

Preview: microbial ecology

- What's microbial ecology?

Producer

Consumer

Decomposer

- How do the microbes contribute to food production?

Direct/fermentation

- How to preserve food and avoid food-borne illness?

promote/inhibit microbial growth

Microbial Ecology

Microbial ecology

The study of the relationship in microorganisms with one another and with their environment

Community

Ecosystem

Biosphere

a group of interacting organisms sharing an environment

Biodiversity

Ecological niche

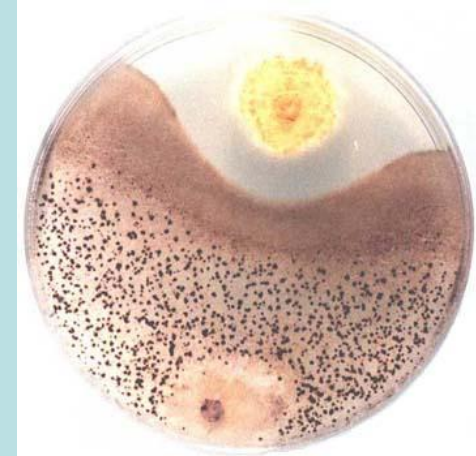
a natural unit consisting of all plants, animals and micro-organisms (biotic factors) in an area functioning together with all of the non-living physical (abiotic) factors of the environment

The region of earth inhabited by living organisms

the variation of life forms within a given ecosystem, or for the entire Earth

the role of an organism plays in a particular ecosystem

Biomass = weight of all organisms present in an ecosystem



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Biomass production

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estuaries, swamps,
and marshes



tropical
rain forests



coral reefs



temperate deciduous
forests



temperate
grasslands (prairies)



lakes and streams



rocky beaches and
sandy beaches



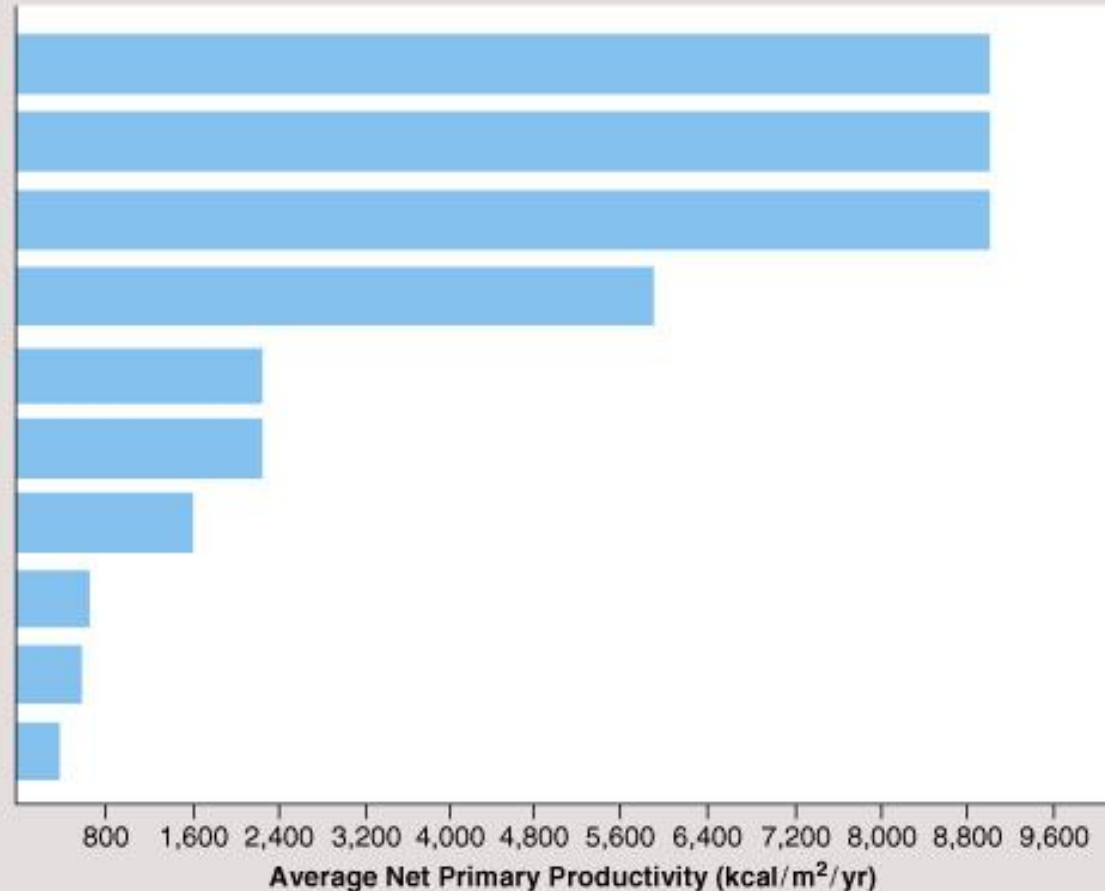
tundras



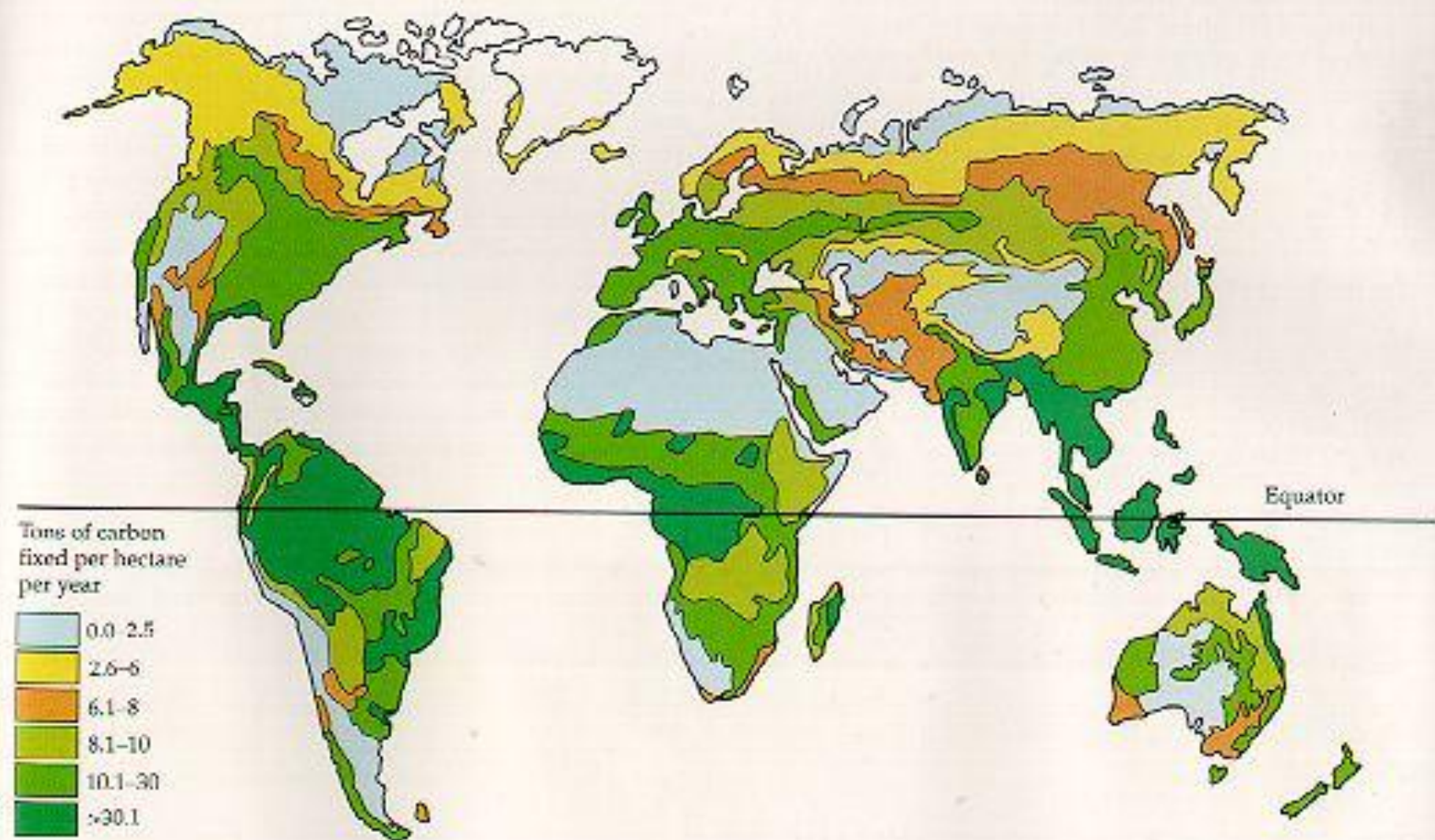
open oceans



deserts



Microbes contribute more than 70%
in these ecosystems



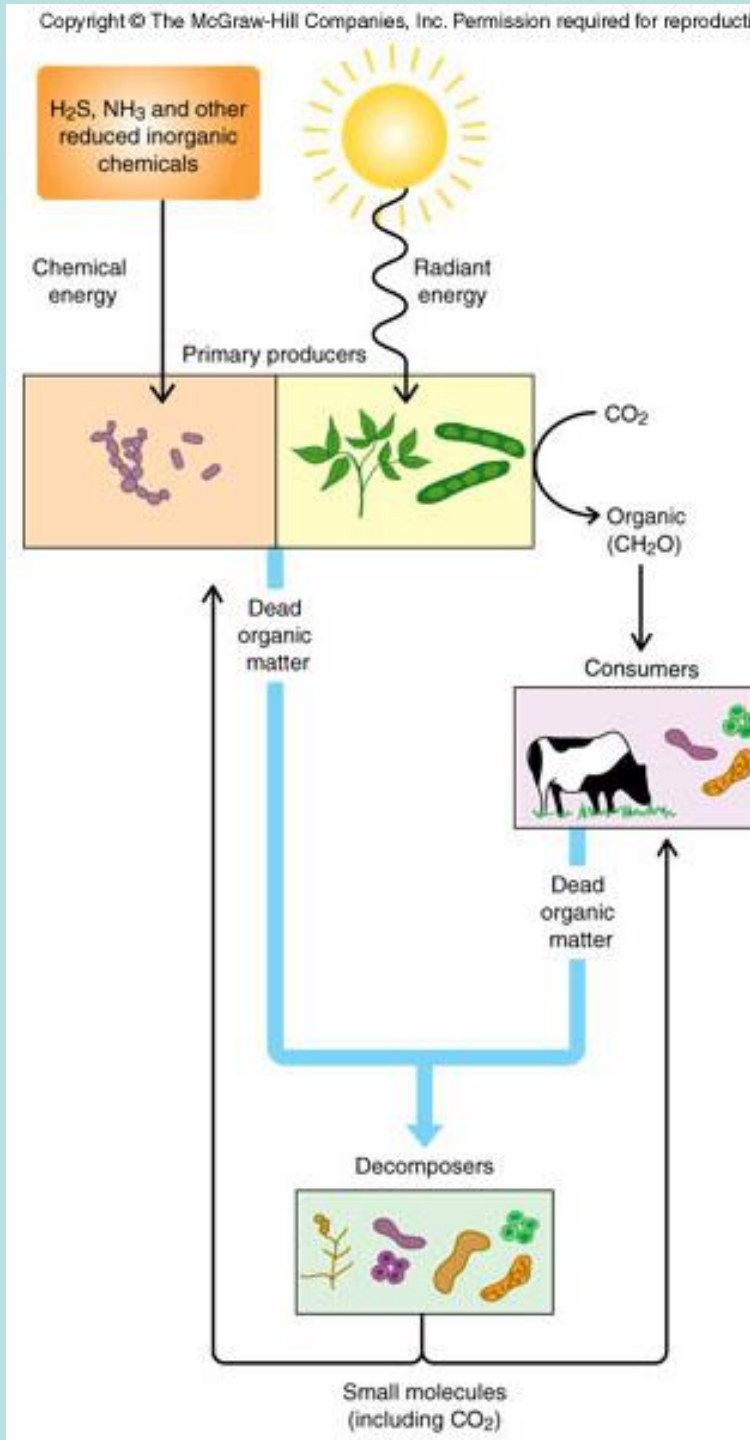
47.15 Biological Production of Terrestrial Ecosystems
 Areas of high annual production are in wet tropical and subtropical regions and the wetter parts of temperate latitudes. Low production characterizes the hot subtropical

deserts (where moisture is limiting) and high latitudes (where cool temperatures lower photosynthetic rates). This map plots primary production in tons of carbon fixed per hectare per year.

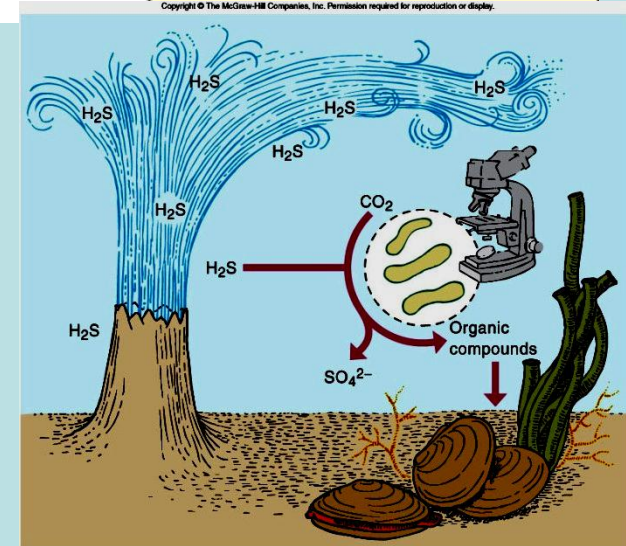
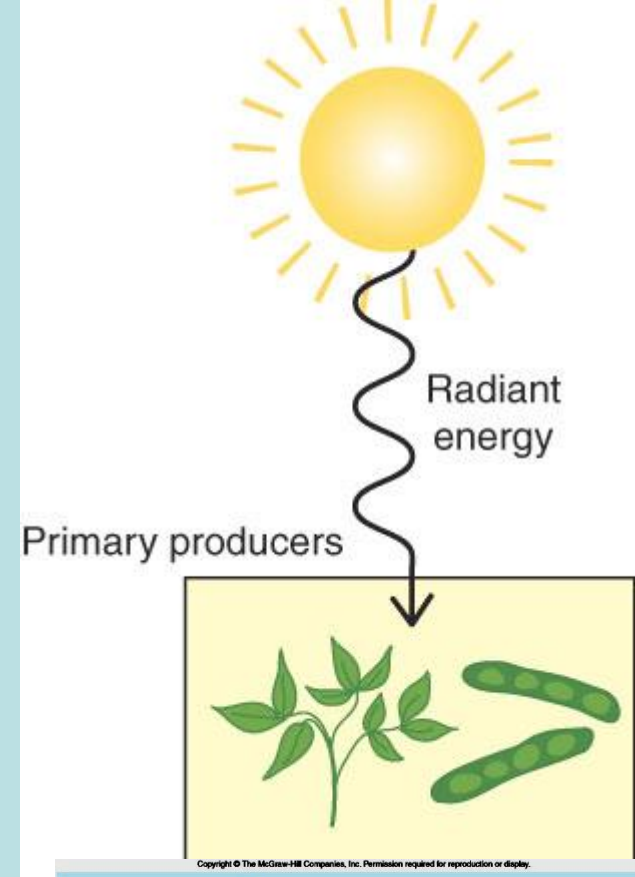
Principles of Microbial Ecology

- Microorganisms play major role in most ecosystems

- Role an organism plays in ecosystem is termed **ecological niche**
- Environment immediately surrounding microorganism is termed **microenvironment**
 - Most relevant to that cell
 - Often difficult to identify and measure
 - Macro environment may be more easily measured and is very different from microenvironment



- Primary **producers**
 - Primary producers are autotrophs
 - Convert carbon dioxide to organic materials
 - Include
 - Photoautotrophs
 - Plants
 - Algae
 - Cyanobacteria
 - Anoxygenic phototrophs
 - All use sunlight for energy
 - Chemoautotrophs
 - Oxidize inorganic compounds for energy
 - Primary **producers** serve as food source for **consumers** and **decomposers**



Principles of Microbial Ecology

• Consumers

- Consumers are heterotrophs
- Rely on activities of primary producers
- Herbivores eat primary producers
 - Termed primary consumers
- Carnivores consume herbivores
 - Termed secondary consumers
- Carnivores that eat other carnivores
 - Termed tertiary consumers
- Chain of consumption called **food chain**
- Interaction between food chains called **food webs**

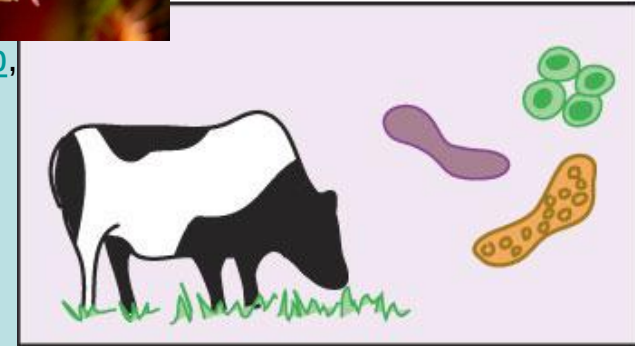


Venus flytrap,

Organic
(CH_2O)

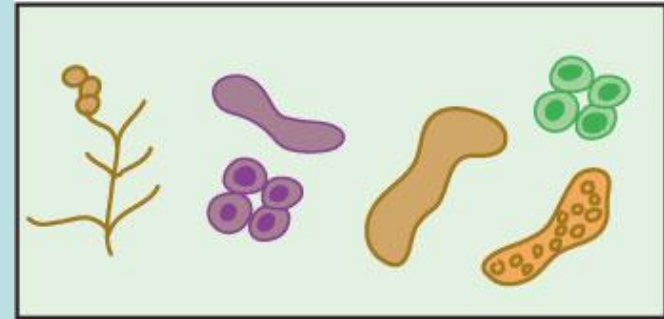
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Consumers



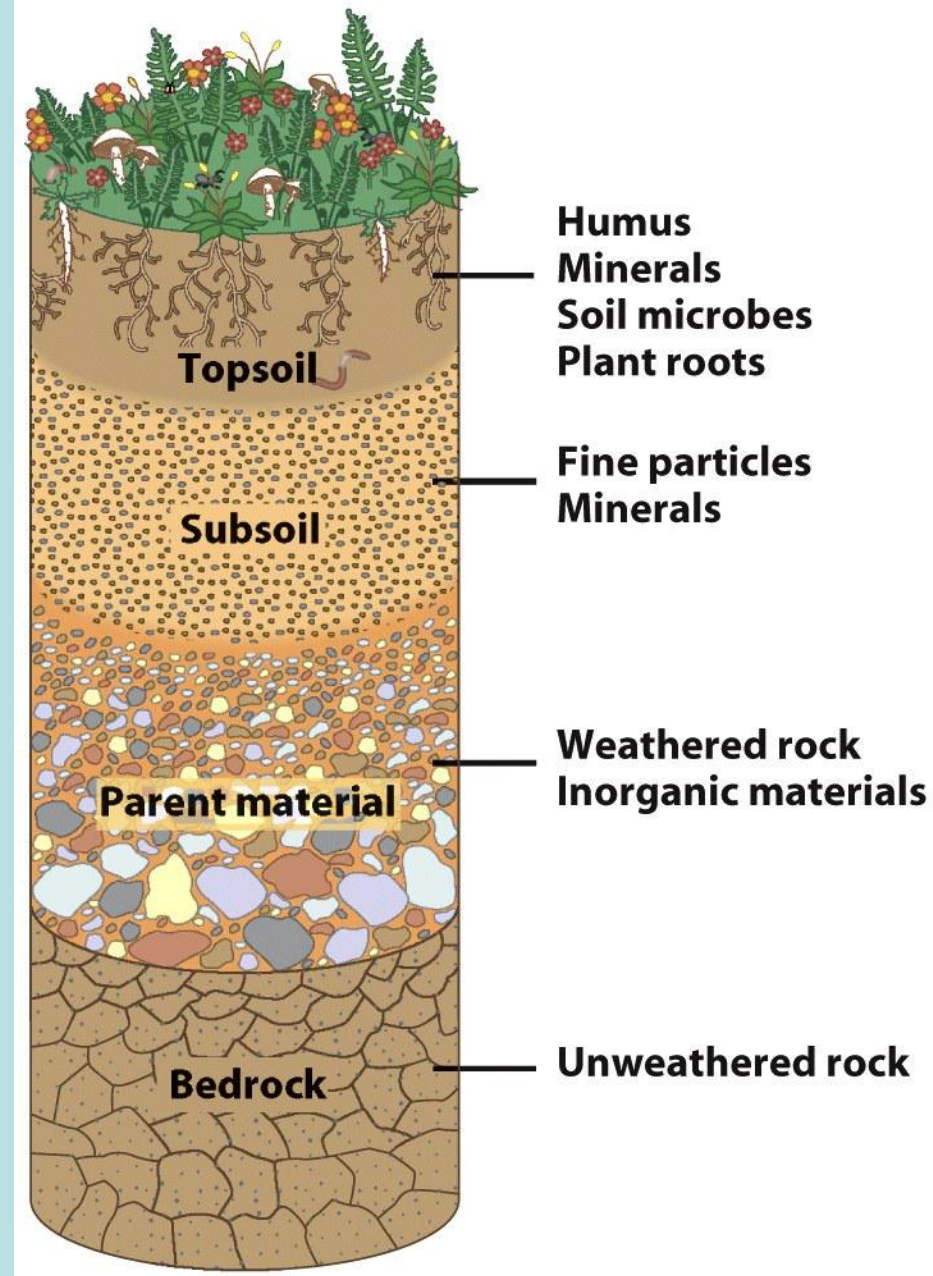
- **Decomposers**

- Decomposers are heterotrophs that digest remains of primary producers and consumers
 - Partially decomposed organic matter of other trophic levels termed detritus
- Decomposers specialize in digestion of complex material
 - Convert them into small molecules
 - Molecules more readily usable by other organisms
- Complete breakdown of organic molecules to inorganic molecules is termed mineralization



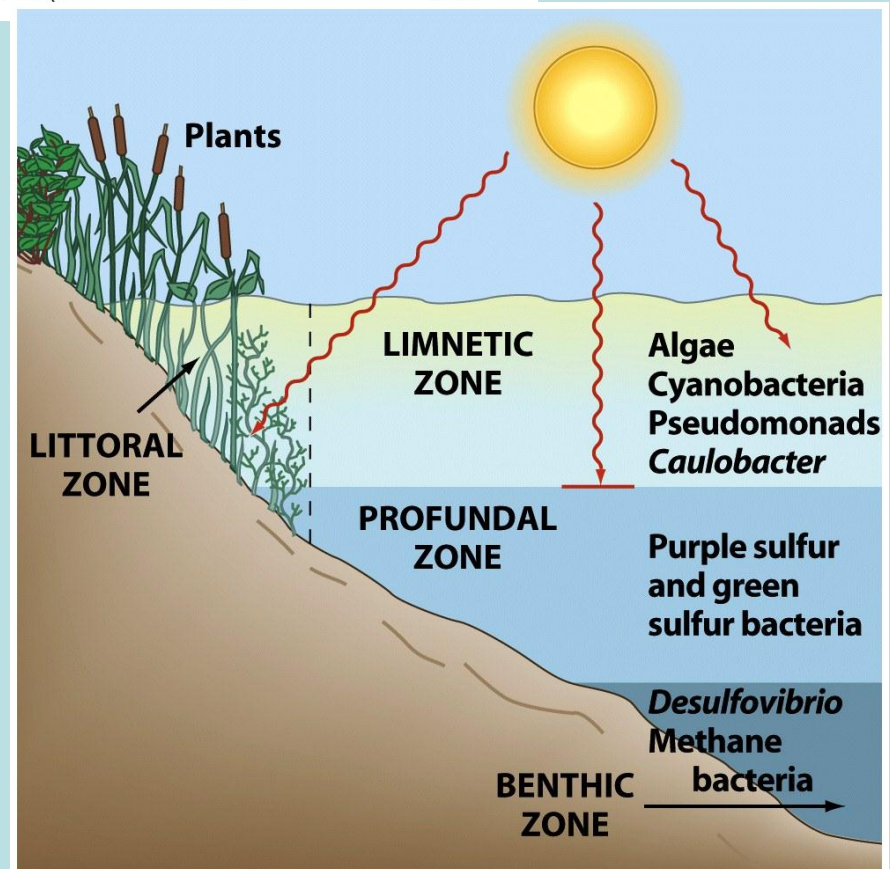
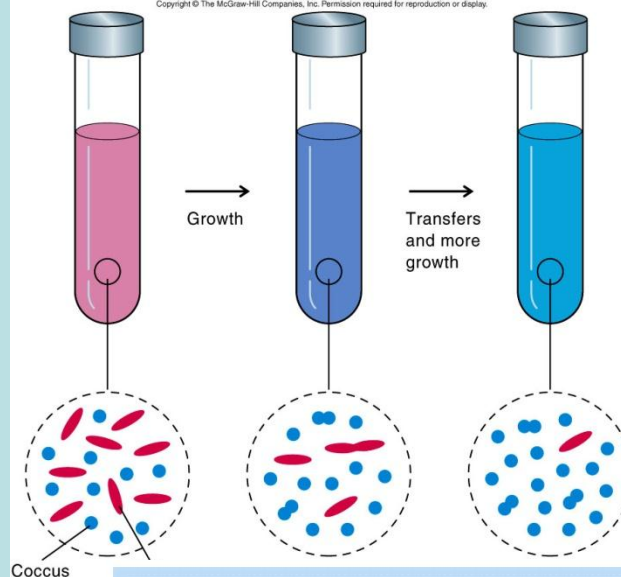
Principles of Microbial Ecology

- Bacteria in low-nutrient environments
 - These environments common in nature
 - Growth in these areas most often in form of **biofilm**
 - Microbes can extract amounts of nutrient absorbed by water
 - Organisms that survive in low nutrient environments often have highly efficient transport systems for nutrient procurement



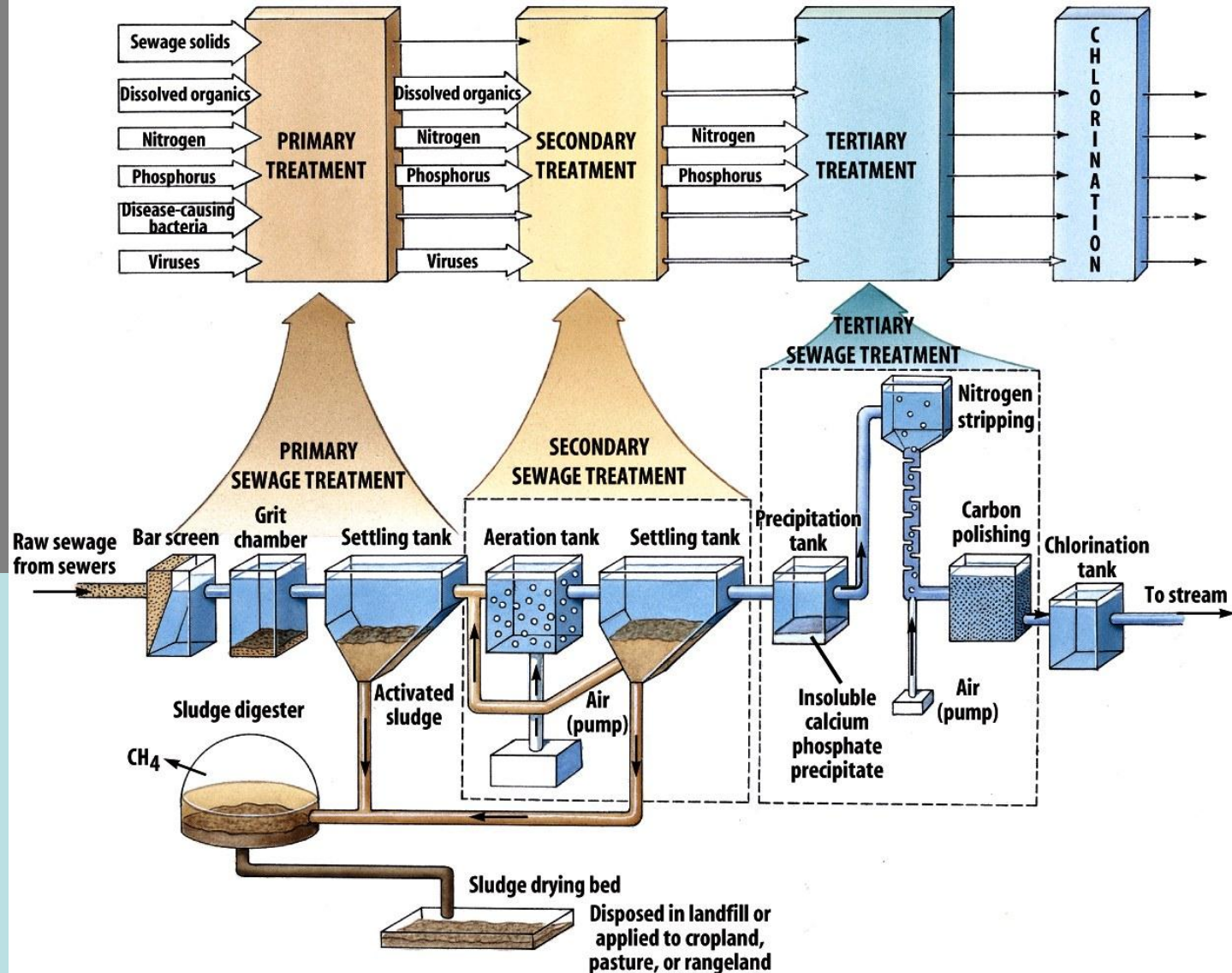
Principles of Microbial Ecology

- Microbial competition and antagonism
 - Results of competition evident among organisms
 - Ability to compete is generally related to rate of growth
 - Antagonism helps determine make-up of population
 - Bacteriocines produced by certain species to kill other strains



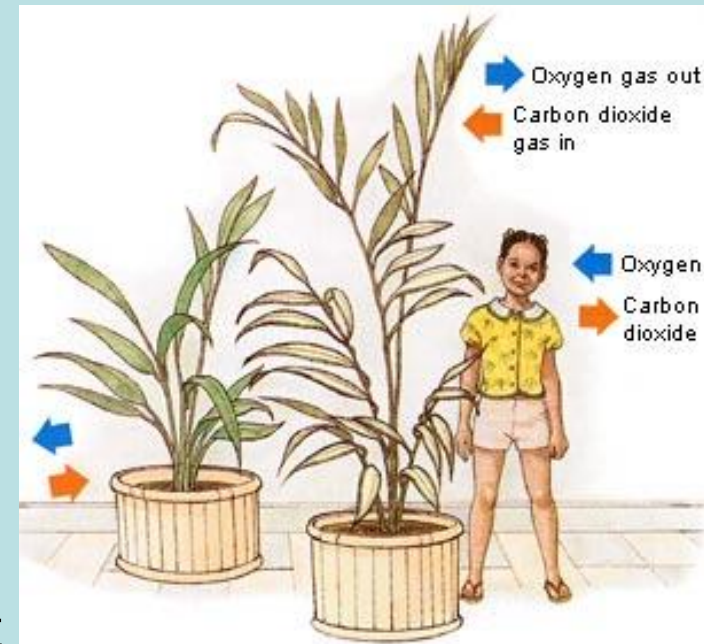
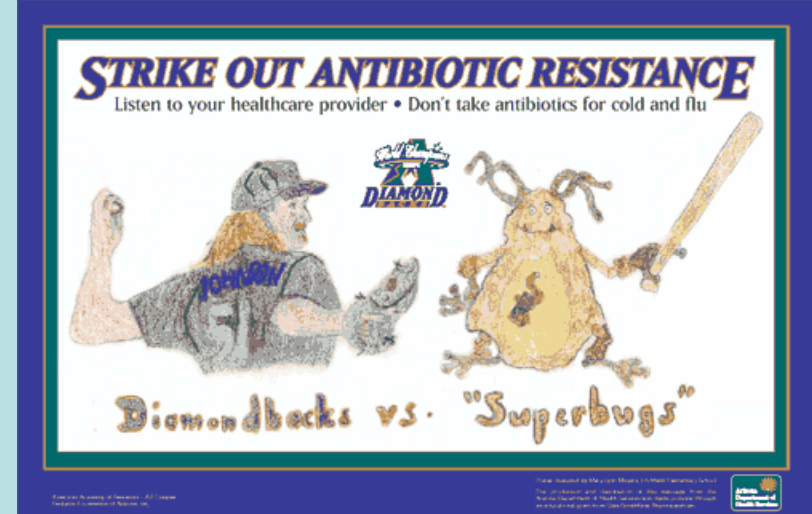
Sewage Treatment

- Primary
- Secondary
- Tertiary



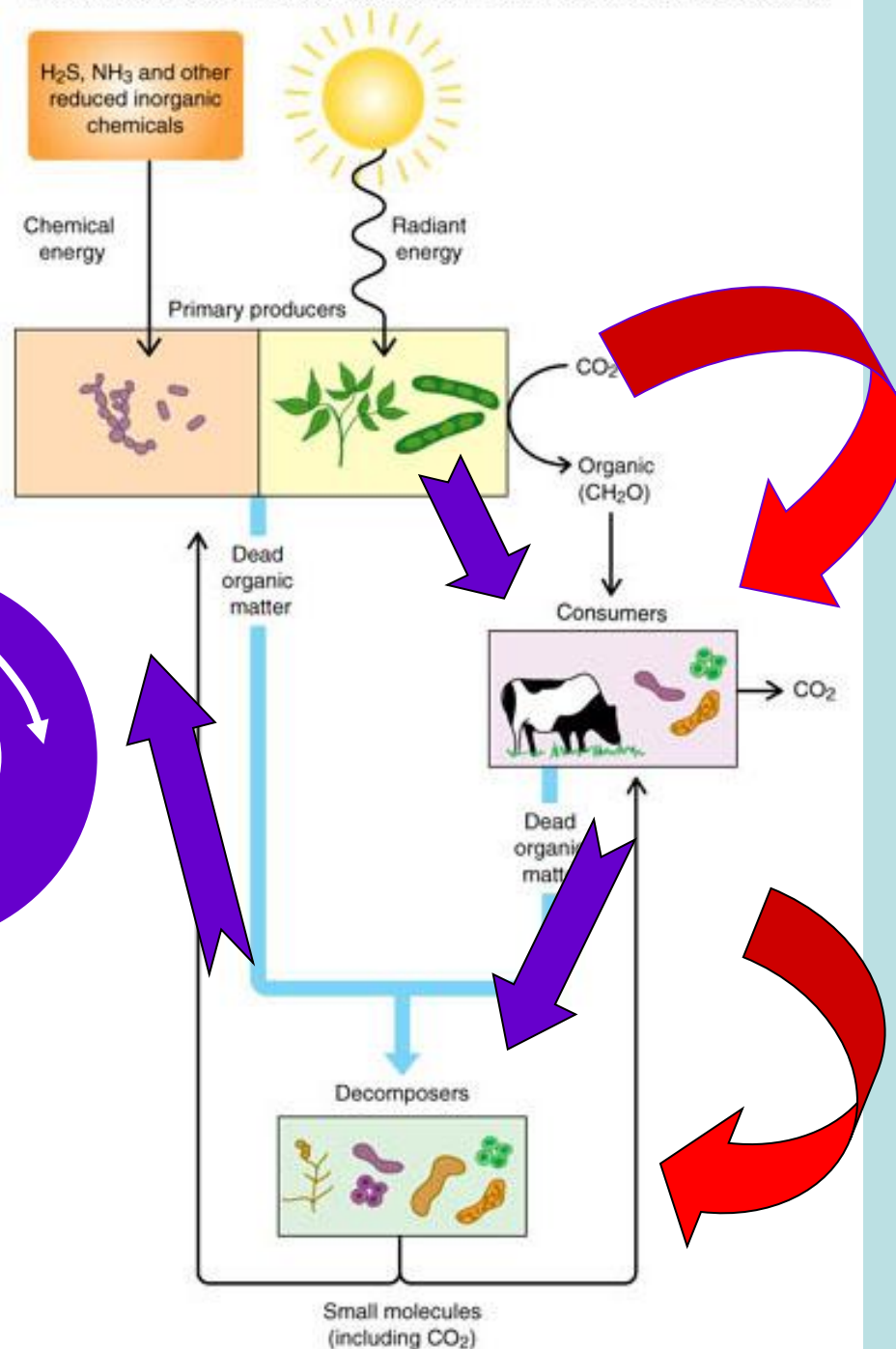
Principles of Microbial Ecology

- Microorganisms and environmental change
 - Environmental change often results in alterations in a bacterial community
 - In order for organism to survive in new conditions it must adapt to altered environment
 - In response to new stimuli microbes stop producing enzymes that serve no purpose
 - Mutants within a population may remain in minority in current population
 - Mutation may make organism well suited for new changed environment



Biogeochemical Cycling and Energy Flow

- **Biochemical cycles** are cyclical paths that elements take as they flow through living and nonliving components of the ecosystem
 - Living = **biotic**
 - Non-living = **abiotic**
- Cycles are important
 - Allows ecosystem to sustain characteristic life forms through recycling of elements
 - Carbon and nitrogen cycle important in the recycling of environmental components

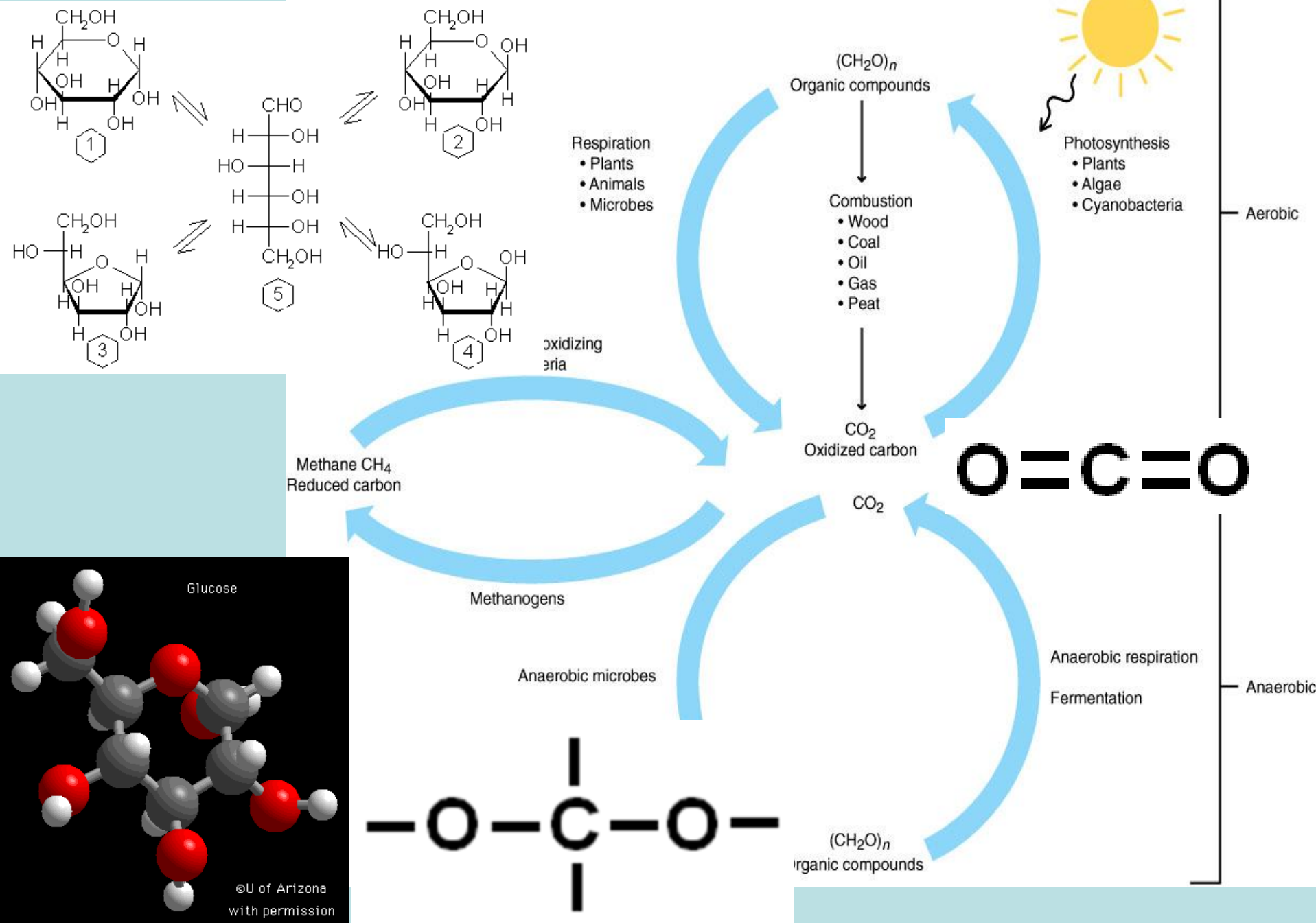


Microbial Ecology:

produce energy
use energy

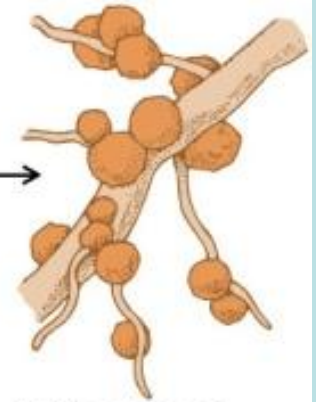
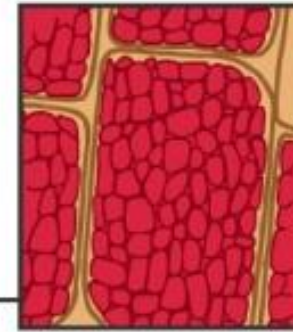
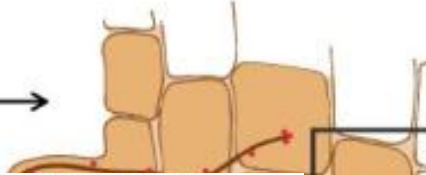
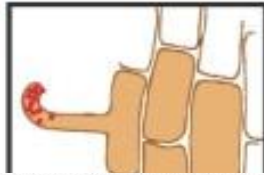
deliver elements to
keep cycling

Carbon cycle: Energy Flow



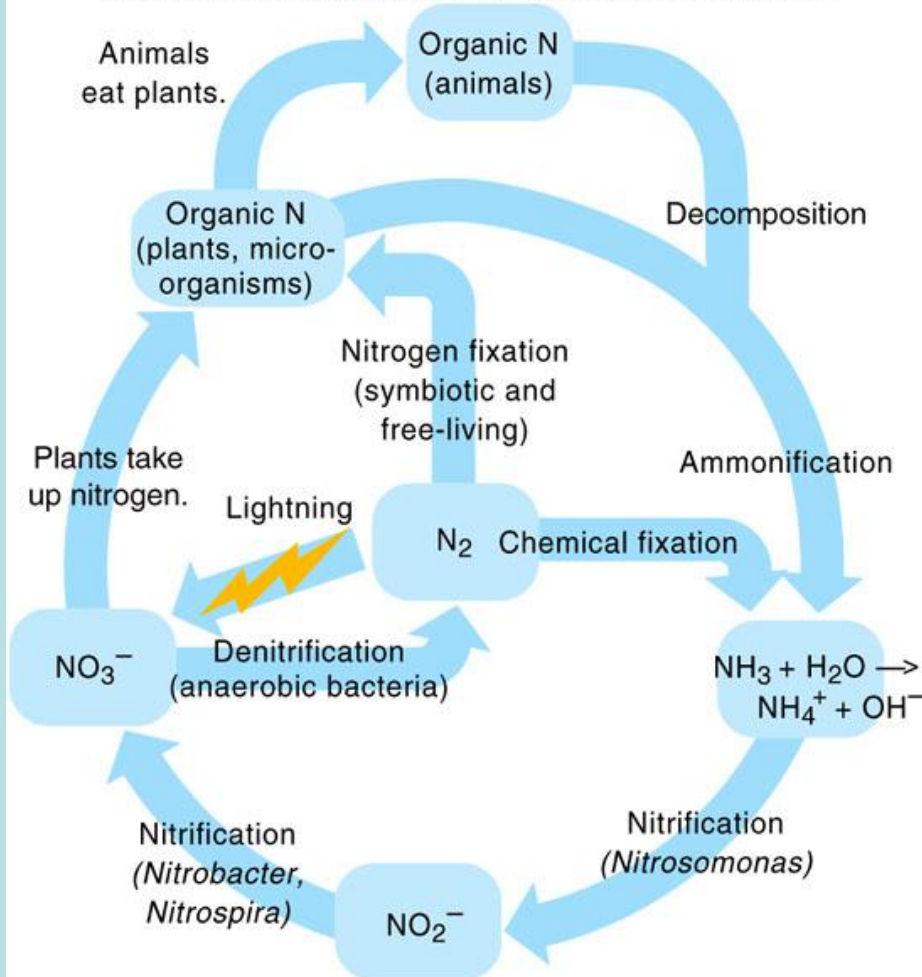


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Rhizobium cells develop into bacteroids, which pack the enlarged plant cells.

Nodule consists of enlarged plant cells packed with bacteroids.



b)

Food microbiology: a special ecosystem

Fermented food: food that have been intentionally altered during production by carefully controlling the activity of bacteria, yeast, or mold.

Virus?

Food preservation: increasing the shelf life of foods by preventing the growth and concurrent metabolic activities of microorganisms.

Food spoilage: biochemical changes in foods that are perceived as undesirable.

Foodborne infection: illness that results from consuming microbes in a food product; ingested microbes colonize the host and cause disease

Foodborne intoxication: illness that results from the consumption of an exotoxin produced by a microorganism growing in a food product

Water activity (a_w): the relative amount of water available; pure water is 1.0.

- Cheese production

- Cottage cheese easiest cheese to make

- Pasteurized milk inoculated with starter culture
 - Culture causes milk proteins to coagulate
 - » Coagulated proteins called curd
 - Curd heated and cut into small pieces to facilitate drainage of liquid waste
 - Waste termed whey



P. shermanii , bacteria



- Curds salted after whey is separated and pressed and ripened to encourage changes in texture and flavor

- Ripening can take weeks to years
 - Longer ripening produces more acidic sharper cheese
 - Certain organisms produce certain characteristics
 - » *Propionibacterium shermanii* → Swiss cheese
 - » *Penicillium roquefortii* → Roquefort, and gorgonzola



P. roquefortii , fungus



- Yogurt

- Pasteurized milk is concentrated slightly then inoculated with starter culture
- Mixture is incubated for several hours at 40° C - 45° C for several hours
 - Thermophilic bacteria grow rapidly at higher temperatures
 - Produce lactic acid and other end products
 - » Contribute to flavor
- Controlled incubation ensures proper levels of acid and flavor compounds



Lactobacillus Acidophilus



Streptococcus thermophilus

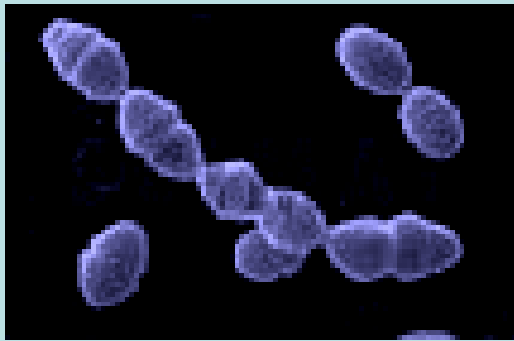
- **Pickled vegetables**

- Pickling originated as way to preserve vegetables

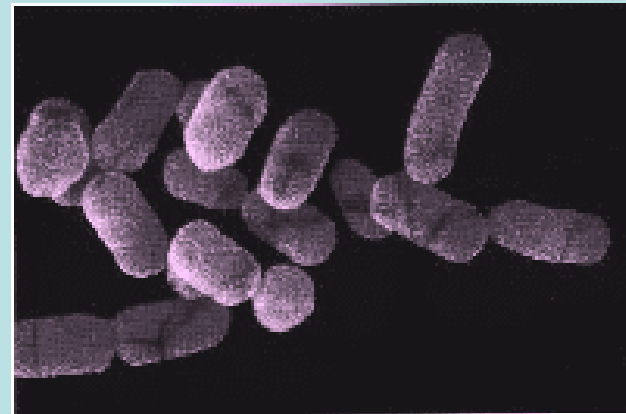
- Particularly cucumbers and cabbage

- **Pickling** uses naturally occurring lactic acid bacteria residing on vegetables

- Unlike fermentation of milk products which relies on starter culture

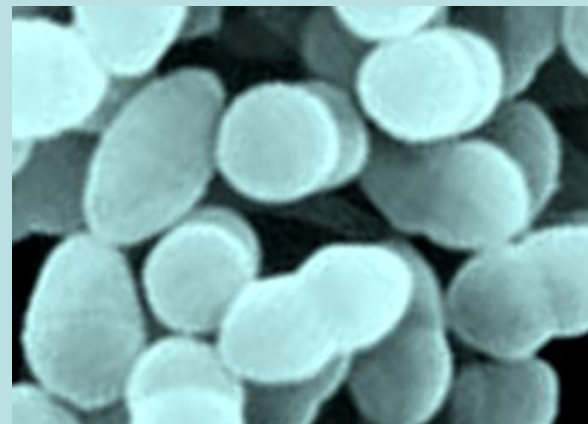


Leuconostoc mesenteroides,
active in lower temperature,
produce acids, alcohol, and aroma compounds

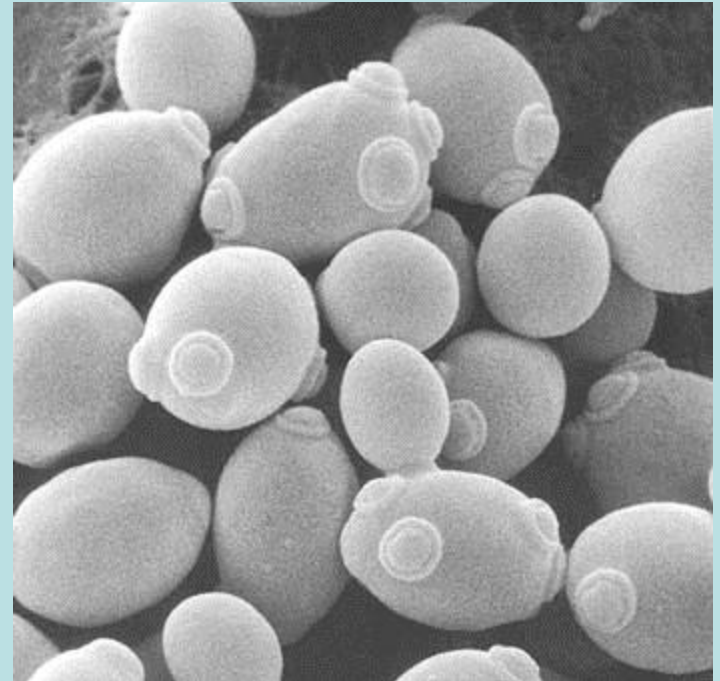


Lactobacillus plantarum,
active in higher temperature,
produce lactic acids

- Fermented meat products
 - Traditionally were produced by letting small numbers of lactic acid bacteria to multiply to dominance
 - Natural fermentation of meat inherently risky
 - Incubation that initiates fermentation can support growth and toxin production of pathogens
 - » *Clostridium botulinum* and *Staphylococcus aureus*



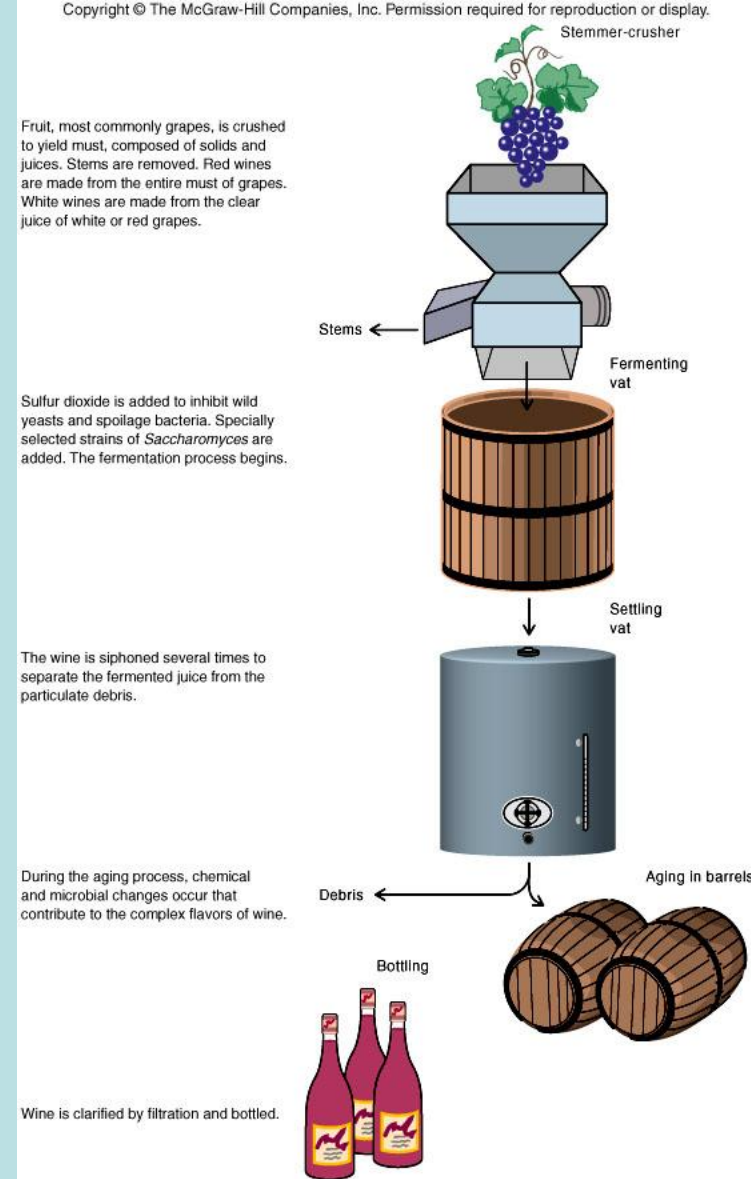
- Alcoholic fermentations by yeast
 - Some yeasts ferment sugars to produce ethanol and carbon dioxide
 - Yeasts are used to make variety of alcoholic beverages as well as vinegar and bread
 - Alcoholic beverages include
 - Wine
 - Beer
 - Distilled spirits



Microorganisms in Food and Beverage Production

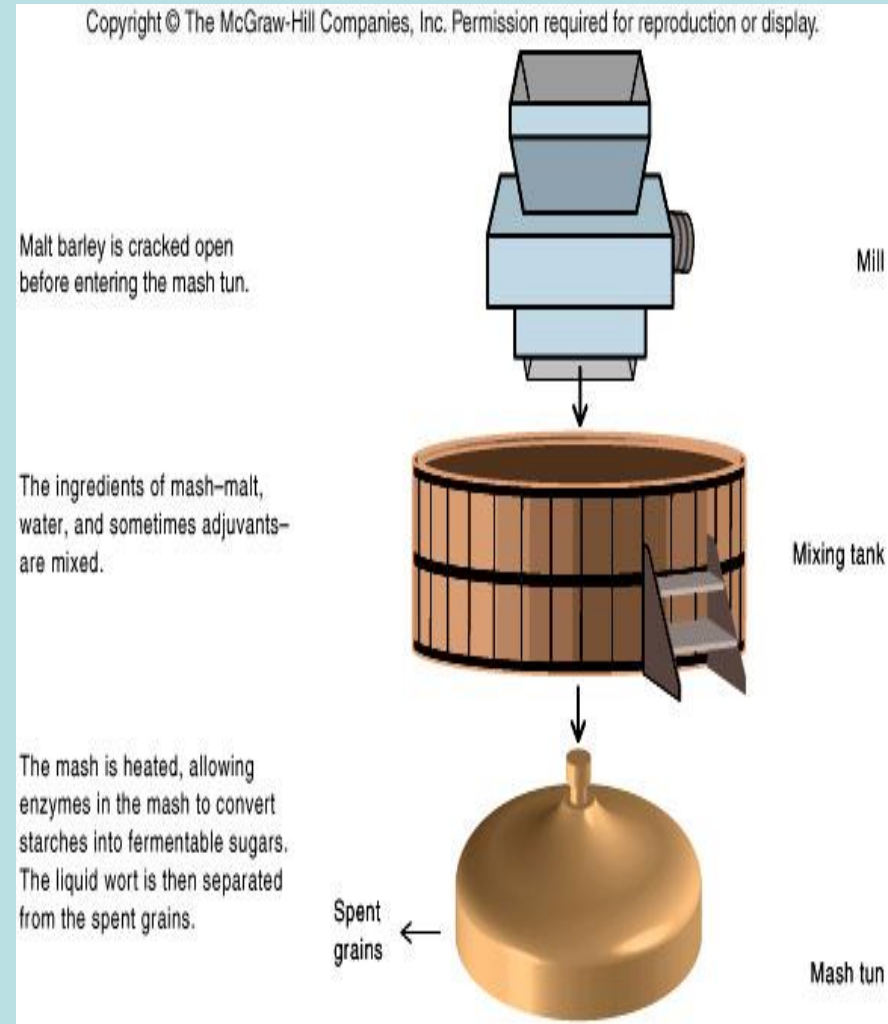
Wine

- Fermentation must be carefully controlled to ensure proper reactions
- Sulfur dioxide is added to inhibit growth of natural microbial population
 - These convert alcohol to acetic acid (vinegar) and most responsible for spoilage
- Fermentation process is initiated by addition of selected strains of yeast
- At completion of fermentation wine siphoned several times to separate juice from sediment
- Wines then aged in oak barrels
- Wine is filtered for clarification then bottled



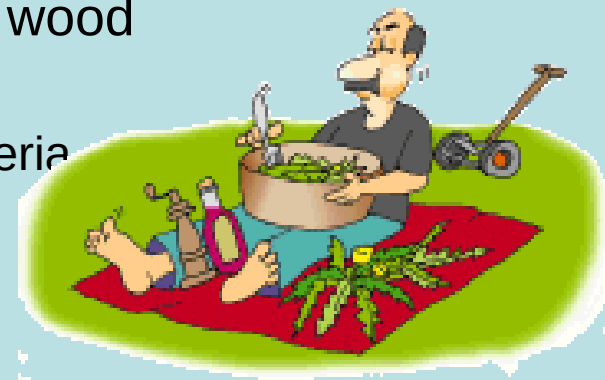
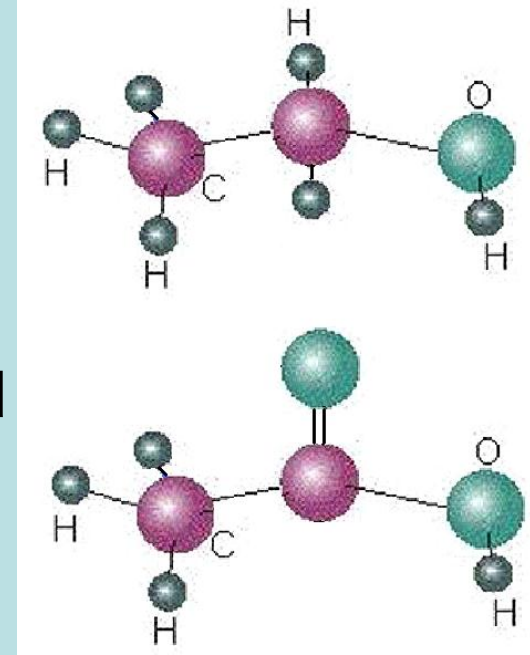
Microorganisms in Food and Beverage Production

- Beer
 - Production of beer is multistep process
 - Designed to breakdown starches in grain to produce simple sugars
 - Sugars are fermented
 - Yeast lack enzymes to convert grains to alcohol
 - Malted barley (malt) contains enzymes
 - Malt and starch, sugars and other adjuncts soaked in warm water
 - Termed mashing
 - Enzymes in malt act on starches converting to fermentable starches
 - Spent grains removed
 - Remaining liquid called wort



Microorganisms in Food and Beverage Production

- Vinegar
 - Aqueous solution of at least 4% acetic acid
 - Product of oxidation of ethanol
 - Strictly aerobic process
 - Fermenting bacteria are obligate aerobes
 - Organisms can tolerate high concentration of acid
 - Vinegar generator produces available oxygen to hasten oxidation
 - Sprays alcohol on biofilm of acid bacteria on wood chips
 - Alcohol trickles down and is oxidized by bacteria



Microorganisms in Food and Beverage Production

- Bread
 - Bread rises due to carbon dioxide produced through fermentation of sugars by baker's yeast
 - Any alcohol produced evaporates during baking
 - Characteristic flavor of sour dough bread due to the addition of lactic acid bacteria to bread making ingredients

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Ingredients (mix)



Ingredients of bread include yeast, milk or water, oil, flour, salt, and sugar.



Rise



Note the holes caused by the production of CO_2 and the evaporation of ethanol in the finished loaf of bread.

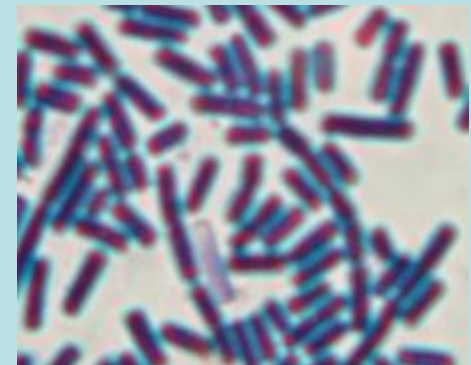
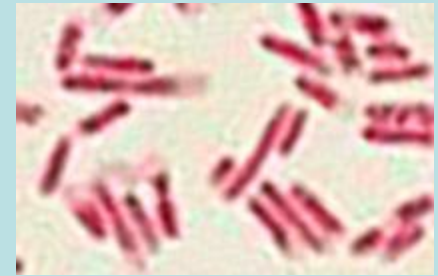
Food Spoilage

- Food **spoilage** encompasses any undesirable change in food
 - Spoiled food is generally not harmful
- Spoiled food considered unsafe because high numbers of spoilage organisms indicate foodborne pathogen may be present



Food Spoilage

- Common spoilage bacteria
 - Wide range of bacteria important in food spoilage
 - *Pseudomonas* can metabolize a wide variety of compounds
 - Psychrophilic organisms can multiply in refrigerator
 - Most common genera include
 - *Erwinia*
 - *Acetobacter*
 - *Alcaligenes*
 - Endospore forming organisms can survive cooking and in some cases canning processes
 - Prevalent spore formers include
 - *Clostridium* species
 - *Bacillus* species

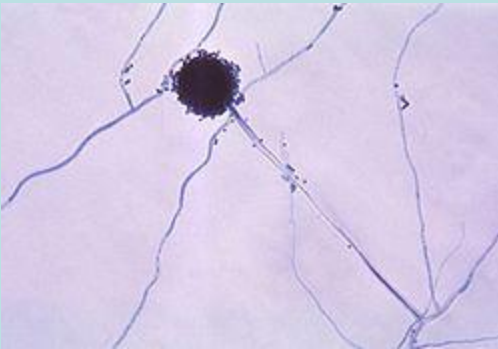
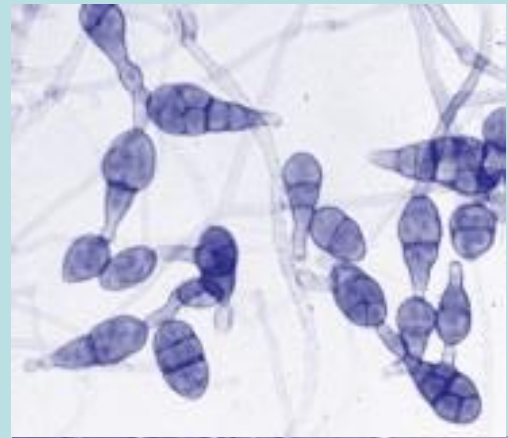
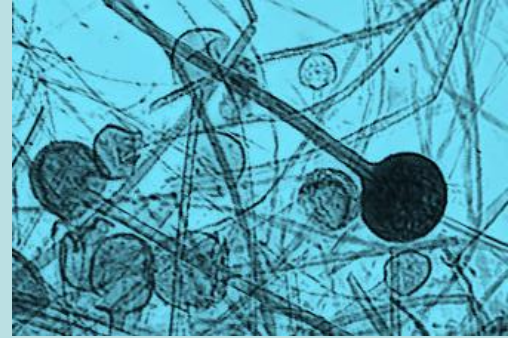


Q: How long can the cold virus live after expelled from the human body?

- A) few seconds
- B) 2 days
- C) from a few seconds to 2 days
- D) more than one week

Food Spoilage

- Common spoilage fungi
 - Wide variety of fungi spoil foods
 - Some of the most common include
 - *Rhizopus*
 - *Alternaria*
 - *Penicillium*
 - *Aspergillus*
 - *botrytis*
 - Fungi grow readily in acidic low-moisture environments



Foodborne Illness

- Commonly referred to as food poisoning
 - Occurs when a pathogen or its toxin is consumed
 - Consumers must employ sound preserving, preparation and cooking techniques to avoid hazards of food products
 - Estimated millions of cases of food poisoning occur each year
 - Vast majority could have been prevented

Foodborne Illness

- Food **intoxication**
 - Illness resulting from consumption of an exotoxin produced by organisms growing in food product
 - When food is ingested it is the toxin responsible for illness not organism
 - Common causes of foodborne intoxication are
 - *Staphylococcus aureus*
 - *Clostridium botulinum*

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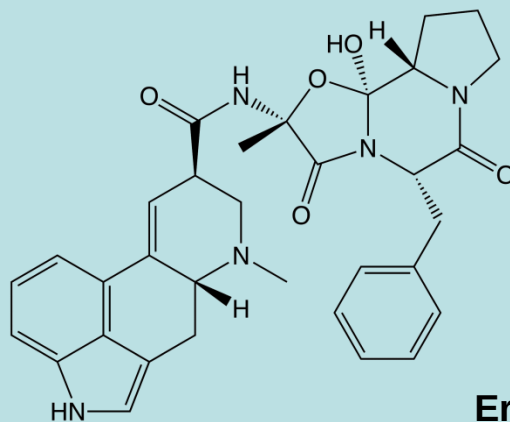


Foodborne Illness

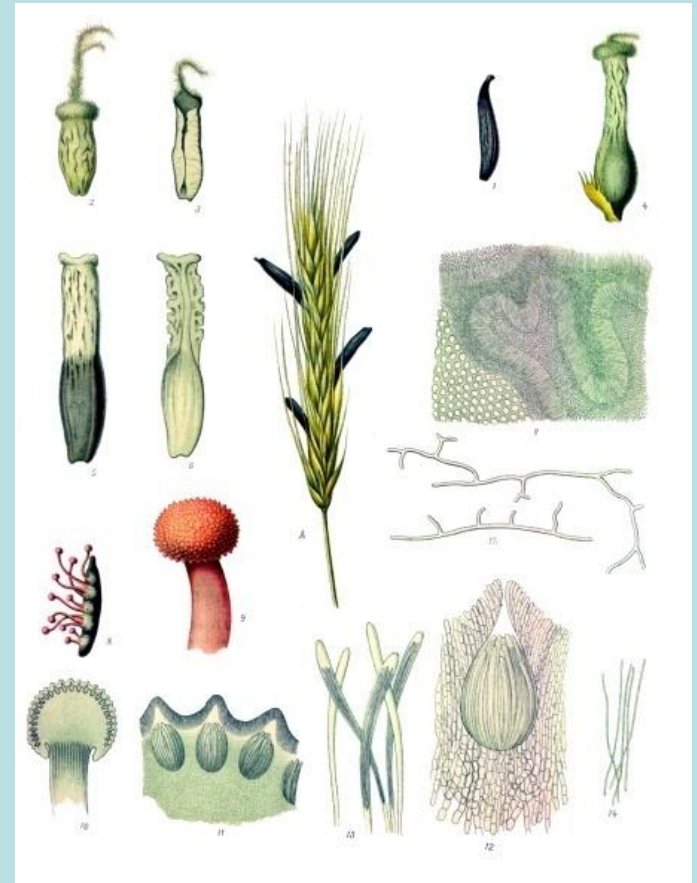
- Staphylococcus aureus
 - Produces toxin that causes nausea and vomiting
 - Thrives in moist, rich foods in which other organisms have been killed or inhibited
 - Survives well in unrefrigerated foods with high salt content
 - Source of *S. aureus* generally human carrier
 - Organism is inoculated into food during preparation
 - Food left at room temperature allows organism to grow and produce toxin
 - Toxin is heat stable and not inactivated by cooking

Q: 2. Ergot poisoning may occur in improperly stored:

- a) meats.
- b) fruits.
- c) grain.
- d) vegetables



Ergotamine



Foodborne Illness

- Botulism
 - Paralytic disease caused by ingestion of a neurotoxin
 - Produced by *Clostridium botulinum*
 - Growth of organism or production of toxin may not result in changes in taste or appearance of food
 - Canning process designed to destroy endospores
 - Processing errors can allow germination of endospores
 - Errors extremely rare in commercial canning
 - Home canned foods should be boiled for 10 to 15 minutes immediately before consumption
 - Heat destroys toxin

Foodborne Infection

- Foodborne infection requires consumption of living organisms
- Symptoms do not appear for at least one day after ingestion
 - Major symptom usually diarrhea
 - Thorough cooking of food immediately before consumption will kill organisms
 - Prevent infection
 - Foodborne illness commonly caused by
 - *Salmonella*
 - *Campylobacter*
 - *Escherichia coli* O157:H7

Foodborne Infection

- *Salmonella* and *Campylobacter*
 - Commonly associated with poultry products
 - Inadequate cooking can result in foodborne infection
 - Cross-contamination can result in transfer of pathogens to other foods
 - Cutting boards and knives often become contaminated



Foodborne Infection

- *Escherichia coli* O157:H7
 - Causes bloody diarrhea
 - Sometimes develops into hemolytic uremic syndrome (HUS)
 - Life threatening
 - *E. coli* O157:H7 responsible for several large food poisoning outbreaks
 - Ground meats are troublesome source of foodborne infection
 - ground meat should be cooked thoroughly through

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Factors Influencing Growth of Microorganisms in Food

- Intrinsic factors
 - Water availability
 - Most bacteria require a_w of above 0.9
 - Most fungi require a_w of above 0.80
 - pH
 - Nutrients
 - Biological barriers
 - Rinds, shells and other outer coverings help protect foods from microbial invasion
 - Antimicrobial chemicals
 - Some foods contain natural antimicrobial chemicals that inhibit growth of organisms responsible for spoilage
- Extrinsic factors
 - Extent of microbial growth largely dependent on storage of food
 - Microbes multiply rapidly in warm, oxygen-rich environments
 - Extrinsic factors include
 - Storage temperature
 - Atmosphere

Food Preservation

- Preventing growth and metabolic activities of organisms that cause spoilage and foodborne illness preserves food quality
- Preservation methods include
 - Canning
 - Pasteurization
 - Cooking
 - Refrigeration
 - Freezing
 - drying,/reducing water availability

Food Preservation

- Canning
 - Destroys all spoilage and pathogenic organisms
 - Low acid foods use steam under pressure to destroy endospores
 - Acidic food methods not as stringent
 - Spore forming bacteria can't grow or produce toxin in high acid environment
- Pasteurization
 - Heating foods under controlled conditions at high temperatures for short periods
 - Reduces number of spoilage organisms
 - Does not alter taste of food significantly

Food Preservation

- Cooking
 - Can destroy non-spore forming organisms
 - Alters characteristics of food
 - If heat is uneven some organisms may survive in undercooked portion of food
- Refrigeration
 - Preserves food by slowing growth rate of spoilage organisms
 - Many organisms unable to multiply in low temperatures

Food Preservation

- Freezing
 - Stops microbial growth
 - Water unavailable due to ice formation
 - Portion of organisms remaining can grow when food is thawed
- Drying/reducing water availability
 - Inhibits microbial growth by decreasing available moisture
 - Molds may grow eventually

Review: antimicrobial

- What's microbial ecology?

Producer

Consumer

Decomposer

- How do the microbes contribute to food production?

Direct/fermentation

- How to preserve food and avoid food-borne illness?

promote/inhibit microbial growth