Lecture 2 & 3 – Quasi life and Bacteria

Key terms:

Archaea
Bacteria
Coccus
Bacillus
Strepto
Spirochete
Biofilm
Peptidoglycan
Flagella
Pili (textbook)
Conjugation (textbook)
Chemotaxis
Bioluminescence
Anaerobic
Aerobic
Fermentation
Obligate anaerobes (textbook)
Faculative anaerobes (textbook)
Obligate aerobes (textbook)
Autotrophs
Heterotrophs
Chemolithoautotroph
Chemolithoheterotroph
Chemoorganoautotroph
Chemoorganoheteroph
Photolithoautotroph
Photolithoheterotroph
Photoorganoautotroph
Photoorganoheterotroph
Gram Stain
Gram negative
Gram positive
Plasmids
Ribosomes
Endospores
Nitrogen fixation
Nitrification
Denitrification
Halophiles (textbook)
Methanogens (textbook)
Thermphiles(textbook)
Prion
Spongiform encephalopathies

Obligate parasite
Lytic Cycle
Lysogenic Cycle
Phages
Retrovirus
RNA replicase
Reverse transcriptase

Possible midterm question : (example from prof)
Who has bigger ribosomes? Archaea or Bacteria?

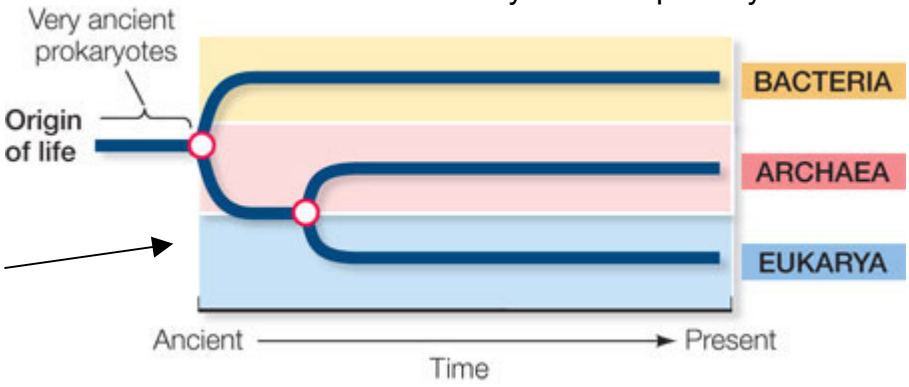
Difference between prokaryotes and eukaryotes:
Some key ones:

1) Different reproductive process. Binary fission in prokaryotes due to the lack of cytoskeleton while eukaryotes perform mitosis/meiosis.
2) Different chromosomes- single, circular in prokaryotes while N strands in eukaryotes
3) Lack of organelles in prokaryotes
4) Flagella that rotate like propeller in prokaryotes rather than beat in eurkaryotes –also totally different flagella structure

Prokaryote is divided into two domains-**archaea** and **bacteria**. There are some key differences between the two.

1) Archaea got this weird lipid layer (book defined as hydrocarbons connected to glycerol rather than the usual fatty acid-glycerol connection)
2) Bacteria have a **peptidoglycan** layer of cell wall
3) Bacteria have smaller **ribosome** size (70S compared to 80S in archaea)
4) Archaea are usually very extreme dudes (**thermophile** (heat lover), **halophile** (salt lover), **methanogens** (methane producer)

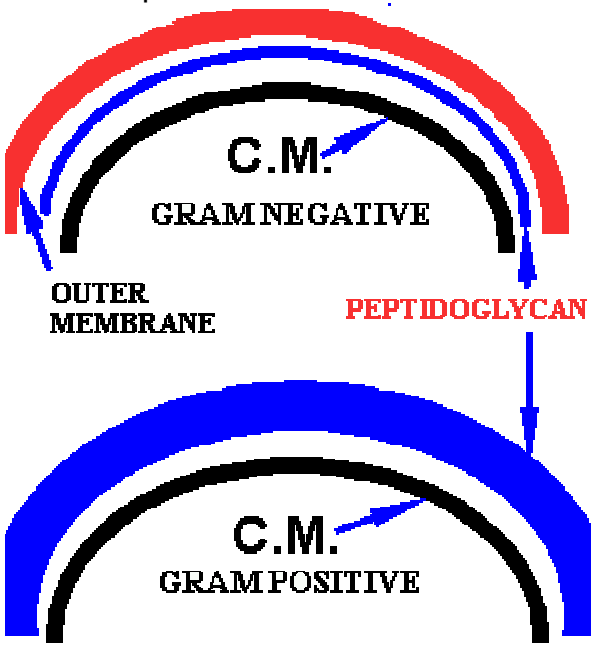
Archaea have more in common with eukaryotes than with prokaryotes. This is seen in a more recent common ancestor between eukaryotes and prokaryotes.



Misc Things about Prokaryotes
Prokaryotes are almost all unicellular.
Biofilms are communities of prokaryotes. This is formed when bacteria lay down stick gel like polysaccharide matrix that trap other prokaryotes. A good example of this biofilm is the plaque on our teeth.

Bacteria classification
There are two methods of traditional classification: bacteria shape and **gram test.**
The first method is quite obvious. The book give three shapes – **bacilius** (rod, think bat), **coccus** (sphere, think coconut), and **helical**. Professor added two in- **spirochete**, which is spiral. Kind like helix I suppose. The other one is **strepto**, which is a chain shape.

The second classification method has to do with the cell walls of bacteria. This method is called **Gram testing**. There are basically two kinds of cell walls. One is a really thick peptidoglycan layer while the other one is a thin peptidoglycan layer with an outer membrane on top. It looks like this..



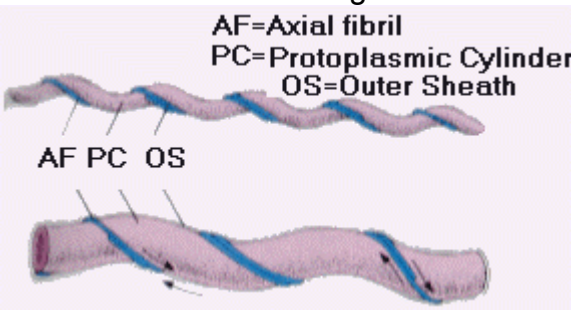
The one with the thinner peptidoglycan layer is the gram negative variety. Because it is so thin, it does not trap the purple dye that is applied first. (since it so thin) You can easily wash the purple away and apply a pink dye. It will display the pink dye.

Gram positive variety have a thick peptidoglycan layer. It traps the purple dye and thus does not come off when you wash it. When you apply the pink dye, the purple will still be there.

A more modern and more accurate method of classification is to compare the DNA sequence on ribosomes of bacteria. (Has to do with the fact that DNA on ribosomes is more ancient or something)

Prokaryote locomotion:
Professor Mcgill only talked about the **flagella**. Yes, most prokaryotes use flagella to move around but they can also use axial filaments (seen in helical bacterias) and gas vesicles to move around.

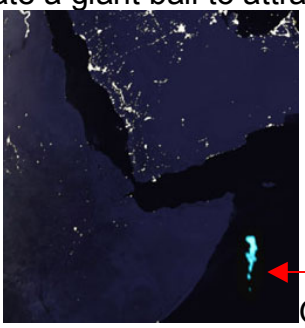
Axial filament is basically a big corkscrew that bacteria wrap itself on. Then it turn the big corkscrew and off the bacteria goes.



Prokaryote Reproduction:
Prokaryote reproduce by **binary fission**, which is an asexual process. However, they do have sex (transfer of genetic materials). This is done by using the **pili** to hook themselves up. Then they exchange **plasmids,** (smaller rings of DNA in addition to the main chromosome). These plasmids contain information about resisting antibiotics etc..This is how bacteria acquire resistance very quickly! You do not need bacteria of the same species to do this. Two different species of bacteria can do it.

Bacteria Communication:
Bacteria can communicate chemically or physically (via light).
They can sense chemical signals/concentration. This is called **chemotaxis.** This allows them to move towards food and move around from toxins.

They can release light but not heat in a process called **bioluminescence.** This is a fairly complex process powered by ATP. Bacteria can gather in a bioflim and do it together to create a giant ball to attract fish that can eat them.


Giant ball of bacteria

Diversity and How to kill it
There are a lot of bacteria on earth, more than the stars in the galaxy. Prokaryotes can live in very extreme conditions (Especially archaea) like boiling water at hypothermal vents of 120 Celsius or salt farms. They live in our body and there are more bacteria in our body than our cells. The only place in our body that bacteria do not exist are blood, urine, brain and lungs. They help us to digest , produce Vitamin K, folic acid and outcompete bad pathogens.

Killing bacteria is very easy because they have a number of special features that eukaryotes do not have.

1) Peptidoglycan cell wall. Drugs can be made to target them specifically. (i.e. Penicillin)
2) Smaller/different ribosome composition – can be targeted by drugs as well
3) **Folic acid synthesis** – we do not produce them, bacteria does.

Note that these do not apply to archaea. Archaea are generally much harder to kill (no, peptidoglycan, same size of ribosome as eukaryotes) but they are usually not pathogenic.

Metabolic diversity
Prokaryotes beats the pants off any eukaryotes.
First, you are going to need energy, electron acceptor/donor (for photosynthesis or cellular respiration) and carbon. Prokaryotes can use 8 ways to obtain these.

Professor Mcgill made this part very confusing for me so I am not sure which version is correct. He uses a different method than the book. This is the one he used.

e⁻ source (in)	e⁻ destination (in/out)	C source (in)	
Chemo (chemical)	litho (inorganic: e.g. Fe, S, H_2O, O_2, $NO_{1,2,3}$)	hetero (organic)	+troph
Photo (light)	organo ($C_nH_mO_p$)	auto (CO_2)	

Now, since I don't understand his method, I will use the textbook method here until someone explain to me what he means.

First, you are going to need energy. Now, you can obtain energy from the sun (Photo, usually in photosynthesis) or you can obtain energy by oxidizing chemicals organic or inorganic. (Chemo, usually in cellular respiration) This makes up the Photo – and Chemo – prefix.

Next, you are going to need electrons or you will give off electrons. (Need in the case of photosynthesis, give off in the case of respiration). Therefore, you are going to need electron acceptors or donors. Now, if your electron donor/acceptor is an inorganic compound (H_2S, O_2 or H_2O), you would write the litho infix. If your electron donor/acceptor is organic, you would write organo.

Last, you need carbon. You can either obtain carbon from carbon dioxide or from other organic compounds. If from carbon dioxide, you are a autotroph. If from other organic compounds, you are heterotroph.

By combining these three, you get some big long word that describes how a particular species obtains its nutrients.

For example, plants are photolithoautotrophs. Photo because they take energy from the sun for photosynthesis. Litho because they take electron from water for photosynthesis. (Water, inorganic, becomes the electron donor in this case). Autotroph because you get carbon from carbon dioxide in the atomosphere (by the Calvin cycle, carbon fixation)

Humans are Chemolithoheterotrophs or Chemoorganoheterotrophs, depending if you are doing cellular respiration or fermentation. If you are in an environment where your body lack oxygen, then you are chemorganoheterotroph because you oxygen is no longer an electron acceptor. Instead, some other organic compound replaces oxygen as the oxidizing agent. Otherwise, you are a chemlithoheterotroph because you can use oxygen, which is inorganic, to act as your oxidizing agent.

Prokaryotes also have a variety of metabolic pathways. They can operate under anaerobic conditions, in which they perform **anaerobic photosynthesis, or fermentation.** They can also operate under aerobic conditions, in which they will perform **cellular respiration.**

In fermentation, they take glucose, and convert it to pyruvate. During the process, they lose electrons to NADPH+. NADH+ either give electrons back to pyruvate, in which case you would have lactic acids or carbon dioxide is removed from pyruvate and then electron returned. In that case, you would have ethanol.

In anaerobic photosynthesis, H_2S is commonly used instead of water. Then you would produce sulfur instead of oxygen. This occur in plants that cannot live in aerobic environments.

Cellular respiration is one in which you go through glycolysis and then Krebs cycle to produce a large amount of ATP.

Prokaryotes that can live only under aerobic conditions are called **obligate aerobes**. Those that can live only under anaerobic conditions are called **obligate anaerobes.** Those that can live either in aerobic or anaerobic conditions are called **facultative aerobes.**

Bacteria are very important in the nitrogen cycle because they can produce nitrogen in form that plants can use. They are **nitrogen fixing** bacteria that take nitrogen from the atmosphere and oxidize it to ammonium. There are also nitrifier

bacterias that convert ammounium to nitrate. Then they are also bacterias that convert nitrate back to nitrogen gas in the atmosphere. Without bacteria, there would be no nitrogen to build your proteins and nucleic acids.

Withstand environment conditions:
We talked about chemotaxis earlier, so we won't do it here.
Bacteria can form **endospores**, extremely durable wall to withstand harsh environmental conditions.

Endospores are formed when bacteria face extremely harsh conditions. The original cell duplicates its chromosome and one copy of the chromosome gets surrounded by this durable wall. This structure is not designed to be a reproductive one. It is a resistant, dormant survival form of the organism. When the conditions become better again, the bacteria will reemerge from the endospore. Boiling water is not enough to kill this structure.