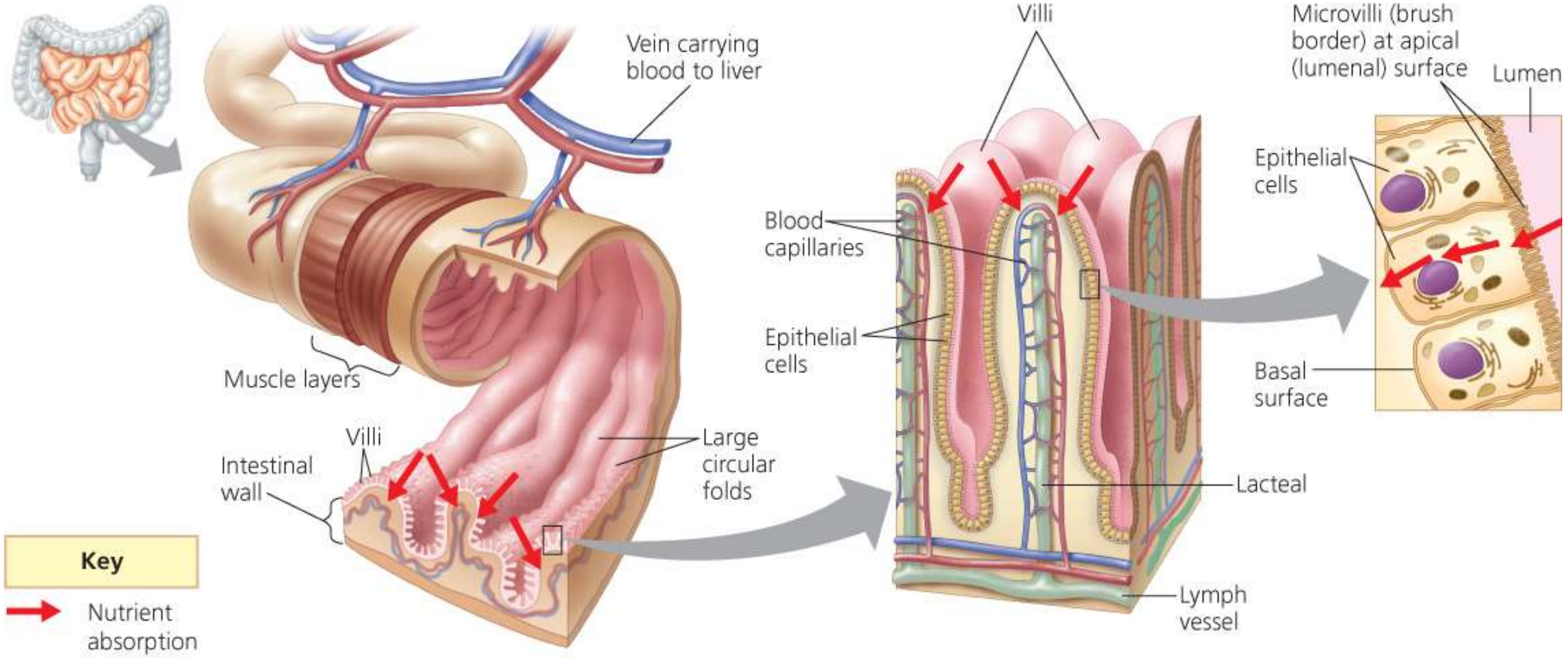
Check list for last week's assignments:

- ❑ you attended three lectures and did the short answer practice question
- ❑ you checked out the location of the walrus for Virginia's office hours
- ❑ your clicker is registered (no need to do this if you were in 102)
- ❑ you read selected sections of the text chapters IF you didn't understand the lectures
- ❑ you reviewed the formation of peptide bonds from Biol 102, IF you needed to do so
- ❑ you did your assigned homework:
  - (a) the parts of the digestive system were reviewed
  - (b) you read about ruminants
  - (c) you read about crops, the gizzard & stomach
- ❑ you have checked out onQ and saw that the first assignment will be available starting on Wednesday Jan 18 and will be available for ~10 days

Absorption

Absorption of the digested products, vitamins, minerals and water occurs in the small intestine. This is assisted by the huge surface area of the small intestine contributed by the villi (contains lacteals, and capillaries) and microvilli.



▲ **Figure 41.12 Nutrient absorption in the small intestine.**

Homework: please read about absorption pg. 950-952

Digestion in insects

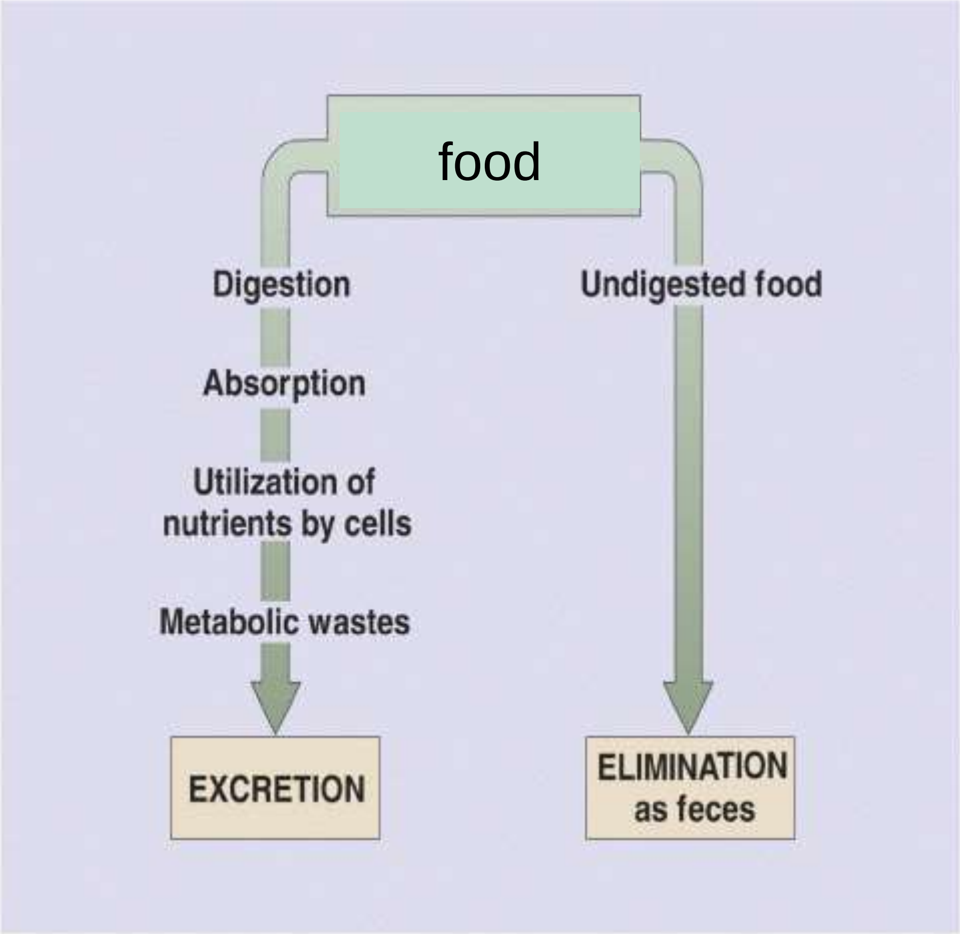
- Similar to digestion in vertebrates, but no pepsin

  Why?
- A few interesting adaptations:

  salivary glands (discussed)

  active proteases eliminated with feces

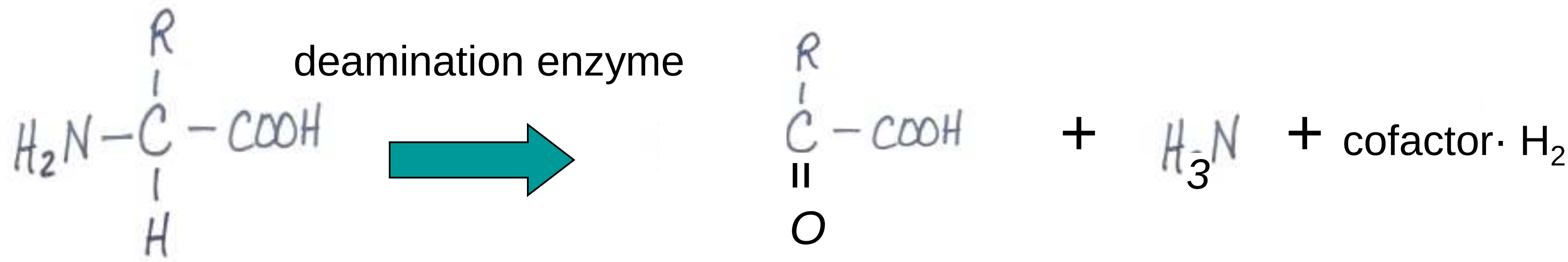
II. Excretion & Ion Transport



General Reference: Chapter 44 as well as some review of Biology 102

After digestion, individual amino acids are absorbed by cells lining the small intestine and then enter the blood. But what happens then? What do we need amino acids for? Can we store amino acids in the circulatory system, like insects or plants?

Liver:

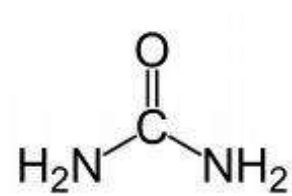


amino acid

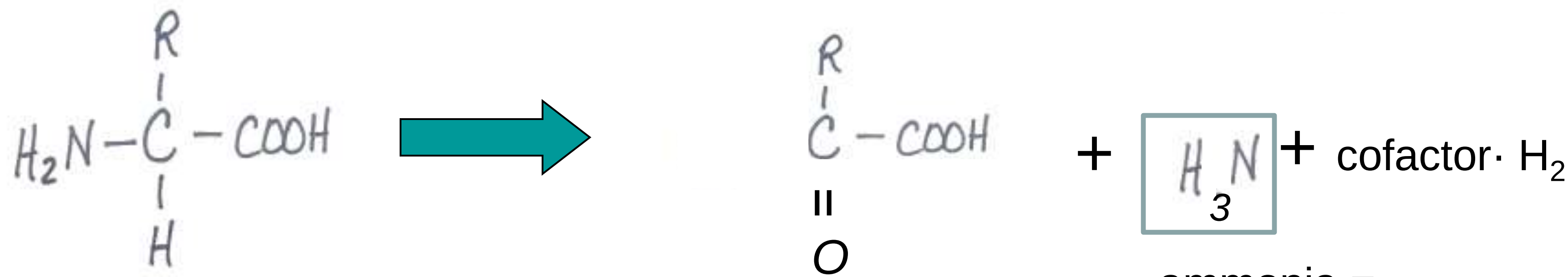
a form that can be stored and/or used for energy = deaminated amino acid or α-ketoglutaric acid

Liver (urea cycle):

NH_3 + CO_2 + H_2O ➡➡➡➡➡



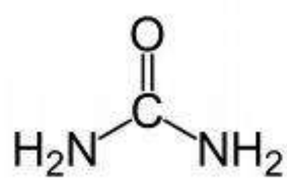
deamination:



ammonia =
nitrogenous waste
product in fish &
other aquatic
organisms

urea cycle:

$NH_3 + CO_2 + H_2O \rightarrow\rightarrow\rightarrow\rightarrow\rightarrow$



urea

& now some applications of this knowledge…..

Research news: sharks and climate change (Univ. Manitoba and Mount Allison U)

News in science

Print Email to a friend

Shark blood changes all the time

Jennifer Viegas
Discovery News

Sharks change their blood volume depending on the saltiness of the water they're swimming in, according to new research.

So sharks must continuously regulate their blood and other body-fluid volumes as water salinity changes.

The paper, in the latest issue of the journal *Comparative Biochemistry and Physiology*, provides one of the most extensive looks at this phenomenon, and points out how massive ice melt triggered by warming could spell trouble for sharks.

Sharks have evolved a five-step process to regulate the volume of their blood, including the development of a bizarre salt-secreting gland *(Image: iStockphoto)*

"Body fluid regulation is important for sharks in the same way it is important for humans," says lead author Gary Anderson, an assistant professor of biological sciences at Canada's University of Manitoba.

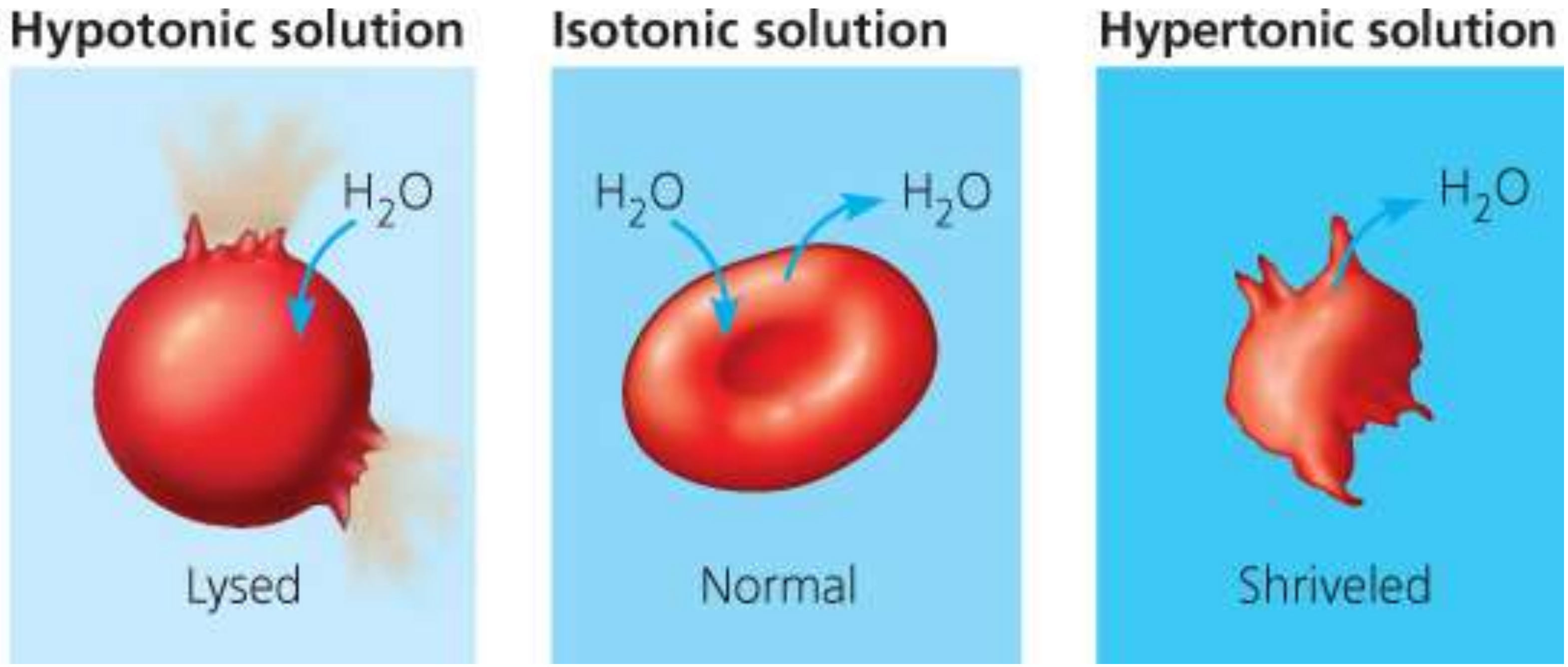
"Without appropriate regulation of body fluid volumes, physiological systems, such as the cardiovascular and renal systems, would not function optimally and therefore the animal would suffer as a result," he says.

Shark blood consists of cells and plasma, a protein, water and a mineral-containing substance.

Anderson and his team say that sharks in low salt or freshwater environments have much higher blood volumes than sharks in salty water.

When shark plasma amounts rise, their cell counts remains the same, so sharks in fresh water essentially develop watery blood in response to certain surroundings.

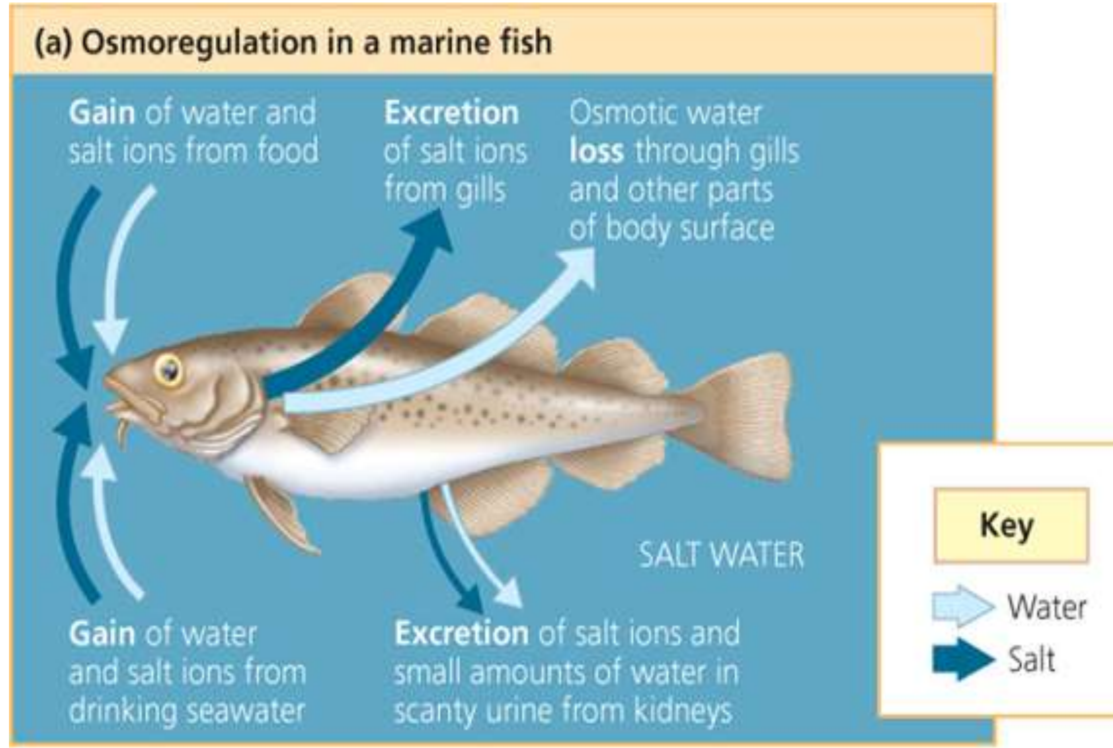
<u>If</u> you have forgotten osmosis from Biol 102, please review Fig. 7.13 for homework and read pg 1022



Saltwater fish (bony fish) – they are:

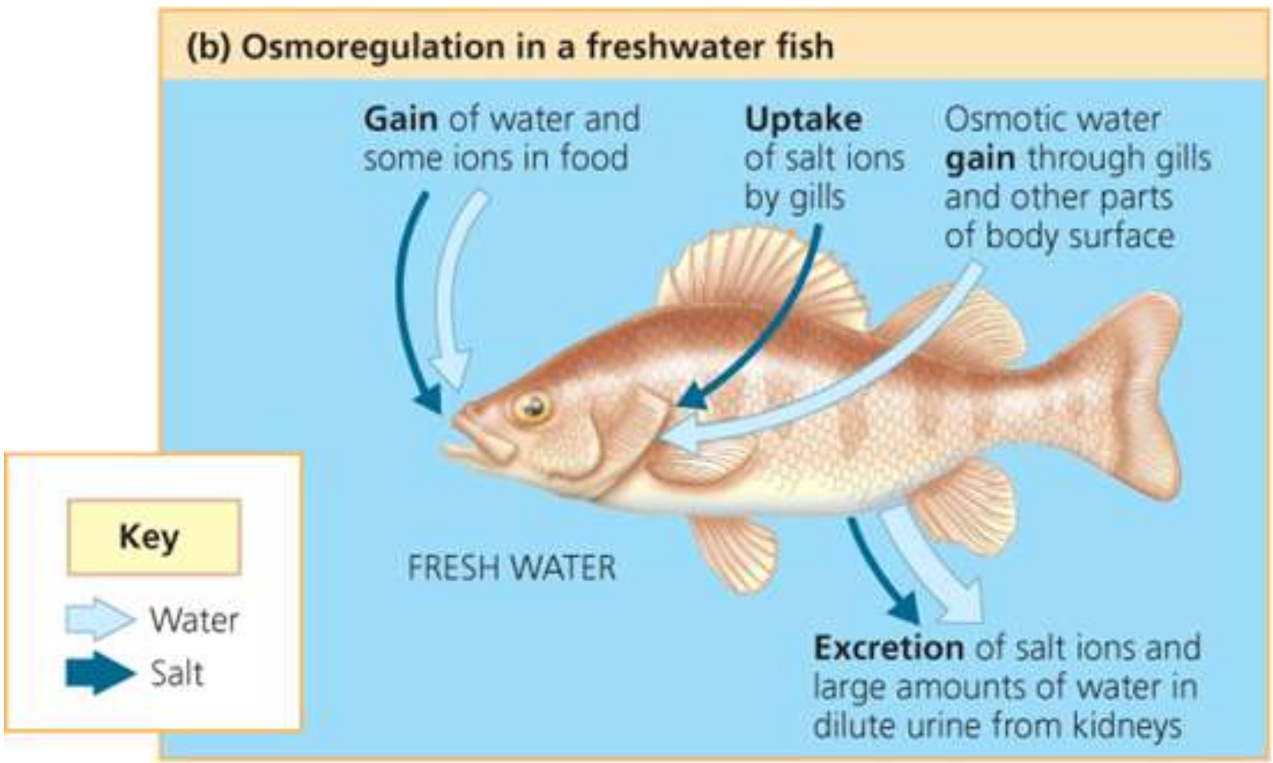
- Hypotonic; in danger of dehydrating with water lost across the gills.
- Therefore, they have to drink lots of water
- Excreted ammonia is diluted with a minimum amount of water

  = concentrated urine
- Excess salt is transported out of body by specialized cells in the gills

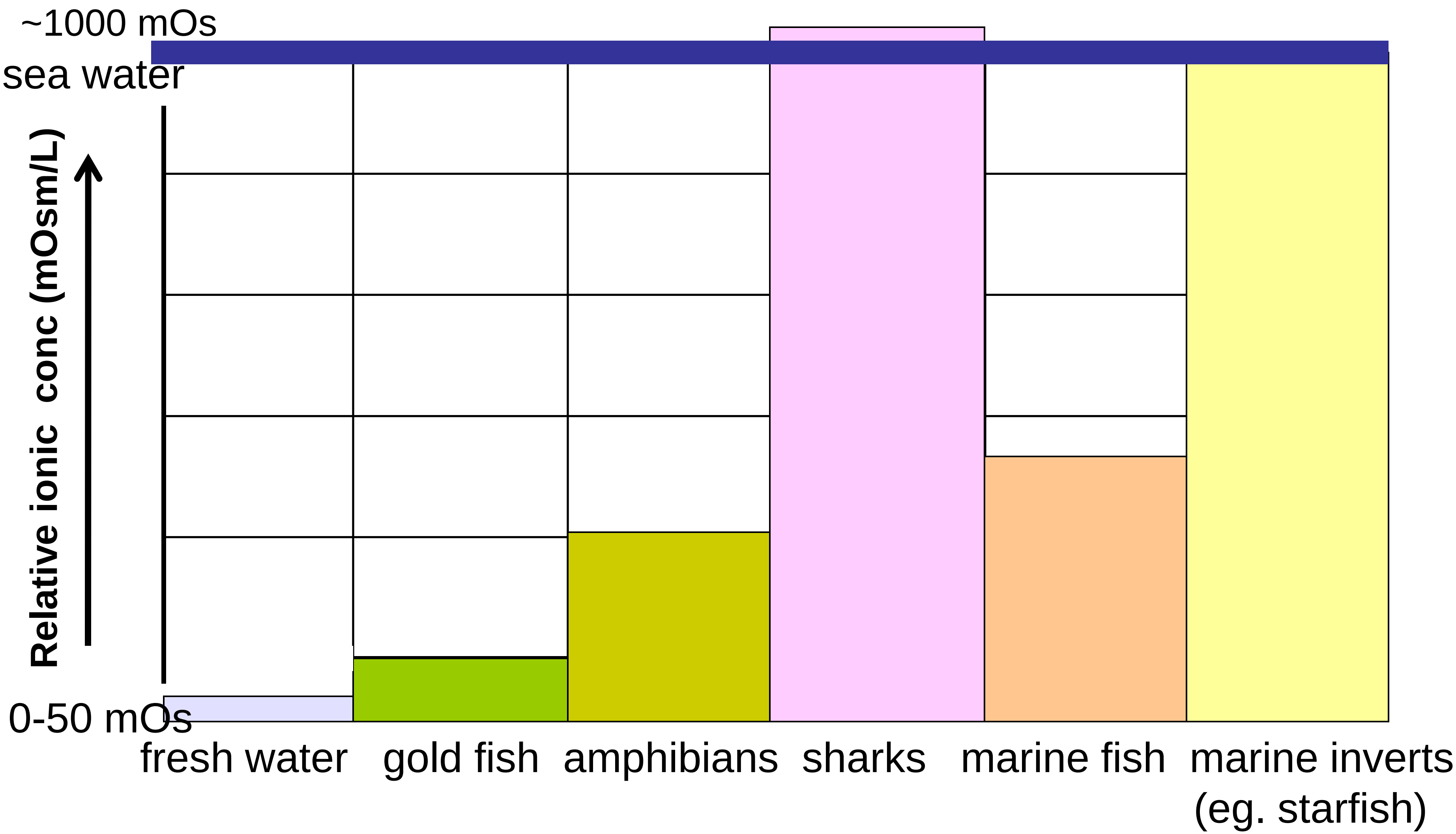


Just to complete the story….**Freshwater fish**:

- Are in danger of being “water logged” (hypertonic)
- Produce large amounts of dilute urine
- Specialized gill epithelial cells transport Na^+ and Cl^- from water into fish’s capillaries (concentrate salts)



Relative salt concentration in various animals and the ionic concentration (Cl^-) of seawater



Guideline for the Release of Ammonia Dissolved in Water Found in Wastewater Effluents

Table of Contents

Ammonia dissolved in water is a substance specified on the List of Toxic Substances in Schedule 1 of the *Canadian Environmental Protection Act, 1999*. The Minister of the Environment published a Proposed Notice requiring the preparation and implementation of pollution prevention plans for ammonia dissolved in water, inorganic chloramines and chlorinated wastewater effluents (PDF, 2497KB, page 7) in the *Canada Gazette*, Part I, on June 7, 2003. Persons were given the opportunity to file comments with respect to the proposed Notice for a comment period of 60 days. The Minister has considered all comments received and has published a Response to Stakeholders' Comments that summarizes how the comments were dealt with.

This Guideline is issued as an instrument respecting preventive and control actions in relation to ammonia dissolved in water found in wastewater effluents in application of section 92 of the Act. The Minister of the Environment has published a *Notice requiring the preparation and implementation of pollution prevention plans for inorganic chloramines and chlorinated wastewater effluents (PDF, 1225KB, page 13)*. The Minister of the Environment, pursuant to subsection 54(1) of the *Canadian Environmental Protection Act, 1999*, has decided to issue a Guideline as a means to reduce the impact of releases of ammonia dissolved in water to surface water, and pursuant to subsection 54(4) directs that it be published in the *Canada Gazette*, Part I.

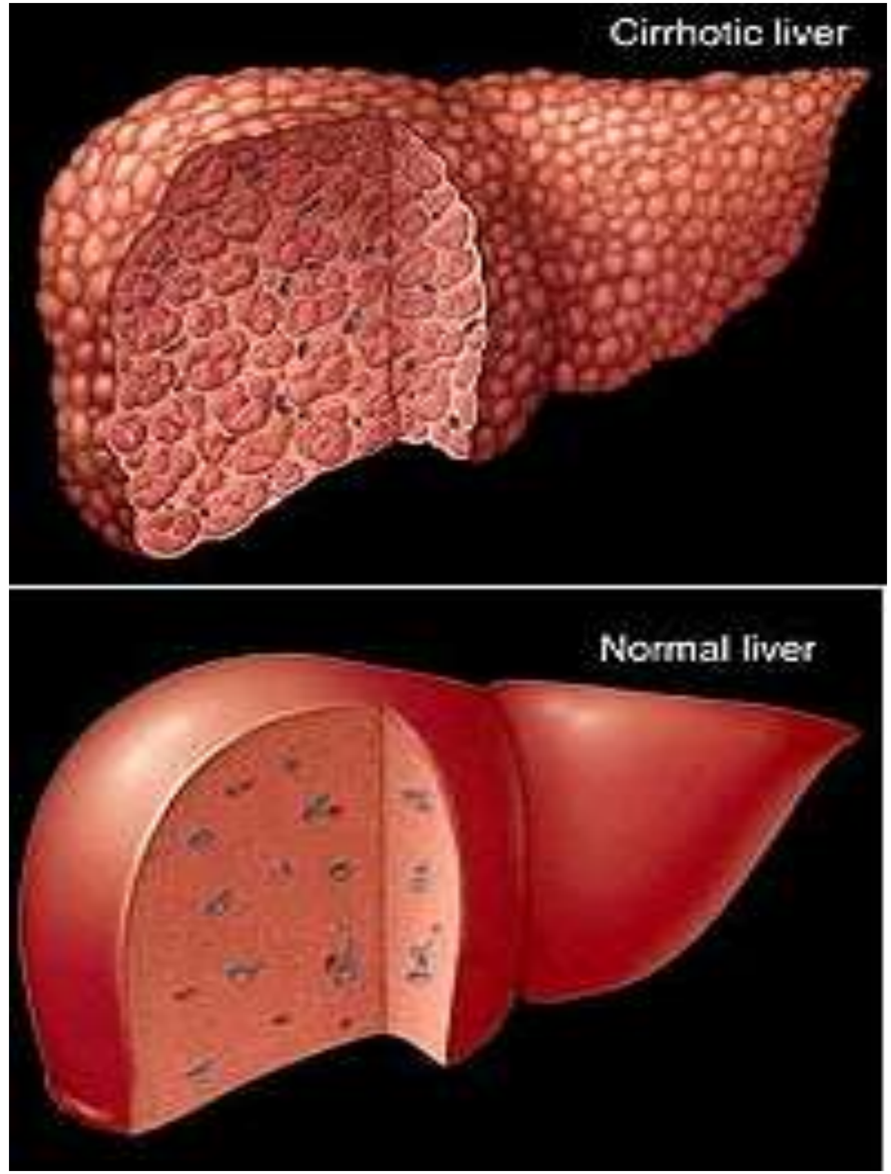
- Guideline for the Release of Ammonia Dissolved in Water Found in Wastewater Effluents (PDF, 1225KB, page 5)

Background information

- Frequently Asked Questions
- Revised Draft: Guideline for the Release of Ammonia Dissolved in Water Found in Wastewater Effluents (for information purposes only)
- Response to Stakeholders' Comments

Human disease:

Liver cirrhosis caused by alcoholism, infectious disease (*e.g.* hepatitis) or fatty liver disease. It is one of the leading causes of death in the middle years in western countries. One consequence is that the damaged liver cannot efficiently carry out the urea cycle.



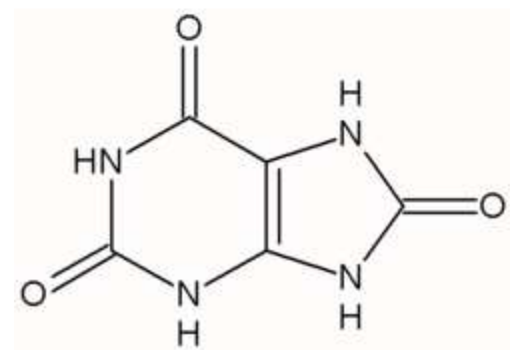
In birds, reptiles and insects….

(again in the liver, or analogous organ or tissue)

~15 steps

$NH_3 + CO_2$

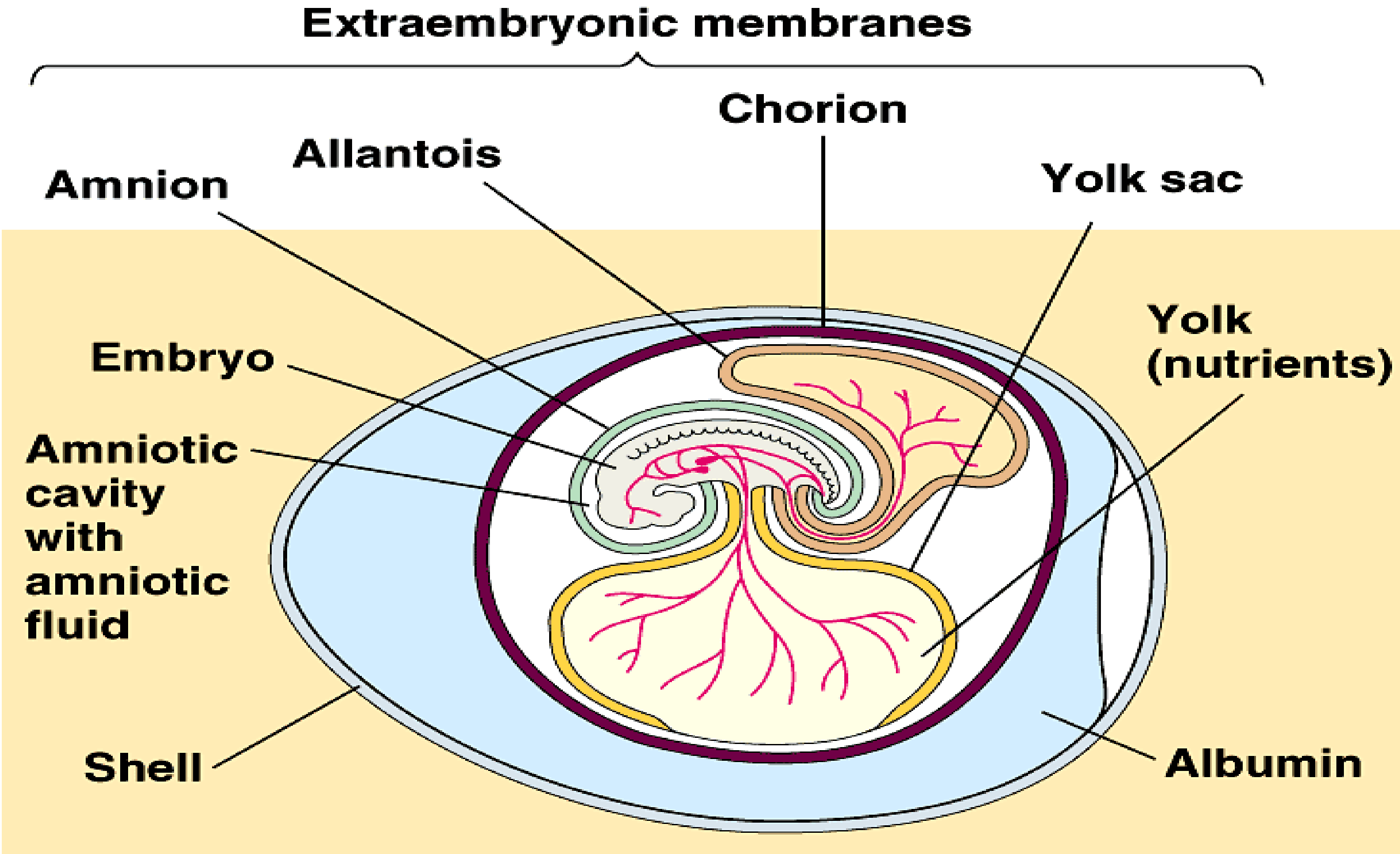
ATP



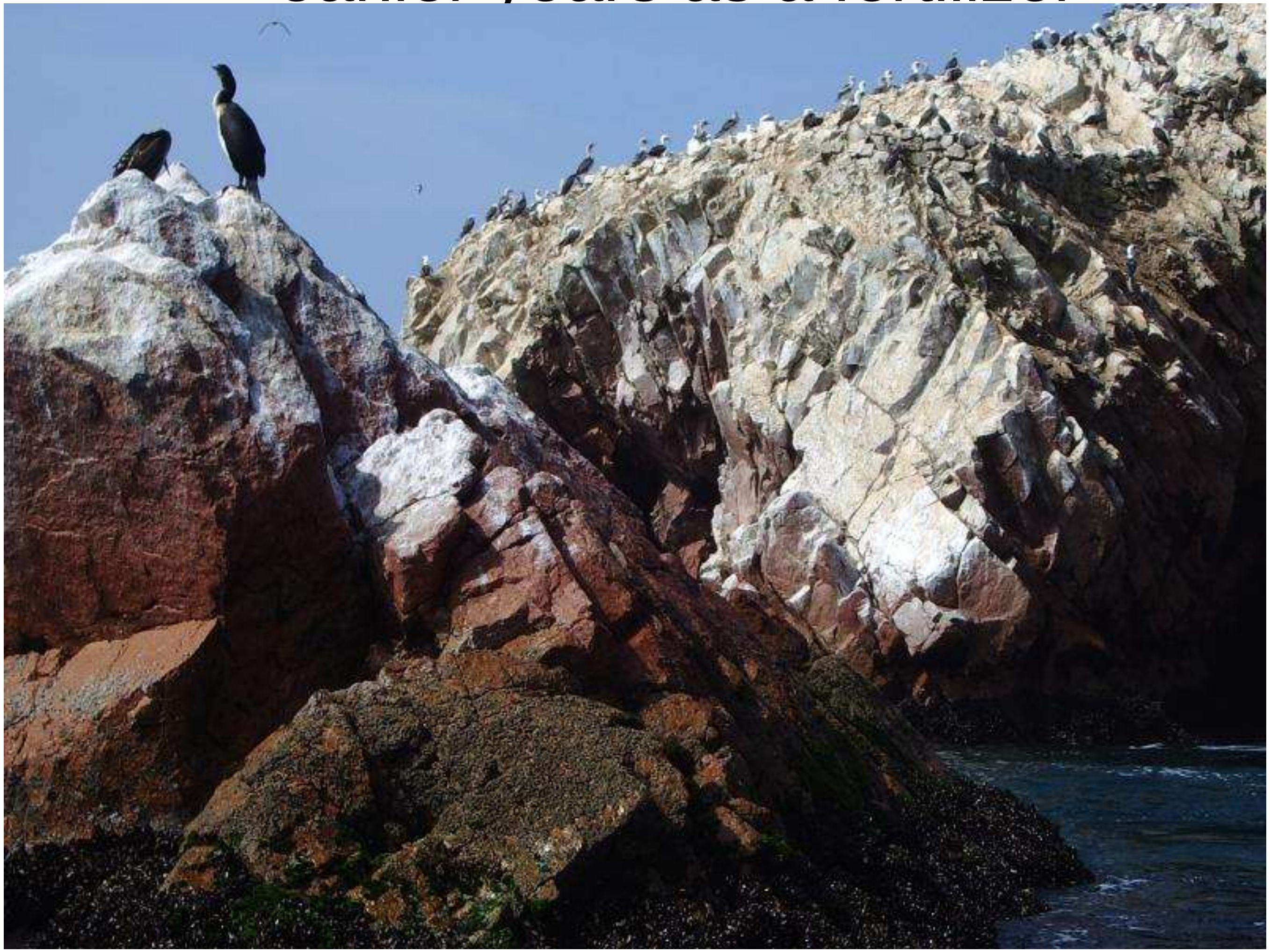
uric acid

(**WHY** is uric acid the nitrogenous waste of birds?)

The anatomy of a bird egg. Uric acid is stored in the allantois and is left behind at hatching

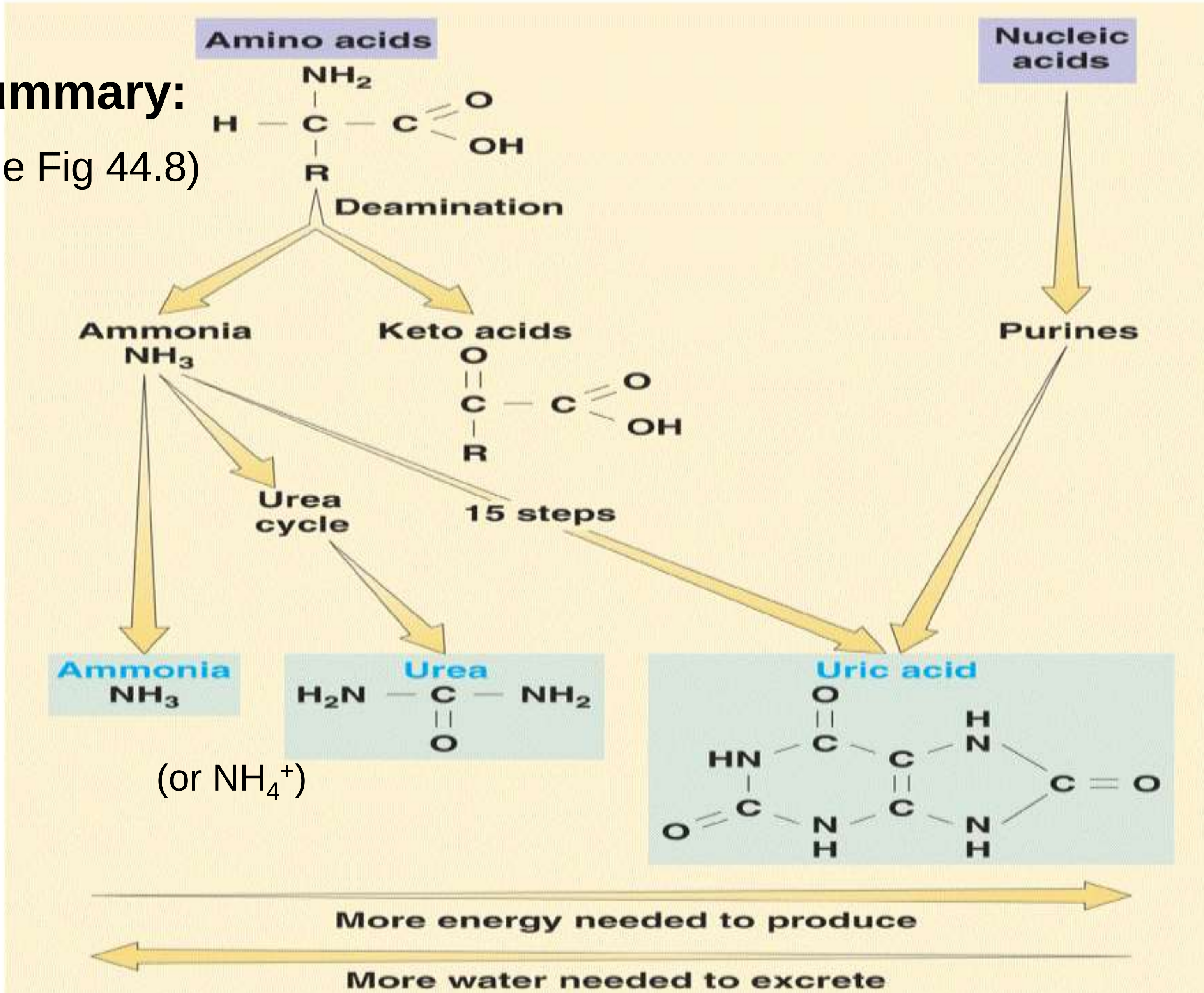


Guano: birds excrete uric acid and this is found in droppings with digestive waste. It was important in earlier years as a fertilizer



Summary:

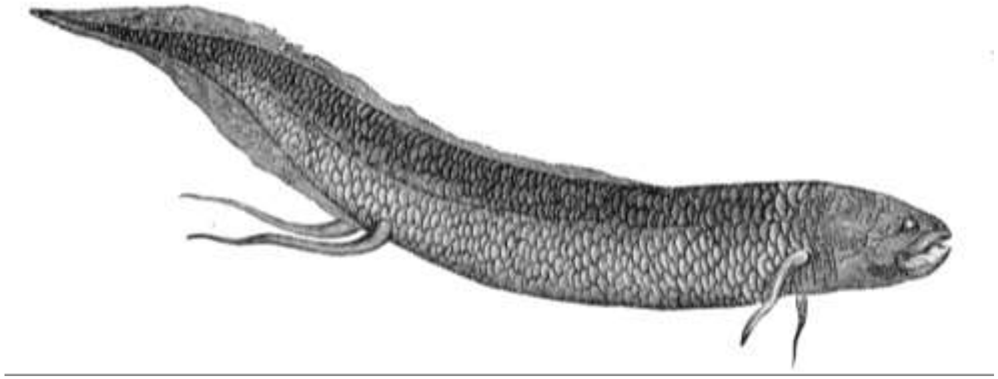
(see Fig 44.8)



(or NH_4^+)

A number of interesting adaptations

1. Lungfish (*Protopterus*) ["living fossils" present 410 Mya]



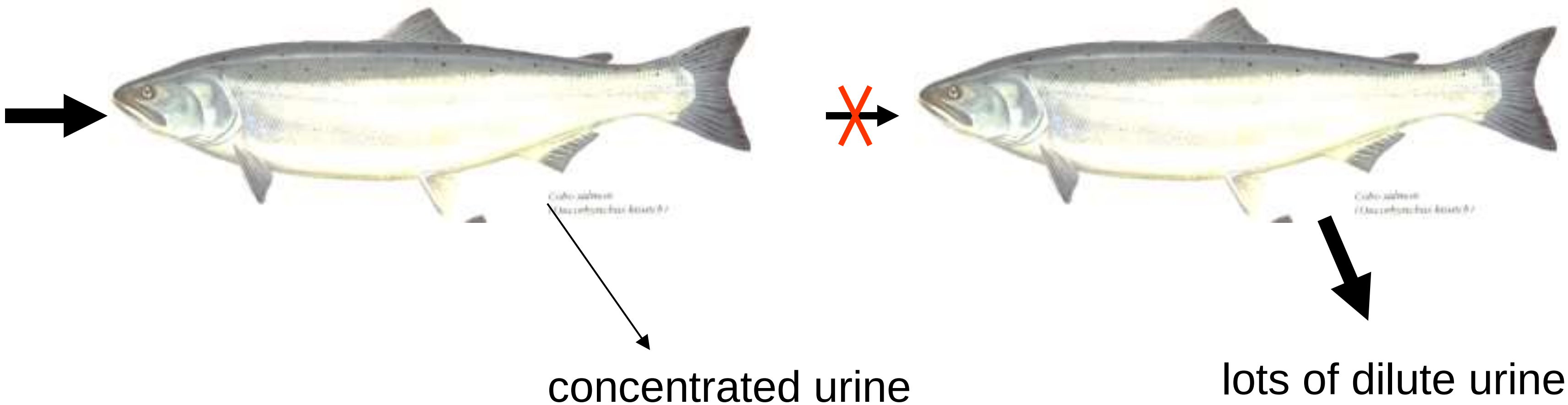
Dr. 'Alex' Ip of National University of Singapore studies lungfish to try to understand their adaptation to high ammonia concentrations. He hopes to apply this work to human patients with liver failure.

Reference: Hiong et al. (2015) PLoS ONE 10(3): e0121224- no you don't need to look this up!

2. Salmon

Ocean

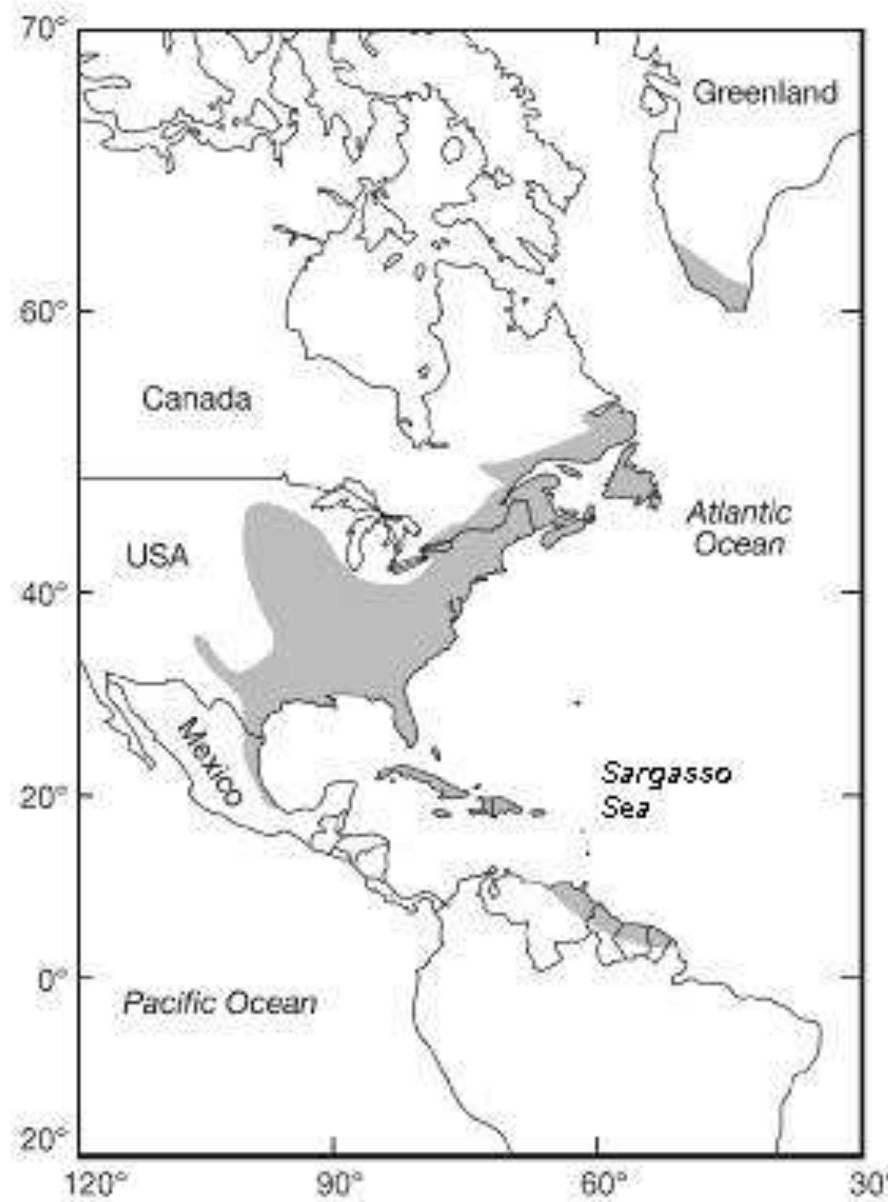
Fresh water



Salmon have to make to make these drastic changes twice in their lives. The gill epithelial cells are able to transport both Na^+ and Cl^- against the concentration gradient (using ATP)

3. Eels

The American eel is found in fresh and sea waters along the coasts and into Lake Ontario. (Fisheries and Oceans Canada, American Eel, Underwater World- Ontario Ministry of Natural Resources).

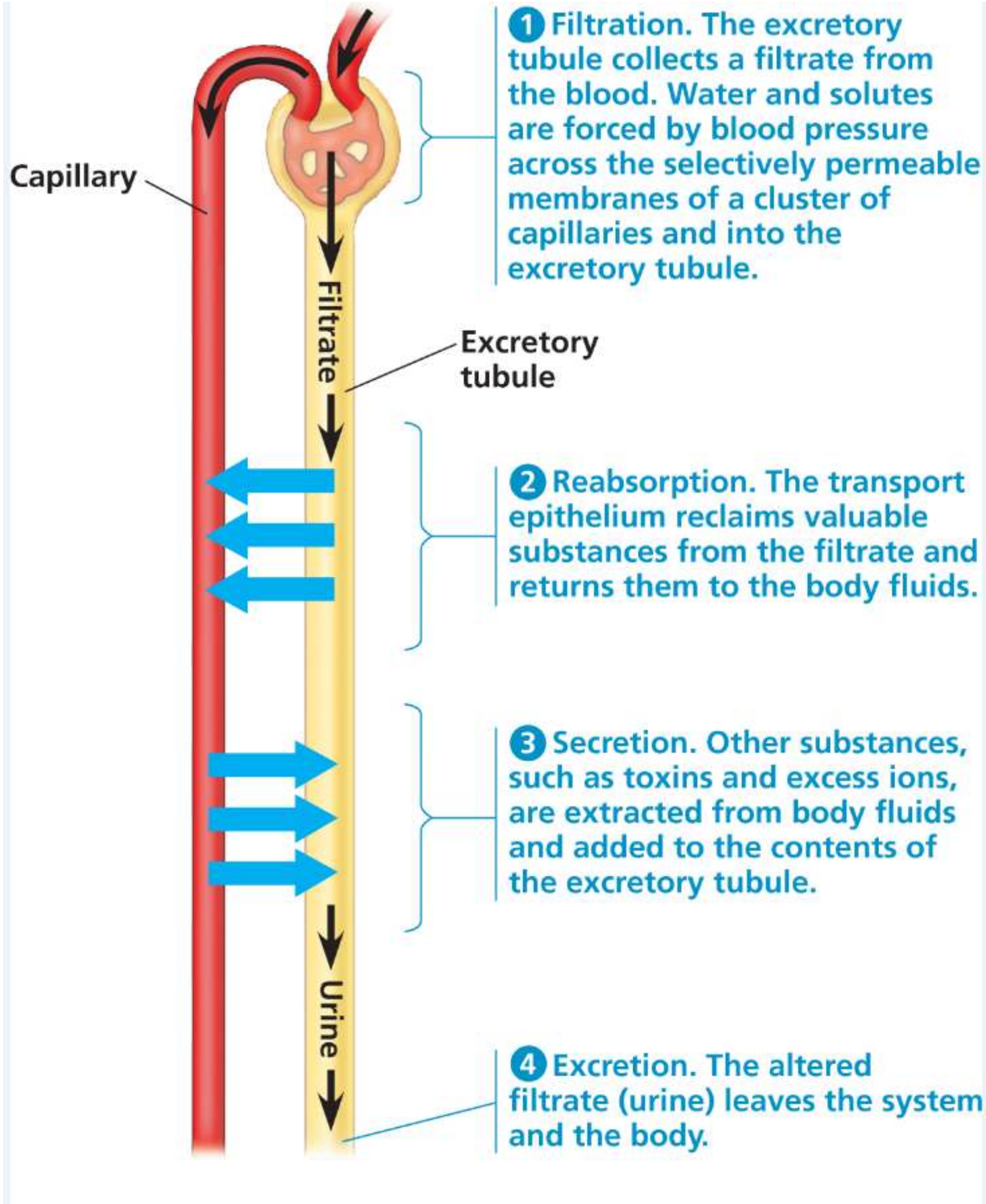


To get rid of these nitrogenous wastes, organisms need **excretory organs**

Three functions:

1. Filtration - acts like a filter to remove water and small solutes from body fluids or blood while leaving behind blood cells, proteins & other large solutes
2. Reabsorption – useful material in the filtrate recaptured and returned to blood
3. Secretion – may put additional solutes into the filtrate (can aid in the elimination of toxins)

Fig. 44.10


Capillary
Filtrate
Excretory tubule
Urine
1 Filtration. The excretory tubule collects a filtrate from the blood. Water and solutes are forced by blood pressure across the selectively permeable membranes of a cluster of capillaries and into the excretory tubule.
2 Reabsorption. The transport epithelium reclaims valuable substances from the filtrate and returns them to the body fluids.
3 Secretion. Other substances, such as toxins and excess ions, are extracted from body fluids and added to the contents of the excretory tubule.
4 Excretion. The altered filtrate (urine) leaves the system and the body.

Vertebrates have a <u>kidney</u> containing specialized tubules with cells that actively transport ions for salt and water homeostasis and nitrogenous waste elimination.

The rest of the urinary system consists of the <u>ureters</u>, <u>urinary bladder</u> and <u>urethra</u>

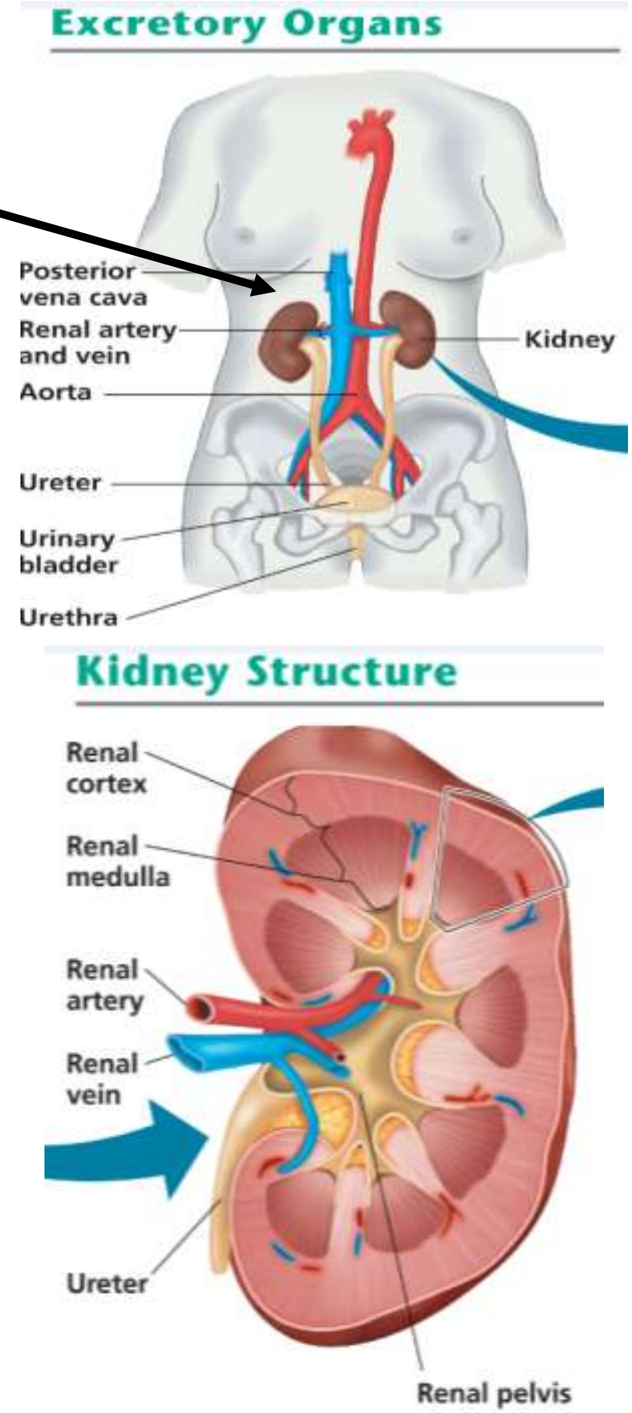


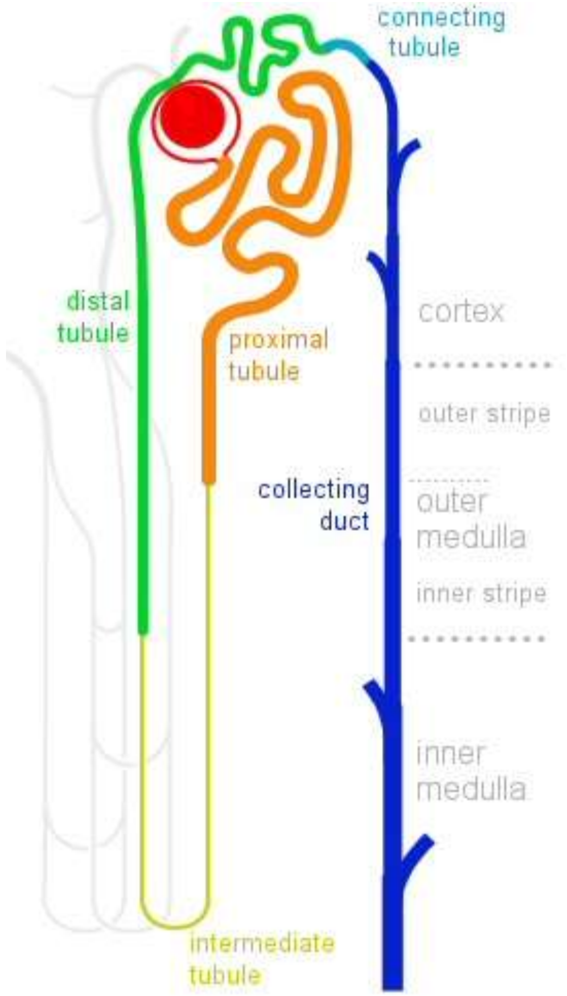
Fig. 44.14

The nephron

Functional unit of the kidney in higher vertebrates (several million nephrons in each kidney)

Nephrons are composed of:

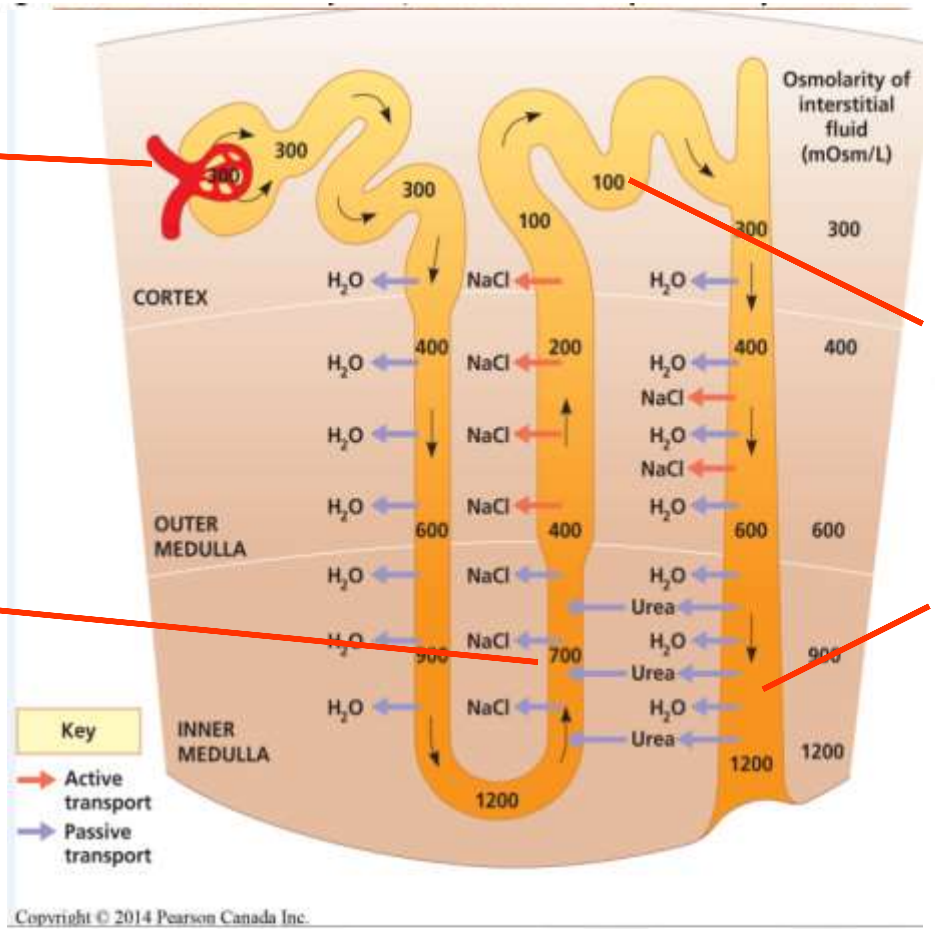
1. Capillary network in the renal corpuscle (Bowman's capsule + glomerulus). This forms filtrate
2. A long tubule that performs secretion and reabsorption.
3. A collecting duct that empties into the central cavity of the kidney



Homework: Fig. 44.16. Please get a basic understanding of why we have kidneys and what they do. There is no reason to memorize detailed parts of the kidney and the osmolarity of the filtrate

Fluid enters the loop of Henle (same osmolarity as the blood), but it gets more concentrated as water diffuses out in the descending limb.

Later Na and Cl ions are transported out of the tubule but this portion of the tube is not permeable to water



In the distal region, the combination of water and ion loss has made the filtrate dilute again

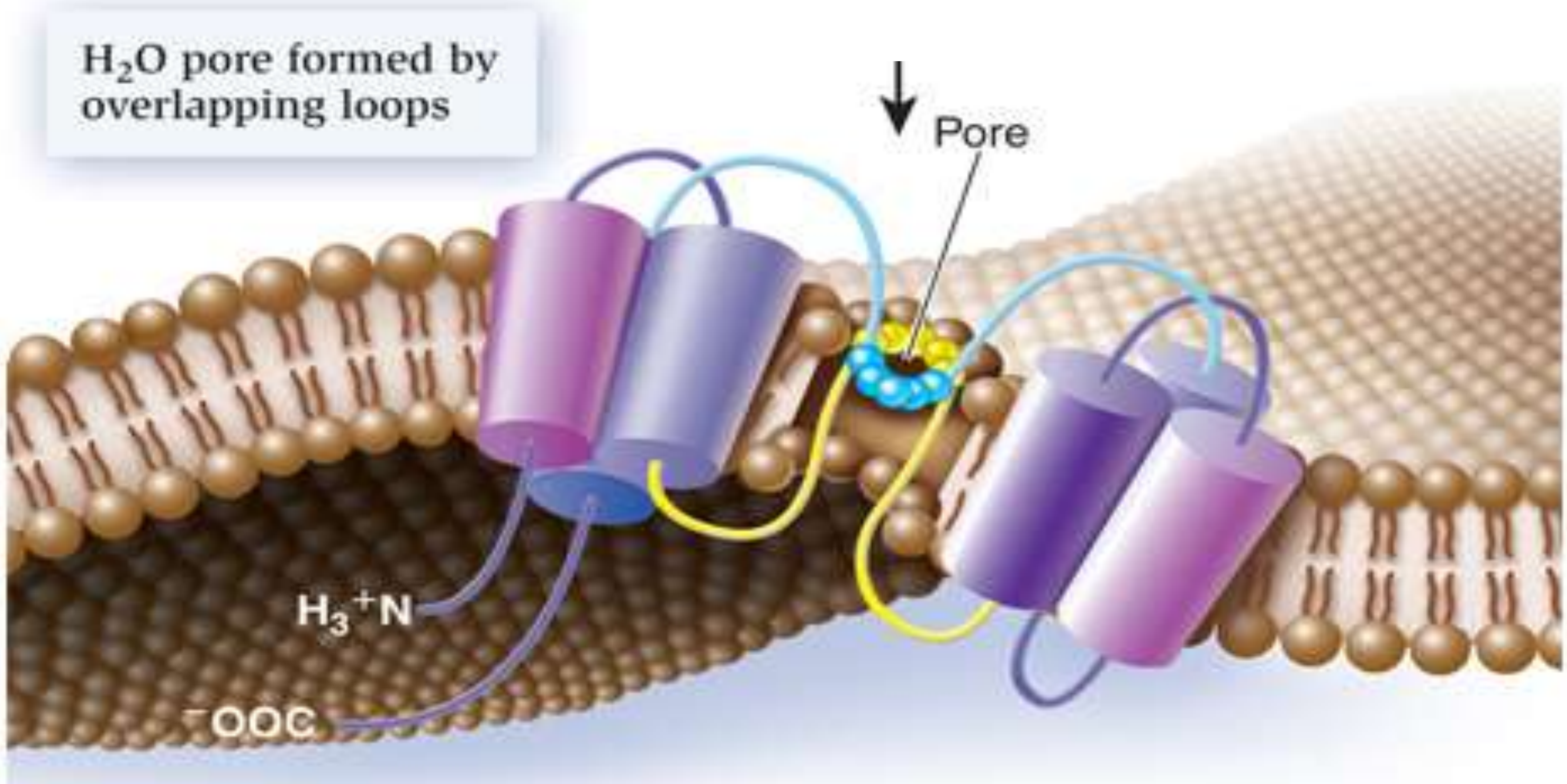
The fluid becomes concentrated again in the collecting duct by the loss of water (urea can also diffuse out into the medulla to maintain the osmotic gradient; hormonal action can also assist)

Modified from Fig. 44.16

Water moves very quickly across the nephron membranes. Agre *et al.* (Nobel Prize in 2003) discovered that the rapid movement of water was aided by “water pores” or aquaporins

- This discovery explained why water can diffuse through kidney membranes more quickly than theoretically possible.
- Aquaporin family members can also transport other small molecules (*e.g.* urea).
- The protein structure makes loops, which form openings about the same width as the small molecules that will be transported.

At least 13 members of the ‘aquaporin gene family’ have been cloned in humans. Some of these genes are expressed in different parts of the kidney. For example, aquaporin 1 is expressed in the proximal part of the tubule and aquaporin 2 and 3 are expressed in the collecting ducts.

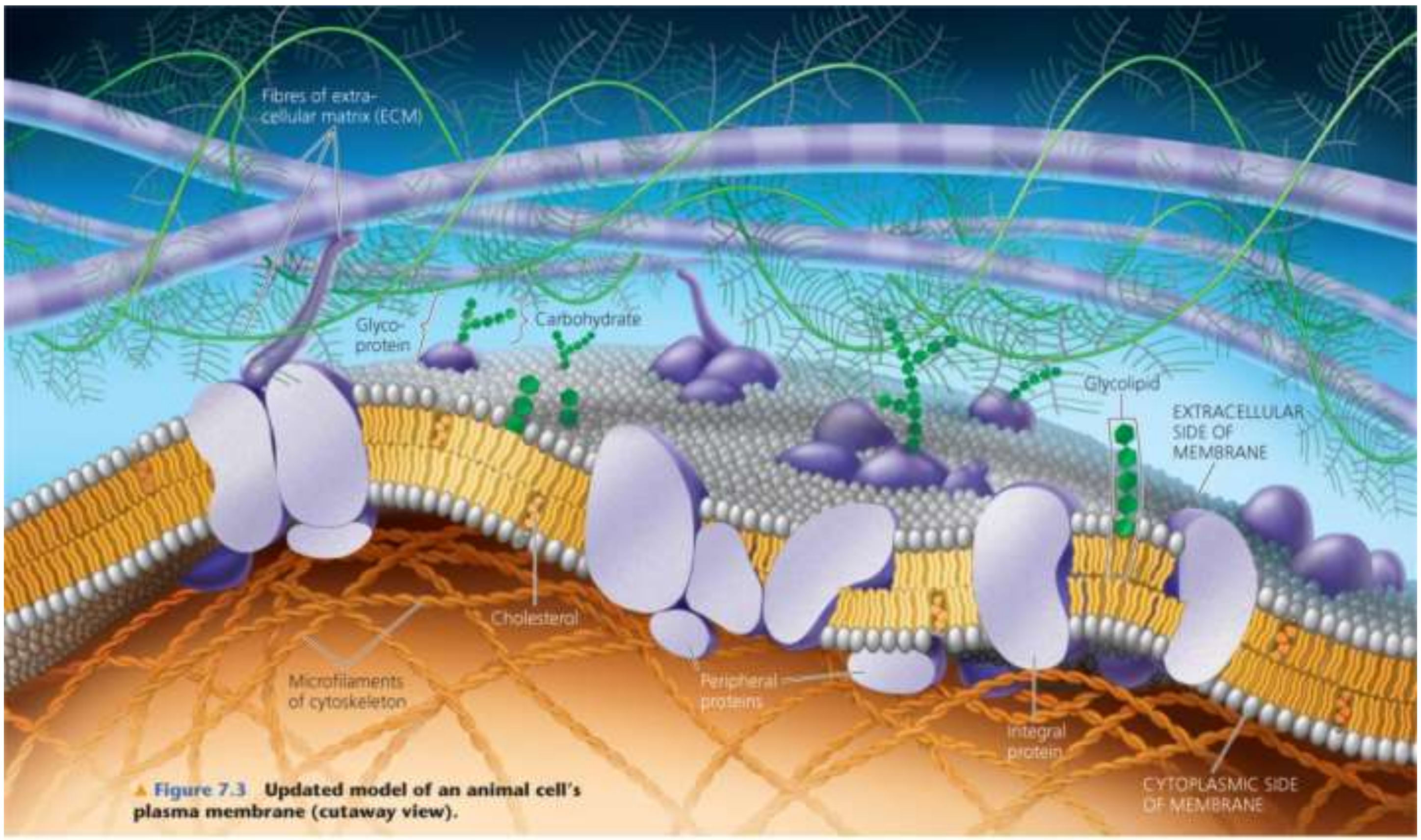


(b) Three-dimensional (tertiary) structure of aquaporin

http://biology-forums.com/index.php?action=gallery;sa=view;id=1315

As mentioned, in the kidney, active transport of Na^+ and other substances is needed. Active transport is also required in the salt-secreting cells in fish gills. What do you remember about transport?

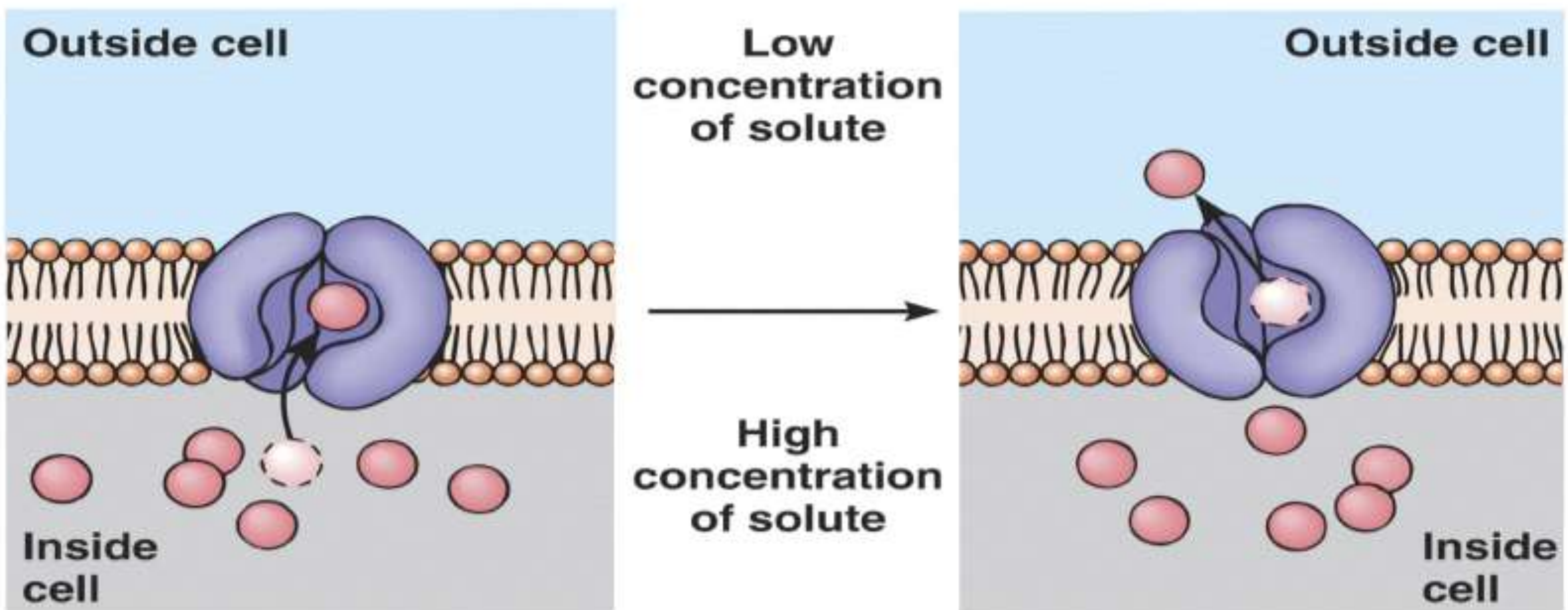
Fig 7.3



▲ **Figure 7.3 Updated model of an animal cell's plasma membrane (cutaway view).**

Quick review of Biol 102:

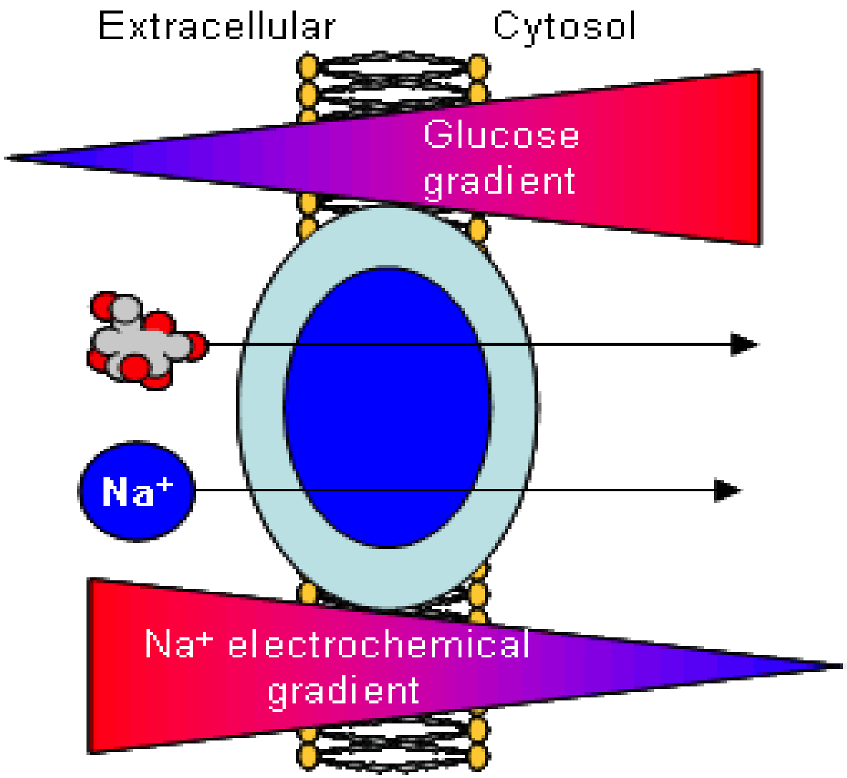
(i) Facilitated diffusion: A channel in the membrane allows transport across the membrane into the cell, or out of the cell.



e.g. after digestion of carbohydrates, fructose enters the cells lining the small intestine using facilitated diffusion (pg. 144).

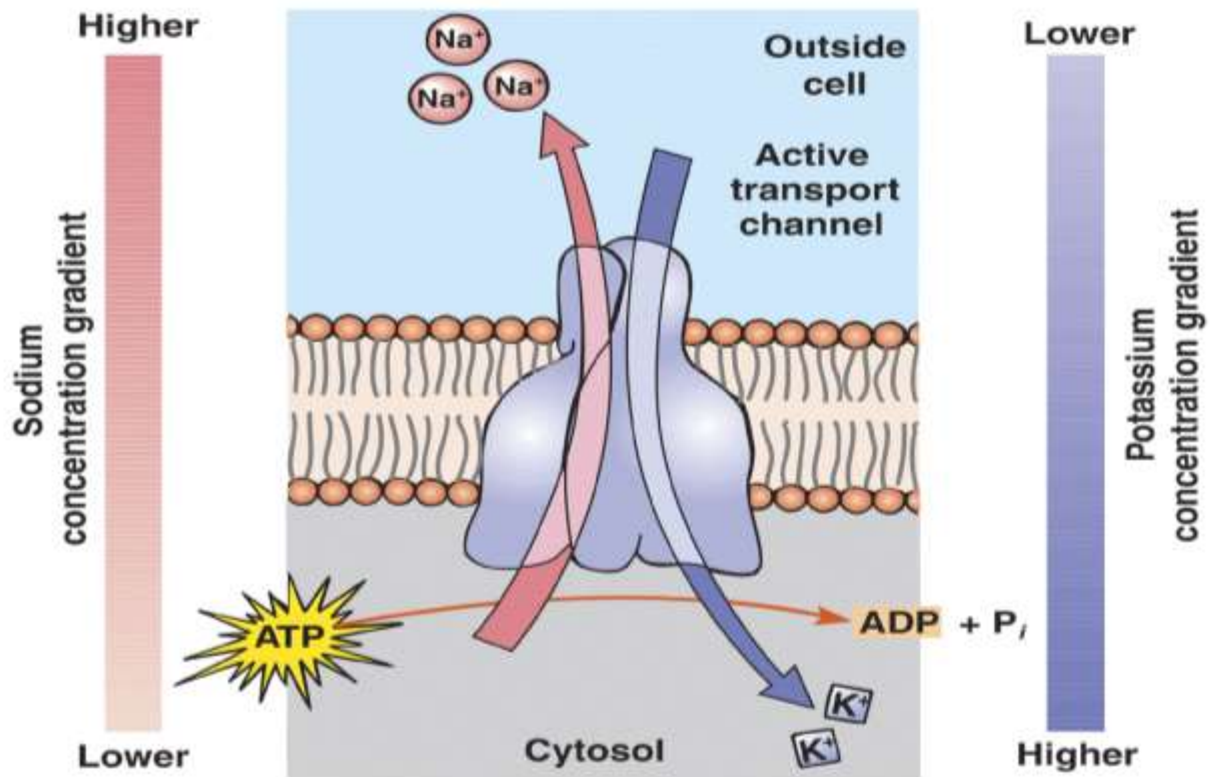
review continued..

(ii) Co- transport or secondary active transport

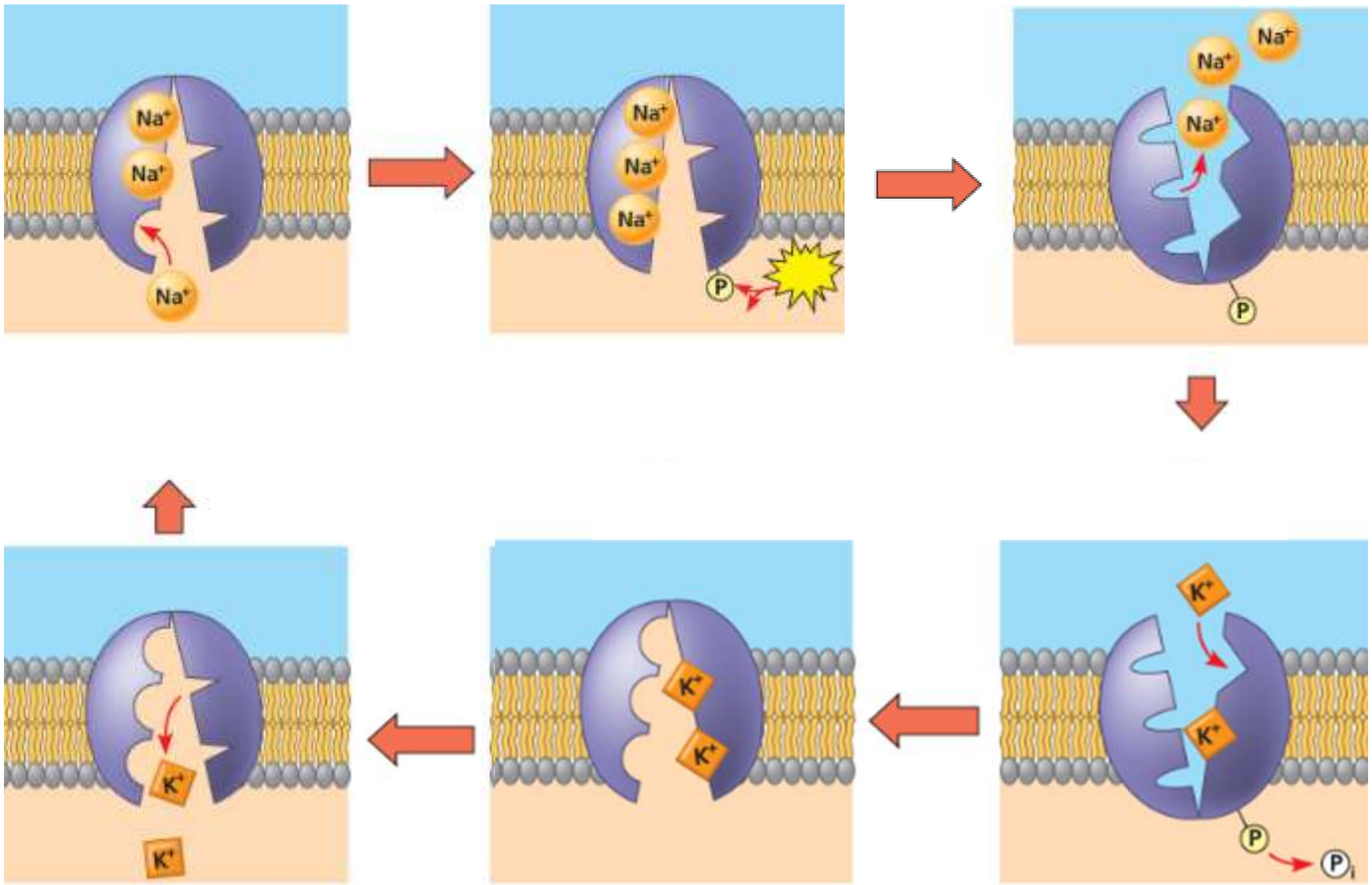


e.g. after digestion, Na^+ and glucose enter the cells lining the small intestine (see Fig. 7.19, pg. 147)

(iii) Transporters
(for example Na^+/K^+ ATPase, also known as the sodium potassium pump- see Fig. 7.16)

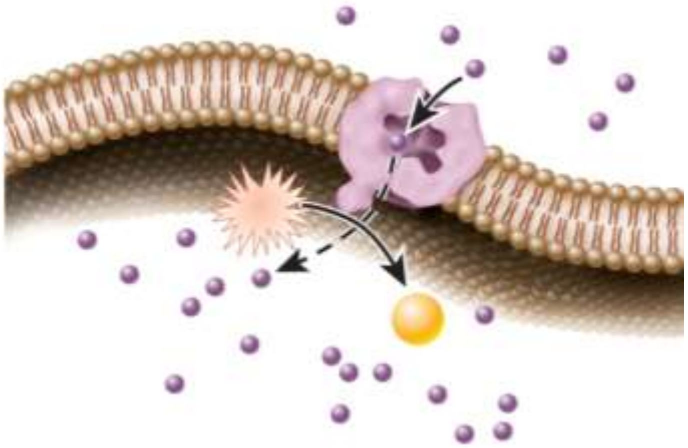


Homework: If you have forgotten this, please review it (Fig. 7.14)

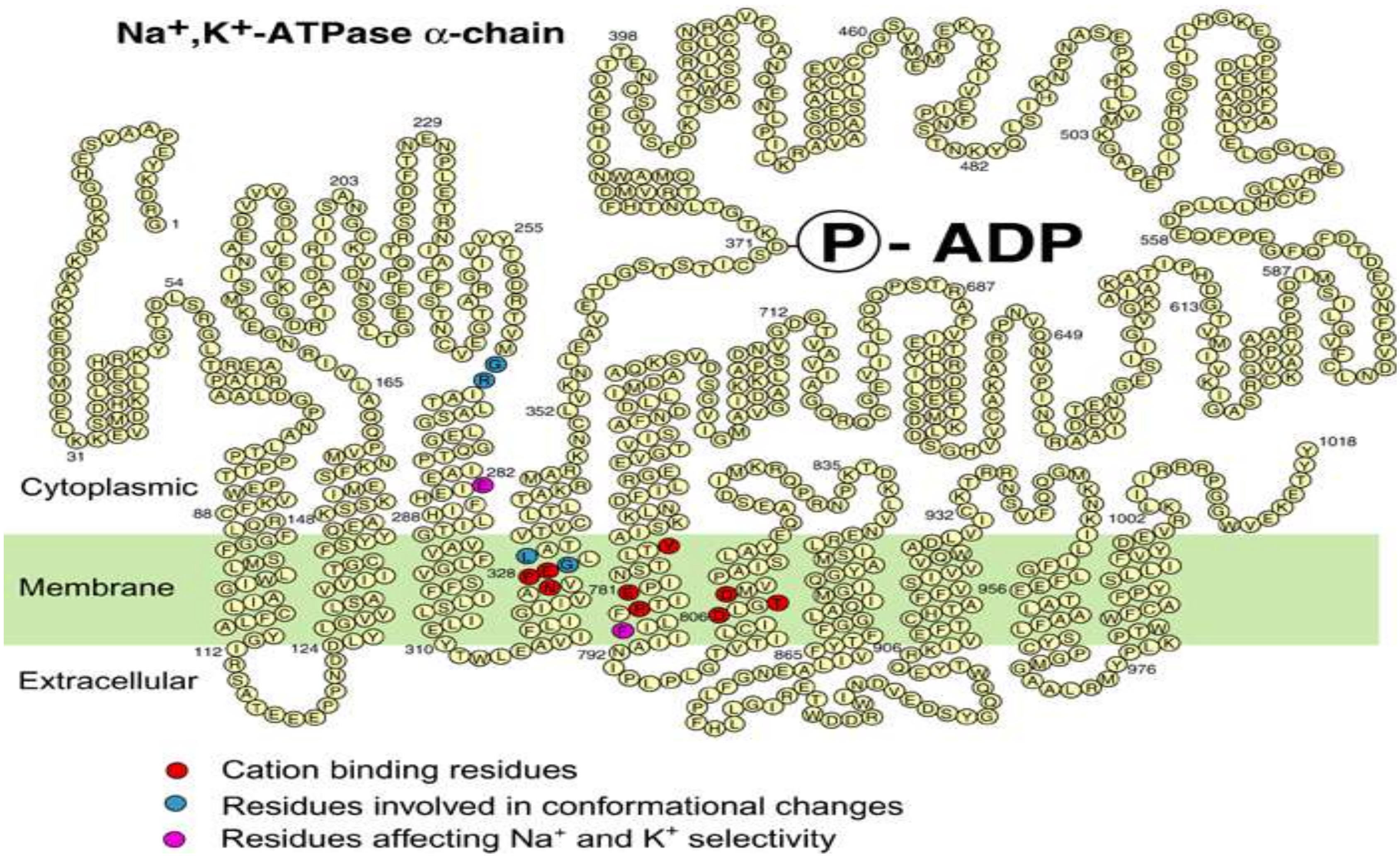


What are the consequences of Na+/K+ ATPase?

Review continued

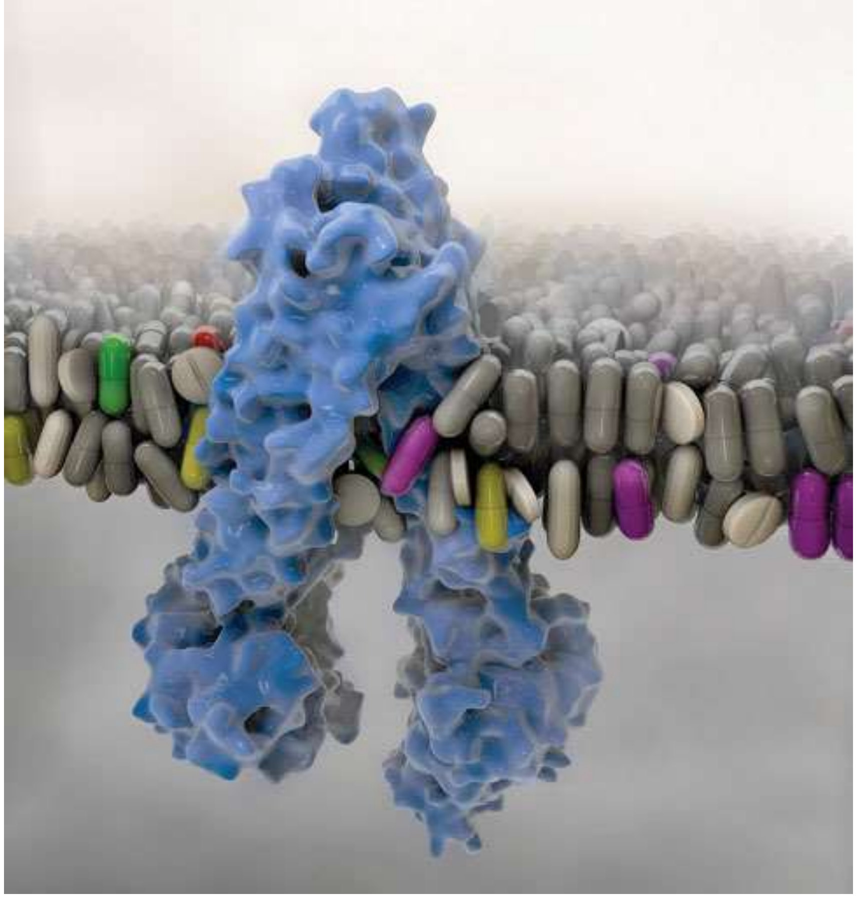


Does Na^+/K^+ ATPase really look like a blue petunia? No; it is really a tetramer encoded by 2 different genes! (Fig. from www.fi.au.dk/bv/ Na,K-2-700.gif)



Examples of other pumps

1. P-glycoprotein pump (also known as MDR (multiple drug resistance):



These are drug efflux transporters, which are important for the transport of hydrophobic drugs out of the cell. They have ATP binding sites.

Figure from *Clinical Pharmacology & Therapeutics*, Jan 2010 (G. Johnson).

The inward-facing structures have two portals that allow entry of hydrophobic molecules directly from the inner leaflet of the lipid bilayer

P-glycoprotein pump continued:
(a simpler model of the pump)

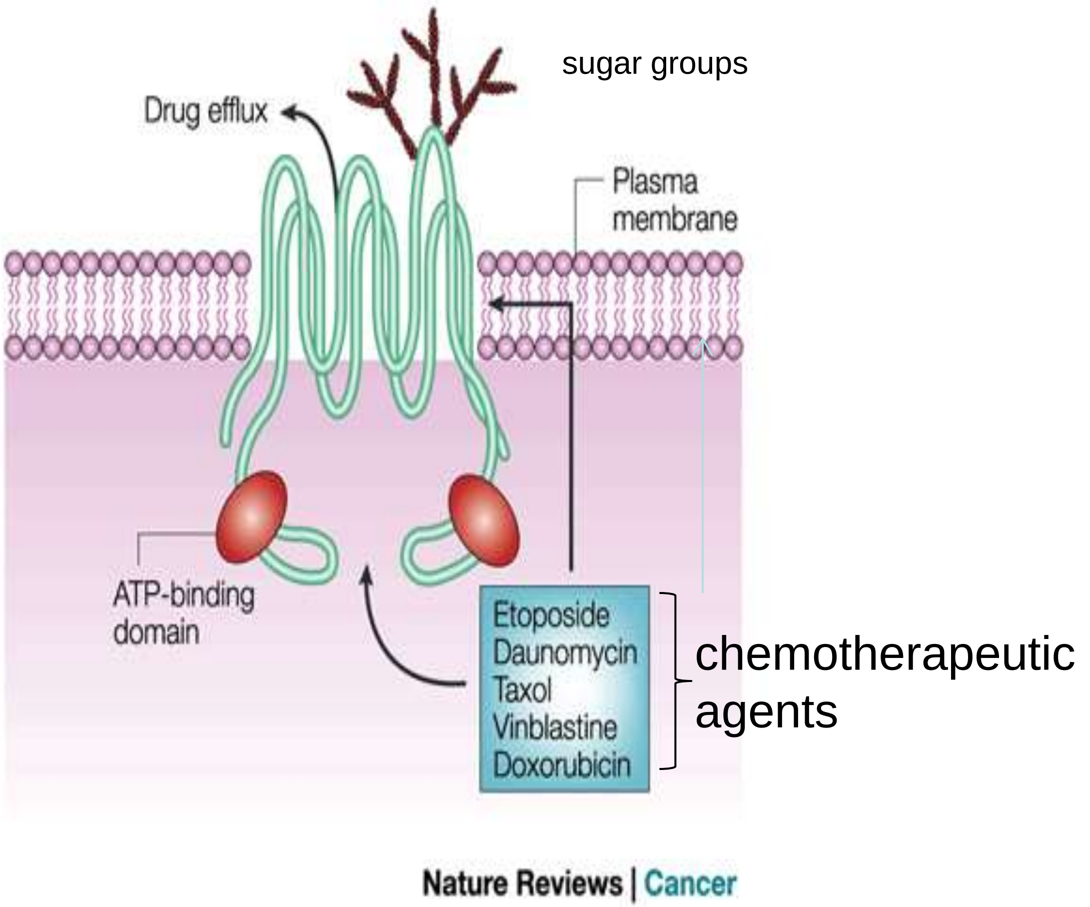
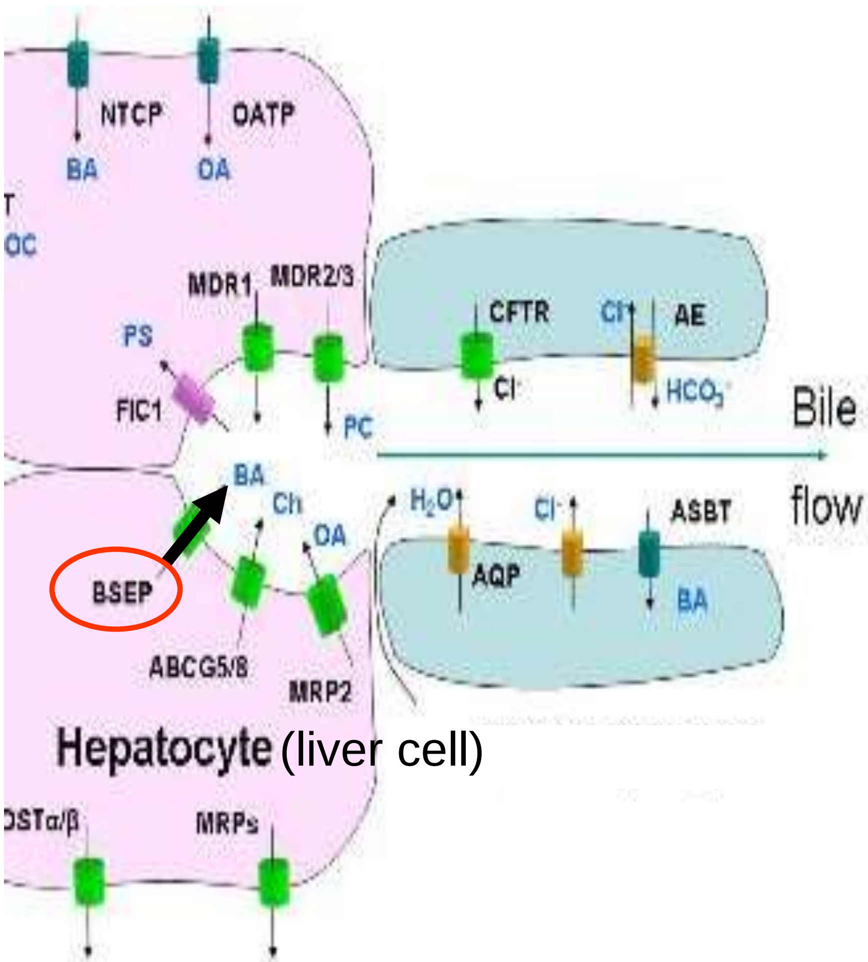


Figure from: http://www.nature.com/nrc/journal/v2/n6/fig_tab/nrc823_F3.html

2. Bile salt export pump (BSEP):



This ATP-dependent bile salt transporter functions in the liver. Mutations in this gene can lead to cholestasis characterized by poor fat metabolism, dark urine, severe itching, jaundice, liver failure and death (some are saved with a liver transplant but there are not nearly enough donated organs from those who have died to save all…consider this when renewing your driver's license).

Figure modified from: Richard Thompson, King’s College Hospital, UK

3. Cystic fibrosis transmembrane conductance regulator protein (or CFTR permease):

This pump is a chloride transporter found in lungs, sweat glands and some cells of the digestive tract. Recent publications show that it has two ATP binding sites and is an active transporter. About 4% of Canadians have a mutant CFTR gene.

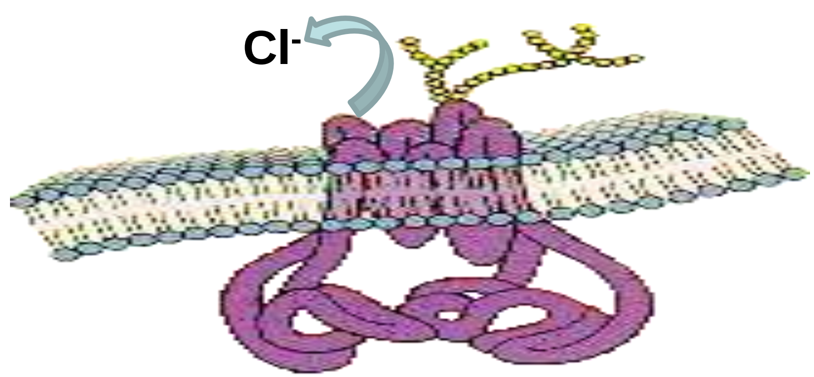
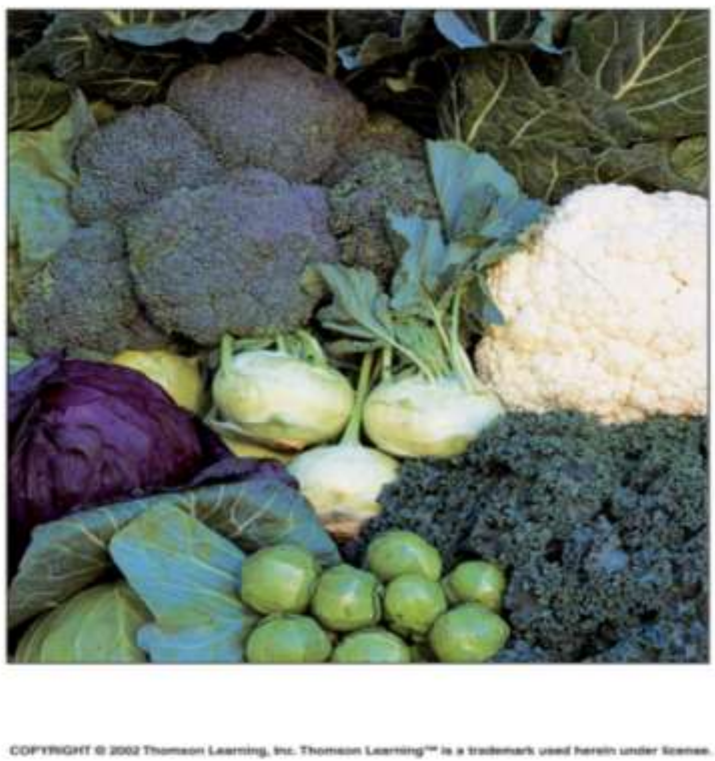


Fig modified from: www.people.virginia.edu/ ~rjh9u/gif/cftr.gif

III. Movement and Muscle Control
Chapter 50

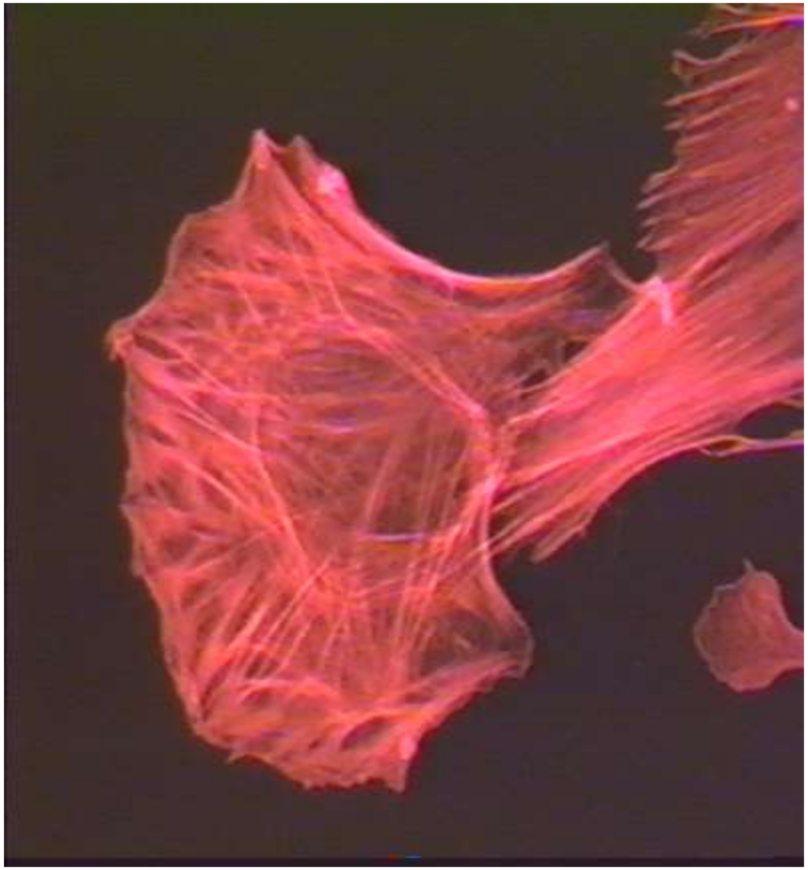


Plants move using turgor pressure and protists can move using cilia or flagella (do you need to review microtubules?)

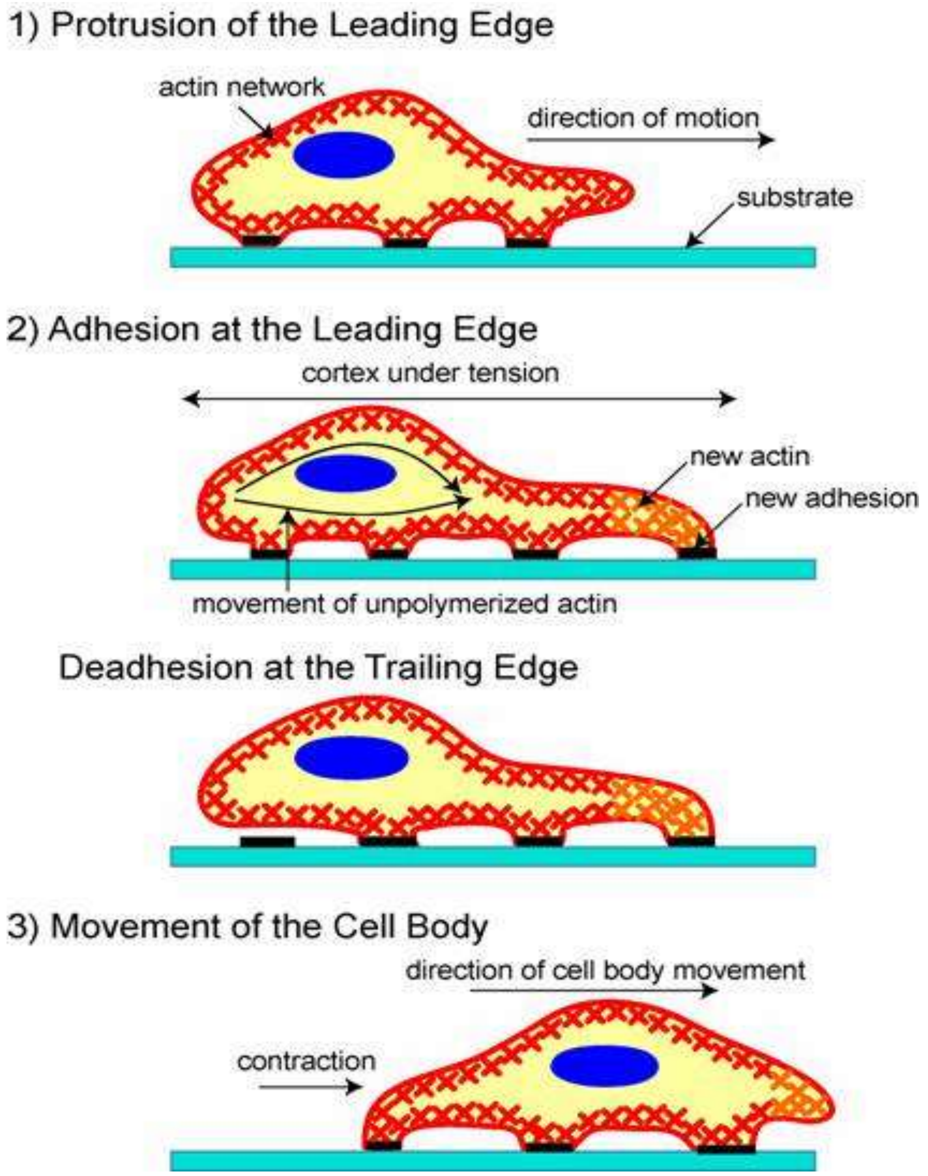
Right figure from: www.sams.ac.uk/dml/projects/ microeco/images/ciliate.jpg

Animal cells move using contractile proteins in microfilaments

www.biosci.ohio-state.edu/~eeob/eeob405/labs/ameba.jpg



Rat smooth muscle cell stained for actin (by Kevin Miller).

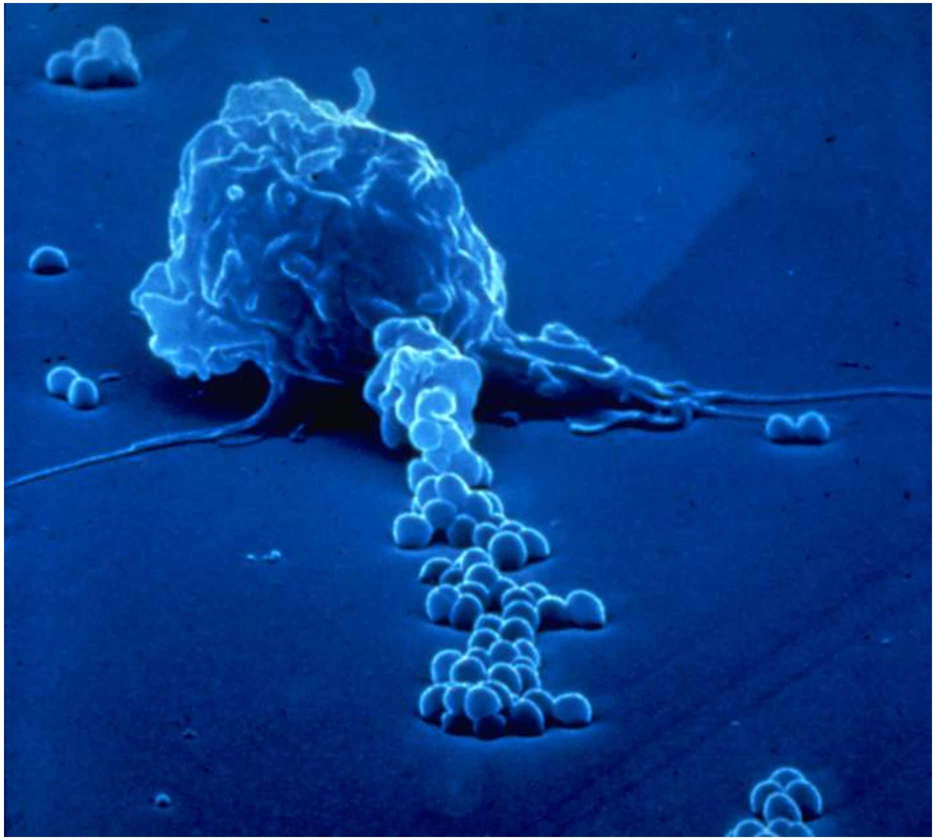


e.g. the movement of an amoeba

Ref: Ananthakrishnan & Ehrlicher (2007) Int. J. Biol. Sci 3:303 (no, you don't need to look this up)

From cells to whole organisms:

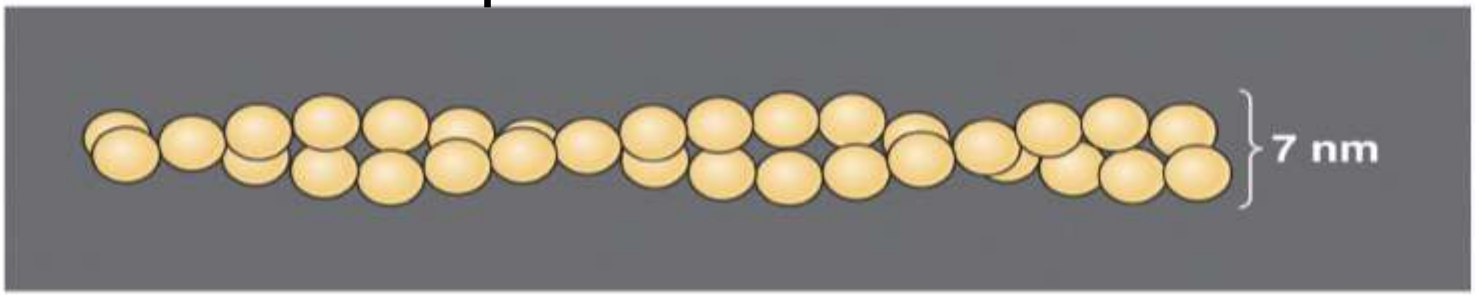
1. Here a white blood cell moves toward bacteria in preparation for phagocytosis



2. Vertebrates move using skeletal muscles that act on the skeleton

Homework: Read pg. 1188; exoskeletons *vs.* endoskeletons

Two major proteins (discussed in Biol 102) and many minor proteins are involved:



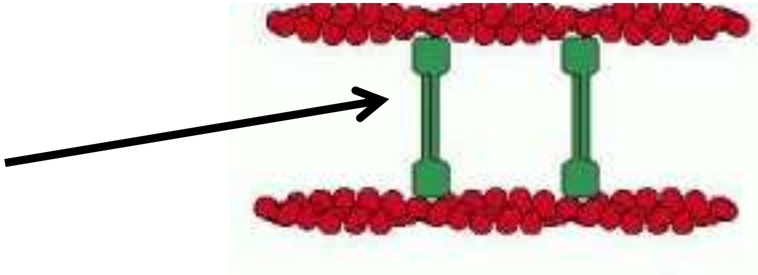
1. Actin: α actin filament or thin filament

2. Myosin: myosin filament or thick filament

From: www.bmb.psu.edu/courses/bisci004a/ muscle/musc-img/myosin.jp

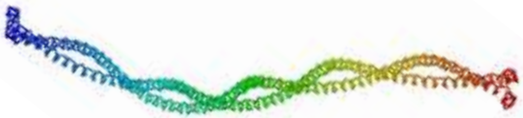
<u>Minor proteins</u>

3. α- actinin

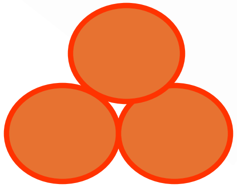


4. capping protein

5. tropomyosin



6. troponin complex



+ other proteins

All these proteins work together to form skeletal muscles

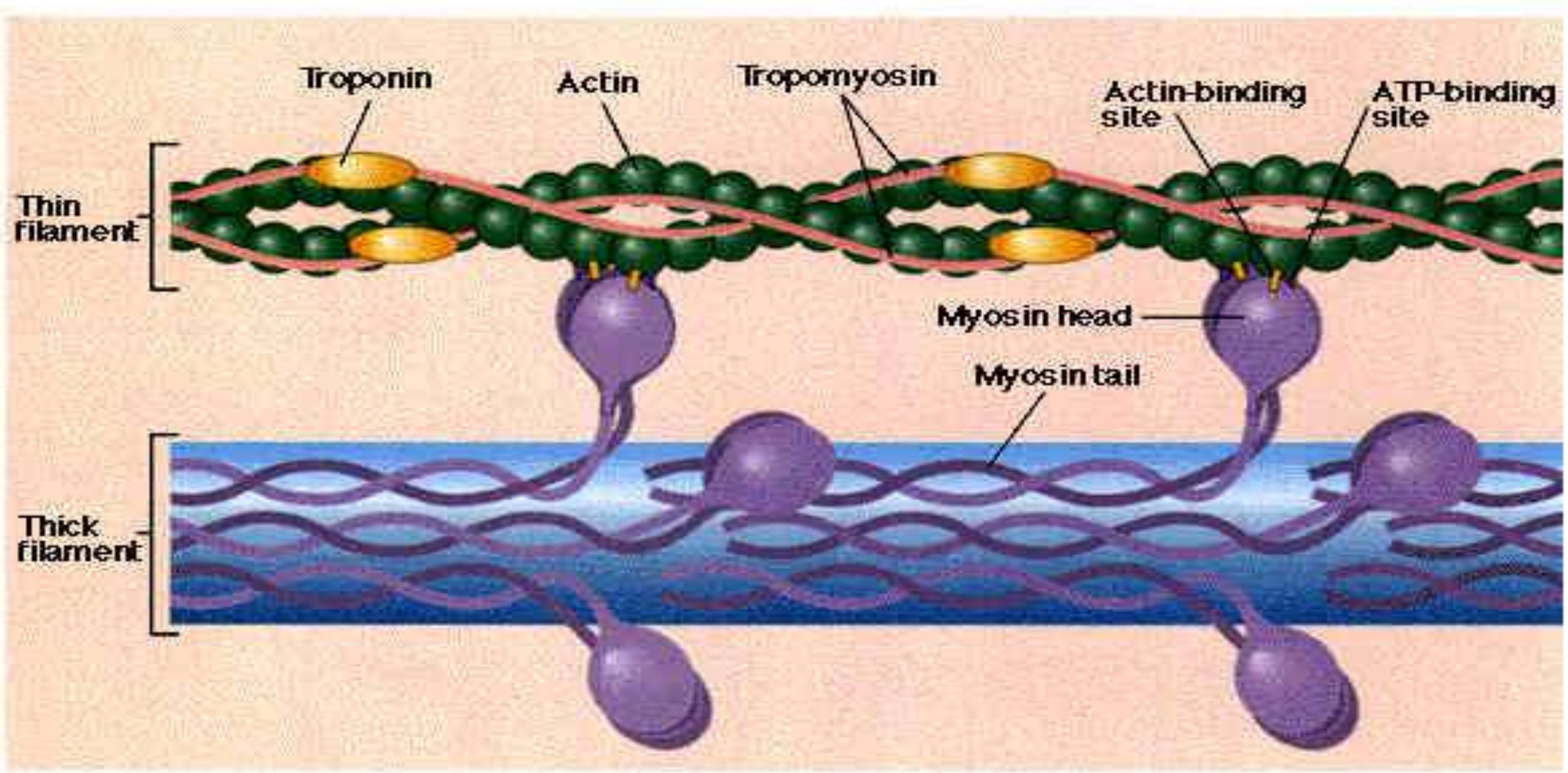
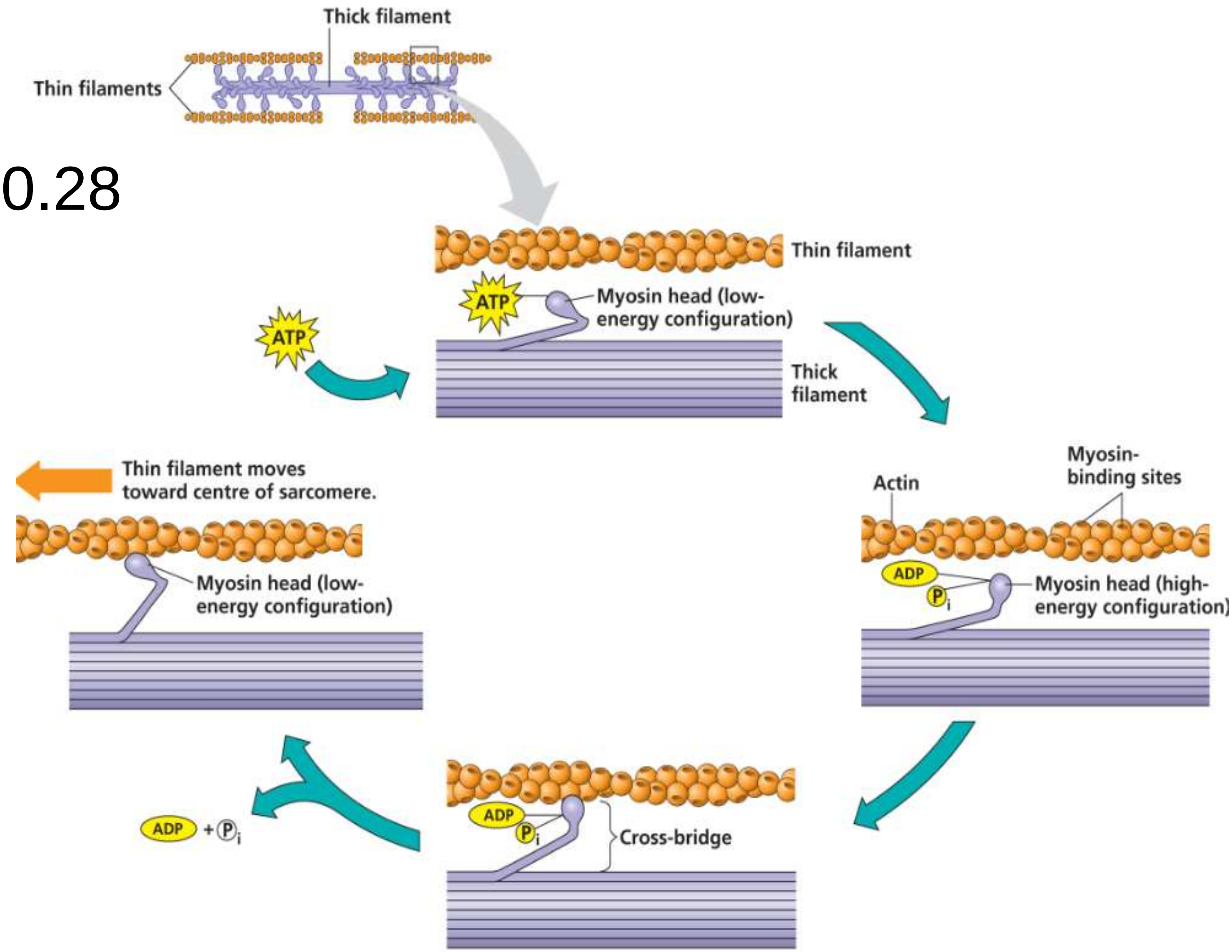


Figure from: www.uscs.edu/~gtardie/ MYOSIN.JPG

Homework: explain muscle contraction to a friend!

Fig. 50.28



Tender steak for supper tonight?

Dr. Ron Locker (New Zealand Meat Research Institute) realized that meat must be hung to be tender. Freezing meat right after slaughter allows ice crystals to rip open the sarcoplasmic reticulum, allowing muscles to contract when they thaw.

For beef, it is best to keep the carcass cool (not freezing) for several days. Calpain, a Ca^{++} activated protease, as well as aminopeptidase, may be involved by breaking the cross-links to actin during hanging.

*thanks to University of Guelph for information

Skeletal muscle structure –the big picture

- A muscle is a grouping of cells (muscle fibers) bound together by connective tissue
- Tendons link bones to skeletal muscle
- Skeletal muscle fibers increase in size during growth but no new fibers are formed

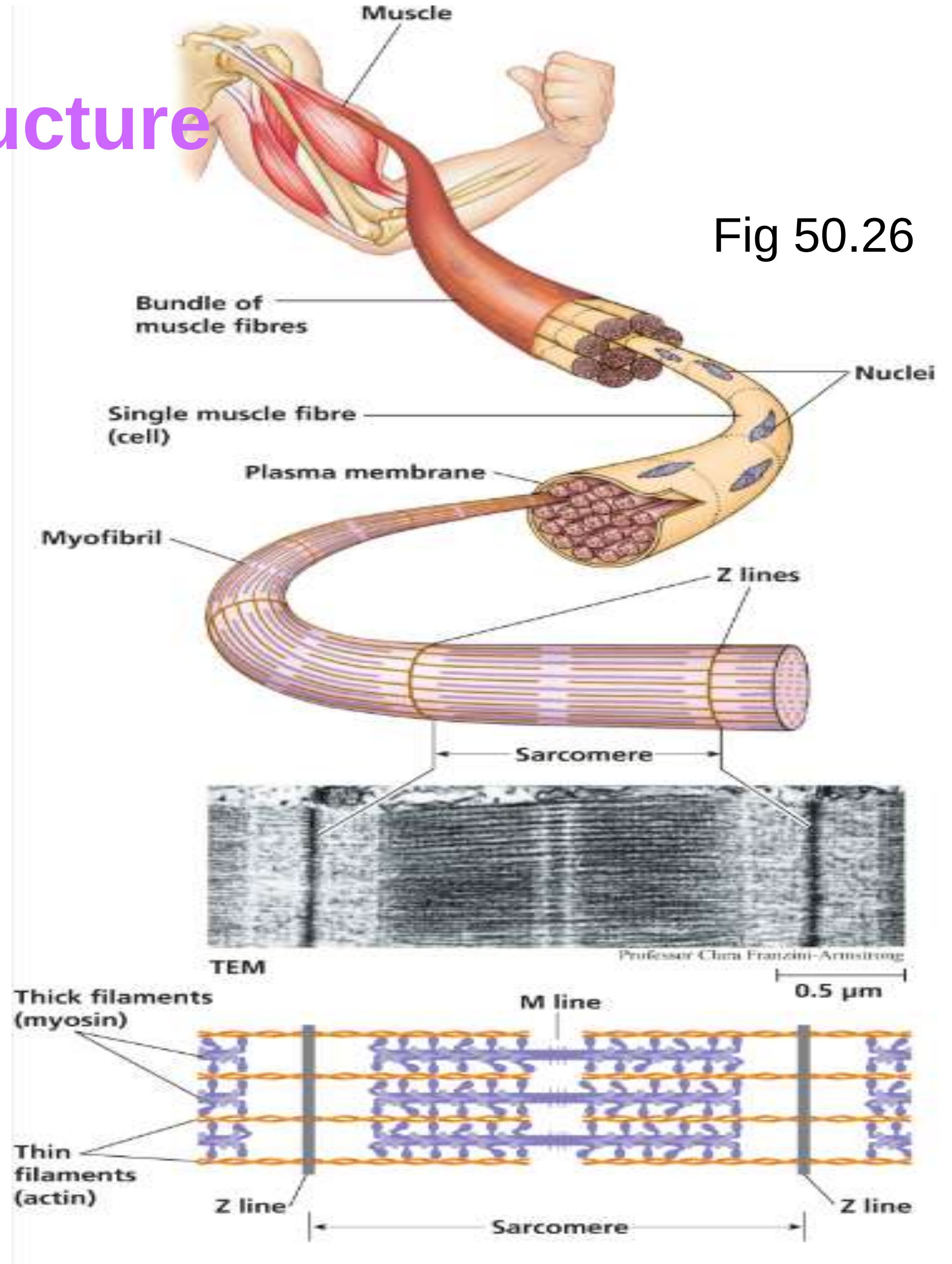
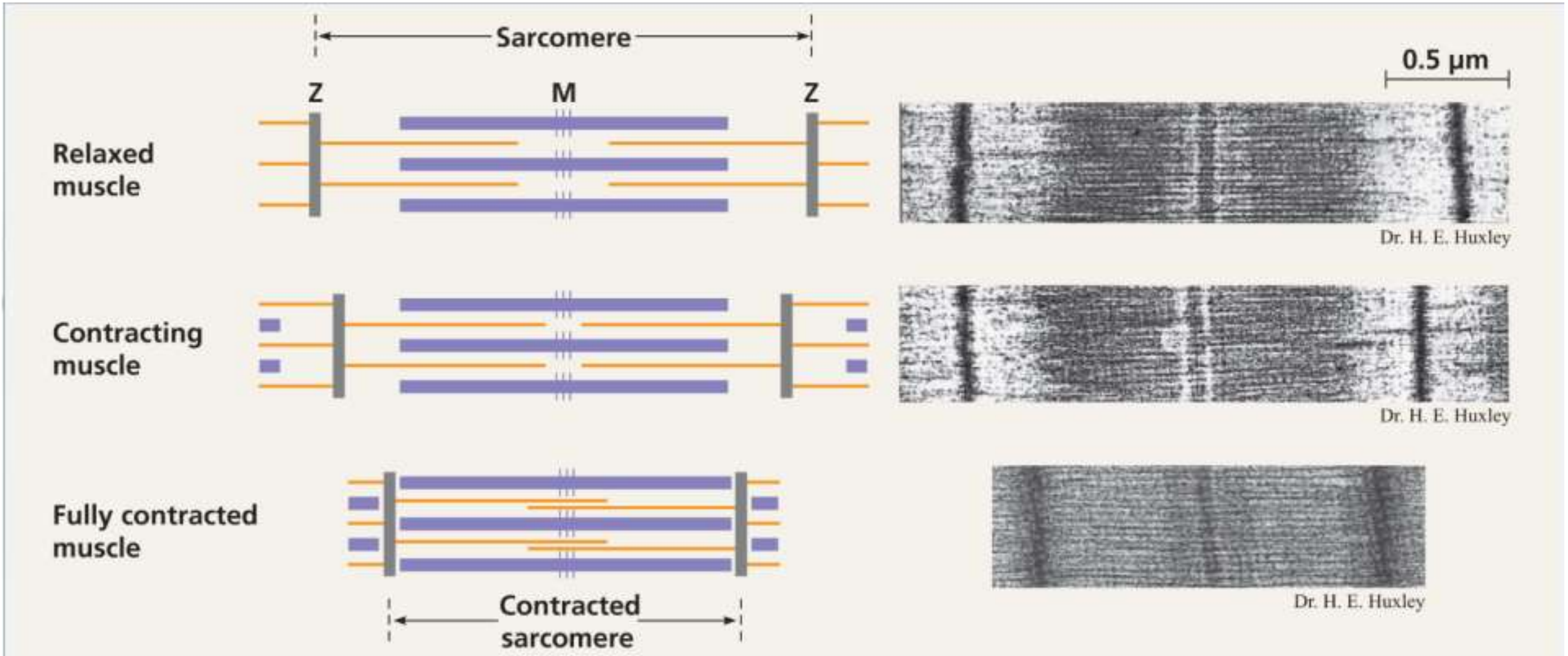
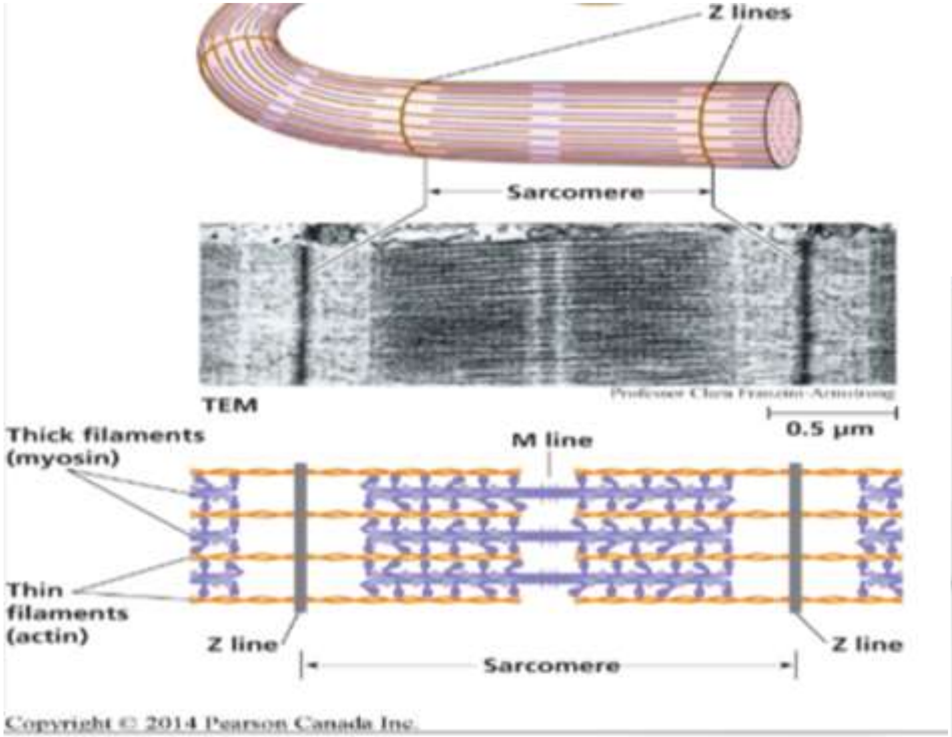


Fig 50.26

Homework: Please read about skeletal muscle structure pg. 1180-1181

Fig. 50.27





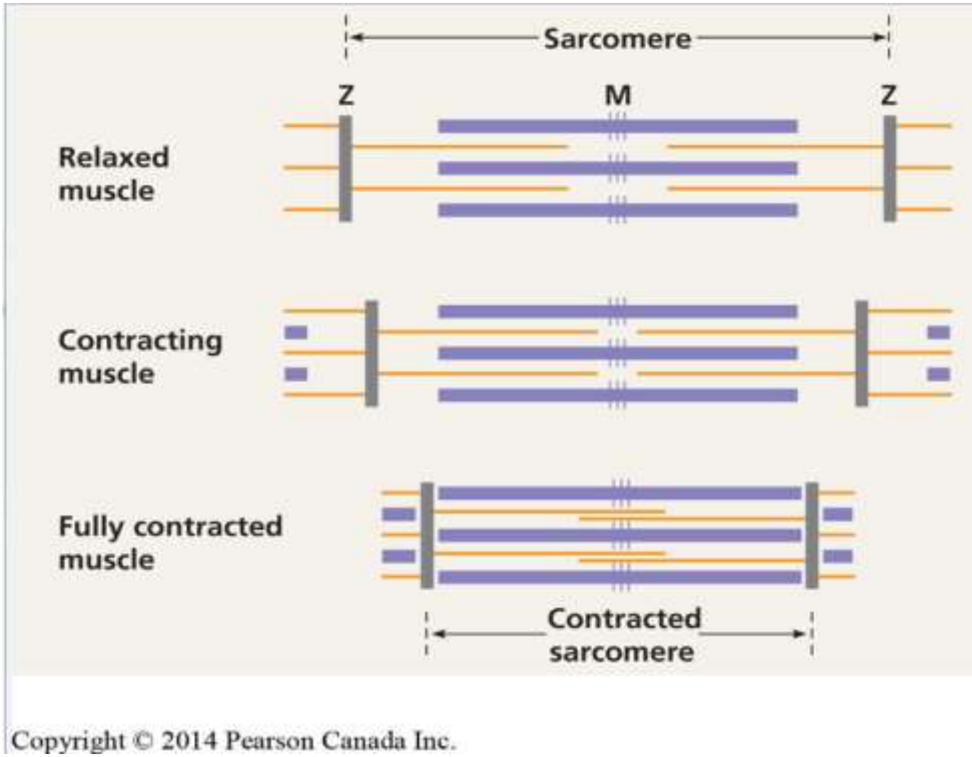


Fig. 50.26 & 50.27 Sarcomeres shorten as thin filaments slide past stationary thick filaments. Myosin molecules attach to thin filaments and forces them toward the center of the sarcomere. Formation of cross-bridges repeats the motion as long as the stimulation to contract continues.

Putting it together