Hadean and Archean eons

Whirlpool galaxy M51

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Geological time scale and life forms

(Table 1.1 pg xii)

- **Major Eons**
  - **Phanerozoic** (543 Ma to present time)
    - Multicellular organisms
  - Proterozoic (2,500 – 543 Ma)
    - Oxygen atmosphere, single celled aerobic organisms
  - **Archaean** (3,800 – 2,500 Ma)
    - Anaerobic bacterial life, oxygen starts to accumulate
  - **Hadean** (4,600 – 3,800 Ma)
    - Formation of the solar system and planet, ends with origin of life

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-First 8 million years, waiting for things to start

Anaerobic bacteria: is all that was found in the oceans, during the Archaean time period

Proterozoic: new oxygen will rust all exposed elements on the Earth's surface, which will then fuse with atmosphere and oxygen molecules can be fused to form ozone that will filter UV light so that animals and living organisms are not harmed and Earth is protected

Geological time scale and building height

(1floor – 60Ma, 72 floors, 12 feet/floor)

- **Major Eons (Ma)**
  - **Phanerozoic**
    - (543 Ma to present time, top 9 floors)
  - Proterozoic
    - (2,500 – 543 Ma, 33rd -63rd)
  - **Archaean**
    - (3,800 – 2,500 Ma, 12th – 33rd)
  - **Hadean**
    - (4,600 – 3,800 Ma, 0-12th)

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Hadean and Archean eons

Geological time scale and life forms
(Table 1.1 pg xii)

- **Major Era**
  - **Phanerozoic** (550 Ma to present time)
    - Cenozoic (65Ma to present time)
      - Dinosaurs disappear, mammals and birds
    - Mesozoic (251-65 Ma)
      - Flowering plants, dinosaurs, even more insects
    - Paleozoic (543-251 Ma)
      - Marine invertebrates, algae, "Cambrian explosion", first land plants and insects.
  - Proterozoic (2,500 – 543 Ma)
  - Archaean (3,800 – 2,500 Ma)
  - Hadean (4,600 – 3,800 Ma)

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-Ecological destruction was caused when the dinosaurs went extinct due to an asteroid interfering with the trophic levels in the food chain

Geological time scale and building height
(1floor – 60Ma, 72 floors, 12 feet/floor)

- **Major Era**
  - **Phanerozoic**
    - Cenozoic (65 Ma to present time, 72nd floor)
    - Mesozoic (251-65 Ma, 65th to 71st)
    - Paleozoic (543-251 Ma, 63th to 65th)
  - Proterozoic (2,500 – 543 Ma)
  - Archaean (3,800 – 2,500 Ma)
  - Hadean (4,500 – 3,800 Ma)

Your life span = 0.0002 inches
Human hair = 0.001 inches

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-The formation of the solar system and our planet

Galaxies

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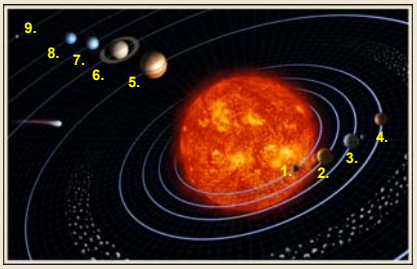
Our Solar system

Nat Geo Sun video

1. Mercury
2. Venus
3. Earth
4. Mars
5. Jupiter
6. Saturn
7. Uranus
8. Neptune
9. ~~Pluto~~



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-The sun's attraction force pulls planets into an orbit

Sun=99% mass of the solar system

Goldilock Zone, because the conditions are just right

Habitable zone

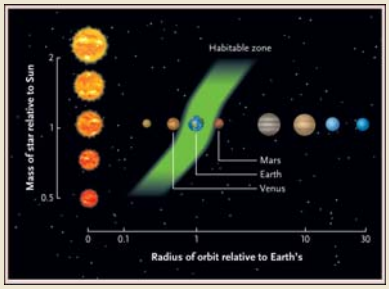

Figure 3.8

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-We need to have liquid water, so there is only a very small zone that is acceptable

-The green strip is known as the Goldilocks zone, where water is available in the liquid form

-Jupiter and Saturn pulled in meteorites from Earth due to their large gravitational pulls

-Mars is on the edge of the Goldilocks zone, and it could potentially tell us how Earth was before water existed

Hadean and Archean eons

Hadean eon

- Building phase
- Stabilizing phase

Orion nubula (NASA)

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Earth 4,000 Ma

Figure 3.7

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-When a planet starts to cool, a meteor can hit Earth again which would cause the crust to re-liquify once again
- We are seeing gasses held in place, water rise to the atmosphere, and as the earth cools, it all comes back down
-Water on the planet is constantly being flash-sterilized
- Its a cycle that repeats, and slowly the earth is increasing in size as well as in regards to the water on the planet
-The crust sometimes forms on the surface, and sometimes some stray meteors hit the planet (they don't have enough energy, so they essentially punch a hole straight through to the magma which wells up and becomes incorportated into the crust

Origins of life on earth

- Special creation
- Extraterrestrial origins (Panspermia)
- Chemical evolution

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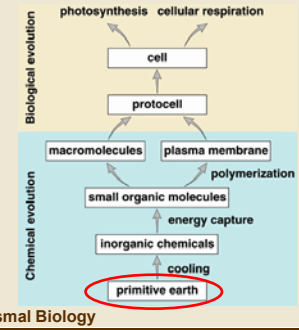
Panspermia: life came from somewhere else (Mars) and hit our planet
-The first organism was a very hearty bacteria cell that could withstand many conditions (archean bacteria)
-Archeas are prime suspects for being the first habitants of earth
-An archea came via a meteor and ended up starting the evolutionary sequence of life
The question is: how did that first cell evolve?
The answer is: first cell evolved here, on our planet.

Origins of life on earth



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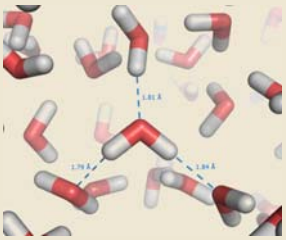
-What is the link between inorganic and organic chem?
Organic vs. Inorganic--> carbon is in chains in orgo chem
Chemical Evolution: how organic molecules evolve into macromolecules needed for life

Primitive Earth: water is not pure water, it also contains minerals and inorganic chemicals
-the primitive earth cools, and the atmosphere emits gasses naturally and many are also dissolved in the water (inorganic compounds)

Wacky water

- Cohesion, adhesion and surface tension
- Solvent properties
- Ice formation
- Temperature



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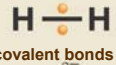
-Water does many things that other substances don't do
-Due to its polarity, it is a universal solvent

Wacky water
Polar bonds and hydrogen bonding

Nonpolar covalent bonds



Polar covalent bonds

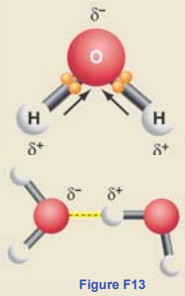


Figure F13

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Wacky water
Surface tension

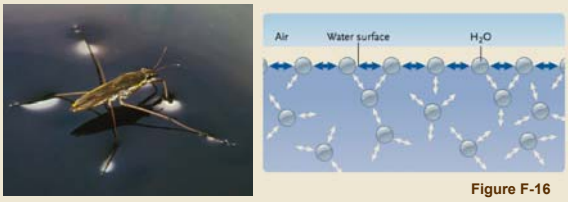

Figure F-16

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Capillary Action: allows plants to draw water into their systems without using and consuming energy

Wacky water
Solvent properties

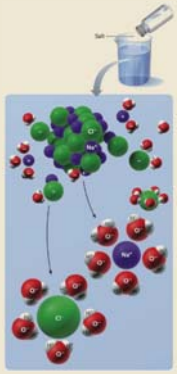

Figure F-17

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-The only group of compounds that will not dissolve are the lipids; they are non-polar

Wacky water
Ice and water formation

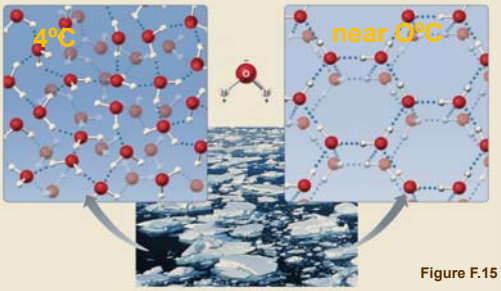

Figure F.15

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-At colder temperatures, the density increases
-At 4 degrees C, they form a lattice network that is fixed in size
-The density of water actually becomes lighter than the water at 5 degrees when the lattice network is formed
-It actually acts as an insulating layer while insulating the water below it
-It is one of the only compounds in which the solid form is lighter than the liquid form
-The oceans are primarily 4 degrees celcius

-It is a crucial buffer

Wacky water

Temperature

Specific heats of some liquids (joules)	
Liquids with high levels of hydrogen bonding	
Ammonia (NH_3)	4.70
Water (H_2O)	4.18
Liquids with moderate levels of hydrogen bonding	
Ethanol (CH_3CH_2OH)	2.44
Ethylene glycol ($HOCH_2CH_2OH$)	2.22
Liquids with low levels of hydrogen bonding	
Benzene (C_6H_6)	1.80
Zylene (C_8H_{10})	1.72
Sulfuric acid (H_2SO_4)	1.40

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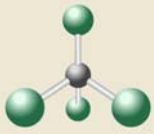
-As the levels of hydrogen bonding increase, so do the specific heats of some liquids

Organic evolution

"Carbon is central to life...carbon atoms link in chains, bind with other atoms to make the array of organic chemicals that constitute life itself, from DNA to toenails" – Richard Fortey – Life



Carbon molecule

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-When a sun dies, carbon rains down on the solar system

Miller-Urey Apparatus

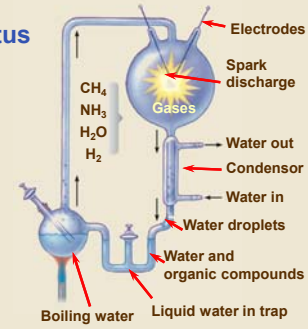

Figure 3.9

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Where did the first organic compounds come from?

-An experiment was conducted where an experimental reconstruction of Earth was created on a small scale
-A week later, they found basic skeletons of allmost all amino acids, purines, pyramidines, and most organic building blocks of life in their model

-Adding CO2 increased the yield of these organic substances

Chemical evolution

Origins of organics (monomer)

- Prebiotic soups
- Hydrothermal vents
- Interstellar organics

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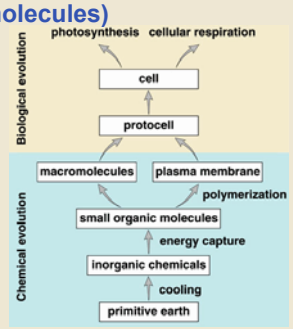
Chemical evolution

Biopolymers (macromolecules)

- Proteins
- Nucleic acids
- Carbohydrates
- Lipids



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-Small organic molecules to macromolecules is a roadblock due to insufficient conditions

Central Dogma of Biology

1. Replication
2. Transcription
3. Translation

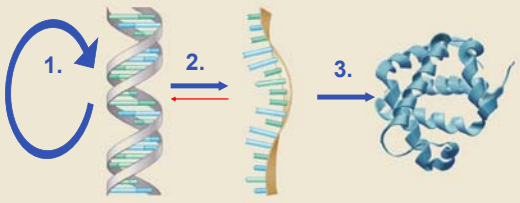

Figure 3.14

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-Genetic information is in DNA, copied into a double strand, and when a functional element is needed, RNA and tRNA makes a protein
-Back-up info in the DNA due to the double helix
-When we need to make a protein, the message RNA is made to assemble amino acids along the length to form the protein to do the work

-It was later discovered that RNA can go back to DNA
-Studies show that certain proteins can revert back to RNA also

Biotic chemistry (Polymers)

- Panspermia
- The RNA world
  - Ribozymes
- Proteins first
- Clays

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-A catalyst is a molecule that folds onto itself, and has charged groups that are enzamatically active thus making it easier for molecules to link with one another

-One concept was that the first molecule was a RNA molecule
-When it falls out of the active pocket, we have a reaction
-It is hard for 4-5+amino acids to stitch together to form a protein artificially in solution

-Also it is not possible to artificially create a nucleotide

Evolution of information flow from an RNA world

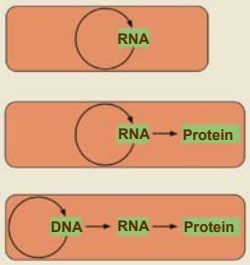

Figure 3.16

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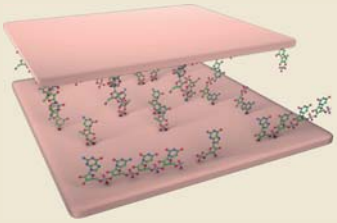
-Rna was the very first molecule to be produced, followed by protein
-RNA was first catalyticially, then protein
-It is also possible for this to go backwards
-It became better to create a storage for the code, and have an intermediary actually create the code
-A copy is kept as a back-up

-Proteins as catalysts are tertiary structures with catalytic sites that promote reactions

Biotic chemistry (Polymers)

- Panspermia
- The RNA world
  - Ribozymes
- Proteins first
- Clays



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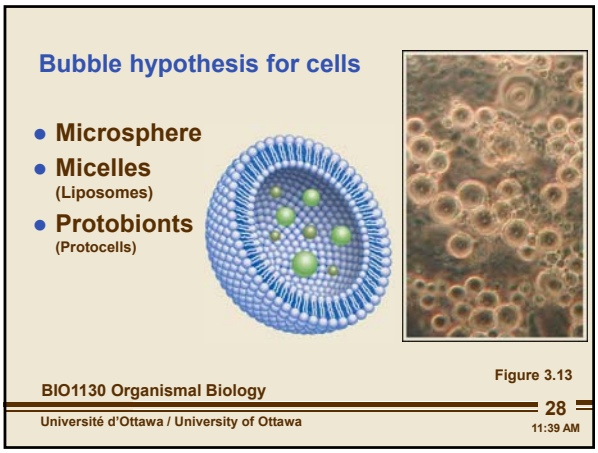
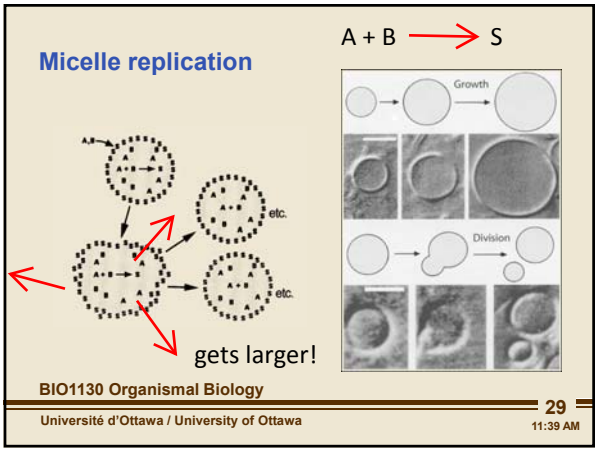
-The clays were an attempt at a solution to the roadblock
-Clays are usually in crystal lattice structure ,with lots of polymers and charges
-Linking of peptides in solutions VS. monomers on clays first then catalytic structures would link them together



How do we create a cell membrane?

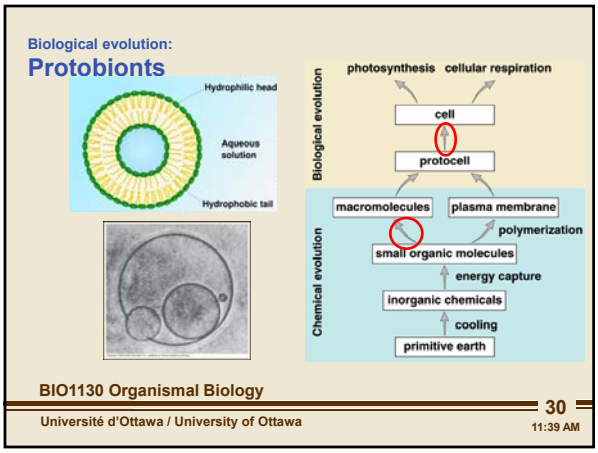
Inside=aquatic environment in wich reaction occurs

Outside=lipid, amino acid is inside



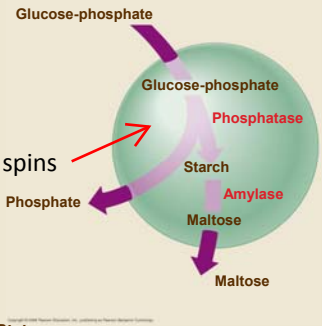
-Lipid spheres will grow and they will naturally

subdivide



= trouble spots

Biological evolution:
Protobionts



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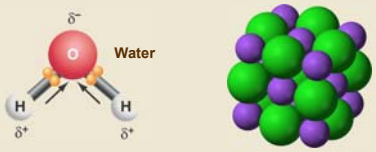
What is life and emergence?

- **Organicists (1930) – vital force replaced by genetic program and the importance of emergence.**
- **Emergence - More than the sum of the parts**



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Organicists: vital force replaced by genetic program and the importance of emergence

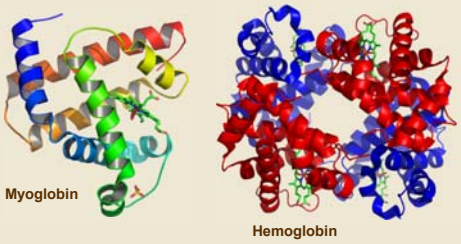
Chemical emergence: e.g. water and NaCl

Na= combusts in air

Cl= poisonous gas

What is life and emergence?

- **Emergence - More than the sum of the parts**



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Hemoglobin= 4 myloglobins

Hemoglobin's oxygen binding properties>

4 myoglobin's oxygen binding properties seperately

What is life?
(Figure 2.2)

- ✗ **Self replicating** - Life from life with a genetic program
- ✓ **Metabolizing** - Capturing and releasing energy
- ✗ **Self regulating** - A delicate balance
- ✗ **Reproduce** – life from life
- ✗ Evolving - Adapting and changing
- ✗ **Responding** - Sensing and interacting with the surrounding world
- ✗ **Growth** – increase in size

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FINAL

Prokaryotes - Domains Bacteria and Archaea

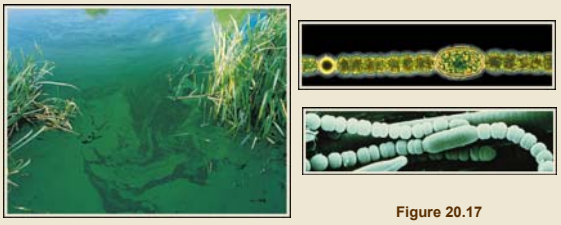

Figure 20.17

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Hadean Eon

Archaean Eon

Proterozoic Eon

Phanerozoic
- -**P**aleozioc Era: **C**ambrian, **O**rdivician, **S**ilurian
- -**M**esozoic Era
- -**C**esozoic Era

Prokaryote diversity

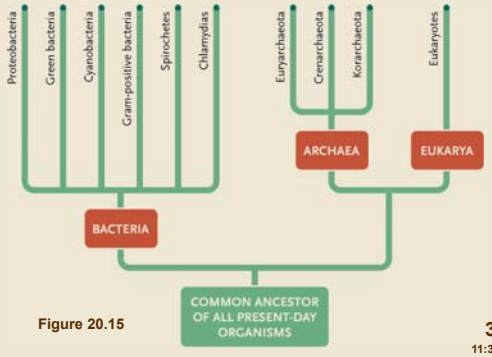

Figure 20.15

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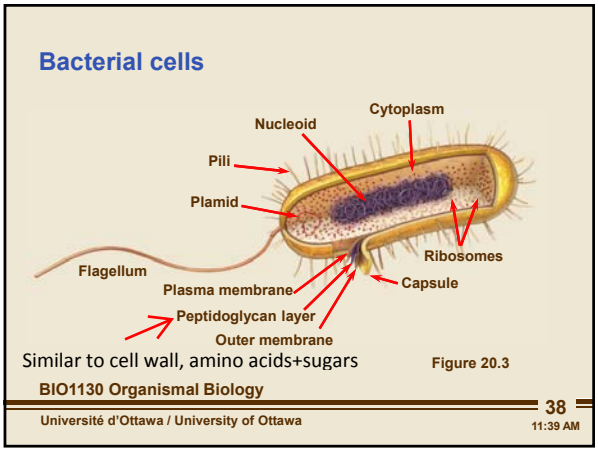
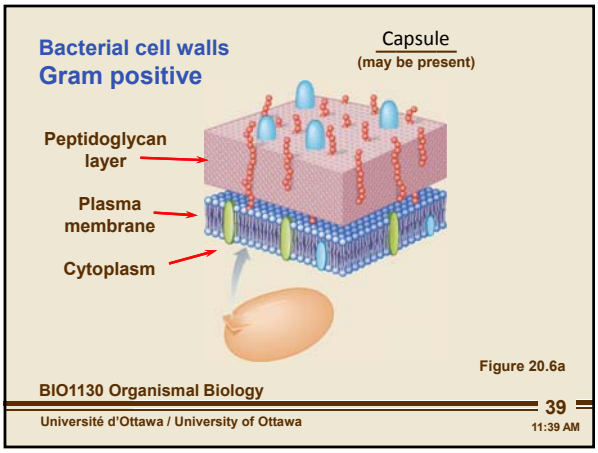
Bacteria= Eubacteria as well



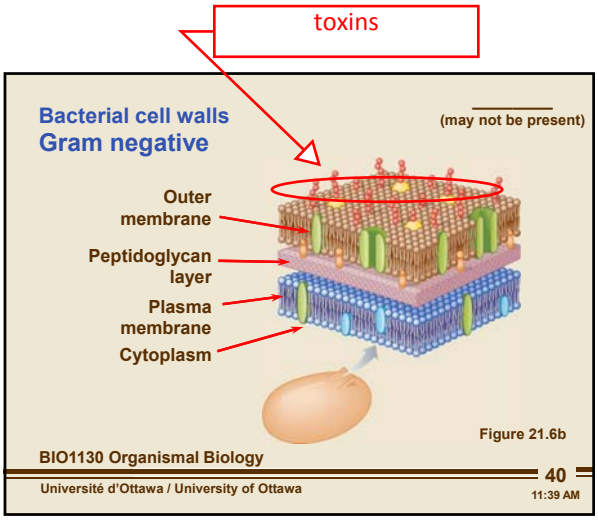
Common Structural form: simple, not many organelles
-circular or oval
-no nucleus, and no region of specializtion
-genomic dna
-plasmic dna (sometimes missing) , these are both located in the cytoplasm
-surrounded by a membrane

There can be many layers beyond the fundamental layers; some may have capsules
-There is no cytoskeleton, there is a little bag of biochem with a nucleur region not being specialized that is carrying out functions
-They have a flagellum to be mobile so they may swim and migrate

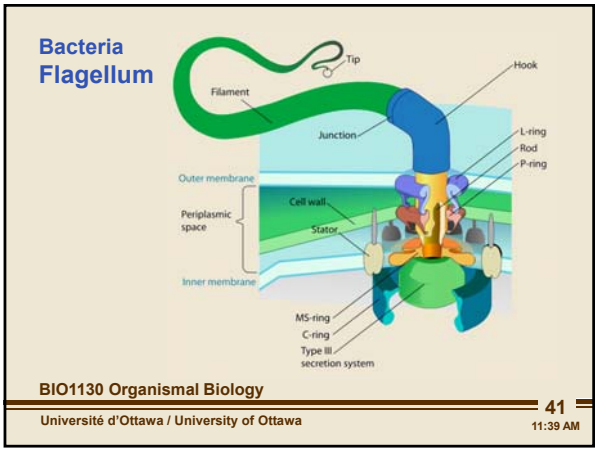


The gram stain: the result would be either positive or negative
-if it picked up colour it was positive, and vice versa

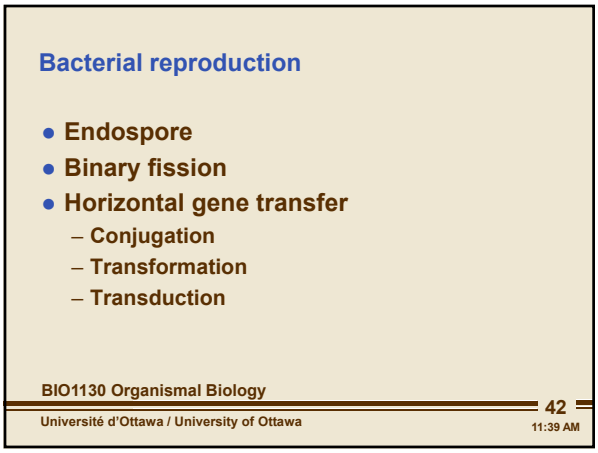
-A colour rxn would occur with the peptidoglycan matrix and thats how it would stain and be positive or negative
-The staining procedure would always wash the capsule away



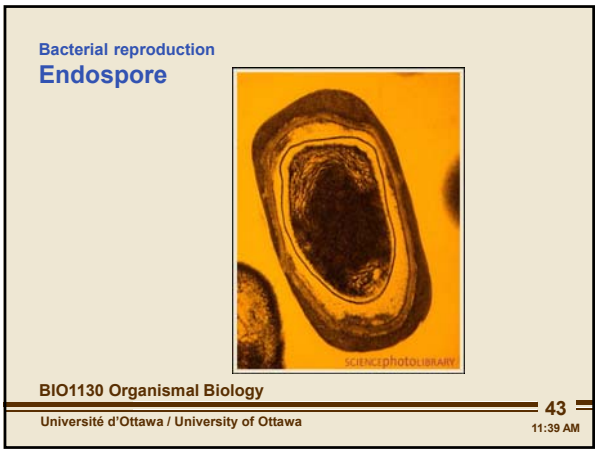
-their P.layer is very small and is sandwiched
-the lipids are polysacharide lipids, which is different then phospholipids we associate with the cell membrane
-the stain is blocked from getting to the P.layer which causes us to not see any staining
-the outer layer prevents the staining to contact the other layer, therefore there is no colour reaction, and it is gram negative
-they are the most toxic, a decision could be made based on the gram (negative) could be very dangerous
-penicillan breaks the P.layer, but it has no effect on the gram negative because the layer protects the bacteria against the antibiotic
-for the most part, disease pathogens are associated with this type of structure
-the lines of defence of a bateria to be able to survive are shown by variations of proteins on the surface of the cell



-it is a molecular motor
-in ecoli- there are 40 proteins involved
-this is a gram negative bacteria
-the proteins called rings are used to anchor the casing of the motor
-they are hollow in the middle and sit in the membrane anchored into the different layers
-proteins create a shaft that run through the central part
-associated with the motor that drives the flagellum
-protons are pumped to build a gradient by the mitochondria, the gradient has potential to work
-if the movement of protons can be controlled from high [ ] to low [ ] , work can be done
-protons flow through the motor, and the proteins in the motor change shape to reach out and interact with the shaft and this moves the shaft a little bit, and the shaft starts to spin fast
-the sleeve of protein on the shaft is called the "hook" which spins, causing the flagelum to spin, and movement hence occurs



-these organisms do not carry out any form of sexual reproduction
-they replicate their dna to make a perfect copy
-every single bacterium is a clone of the parent dna

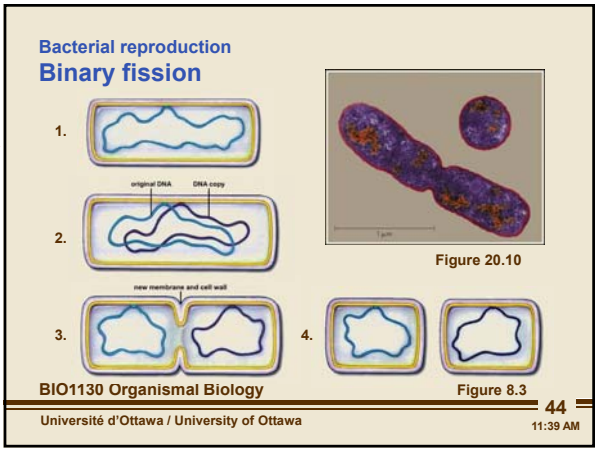


Endospore: dormant, tough, non-reproductive structure produced by a small number of bacteria

Primary function: ensure the survival of a bacterium through periods of environmental stress

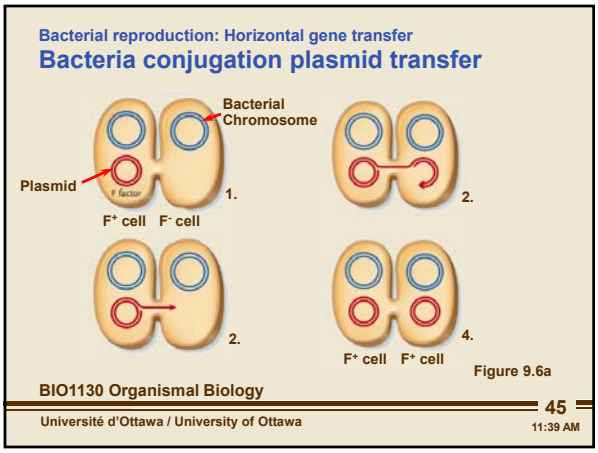
Therefore, they are resistant to UV and gamma radiation, temperature, starvation, and chemical disinfectants

podcast

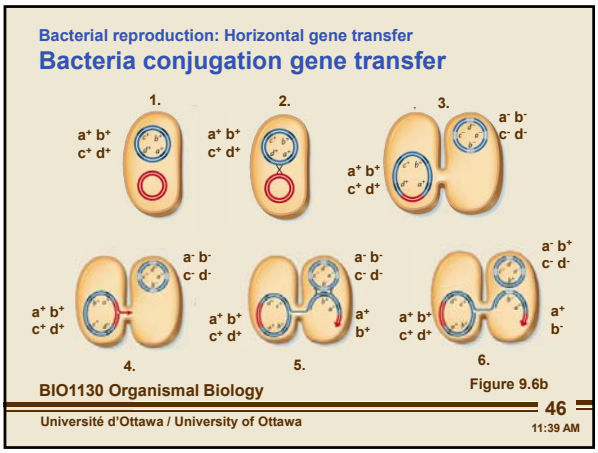


-simplest form of reproduction

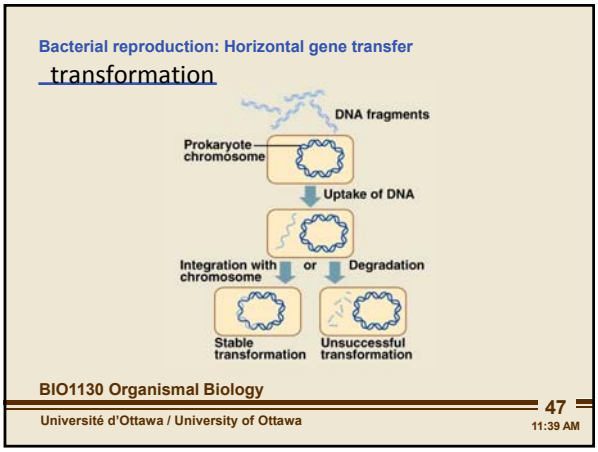
podcast



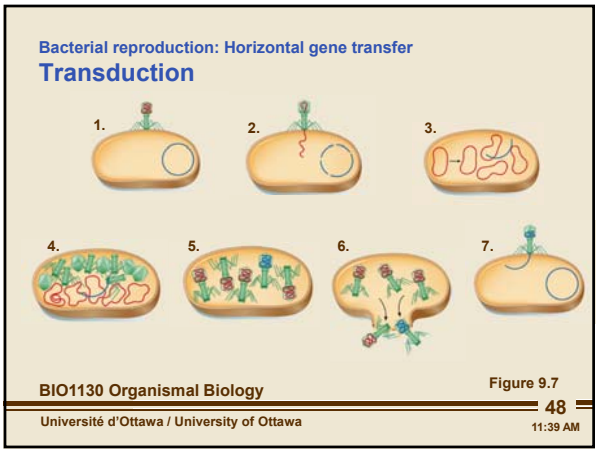
-bacteria are fusing together, and swap and pass dna back and forth to each other
-some of them have a plasmid dna
-the plasmid usually divides with the cell



-fig.9.6b from textbook
-plasmids also like hooking themselves into the genomic dna of a bacterial cell (2, 3)
-plasmid dna can pop in, as well as pop back out
-sometimes a perfect break is not made, and we end up with a little piece of genomic dna combined with plasmid dna
Bottom half:
-plasmid tries to unwrap itself, plasmid can be send over to another bacteria as plasmid or genomic+plasmid



-bacteria will pick up dna from anywhere and begin to incorporate them into their genomes
-there is trememdous potential for things to be swapped back and forth



-inject their dna into a host cell, which will take over
-these pieces of host dna sometimes do not get destroyed, and a strand is left over

Metabolic diversity in ATP production and carbon sources (Table 20.1 in part)

- Autotrophic
  - Photoautotrophs
  - Chemoorganotrophs
  - Chemolithotrophs
- Heterotrophs
  - Photoheterotrophs
  - Chemoorganoheterotrophs
  - Chemolithotrophic heterotrophs

Redox pair

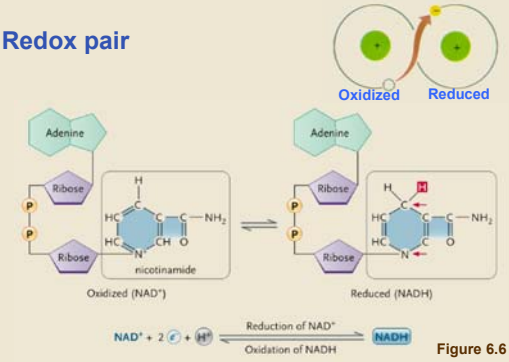


Figure 6.6

Cellular respiration

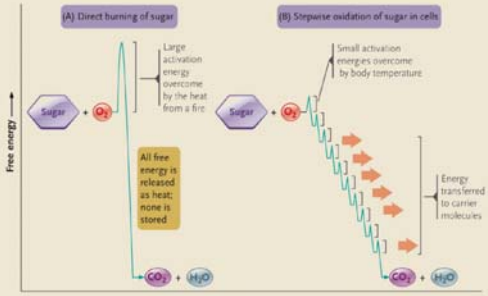


Figure 6.5

Metabolic diversity

		By products	
Initial electron donor	Electron acceptor	From electron donor	From electron acceptor
Sugar	O_2	CO_2	H_2O
H_2 or organics	SO_4^{2-} (Sulfate)	H_2O or CO	H_2S (hydrogen sulfide)
H_2	CO_2	H_2O	CH_4 (Methane)
CH_4	O_2	CO_2	H_2O
S^{2-} or H_2S	O_2	SO_4^{2-} (Sulfate)	H_2O
Organics	Fe^{3+}	CO_2	Fe^{2+}
NH_3 (Ammonia)	O_2	NO_2^- (Nitrite)	H_2O
NO_2^- (Nitrite)	O_2	NO_3^- (Nitrate)	H_2O

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Bacterial importance

- Disease
- Nitrogen fixation
- Decomposition
- Unique biochemical pathways
- Extremophiles (Archea)

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Prokaryotes and humans

Transmission	Disease - *Bacterium*
Airborne	Legionellosis - *Legionella pneumophobia* Diptheria - *Corynebacterium diphtherium* Tuberculosis – *Mycobacterium tuberculosis*
Arthropod	Lyme disease – *Borrelia burgdorfei* Bubonic plague – *Yersinia pestis*
Direct contact	Gonorrhea – *Neisseria gonoffhoeae* Anthrax – *Bacillus anthracis*
Food or waterborne	Food poisoning – *Salmonella enteritidis* Cholera – *Vibrio cholerae* Listeriosis - *Listeria monocytogenes*

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Nitrogen fixation

$N_2 + 8H^+ + 8e^- + 16\ ATP \rightarrow 2NH_3 + H_2 + 16ADP + 16\ P_i$

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Nitrogen cycle

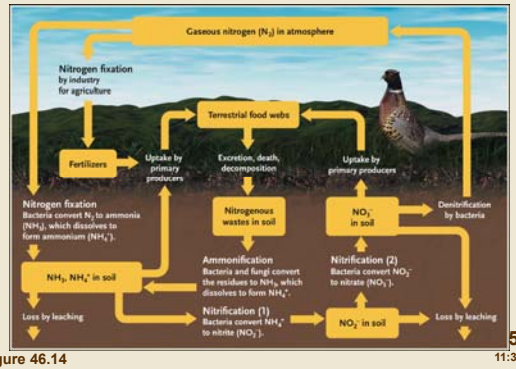

Figure 46.14

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Extremophiles (Archaea)

Halophiles

Figure 20.20

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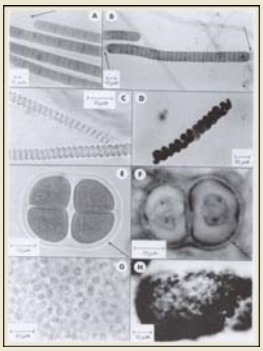
Fossil bacteria



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Stromatolites

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Figure 3.14

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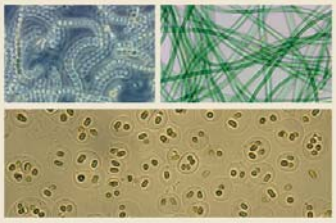
Cyanobacteria and earth's evolution

$CO_2 + H_2O$ + light

↓

$(CH_2O)_n + H_2O + O_2$



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Oxygenation of the planet

Figure 3.18

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Bacterial evolution

- Cyanobacteria
- Asexual reproduction
- "Living fossils"

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