


Updated: 4 October 2019 [Print version](#)

CEE 370 Environmental Engineering Principles

Lecture #15 Environmental Biology IV Microorganisms

[Reading: Mihelcic & Zimmerman, Chapter 5](#)
[Davis & Masten, Chapter 3](#)

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Environmental Microbiology

- Types of Microorganisms
 - Bacteria
 - Viruses
 - Protozoa
 - Rotifers
 - Fungi
- Metabolism
- Microbial Disease
- Microbial Growth

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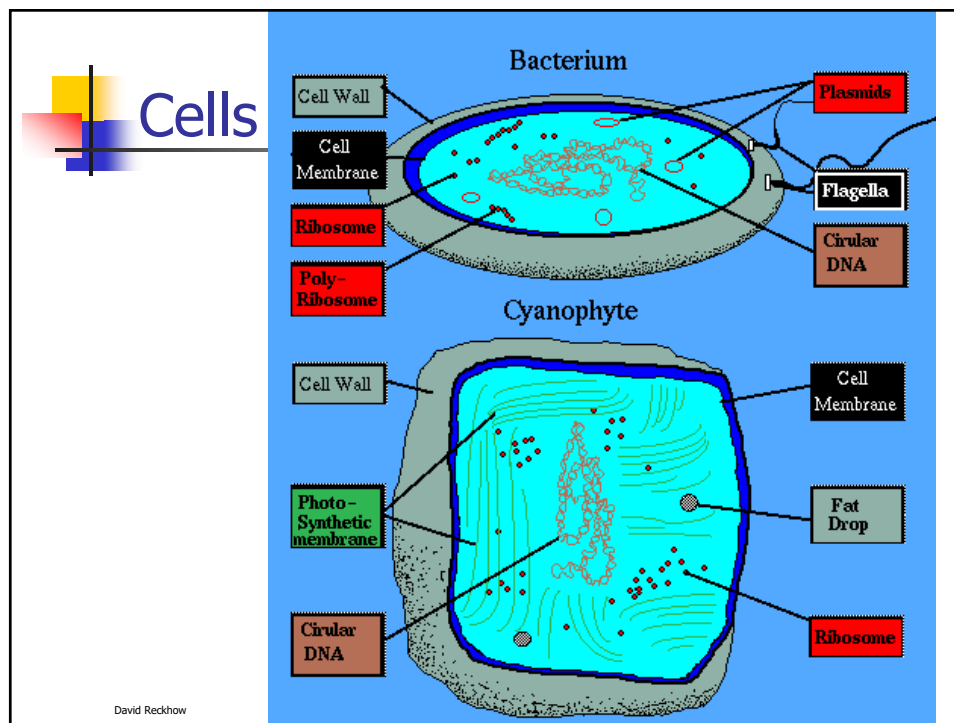
Prokaryotic and Eukaryotic cells

- Eukaryotes: Organisms whose cells contain compartments or organelles within the cell, such as mitochondria and nucleus
 - Animals, plants
- Prokaryotes: Whose cells do not have these organelles (e.g. bacteria)
 - Most prokaryotes have a smaller genome, typically contained in a single circular DNA molecule.
 - Additional genetic information may be contained in smaller satellite pieces of DNA called plasmids

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Non living disease agents

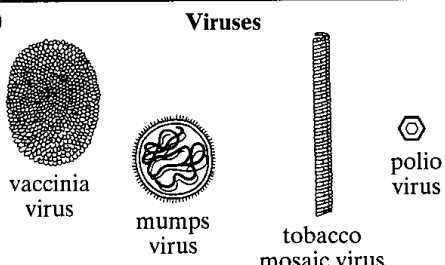
- Viroids
 - Small RNA molecules that infect plants
- Prions
 - Protein molecules that infect animals
 - Scrapie in sheep & goats
 - Mad Cow Disease

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Viruses

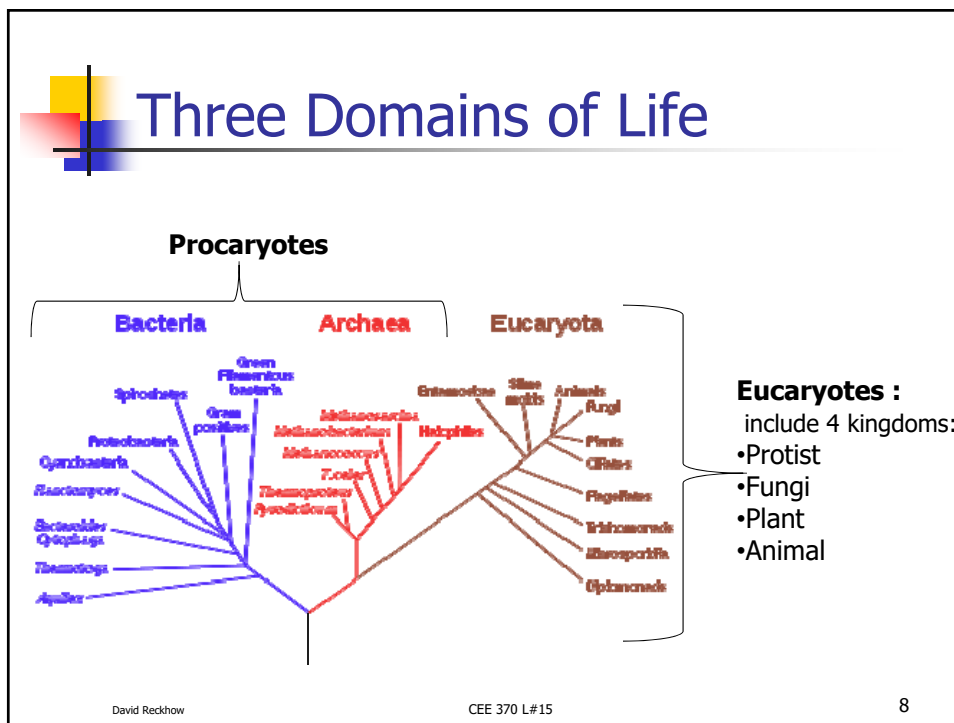
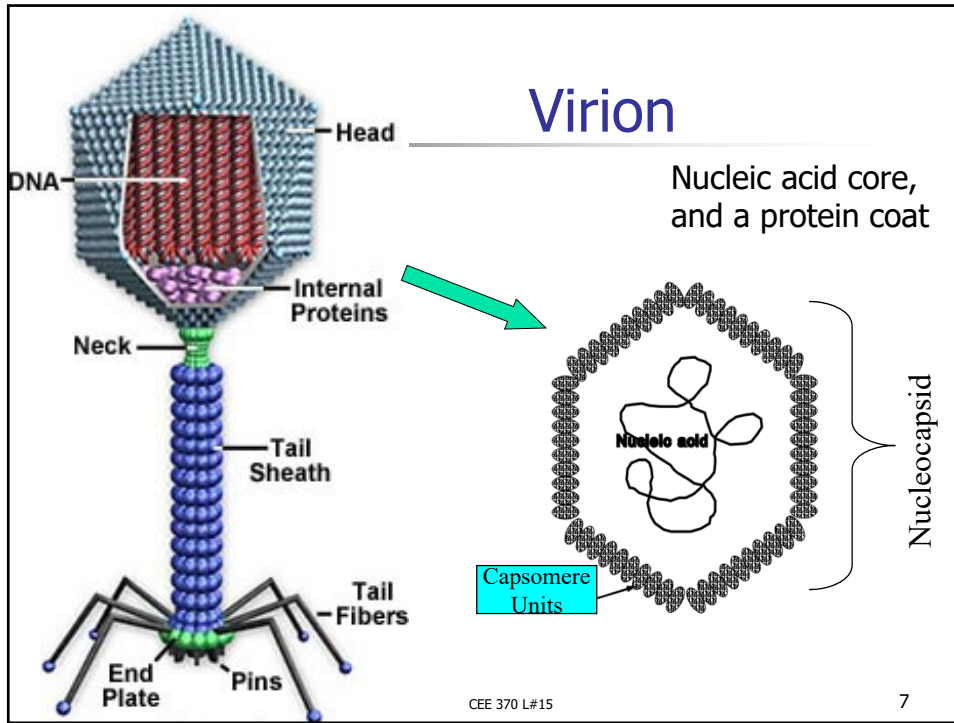
- Between biochemicals and living organisms
- Smallest "organisms"
 - 0.02 μm to 0.3 μm
- All are parasitic
 - Host supplies protein & energy
- All are pathogenic
 - AIDS
 - Hepatitis
 - Polio

(a) Viruses



vaccinia virus mumps virus tobacco mosaic virus polio virus

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Bacteria

- Unicellular organisms
- no nuclear membrane
- size: 0.1 μm to 10 μm
- shape: cylindrical to spherical
- some have flagella etc.
- Many are pathogenic
 - Tuberculosis
 - Diphtheria
 - Strep throat
 - Lyme disease
 - Cholera
 - typhoid

(b) **Bacteria**

The diagram illustrates three bacterial morphologies: 'cocci' shown as a cluster of small circles, 'spirilla' shown as three wavy, spiral-shaped lines, and 'bacilli' shown as a vertical chain of four oval shapes.

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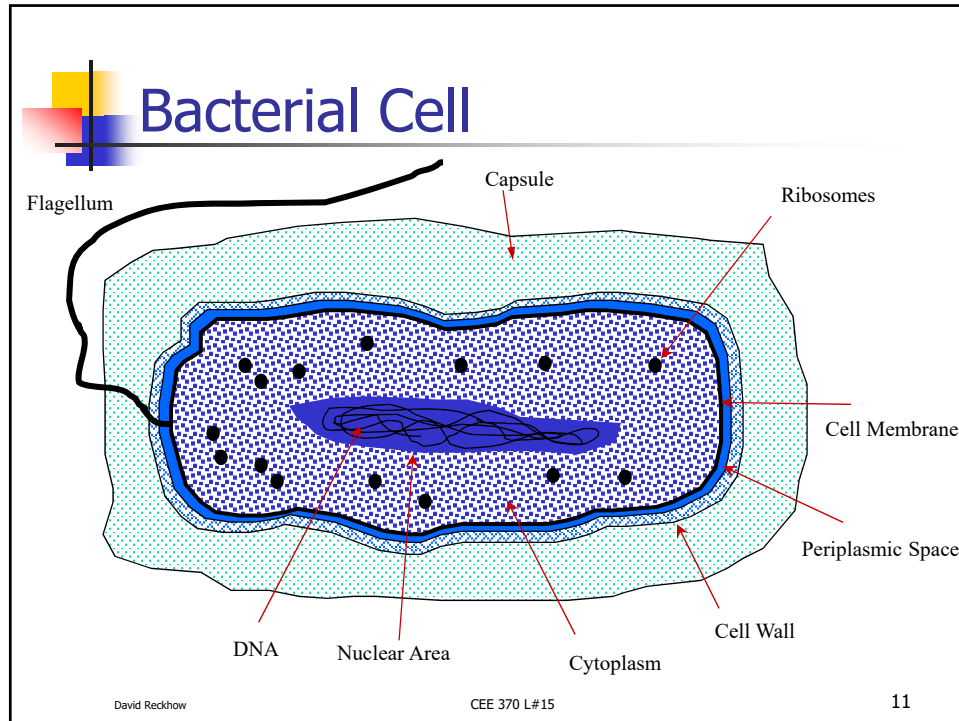
Bacteria

- Important in cycling material and energy in Natural & engineered systems
 - Purification of municipal wastewater
 - Activated sludge process
 - Remediation of contaminated soil and "natural attenuation"
 - Hydrocarbon degrading organisms

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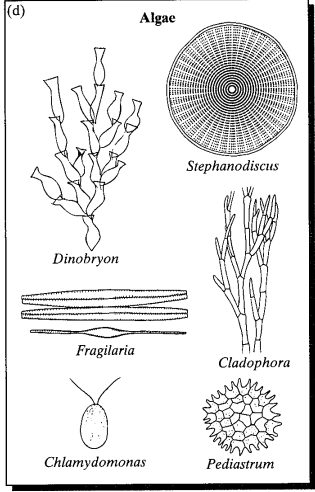
Algae

- Eucaryotic (nuclear membrane)
 - except for blue-greens
- Thick cell walls
- Contain photosynthetic pigments (e.g., chlorophyll)
 - in plastids, chloroplasts or chromatophores
- Important primary producers
- Can cause problems in DWT
 - tastes & odors
 - filter clogging
- Algal blooms & eutrophication

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Algae: Classification I

- Blue-greens (prokaryotic: bacteria)
 - *Cyanophyta*; unicellular, nitrogen fixers
 - Fresh water, warm, often polluted, often responsible for blooms
 - *Anabaena*, *Oscillatoria*, *Anacystis*
- Green
 - *Chlorophyta*: mostly colonial, filamentous
 - Fresh water, mostly unpolluted
 - *Chlorella*, *Scenedesmus*, *Spirogyra*, *Selenastrum*
- Yellow Greens
 - *Chrysophyta*: some colonial, diatoms have silica in walls
 - Cold water, clean
 - Diatoms: *Asterionella*, *Fragilaria*, *Synedra*



(d) Algae

Dinobryon

Stephanodiscus

Fragilaria

Cladophora

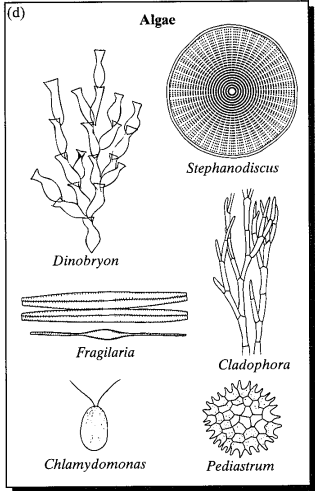
Chlamydomonas

Pediatrum

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Algae: Classification II

- Yellow-Browns
 - *Pyrrophyta*; 90% unicellular, two flagella
 - Mostly marine
 - *Cyclotella*, *Melosira*
- Euglenoids
 - *Euglenophyta*: motility by flagellum, requires organic nitrogen
 - Freshwater
 - *Euglena*
- Red
 - *Rhodophyta*: colonial, sheets are common
 - Mostly marine, very clean, warm water
 - *Gracilaria*, *Corallina*



(d) Algae

Dinobryon

Stephanodiscus

Fragilaria

Cladophora

Chlamydomonas

Pediatrum

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Algae: Class

- Browns
- *Phyophyta*; colonial, large
- Marine, cool water
- *Macrocystis*, giant kelp

(d) Algae

See also:
Henry & Heinke, 1996

From: *Standard Methods for the Examination of Water and Wastewater*

Plate B. Filter clogging algae

Fungi

(c) Fungi

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Protozoa

- ❖ Much larger than bacteria
- ❖ Unicellular
 - ❖ flagellated (e.g., Euglena)
 - ❖ ciliated (e.g., Paramecium)
 - ❖ amoebiods (e.g., Entamoeba)
- ❖ Form cysts - difficult to kill
- ❖ Life cycles
 - ❖ some are bacterial predators
 - ❖ some are human pathogens
 - ❖ amebic dysentery
 - ❖ giardiasis
 - ❖ cryptosporidiosis

(f) Protozoa

Vorticella Paramecium Amoeba Bodo

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Rotifer

- ⌚ Multicellular animals
- ⌚ Predators
- ⌚ ciliated
- ⌚ important in wastewater treatment
- ⌚ indicator organisms

Rotifer

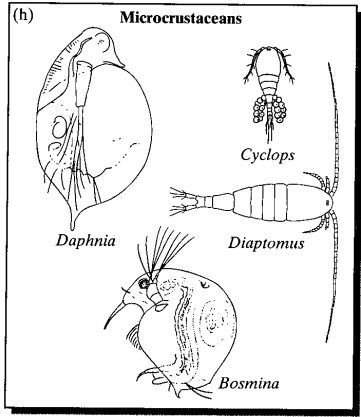
(g) Rotifers

Philodina Keratella Polyarthra

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Microcrustaceans

- Animals: 1-10 mm
- Primary food source for fish
- Important in energy & material transfer
- An important component of zooplankton (includes also protozoa and rotifers)



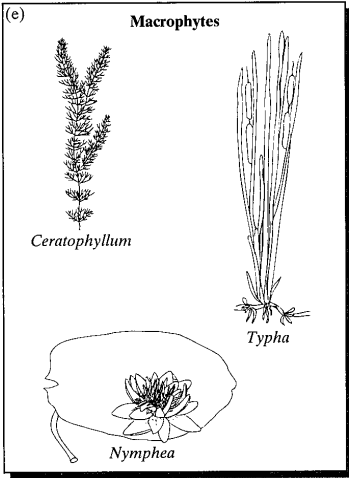
(h) Microcrustaceans

The diagram illustrates four types of microcrustaceans: *Daphnia* (a large, pear-shaped organism with a long tail), *Cyclops* (a small, pear-shaped organism with a long neck and two large eyes), *Diaptomus* (a small, segmented organism with a long tail), and *Bosmina* (a small, pear-shaped organism with a long tail and a prominent head).

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Macrophytes

- Larger, vascular plants that grow submerged, floating or emergent in fresh waters
- Provide habitat for fish
- Can aggravate nutrient problems



(e) Macrophytes

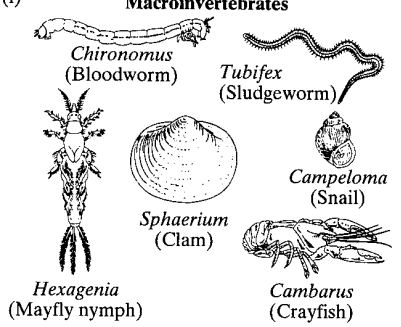
The diagram illustrates three types of macrophytes: *Ceratophyllum* (a submerged plant with many small, feathery leaves), *Typha* (an emergent plant with long, narrow leaves and a central stalk), and *Nymphaea* (a floating plant with large, round leaves and a central flower).

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Macroinvertebrates

- Higher animals
 - Invertebrates lack a spine or backbone
- Most are bottom feeders
- Important in recycling dead matter
- Can accumulate pollutants

(i) **Macroinvertebrates**



Chironomus (Bloodworm) *Tubifex* (Sludgeworm)

Sphaerium (Clam) *Campeloma* (Snail)

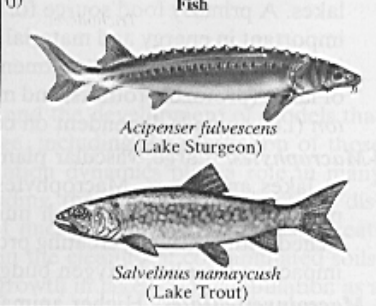
Hexagenia (Mayfly nymph) *Cambarus* (Crayfish)

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Fish

- Higher up the food chain
 - Therefore, they further concentrate some hydrophobic pollutants


(j) **Fish**



Acipenser fulvescens (Lake Sturgeon)

Salvelinus namaycush (Lake Trout)


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Clicker question

- Chemotrophs are organisms that:
 - A. Obtain energy from the metabolism of chemicals, either organic or inorganic
 - B. Obtain carbon from organic chemicals
 - C. Grow toward organic chemicals
 - D. Grow by producing chemical byproducts
 - E. None of the above


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Microbial Terms to Know (#1)

Aerobes:	Aerobes Organisms which require molecular oxygen as an electron acceptor for energy production. See anaerobes.
Anabolism:	Anabolism Biosynthesis, the production of new cellular materials from other organic or inorganic chemicals.
Anaerobes:	Anaerobes A group of organisms that do not require <i>molecular</i> oxygen. These organisms, as well as all known life forms, require oxygen. These organisms obtain their oxygen from inorganic ions such as nitrate or sulfate or from protein.
Autotrophs:	
Biosynthesis:	
Catabolism:	
Chemotroph:	
Eucaryotic:	
Facultative:	
Fermentation:	

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Archaea one of three domains of life, primitive single cell procaryotes


Autotrophs A group of organisms capable of obtaining carbon for synthesis from inorganic carbon sources such as carbon dioxide and its dissolved species (the carbonates). This group includes plants and algae.

Biosynthesis Catabolism, the production of new cellular materials from other organic or inorganic chemicals.

Catabolism The production of energy by the degradation of organic compounds.

Chemotroph Organisms which obtain energy from the metabolism of chemicals, either organic or inorganic.

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Eucaryotic organisms Organisms which possess a nuclear membrane. This includes all known organisms except Bacteria and Archaea.

Facultative A group of microorganisms that are capable of using both oxygen and other terminal electron acceptors, depending on which is available.

Fermentation Energy production without the benefit of oxygen as a terminal electron acceptor, i.e. oxidation in which the net effect is one organic compound oxidizing another. See respiration.


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Microbial Terms to Know (#2)

Heterotrophic:	Heterotrophic A group of organisms which obtain carbon for synthesis from other organic matter or proteins.
Metabolism:	Metabolism The processes which sustain an organism, including energy production, synthesis of proteins for repair and replication.
Anaerobes:	Metabolism The processes which sustain an organism, including energy production, synthesis of proteins for repair and replication.
Ox. Phosphorylation:	Oxidative phosphorylation The synthesis of the energy storage compound adenosine triphosphate (ATP) from adenosine diphosphate (ADP) using a chemical substrate and molecular oxygen.
Phosphorylation:	
Photophosphoryl. :	
Phototroph:	
Procaryotic:	
Respiration:	
Substrate level Phos.:	

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Phosphorylation The synthesis of the energy storage compound adenosine triphosphate (ATP) from adenosine diphosphate (ADP).

Photophosphorylation The synthesis of the energy storage compound adenosine triphosphate (ATP) from adenosine diphosphate (ADP) using solar energy.

Phototroph Organisms which obtain energy from light using photooxidation.

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Prokaryotic organisms Organisms which do not have a cellular membrane, including Bacteria and Archaea.

Respiration Energy production in which oxygen is the terminal electron acceptor, i.e. oxidation to produce energy where oxygen is the oxidizing agent. See fermentation.

Substrate level phosphorylation The synthesis of the energy storage compound adenosine triphosphate (ATP) from adenosine diphosphate (ADP) using organic substrates without molecular oxygen.

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