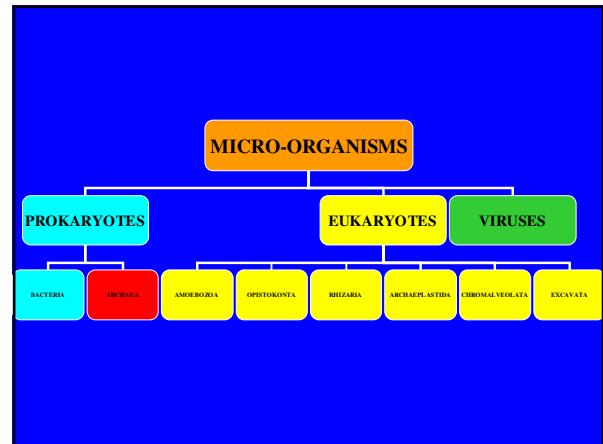


BIODIVERSITY I

BIOL 1051

What are Archaea?

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What are Archaea?

1. Archaea are prokaryotic cells.
- 2. Archaea are unicellular.
- 3. Archaea are microscopic.
- 4. Archaeal forms
- 5. Archaeal structures
- 6. Archaeal metabolisms
- 7. Archaeal diversity

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1. Archaea are prokaryotic cells.



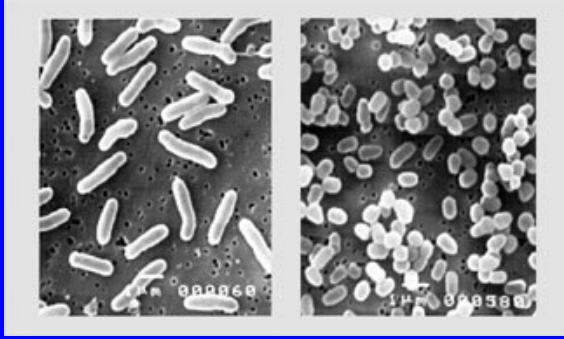
- Archaea are prokaryotic cells.
 - Cytoplasmic membrane: **ether linked lipids to glycerol**
 - **70S ribosomes,**
 - **16S r-RNA.**
 - Cell wall **without** peptidoglycan
 - **histones-like proteins** associated with the DNA.
- No true **nucleus** (nucleoid in the cytoplasm)
- **No organelles.**

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2. Archaea are unicellular.

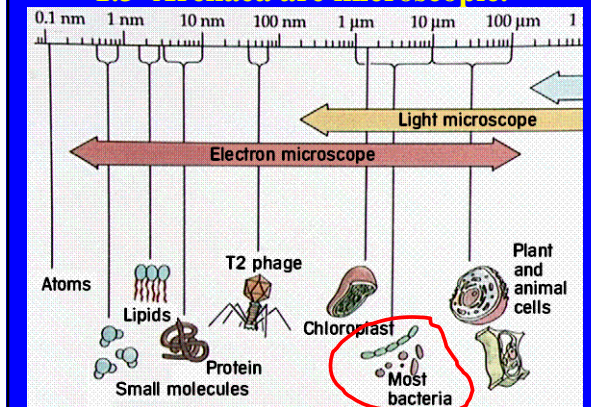
- As Bacteria, Archaea are mostly unicellular.



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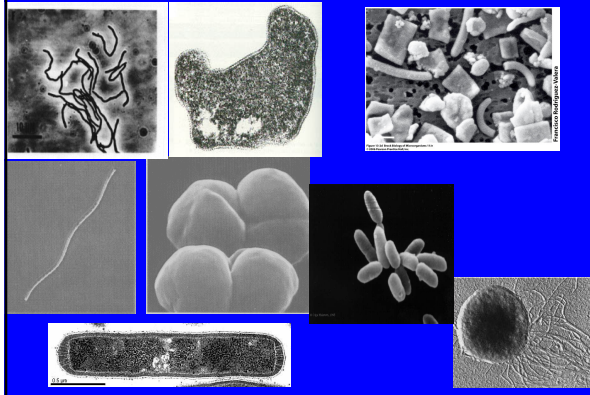
1.3 Archaea are microscopic.



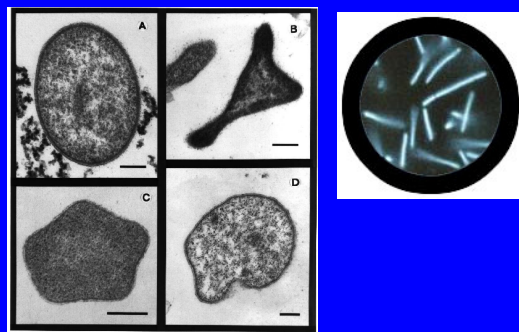
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4. Archaeal forms



4. Archaeal forms



What are Archaea?

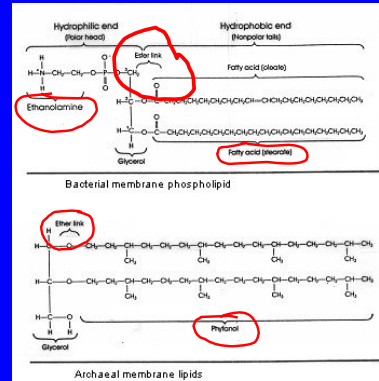
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5. Archaeal structures

1. Cytoplasmic membrane

Ether-linked lipids

Phytanol



5. Archaeal structures: membrane composition

Characteristics	Bacteria	Eukaryotic	Archaea
Protein content	High	Low	High
Lipid composition	Phospholipids	Phospholipids	Sulfolipids, glycolipids, nonpolar isoprenoid lipids, phospholipids
Lipid structure	Straight chain	Branched	Straight chain
Lipid linkage	Ester linked	Ester linked	Ether linked (di& teraethers)
Sterols	Absent	Present	Absent

5. Archaeal structures

2. Cell Wall

Variable cell wall composition (some do not contain cell walls, e.g., *Thermoplasma*)

- *Methanobacterium* sp.: glycans (sugars) & peptides
- *Methanosarcina* sp. non-sulfated polysaccharides
- *Halococcus* sp. sulfated polysaccharides
- *Halobacterium* sp.
 - negatively charged acidic amino acids
 - counteract + charges of high Na^+ in environment.
 - Cells lyses in NaCl concentrations $< 15\%$.
- *Methanomicrobium* sp. & *Methanococcus* sp. exclusively made up of protein subunits.

5. Archaeal structures

3. Chromosome, ribosomes, RNA-Polymerase

Eukaryotic Traits	Bacterial Traits
<ul style="list-style-type: none"> • DNA replication machinery • histones-like • nucleosome-like structures • Transcription machinery RNA polymerase Transcription Factor IIB TATA-binding protein (TBP) • Translation machinery initiation factors ribosomal proteins elongation factors poisoned by diphtheria toxin 	<ul style="list-style-type: none"> • single, circular chromosome • operons • no introns • bacterial-type membrane transport channels • Many metabolic processes energy production nitrogen-fixation polysaccharide synthesis

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Archeal metabolism diversity

ALL ARCHEA ARE CHEMOTROPHIC
No photosynthetic Archea known
Enormous phenotypic diversity

6. Archeal metabolism diversity

ENERGY SOURCE	ELECTRON DONOR	CARBON SOURCE	ORGANISMS
		AUTO- (CO ₂)	PROKARYOTES Algae Certain Protists Plants
PHOTO- (Light)	LITHO- (Inorganic compounds and C ₁)	HETERO- (H ₂ , CO ₂)	None
	ORGANO- (Organic compounds)	AUTO-	None
		HETERO-	PROKARYOTES
		AUTO-	PROKARYOTES
	LITHO-	HETERO-	PROKARYOTES
CHEMO- (Chemical compounds)		AUTO-	PROKARYOTES
	ORGANO-		PROKARYOTES Most Protists Fungi Plants (non-photosynthetic) Animals
		HETERO-	

7. Bacterial metabolism diversity Many Archea are extremophiles "THE MOST"

Table 2.1 Classes and examples of extremophiles*

Extreme	Descriptive term	Genus/species	Domain	Habitat	Minimum	Optimum	Maximum
Temperature High	Hyperthermophile	<i>Pyrolobus fumarii</i>	Archea	Hot, undersea hydrothermal vents	90°C	106°C	113°C ^b
Low	Psychrophile	<i>Polaromonas vacuolata</i>	Bacteria	Sea ice	0°C	4°C	12°C
pH Low	Acidophile	<i>Picrophilus_torresmaris</i>	Archea	Acidic hot springs	-0.06	0.7 ^c	4
High	Alkaliphile	<i>Natronobacterium gregoryi</i>	Archea	Soda lakes	8.5	10 ^d	12
Pressure	Barophile	<i>Moritella yanamosii</i> ^e	Bacteria	Deep ocean sediments	500 atm	700 atm	>1000 atm
Salt (NaCl)	Halophile	<i>Haloquadratum walsbyi</i>	Archea	Saltlakes	15%	25%	32% (saturation)

* In each category the organism listed is the current "record holder" for requiring a particular extreme condition for growth.
^b A newly isolated archaeon can apparently grow up to 121°C.
^c *P. torresmaris* is also a thermophile, growing optimally at 60°C.
^d *N. gregoryi* is also an extreme halophile, growing optimally at 20% NaCl.
^e *Moritella yanamosii* is also a psychrophile, growing optimally at about 4°C.

Table 2-1 Brock Biology of Microorganisms 11/e
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6. Archaeal metabolism diversity Thermophilic Archea

- Extreme thermophiles:
- survived at 350°C under tremendous pressure
- Optimal "operating temperature" is just over 110°C
- survive anaerobically at 250°C degrees !
- These cells could have survived on a young Earth under conditions that are thought to be uninhabitable by all known life forms.

Pyrolobus fumarii:

Opt. 106°C, most thermophile, Max T = 113°C
Unable to grow below 90°C (too cold!)
Wall black smokers, hydrothermal vents
Coccoid-shaped, Cell wall: protein
Obl. H₂ chemolithotroph
Resist 121°C (autoclave) 1h



6. Archaeal metabolism diversity

Methanogens

- obligate anaerobes
- Marine, freshwater sediments, deep soils, and intestinal tracts of animals.
- H₂ = energy; CO₂ = carbon source; produce CH₄.
- Associated with heterotrophic eubacteria and protozoa.
- **Most diverse group of Archaea.**
- Extreme thermophiles, moderate thermophiles, or mesophiles.
- Morphology can be cocci, rod, or spirillum



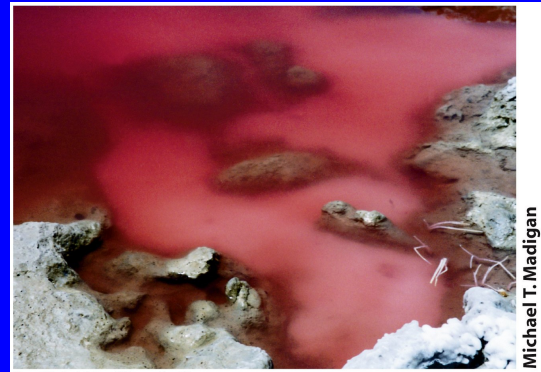
6. Archaeal metabolism diversity

Halophilic Archea

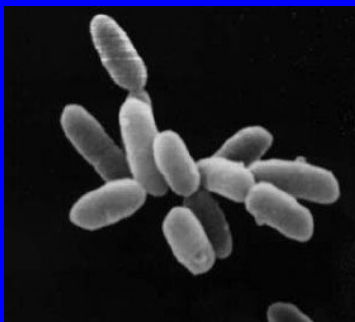
- Found in salt flats and evaporation ponds.
- Color these areas **pinkish-red**.
- They can't live in salt concentrations below 10%!
- Bright red carotenoid pigment protects the cells from intense solar radiation.
- **Bacteriorhodopsin**: use sunlight for energy.
- Produce their own ATP using this pigment.
- Directly produce ATP by chemiosmosis.



6. Archaeal metabolism diversity



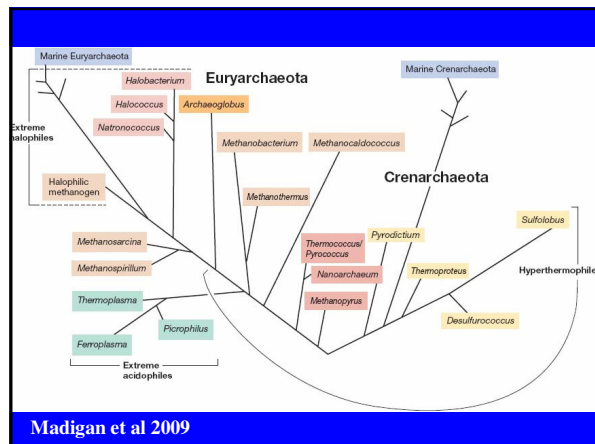
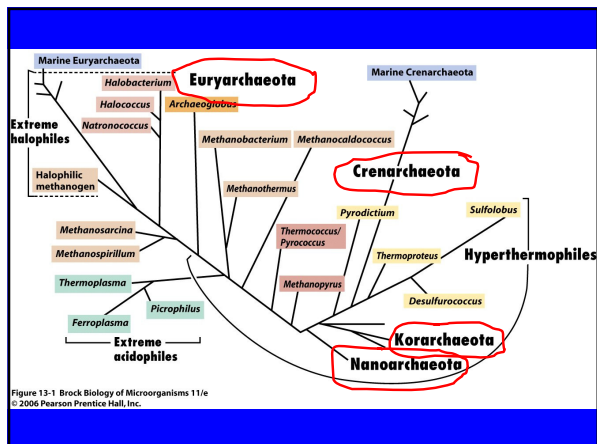
6. Archaeal metabolism diversity



Halobacteria sp. strain NRC-1

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- **REFERENCE:**
 - MADIGAN, MT, MARTINKO, JM, DUNLAP, PV & CLARK DP Brock Biology of Microorganisms, 12th ed, 2009, Pearson, Benjamin Cummings, p. 487-515.
 - PURVES, WK, SADAVA, D, ORIAN, GH, HELLER, HC. Life, The Science of Biology, 6th ed, 2001, Sinauer Associates Inc., p. 472-473.
 - PRESCOTT, LM, HARLEY, JP, KLEIN, DA. Microbiology, 3rd ed, 1996, Wm C. Brown Publishers, A Times Mirror Company, p. 477-490.

- ### What are Archaea?
- **WEB Sites:**
 - <http://fox.rollins.edu/~egregory/Archaeobacteria.html>
 - <http://www.ucmp.berkeley.edu/Archaea/Archaeamm.html>
 - http://trishul.sci.gu.edu.au/courses/ss12bmi/microbe_structure.html
 - <http://www.personal.psu.edu/users/a/b/abt113/bio/webpage4.html>
 - <http://daphne.palomar.edu/wayne/ploct97.htm#stromato.gif>

- ### What are Archaea?
- **WEB Sites:**
 - www.bact.wisc.edu/Bact303/MajorGroupsOfProkaryotes
 - www.uga.edu/~cms/FacWBW.html
 - www.unmc.edu/Students/corbitt/Archaeobacteria.html
 - <http://daphne.palomar.edu/wayne/ploct97.htm#stromato.gif>
 - <http://cw.prenhall.com/bookbind/pubbooks/brock/>