**Final Exam Study Guide**

**Rhizosphere**

* *Def*: a region around the plant root where materials released from the root increase the microbial population and its activities.
	+ Plants have roots with epithelia that absorbs nutrients from the environment
	+ The area of the soil under influence of root where plants with other microbes
	+ Roots exude soluble organic compounds such as sugars, amino acids and mucalose
		- Stimulates many soil organisms that grow quickly on these grow quickly on solubles

**Carbon sequestration**

* *Def*: natural process by which carbon dioxide is removed from the atmosphere and help in solid or liquid form. For our purposes, microbes in the soil do this on a large scale.
	+ Transferringcarbon to soil through crop residues and other organic solids
	+ Some is released as CO2
	+ There is already a lot more organic matter in soil than in atmosphere

**Nitrogen mineralization**

* *Def*: the release of nutrients from organic molecules that are needed for plant uptake and growth (nitrogen in this case).
	+ Nutrient recycling – organic nutrients to mineral nutrients like ammonium and sulfate
	+ Can be aerobic or anaerobic
	+ These nutrients are needed by plants for their growth
	+ Organisms secrete
	+ Can be done by bacteria and saprotrophic protists and mycorrhizal fungi

**Nitrogen fixation**

* *Def*: The metabolic process in which atmospheric molecular nitrogen (N2) is reduced to ammonia; carried out by cyanobacteria, rhizobium, methanogens, and other nitrogen fixing bacteria.
	+ *Rhizobium* is a model organism for bacterial mutualism with plants (leguminous) because it provides a majority of nitrogen to all ecosystems and all of life for that matter.
		- Must do its nitrogen fixation from within the host cell; it gets sugar from plants
	+ Nitrogen in the air is stable so it is hard to pull out of the atmosphere, but nitrogen is needed to incorporate into amino acids
	+ We didn’t have another source of providing nitrogen for a while, so these mutualisms were very important.
		- Now its about half natural, half synthetically made via fertilizers etc.
	+ Occurs in symbiosome in root nodule
	+ In cyanobacteria, takes place in heterocyst where there is little oxygen diffusion (photosystem II turned off)
	+ Cannot be done by mycorrhizal fungi

**Nitrogenase**

* *Def*: The enzyme that catalyzes biological nitrogen fixation
	+ Breaks dinitrogen bond
	+ Nitrogenase is destroyed by O2 (must be protected, see below)

**Root nodule**

* *Def*: gall-like structure that contain endosymbiotic nitrogen fixing bacteria
	+ Protects nitrogenase from O2 in leghemoglobin
	+ If this did not exist, Nitrogenase would be destroyed and nitrogen fixation could not occur

**Eutrophication**

* *Def*: the enrichment of an aquatic environment with nutrients
	+ Usually caused by agricultural runoff of nutrients in soil. Can also occur from septic systems near lakes and point source runoffs from large cities.
	+ It can cause excess growth of cyanobacteria and other protists.
	+ Algae blooms can result in a lack of oxygen in the water body
		- Blooms prevent sunlight from reaching other plants, so they die and oxygen will be depleted when decomposers use up the remaining oxygen.
	+ Toxins can be produced
	+ Some species that grow can be toxic – e.g. microcystis (a cyanobacteria) in Lake Eire led to the Toledo water crisis.

**Phycobilliproteins**

* *Def*: photosynthetic pigments found in membranes of cyanobacteria that are composed of proteins with attached tetrapyrroles.
	+ Accessory pigments that absorb photons and feed them into the photo centers.
	+ One way of getting maximized energy from photons from sun.
	+ These pigments aggregate in phycobilisomes on internal thylakoid membranes.

**Photosystem I**

* *Def*: the photosystem in eukaryotic cells and cyanobacteria that absorbs longer wavelength light, usually greater than about 680 nm, and transfers the energy to chlorophyll P700 during photosynthesis; it is involved in both cyclic and noncyclic photophosphorylation.
	+ Electron from photosystem I goes through electron carriers then goes immediately to the cytochrome then back to the photosystem.
	+ Does not create NADPH, but does produce hydrogen ion gradient. This creates electron transport chain, PMF, and ATP production.
	+ Electron is reused over and over again – cyclic.

**Photosystem II**

* *Def*: the photosystem in eukaryotic cells and cyanobacteria that absorbs shorter wavelength light, usually less that 680nm, and transfers the energy to chlorophyll P680 during photosynthesis. It participates in noncyclic photophosphorylation
	+ Non cyclic
	+ Generates O2
	+ Creates NADPH (both photosystems must be used).
	+ Unfavorable reaction because water becomes O2 and H, but O2 is best as an electron acceptor forming water.

**Thylakoid membranes**

* *Def*: a flattened sac in the chloroplast stroma that contains photosynthetic pigments and the photosynthetic electron transport chain. Similar structures are observed in the cytoplasm of cyanobacteria.
	+ Houses phycbillisomes and other pigments.
	+ Light energy is captured by antennas – complexes of linked chlorophyll and other pigments
		- Light energy gets into auxiliary pigment or chlorophyll and is transferred between molecules until we get to a reaction center; electrons get excited allowing hydrogen gradients to build across a membrane, some cases you have an electron acceptor.

**Rubisco (Ribulose-1,5-bisphosphate carboxylase/oxygenase)**

* *Def*: the enzyme that catalyzes incorporation of CO2 in the Calvin cycle
	+ Most abundant enzyme on earth because of carbon fixation.

**Carboxysome**

* *Def*: polyhedral inclusions that contain the CO2-fixation enzyme rubisco and are a site where CO2 fixation takes place. They are considered to be a type of microcompartment.
	+ inside the cell, pockets or clusters of rubisco that are stored inside cyanobacteria
	+ has a specific quality that allows CO2 in, but does not allow for it to get out so the calvin cycle occurs inside

**Akinete**

* *Def*: specialized, nonmotile, dormant, thick-walled resting cells formed by some cyanobacteria.
	+ Dormant, tick walled resting cell used for spreading purposes
	+ Similar to spores in actinobacteria, endospores in firmicutes, or reticulate bodies in chlamydia.

**Heterocyst**

* *Def*: specialized cell of cyanobacteria that are the sites of nitrogen fixation.
	+ Occurs in *rhizobia*
	+ Photosystem II turned off so that O2 is not allowed in – it would degrade nitrogenase.
	+ Uses cyclic phosphorylation – photosystem I

**Reverse electron flow**

* *Def*: an energy-consuming process used by some chemolithotrophs and phototrophs to generate reducing power.
	+ NADH is produced by reverse electron flow
	+ \*\*\*CHEMOAUTOLITHOTROPHS – have to do this because no sunlight is there like in autolithotrophs. Use same electron and energy source, but everything sucks. Nothing is energetically favorable for them. Can make energy fine, but have to spend energy for carbon fixation
	+ case study: nitrobacter and nitrosomonas (nitrification) acidolithobacillus

**Chitin**

* *Def*: a tough, resistant, nitrogen containing polysaccharide found in the walls of certain fungi, the insects of arthropods, and the epidermal cuticle of other surface structures of other protists and animals.
	+ Cell walls of fungi
	+ Polymer of NAG (one part of peptidoglycan) is used for chitin synthesis
	+ Antifungals often target chitin synthesis
	+ Plant immune systems produce chitinase to attack parasitic fungi cell walls

**Yeast**

* *Def*: a unicellular, uninuclear fungus that reproduces either asexually by budding or fission, or sexually through spore formation
	+ Single celled, grow and reproduce via budding – asymmetric compared to
	+ Anaerobic yeast makes wine
	+ Yeast grows in the body, for example *Histoplasma capsulatum* will do YM shift to mycelium in soil.
	+ Candida typically exists as a yeast, but also can be multicellular in the body.

**Hyphae**

* *Def*: the unit of structure of most fungi and some bacteria; a tubular filament.
	+ Growing by long tubes and chains, multicellular, do not break up naturally on their own
	+ Connected by crosswalls which will be described below

**Mycelium**

* *Def*: a mass of branching hyphae found in fungi and some bacteria
	+ Complexes of hyphae from mycelia

**Dikaryotic**

* *Def*: in fungi, having pairs of nuclei within cells or compartments. Each cell contains two separate haploid nuclei, one from each parent.

**Monokaryotic**

* *Def*: in fungi, a single nucleus within cells or compartments.

**Septate**

* *Def*: divided by a septum or cross wall; also with more or less regular occurring cross walls.

**Coenocytic**

* *Def*: refers to a multinucleated cell or hypha formed by repeated nuclear divisions not accompanied by cell divisions
	+ Strange arrangement, also in hyphae form but do not have septa. So, there is big blob of cytoplasm with multiple nuclei. Not separated into discrete cells.

**Ascospores**

* *Def*: a spore contained or produced in an ascus.
	+ Fungi in phylum Ascomycota produce these
	+ Usually exposed on the surface of fruiting bodies such as morels
	+ Result in highest occurrence of human fungal disease.
	+ Grow a little more rapidly on simple substrates

**Basidiospores**

* *Def*: a spore borne on the outside of a basidium following karyogamy and meiosis
	+ Under the classic mushroom shaped cap
	+ Reside in gills
	+ Can grow on more complex substrates

**Saprotrophic**

* *Def*: an organism that takes up nonliving organic nutrients in dissolved form and usually grows on decomposing organic matter.
	+ Free living scavengers
	+ Decompose dead material for mineralization of nutrients, symbionts; adaptations include
		- Colonize through spores, penetrate tissues with hyphae
		- Nutrient transport to balance conditions
		- Have extracelluar enzyme capacities
		- Produce antibiotics

**Mycorrhizae**

* *Def*: fungi that form stable mutualistic relationships on or in the roots of vascular plants
	+ Present in almost every species of plant (80%) – needed certain types of tree growth
	+ Can be different types
	+ Provide nutrients to the soil. Exchange C for nutrients. mineralizes, soil stability, protection from pathogens, water uptake, metal resistance
	+ Require 20% of the carbon that is normally fixed by plants – costs the plants a lot!
		- Can lead to both yields and declines – specifically declines in some agricultural farming by excess nutrients in the soil.
	+ Start symbiosis, then extend out much further into the soil
	+ Are found as fossils in first land plants

**Ectomycorrhizal**

* *Def*: A mutualistic association between fungi and plant roots in which the fungus surrounds the root tip with a sheath.
	+ Phyla Ascomycota and basidiomycota
	+ Formed by temperate trees
	+ Many fruiting bodies in forests – can be attached to root systems underneath them
	+ Sheathed – colonize mostly in the cell wall and change morphology of roots
	+ Can be sexual or asexual

**Endomycorrhizal**

* *Def*: referring to a mutualistic association of fungi and plant roots in which the fungus penetrates into the root cells.
	+ Most plants do this
	+ Widespread and ancient

**Arbucular mycorrhizal**

* *Def*: the mycorrhizal fungi in a fungus-root association that penetrate the outer layer of the root, grow intracellularly, and form characteristic much-branched hyphal structures call arbuscules.
	+ Type of endomycorrhizal
	+ In phylum glomeromycota
	+ Asexual spores only – no fusion of nuclei
	+ Ex *Gigaspora margarita*
	+ Majority of plants do this, including first land plant colonizers
	+ Also very important in the tropics

**Orchid and Monotropoid Mycorrhizae**

* + Plant obtains C from fungus
	+ Fungus often obtains C from other plants or saprotrophically
	+ This is actually a parasitism, where the plant is the parasite; parasitizes ectomycorrhizae of other trees.
	+ Indian pipe (*monotropa uniflora*)

**Yeast-mycelium (YM) shift**

* *Def*: the change in shape of a dimorphic fungi when they shirt from the yeast form in the animal body to the mold or mycelial form in the environment.
	+ Allows for human disease
	+ Fungus grows as hyphae in soil (usually on dead material and bird poop)
	+ Colonize asexually or sexually through spores
	+ Once breathed in, they turn into yeast to grow inside the body
	+ Some basidomycota do this, but no specific examples we need to know about

**Tinea**

* *Def*: A name applied to many different kinds of superficial fungal infections of the skin, nails, and hair, the specific type (depending on the characteristic appearance, etiologic agent, and site) usually designated by a modifying term
	+ Skin infections caused by fungi known as dermatophytes
	+ Ex is trichophyton
	+ These then grow on the surface of human skin or right under skin (dermal layer)
	+ Tinea corporis is a more typical type of the infection. Ringworm, capitis, pedis.
	+ Usually contance

**Dermatophyte**

* *Def*: a parasitic fungus of the skin
	+ Refer to above about tinea

**Biotroph**

* *Def*: plant pathogens
	+ Parasitize living cells and reside withtin them
	+ Immune system will work to fight these off, but may perform hypersensitive response as result

**Necrotroph**

* *Def*: a parasitic fungus that kill the living cells of its host and then feeds on the dead matter
	+ Kill cells and live saprotrophically
	+ Plants will not use hypersensitive response as a defense against these types of fungi

**Lignification**

* *Def*: a response to plant fungal infection that increases physical barriers “the process of turning to wood.”
	+ A plant’s response to increase physical barriers when infected
	+ Fungi does not grow on lignin effectively
	+ Hardens cell wall
	+ May stop the necrotroph from growing as quickly on the plant

**Suberization**

* *Def*: a response to plant fungal infection that increases physical barriers
	+ Like lignification, parasitic fungi do not grow well on this

**Chitinase**

* *Def*: a compound released by plant immune response that attacks the cell wall of fungus
	+ Antimicrobial protein secretion that attacks the cell wall of parasitic fungi

**Hypersensitive response**

* *Def*: a plant immune system response that induces programmed cell death
	+ Will not use this response against necrotrophs
	+ Only used in response to biotrophic parasites

**Aflatoxicosis**

* *Def*: a poisoning that results from ingestions of aflatoxins in contaminated fod or feed. Aflatoxins are a group of structurally related toxic compounds produced by certain strains of the fungi aspergillus flavus and aspergillus parasiticus that can cause cancer and other disease.

**Ergotism**

* *Def*: a condition caused by the dried sclerotium of *Claviceps purpurea*. It parasitizes rye and releases ergot alkaloids which causes ergotsim.
	+ Symptoms include hallucinations, mania, convulsions, death.
	+ Severe vasoconstriction causes gangrene
	+ Has caused odd behavior in humans and is thought to be responsible for events such as the Salem witch trials and the French revolution due to the fungus contaminating the food supply.

**Vesicle**

* *Def*: a membrane bound sac used for transport in eukaryotes
	+ In some cases, such as Anabaea, gas vesicles regulate buoyancy.
	+ This controls how deep certain bacteria are in the water
	+ Something in endomycorrhizal fungi too??
	+ Formed by arbuscular fungi
	+ High lipid storage structure (energy)

**Arbuscule**

* *Def*: form when hyphae invade plant roots.
	+ Inside of cells
	+ inverted tree structure
	+ carbon and nutrient exchange

**Hartig net**

* *Def*: the area of nutrient exchange between ectomycorrhizal fungal hyphae and plant host cells.
	+ Specific to ectomycorrhizae
	+ Grow in between the plant cells
	+ Nutrient exchange

**Protists**

* *Def*: unicellular and sometimes colonial eukaryotic organisms that lack cellular differentiation into tissues. Many chemoorganotrophic protists are referred to as protozoa. Many phototrophic protists referred to as algae.
	+ Eukaryotic and mostly unicellular, but some are multicellular
	+ Also characterized by being not plants, animals, or fungi.

**Protozoa**

* *Def*: a common term for a group of unrelated unicellular, chemoorganotrophic protist
	+ Usually motile unicellular
	+ Some have complex multicellular stages
	+ Most don’t interact with humans
	+ Many perform mineralization – most important role

**Algae**

* *Def*: a common term for several unrelated groups of photosynthetic eukaryotic microorganisms lacking multicellular sex organs and conducting vessels. Most are now considered protists.
	+ Photosynthetic eukaryotes lacking multicellular reproductive structures
	+ includes brown algae or kelps and diatoms

**Cysts**

* *Def*: a general term used for a specialized microbial cell enclosed in a wall. Cysts are formed by protists and a few bacteria. They may be dormant, resistant structures formed in response to adverse conditions or reproductive cysts that are a normal stage in that life cycle.
	+ Dormant stage with resistant cell wall
	+ Resistant to toxins and heat
	+ May be involved in cell division, but usually wait for better conditions to be more favorable in which they will undergo excystment
	+ Amembic dysentery spread like this
	+ Enantomoeba grow these

**Trophozoites**

* *Def*: the active, motile feeding stage of a protozoan organism; in the malarial parasite the stage of schizogony betwee the ring stage and the schizont.
	+ active cells that have emerged from excystment
	+ in dysentery, trophozoites attach tightly to epithelial cells in the small intestine

**Viruses**

* + no activity outside of host cells
	+ They regulate population size, perform genetic recombination, recycle nutrients and organic carbon
	+ Infect everything, can be pathogenic
	+ Can have single strand coding and non coding RNA, Double stranded RNA, retroviruses or double strand DNA
	+ Reproduction include:
		- Adsorption – mediated by surfaces proteins; receptors, spikes, capsids, etc.
			* Infuenza uses hemagglutinin to bind sialic acid
		- Penetration and uncoating – endosomes may release the virion into cytoplasm or extrude the DNA only into cytoplasm
		- Genome replication and expression
			* DNA- use host DNA and RNA polymerase, may also code for viral polymerase
			* RNA- Use RNA dependent RNA pol and RNA dependent DNA pol (reverse transcriptase) for retroviruses; bring them with them or bring genes with them
				+ Have to overcome additional challenge in copying itself because all host RNA pol are only transcribed from DNA
		- Assembly of virions
			* Assemble themselves within the cell
		- Virion release
			* Can be delayed and may or may not destroy host cell
				+ If delayed, it is called latent
				+ Can insert in genome to make cell malignant (cancer)
	+ Antigenic drift – accumulation of mutations
	+ Antigenic shift – recombination in cells infection by multiple strains (from multiple reservoirs); causes novel strains
		- These are used to try to predict future strains for vaccines – usually new one per flu season.

**Spikes (peplomer)**

* *Def*: a protein or a protein complex that extends from the viral envelope and is often important in virion attachment to the host cell surface.
	+ Pieces of membrane virions pick up on the way out of a host cell

**Receptors**

* *Def*: proteins that bind signaling molecules (ligands), therby initiating cellular responses. Many viruses use host receptors to gain access to the cell.

**Envelope**

* *Def*: In virology, an outer membranous layer that surrounds the nucleocapsid in some viruses
	+ Envelopes are very important in human disease

**Virion**

* *Def*: a complete virus particle; at the simplest, it consists of a protein capsid surrounding a single nucleic acid molecule.

**Reverse transcriptase**

* *Def*: a multifactorial enzyme used by retroviruses and reverse transcribing DNA viruses during their life cycles. It has RNA-dependent DNA polymerase, DNA-dependent DNA polymerase, and RNAase activity. Its function in these viruses is to synthesize double-stranded DNA from single-stranded RNA; this is a reverse of the flow of genetic information in cells, which proceeds from DNA to RNA.
	+ RNA-dependent DNA pol
	+ Retroviruses use this

**Neuraminidase**

* *Def*: an enzyme that cleaves the chemical bond linking neuraminic acids to the sugars present on the surface of animal cells; in virology, one type of envelope spike on influenza viruses has neuraminidase activity and is used to identify different strains.
	+ Used specifically for release in influenza
	+ Trigger immune responses
		- 9 N forms, 2 infect humans
	+ dozens more variations of both H and N
	+ monoclonal antibodies are respsonse

**Hemaglutinin**

* *Def*: one of the envelope spikes of influenza viruses. They are the basis for identifying different influenza virus strains.
	+ Will bind sialic acid to trigger getting into the cells
	+ Trigger immune response
		- 16 H forms, 3 commonly infect humans
	+ monoclonal antibodies are response

**Retrovirus**

* *Def*: A group of viruses with RNA genomes that carry the enzyme reverse transcriptase and form a DNA copy of their genome during their life cycle.
* **For each disease-causing organism (or virus) we discussed, describe route of colonization, disease symptoms, virulence factors, and prevalence in the US and world.**
* **For each commensal organism we discussed, describe normal habitat, activities, potential benefits to us, and potential for the organism to become an opportunistic infection.**
* **For each group on the taxa list, describe features we discussed. (e.g., Gram positive or negative?, unique shape?, obligate symbiont?, special structures?, growth rate and needs?, etc.)**

XI and XII. Environmental bacteria

* In what ways are microorganisms important in regulating global cycles of C and N?

For a long time, microorganisms were the major ways that nitrogen and carbon were fixed by microorganisms. They play major roles in nutrient cycling and there a species involved for about every process you can think. Perform mineralization, decomposition etc.

Nitrogen mineralization – the conversion of nitrogen containing organic molecules to inorganic ions (ex pseudomonas and Streptomyces. Saprotrophs degrade plant litter and release inorganic molecules needed for

Nitrogen fixation – the conversion N2 to incorporate it (full process of denitrification); rhizobium

Nitrification – ammonia to nitrite – nitrobacter, nitrosomonas

Denitrification – nitrate reduction from NO3+to NH4+

Carbon fixation – the fixation of CO2 to organic compounds - prochlorococcus

Photosynthesis – conversion of simple sugars to energy and O2 – cyanobacteria; a special type of carbon fixation

Sulfur Reduction – Reducing SO4 to H2S - acidolithobacillus

Sulfur Oxidation – oxidize H2S to S and or to SO4 (leeching results in very reduced pH in water) acidithiobacillus and chrenarcheota

Methanogenesis – H2 and CO2 to fix carbon and produce methane

Nitrogen is hard to get but everything needs it for amino acids. Highly competitive. If organisms can escape this by N fixation. Less energy given, so usually has to be done in symbiosis to get energy needed

Cyanobacteria – do this too

In summary, all nutrients move through the ecosystem in biogeochemical cycles. This is crucial because inorganic forms of essential molecules such as N2 and CO2 must be converted into usable forms for organisms. Life could not exist if microbes did not perform these cycles continually.

* In what ways could bacteria affect plant health?

Some plants can form symbioses with bacteria. One such example is rhizobium forming root nodules. Here, the bacteria helps the plant by supplying nitrogen that has been recently fixed.

Some bacteria, however, are plant pathogens. One example is agrobacterium which causes plant like tumors to grow on the plants. It does so by injecting DNA into the plant host DNA. We can use this to our advantage to make genetically modified organisms.

Some bacteria such as pseudomonas can be used to control weeds (kill plants) and even kill pests that feed on plants.

* What are different characteristics of bacteria that grow in the rhizosphere versus those that that degrade dead plants?
* These organisms will use molecules around them to from mutualistic relationships with plants. Rather than breaking down complex plant molecules, it will break down other things (nutrient mineralization) and supply vital nutrients to the plant. In return, the plant supplies energy in the form of carbon sugars to the bacteria.
* -Nod genes will be activated in the presence of flavonoids.
* -bacteria that degrade plants grow in networks of hyphae, produce antibiotics, and may produces spores.
* What are some recent discoveries about microbial diversity in the environment?

-We can use soil carbon sequestration to try to manage CO2 pollution

-we need organism to fix nitrogen because for a long time only organisms did this, now, we have a few extra ways.

-there are specific species of bacteria that were once in pseudomonas that have now been reclassified with phlyogenics/sequencing

-streptomyctes are not weird mix of bacteria and fungi – just bacteria

-chemoautolithotrophs oxidize ammonium

Several phyla were discovered in the 1990s, such as *Acidobacteria*, *Verrucomicrobia*, *Chloroflexi*, *Planctomycetes*, and *Gemmatinoadetes*.

* What are four ways that environmental bacteria cause problems that humans need to counteract?
* -plant pathogens
* -toxin producers (eutrophication)
* -greenhouse gas producers
* -food contaminators

Consequences of chemoautotrophy

* Creates mobile forms of N (NO3 - ) and S (SO4 3- )
	+ Important because that nitrate that gets produced is highly mobile while ammonium is sticky
	+ If nitrate doesn’t get taken up and instead leeches out into ground water then it can cause problems
		- Bc…..runs into stream or lake and causes algal blooms
		- Nitrates are carcinogens
		- Nitrate contamination in wells is a major problem esp on farms where nitrate builds up bc of tons of animal manure
		- Nitrate interferes with respiration of people that drink that water
		- Blue baby syndrome is from that
		- The dudes on farm face problems bc soil more and more acidic which is bad for plants
		- Nitrogen wants to get into plans bc bigger fatter veggies but if nitrogen is leaking into water you lose resources for plants
	+ Acid mine drainage etc
* What are four ways in which we use them for our benefit?

-Nitrogen is hard to get but everything needs it for amino acids. Highly competitive. If organisms can escape this by N fixation. Less energy

-prochlorococcus gives us oxygen

-streptomyces = antibiotics and antifungals

-agrobacteria used to genetically modify plants

-some may produce insecticides

* Why are special structures often used by bacteria fixing nitrogen from the atmosphere? What are some of these structures?

Heterocysts – minimizes oxygen diffusion, photosystem II turned off, cyclic phosphorylation; does this because the presence of oxygen breaks down nitrogenase which is the enzyme needed to perform fixation

Root nodules also do this by protecting nitrogenase from O2 by using leghemoglobin

* Oxygenic photosynthesis involves the least energy efficient net chemical reactions carried out by any organisms. What is the net chemical reaction? Describe the special structures and process in cyanobacteria that allow them to be successful performing this process.

6CO2 + 6H2O -> C6H12O6 + 6O2

Also 2H2O -> 4 H+ + O2 + 4e- … deltaG=315 (energetically unfavored)

* CO2 + 4H^+ + 4 e- → CH2O + H2O
	+ Half reaction of carbon fixation

-as other phototrophs, contains photosynthetic pigments

It is least efficient because it uses the worst electron acceptor and worst electron donor. But its okay because they get energy from the sun.

They use rubisco as the enzyme to achieve this and it exists within carboxysomes. It allows CO2 in but not out, allowing for the calvin cycle to take place

Also may have gas vesicles to regulate buoyancy in water

Akinetes are dormant, thick walled resting cells used for spreading

* What are the series of forms of energy that sunlight energy is transformed into inside a cyanobacteria cell?

-It is used to give energy to power photosystems

-Can be used to form hydrogen ion gradient and proton motive force for ATP synthesis (electron transport chain

-produce ATP and NADPH

* What are the inputs and products of photosystems I and II in cyanobacteria? Under what circumstances would they be used?

Different electron carriers for different situations. Light needed for both. Whole thing is energetically unfavorable, so it gets its energy needed for the reaction to progress. Cyanobacteria do this. If this were to reverse, ½ O2+ H2 is pathway used by chemoorganoheterotroph.

Photosystem I – gets electrons from end of photosystem II or cytochrome bf to either recycle through again (cyclic) or makes NADPH. Oxygen is turned off. Needs Photosystem I and vise versa when non cyclic.

Photosystem II – gets electrons from H2O all the way through, NADPH. Oxygen dependent

* For different types of autotrophic organisms, what are energy sources, electron donors, electron acceptors, and other special features?
* Chemoautolithotrophs:
* Energy Source: inorganic molecules
* Carbon Source: CO2
* Electron Source: NH3, NO2-, H2S, S2O32-, H2, Fe2+, Mn+ (depends on what kind of *oxidizers* they are
* Electron Acceptor:

Autolithotrophs:

* Energy Source: sunlight
* Carbon Source: CO2
* Electron Source: Water
* Electron Acceptor: CO2
* Why do some autotrophic organisms require multiple electron acceptors, while others do not?

Under certain conditions, one electron acceptor may be favored over another, specifically during aerobic vs anaerobic respiration. Some may be able to perform both while others may only be able to do a few

????

* Where does reducing power come from in different types of autotrophic organisms? How is this related to growth efficiency?

Either the sun or inorganic molecules.

Chemolitoautotrophs grow very slowly because nitrate is not good at energy production.

XIII. Archaea

* Where are different types of archaea found? In what ways do archaea affect the environment?

Are ubiquitous, both in hospitable and inhospitable environments. In humans, water bodies, soil, plants, hydrothermal vents.

They can produce methane from growth on H2 and acetate. Can oxidize ammonium. Can form symbioses and may be lined to some diseases.

* Why don’t we know much about archaea?

-They are very hard to culture (even though there are some ubiquitous strains) because they grow in extreme environments

-size and shape are similar to bacteria

-small population sizes

* What are biochemical and genetic differences between archaea, bacteria, and eukarya?
* -No peptidoglycan and have unique ether containing phospholipids (chemically variable)
* -no nucleus or membrane bound organelles
* -has pseudomurein
* -alkene fatty acids
* -pentacyclic phospholipids
* -one molecule with two polar head groups
* can make them stable in warmer environments
* -many different metabolisms
* -full or partial TCA but alternate enzymes employed; will protect these like nitrogenase was protected
* -genes similar to both. Transcription, translation, replication similar to eukarotes, metabolism similar to bacteria, circular genome but with histones.
* Methanogens are dependent on what other group of organisms?

They depend on organisms that release short carbon molecules (fermentative bacteria) as a carbon source for methane reduction.

* How do humans interact with methanogens?

-½ of people carry methanogens as commensals in the gut (mathanobrevibacter smithii)

-greenhouse gasses

-may cause disease?

XIV. Fungi

* Describe why all spores produced by fungi are haploid.

They are the reproductive structures (gametes) and gametes are haploid coming out of meiosis

* What is the difference between monokaryotic and haploid?
* Monokaryotic = single nucleus
* Haploid = 1 copy of each chromosome
* Diploid = 2 copies
* Dikaryotic 2 nuclei (n+n) (each nucleus is haploid)
* What was classical fungal taxonomy based on? What is it based on now?

Was defined by morphology of sexual spore formation. Now it is based on phylogenetic/molecular techniques.

* What are some factors that make it more likely that someone will develop a fungal infection?

If there was prior infection/immunocompromized, nosocomially acquired. To where the fungus is endemic

* Fungal species can often produce two types of mycelia that have major differences in the organization of their genomes. How are they related by the fungal life cycle?

Mycelia can be septate or coenocytic . Coenocytic will occur in the dikaryotic phase, usually where as sepate most often occur in either the 2n or n monokaryotic stage.???

* What are differences in symptoms of and effective plant immune responses to necrotrophic and biotrophic fungal pathogens?

Biotrophs parasitize living cells

Necrotrophs kill cells and live saprotrophically

Lignification and suberization is effective against necrotrophs

Hypersensitive response only effective against biotrophs

* How do plant pathogens affect humans?

We are in direct competition with fungi for some of our foods. Example in powerpoint was strawberries. If they contaminate our foods, we might not be able to eat.

The corn smuts can be eaten however (ustilago maydis)

* What are the costs and benefits to plants of forming a mycorrhizal association?

Usually benefits plants by providing/performing: mineralization, soil stability, protection from other pathogens, water uptake, metal resistance, colonizing roots and extending out into the soil in a much more extensive and complete way than the roots can themselves.

Can be flipped and plant can be the parasite, taking carbon from the fungus

Heavy carbon cost – 20% goes to fungi

Can lead to both enhancements and decline in agriculture

If we supply too much nutrients in agriculture, the fungus may just use these and exploit the plant without providing extra nutrients

* How common are mycorrhizal associations in plants? What types of plants form the two major types of mycorrhizae? What types of fungi?

Mycorrhizal associations are extremely common (in almost every plant) and probably helped plants first colonize land.

Arbuscular (asexual) grow inside plant roots and were present in first land plants. Most widespread and most ancient. Very common in crops. Formed by glomeromycota

Ectomycorrhizal (sexual) are formed by Ascomycota and basidiomycota and are found in oak and pine (temperate) trees. Formed by glomeromycota

* How do arbutoid/orchid mycorrhizal fungi change the symbiosis?

Monotropa uniflora does this. Plant parasitizes fungi of other plants to get carbon. Plant is parasite rather than fungus

* Describe characteristics of saprotrophic fungi that can make them good decomposers of complex plant tissue.

-They colonize though spores

-penetrate tissues with hyphae to balance nutrients (get nutrients from around mycelial network)

-nutrient transport to balance conditions across mycelium

-extracellular enzyme capacities for degradation

-antibiotic production

* During decomposition of plant material, why is there change in the fungal species that are present over time?

-Primary degraders like rhizopus and aspergillus colonize rapidly and grow on simple substrates

-Secondary degraders like basidiomycetes come later and degrade wood (cellulose and lignin) with oxidative enzymes ex agaricus

C1-proteins and soluble surgars

C2-cellulose

C3-lignin

XV. Protists

* What are the range of roles that protozoa play in ecosystems?

-saprotrophic free living scavengers

-commensals

-parasites

-predators (phagocytose and eat bacteria)

-\*\*\*provides source of mineraliztion; releases large amount of nutrients from living biomass that is microbial

-make available nutrients and carbon sequestered in bacterial biomass

* How does the slime mold life cycle differ from that of fungi?

-slime molds – no dikaryotic phase, may be multinucleated, no mycelia, amoeboid cells, mobile. Can prey on bacteria or each other. Flagella, aggregation of amoeboid cells to form plasmodium

-fungi – have mycelia, non mobile, no flagella

 -both produce haploid spores

* What are some problems associated with treating protozoan infections in individuals?

-these diseases, like fungi have closely related metabolisms and they are diverse, so they are hard to treat

-refer below to similar explanation

-they also can have complex life cycles that make them hard to target

African sleeping sickness – treatment as bad as disease sometimes

Chagas – varies cell membrane

Asymptomatic sometimes

* What are challenges in the elimination of protozoan diseases? How does this differ between malaria and other diseases?

-they can be asymptomatic; turn latent

-malaria has only one animal reservoir; other protozoans have multiple hosts/reservoirs

-like fungi, protists are more closely related to us so drugs are hard to develop vaccines

* Why have some countries been successful at locally eliminating malaria and other countries have not?

The majority of countries that have eliminated malaria are wealthier countries with a vast healthcare infrastructure. Poorer and less developed countries do not have the knowledge, education, resources, or good enough healthcare structures in place for eradication.

* What are the consequences of these diseases for individuals and society?

-these diseases can hinder development of already underdeveloped countries

-make individuals sick or asymptomatic carriers

-need to be proactive in study

*-Entamoeba histolytica* – common cause of gastroenteritis in children; can cause liver failure

*-Giardia intestinalis* – disease persists, spreading from person to person; severe to

asymptomatic carriers

-Malaria – associated with poverty; kills 1 million people per year

-African Sleeping Sickness – disease is so severe, prevents use of 11 million square miles of

African grazing land

-Chagas’ Disease – causes heart problems, which is often cause of death (COD)

-Leishmaniasis – permanent scaring and disfigurement

XVI. Viruses

* How do viruses affect ecosystems?

-regulates population sizes with mortality

-genetic recombination can be very good or very deleterious

-recycle nutrients and organic carbon; as things die, the energy and carbon that have been locked up becomes available to then be used up

* What are different paths that a virus can take in each of the steps of infection of a host cell?

Gets inside:

-endocytosis

-adsorption

-membrane fusion with envelope

Can be latent, can become acute, or malignant.

There is self assembly that occurs at the very end once genome has been replicated and proteins are expressed.

Spike receptor link has to occur to bring into the cell (don’t produce their own membrane, produce envelope using past infected membranes)

* Why are vaccines against influenza only partially effective, and only for a short period of time?

-strains circulate all the time and new strains

-due to combination with animal and human reservoirs

-very high mutation rates and very high recombination rates

-antigenic drift (mutation) – fine within one population; when drift and this happens look out

-antigenic shift (recombination) – makes scary stuff from bunch of different species

* What are differences between latent HIV and latent herpes viruses?

HIV

Phases:

-Acute- 2-8wk, virus spreads to T cells, mutations occur and people feel ill.

-Asymptomatic - 0.5-10yr. - often coincides with latent cells

-Chronic symptomatic- months to years, CD4 declines, viral protein in blood increases

-AIDS - <200 CD4 in blood , secondary infections, can cause CNS damage and cancer

**Things to think about and review for final**

Bacterial cell wall structure and function (Gram +, Gram -, eukaryotic organelle equivalents)

-Gram + - firmicutes (bacilli and clostridia)

* + One thick peptidoglycan layer with non outer membrane
	+ Very small periplasmic space
	+ No lipopolysaccharides
	+ Teichoic acid bound to peptidoglycan
	+ Use sec system, ABC, Type I and Type II secretion systems
	+ Conjugation occurs without pilus.
* Gram-negative
	+ - Plasma membrane: innermost layer of the outer cellular structure composed of a phospholipid bilayer
			* *Phospholipid profiles of fatty acid chains can be used for bacterial identification!!!!!*
			* Selectively permeable and houses metabolic functions using a chemical gradient
		- Peptidoglycan/murein: two alternating amino-monosaccharides found in the periplasmic space
			* NAG: n-acetylglucosamine
			* NAM: n-acetylmuramic acid
				+ Four peptide chains attached to each NAM

Has some D-configuration amino acids (L found in most proteins)

DAP: diaminopimetic acid; unique amino acid found in NAM

* + - * Chains are helical and can crosslink in any direction
				+ Provides stability to structure
		- Periplasmic space: liquid/gel-filled space between the plasma and outer membranes
			* Thicker in Gram-negative bacteria
		- Outer cell membrane: lipopolysaccharides forming the outermost layer of *E. coli*
			* Attached to peptidoglycan via *Braun’s lipoprotein*
			* Lipopolysaccharide composition:
				+ Negatively charged
				+ O-side chain/O-antigen: portion of the lipoprotein causing the immune response

Can be changed by bacteria to avoid the response

Causes a systemic inflammatory response (is an endotoxin)

* + - * Proteins present:
				+ Integral proteins are not easily removed (have a transmembrane motif)

Are also *amphipathic*

* + - * + Peripheral proteins are more easily removed (reach into the periplasmic space)

How do bacteria interact with their environment (food, surfaces, enemies)?

-Actual interactions

* + Structure outside the cell wall:
		- Several types of protein appendages:
			* Fimbriae/Adhesion pili: hairlike protein tubes extending from the cell
				+ Helps *E. coli* adhere to surfaces (usually epithelial tissue) and increases motility

Protein called adhesin mediating binding at the tip

* + - * + Important virulence factor for ExPEC, ETEC, EPEC, and EHEC strains
			* Sex pili: thicker protein tubes extending from the cell
				+ Allows plasmid DNA to be transferred from one cell to another (*conjugation*)
			* Flagella: taillike protein tubes used for motility
				+ *E. coli* have *peritrichous flagella* (several and randomly distributed)
				+ Anchored to the cell wall via a basal body

Basal body also rotates *rod and ring proteins* attached to the main flagellum filament

Driven by ion gradients (does NOT use ATP)

* + - * + Filament is composed of *flagellin* protein units

Sometimes coated in a sheath (but not in *E. coli*) for protection

* + - Other structures:
			* Slime layers: layers of polysaccharides and protein outside the cell wall
				+ Diffuse, unorganized, and easy to remove
				+ Used for attachment to surfaces and protection from predators, toxins, pH fluctuations, and desiccation
				+ Combined slime layers from many cells are called a biofilm

Provides extra protection for the bacteria inside

Bacteria form their own microenvironment

* + - * Capsule: layers of polysaccharides and protein outside the wall that is organized and not easily removed
				+ A special type of capsule or slime layer composed only of polysaccharides is called the *glycocalyx*
				+ Same functions as slime layers
				+ Important virulence factor for ExPEC strains (also O-antigens)
	+ Can lose pamps in response to harsh environment
	+ Some create spores

Nutrition basics – terminology, distribution, diversity, efficiency

What are ranges of C sources, Energy sources, Electron sources, and Electron acceptors that microbes use? Where are these used in metabolic pathways?

**Chemotroph**

* *Def*: Organisms that obtain their energy from the oxidation of chemical compounds.
	+ Chemolithotroth – reduced inorganic compounds as energy/electron source
	+ Chemolithoheterotroh –reduced inorganic compounds for energy and electrons; organic molecules as the carbon source
	+ Chemoorganoheterotroph – pre formed organic compounds as sources of energy, electrons and carbon. Also called chemoheterotroph and chemoorganotroph. Many bacteria, all fungi all protozoa, animals, pathogens
* *E. coli* is a chemoorganoheterotroph
	+ Energy source – organic molecules
	+ Carbon source – C stored in organic molecules
	+ Electron Source – Organic molecules
	+ Electron Acceptors – O2 (final) + various other molecules

 **Organotroph**

* *Def:* Organic compounds as electron source

**Heterotroph**

* *Def*: uses reduced, preformed organic molecules as its principle carbon source

**Phototroph**

* *Def*: uses light as main energy source

**Diauxic growth**

* *Def*: biphasic growth response in which a microorganism, when exposed to two nutrients, initially uses one of them for growth then alters its metabolism to make use of the second.
	+ Best first, then next
	+ Ex: Lac operon is diauxic because it uses glucose first if possible because it would not have to make any enzyme to break down other more complex sugars.
* Will enhance and repress genes that will allow it to make better use of nutrients.

**CATABOLISM**

1. Stage one – Depolymerization

It breaks apart polymers into monomers that can be taken up by cells. Polysaccharides are degraded by hydrolysis while disaccharides can be degraded by either hydrolysis or phosphorylation. Extracellular enzymes perform digestion outside the cell because there is no phagocytosis in bacteria. Other enzymes can be used when maltose or sucrose is the substrate.

1. Stage Two – forming common simple molecules to go to TCA

Embden-Meyerhoff Pathway (traditional glycolysis)

Occurs in the cytoplasm and is amphibolic. Biggest key is to convert glucose to pyruvate to enter TCA cycle. ATP generated through substrate level phosphorylation here. It is divided into 6 and 3 carbon steps. It inputs glucose, 2 ADP, 2 Pi and NAD+. Outputs are 2 pyrvuate, 2 ATP, 2 NADH and 2 H+. One important intermediate is PEP.

 Pentose Phosphate Pathway

Can aerobic or anaerobic and can be used in conjunction with Embden-Meyerhoff Pathway. Intermediates can be used for aromatic amino acids and nucleic acids or go into glycolysis. Key is NADPH production. Inputs glucose, 12 NADP+, 7 H2O, and ATP. Outputs CO2, **12 NADPH,** 12H+ ADP or Pi. NADPH serves as any energy source for reducing power and is an electron carrier.

1. Stage 3 – TCA/Fermentation
* Occurs in cytoplasmic matrix. It fully oxidizes pyruvate to 3CO2. NADH and FADH2 synthesized for oxidation in ETC. The cycle requires two pyruvate per cycle (per glucose). Per pyruvate, products are 4 NADH, 1 FADH2, 1 GTP and CO2. Ends up reducing O2 as final electron acceptor. Dissimilatory Nitrate reduction and denitrification are anaerobic and uses nitrate as final electron acceptor. Fermentation is also anaerobic, NADH is oxidized to keep glycolytic pathways going. No change in redox state in fermentation and there can be various by products possible. One is lactate.

 **Nitrogen Biosnythesis**

-First, if there is already an amino acid present that is able to be most directly used, it will attempt to take it up. If not, there are the processes of ammonia incorporation/assimilatory nitrate reduction. Glutamate dehydrogenase pathway will be used with ammonia concentration is high, and glutamate comes from alpha-ketogluterate produced in TCA. When ammonia is low, GS-GOGAT is used because it is better at scavenging ammonium, but it is less efficient energy wise. \*Spend energy to convert nitrate to ammonium for incorporation

Taxonomy and phylogeny of microorganisms – How have genome sequences helped us understand microbial evolution and altered microbial taxonomy? How does gene transfer work in bacteria and affect their evolution?

Geneome sequencing has allowed us to phylogenetically organize our taxonomy rather than based on phenotype. We can see how closely related genes are and such.

* + Frequency of HGT goes up as strains are more closely related because chromosomal sequences are more homologous. More likely to recognize conjugative mechanisms, have similar sites for recombination, certain phages may be more attracted to a specific group of bacteria. This helps maintain species integrity. Can also, over time, lead to new species.
	+ HGT allows for some current barriers to pathogenicity to be lost or inactivated, as well as other genes to become activated that can produce enterotoxins etc. Refer to pathogenicity islands as well as slides that include these specific details.

What are consequences of not storing chromosome in a nucleus?

* + Translation and transcription occur simultaneously in cytoplasm. Eukaryotes splice introns, while bacteria do not.
		- Since they happen simultaneously, attenuation can happen. This depends on ribosome and RNA polymerase to be bound to same molecule.
		- mRNA can be polycystronic
	+ Doesn’t have as much processing such as poly A tail etc.
	+ It is control of transcription levels by amount of a specific tRNA
	+ Bacteria don’t have introns to splice, don’t have to export from the nucleus, and both transcription and translation occur in the cytoplasm.
		- Attenuation depends on transcription and translation being able to occur simultaneously.

Acquired vs. innate immune systems

 How are they different? How do they interact?

\*REFER TO PREVIOUS STUDY GUIDES AND STUFF FOR HOW THEY INTERACT

-STEPS TO COMPLETE IMMUNE RESPONSE

Microbial interactions with human hosts

-How do microbes eat?

Most have to secrete digestive enzymes outside the cell

-How do microbes move?

Some have flagella that can either be polar, peritrichous etc.

-How do microbes deal with problems in their environment?

They can lose PAMPs or go dormant whether in endospores, reticulate bodies, tubercles, exospores,

EXTRA NOTES/REVIEW SESSIONS

Dikaryotic nuclei = fruiting body

Nuclei fuse to make diploid and make asexual spore

Monokaryotic = single nucleus

Haploid = 1 copy of each chromosome

Diploid = 2 copies

Dikaryotic 2 nuclei (n+n)

Fungal life stage Diploid monokaryotic 2n -> *meiosis* -> Haploid monokaryotic (N) -> *cytoplasmic fusion*-> dikaryotic n+n -> *Nuclear fusion … zygote ->* diploid stage 2n

Asexual – no need for other hyphae

Sexual – recombination can be beneficial or deleterious