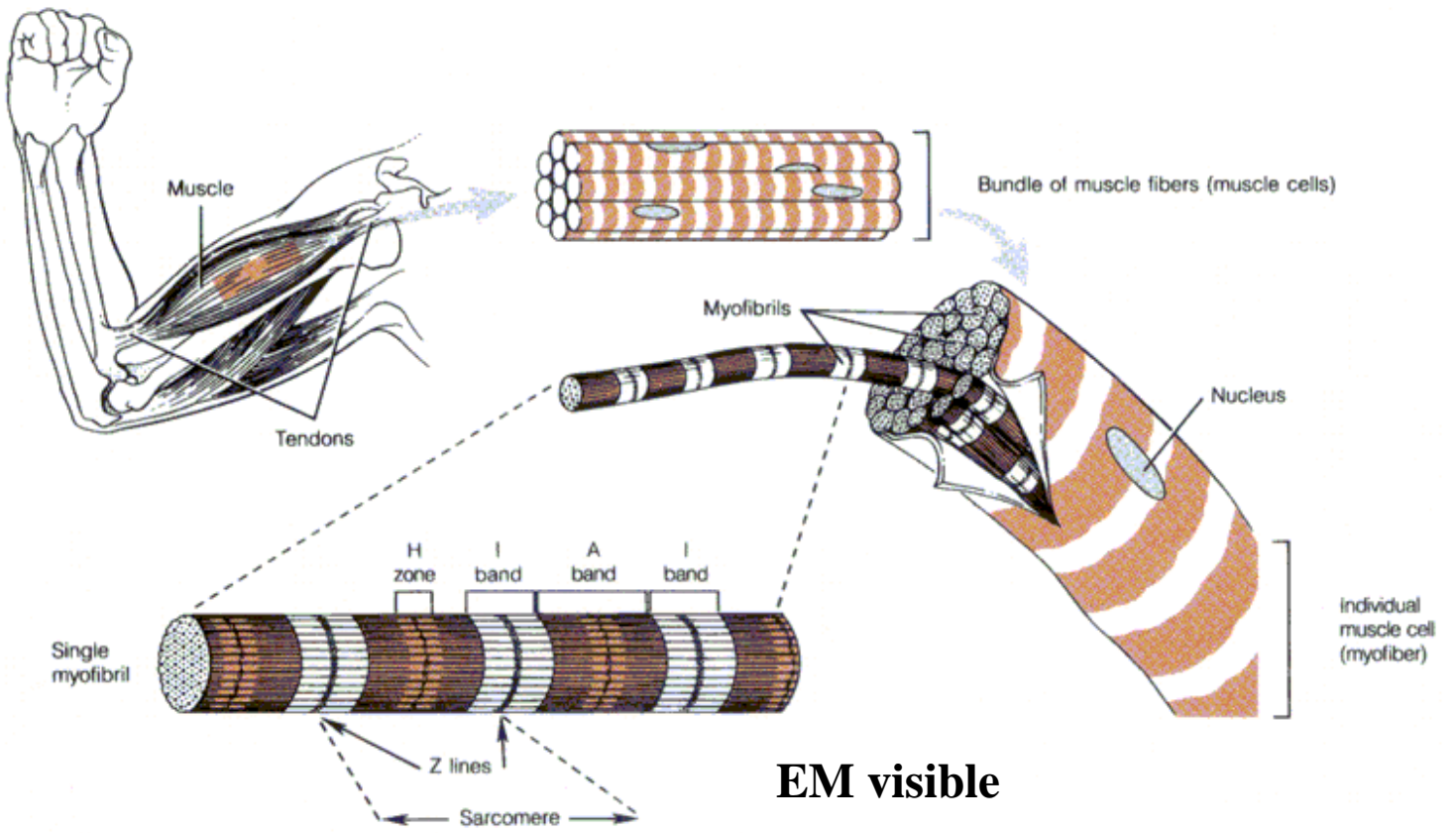
MODERN BIOLOGY (and medicine!!)

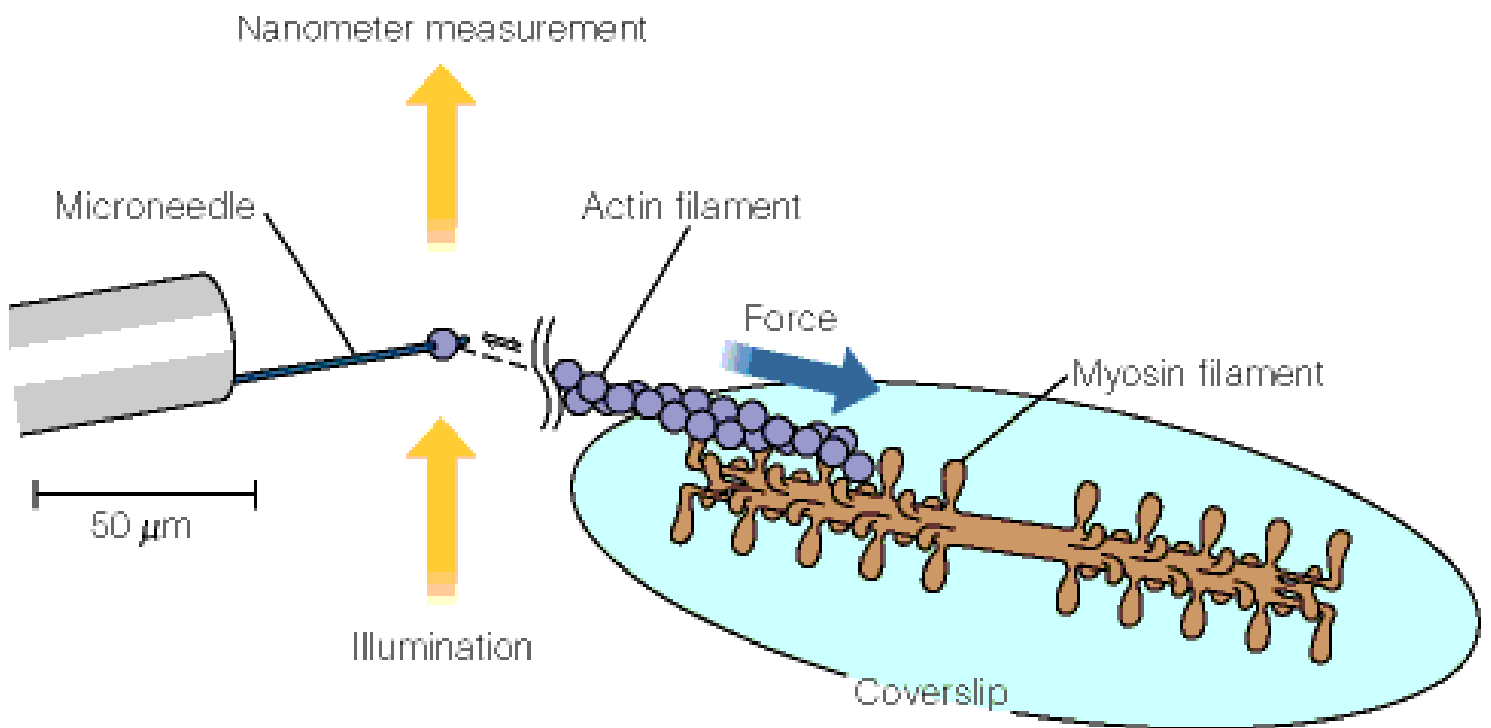
Supramolecular Assemblies >>>> Biological Function

Muscle Structure >>>>contraction and movement

Microtubule structure >>>movement

**What kinds of experiments are important in
proposing and testing models???**





Contraction is caused by actin/myosin moving relative to each other.

Experimental Techniques for Muscles

Electron Microscopy (low resolution--bands, striations, thick and thin filaments)

X-ray diffraction on small protein fragments

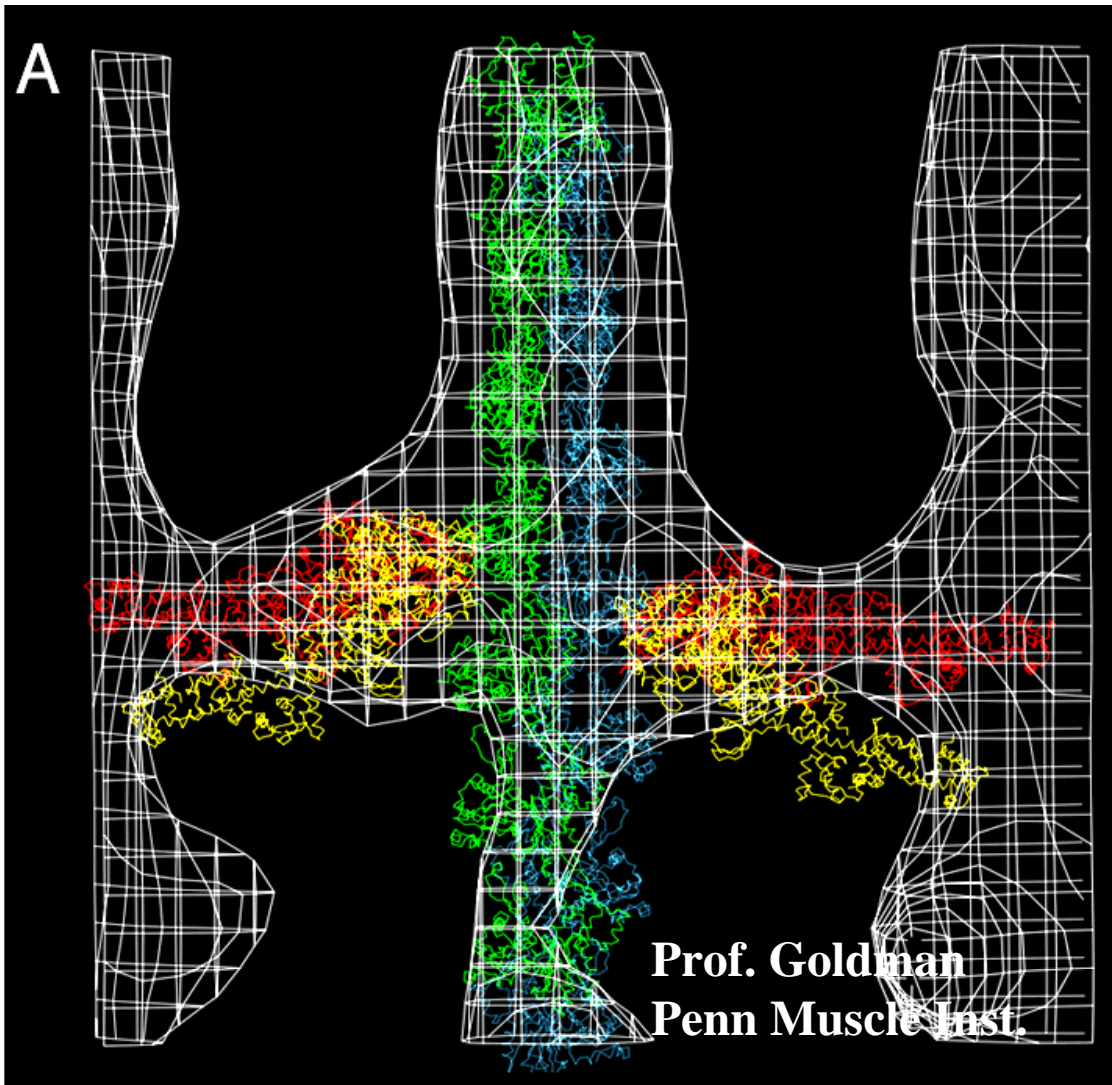
Cryoelectron microscopy

Time-resolved X-ray diffraction

Ability to “prepare” samples in various stages

In vivo NMR of ^{31}P

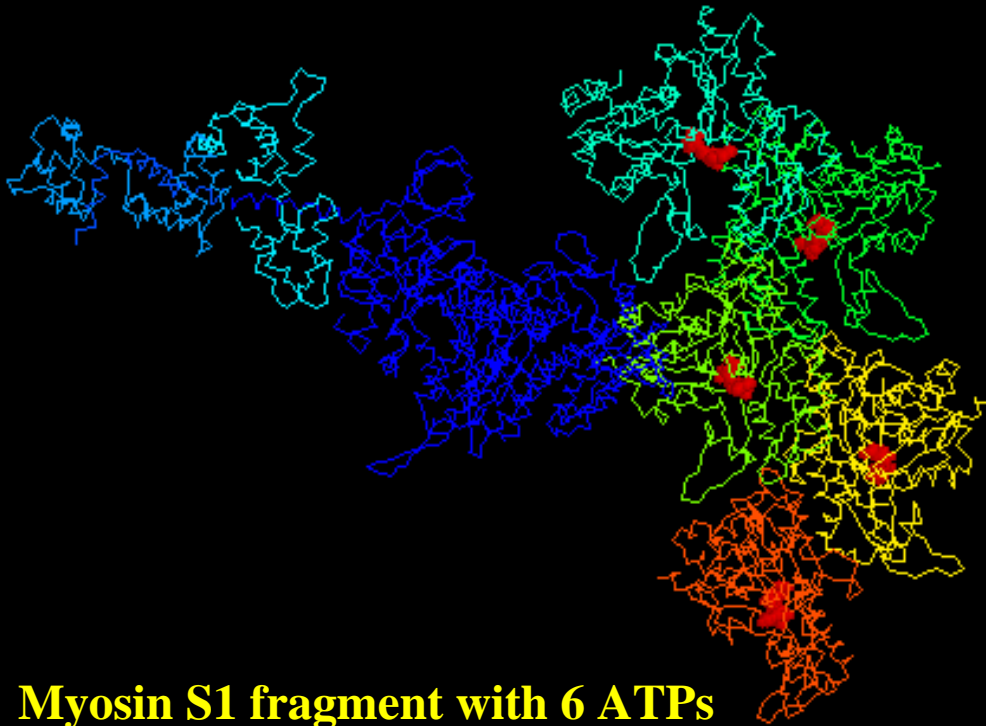
Fluorescent Antibodies --cellular location



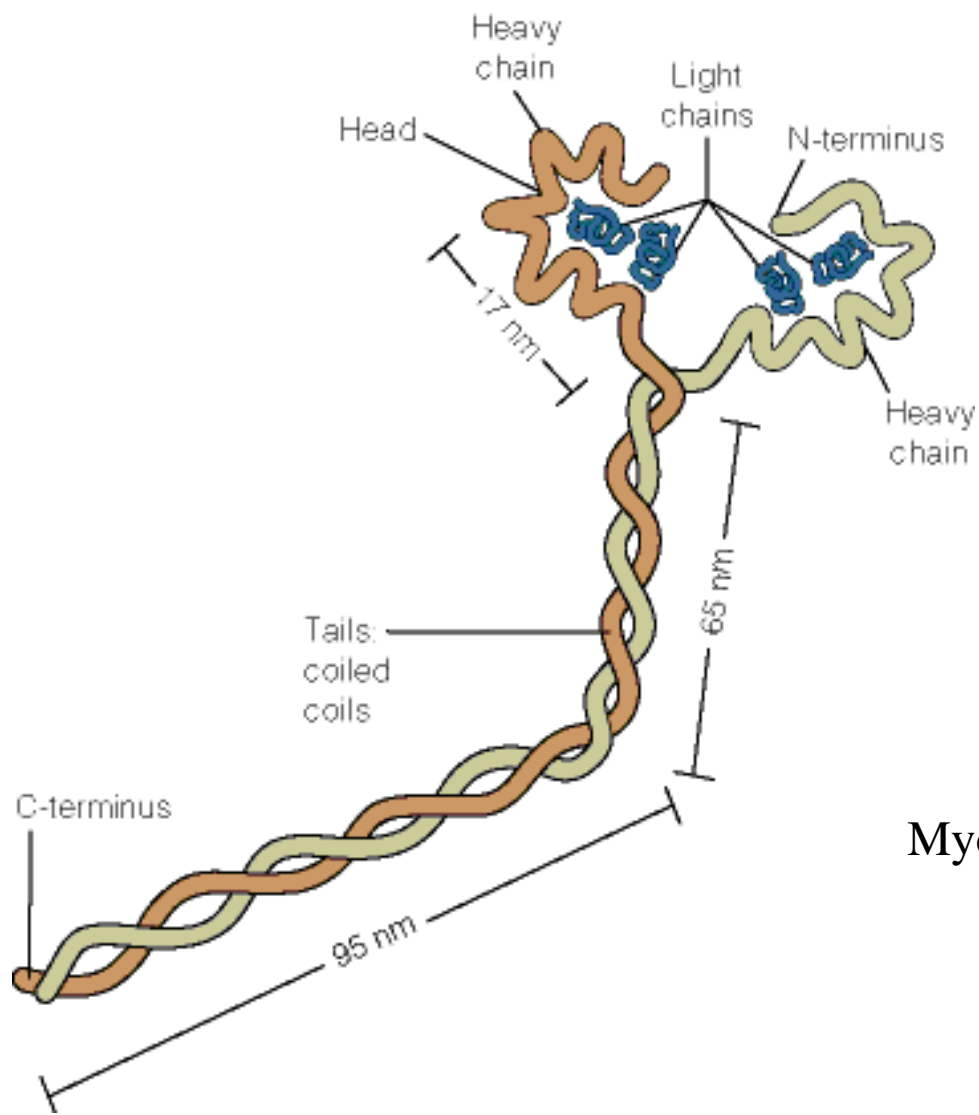
Cryo EM

- 1) Freeze hydrated muscles**
- 2) Get EM images of various orientations**
- 3) 3D image reconstruction to produce white cages.**
- 4) Fit structures determined by X-ray diffraction (colors) into cages.**

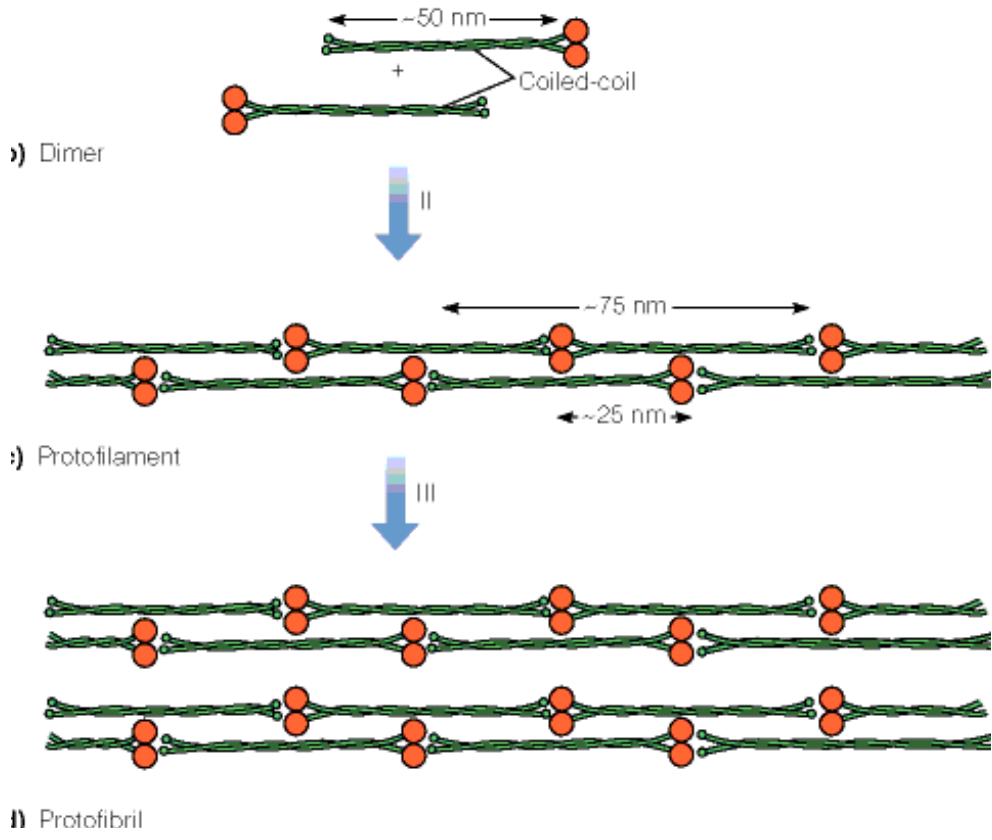
**Forms cross bridges to actin
and flexes during “power stroke”.**



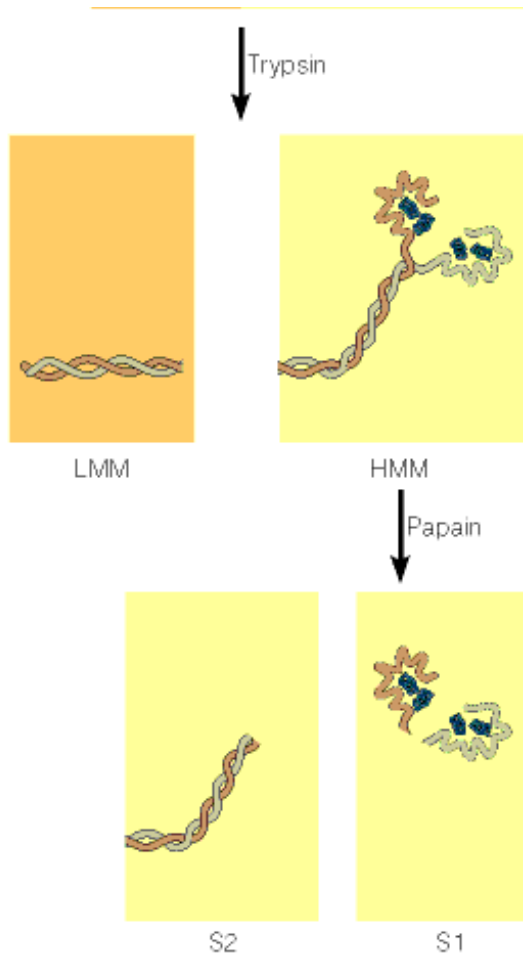
**Myosin S1 fragment with 6 ATPs
(only 1 is relevant!). Forms thick
Filament.**



Myosin

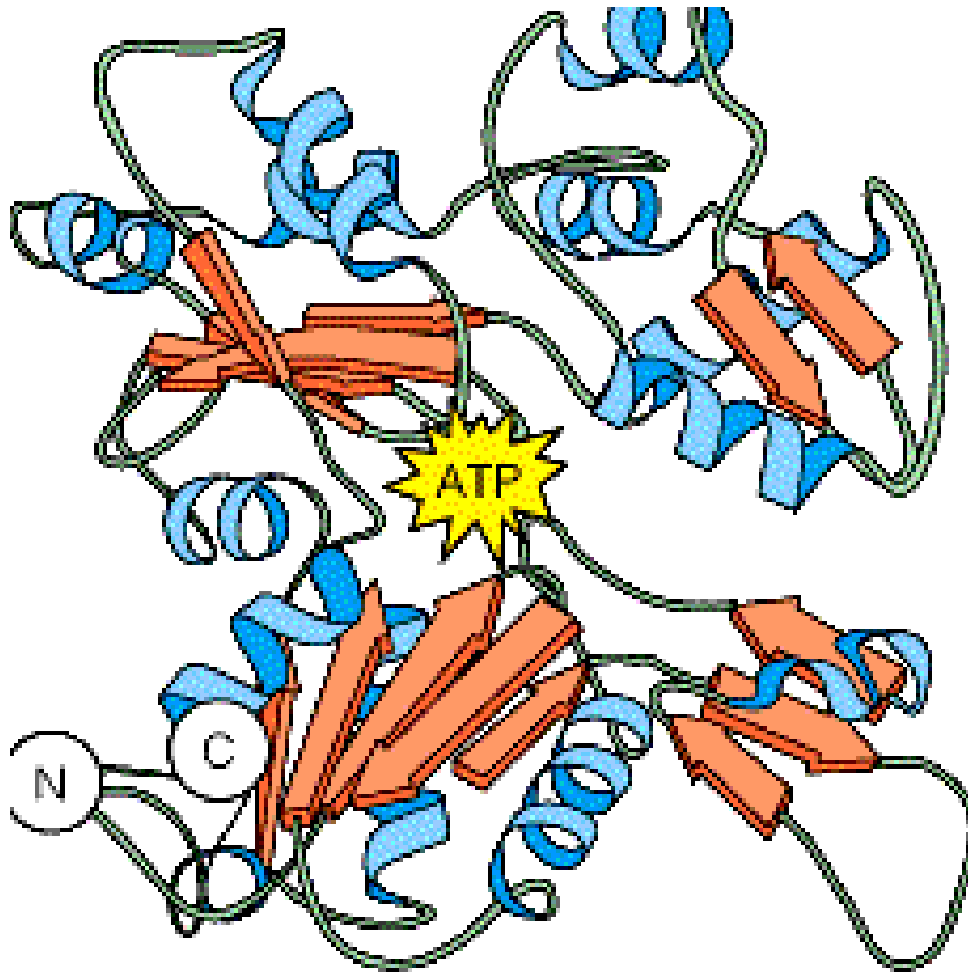


**Keratin,
another
coiled-coiled
fibrous
protein
similar to
myosin.**



Protease cleavage of myosin is important in studying function.

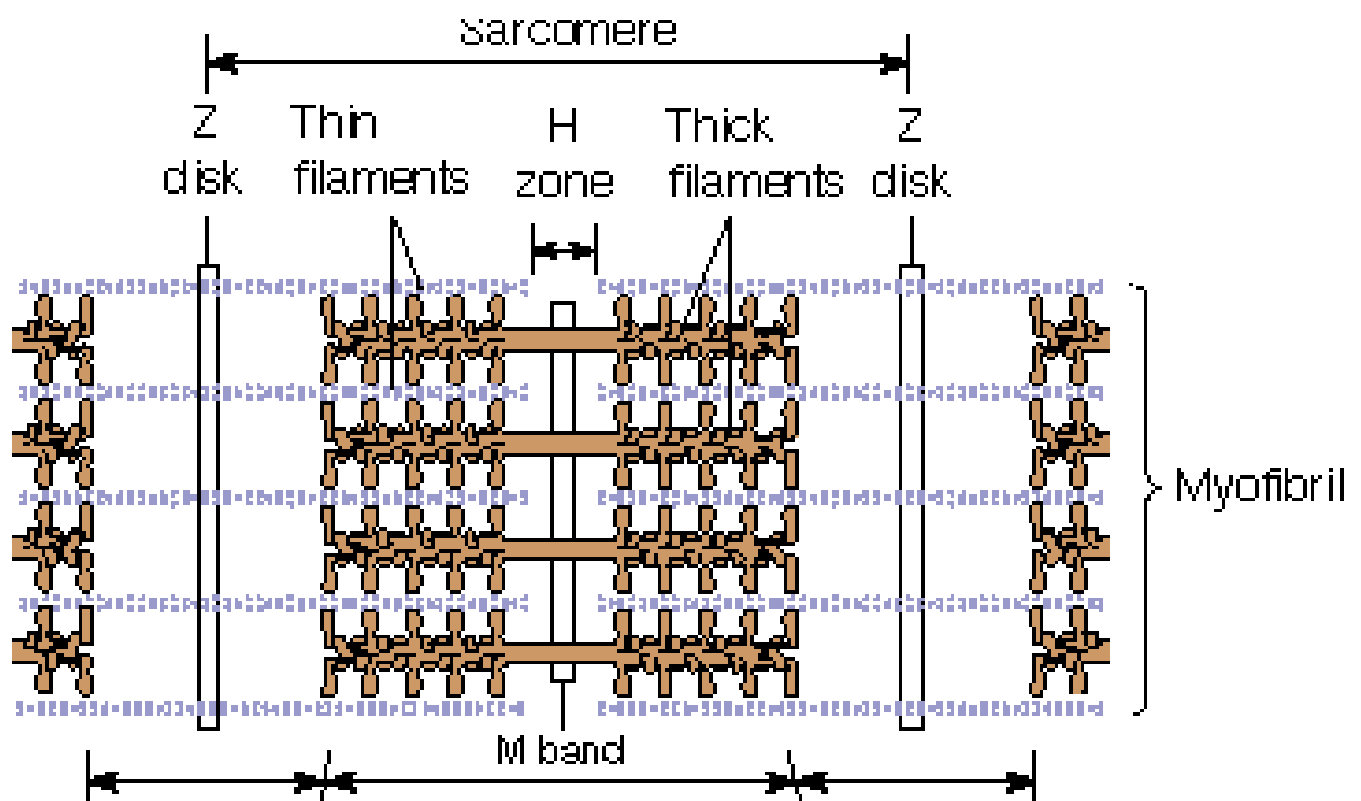
S1 fragments Bind/unbind actin and hydrolyse ATP.

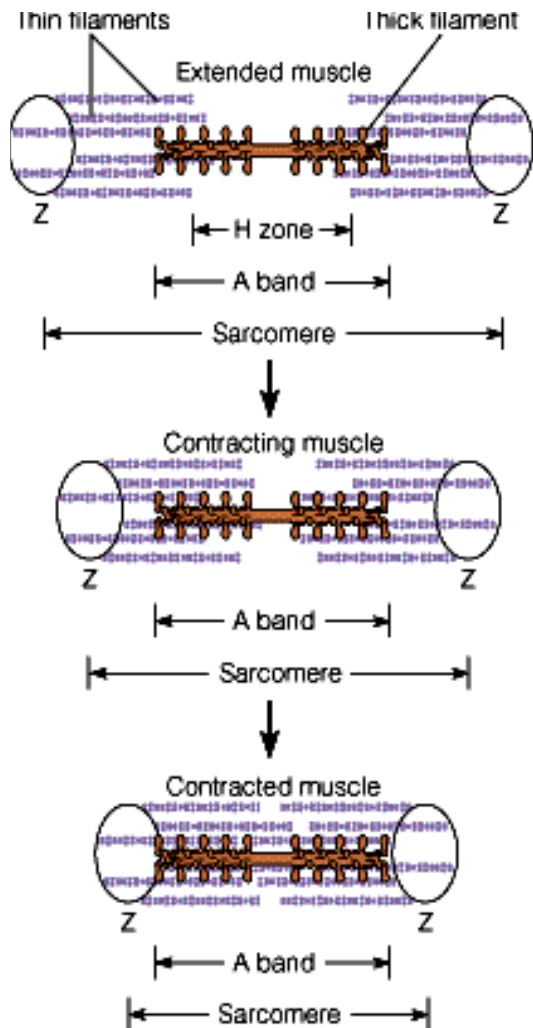


**Actin G
(globular
form)**

**This molecule
was crystallized
with DNA
polymerase
to prevent
polymerization.**

**Actin F forms
long polymers
and thin filaments.**



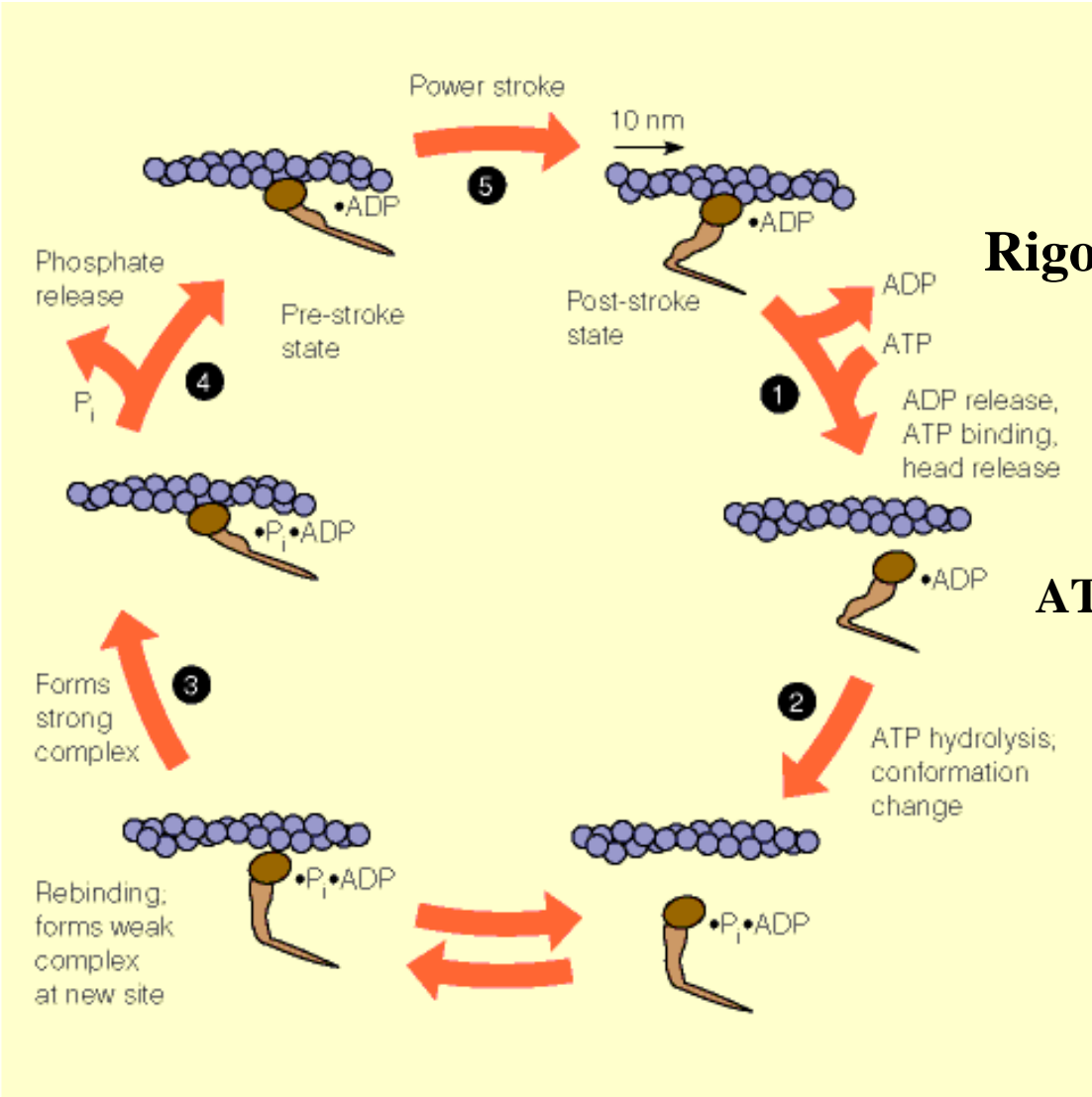


Sliding filament model for muscle contraction

The myosin heads “walk” Along actin filaments.

Electron micrographs Distinguish regions of

- 1) just actin
 - 2) just myosin (but many)
 - 3) actin + myosin
- giving muscles a banded appearance that varies during contraction.

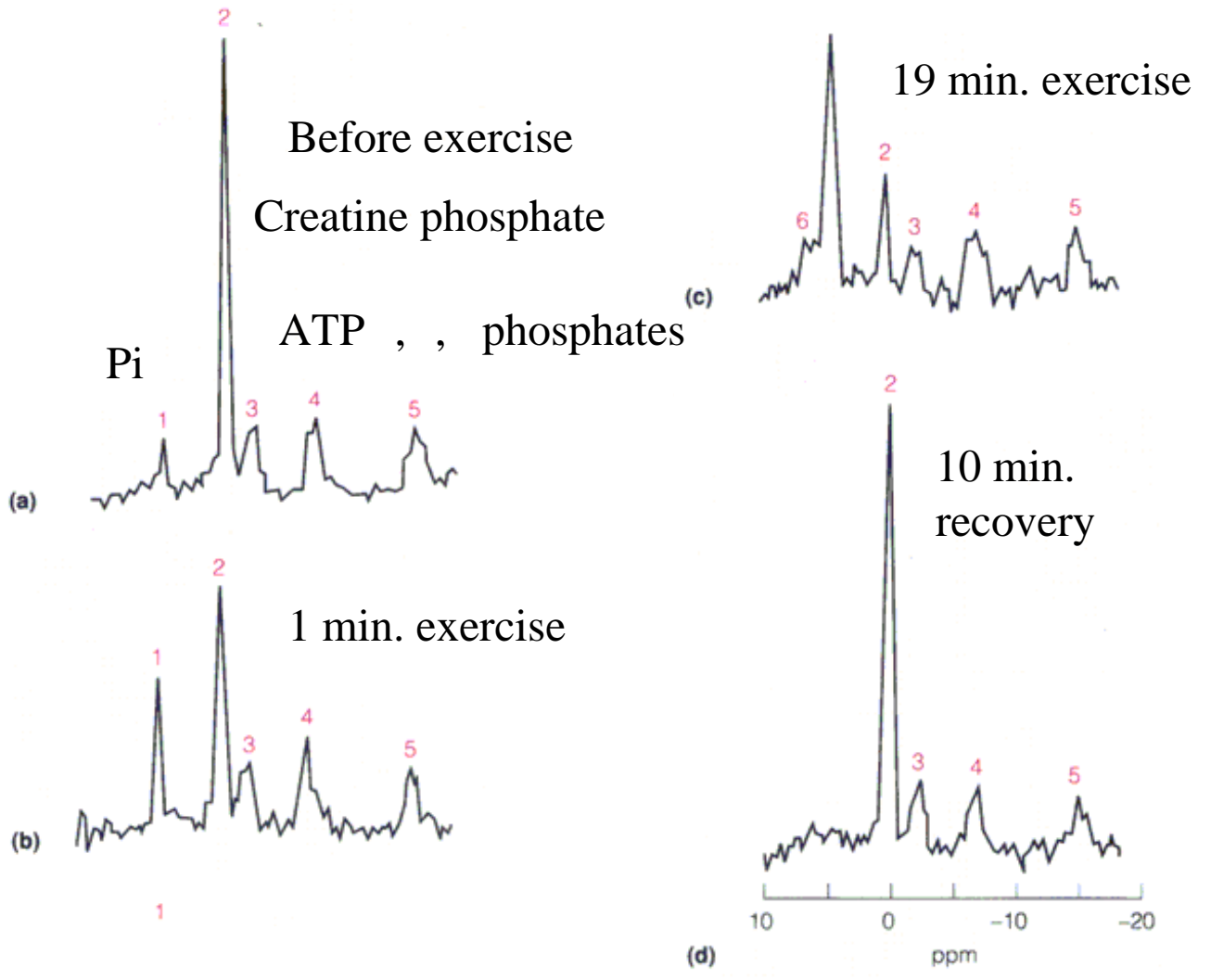


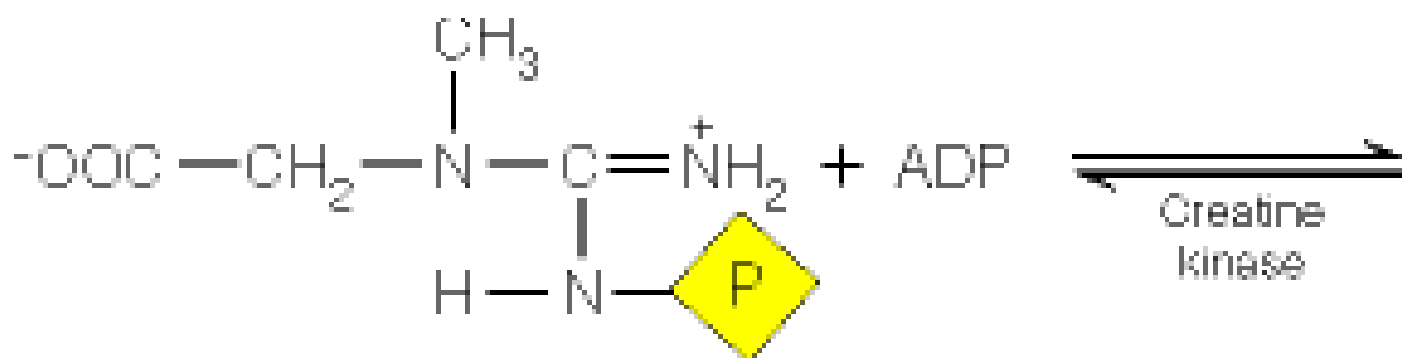
Rigor Mortis

ATP

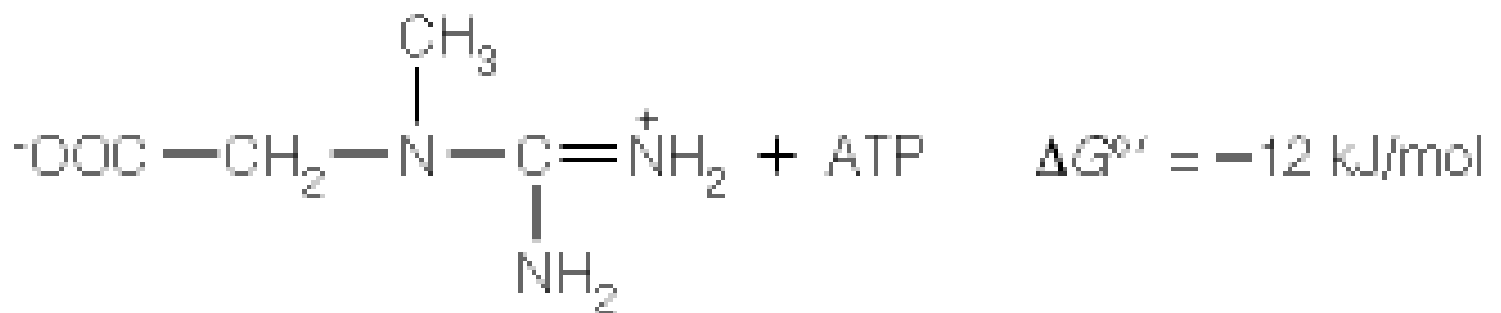
What does the ATP do?

**Is its hydrolysis the source of mechanical energy?
If, so [ATP] should decrease during exercise.**





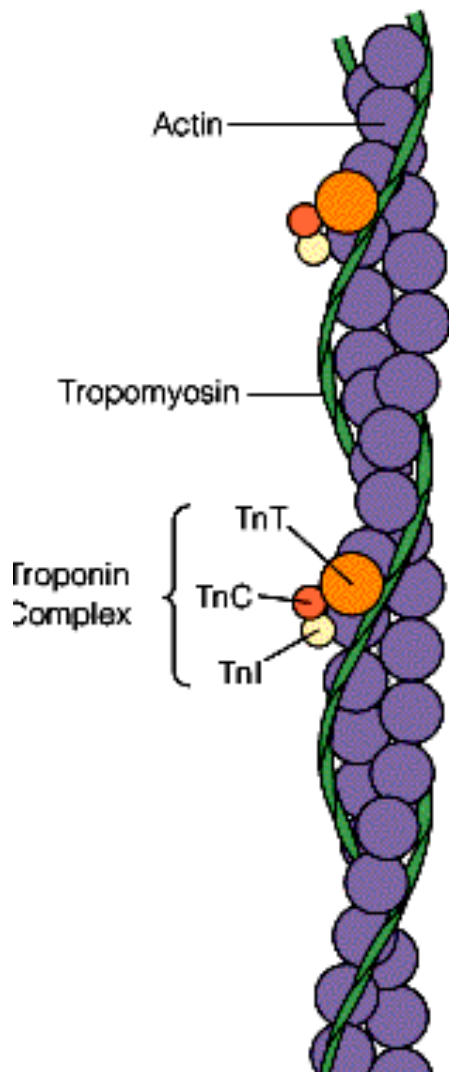
Creatine phosphate



Creatine

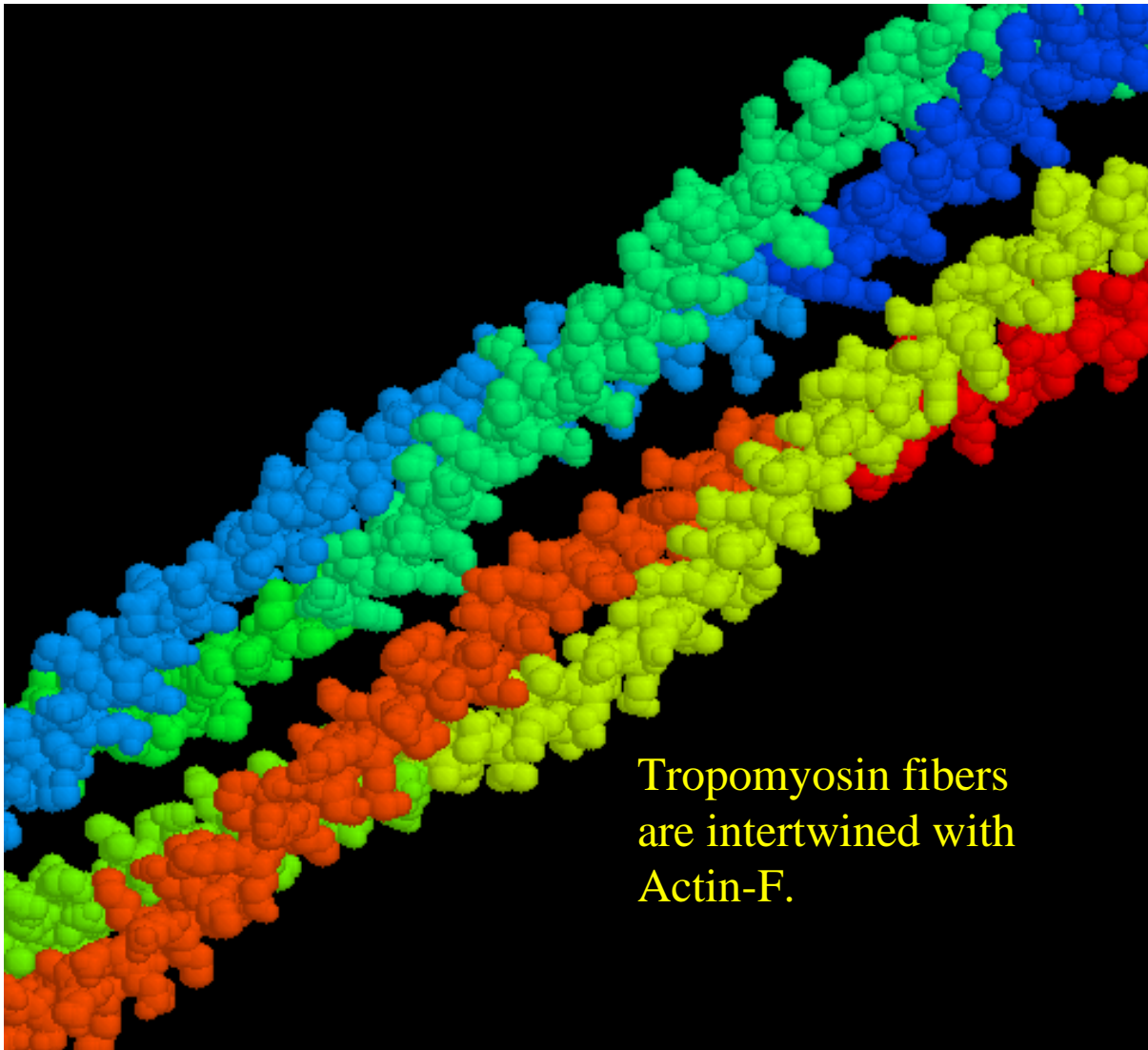
Why is creatine phosphate hydrolysis so exergonic????

Should weight lifters consume it?

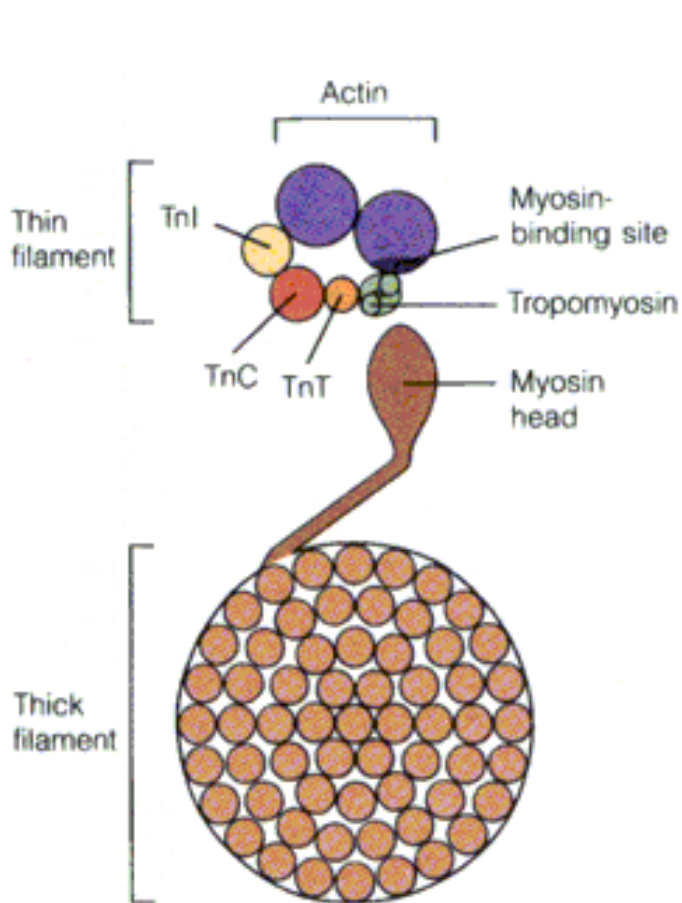


It's Ca^{2+} which actually initiates the muscle contraction.

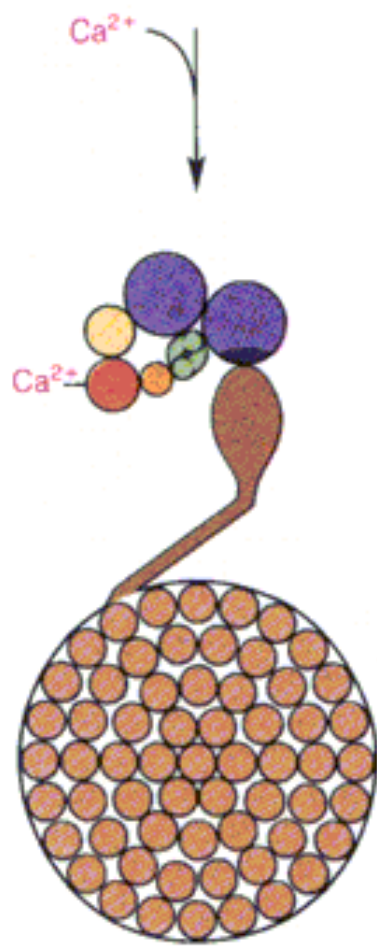
In the absence of Ca^{2+} The myosin heads can't rebind the actin because of the troponin complex.



Tropomyosin fibers
are intertwined with
Actin-F.



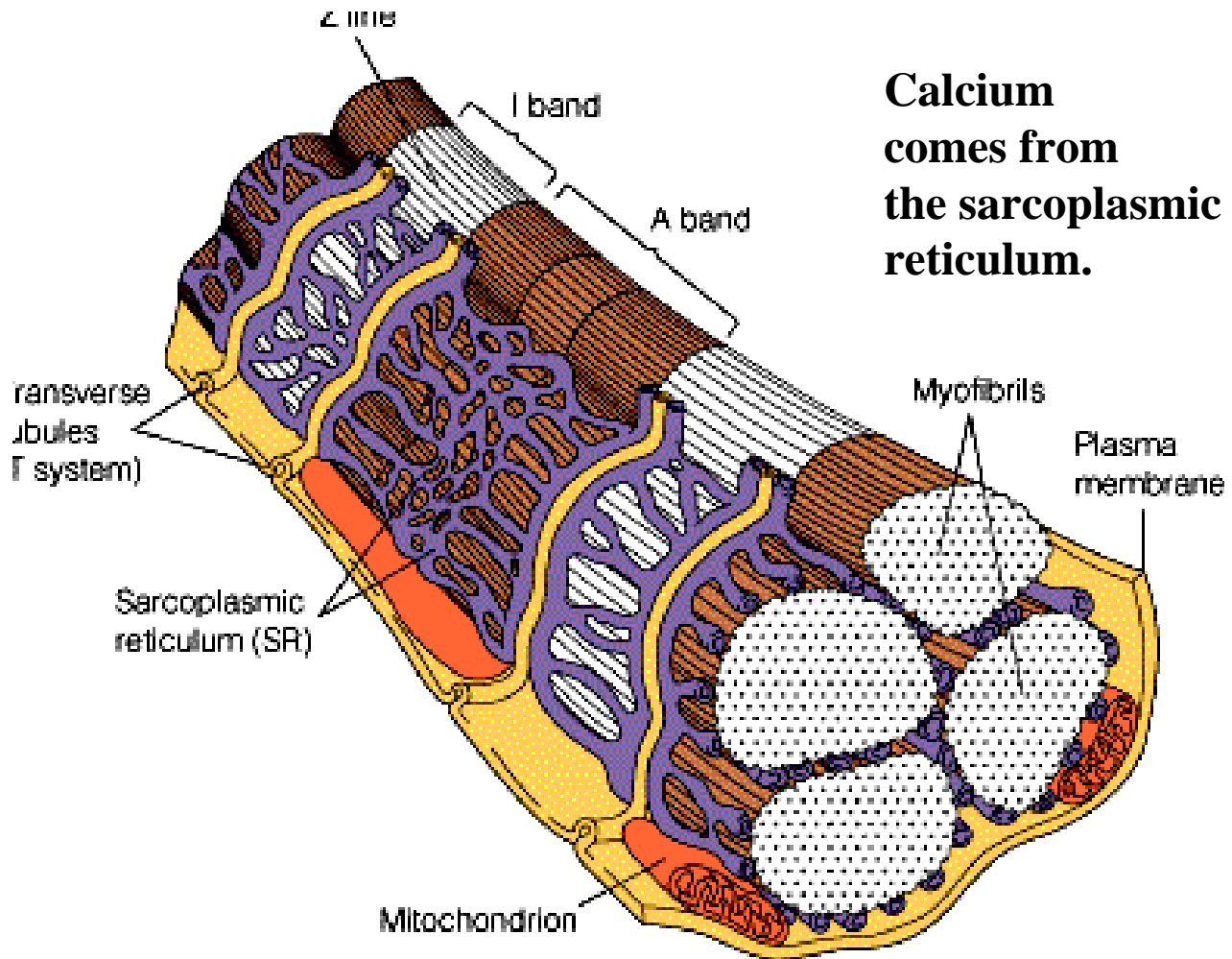
(a) Low calcium concentration
 ($<10^{-7} \text{ M Ca}^{2+}$)



(b) High calcium concentration
 ($>10^{-6} \text{ M Ca}^{2+}$)

**“Caged”
 Ca²⁺ can
 be
 delivered
 to all cells
 simultane-
 ously in
 The lab
 or by
 nerve
 action.**

**Calcium
comes from
the sarcoplasmic
reticulum.**



ATP is produced as a result of glucose (anaerobic) or fatty acid (aerobic) metabolism.

	Red	White
Relative fiber size	Small	Large
Mode of contraction	Slow twitch	Fast twitch (about 5 times faster)
Vascularization	Heavy	Lighter
Mitochondria	Many	Few
Myoglobin	Much	Little
Major stored fuel	Fat cells	Glycogen in muscle
Main source of ATP	Fatty acid oxidation	Glycolysis

Chicken legs (walking) vs chicken breast (flying)



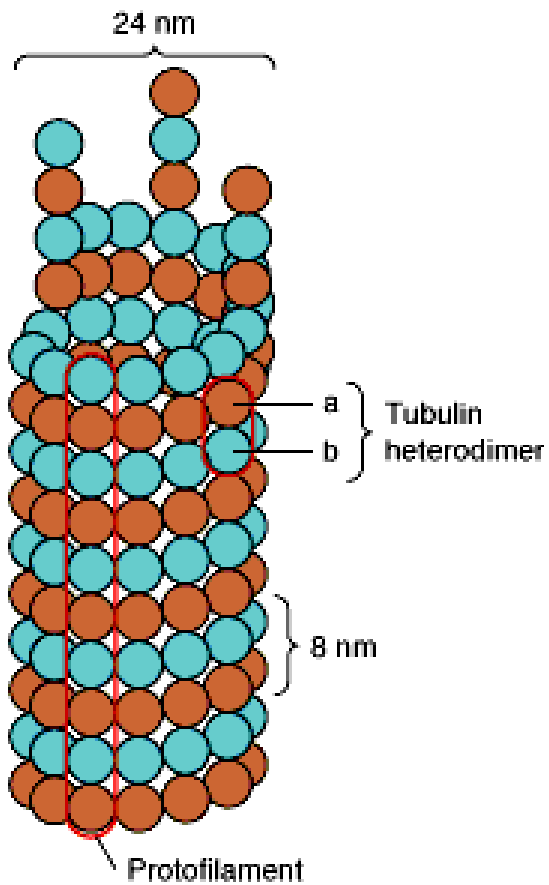
SW's African hen

**Non-muscle roles for actin and myosin--
Cytoskeleton (the cell is not a sack of water!)**

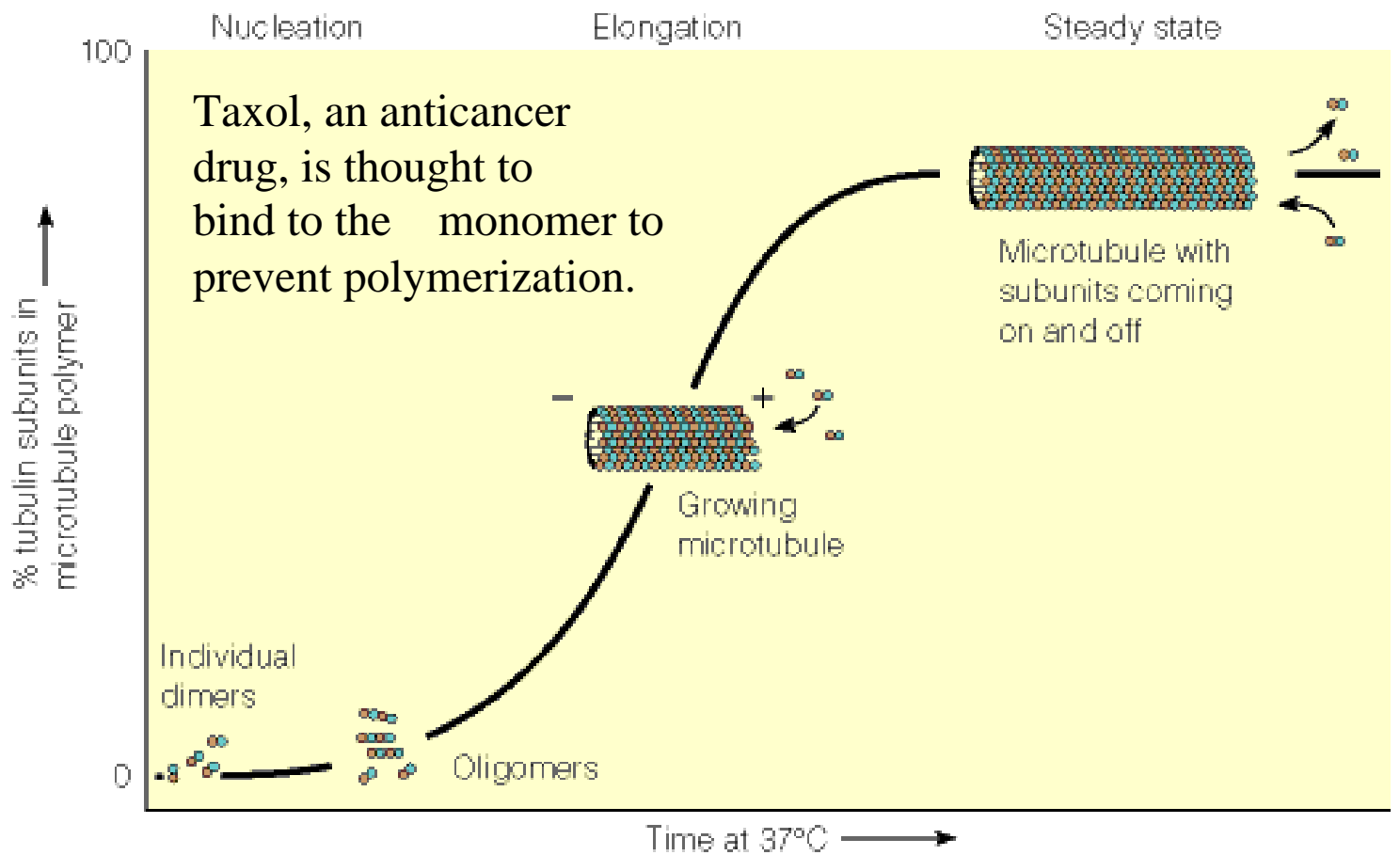
**Cell contraction
(myosins two different actins form tail dimers)**

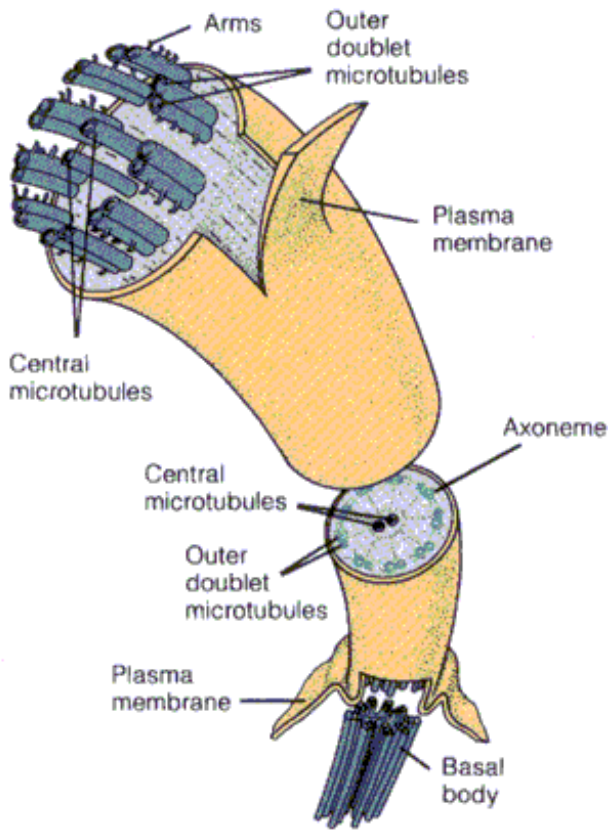
Cell division

**Transport along actin fibers
(simple diffusion is too slow--actin provides
a highway). (kinesins hydrolyze ATP)**



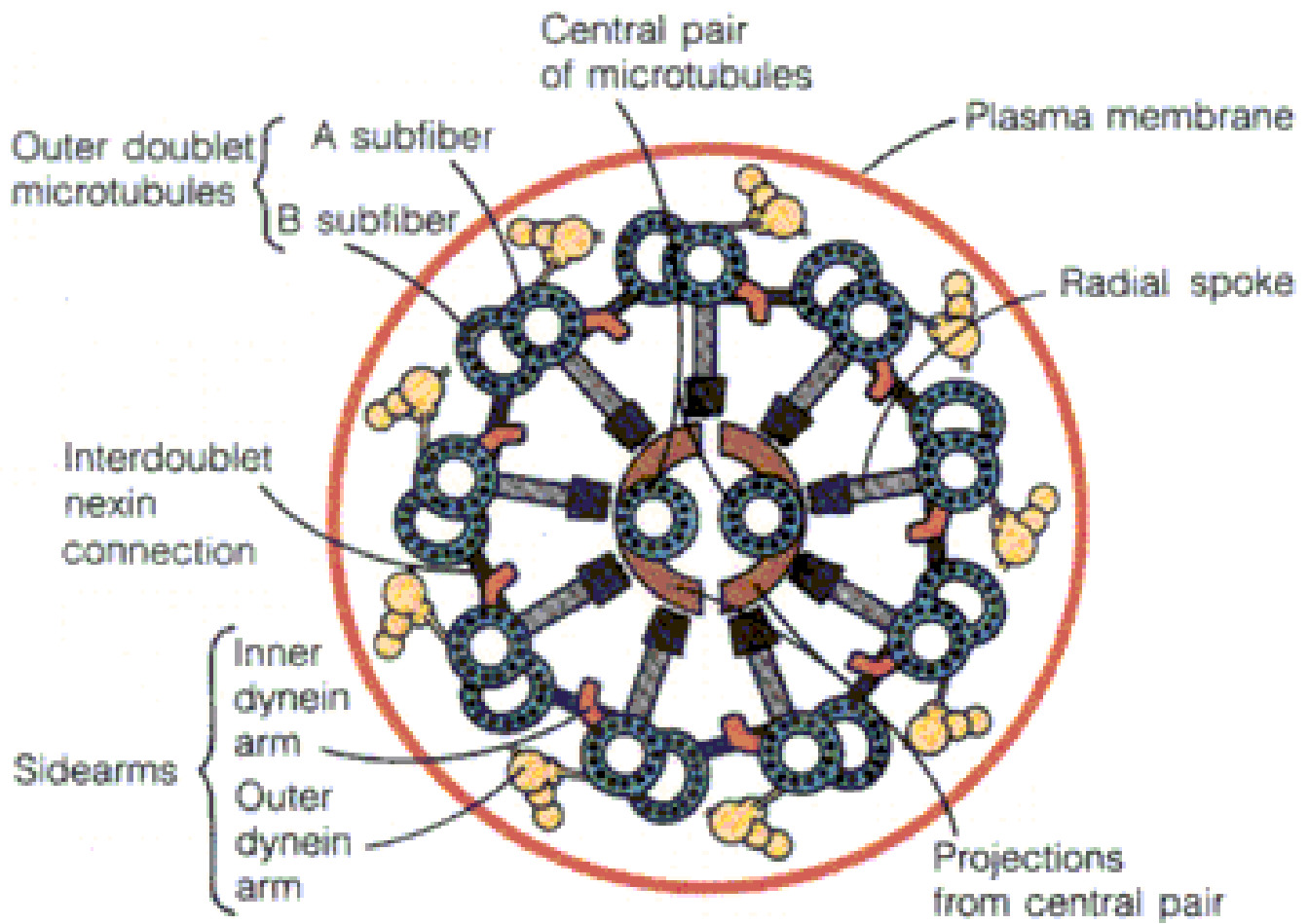
**Microtubules--
Different proteins
similar movements
and energy source.**

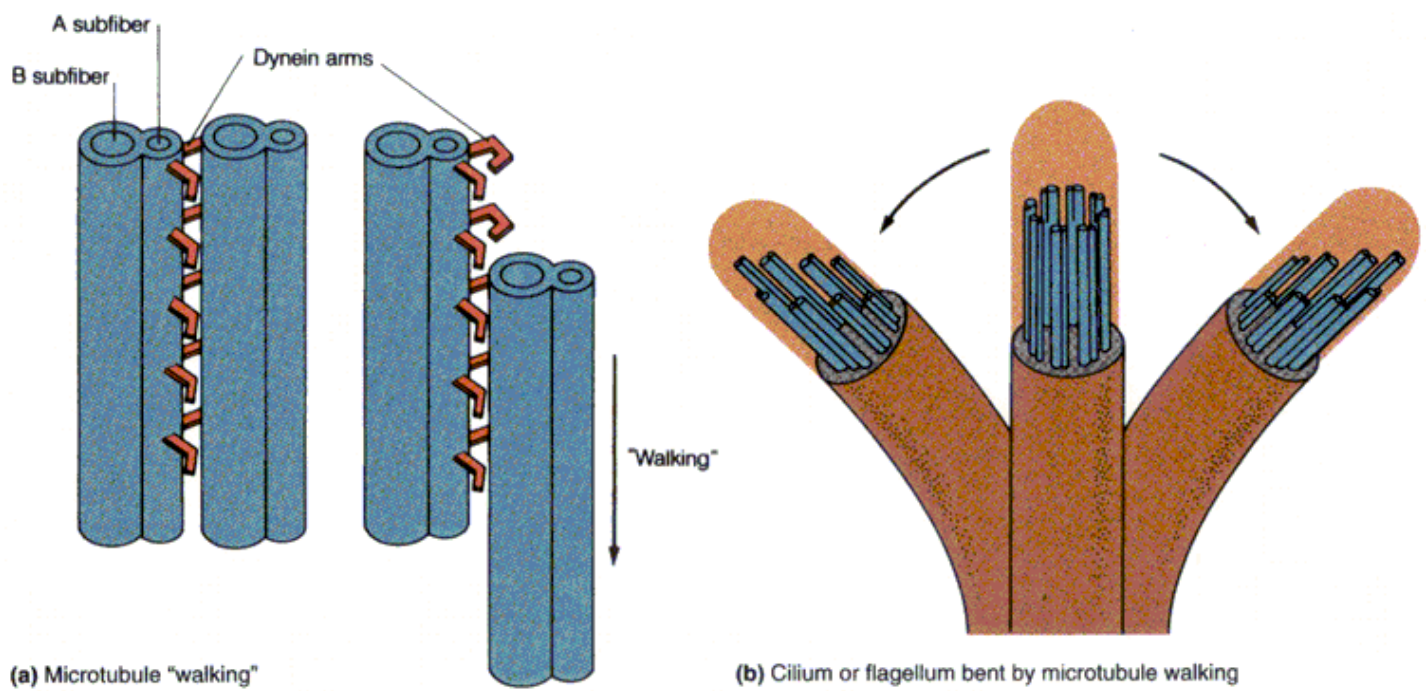




**Cilia have
a 9 + 2
architecture.**

(b)





Dynein arms walk along microtubules to bend cilia.
The action is fueled by ATP hydrolysis.

Chapter 9--Carbohydrates

Metabolic energy (ATP) is derived from plant carbohydrates.

Plants produce carbohydrates from solar energy, CO₂, and O₂.

Cell / cell recognition

Blood types

Structural and storage

Chitin, cellulose

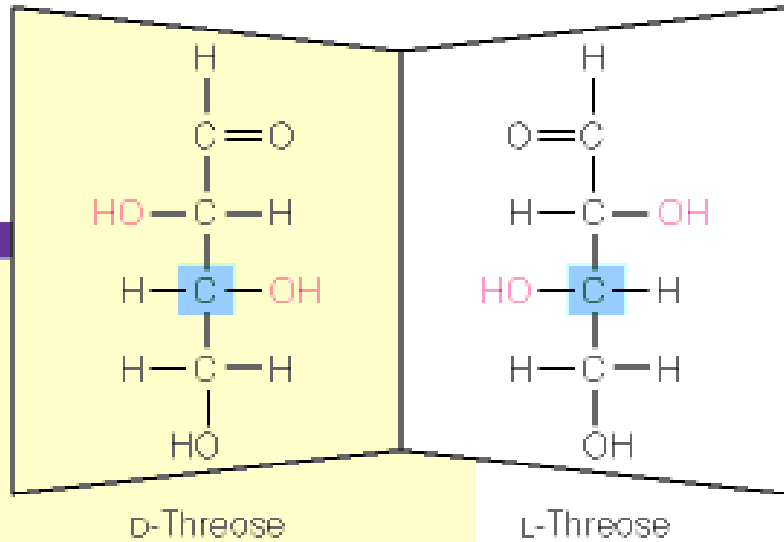
Glycogen

Accent on understanding glucose.

Enantiomers

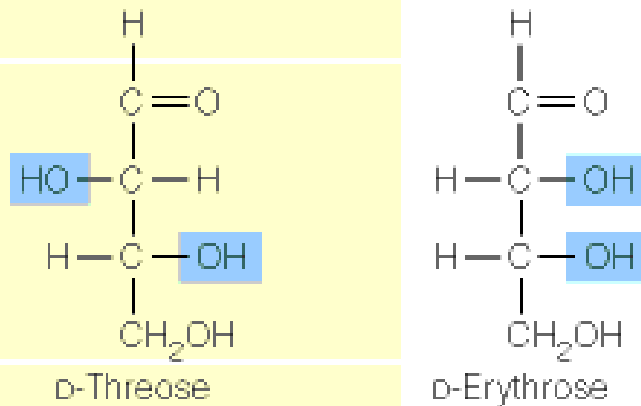
Stereoisomers that are mirror images of one another

The boxed asymmetric carbon (farthest from aldehyde) determines d/L designation



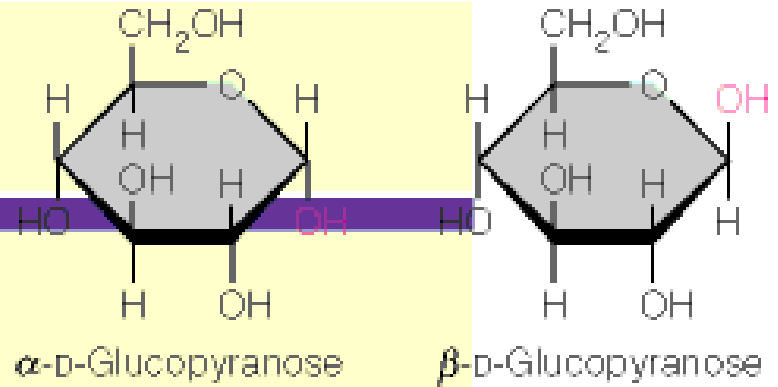
Diastereomers

Stereoisomers that are not mirror images of one another



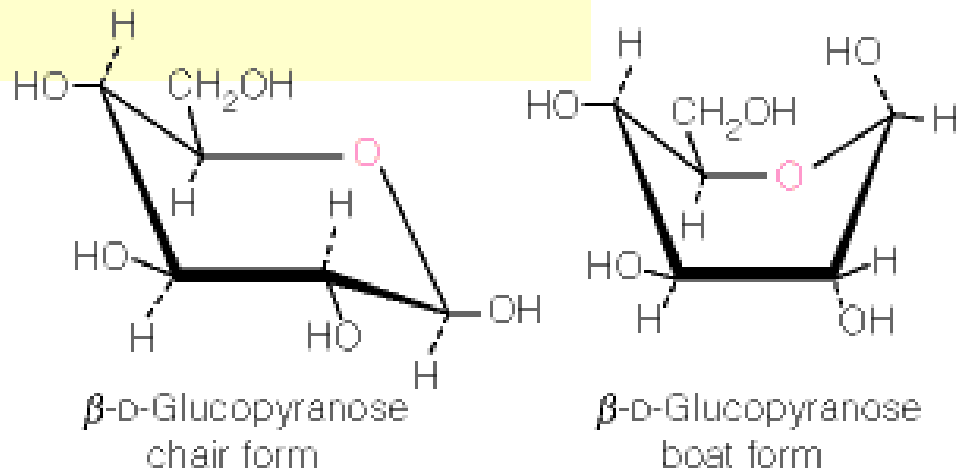
Anomers

Stereoisomers that differ in configuration at the anomeric carbon



Conformational isomers

Molecules with the same stereochemical configuration, but differing in three-dimensional conformation



GLUCOSE review (see organic text)

Draw glucose Fisher projection

Draw aldose-ketose transition

Draw cyclization of aldose to produce α and β anomers

Draw Haworth Projection

Draw chair conformation

GLUCOSE review (see organic text)

Draw glucose Fischer projection
(right = down, aldehyde = C #1)

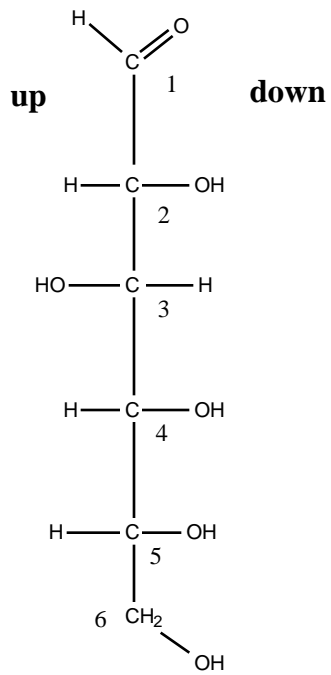
Draw aldose-ketose transition
(ene-diol intermediate from C1 and C2)

Draw cyclization of aldose to produce α and β anomers
(O bonded to C5 attacks C1, α anomer has C1 OH and C6 trans)

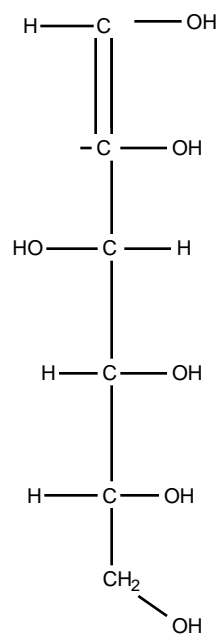
Draw Haworth Projection
(right hand substituents are down, C6 is up)

Draw chair conformation
(up and down substituents are preserved, O is back right)

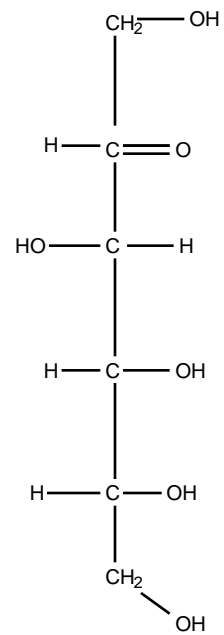
GLUCOSE Fischer



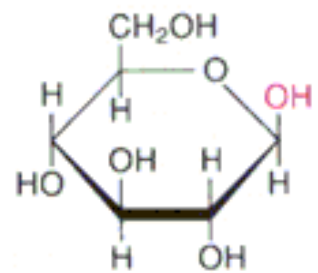
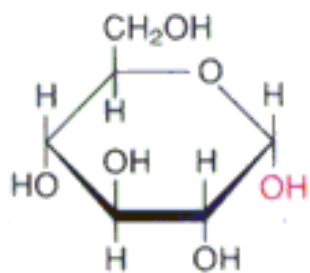
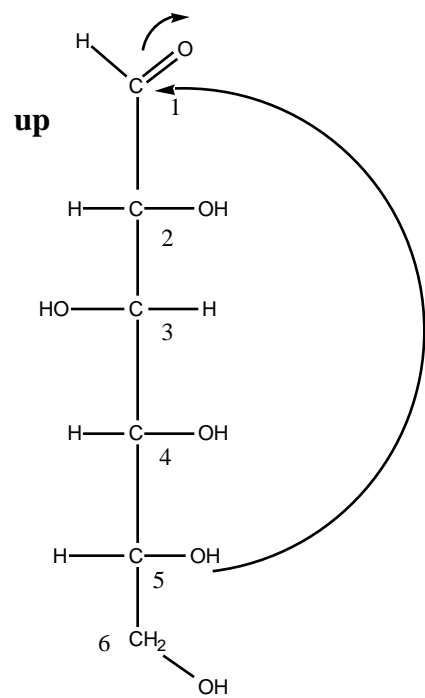
aldose

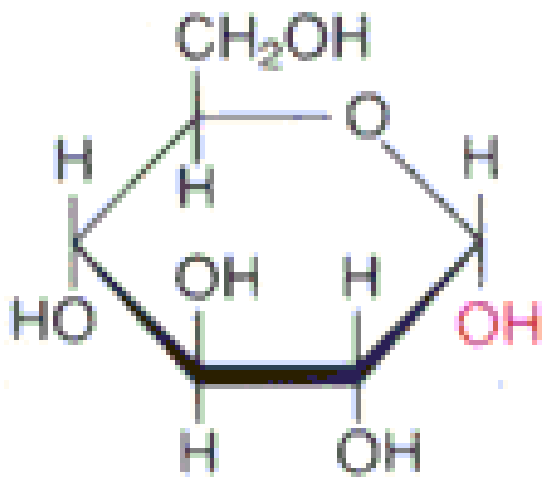


ene diol

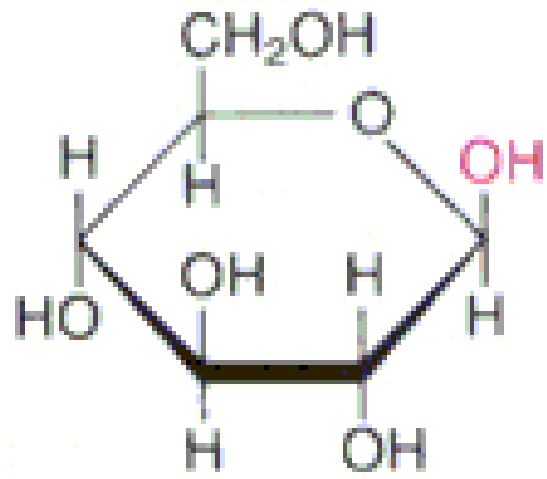


Ketose

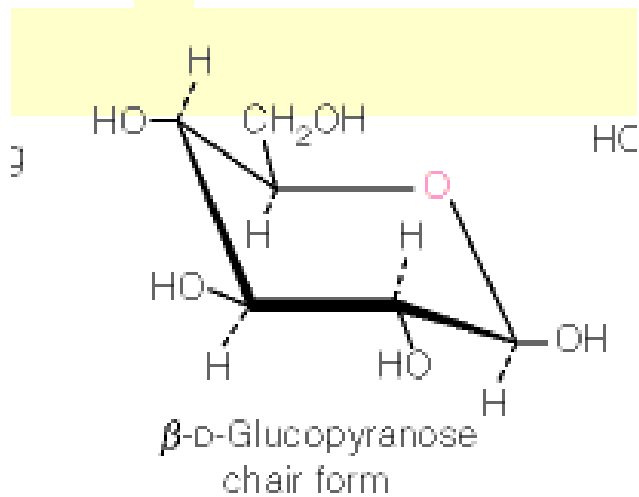
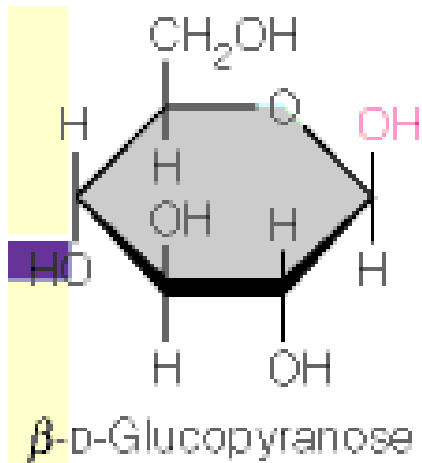




α -D-Glucopyranose



β -D-Glucopyranose



Up and down are preserved
In Haworth and Chair forms.

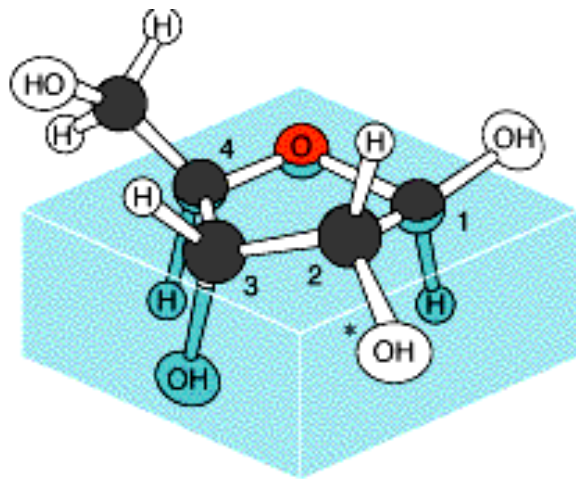
Most reactive Carbon?

Reducing end?

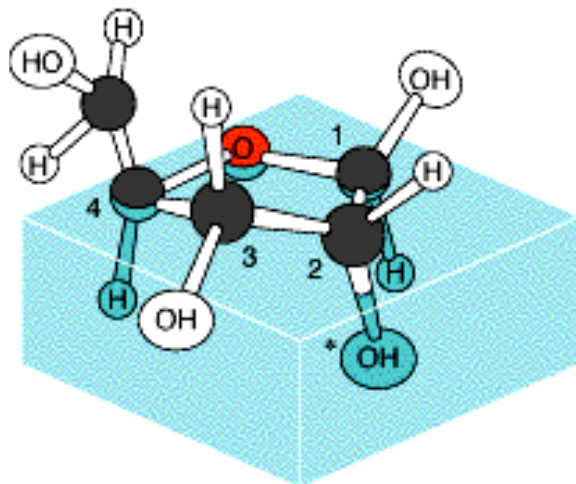
Anomeric carbon?
-- or ?

Carbon numbering?

Importance of axial and
equatorial?

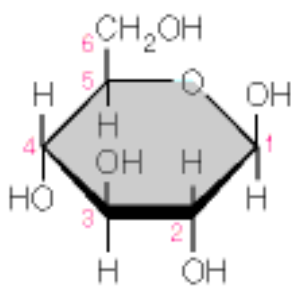


(a) β -D-Ribofuranose, C-2' endo

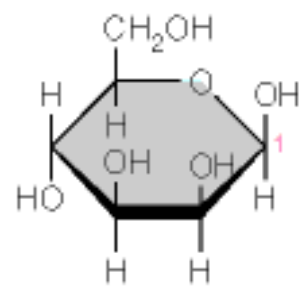


(b) β -D-Ribofuranose, C-3' endo

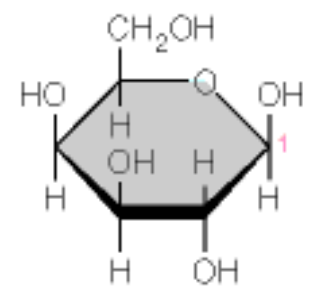
**Pentose puckers
play an important
role in DNA and RNA
structure.**



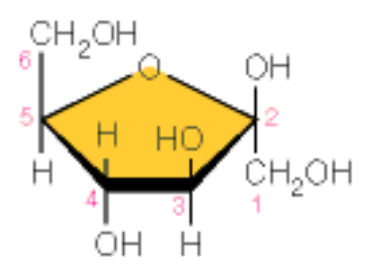
β-D-Glucopyranose



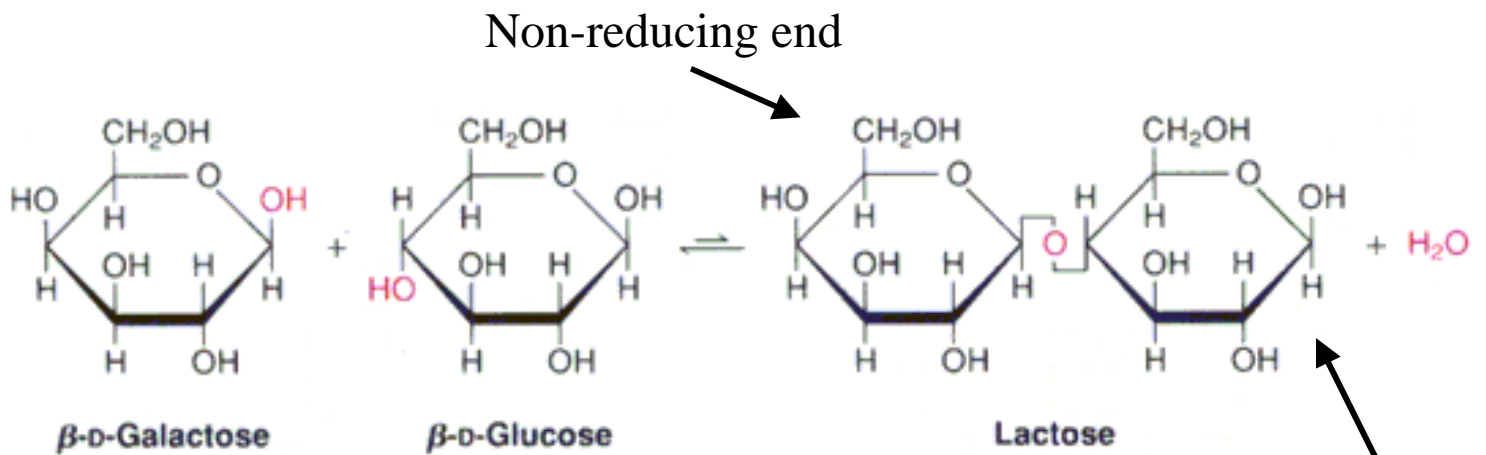
β-D-Mannopyranose



β-D-Galactopyranose



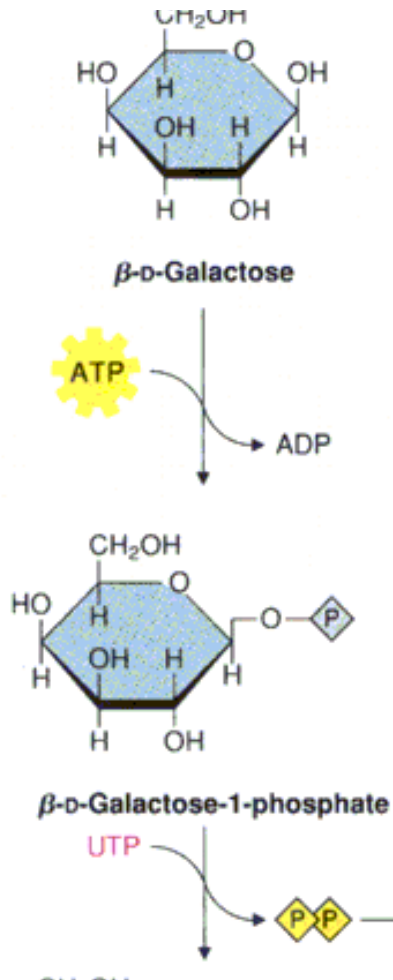
β-D-Fructofuranose



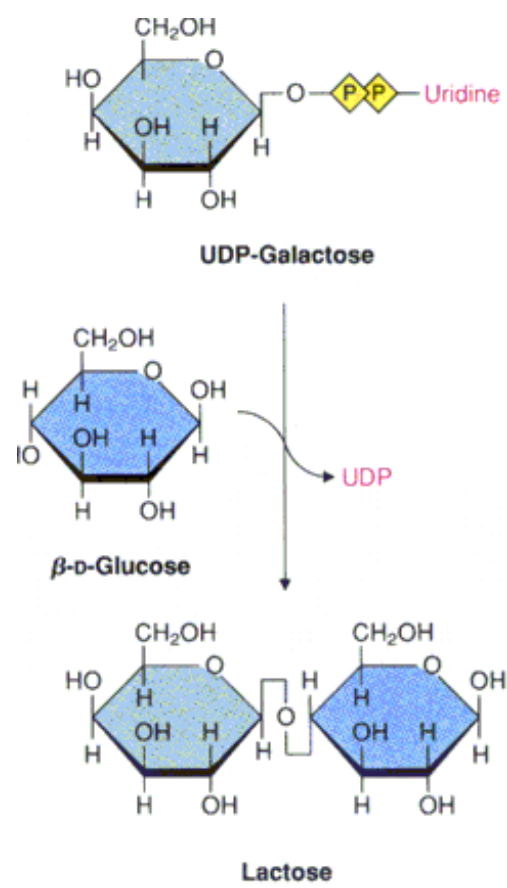
Disaccharides are **not** formed by simple dehydration!!!

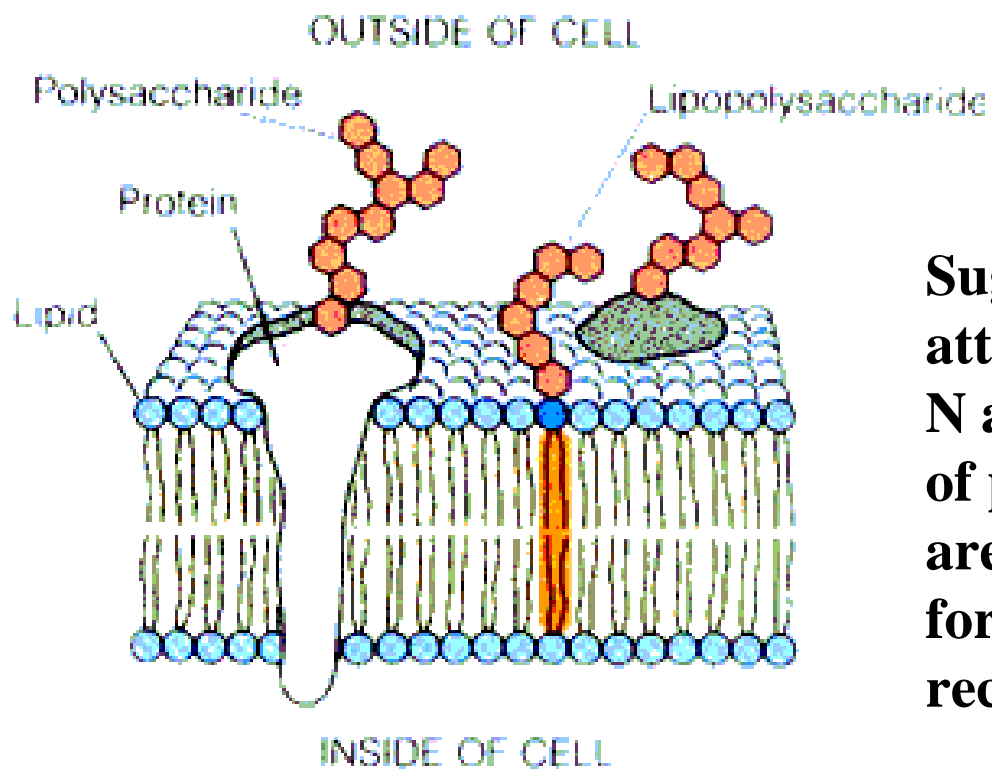
This is a 1 >>4 linkage Gal -Glu

Lactose intolerant people lack the enzyme required to hydrolyze this linkage.



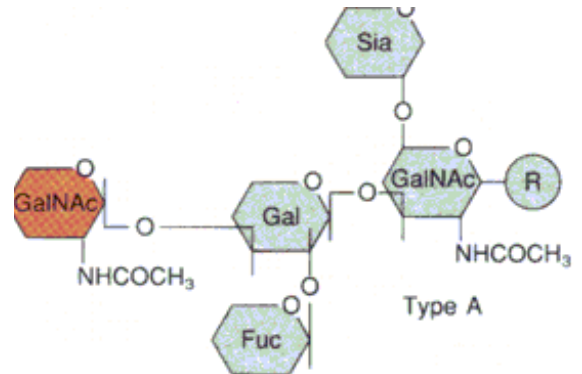
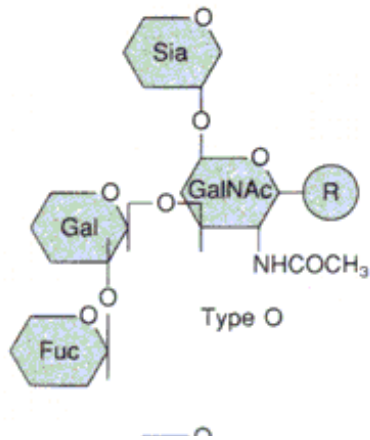
Energetics
 dictate
 a “high
 energy”
 intermediate



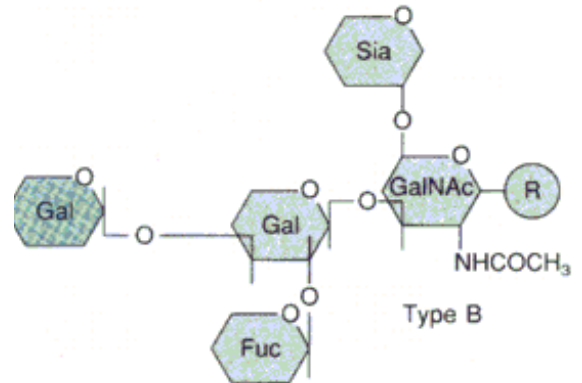


Sugars attached to N and O of protein are important for cell-cell recognition

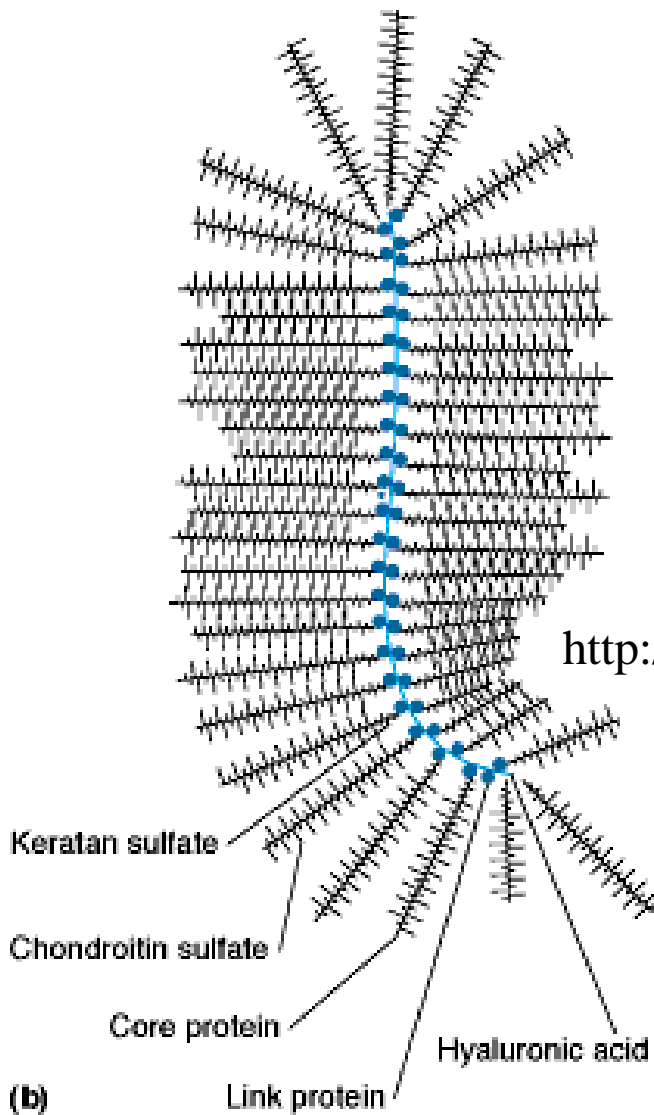
(a) Cell surface oligosaccharides



**Everyone has “type O”
So no one makes antibodies**



**People who don’t have “type A” make antibodies
against this antigen.**

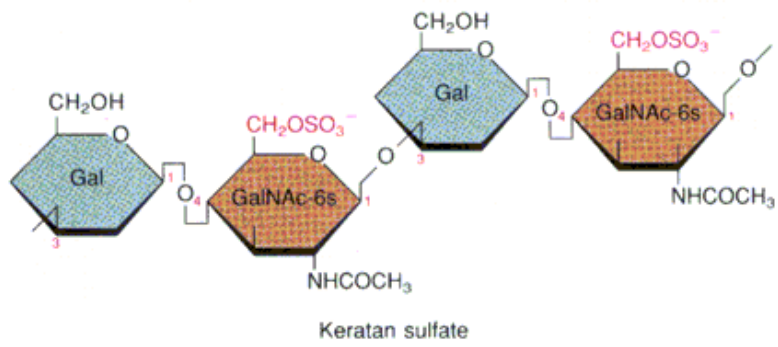
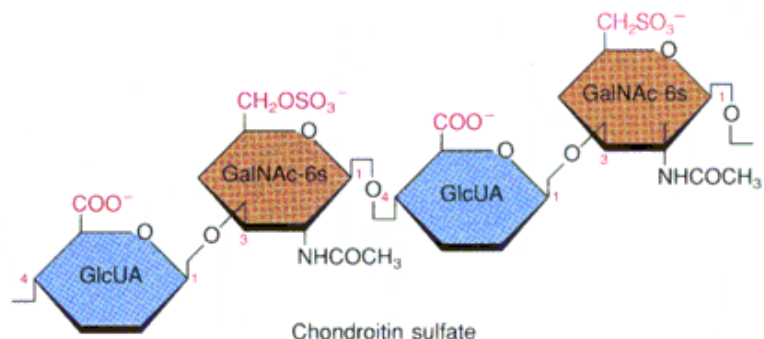


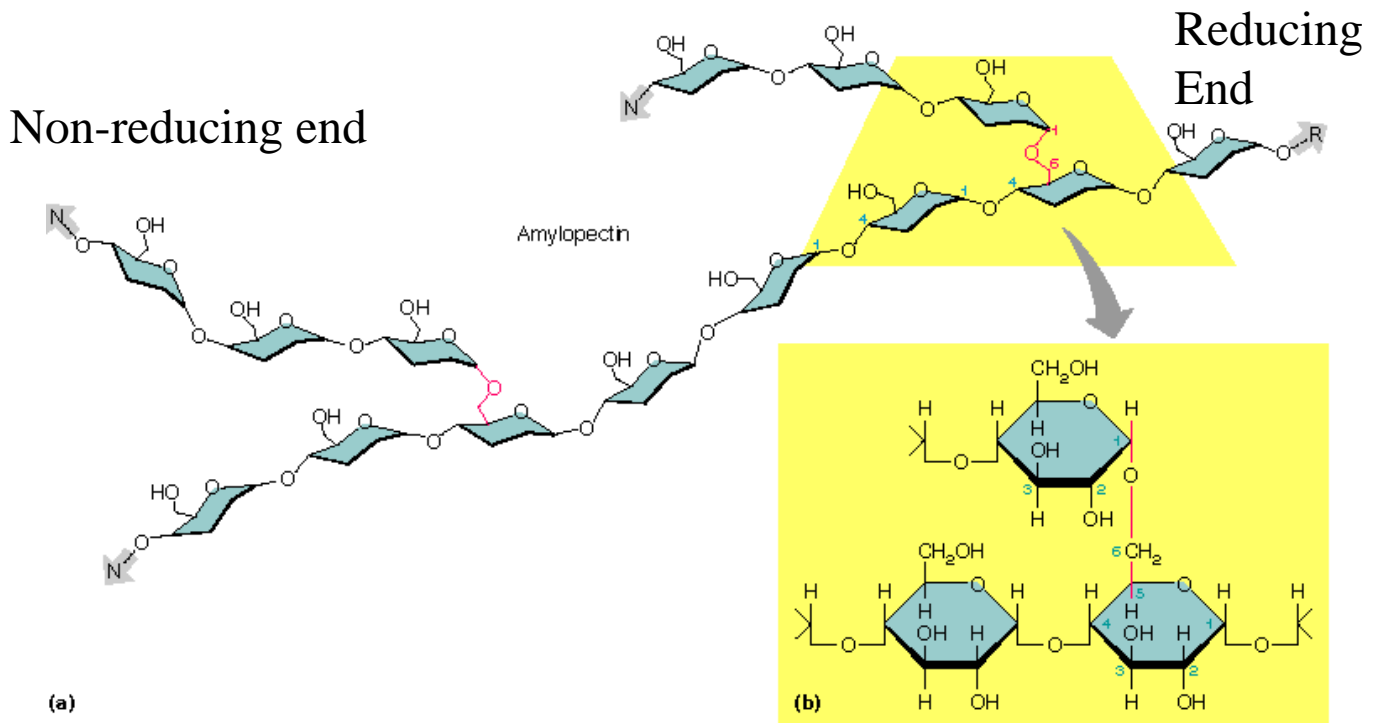
Bad knees???

You may buy these
Items as nutritional supplements.

<http://questivhealth.com/glucosamines.htm>

Very hydrophilic and viscous





Glycogen also has 1>>4 linkages and more 1>>6 branches

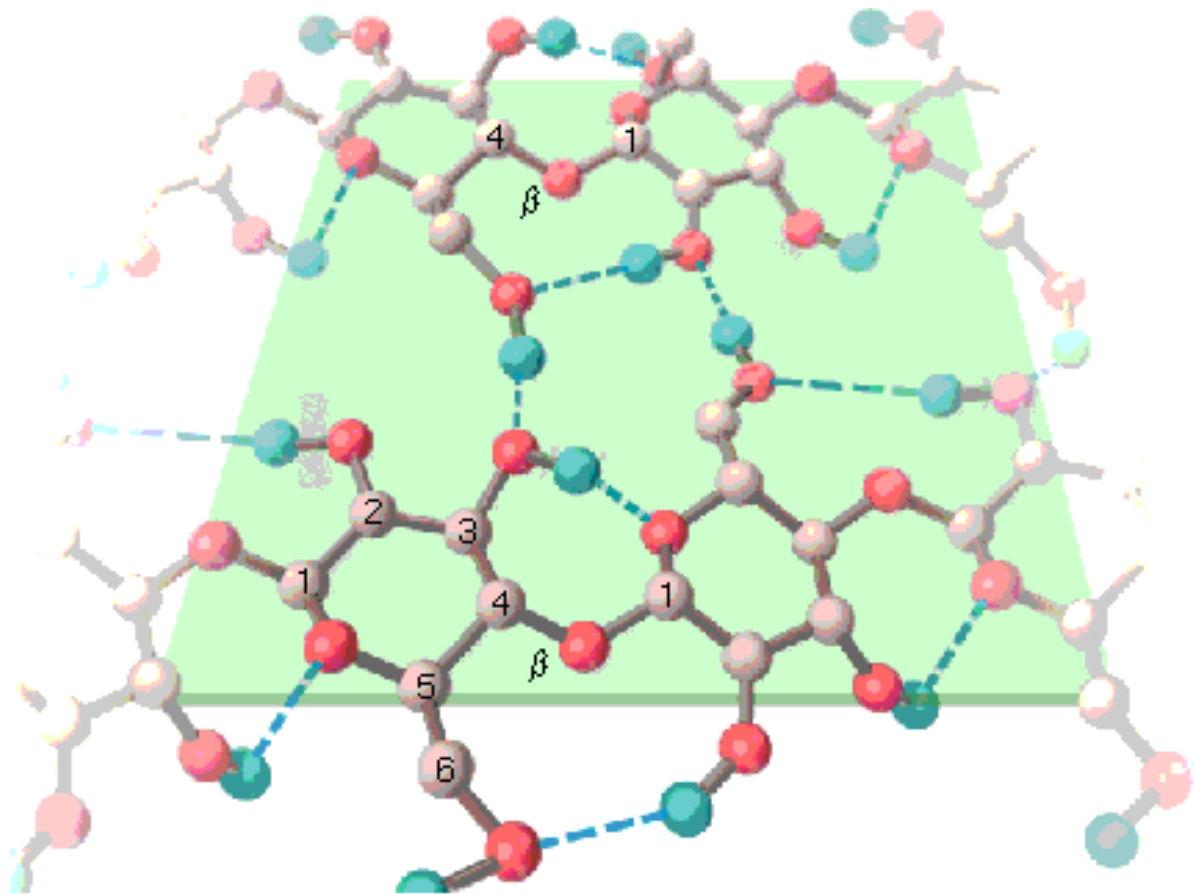
Why store polymerized glucose as branched polymer??

Fast mobilization

Require separate enzymes for 1 \gg 4 and 1 \gg 6 linkages.

Osmotic pressure

Are amino acids or nucleotides stored in this manner?



Cellulose--linear D-glucose β -1,4 linkages & extensive H bonds
Humans lack an enzyme to break this linkage.