

LECT 1

1. Which of the following structures is found only in Bacteria?

- A. cell wall
- B. flagellum
- C. cell membrane
- D. nucleus
- E. lipopolysaccharide

2. Which of the following statements about viruses is true?

- A. They have an active chemical metabolism.
- B. Viruses that infect bacteria cannot infect humans.
- C. They have only RNA, no protein.
- D. They cannot infect bacteria.
- E. They are usually surrounded by a lipid envelope.

3. What are prions?

- A. Infectious proteins with no nucleic acid.
- B. Very tiny virus-like particles.
- C. Infectious RNA with no protein.
- D. Peptidoglycan particles that affect the immune system.
- E. Small cells that lack a cell membrane.

4. Taken together, the experiments of Pasteur, Tyndall and Koch demonstrated that . . .

- A. some bacteria cannot be killed
- B. as long as air can be kept out, a solution can be kept sterile
- C. as long as no living organisms enter a solution, it can be kept sterile indefinitely
- D. sometimes an experiment must be repeated for it to work right
- E. some forms of bacteria are not living organisms

5. There is much interest in using bacteriophages to kill the bacteria that cause infectious diseases in humans. Which of the following is a valid concern about such therapy?

- A. The bacterial viruses might also infect humans.
- B. The bacterial viruses might carry bacterial DNA into human cells.
- C. Bacterial viruses might mutate into uncontrollable “superbugs.”
- D. The virus preparation might be contaminated with a few live bacterial cells.
- E. The viruses might evolve into new bacterial cells.

6. Viroids are . . .

- A. small virus-like particles
- B. small pieces of RNA without a protein coat
- C. empty protein coats without any nucleic acid
- D. infectious proteins that serve as folding templates for other proteins
- E. another name for plant viruses

7. Archaea have . . .

- A. a nucleus
- B. a cell membrane
- C. peptidoglycan
- D. chloroplasts
- E. phosphotransferase systems

8. In Pasteur's famous experiment that finally disproved spontaneous generation, bacteria grew

- A. only in the flasks with a swan neck
- B. only in media that came in contact with air
- C. only in media that came in contact with other bacteria
- D. only once the media had been boiled
- E. in all flasks, regardless of how they were treated experimentally.

9. Tyndall repeated the same experiment, but got different results. This was because

- A. he didn't do the experiment right
- B. he used different flasks than Pasteur
- C. he was working in England, but Pasteur was working in France
- D. he didn't boil the flasks for as long a time as Pasteur did
- E. the media he was trying to sterilize contained endospores

10. Which of the following is currently (2008) believed to be a major difference between prokaryotes and eukaryotes?

- A. Eukaryotes are all multicellular.
- B. Eukaryotes have a cytoskeletal framework inside the cytoplasm.
- C. Prokaryotes all have cell walls made of peptidoglycan.
- D. Eukaryotes have a nucleus surrounded by a nuclear membrane.
- E. Prokaryotes have RNA, but eukaryotes have DNA.

11. Which of the following entities makes more copies of itself by acting as a template for protein folding?

- A. Prion
- B. Prokaryote
- C. Provirus
- D. Virus
- E. Viroid

12. Single-celled photosynthetic organisms with nuclei and without cell walls are . . .

- A. Cyanobacteria
- B. Purple Sulfur Bacteria
- C. Algae
- D. Plants
- E. Fungi

13. Which of the following statements about bacteriophage is correct?

- A. They can infect both bacteria and plants.
- B. They contain both DNA and RNA.
- C. They are very tiny infectious RNA particles.
- D. They have a protein coat.
- E. They are examples of chemolithoheterotrophs.

14. How do prions cause diseases like mad cow disease?

- A. They act as a template to misfold native proteins.
- B. They reproduce by inserting their DNA into host cells.
- C. Their RNA interferes with the production of RNA in host cells.
- D. They use the host cell's metabolism to reproduce, very much like viruses do.
- E. They produce and secrete a potent neurotoxin.

15. The three main branches in the phylogenetic "tree" of life are . . .

- A. Plants, Animals and Fungi
- B. Bacteria, Plants and Animals
- C. Prokaryotes, Eukaryotes and Archaea
- D. Protozoa, Eukaryotes and Bacteria
- E. Bacteria, Archaea and Eukaryotes

16. Which of the following is a hallmark of protozoa, but NOT of bacteria?

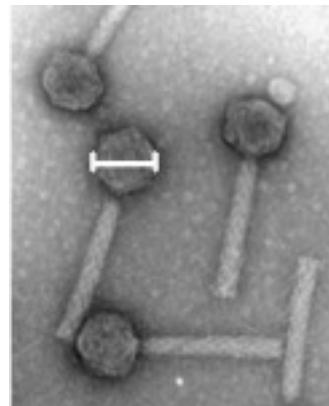
- A. life in extreme environments
- B. endocytosis to engulf nutrients
- C. saprophytic lifestyle
- D. the presence of a cytoskeleton
- E. two cell forms – yeast and mold

17. These viruses infect the bacterium *Escherichia coli*. Which of the following MUST also be true?

- A. They have a lipid envelope.
- B. They contain no protein.
- C. They cannot infect humans.
- D. The viruses are prokaryotes.
- E. Their diameter (white line) is less than 1 nanometer.

18. Prions are infectious agents that contain

- A. protein only
- B. RNA only
- C. RNA and protein
- D. DNA and protein
- E. RNA, DNA and protein



19. We said in an early lecture that science should be "predictive." What does this mean?

- A. If you repeat the same experiment, you get the same results.
- B. You know in advance which experiments will work and which won't.
- C. If you change a variable in an experiment, you know how the results will change.
- D. You can try a completely new experiment and know in advance what the results will be.
- E. You can deduce how a biological system will evolve in the future.

20. Which of the following correctly describes comparisons between Bacteria, Eukaryotes and Archaea?

- A. Archaea have no protein, just RNA.
- B. Only Eukaryotes have a cytoskeletal protein network within their cells.
- C. Bacteria and Eukaryotes have a nucleus; Archaea don't.
- D. Only Bacteria have peptidoglycan in their cell structures.
- E. Eukaryotes are a much more diverse group than the other two.

21. Last semester, when he was working with bacteriophage in the lab, a student came to me and said his doctor had told him he had a viral infection. He was pretty sure he had acquired the infection from the bacteriophage he was working with in lab. What would you have told him?

- A. Bacteriophage are not viruses.
- B. Bacteriophage can't infect humans.
- C. Bacteriophage are dimorphic. We don't use the human variety in lab.
- D. Bacteriophage don't have DNA, so the infection shouldn't be too serious.
- E. The student should work on his sterile technique so something like this won't happen again.

22. The pictures shown here represent the same organism at different stages in its life cycle. What is the organism?

- A. a type of algae
- B. a type of fungus
- C. a protozoan
- D. a bacteriophage
- E. a type of archaea



23. A structure that is 50 nanometers in diameter and is composed only of protein, RNA and lipid would most likely be an example of which of the following?

- A. an enveloped virus
- B. a naked virus
- C. a viroid
- D. a prion
- E. a micelle

24. Which of the following is something that Pasteur could have concluded logically after his swan-necked flask experiment?

- A. Bacteria use pili to adhere to dust particles in the air.
- B. Endospores are very difficult to kill, and can survive boiling.
- C. Bacteria need air in order to grow.
- D. Boiling destroys microbes in broth, and they do not regrow from air.
- E. Microbes can regenerate spontaneously from a "vital principle" in the broth.

25. Saying that microbes are "diffusion limited" is the same as saying that they . . .

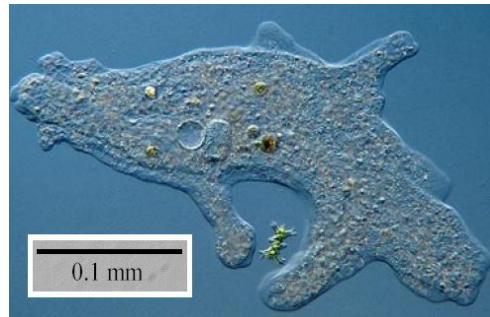
- A. have a cytoskeleton
- B. lack an organized intracellular transport system
- C. are eukaryotes
- D. usually grow in an environment with a high diffusion rate
- E. rely on passive diffusion for transport across their membrane

26. What are Archaea?

- A. A kingdom of Prokaryotes that lack peptidoglycan
- B. One of the two forms in the fungal life cycle
- C. An unusual type of Bacteria that grows in harsh environments
- D. One of the forms of the algal life cycle
- E. A type of virus that infects bacterial cells

27. What is the organism that is depicted in the micrograph at the right (note the scale bar)?

- A. A fungus
- B. A bacterium
- C. A virus
- D. An endospore
- E. A protozoan



28. You have discovered a new organism that is about 200 nm across its largest dimension. It contains DNA, RNA, protein and lipid. It can replicate its DNA, but requires a host cell in which to do that. It appears to have no ATP generating mechanism. What is it? Why?

- A. A virus because of its size
- B. A viroid, because it's small, but isn't a virus
- C. A prokaryote because of its composition
- D. A parasitic eukaryote because of its size
- E. A prion because it has protein and can replicate

29. The fact that bacteria lack an endomembrane system explains their . . .

- A. small size
- B. use of a peptidoglycan cell wall
- C. lack of any internal structures
- D. motility
- E. need for a cytoskeleton

30. You are examining an organism under the microscope. It is about 15 micrometers (μm) in diameter. A chemical analysis shows that it contains DNA, RNA and protein, as well as other macromolecules. You grow it on a petri dish to get a pure culture, but this time when you look at it under the microscope it consists of filaments 100 μm long and 8 μm wide. Explain this.

- A. You are looking at eukaryotic algae, with long flagella.
- B. You are looking at a culture of ciliated protozoan.
- C. You are looking at a fungal culture.
- D. You were looking at a virus that became contaminated with rod-shaped bacteria.
- E. It is diffusion-limited when it is growing on the petri dish.

31. We mentioned that viroids can infect and kill plant cells. How?

- A. They inhibit protein synthesis by the plant cell.
- B. Their DNA takes over the plant cell's nucleus.
- C. They replicate to fill the plant cell's cytoplasm.
- D. They cause other proteins in the plant cell to misfold.
- E. Their coat interacts specifically with proteins on the plant cell wall.

32. Modern Biology considers that the three domains (kingdoms) of life are . . .

- A. Bacteria, Plants and Animals
- B. Prokaryotes, Eukaryotes and Viruses
- C. Archaea, Eukaryotes and Plants
- D. Archaea, Bacteria and Eukaryotes
- E. Animal, Vegetable and Mineral

33. You inoculate a pure culture onto a petri dish, but when you look at the culture after it has grown, you find both of the organisms shown at the right. What is the best explanation for this?



- A. Your pure culture was a fungus.
- B. Your culture was contaminated with prokaryotes.
- C. Your bacterial culture was contaminated with phage.
- D. You plated a culture of algae.
- E. Some of the protozoa you plated have formed spores.

34. Eureka! You have discovered a new organism! You decide to analyze it chemically. Finding which of the following would mean that your new organism CANNOT be a virus?

- A. DNA
- B. RNA
- C. Protein
- D. Lipids
- E. NADH

35. How do prions cause infectious diseases?

- A. They grow inside a host cell and eventually become numerous enough to lyse it.
- B. They secrete digestive enzymes that kill a host and then consume it saprophytically.
- C. They misfold, and then cause other proteins to misfold, eventually damaging host cells.
- D. They bind to a mRNA, preventing it from being translated into a protein that the host needs.
- E. They insert their DNA into the host's DNA, thereby taking over the host cell genetically.

LECT 10

1. A non-competitive (allosteric) enzyme inhibitor ____.

- A. must resemble the substrate at least partially
- B. binds to an enzyme's active site
- C. induces a shape change in the active site
- D. must be present in large excess to inhibit an enzyme effectively
- E. affects only the allosteric site where it binds

2. Oxidative decarboxylation occurs during three separate reactions in central catabolism. The main purpose of these reactions is to ____.

- A. produce reducing power
- B. oxidize CO₂
- C. make glucose
- D. donate electrons to pyruvate
- E. produce ATP by substrate-level phosphorylation

3. Amino acids are NOT synthesized from ____.

- A. TCA cycle intermediates
- B. pyruvate
- C. glycolytic intermediates
- D. pentose phosphate pathway intermediates
- E. fermentation products

4. A competitive inhibitor of an enzyme ____.

- A. must structurally resemble the substrate of the enzyme it inhibits
- B. binds to an allosteric site on the enzyme
- C. works by denaturing or modifying the shape of the active site
- D. inhibits an enzyme even at a much lower concentration than the substrate
- E. can only inhibit enzymes in anabolic pathways

5. The main purpose of the TCA cycle in central catabolism is ____.

- A. to produce additional ATP
- B. to regenerate NAD⁺ from NADH
- C. to produce carboxylic acids for metabolism
- D. to produce additional reducing power
- E. to feed compounds from the Pentose Phosphate Cycle into central catabolism

6. This molecule is one of the most versatile in central catabolism. It can be oxidized or reduced. It is a point at which side reactions feed into central catabolism, and is also a starting material for anabolic reactions.

- A. Glucose
- B. ATP
- C. Acetyl-CoA
- D. Pyruvate
- E. CO₂

7. What form of energy is **directly** generated by the oxidative decarboxylation of pyruvate?

- A. ATP
- B. A H⁺ gradient
- C. Rotary motion
- D. Acetyl-CoA
- E. NADH

8. Some bacteria can catabolize lipids as carbon and energy sources. How do lipids enter central metabolic pathways?

- A. They are decarboxylated and enter glycolysis as sugar.
- B. They are first deaminated, and then enter central catabolism in many places.
- C. They are reduced and then fermented to ethanol and CO₂.
- D. They are first hydrolyzed, then oxidized, and enter glycolysis and the TCA cycle.
- E. They are first oxidized, then enter glycolysis and the pentose phosphate pathway.

9. In a chemotrophic bacterial reaction, electrons are donated from glucose to NAD⁺, forming 2 molecules of pyruvate plus NADH. Which of the following must also be true?

- A. Pyruvate is at a higher energy level than NAD⁺.
- B. Glucose is at a higher energy level than NADH.
- C. Glucose is being reduced during this reaction.
- D. If this reaction were reversed, NAD⁺ would donate electrons to glucose.
- E. This bacterium must be either aerobic or facultatively anaerobic.

10. Which of the following statements about enzyme inhibitors is correct?

- A. A noncompetitive inhibitor must resemble the substrate at least partially.
- B. Competitive inhibitors are usually for anabolic pathways.
- C. An allosteric inhibitor binds to an enzyme's active site.
- D. A competitive inhibitor induces an irreversible shape change in the active site.
- E. An allosteric inhibitor functions even at a much lower concentration than the substrate.

11. The main purpose of fermentation reactions in a typical bacterial cell is _____.
A. to generate a little bit more energy than just glycolysis does
B. to prepare pyruvate to enter the TCA cycle
C. to oxidize NADH
D. to carry out the first step in anabolic reactions that make new cell material
E. to make a PMF in the absence of an electron transport chain.
12. Why is pyruvate an especially important molecule in central catabolism?
A. It is a high-energy molecule that can serve as an energy source for auxotrophs.
B. It is an important intermediate in the TCA cycle.
C. All carbohydrates are converted to pyruvate before glycolysis can begin.
D. It can either accept electrons from NADH or donate electrons to NAD⁺.
E. It is the starting material for anabolic reactions that make nucleic acids.
13. Which of the following statements about enzymes is INCORRECT?
A. RNA and DNA molecules can have catalytic activity.
B. Enzymes lower the free energy of a reaction.
C. Enzymes lower the activation energy of a reaction.
D. Enzyme pathways require each reaction to occur in order to form the end product.
E. An induced fit enzyme model involves a subtle change in the tertiary structure when binding a substrate.
14. Bacterial central catabolism includes all of the following EXCEPT _____.
A. glycolysis
B. respiratory electron transport
C. TCA cycle
D. formation of reducing power
E. substrate-level phosphorylation
15. Much of the bacterial cell membrane is made of lipids. Where do lipids come from during bacterial metabolism?
A. From fermentation of pyruvate
B. They are made by oxidative phosphorylation
C. Bacteria must ingest lipids in their diet; they cannot be synthesized
D. By catabolic reactions from glucose
E. They are built from glycerol and acetyl-CoA
16. Molecule A donates electrons to molecule B. Which of the following is true?
A. Molecule A is being reduced during this reaction.
B. Molecule B has higher energy than molecule A at the beginning of the reaction.
C. During the reaction, molecule B loses more energy than molecule A gains.
D. During the reaction, molecule A loses more energy than molecule B gains.
E. During the reaction, molecule B loses some energy, but not as much as molecule A gains.

17. The main product of the TCA cycle is _____.

- A. ATP
- B. glucose
- C. NADH
- D. NAD^+
- E. pyruvate

18. From which central metabolic pathway(s) is DNA synthesized by the cell?

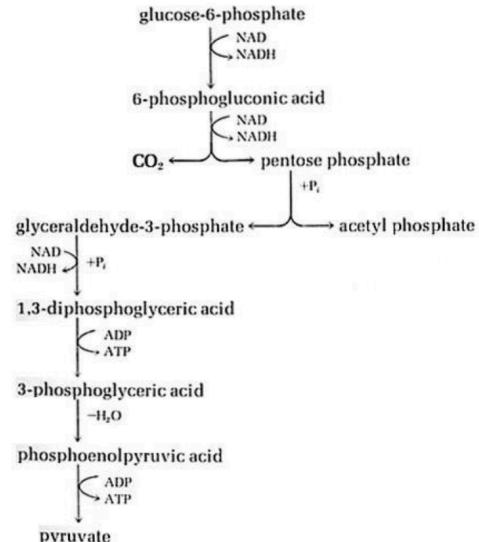
- A. from TCA cycle intermediates
- B. from the oxidative decarboxylation of pyruvate
- C. from glycolytic intermediates
- D. from the pentose phosphate pathway
- E. from glycolytic intermediates condensed with a product of acetyl-CoA

19. Which of the following is the most highly **oxidized** molecule?

- A. $\text{C}_6\text{H}_{12}\text{O}_6$
- B. C_2H_8
- C. CO_2
- D. H_2S
- E. CH_3COOH

20. How many oxidation reactions occur in the biochemical pathway shown at the right?

- A. 5
- B. 3
- C. 2
- D. 1
- E. none



21. Bacteria that can use lipids as a carbon source typically have what type of metabolism?

- A. Strictly respiratory since oxidation of fatty acids generates lots of NADH
- B. Strictly anaerobic, since fatty acids are fermented
- C. Facultatively anaerobic since lipids have both hydrophilic and hydrophobic parts
- D. Entirely oxidative, since fatty acids are oxidized rather than reduced
- E. A lithotrophic one, since lipids are the electron source as well as the carbon source

22. A pharmacist wants to develop a drug that inhibits a bacterial enzyme. He has an option to develop either a competitive inhibitor (CI) or a non-competitive inhibitor (NCI). All other things (toxicity, cost, etc.) being equal, which one would he prefer to develop? Why?

- A. The NCI, because it still allows the substrate to bind to the enzyme's active site
- B. The CI, because it can inhibit the enzyme by several different mechanisms
- C. The NCI, because it does not have to be present in large concentration excess
- D. The CI, because it will specifically target allosteric enzymes
- E. The NCI, because he can design it by derivatizing the enzyme's normal substrate

23. The reaction $\text{NADH} \rightarrow \text{NAD}^+ + \text{H}^+$ occurs in BOTH _____.

- A. glycolysis and the TCA cycle
- B. the TCA cycle and respiration
- C. respiration and fermentation
- D. glycolysis and pyruvate oxidation
- E. respiration and photosynthesis

24. Glucose is "broken down" in glycolysis. What does "broken down" mean in this case?

- A. Glucose is reduced
- B. Glucose is first reduced, and then hydrolyzed
- C. Glucose is first condensed, and then oxidized
- D. Glucose is first oxidized, and then reduced
- E. Glucose is first hydrolyzed, and then oxidized

25. What is the purpose of lactic acid fermentation in bacterial metabolism?

- A. to produce reducing power
- B. to oxidize NADH
- C. to produce ATP anaerobically
- D. to produce a PMF anaerobically
- E. to make lactate, an important growth factor

26. What is the metabolic purpose of beta oxidation?

- A. It is a way to break down protein secondary structures
- B. It is a way to feed cellulose monomers into the pentose phosphate pathway
- C. It is a way to turn fatty acids into TCA cycle precursors
- D. It is a way to make bacterial cell wall precursors
- E. It is a type of bacterial secondary metabolism

27. In the following spontaneous reaction : $A_{\text{ox}} + B_{\text{red}} \rightarrow A_{\text{red}} + B_{\text{ox}}$

- A. A gives electrons to B
- B. A gives energy to B
- C. B loses energy
- D. B_{red} must have lower energy than A_{ox}
- E. A loses both H^+ and electrons

28. Which of the following is true about an **allosteric** inhibitor?

- A. The inhibitor binds to the substrate rather than to the enzyme.
- B. The inhibitor alters the active site without binding to it.
- C. The inhibitor must be present in large excess over the substrate.
- D. The inhibitor must at least partially resemble the substrate.
- E. There is no way to predict the shape of such an inhibitor.

29. Whether a eukaryotic cell will use the TCA cycle depends on how much O_2 is present in the environment. What determines whether a bacterium will use its TCA cycle or not?

- A. Still the amount of O_2 in the environment
- B. Whether there is excess glucose in the cell
- C. The need the cell has for ATP
- D. An excess of NADH in the cell
- E. The need the cell has for reducing power

30. All of the following reactions **release energy** EXCEPT ____.

- A. pyruvate \rightarrow lactate
- B. glucose \rightarrow pyruvate
- C. pyruvate \rightarrow acetyl-CoA
- D. glucose \rightarrow CO_2
- E. NADH \rightarrow NAD^+

31. Which biochemical pathway is correctly matched with a macromolecular product it produces?

- A. Lipids are derived from the Pentose Phosphate pathway
- B. Carbohydrates are produced by beta-oxidation
- C. Proteins come from TCA cycle intermediates
- D. Nucleic Acids are produced from glycolysis
- E. Lipids are derived from TCA cycle intermediates

LECT 2

1. Which of the following is NOT caused by hydrogen bonding?
 - A. protein alpha helices
 - B. ice floats in water
 - C. DNA double helix
 - D. NaCl dissolves in water
 - E. Hydronium ions form in water

2. Van der Waals (hydrophobic) interactions occur when _____.
 - A. one ion interacts with an ion of opposite charge
 - B. a random charge fluctuation sets up a transient dipole in a non-ionic molecule
 - C. a polar molecule interacts with an ion
 - D. a polar molecule with a dipole interacts with another polar molecule
 - E. two molecules get closer together than they would in a covalent bond

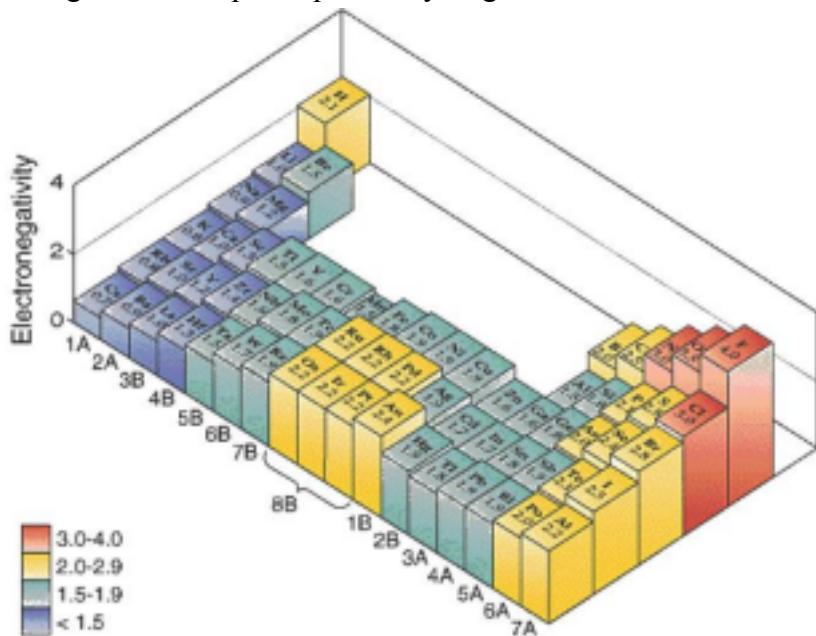
3. Two molecules with polar covalent bonds are attracted to each other. The resulting bond could be a _____.
 - A. Hydrogen bond
 - B. van der Waals bond
 - C. Polar covalent bond
 - D. Nonpolar covalent bond
 - E. Ionic bond

7. Weak bonds are caused by _____
 - A. Partial electron sharing
 - B. Electron sharing
 - C. Charge interactions
 - D. Atoms with lighter nuclei than normal
 - E. Adding heat to strong bonds

8. Why is it important that most intermolecular interactions in cells are weak bonds?
 - A. More energy is released when they are broken
 - B. It takes more energy to form them
 - C. Very few strong bonds can occur in an aqueous solution
 - D. Fewer of them are needed to hold molecules together
 - E. They are more easily reversible

9. What happens when water hydrates itself?
 - A. molecules stick together and become cohesive
 - B. it expands and freezes
 - C. it can not be transported through aquaporins anymore
 - D. H_3O^+ and OH^- ions form
 - E. Water cannot hydrate itself.

10. Which of the following CANNOT participate in hydrogen bond formation?



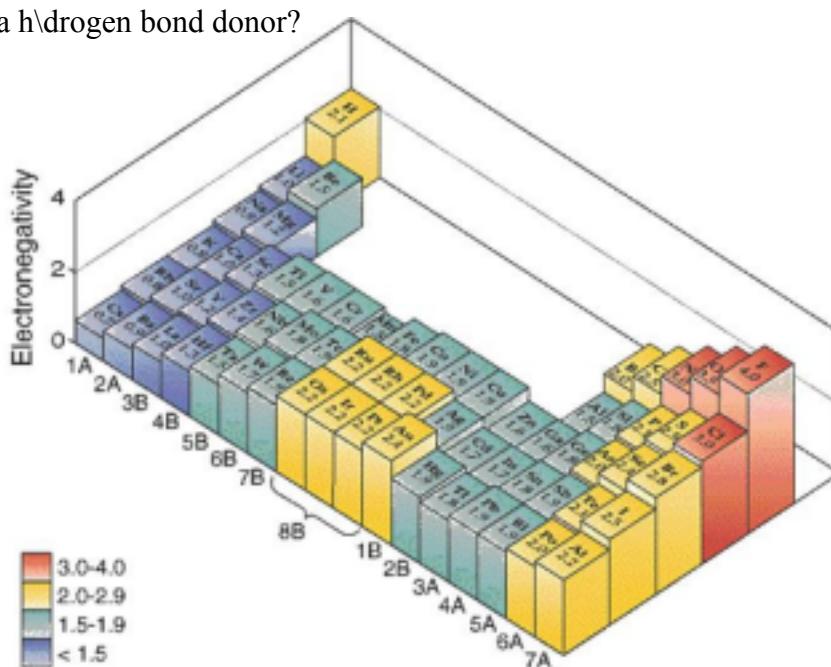
- A. the C in C=O
- B. the H in N-H
- C. the N in N-H
- D. the H in C-H
- E. the O in O-H

11. The pH inside a bacterial cell is 7. The pH outside is 6. What is the size of the H⁺ gradient?

- A. You need more information to answer this question.
- B. There are twice as many protons outside than inside the cell.
- C. There is one more proton inside the cell than outside.
- D. There are 10 times as many protons inside the cell than outside.
- E. There are 10 times as many protons outside the cell than inside.

12. Which of the following can serve as a hydrogen bond donor?

- A. The H in an N-H bond
- B. The H in a B-H bond
- C. The H in a C-H bond
- D. The O in a C=O bond
- E. The O in a P=O bond



13. Weak bonds are caused by _____.

- A. Isotopes with lighter nuclei than normal
- B. Electron sharing
- C. Partial electron sharing
- D. Charge interactions
- E. Adding heat to strong bonds

14. A C-C bond in molecule A undergoes a random charge fluctuation. As molecule A comes close to a C-C bond in molecule B, what will happen to molecule B?

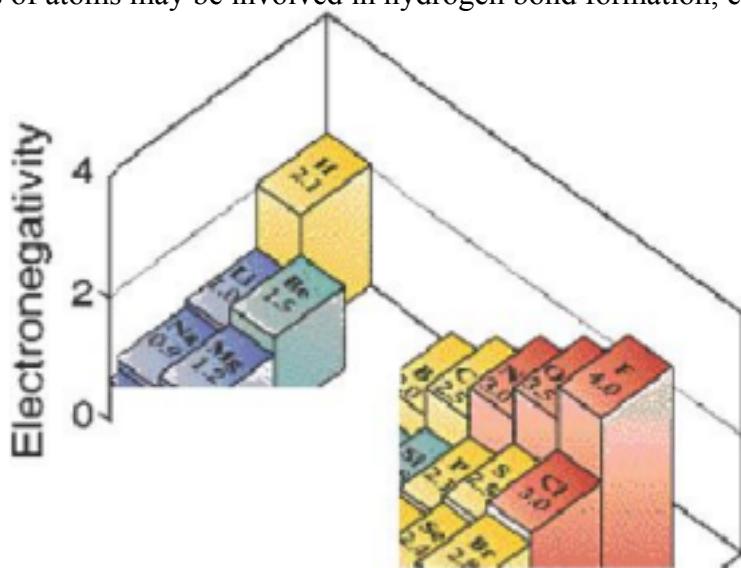
- A. It will form a covalent bond with molecule A.
- B. It will form a polar-covalent bond with molecule A.
- C. It will hydrogen bond with molecule A.
- D. A dipole will be induced which will weakly attract molecule B to molecule A.
- E. Nothing will happen. These molecules cannot interact.

15. The hydrophobic effect is used to explain _____.

- A. the concept of pH
- B. how micelles form in an aqueous environment
- C. the ability of nonpolar molecules to form Van der Waals bonds
- D. the mechanism of dehydration synthesis reactions
- E. why H₂O has a high heat capacity

16. Which of the following pairs of atoms may be involved in hydrogen bond formation, either as donor or acceptor?

- A. C-H
- B. P=O
- C. C=C
- D. S-H
- E. Na-Cl

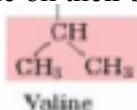


17. A difference between strong bonds and weak bonds is that _____.

- A. only strong bonds have enough energy for use in living cells
- B. weak bonds can be formed by simple enzymes; strong bonds require heat input to form
- C. weak bonds are polar covalent; strong bonds share electrons equally
- D. weak bonds involve temporary electron sharing between two atoms
- E. weak bonds involve charge attraction between two molecules or within a large molecule

18. Proteins with the amino acid valine on their surface often stick together when placed in water.

Why? Here is the R-group of valine:



- A. Valine forms H-bonds with water.
- B. Valine forms H-bonds with other valine molecules rather than with water.
- C. Valine is attached to other valine by very strong van der Waals interactions.
- D. Due to the hydrophobic effect, H₂O forms a network of H-bonds around collected valines.
- E. Valine's R-group forms covalent bonds with other valine R-groups.

19. The pH of bacterial cytoplasm is 7, and the pH of the environment where the bacterium is growing is 5. How much difference is there in the H⁺ concentration between the inside and outside of the bacterial cell?

- A. The outside of the cell has 100 times as many protons as the inside.
- B. The inside of the cell has 100 times as many protons as the outside.
- C. The outside of the cell has twice as many protons as the inside.
- D. The inside of the cell has twice as many protons as the outside.
- E. The inside of the cell has 2 more protons than the outside.

20. Which of the following statements is true about polar covalent bonds (P.C.B.s)?

- A. The atoms in a P.C.B. must have equal electronegativity values.
- B. P.C.B.s are characterized by a temporary dipole moment.
- C. Hydrogen bonds are one example of a P.C.B.
- D. P.C.B.s are a type of weak molecular interaction.
- E. Electrons in a P.C.B. spend more time around one of the bond atoms than the other.

21. What advantage is it for biological systems to use hundreds of weak bonds rather than one strong bond to hold two molecules together?

- A. Weak bonds are better suited to enzyme-catalyzed reactions than strong bonds are.
- B. It takes less energy to make hundreds of weak bonds than to make one strong bond.
- C. Tetrahedral carbon atoms form weak bonds more readily than strong bonds.
- D. Weak bonds can be broken with less energy input than strong bonds.
- E. It isn't. Biological molecules are joined more by strong bonds than by weak bonds.

22. Which of the following is a consequence of water forming hydrogen bond networks?

- A. Water dissolves polar molecules and ions easily.
- B. Hydrophobic molecules form micelles in water.
- C. Water evaporates more easily than most other solvents.
- D. Water consists of mostly H₃O⁺ and OH⁻ ions.
- E. The hydrophobic effect only occurs in the absence of water.

23. An acidiphilic bacterium lives in an environment with an external pH of 3. There are approximately ____.

- A. 4 times as many H⁺ outside than inside the cell
- B. 4 times as many H⁺ inside than outside the cell
- C. 10,000 times as many H⁺ outside than inside the cell
- D. 10,000 times as many H⁺ inside than outside the cell
- E. There is no way to estimate this without further information.

24. Which of the following could be a hydrogen bond **acceptor**?

Electronegativities

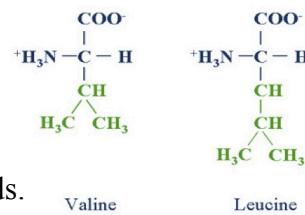
- A. The C in a C-H bond H = 2.1
- B. The N in a C-N bond P = 2.1
- C. The P in a P-O bond C = 2.5
- D. The N in an N-O bond N = 3.0
- E. The H in a C-H bond O = 3.5

25. What makes a biological strong bond?

- A. It forms spontaneously without involvement of enzymes
- B. A large electronegativity difference between atoms in the bond
- C. A large number of charge interactions
- D. Hydration by water
- E. Electron sharing between atoms in the bond

26. How can the R-group of leucine interact with the R-group of valine?

- A. A hydrogen bond can form between the CH₃ groups of the two amino acids.
- B. CH₃ hybridization forms tetrahedral carbon atoms that interact covalently.
- C. Leucine's R-group can ionize and be attracted to opposite ions in valine's.
- D. A temporary dipole in leucine's R-group can induce another dipole in valine's.
- E. These two R-groups cannot interact since there are no bonding forces between them.



27. Which of the following is a consequence of the unique structure of water molecules?

- A. Water interacts with the fatty acid groups of phospholipids.
- B. The density of solid H₂O is greater than that of liquid H₂O.
- C. There are a small number of ions even in pure water.
- D. Water evaporates more easily than other molecules with the same mass.
- E. As water is heated, more hydrogen bonds form between H₂O molecules.

28. Two molecules are composed of the same atoms, but the molecules have different molecular weights. This can be explained by the existence of ____.

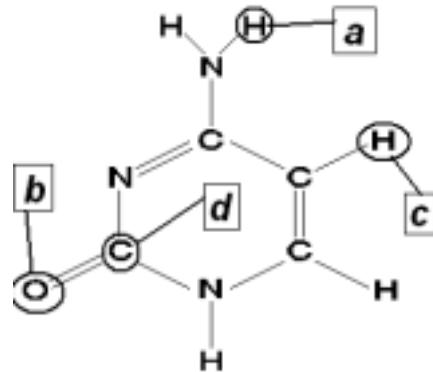
- A. isomers
- B. isotopes
- C. ions
- D. sp^3 orbital hybridization
- E. a dipole moment

29. In a biological context, which of the following describes a strong bond?

- A. All biological bonds are strong, otherwise the cell would disintegrate.
- B. An attraction between molecules with multiple charges.
- C. Any molecular interaction that requires energy input to break apart.
- D. Many hydrophobic interactions between lipid tails in the cell membrane.
- E. Electron sharing between atoms with an electronegativity difference less than 1.6

30. Which of the atoms in the structure at the right could be a H-bond donor? A H-bond acceptor?

- A. Donor = **a**; Acceptor = **b**
- B. Donor = **a**; Acceptor = **d**
- C. Donor = **c**; Acceptor = **d**
- D. Donor = **d**; Acceptor = **b**
- E. This molecule has no H-bond donors or acceptors.



31. Which of the following is most important in the formation of micelles from a collection of phospholipids? Why?

- A. The van der Waals interactions between the lipid tails because there are so many of them.
- B. The H-bonds between the fatty acids because they hold the lipids close enough together that the micelle can form.
- C. The covalent bonds between the phosphate head groups because they are strong enough to keep water out of the interior of the micelle.
- D. The hydrophobic effect since without water the micelle will fall apart.
- E. ATP, because it provides the energy needed for micelles to form.

32. In order to make ATP, a bacterium needs a ΔpH of about 2. Assume ions can pass through porins freely. If the bacterium is growing in a neutral solution, what must be the proton concentration in the bacterial cytoplasm?

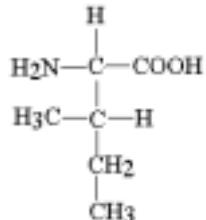
- A. 10^2 molar
- B. 10^9 molar
- C. 10^{-9} molar
- D. 10^{-2} molar
- E. 2 molar

33. What can you say about the element Phosphorus from its entry in the periodic table?

- A. It has two very common isotopes.
- B. With a full outer energy shell it would be a (-3) ion
- C. One isotope has a +5 charge
- D. It has 2 unpaired electrons in bonding orbitals
- E. In its ionic form it has 15 neutrons

34. The amino acid depicted at the right can participate in what sort of **tertiary** interactions?

- A. van der Waals interactions
- B. Ionic interactions
- C. Covalent bonds
- D. Hydrogen bonds
- E. Strong bonds but only if there is a lot of it



35. Which of the following is **NOT** a description of the hydrophobic effect?

- A. The force that causes membranes to form
- B. The surrounding of nonpolar substances by water
- C. A transient interaction between temporary dipoles
- D. The reason why nonpolar amino acids are buried inside a protein
- E. Occurs because water molecules H-bond with each other as frequently as possible

LECT 3

1. Enzyme X has the amino acid threonine in its active site. A mutation that replaced threonine with valine would likely have what effect on enzyme X?

- A. It would have very little effect.
- B. It would cause the active site to become partially denatured.
- C. It would cause the active site to become an allosteric site.
- D. It would cause the enzyme to completely denature.
- E. It would denature alpha helices, but not beta sheets.

2. We can't digest cellulose, though bacteria can, because . . .

- A. we can't deal with the many branches in the polymer
- B. cellulose is too highly crosslinked by H-bonds for our digestive system
- C. we can't make cellulose storage polymers, but bacteria can
- D. we can't digest β -glycosidic bonds, but bacteria can.
- E. cellulose is a polymer of sugars and amino acids, much like peptidoglycan

3. Nucleic acids are put together from their monomers, nucleotides, with _____ bonds.

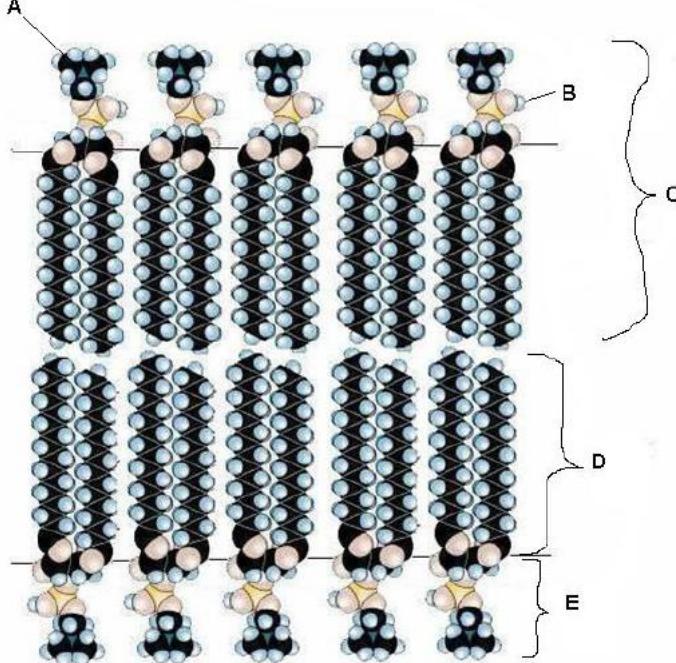
- A. phosphodiester
- B. phosphate
- C. peptide
- D. parallel
- E. ionic

4. Rank the following lipids in order from MOST SOLID to LEAST SOLID at room temperature.

- (1) Saturated lipids
- (2) Cis-unsaturated lipids
- (3) Trans-unsaturated lipids

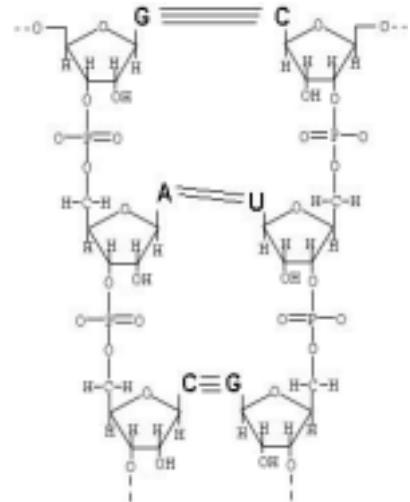
- A. MOST SOLID (1) > (2) > (3) LEAST SOLID
- B. MOST SOLID (3) > (2) > (1) LEAST SOLID
- C. MOST SOLID (1) > (3) > (2) LEAST SOLID
- D. MOST SOLID (3) > (1) > (2) LEAST SOLID
- E. MOST SOLID (2) > (1) > (3) LEAST SOLID

5. In the following depiction of a phospholipid membrane, what represents the fatty acid component of the membrane?



6. What is wrong with this model of a nucleic acid molecule?

- A. A doesn't pair with U
- B. The bases are not attached to the correct carbon
- C. The phosphodiester bonds are not represented correctly
- D. G:C should have only two hydrogen bonds and A•U one
- E. The model is not antiparallel



7. Which of the following is NOT true of cellulose?

- A. It has intramolecular hydrogen bonds
- B. It is branched
- C. It is linked β -1,4
- D. It contains just one glucose isomer
- E. It is considered biodegradable, even though humans can't digest it.

8. Bacteria can vary the lipids they use in their membrane, depending on the temperature. The goal is to keep the membrane from melting, but not allowing it to get so solid that proteins can't move around. How would the membrane of a psychrotroph growing at 28°C compare to the membrane of the same organism growing at 5°C?

- A. It would have more saturated lipids at 5°C
- B. It would melt at 5°C
- C. It would have more cis-unsaturated lipids at 5°C
- D. It would consist of all trans-unsaturated lipids at 5°C
- E. It would solidify at 5°C

9. Amphipathic phospholipids form a membrane bilayer if placed in water. What would happen if the membrane were placed in a nonpolar solvent?

- A. The bilayer would fall apart and form a thin monolayer on top of the solvent
- B. It would form a micelle
- C. It would turn inside out
- D. The phospholipids would no longer be amphipathic
- E. Nothing - because it's amphipathic it would be the same as in water

10. In a protein tertiary structure, the side chains (R-groups) of the amino acids valine and isoleucine (structures on p. 13) could interact by . . .

- A. van der Waals interactions
- B. hydrogen bonding
- C. ionic interactions
- D. covalent bonding
- E. polar covalent bonding

11. Which of the following does NOT involve hydrogen bonding?

- A. Ice floats in water.
- B. DNA forms a double helix.
- C. Lipids form from fatty acids and glycerol.
- D. Evaporation of sweat cools your body.
- E. Water striders (insects) can walk on the surface of a pond.

12. Which of the following describes the hydrophobic effect?

- A. Temporary charge interactions between hydrophobic molecules
- B. Covalent bonds between hydrogen and carbon
- C. Hydrogen bonding of water around hydrophobic molecules
- D. Formation of H_3O^+ and OH from 2 H_2O
- E. Ions surrounded by charge-coordinated water molecules

13. In a protein alpha helix, hydrogen bonds form between . . .

- A. purine and pyrimidine nucleotides
- B. R-groups (side chains) of the polar amino acids
- C. the sugars ribose and deoxyribose
- D. the chiral carbon atoms of the amino acids
- E. atoms in the peptide bonds that join amino acids together

14. A great deal of the structure of a bacterium is composed of carbohydrates. Which of the following structures does NOT involve carbohydrates?

- A. LPS (lipopolysaccharide)
- B. Carboxysomes
- C. Peptidoglycan
- D. Glycocalyx
- E. Starch granules

15. A nucleic acid polymer is formed by . . .

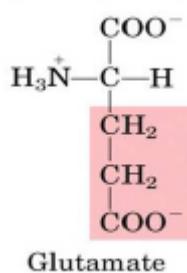
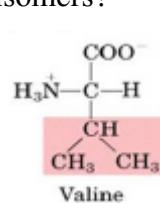
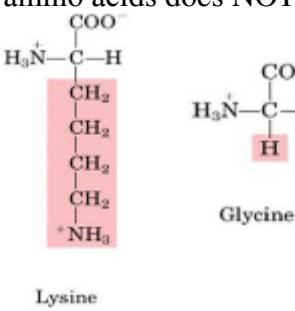
- A. Phosphodiester bonds between 5' and 3' carbon atoms
- B. Phosphodiester bonds between 5' and 2' carbon atoms
- C. Phosphate -Phosphate ionic interactions
- D. Peptide bonds between alpha carbon atoms
- E. Parallel bonds between alpha and beta carbon atoms

16. Which of the following lipids would be the most **fluid** at room temperature?

- A. Phospholipids
- B. Lipids with 3 saturated fatty acids
- C. Lipids with mixed cis- and trans-unsaturated fatty acids
- D. Lipids with 3 cis-unsaturated fatty acids
- E. Lipids with 3 trans-unsaturated fatty acids

17. Which of the following amino acids does NOT have D- and L- stereoisomers?

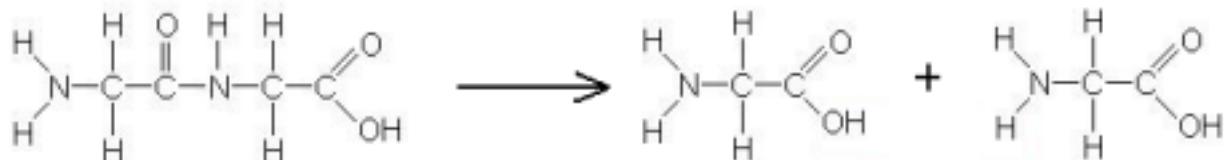
- A. Phenylalanine
- B. Glycine
- C. Glutamate
- D. Valine
- E. Lysine



18. Alpha helices and beta pleated sheets . . .

- A. both involve hydrogen bonding among amino acid R-groups
- B. both require enzymes in order for them to form
- C. are both considered to be protein secondary structures
- D. both involve hydrophobic interactions in addition to hydrogen bonds
- E. cannot be digested by humans, but can be by bacteria

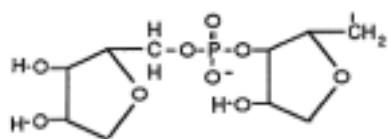
19. This reaction is an example of . . .



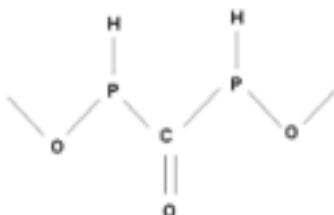
- A. hydrolysis
- B. oxidation
- C. reduction
- D. condensation
- E. transpeptidation

20. Which of the following shows a phosphodiester bond?

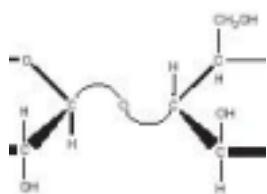
A.



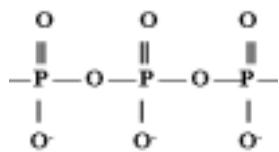
B.



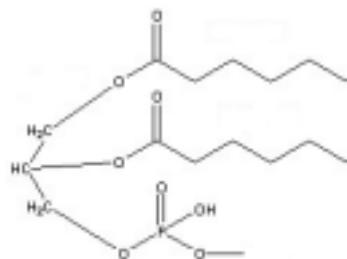
C.



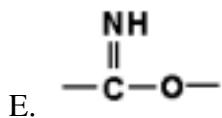
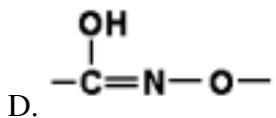
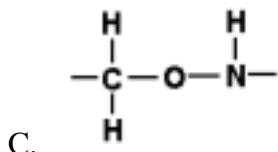
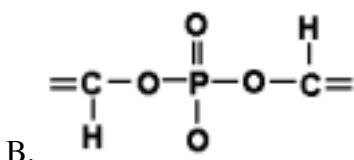
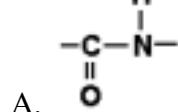
D.



E.



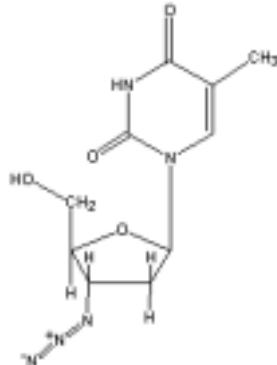
21. Which of the following represents the structure of a **peptide bond** correctly?



22. Why is it important to understand that glycosidic bonds can have both alpha and beta anomers (that there can be α and β glycosidic bonds)?

- A. Though α -glycosidic bonds are not common, they are found in peptidoglycan.
- B. Alpha bonds are helical and beta are flat. This is important for protein function.
- C. It is much harder to digest β -glycosidic bonds. Only bacteria can do it.
- D. Beta glycosidic bonds can participate in hydrogen bonding. Alpha cannot.
- E. Alpha glycosidic bonds form spontaneously. Beta require enzyme catalysis.

23. This is the structure of the DNA synthesis inhibitor and antiviral drug AZT. How does AZT interfere with the structure of nucleic acids so much that it can be used as an antiviral?



- A. Its nitrogenous base can't form H-bonds.
- B. It doesn't have a sugar in its structure.
- C. Its 5' end cannot participate in a dehydration synthesis reaction.
- D. Its 3' end cannot participate in a dehydration synthesis reaction.
- E. Its base has an alpha linkage to its sugar rather than a beta linkage.

24. Condensation reactions . . .

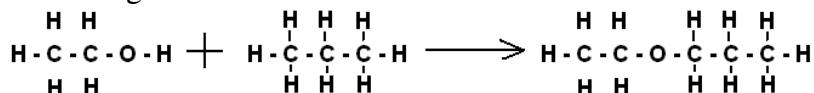
- A. usually require energy input
- B. are usually catabolic
- C. are classed as reduction reactions
- D. are classed as oxidation reactions
- E. involve an $-OH$ from one molecule and a $-C=O$ from another

25. How is hydrogen bonding involved in the structure of cellular lipid molecules?

- A. Fatty acids join to glycerol by H-bonds.
- B. More H-bonds cause straighter phospholipids.
- C. The many C-H groups in fatty acids can form an extensive H-bonded network.
- D. Proteins and lipids join by H-bonding to form biological membranes
- E. H-bonding is not involved in the structure of a lipid molecule.

26. Which of the following is true about a **condensation** reaction?

- A. It involves loss of water from the cell in a hypertonic environment.
- B. It generally requires energy input.
- C. It is one way cells can "break down" long polymers.
- D. It is usually regarded as a catabolic reaction.
- E. An example is the following reaction:



27. What is a disulfide bond?

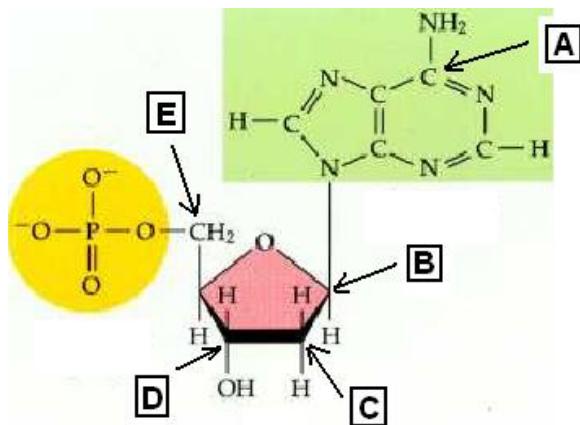
- A. A type of bond that holds carbohydrate polymers together
- B. A bond found in alpha helices and beta sheets
- C. A type of hydrophobic bond between cysteine amino acids
- D. A bond between the sulfur atoms in a DNA double helix
- E. A covalent bond that is involved in forming protein tertiary structures

28. In which of the following polymers would you find alpha glycosidic bonds?

- A. Peptidoglycan
- B. Proteins
- C. Starch
- D. Cellulose
- E. DNA

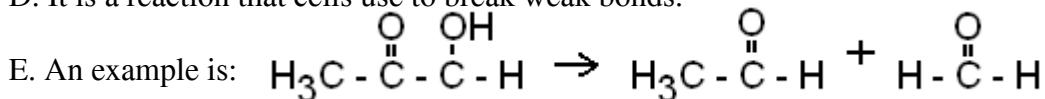
29. Which of the carbon atoms in this nucleotide could be the 3' end of a DNA molecule?

- A. A
- B. B
- C. C
- D. D
- E. E



30. Which of the following is a correct reference to a **hydrolysis** reaction?

- A. It is a type of anabolic reaction.
- B. Carrying it out releases energy.
- C. It is a type of oxidation reaction.
- D. It is a reaction that cells use to break weak bonds.



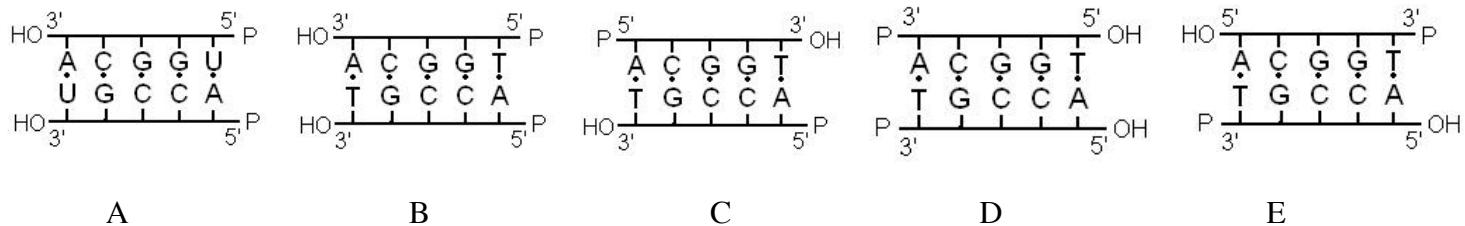
31. Beta sheets . . .

- A. are bonds found in cellulose
- B. involve peptide bond amino groups as H-bond donors
- C. may involve H-bonds between the R-groups of nonpolar amino acids
- D. may involve H-bonds between the R-groups of polar amino acids
- E. are a type of structure in which D-amino acids are more common than L-amino acids

32. We now know that *trans*-unsaturated fatty acids contribute to heart disease, but they were formerly in widespread use in the food industry. What was the advantage in using them?

- A. They flow easily as liquids even at cold temperatures.
- B. They are found in many natural sources, both plant and animal.
- C. They are the most solid of the natural fats, and were used to solidify other fats.
- D. They are the most common fatty acid in cell membrane phospholipids.
- E. They could be synthesized cheaply by heating cholesterol-free natural oils.

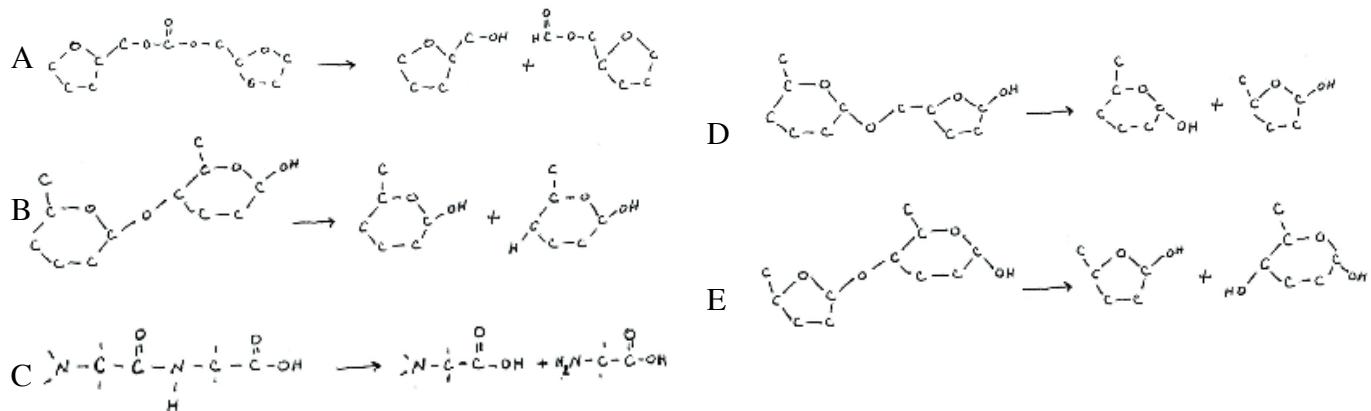
33. Which of the following most accurately represents the structure of DNA?



34. Which of the following would NOT require enzyme catalysis?

- A. Folding of a protein into an alpha helix
- B. Condensation of two amino acids to form a peptide bond
- C. "Breaking down" a protein's primary structure
- D. Interaction between the R-groups of two cysteine amino acids
- E. Rotation of proline's R-group by 180 degrees

35. Which of the following correctly depicts hydrolysis of a beta-glycosidic bond?



36. Which of these is NOT a correct description of a double stranded nucleic acid?

- A. The 5' ends are phosphorylated and the 3' ends are hydroxylated.
- B. The 5'-to-3' direction on one strand is opposite to the 5'-to-3' direction on the other strand.
- C. The sugars in the monomer structures come from the Pentose Phosphate Pathway.
- D. Purines must hydrogen-bond with other purines and pyrimidines with pyrimidines.
- E. Each strand is synthesized by forming covalent phosphodiester bonds between monomers.

37. It is important for a bacterium to keep its membranes from either melting or solidifying as the temperature of the environment changes. Membranes of psychrophilic bacteria must therefore have more _____ than membranes of mesophiles.

- A. cis-unsaturated lipids
- B. trans-unsaturated lipids
- C. saturated lipids
- D. lipopolysaccharide
- E. phosphate groups

38. What is currently our best description of a biological membrane?

- A. Mostly protein with a few phospholipids scattered among the proteins.
- B. Mostly phospholipids with a few peripheral and integral membrane proteins.
- C. About 50% protein with phospholipids grouped in mobile rafts between the proteins.
- D. The inside part of the membrane is phospholipid; the outside part is protein.
- E. The outside part of the membrane is phosphate, the inside part is lipid.

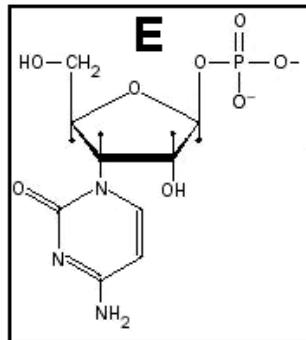
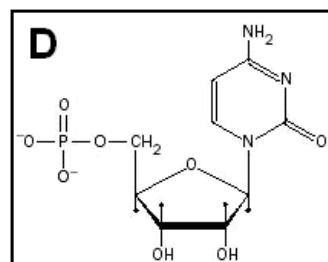
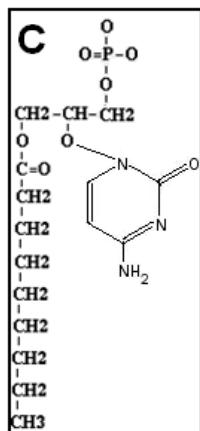
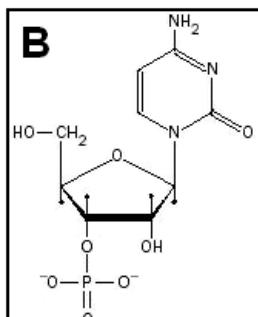
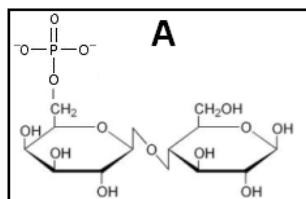
39. Which of the following is true about weak bonds in protein tertiary structure?

- A. It is important for protein function that they can form and break spontaneously.
- B. They only occur when cysteine is present in the protein's primary structure.
- C. They form between amino groups and carboxyl groups within peptide bonds.
- D. They form only between amino acids with nonpolar R-groups.
- E. They include the structure O=C - - - N-H

40. How does starch compare to cellulose?

- A. Starch is an alpha helix; cellulose is a beta sheet.
- B. They are composed of different carbohydrate monomers.
- C. Starch is more linear (less highly branched) than cellulose.
- D. Cellulose degradation requires enzymes; starch degradation does not.
- E. Starch has fewer hydrogen bonds in its structure than cellulose does.

41. Which of the following structures correctly depicts the assembly of a nucleotide?



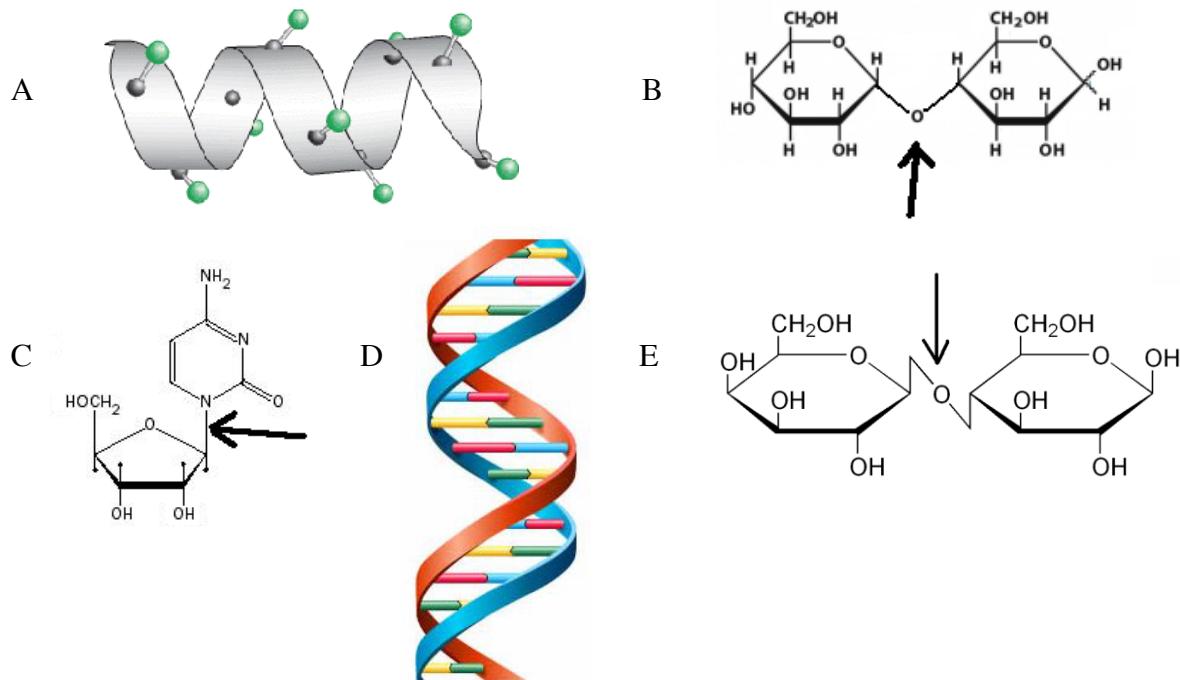
42. Compared to a mesophile, a psychrophile should have . . .

- A. a greater number of membranes
- B. proteins with more surface charges
- C. more saturated lipids
- D. more cis-unsaturated lipids
- E. more hydrogen bonding between lipids

43. Which of the following reactions involves a **net release** of energy?

- A. Making glucose from starch
- B. Assembling a protein from amino acids
- C. Making a membrane from phospholipids
- D. Reducing CO_2 to glucose
- E. Adding a phosphate to the structure of a protein

44. Which of the following structures represents an **alpha glycosidic bond**?



45. A **phosphodiester bond** is important in the structure of . . .

- A. The PTS system
- B. Phosphorylated proteins
- C. RNA
- D. An alpha helix
- E. Phospholipids

46. An unusual membrane lipid is shown at the right. How does this differ from a typical lipid?

- A. The type of bond to the glycerol, and the saturation of the lipid
- B. The type of bond to the glycerol, and the attachment to two glycerols
- C. The type of bond to the glycerol
- D. The fact that it is not a bilayer
- E. The saturation of the lipid and presence of two fatty acids



LECT 4

1. What type of microscope views a specimen with light reflected from the specimen rather than passed through the specimen?

- A. bright field
- B. phase contrast
- C. confocal scanning laser
- D. interference (Nomarski)
- E. dark field

2. What type of microscope would you use to examine a biofilm that was 2 mm thick?

- A. phase contrast
- B. interference (Nomarski)
- C. confocal scanning laser
- D. transmission electron
- E. atomic force

3. What type of microscope measures electric current passing through a probe rather than using any part of the electromagnetic spectrum?

- A. atomic force
- B. interference (Nomarski)
- C. scanning electron
- D. electron tomography
- E. bright field

4. What is the main difference between a negative stain and a positive stain?

- A. A negative stain has a negative charge; a positive stain is positively charged.
- B. A negative stain is used for Gram negative cells, a positive stain for Gram positive.
- C. A negative stain stains negative charges; a positive stain stains positive charges.
- D. A negative stain is not charged, and stains the background rather than the cell.
- E. A negative stain stains the inside of cells; a positive stain stains the outside.

5. Which type of microscope uses special prisms to make a thin specimen appear pseudo-3-dimensional?

- A. Phase Contrast
- B. Dark Field
- C. Scanning Electron Microscope
- D. Differential Interference Contrast
- E. Atomic Force Microscope

6. What is the main advantage of using an electron beam rather than light to illuminate a specimen?

- A. The electron beam is brighter
- B. The electron beam penetrates thick specimens better
- C. Electrons have a shorter wavelength than light
- D. It is easier to focus an electron beam
- E. An electron beam can be used to view live, unstained cells

7. What is the best technique to use if you wish to count the relative numbers of two different bacterial species on the same slide?

- A. Bright Field, with a negative stain
- B. Fluorescence Microscope, with fluorescent antibody stain
- C. Phase Contrast microscope, with a Gram stain
- D. Atomic Force Microscope, unstained
- E. Confocal Scanning Laser Microscope, with a simple stain

8. Which type of microscopy would be most suitable for examining the 3-dimensional appearance of magnetosomes inside a bacterial cell?

- A. Differential Interference contrast
- B. Phase contrast
- C. Transmission electron microscopy
- D. Confocal scanning laser microscopy
- E. Electron crytomography

9. Why is that live bacteria cannot be seen well with a bright field microscope?

- A. They are too small.
- B. The resolution of a bright field microscope is too poor.
- C. The high energy light of the bright field microscope kills them.
- D. Bright field microscopes "see" 3-dimensions, but bacteria have only two.
- E. The contrast achieved by bright field microscopy is too low.

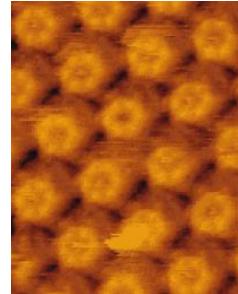
10. Which of the following microscopes depends on interference of illuminating waves that pass through internal cellular structures that have a different refractive index?

- A. Transmission electron microscopy
- B. Dark field microscopy
- C. Phase contrast microscopy
- D. Electron crytomography
- E. Fluorescence microscopy

11. The important feature of a Confocal Scanning Laser Microscope is _____.

- A. a ring condenser that only allows illumination from the side of the specimen
- B. a pinhole that blocks light from all but one plane of a thick specimen
- C. a nanoprobe that measures electric current at the end of a cantilevered arm
- D. a prism that polarizes light in two planes, thereby allowing 3-D images
- E. a sensitive detector that can detect X-rays bounced from the surface of a specimen

12. The picture at right shows the individual proteins in the outer layer of a phycobilisome, a microcompartment found within the cytoplasm of some bacteria. What sort of microscope was used to image this structure?



- A. Atomic force microscope
- B. Transmission electron microscope
- C. Differential interference contrast microscope
- D. Confocal scanning laser microscope
- E. Scanning electron microscope

13. A negative stain is best used to view _____ structures.

- A. positively charged
- B. negatively charged
- C. uncharged
- D. Gram negative
- E. internal

14. One way to enhance contrast under a microscope without enhancing resolution is to _____.

- A. use microscope slide oil
- B. use a simple stain
- C. use a lower wavelength of illuminating light
- D. use an electron microscope
- E. It is not possible to enhance contrast without also enhancing resolution.

15. In order to view this specimen, a special technique must be used. Why?



- A. This technique must be used to view individual cells.
- B. This technique helps to view very thick specimens.
- C. This technique is a form of differential stain that improves contrast.
- D. The specimen is thinner than 0.2 microns.
- E. The light used by this technique is polarized, which improves resolution.

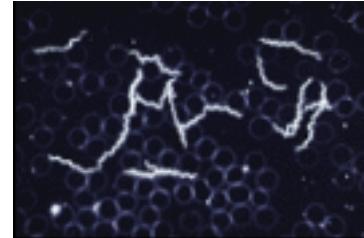
16. An atomic force "microscope" is different enough that some people do not consider it a microscope at all. What is so different about it compared to other microscope types?

- A. It does not use light.
- B. It has complicated electronic components to control the focus.
- C. There is no true magnification system; just a sensitive electrical probe and amplifier.
- D. It produces an image that must be stacked together with other images in a computer.
- E. It uses a rotating illuminating beam to image the sample at multiple angles.

17. How can the **contrast** of a microscopic image be improved?

- A. By using a longer wavelength of illuminating light
- B. By staining the specimen
- C. By using electrons for illumination rather than light
- D. By using microscope slide oil
- E. By increasing the magnification

18. These bacteria are about 0.1 micrometers (μm) in diameter. How is it that we can see them?



- A. We are using an optical trick to see them in 3 dimensions.
- B. This is an electron micrograph.
- C. We have added a fluorescent dye and are using confocal microscopy.
- D. We are illuminating them obliquely and viewing the reflected light.
- E. 0.1 μm is pretty big for a bacterium, so size is not a problem in this case.

19. Both Phase Contrast and Nomarski (DIC) microscopy are based on what optical principle?

- A. Light can be separated into perpendicular polarized beams.
- B. A 3-dimensional image can be built up by combining plane images.
- C. Passing through a specimen alters the spacing of the peaks in a light wave.
- D. Light waves can add to or cancel each other resulting in a dark image.
- E. The angle of incidence of a light wave equals the angle of reflection.

20. This microscope is especially useful for viewing biofilms and other thick specimens. A movable pinhole contributes to the clarity and focus of the image.

- A. Confocal Scanning Laser Microscope
- B. Scanning Electron Microscope
- C. Fluorescence Microscope
- D. Transmission Electron Microscope
- E. Bright-field Microscope

21. Which type of microscope is best for examining unstained protozoal cells?

- A. Bright field microscope
- B. Fluorescence microscope
- C. Differential interference contrast microscope
- D. Transmission electron microscope
- E. Atomic force microscope

22. Which type of microscope is the best to use for viewing viruses attached to human host cells?

- A. Atomic force microscope
- B. Scanning electron microscope
- C. Confocal scanning laser microscope
- D. Phase contrast microscope
- E. Dark field microscope

23. Electron cryotomography is most useful for _____.

- A. observing motile bacteria
- B. viewing thick specimens
- C. observing the molecular details of a chemical compound
- D. obtaining a three-dimensional view of internal cellular structures
- E. identifying multiple bacterial species simultaneously from a single sample

24. The acid-fast stain is an example of a differential stain. What makes it "differential"?

- A. It uses a special differential dye during the staining process.
- B. It stains the background of the slide rather than the cells.
- C. It stains positively charged molecules in the cell rather than negatively charged molecules.
- D. It stains special bacterial structures called differentials that are present in some cells.
- E. It uses two stains, along with a solvent that removes stain from some cells but not all.

25. A phase contrast microscope involves the use of which of the following hardware items?

- A. two Wollaston prisms
- B. a movable pinhole
- C. a fluorescence emission filter
- D. an annular diaphragm and an etched glass plate
- E. a detector for reflected light beams

26. For many years, when we examined the structure of certain cells by transmission electron microscopy, we saw linear striations (or stripes) that may or may not correspond to round bodies seen in cross sections of these same cells (see arrows). It would be of interest to know how many of these there are, and whether they are folded and doubled back on each other within one of the layers of the cell. What tool could best be used to answer this research question?

- A. Scanning electron microscopy
- B. Electron cryotomography
- C. Dark-field microscopy
- D. Atomic Force microscopy
- E. Nomarski (DIC) microscopy



27. For what purpose would you use a **negative stain**?

- A. to stain the background around uncharged structures
- B. to stain cells whose membranes have a positive charge
- C. to stain cells with a thick peptidoglycan layer
- D. to stain cells with a thin peptidoglycan layer
- E. to stain cells without a cell wall

28. A positive diagnosis for a particular disease is made by examining a throat swab stained with the Acid-Fast stain. What organism is causing this disease?

- A. A Gram positive organism like Streptococcus
- B. An encapsulated organism like Klebsiella
- C. Mycobacterium
- D. Mycoplasma
- E. an enveloped virus like Influenza

29. The **contrast** of a specimen viewed by light microscopy can be improved by ____.

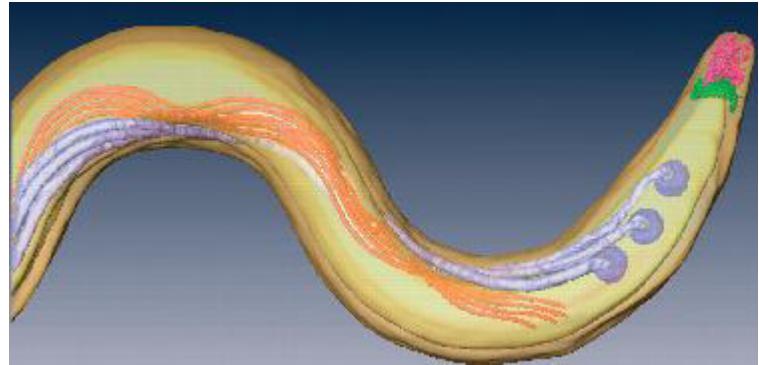
- A. using immersion oil
- B. blocking directly transmitted light
- C. increasing the magnification
- D. using a blue filter under the condenser
- E. using a longer wavelength light to illuminate the specimen

30. Viewing a thick specimen, such as a bacterial biofilm, would likely require which of the following?

- A. a special condenser
- B. a differential stain
- C. two Wollaston prisms
- D. a movable pinhole
- E. a phase-shifting element

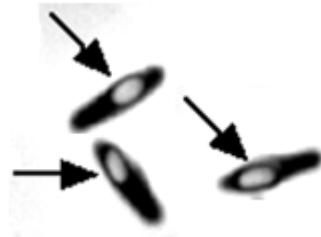
31. The picture at the right shows an unusual type of bacterium that has its flagella within its periplasm. What microscopic technique was needed to observe these flagella?

- A. Atomic force microscopy
- B. Electron cryotomography
- C. Electron chromatography
- D. Scanning electron microscopy
- E. Phase contrast microscopy



32. In this picture you are looking at _____ under a _____ microscope, stained with _____.

- A. endospores, phase contrast, nothing
- B. rod-shaped bacteria, dark-field, the Gram stain
- C. capsules, bright-field, negative stain
- D. endospores, transmission electron, nothing
- E. protozoa, DIC (Nomarski), simple stain



33. How can you improve the **resolution** of a light microscope?

- A. Use a blue filter under the condenser.
- B. View the specimen with a negative stain.
- C. Dim the intensity of the light source.
- D. Use a microscope with enhanced contrast.
- E. Have the light pass through a medium with a refractive index <1

34. Which of the following microscopes depends on the phenomenon of photon drag to differentiate between structures with different refractive index?

- A. Dark-field
- B. Confocal
- C. TEM
- D. Phase contrast
- E. Bright-field

35. What type of picture is the one that is being used to examine the very tiny organism at the right (note the scale bar)?

- A. DIC (Nomarski) micrograph
- B. Transmission electron micrograph
- C. Atomic force micrograph
- D. Electron cryotomogram
- E. Confocal micrograph



36. Which staining technique is correctly matched with a microscope technique for which that stain would typically be used?

- A. Negative stain and dark-field microscopy
- B. Gram stain and differential interference contrast microscopy
- C. Acid-fast stain and bright-field microscopy
- D. Fluorescent stain and phase contrast microscopy
- E. Methylene blue simple stain and transmission electron microscopy

LECT 5

1. A major difference between Gram negative and Gram positive cell walls is . . .

- A. Gram negative walls have teichoic acid storage polymers
- B. Gram positive walls are made of peptidoglycan
- C. Gram negative walls are much thicker than Gram positive walls
- D. Gram positive walls are enclosed within a membrane-bound space
- E. Gram positive walls are crosslinked via a pentaglycine interbridge

2. The purpose of osmoprotectants accumulating within bacterial cells is to

- A. prevent the cytoplasm from shriveling up in hyperosmotic environments
- B. prevent the cytoplasm from shriveling up in hypoosmotic environments
- C. prevent the cell from lysing in hyperosmotic environments
- D. prevent the cell from lysing in hypoosmotic environments
- E. Prevent the cell from either lysing or shriveling up, depending on the environment

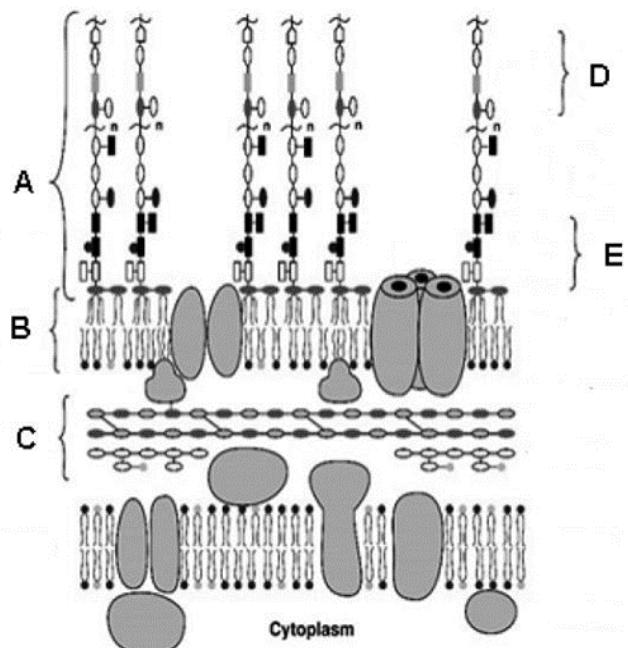
3. The PMF is used directly for all of the following EXCEPT. . .

- A. flagellar rotation
- B. transport through major facilitator (MFS) transporters
- C. transport of water through aquaporins
- D. ATP synthesis via chemiosmosis
- E. transport of the amino acid glutamate into the cell

4. In an environment that was isotonic to the cell's cytoplasm, what effect would penicillin have on logarithmic phase Gram negative rod shaped cells?

- A. no effect
- B. The cells would lose their rod shape
- C. The cells would die but remain intact
- D. The cells would lyse
- E. The cells would become Gram positive

5. In this diagram of a Gram negative cell wall, which letter designates the O-antigen (O polysaccharide) component of the LPS layer?

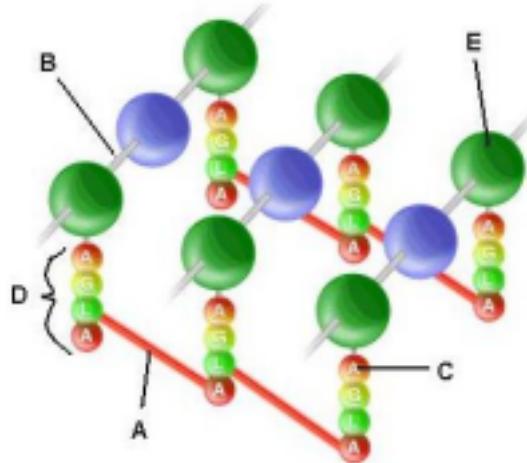


6. What would happen to Mycoplasma cells placed in a solution that was hypotonic with respect to the cytoplasm of the cells?

- A. They would plasmolyze
- B. They would synthesize osmoprotectants
- C. They would lyse
- D. They would experience an increase in turgor pressure, but would not lyse
- E. They would not experience any changes

7. Refer to the diagram of peptidoglycan at the right. What is different between Gram negative and Gram positive peptidoglycan?

- A. The structure marked "A" is only found in G+ cells
- B. The bond marked "B" is an α -1,4 bond in G+ cells and a β -1,4 bond in G- cells
- C. The amino acid marked "C" is an L-amino acid in G+ cells and a D-amino acid in G- cells
- D. The structure marked "D" does not exist in G- cells
- E. The molecule marked "E" is a sugar in G+ cells and an amino acid in G- cells



8. How does an amino acid get through the Gram negative outer membrane?

- A. By simple diffusion
- B. LPS is much more permeable than phospholipid
- C. By use of energy from the PMF
- D. Through special facilitated diffusion channels
- E. Through teichoic acid channels

9. What part of bacterial cells is called "endotoxin" because of its toxic effects in vertebrates?

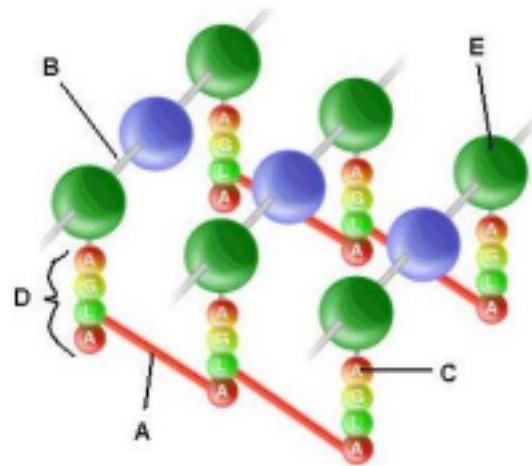
- A. Peptidoglycan
- B. Flagella
- C. Pili
- D. Lipopolysaccharide
- E. Teichoic acids

10. Which of the following is NOT involved in the formation of a proton motive force (PMF) in bacteria?

- A. an electron transport chain
- B. an ion gradient across the cell membrane
- C. a charge separation (voltage gradient) across the cell membrane
- D. a proton pump that uses energy from sunlight
- E. an ABC transport protein

11. Which of the structures on the diagram at the right is affected by the enzyme lysozyme?

- A. A
- B. B
- C. C
- D. D
- E. E



12. Is a blood infection with Gram negative or Gram positive cells more dangerous? Why?

- A. G+, because of teichoic acids in the membrane
- B. G+, because the cells can't be killed with readily available antibiotics
- C. G-, because of toxic shock induced by LPS "endotoxin"
- D. G-, because of the O-antigen layer of the outer membrane
- E. G-, because we can't make antibodies against any G- cell surface structures.

13. Mycolic acids cause mycobacteria to . . .

- A. be shapeless
- B. be Gram positive
- C. resist chemical damage
- D. stick to surfaces
- E. be toxic to humans

14. If a Gram positive bacterium is placed in a solution that is hypotonic with respect to its cytoplasm, how will it survive?

- A. It will rapidly secrete solutes.
- B. It will synthesize osmoprotectants.
- C. It will rapidly secrete water.
- D. It will synthesize a second membrane.
- E. It has a cell wall.

15. LPS (lipopolysaccharide) is highly toxic to mammals. What feature of LPS makes it so unusual compared to other molecules in its class?

- A. It has a lipid that is not based on a glycerol backbone.
- B. It has a sugar with both alpha and beta glycosidic bonds.
- C. It is a lipid, but is amphipathic.
- D. It contains a protein without any chiral carbon atoms.
- E. It contains a branched polymer of sugar molecules.

16. What is the unique feature of the Mycobacterial cell wall?

- A. It contains a thick layer of very dense lipids.
- B. Its peptidoglycan is crosslinked directly rather than with a pentaglycine spacer.
- C. It is made of protein rather than lipids and peptidoglycan.
- D. It stains better with a negative stain than with a positive stain.
- E. It has no cell wall, only a membrane.

17. When a Gram positive bacterial cell is placed in a hyperosmotic environment, what happens?

- A. It lyses.
- B. Turgor pressure builds up inside the cell, but the cell does not lyse.
- C. Ions flow rapidly into the cell through the membrane.
- D. Water flows out of the cell through passive diffusion carriers.
- E. Water must be pumped into the cell to dilute the salts.

18. A typical bacterial cell is growing in a typical culture. It is using the ATP synthase to make ATP. Then a scientist adds a chemical to its membrane that permits protons to flow freely across the lipid bilayer. Will the bacteria still be able to use its ATP synthase?

- A. Yes, because it can still have a PMF, even without a proton gradient.
- B. No. The reaction to make ATP requires that 2 H⁺ be donated to ADP.
- C. Yes, because electrons can still be donated to ADP to make ATP.
- D. No. Without a proton gradient, there is no PMF, and no PMF means no ATP synthase.
- E. Yes, but only as a Type III secretory system, which uses ATP rather than the PMF.

19. Why are Mycoplasma bacteria considered “pleomorphic”?

- A. They have a thick peptidoglycan layer.
- B. They have no cell wall.
- C. They have a layer of mycolic acid.
- D. They can protect themselves from osmotic pressure.
- E. They contain an outer membrane of LPS.

20. We said that membranes are semi-permeable. Which of the following can pass freely through the membrane without the use of transporter proteins?

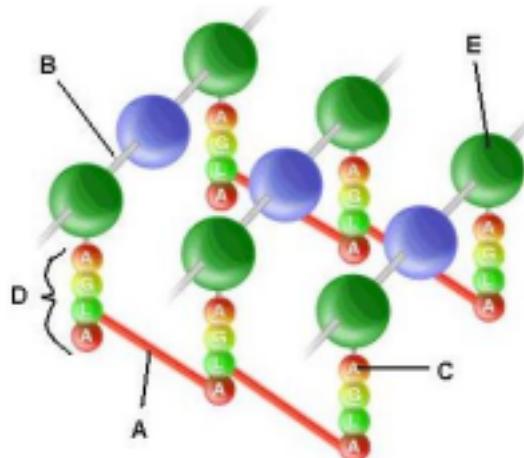
- A. small non-polar molecules
- B. small polar solvents like water
- C. H⁺ ions
- D. polysaccharides
- E. ATP

21. What will happen when cells of the bacterium Mycoplasma are placed in distilled water?

- A. They will synthesize osmoprotectants so that they do not plasmolyze.
- B. They will plasmolyze.
- C. They will swell with turgor pressure, but will not burst.
- D. They will lyse.
- E. These are very robust cells, and they will grow in distilled water.

22. Which of the following peptidoglycan structures is affected by penicillin?

- A. A
- B. B
- C. C
- D. D
- E. E



23. Some bacteria have mycolic acids in their outer membrane. What property does the mycolic acid give these bacteria?

- A. Increased membrane permeability
- B. Resistance to lysozyme
- C. A supplemental Proton Motive Force
- D. The ability to store phosphate in molecular form
- E. Resistance to chemical disinfectants

24. Some bacterial cells can synthesize osmoprotectants to avoid _____.

- A. lysis in a hypotonic environment
- B. lysis in a hypertonic environment
- C. turgor pressure against their cell walls
- D. plasmolysis in a hypotonic environment
- E. plasmolysis in a hypertonic environment

25. Most, though not all, bacteria have an electron transport chain. Why?

- A. to carry out redox reactions
- B. to create a proton gradient
- C. to use O₂ to synthesize ATP more directly
- D. to perform substrate-level phosphorylation
- E. to remove excess electrons from the cell

26. A former student of mine now works as a microbiologist for a company that makes medical implants. His company was thinking of using cell mass as a surrogate measurement (as a "stand-in") for endotoxin concentration. My student wondered whether this was a good idea, and he called to ask me about it. What do you think? Was it a good idea?

- A. Yes. The more cells there are, the more endotoxin they would have.
- B. Yes. Endotoxin makes up a substantial portion of the peptidoglycan structure. C.
- No. Not all bacteria have endotoxin. Mass wouldn't tell you if they have it or not. D.
- No. It would be better to use a viable cell count for this.
- E. It doesn't matter, since endotoxin is only toxic to other bacteria.

27. Bacterially synthesized osmoprotectants are most useful to prevent _____ in a _____ environment.

- A. lysis ; hypotonic
- B. lysis ; hypertonic
- C. plasmolysis ; hypotonic
- D. plasmolysis ; hypertonic
- E. denaturation ; thermophilic

28. Is it possible for a bacterium to have a PMF if the bacterium is in an isotonic environment?

- A. Yes. Individual ions can still form charge and concentration gradients even though the overall ion concentration is isotonic.
- B. No. Isotonic means that there are no gradients of any kind across bacterial membranes.
- C. Yes. But the bacterium must spend ATP to create the PMF by pumping ions. D. No. Equalization of solute concentrations will also equalize charges, so there will be no overall membrane potential in an isotonic environment.
- E. Yes, but the bacterium must be Gram negative, since gradients are formed across the inner membrane of Gram negative bacteria.

29. What is the feature of the Mycobacterial cell envelope that is not found in other bacteria?

- A. Its peptidoglycan is crosslinked with a pentaglycine spacer.
- B. It has an outer membrane with porins to allow small molecules to enter the cell.
- C. It contains a thick layer of very dense lipids in its outer membrane.
- D. It is made of protein rather than lipids and peptidoglycan.
- E. It has no cell wall, only a membrane.

30. If a typical (non-halophilic) bacterial cell is placed in a hypertonic environment . . .

- A. it will build up turgor pressure, but will not lyse because it has a cell wall
- B. it will undergo plasmolysis
- C. it will be fine, because the cell wall will prevent it from shrinking too much
- D. salt will rush in to equalize concentrations on both sides of the membrane
- E. it will undergo lysis

31. Which of the following is a unique molecule in the Gram positive cell envelope (envelope = wall + membrane(s))?

- A. D-alanine
- B. glycine
- C. lipid A
- D. lipoteichoic acid
- E. lipoprotein

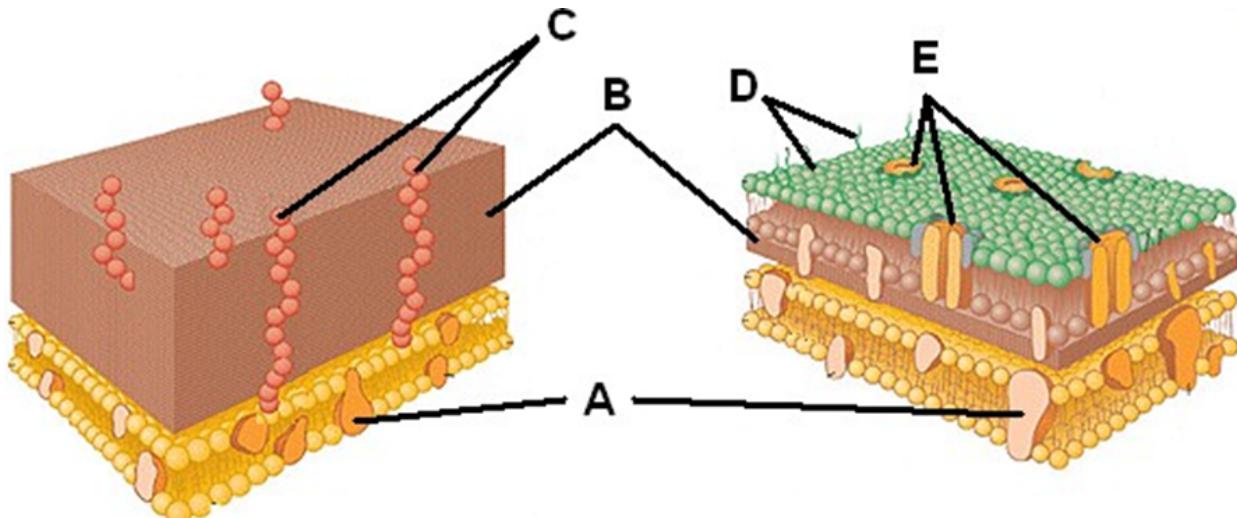
32. You stain a slide of Mycobacterium according to the Gram stain procedure. What will you see under a bright-field microscope?

- A. It has no cell wall, so you won't see anything – it won't stain.
- B. It has no peptidoglycan, so it would stain pink.
- C. It has a lot of protein in its outer membrane, so it will stain purple.
- D. It has only one membrane, so it will stain purple.
- E. It has a very hydrophobic substance in its outer membrane, so it will not stain.

33. Cytoplasm in normal cells typically has about 15 mM $[Na^+]$. If you placed typical cells in a solution with 150 mM $[Na^+]$, what would happen?

- A. H_2O would rapidly leave the cells
- B. H_2O would rapidly enter the cells
- C. Na^+ would rapidly enter the cells
- D. Na^+ would rapidly leave the cells
- E. H^+ would rapidly leave the cells

34. Which of the structures below most accurately represents a **porin**?



35. What is the function of the LPS that is a part of some bacterial cell envelopes?

- A. It is a phosphate storage polymer.
- B. It is necessary for bacteria to invade human host cells.
- C. It is a carbohydrate storage polymer.
- D. It is an additional permeability barrier.
- E. It helps some cells retain turgor pressure to avoid lysis.

36. Which of the following is NOT a structural component of Archaeal cell walls?

- A. Chondroitin
- B. Pseudopeptidoglycan
- C. Protein
- D. Lipopolysaccharides
- E. All of the above are structural components

37. Which of the following bacteria does NOT contain peptidoglycan in their cell walls?

- A. Gram positive
- B. Gram negative
- C. Mycoplasma
- D. Mycobacteria
- E. All of the above contains peptidoglycan

LECT 6

1. An active transport uniport uses what source of energy to bring molecules across the cell membrane?
 - A. Uniports do not use energy
 - B. The potential energy in the gradient of the molecule being transported
 - C. The voltage potential (electrical charge) across the membrane
 - D. The proton gradient
 - E. ATP
2. A primary active transporter is essentially irreversible (it only transports molecules in one direction) because...
 - A. It is the main type of transporter in most cells
 - B. It establishes a molecular gradient that keeps molecules from moving in the other direction
 - C. It uses ATP, which is a much more powerful energy source than the PMF
 - D. It alters the molecule once it is inside the cell, so it cannot go back out
 - E. It requires a protein to bond from the outside before the channel can open
3. Which of the following is NOT true of the PTS (phosphotransferase) transport system?
 - A. It involves direct transfer of a phosphate from ATP to glucose
 - B. It uses energy from a high energy phosphate, though not from ATP
 - C. It is found only in Bacteria, not Archaea or Eukaryotes
 - D. It involves multiple phosphate transfers in a “relay”
 - E. It is used mostly for transport of carbohydrates
4. Why are we interested in studying type III secretion systems?
 - A. They allow secretion of fully folded proteins
 - B. They are often associated with insertion of toxins directly into eukaryotic cells
 - C. They can secrete proteins constantly without any external secretion signal
 - D. They produce a periplasmic intermediate, whose folding in the periplasm is unique
 - E. They are involved in bacterial cell motility, just like flagella
5. What type of transport is carried out by the PTS (phosphotransferase system)?
 - A. Import of sugars
 - B. Export of fully folded proteins
 - C. Import of negatively charged amino acids
 - D. Export of proteins into the cell membrane
 - E. Import of positively charged ions such as NH_4^+

6. A hallmark of a type III secretion system is...
- A. Ability to concentrate proteins a million fold or more
 - B. Secretion only once contact has been made with a host cell membrane receptor
 - C. Use of cytoplasmic chaperone, Sec B
 - D. Secretion only through the outer membrane
 - E. Presence of periplasmic intermediate
7. Why does passive transport require energy?
- A. To concentrate a molecule against its concentration gradient
 - B. To pump a molecule against the PMF
 - C. To force a molecule through the hydrophobic interior of the membrane
 - D. To open facilitated diffusion channels in the membrane
 - E. Passive transport doesn't require any energy
8. How does the MFS antiport pump Na^+ out of the cell?
- A. It uses the energy of the proton gradient
 - B. It uses the membrane potential (charge component of the PMF)
 - C. It uses both the membrane potential and proton gradient energy
 - D. It uses energy in the Na^+ gradient
 - E. It uses the energy from ATP hydrolysis
9. Which of the following is a characteristic of a bacterial type II export system?
- A. Secretion of carbohydrates out of the cell
 - B. Use of a leader peptide (signal sequence) to determine which proteins to secrete
 - C. Secretion of fully folded proteins and nucleic acids
 - D. Secretion through both inner and outer membrane simultaneously
 - E. Secretion from a bacterium directly into a eukaryotic host cell
10. Why does the PTS (phosphotransferase system) use a phosphorelay mechanism?
- A. To sense the available carbohydrate and regulate cell responses accordingly
 - B. The phosphate picks up a little more energy with each transfer
 - C. It is the simplest possible mechanism to import glucose
 - D. To pump phosphate out of the cell against the membrane potential
 - E. It is the only mechanism available for primary active transport
11. Which of the following is NOT a feature of the “gated rocker-switch” mechanism for transporter function?
- A. Transport channel open alternately to the outside, then the inside of the cell
 - B. Plug in transport channel moved aside by energy from ATP
 - C. Substrate binding site near the middle of the membrane bilayer
 - D. Gates help reduce transport in the reverse direction
 - E. Gate opening stabilized by binding of symported or antiported ion

12. Why is the phosphorelay mechanism involved in sugar transport in bacteria?
- A. The energy from the phosphate is increased slightly at each step until it is enough to open the transport channel
 - B. Each protein in the phosphorelay can transport a different sugar molecule
 - C. Each protein in the relay can be used to regulate other cell processes based on the presence or absence of sugar in the environment
 - D. Each protein in the relay can receive a phosphate from a different phosphate carrier, either ATP, ADP, or PEP
 - E. The phosphorelay can be used to make a PMF, which can then be used to make ATP
13. Structurally, what does it mean that transport of solute #1 with its gradient allows transport of solute #2 against its gradient?
- A. Solute #1 will be transported into a cell, solute #2 out, as in an antiport
 - B. Solute #1 will bind to the inside of the transporter, solute #2 to the outside
 - C. Solute #1 forms weak bonds with solute #2 so that they enter the cell together
 - D. Solute #1 holds the transporter open long enough for solute #2 to bind
 - E. It is a thermodynamic “trick”. Solute #1 is actually turned into solute #2 inside the cell
14. Which of the following is a unique feature of the PTS transport system?
- A. The use of periplasmic binding protein
 - B. A relay that allows many opportunities for regulation of the transporter
 - C. The use of ATP as an energy source rather than the PMF
 - D. Two-stage transport with an intermediate in the periplasm
 - E. Solute-controlled gates to prevent transported solutes from leaving the cell
15. There is currently much interest in studying efflux pumps that bacteria use to eliminate toxins and antibiotics. What is one characteristic of these efflux pumps?
- A. They allow secretion of fully folded proteins
 - B. They include a long extracellular “needle complex”
 - C. The toxin is secreted through bacterial membranes in 1 step
 - D. The toxin is secreted through both bacterial membranes and a host cell membrane in one step
 - E. They are made of lipids rather than proteins
16. Which of the following is NOT a feature found in Type II secretion systems (T2SS)?
- A. A leader peptide (signal sequence) that identifies proteins to be secreted
 - B. A chaperone that prevents the protein from folding before it is secreted
 - C. Two-stage secretion with a periplasmic intermediate
 - D. A large transport complex in the inner membrane called the “Sec translocon”
 - E. Transport is blocked until the bacterium contacts another cell

17. What special feature of ABC import transporters make them essentially irreversible?

- A. Molecular gates controlled by binding of the solute to the transporter
- B. A protein that binds solute before it signals from the periplasm for the transporter to open
- C. A rocker-switch that only opens to the periplasm
- D. Their transport of very large, and even fully folded proteins
- E. A signal sequence on transported proteins that does not allow reverse transport

18. What makes passive transport “passive”?

- A. It is unable to concentrate a solute against a chemical gradient
- B. There is no form of energy involved in the transport
- C. There is no transporter involved in the transport
- D. While the PMF can be used for transport, ATP is not
- E. It can only be used for osmotic transport of water, not solutes

19. Some transporters have gates. What is the purpose of the gates in gated transporters?

- A. To ensure that the transporter doesn't open until ATP is hydrolyzed
- B. To increase the accumulation ratio by preventing reverse transport
- C. To make it easier for the solute to bind the active site of the transporter
- D. To reduce the amount of energy needed to move the rocker switch
- E. To stabilize the outward-facing conformation of an import transporter

20. Which of the following is a unique feature of the PTS transport system?

- A. The use of periplasmic binding protein
- B. The ability to import large proteins as well as small ions
- C. The use of ATP as an energy source rather than the PMF
- D. Two-stage transport with an intermediate in the periplasm
- E. A relay that allows many opportunities for regulation of the transporter

21. What is the “Sec translocon”?

- A. A transporter that imports fully folded proteins
- B. A transporter that moves molecules through the outer membrane
- C. A transporter that inserts proteins with a signal sequence through the inner membrane
- D. A chaperone that keeps proteins unfolded for insertion through the inner membrane
- E. A transporter that makes a single channel through both bacterial membranes

22. The most evolutionary primitive rocker-switch model for transport proteins requires...

- A. ATP hydrolysis to provide energy
- B. A transporter with two alternative conformations
- C. A transporter with a periplasmic binding protein
- D. A proton motive force to provide energy
- E. Solute gates to prevent reverse transport

23. A bacterium is growing in a medium with a $[K^+]$ of 1 mM. The bacterium uses a uniport to accumulate K^+ to 10mM concentration inside the cell. What is the energy for this transport?

- A. The membrane potential
- B. The K^+ gradient
- C. The pH gradient
- D. ATP hydrolysis
- E. No energy is required for this transport

24. Which of the following is NOT a characteristic of the bacterial PTS transport system?

- A. It involves phosphate transfer between several protein intermediates
- B. It saves energy by bringing glucose into the cell in a form that is ready for glycolysis
- C. It can be used to import and export a wide variety of solutes
- D. The use of many steps in a relay allows for metabolic regulation in response to glucose
- E. LeChatelier's Principle ensures that phosphorylated solutes can accumulate inside the cell.

25. What is the purpose of a molecular chaperone during protein secretion in bacteria?

- A. It keeps a protein in an unfolded conformation until transport
- B. It shepherds a protein through the endomembrane system to bring it to a transporter
- C. It prevents reverse transport of some proteins
- D. It provides the energy for some protein transporters
- E. It can be used to transport fully folded proteins

26. A certain bacterium uses proline as an osmoprotectant. What sort of proline transporter serves this purpose best? Why?

- A. An ABC system because of a protein that prevents reverse transport
- B. A PTS system because adding phosphate keep proline from leaking back out
- C. A uniport because proline will be the only substrate transported
- D. A proline/ H^+ symport because importing H^+ will reduce the external osmolarity
- E. A Type I Secretion system to secrete proline directly into the environment

27. Which of the following is a similarity between Type II and Type III secretion systems?

- A. Use of ATP hydrolysis as the energy source for transport
- B. Formation of periplasmic intermediate
- C. Presence of an extracellular needle complex
- D. Ability to secrete proteins while they are still being synthesized by the ribosome
- E. Structural relationship to structures for motility

28. How is the energy of a H^+ gradient most directly used by the cell to uptake glucose?

- A. The H^+ gradient makes ATP. Which powers a glucose transporter
- B. Binding of a H^+ flips the transporter to the alternate conformation
- C. Binding of a H^+ holds a transporter open until glucose also binds
- D. The H^+ provides a charge gradient that pulls glucose into the cell
- E. The H^+ binds to glucose and makes it impossible for glucose to leave the cell

29. Which of the following is NOT a feature of facilitated diffusion channels, such as aquaporins?

- A. They transport solutes in only 1 direction
- B. They switch between two stable conformations
- C. They cannot concentrate a solute on one side of the membrane
- D. They require energy in order to open and close
- E. They are considered passive transporters

30. The drug valinomycin affects the membrane potential, but not the ΔpH . Which of the following transporters would be most affected by treatment with valinomycin?

- A. An ADP/ATP antiport
- B. A lysine uniport
- C. A H^+ /glucose symport
- D. A gated H^+ /glucose symport
- E. A type III secretion system

31. What is the role of the periplasmic binding protein in ABC uptake systems?

- A. It hydrolyzes ATP
- B. It provides a channel through the outer membrane
- C. It provides energy to “switch” the conformation of the transporter
- D. It is a chaperone that keeps secreted proteins folded
- E. It blocks reverse transport of the solute

32. All of the following are advantages of the PTS system, EXCEPT...

- A. It allows the cell to sense the presence of glucose
- B. It allows the regulation of intracellular reactions in response to glucose
- C. It is an efficient transfer of phosphate from ATP directly to glucose
- D. It readies glucose for the metabolic reactions in which it will later be used
- E. It takes advantage of LeChatelier’s Principle to increase transport efficiency

33. What do bacterial ABC drug efflux pumps and Type III secretory systems have in common?

- A. Both make use of a needle complex
- B. Both are structurally related to flagella
- C. Both allow transport of fully folded proteins
- D. Neither involves a periplasmic intermediate
- E. Neither requires contact with another cell to initiate transport

LECT 7

1. Pili are involved in all of the following EXCEPT . . .

- A. Horizontal gene transfer
- B. Protein secretion
- C. Motility
- D. Surface attachment
- E. Biofilm formation

2. An organism with **carboxysomes** would be expected to be a . . .

- A. heterotroph
- B. phototroph
- C. autotroph
- D. auxotroph
- E. organotroph

3. Which of the following is NOT a part of the process of endospore formation?

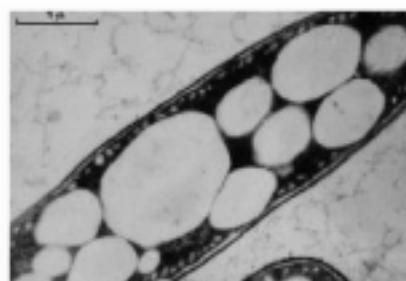
- A. Cell divides asymmetrically
- B. Mother cell engulfs developing spore
- C. Special peptidoglycan layer is deposited around the spore
- D. Spore replicates its DNA one last time in case conditions improve
- E. Mother cell lyses to release spore

4. Which of the following is NOT a function of capsules or slime layers?

- A. surface adhesion
- B. preventing phagocytosis
- C. motility
- D. enhancing biofilm formation
- E. biofouling of filters

5. The large intracellular structures seen inside this cell are likely used for . . .

- A. storage of electron acceptors
- B. photosynthesis
- C. orientation in a magnetic gradient
- D. survival in harsh environments
- E. storage of carbon reserves for later metabolism



6. How are pili involved in bacterial motility?

- A. A H⁺ gradient causes them to rotate like propellers
- B. They move back and forth like oars
- C. They are extended and retracted like grappling hooks
- D. They vibrate rapidly and jiggle the bacterium across a surface
- E. They hook two bacteria together, making other motion more efficient

7. The bacterium *E. coli* exhibits flagellar motility and chemotaxis toward the amino acid alanine. If *E. coli* is placed in a 100 millimolar solution of alanine, which of the following would best describe its behavior?

- A. Motion in a continuous straight line
- B. Motion in continuous counterclockwise circles
- C. Directed motion with occasional random re-orientations
- D. Random, undirected motion
- E. No motion - cells would not be motile in this solution

8. Why do we consider that the bacterial Type III secretion system is an intermediate in flagellar evolution?

- A. Both T3SS and flagella are involved in cell motility.
- B. Both T3SS and flagella are made of the proteins flagellin and pilin.
- C. T3SS and flagella are found only in Gram positive cells.
- D. T3SS and flagella are both hollow filaments with similar membrane proteins.
- E. T3SS and flagella are both examples of bacterial rotary motors.

9. What is the function of the bright structures seen inside these chemolithoautotrophic cells?

- A. They align the cell with a magnetic field.
- B. They can provide a source of electrons.
- C. They store chlorophyll.
- D. They allow the cells to float at the top of a pond.
- E. They store carbon for use during times of starvation.



10. The protein coat of an endospore . . .

- A. is formed very early in the sporulation process.
- B. is deposited between the membranes of the forming endospore and the mother cell.
- C. is involved in drying out the spore core.
- D. is the structural equivalent of the Gram negative outer membrane.
- E. is a thin layer of protein crosslinked with glycosidic bonds.

11. The bacterium *Streptococcus mutans* is well known for its ability to form biofilms. What feature of the bacterium is responsible for this ability?

- A. Adhesion pili
- B. Specialized proteins in its outer membrane
- C. Secretion of alginate
- D. A sucrose-induced glycocalyx
- E. Production of acidic fermentation products

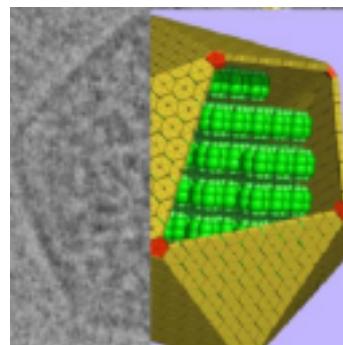
12. Flagella and pili can both be responsible for bacterial cell motility. How are these two types of motility similar?

- A. Both involve rotation of filaments outside the cell.
- B. Both use ATP as their direct energy source.
- C. Both involve secretion and withdrawal of appendages from the cell.
- D. Both cause cells to move faster in higher concentrations of nutrients.
- E. Both cause cells to move in a jerky manner rather than in smooth linear fashion.

13. **Volutin** (metachromatic) granules are used to store . . .

- A. Phosphate
- B. CO₂
- C. Glucose
- D. Sulfur
- E. Photosynthetic pigments

14. What is the function of the bacterial structure shown at the right?
(Shown as a combined microscopic and crystallographic view.)



- A. to store CO₂ in autotrophic bacteria
- B. to concentrate enzymes used to reduce CO₂ in autotrophs
- C. to organize photosynthetic reaction pigments
- D. to store sulfur in lithotrophic bacteria
- E. to store carbon in heterotrophic bacteria

15. Capsules or slime layers are wholly or partly responsible for all of the following EXCEPT ...

- A. motility
- B. surface adhesion
- C. biofouling of filters
- D. avoiding phagocytosis
- E. formation of biofilms

16. The bacterium *E. coli* exhibits flagellar motility and chemotaxis toward the amino acid alanine. Assume *E. coli* is placed in a defined medium, and a crystal of alanine is added. Which of the following best describes the behavior of the *E. coli*?

- A. Continuous straight line motion to the alanine
- B. Continuous motion in counterclockwise circles
- C. Directed motion with occasional random reorientations
- D. Random, undirected motion
- E. No motion – *E. coli* would not be motile in this medium

17. The presence of carboxysomes in a bacterial cell indicates that the cell . . .

- A. can store carbon reserves
- B. can use an organic electron donor
- C. is an auxotroph
- D. is an autotroph
- E. is a phototroph

18. Phosphate that will be used to make cellular structures is stored in . . .

- A. DNA
- B. Volutin granules
- C. PHB granules
- D. Phosphobilisomes
- E. ATP

19. The negative staining procedure must be used to visualize a bacterial capsule in the bright field microscope. What conclusion can you make from that statement?

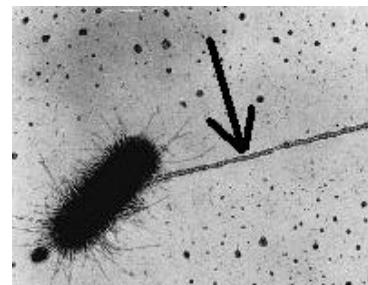
- A. A capsule must be made from positively charged amino acids.
- B. The capsule must be phosphorylated.
- C. Bacteria that have a capsule must also have a thin peptidoglycan layer
- D. Better resolution of capsule structure could be achieved by dark field microscopy.
- E. Carbohydrates must not be able to bind charged dyes.

20. How can an *E. coli* cell move toward a point source of a molecular attractant?

- A. A protein at one end of the cell acts like an "eyespots" to "see" the attractant.
- B. There is a higher attractant concentration at one end of the cell than at the other, and *E. coli* can move forwards or backwards toward the higher concentration.
- C. *E. coli* can tumble less frequently if it is moving towards a continually increasing attractant concentration.
- D. The cell follows signals from other cells that are nearer to the attractant than it is.
- E. It can't. *E. coli* can only move toward attractant that is evenly distributed in a solution.

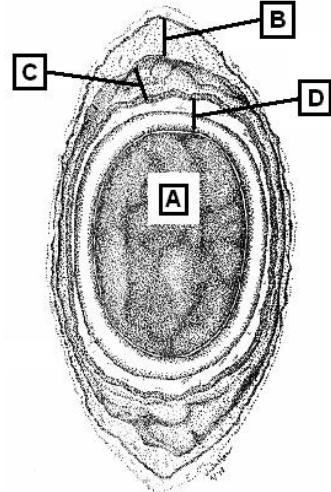
21. The structure indicated by the arrow is most important for . . .

- A. protein storage
- B. electron transfer between cells
- C. motility
- D. surface attachment of biofilms
- E. DNA transfer



22. Which part of a bacterial endospore contains a special type of peptidoglycan that is responsible for absorbing the water from the core to keep it dry?

- A. A
- B. B
- C. C
- D. D
- E. The structure that absorbs water from the core is actually a part of the mother cell, and is lost early during the sporulation process.



23. This is a picture of *Neisseria gonorrhoeae* adhering to cervical epithelial cells. What structure is it using to adhere to the cells?

- A. Capsule
- B. Volutin
- C. Flagella
- D. Pili
- E. Nanowires



24. What happens to a swimming bacterial cell when its flagella reverse their direction of rotation?

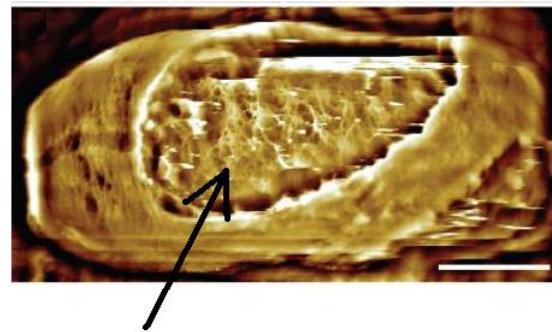
- A. The cell reverses its direction of travel.
- B. The cell re-orientates randomly to face a new direction.
- C. H⁺ are pumped out of the cell rather than flowing in.
- D. Nothing. The bacterium continues until its flagella become methylated.
- E. Flagella are unidirectional. It is impossible for them to reverse rotation.

25. Chemolithoautotrophic bacteria can increase their growth rate if they contain inclusions called _____ that make the cell's metabolism more efficient.

- A. Carboxysomes
- B. PHB granules
- C. Chlorosomes
- D. Metachromatic granules
- E. Phycobilisomes

26. The structure shown here is able to survive boiling water. The arrow is pointing to a layer of this structure. What is the function of this layer?

- A. To protect against radiation and chemicals
- B. To carry genetic material to the next generation
- C. To soak water from the internal part of the structure, keeping it dry and inert
- D. To engulf another cell type by endocytosis
- E. To have DNA wrapped around it so that radiation damage to the DNA can be readily repaired



27. Structures that transport electrons between bacterial cells in a dense culture are called _____.

- A. Electron transport chains
- B. Biofilms
- C. Glycocalyses
- D. Electrosomes
- E. Nanowires

28. *Streptococcus mutans* produces this only in the presence of sucrose, leading to the development of dental caries (cavities).

- A. Type III secretion system
- B. Nanowires
- C. Lactic acid
- D. Adhesion pili
- E. Glycocalyx

29. Why does *E. coli* reverse the direction of its flagellar rotation periodically?

- A. That's how the cell reverses the direction in which it is traveling.
- B. The cell fails to encounter a higher attractant concentration.
- C. So the cell can make ATP rather than use ATP to turn the flagella.
- D. The reversal is random; it is not regulated by the *E. coli*.
- E. It doesn't. *E. coli* flagella fall apart if they reverse rotation.

30. Which of the following would you expect to find in both photolithoautotrophs and chemoorganoheterotrophs?

- A. Chlorosomes
- B. Volutin granules
- C. Sulfur granules
- D. Magnetosomes
- E. Carboxysomes

31. Why is a glycocalyx usually viewed by using the negative staining procedure?

- A. The glycocalyx usually has a positive charge.
- B. The glycocalyx usually has no charge.
- C. The glycocalyx contains negatively charged phosphate groups.
- D. The glycocalyx contains a thin layer of sugars, much like thin peptidoglycan.
- E. This stain is required for the type of microscope usually used to see a glycocalyx.

32. *E. coli* cells are able to chemotax towards a nutrient attractant (*ATR*). How?

- A. By comparing *ATR* concentrations at the "front" and the "back" ends of the cell
- B. By using a Type III ATPase to concentrate the *ATR* at one end of the cell
- C. By never reversing flagella rotation if an *ATR* is in the environment
- D. By sensing *ATR* concentration every few milliseconds and keeping a "memory" of it
- E. By using flagella for propulsion, and "steering" with pili to approach the *ATR* directly

33. What is "Horizontal Gene Transmission"?

- A. The transfer of DNA from one bacterium to another using Type III secretory systems
- B. The transfer of DNA from one bacterium to another using special pili
- C. The exchange of DNA between two bacteria using Type III secretory systems
- D. The exchange of DNA between two bacteria using special pili
- E. The exchange of protein gene products between two bacteria using Type III secretory systems

34. What function do bacterial microcompartments carry out?

- A. They orient bacteria in an oxygen gradient.
- B. They concentrate photosynthetic pigments.
- C. They store carbon reserves that bacteria use during times of carbon starvation.
- D. They store phosphate reserves that bacteria use during times of phosphate starvation.
- E. They concentrate enzymes and their substrates to improve reaction rates.

35. Which of these is important for the function of flagella, but not for Type III secretory systems?

- A. An ATPase
- B. A rotor complex
- C. Membrane bushings
- D. A H⁺channel
- E. A hollow exterior filament

36. You're a microbiologist looking at a biofilm from a lithotrophic bacterium. Some cells have sulfur granules, but not all do. What other organelles could you expect to find in this culture?

- A. Flagella
- B. Phycobilisomes
- C. Nanowires
- D. PHA granules
- E. Magnetosomes

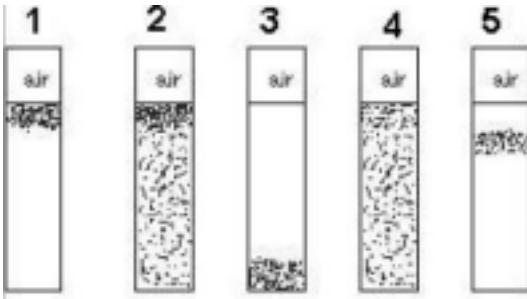
37. Why are Microbiologists so interested in studying bacterial microcompartments (BMCs)?

- A. We can use the materials inside them to make a biodegradable plastic.
- B. They resemble other bacterial structures, including flagella and pili.
- C. They give us insights into the protein secretion systems.
- D. We can concentrate enzymes whose efficiency we want to increase.
- E. Although there is no practical use for BMCs, they are quite interesting scientifically.

LECT 8

1. Tubes 1-5 represent growth in shake tubes. Which of the following is true of the organisms growing in tube # 5?

- A. They are facultatively anaerobic.
- B. They live mostly by fermentation.
- C. They produce lots of catalase.
- D. They are very heavy cells.
- E. They use O₂ as a terminal electron acceptor.



2. The best way to store an unknown bacterial culture long-term is to _____.

- A. leave it in the incubator on a nutritionally rich plate
- B. put it in the refrigerator
- C. freeze it in 15% glycerol
- D. put it on a slant and keep it at 4°C
- E. lyophilize it and store at room temperature

3. Superoxide dismutase is _____.

- A. one of the components of the electron transport system
- B. an enzyme that allows aerobes to survive in oxygen
- C. an enzyme that allows thermophiles to survive high temperatures
- D. an enzyme that allows autotrophs to reduce CO₂
- E. a storage granule for lithotrophic electron sources

4. Adding an antibiotic to a microbial growth medium makes the medium _____.

- A. selective
- B. complex
- C. differential
- D. defined
- E. anaerobic

5. An enrichment culture for a psychrophile would involve which of the following steps?

- A. Grow a mixed culture at a low pH.
- B. Grow a mixed culture in a complex medium which would grow other cells, too.
- C. Grow a pure culture at 15°C.
- D. Grow a mixed culture at 4°C.
- E. Grow a pure culture in a defined medium in which only nutritionally fastidious organisms can grow.

6. The growth temperature profile for a bacterium shows an optimal growth rate at a temperature of 39°C. Which of the following is true?

- A. The organism is probably a thermophile
- B. The organism would probably not grow at 42°C
- C. The organism could probably also grow at 29°C and 49°C
- D. The organism could grow at any temperature that allows water to be a liquid
- E. The natural habitat for this organism is probably soil

7. An organism that does not have a respiratory electron transport chain, but produces some superoxide dismutase (and possibly peroxidase) would be called _____.

- A. An aerotolerant anaerobe
- B. A facultative aerobe
- C. A microaerophile
- D. An obligate anaerobe
- E. An obligate aerobe

8. One consequence of an acidophilic lifestyle is _____.

- A. rapid growth due to the abundance of “natural” PMF energy
- B. the use of an ATP synthase that is powered by Na⁺ ions rather than H⁺
- C. making proteins with a large number of surface charges
- D. the need to use ATP to pump H⁺ out of the cell
- E. a cytoplasmic pH of around 4

9. You wish to perform an enrichment culture to isolate a chemolithoautotroph from the sludge at the bottom of a bog. Which of the following could be a part of this enrichment culture?

- A. Inoculating bog sludge into a complex medium with lots of growth factors
- B. Vigorous shaking under bright lights
- C. Use of a CO₂-enriched atmosphere in a Gas-Pak jar
- D. A minimal medium with glucose as a carbon source
- E. Use of embryonated chicken eggs

10. Adding a pH indicator to a minimal medium makes the medium _____.

- A. selective
- B. complex
- C. auxotrophic
- D. anaerobic
- E. differential

11. A bacterium that is an obligate intracellular parasite of human cells is most likely a/an _____.

- A. mesophile
- B. halophile
- C. psychrophile
- D. obligate anaerobe
- E. acidophile

12. The organism that grows as shown in an agar shake tube . . .



- A. produces lots of catalase
- B. is a facultative anaerobe
- C. would also grow well on a petri dish incubated on a lab bench
- D. requires O₂ as an electron acceptor
- E. is an aerotolerant anaerobe

13. One adaptation made by alkalophiles to live in their environment is . . .

- A. the ability to maintain an acidic cytoplasm
- B. synthesis of osmoprotectants
- C. ability to use a sodium motive force rather than a proton motive force
- D. modification of soluble proteins to have numerous surface charges
- E. proteins with increased stability at high temperatures

14. The purpose of an enrichment culture is to _____.

- A. grow lots of different cells in an enriched medium
- B. prevent or inhibit growth of many bacteria in a sample
- C. allow better growth of one type of bacteria than others from an environmental sample
- D. grow fastidious bacteria or auxotrophs
- E. grow obligate intracellular parasites

15. What does it mean to say that a bacterial colony is "clonal"?

- A. All the colonies on a petri dish are of the same cell type.
- B. All the cells in a colony look the same, though they may not be identical genetically.
- C. All the cells in a colony are genetically engineered with a cloned protein.
- D. All the cells in the colony are growing as fast as they can.
- E. All the cells in the colony arose by binary fission from a single cell.

16. What must be true of a bacterium growing as shown in a thioglycollate tube?



- A. It has both a fermentative and a respiratory metabolism.
- B. It has a respiratory chain with cytochrome c.
- C. It will also grow in a CO₂-enriched atmosphere in a Gas-Pak jar.
- D. It uses pyruvate as a terminal electron acceptor.
- E. It produces gas vesicles.

17. A bacterial growth medium is prepared with Na₃PO₄, K₂SO₄, NH₄Cl, C₆H₁₂O₆ and yeast extract. What is the purpose of the yeast extract?

- A. It allows the growth of nutritionally fastidious organisms.
- B. It makes the medium selective.
- C. It makes the medium differential.
- D. It increases the length of the lag phase in the growth curve.
- E. Without it, organotrophic bacteria will not be able to grow in the medium.

18. Microaerophiles _____.

- A. produce large amounts of the enzyme catalase
- B. grow at the bottom of a shake tube
- C. grow as well in the presence of oxygen as they do without oxygen
- D. are small, obligate parasites of other bacterial cells
- E. usually have a metabolism that depends on a respiratory chain

19. A chemolithoheterotroph might get its _____ from _____.

- A. carbon from CO₂
- B. electrons from glucose
- C. electrons from CO₂
- D. energy from sunlight
- E. energy from glucose

20. The ingredients list for a biological medium is shown at the right. This medium is _____.

KH ₂ PO ₄	6 g/liter
Na ₂ HPO ₄	3 g/liter
(NH ₄) ₂ SO ₄	2 g/liter
CaCl ₂	10 mg/liter
Fe ₂ SO ₄	3 mg/liter
Yeast Extract	1.5 g/liter
Neutral Red (pH indicator)	1 mg/liter

- A. complex
- B. complex and differential
- C. defined
- D. selective
- E. defined and selective

21. What significant information did we discover from our realization in the last 20 years or so that bacteria can form biofilms?

- A. It is much easier to control bacterial growth if they are in biofilms.
- B. Biofilms represent a new, rare form of microbial life that we need to study.
- C. Bacterial populations can become specialized and behave like a multicellular organism.
- D. Biofilm formation involves a unique attachment organelle that was unknown before.
- E. Allowing biofilms to form is an easy way to isolate clonal groups of bacteria.

23. Given their particular lifestyle, thermophilic bacteria must have evolved specialized mechanisms to guard against _____.

- A. solidification of their membranes
- B. denaturation of their enzymes
- C. development of too large a PMF
- D. plasmolysis of their cytoplasm
- E. osmotic lysis of their cell wall

23. In the diagram of a shake tube at the right, dots represent bacterial growth. A bacterial culture that grows as shown _____.

- A. gets more ATP from oxidative phosphorylation than from substrate level phosphorylation
- B. requires oxygen in small amounts but cannot tolerate too much
- C. produces lots of catalase and superoxide dismutase
- D. gets most of its energy from NADH
- E. has no respiratory chain, but can detoxify oxygen



24. A **photoorganautotroph** gets its _____ from _____.

- A. gets its carbon from CO₂
- B. gets its electrons from CO₂
- C. gets its energy from glycolysis
- D. gets its carbon from complex carbohydrates
- E. gets its electrons from light

25. Complex growth factors are most likely to be required _____.

- A. for growth of fastidious organisms
- B. in an enrichment culture
- C. to perform a very complicated experiment
- D. for growing prototrophs
- E. to make a medium "differential"

26. Why is a freezer culture of bacteria stored in a solution of glycerol?

- A. Glycerol provides a carbon source for the bacteria.
- B. Glycerol disrupts the hydrogen bonding structure of frozen water.
- C. Glycerol provides growth factors that are useful when the culture is revived.
- D. Glycerol is important as an osmoprotectant in these bacteria.
- E. Glycerol keeps bacteria metabolically inert during long storage.

27. A bacterium that can grow within the temperature range of 70°C to 110°C typically has an optimum growth temperature of _____.

- A. 70°C
- B. 75°C
- C. 90°C
- D. 105°C
- E. 110°C

28. A growth medium with the recipe shown at the right would be considered a _____ medium.

- A. defined
- B. complex
- C. differential
- D. selective
- E. fastidious

Na ₂ HPO ₄	6gram (g)
KH ₂ PO ₄	3gram (g)
NaCl	0.5gram (g)
NH ₄ Cl	1gram (g)
ddH ₂ O	to 1litre (l)
Note: autoclave. Add 10 ml filter sterilized	
100 mM MgSO ₄ , 20% glucose, 10 mM CaCl ₂	

29. How should you try to grow a bacterium that cannot make its own ATP?

- A. It would not be possible to grow this bacterium in the laboratory.
- B. The bacterium should be grown with complex growth factor supplements.
- C. It should be grown in a specialized atmospheric chamber.
- D. ATP should be provided in the growth medium for this bacterium.
- E. It should be grown on a layer of eukaryotic cells in tissue culture.

30. You have isolated a new bacterium, and you would like to store a culture of it for future use. What is the best way to do that?

- A. Place the broth containing a batch culture of the cells in the refrigerator.
- B. Expose the culture to UV light to get it to form endospores.
- C. Lyophilize the culture and store it in a vial at room temperature.
- D. Add glycerol to 25% concentration and store the liquid culture at -70°C.
- E. Wrap a petri dish containing the culture with parafilm and store it in the refrigerator.

31. Look at the table below. Which row of the table represents **aerotolerant anaerobes**?

	<u>Ability to detoxify Oxygen</u>	<u>Metabolic Style</u>
A.	Yes	Fermentative
B.	No	Respiratory
C.	No	Fermentative
D.	Yes	Respiratory
E.	Yes	Respiratory + Fermentative

32. Which of the following evolutionary adaptations would alkalophilic bacteria need in order to live in the environment where they are found?

- A. A reversed membrane potential
- B. Proteins with more disulfide bonds
- C. A Na^+ transport channel between their flagellar rotor and stator
- D. A highly active respiratory chain with many proton pumps
- E. Ability to use something other than oxygen as the terminal electron acceptor

33. What must be provided in a growth medium in order to grow **auxotrophs**?

- A. CO_2
- B. light
- C. eukaryotic host cells
- D. antibiotics
- E. growth factors

34. Bacterial growth media containing the ingredients shown in the list at the right would be called _____.

- A. differential and defined
- B. selective and defined
- C. differential and complex
- D. selective and complex
- E. defined and complex

per liter of media

Na_2HPO_4	1.3g
KH_2PO_4	2.8g
KOH	0.6g
$(\text{NH}_4)_2\text{SO}_4$	0.5 g
NaCl	1.0 g
glucose	10 g
blood	50 ml

35. A human pathogen whose optimal growth temperature is 37°C is **LEAST** likely to also be able to grow _____.

- A. at 45°C
- B. at 15°C
- C. at pH 5.5
- D. at pH 7.5
- E. without oxygen

36. Addition of yeast extract to a bacteriological growth medium would be most important for the growth of _____.

- A. lithotrophs
- B. autotrophs
- C. auxotrophs
- D. phototrophs
- E. prototrophs

37. You have just incubated a streak plate, and you see that it has two distinct colony types growing on it. You want to save both colony types long term? How?

- A. refrigerate the plate
- B. first make an enrichment culture from the plate
- C. transfer the original culture to a slant rather than to another plate
- D. Lyophilize the broth culture that was used to make the plate
- E. pick each colony to a small tube containing 20% glycerol

38. A psychrotroph growing at 30°C has a membrane with 60% saturated lipids. The same organism incubated at 40°C would most likely . . .

- A. not grow at all
- B. grow, and have 0% saturated lipids
- C. grow and have 30% saturated lipids
- D. grow normally, with about 60% saturated lipids
- E. grow and have 80% saturated lipids

39. What is the purpose of an **osmoprotectant** during growth in a hypertonic environment?

- A. To prevent turgor pressure from lysing the cell
- B. To bind and reduce the concentration of ions in solution
- C. To balance solute concentrations on both sides of a membrane
- D. To block aquaporins and prevent water flow
- E. Nothing. Osmoprotectants are important in a **hypotonic** environment.

40. In the medium used to grow a **lithotroph**, you would most likely require which of the following?

- A. light as a source of electrons
- B. glucose as a source of carbon
- C. a high concentration of NaCl
- D. NH₄⁺ as a source of electrons
- E. complex growth factors as a nutrient source

41. Which of the following makes a bacterial culture **selective**?

- A. addition of blood
- B. culturing on an agar slant
- C. addition of yeast extract
- D. growth in a chemostat
- E. addition of methylene blue

42. Which of the following lists the steps of biofilm creation in the correct order?

- A. Proliferation, cell-cell adhesion, attachment, maturation, dispersion
- B. Cell-cell adhesion, attachment, proliferation, maturation, dispersion
- C. Dispersion, proliferation, cell-cell adhesion, maturation, attachment
- D. Attachment, cell-cell adhesion, proliferation, maturation, dispersion
- E. Attachment, cell-cell adhesion, dispersion, proliferation, maturation

43. Which of the following is not a way to store bacterial cultures long-term?

- A. Agar slants
- B. Agar plates, refrigerated
- C. Add glycerol at 25% and store at -70F
- D. Lyophilized powder
- E. None of the above

44. What is one way that cells can avoid plasmolysis?

- A. Use membrane transporters to move salts out of the cell
- B. Flagella are used to swim towards a osmotic environment
- C. Block aquaporins and preventing water flow
- D. can “adsorb” salt by binding to protein surface charges
- E. Causing the cell membrane to become rigid and inflexible

45. Which of the following is not an elemental nutrient required for bacterial growth?

- A. Carbon
- B. Potassium
- C. Manganese
- D. Sulfur
- E. Nitrogen

LECT 9

1. Which of the following equations would be used to solve this problem? (You may need a calculator for this.)

"How many bacteria would you need to start with in order to have as many cells as the Earth's population (6 billion) within 12 hours? The bacterium divides in 30 minutes."

- A. $(6 \times 10^9) = x e^{(1.39)(12)}$
- B. $(6 \times 10^9) = e^{12 x}$
- C. $(6 \times 10^9) = x e^{(0.5)(12)}$
- D. $x = (6 \times 10^9) e^{(2)(12)}$
- E. $x = (6 \times 10^9) e^{(1.39)(12)}$

2. A pharmaceutical technician wished to produce large quantities of a bacterial secondary metabolite from a chemolithoheterotroph. She grew the organism in a chemostat with glucose, H₂S and oxygen, plus trace elements and growth factors. But she got very low yields of the secondary metabolite. What was her mistake?

- A. She should not have used glucose.
- B. The oxygen was probably toxic to her bacteria.
- C. She should not have used a chemostat.
- D. She needed sulfate in addition to H₂S.
- E. She probably did not wait long enough.

3. Cells in a biofilm are very tightly adherent to one another, have variable metabolic activity, and many are dead. What technique would be best to enumerate (count) the cells in a biofilm?

- A. most probable number method
- B. turbidity measurement
- C. Coulter counter
- D. measure metabolic acid production
- E. dry and weigh the biofilm

4. More than 99% of the organisms present in a soil sample do not grow in laboratory media. What would be the most appropriate way to count the organisms present in a soil sample?

- A. Coulter counter
- B. Petroff-Hausser chamber
- C. Pour plate technique
- D. Dry and weigh the soil sample
- E. Perform a luciferase assay

5. One major difference between batch culture and continuous culture is that _____.

- A. batch culture never reaches stationary phase
- B. batch culture is best used to produce primary metabolites, such as ethanol
- C. continuous culture involves fewer nutrients
- D. continuous culture is set up in a series of flasks, not just one
- E. continuous culture allows the researcher to change the bacterial growth rate

6. The Most Probable Number (MPN) method ____.

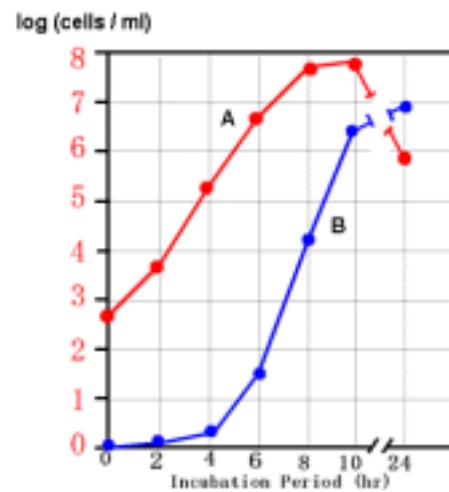
- A. is a rough estimate of the actual titer based on optical density
- B. is usually performed by pouring a sample of the culture through a filter
- C. is used for very large sample volumes
- D. requires multiple culture tubes, but no petri dishes
- E. is considered to be a direct cell count, even though it is statistically based

7. A new bacterial enumeration method has been developed that moves bacteria physically from one chamber of a microchip to another with a micromanipulator (sort of like an atomic force microscope probe tip). This would be an example of ____.

- A. a viable cell count
- B. an indirect measurement
- C. optical density measurement
- D. a direct cell count
- E. a statistical method

8. Compare the two cultures represented by the growth curves at right. Which of the following conclusions can you make?

- A. Culture B has the higher growth rate.
- B. Culture B was likely placed in a nutrient-rich medium just before growth.
- C. Culture A never reaches stationary phase.
- D. Culture A has more persister cells.
- E. After 10 hours, all cells in culture A have stopped dividing.



9. One advantage of growing cells in continuous culture is that ____.

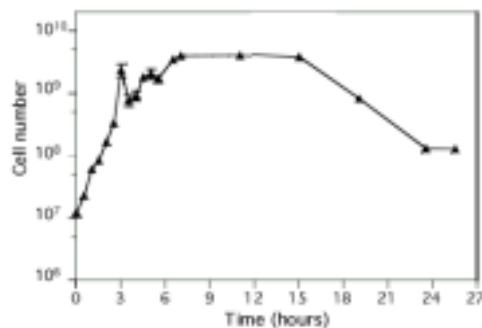
- A. you can get them to produce more secondary metabolites, such as antibiotics.
- B. their growth rate constant (μ) is higher than in batch culture.
- C. you can make the cells grow as fast or as slowly as you want.
- D. there is no special equipment required.
- E. you can count them more easily than in batch culture.

10. Which of the following methods would give the **lowest** count for a population of bacteria in stationary phase?

- A. Petroff-Hauser chamber
- B. Coulter counter
- C. Turbidity measurement
- D. Measuring the mass of the culture
- E. Counting colonies on a pour plate

11. At the right is a bacterial growth curve. What can you conclude about the culture from which the growth curve was measured?

- A. It produced only secondary metabolites.
- B. It was grown in a chemostat.
- C. After 9 hours, no cells are still dividing.
- D. It did not have to adapt to new growth conditions.
- E. After 9 hours, no nutrients are left in the medium.



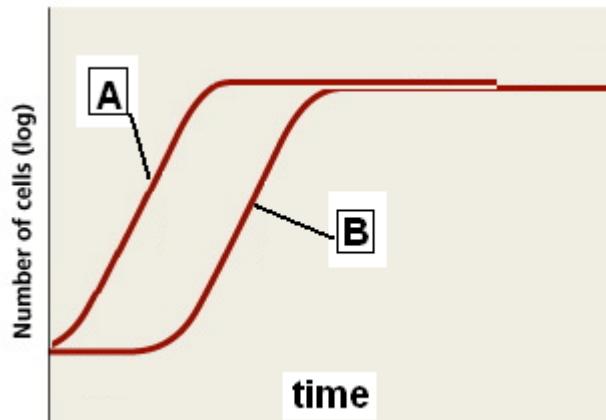
12. You have a bacterial culture with high turbidity. Which of the following would NOT be a reasonable way to quantify the number of bacteria in this sample?

- A. membrane filtration and plating the filter
- B. using a Coulter counter
- C. counting cells in a Petroff-Hausser chamber
- D. dilution of the culture and spread plating
- E. using the luciferase assay

13. Which of the following methods of enumerating bacterial growth could be most easily adapted to counting only motile bacterial cells in a culture?

- A. Membrane filtration and plating
- B. Petroff-Hausser chamber
- C. Luciferase reaction
- D. Coulter counter
- E. Weighing bacterial biomass

14. Two bacterial cultures, A and B, were inoculated into "medium M," and produced the growth curves shown at the right. What can you conclude about these cultures?



- A. Culture A has the higher growth rate.
- B. Culture A produces more primary metabolites than culture B.
- C. Culture A had been growing in a medium similar to "medium M" before it was inoculated.
- D. Culture B had been growing in a nutrient-poor medium before it was inoculated into "medium M."
- E. Culture B eventually becomes a continuous culture.

15. Which of the following would typically be done in a chemostat?

- A. Harvesting antibiotics
- B. Enriching a culture for persister cells
- C. Storing a culture long-term without allowing it to grow
- D. Measuring the growth rate, μ , under a variety of nutrient concentrations
- E. Determining how long bacteria may survive in a natural environment

16. You are using a fluorescence microscope and an antibody-based stain to examine a mixed culture from a patient's blood for the titer of *Treponema pallidum*, the bacterium that causes syphilis. What would be the best method to make this titer determination?

- A. Petroff-Hausser chamber
- B. MPN method
- C. Viable cell count
- D. Membrane filtration and plating
- E. Turbidity measurement

17. Which equation would you use to solve the following problem:

You inoculate a single cell with a doubling time of 30 minutes into 50 ml of culture medium and allow it to grow for 7 days. How many cells will be in the culture after 7 days.

- A. $N = 50 e^{(30)(7)}$
- B. $N = e^{(0.5)(7 \times 24)}$
- C. $50 N = (\ln 30)(7 \times 24)$
- D. $N = e^{(\ln 2 / 0.5)(7 \times 24)}$
- E. Binary fission will not continue for 7 days, so this cannot be solved with the growth equation.

18. The bacterium *Streptomyces* does not undergo binary fission, but rather each cell elongates and then divides to become from 6 to 10 identical daughter cells. What would be the best way to enumerate the cells in this culture?

- A. Turbidity
- B. Viable Cell Count
- C. Coulter Counter
- D. Measure acid production from metabolism
- E. Directly weighing a cell pellet from the culture

19. Which equation could be used to solve the following problem?

A sample of milk has been pasteurized (bacterial count reduced by 5 logs). If the bacteria are growing at the rate of 0.1 per hour, how long will it take until there are as many bacteria in the milk as there were before the pasteurization?

- A. $5 = 1 e^{(0.1)(t)}$
- B. $\ln(100,000) = (0.1)(t)$
- C. $(10^5)e = (0.1)(t)$
- D. $1 = 100,000 e^{(0.1)(t)}$
- E. There is not enough information to set up an equation to solve this problem.

20. Why would a scientist want to grow a bacterial culture in a chemostat?

- A. So she can adjust the bacterial growth rate.
- B. She is probably growing a culture of microaerophiles.
- C. So she can get the bacteria to produce antibiotics.
- D. So the culture will reach stationary phase more quickly.
- E. She probably has a limited supply of growth media.

21. Based on what you know about how the following methods for bacterial growth enumeration work, you should be able to classify one of them as a direct method. Which one?

- A. Gas production measured in a Durham tube
- B. Using the luciferase assay
- C. Acid production measured on a nanochip
- D. Most Probable Number estimation
- E. Measurement of bacterial turbidity with a spectrophotometer

22. In the United States, swimming beaches are periodically tested for bacterial counts. In Indiana, a beach is closed if the bacterial titer exceeds 125 bacteria per 100 mL. Which of the following would be the best way to determine this titer?

- A. Petroff-Hauser chamber
- B. Weighing a cell pellet
- C. Membrane filtration and plating
- D. Coulter Counter
- E. Spread plating on agar in petri dishes

23. Which of the following is NOT an example of a direct cell count?

- A. Detecting acid production in the well of a biochip
- B. Measuring culture turbidity with a spectrophotometer
- C. Detecting when a bacterial particle interrupts an electric current
- D. Obtaining a cell pellet by centrifugation and measuring its mass
- E. Counting the number of cells per grid square on a ruled microscope slide

24. *Salmonella* is one of the important bacteria responsible for causing human diarrhea. It generally takes a million to ten million cells of *Salmonella* to make a person sick. You're running a medical clinic, and a patient comes to you with diarrhea. You want to count the titer of *Salmonella* in the fecal sample accurately, but as quickly as possible. Which of the following would be the best way to do it?

- A. Dilute the fecal sample and plate it on selective media
- B. Use a Petroff-Hausser chamber with a fluorescence microscope
- C. Use a Coulter Counter
- D. Weigh a pellet from a fecal sample
- E. Filter a fecal sample and plate the filter on complex media

25. You are measuring turbidity as a surrogate for cell number to make a growth curve. What will happen during the death / decline phase?

- A. turbidity will decrease, since dead cells will also lyse in this phase
- B. turbidity will remain the same, since dead cells still reflect light
- C. turbidity will increase, since there are still cells dividing during this phase
- D. turbidity will continue to increase for a while, then will decrease
- E. It isn't possible to measure turbidity during the death / decline phase.

26. Secondary metabolites, such as antibiotics, are produced most effectively _____.

- A. by persister cells
- B. by cells in crowded growth conditions
- C. when the number of cells = $N_0 e^{\mu t}$
- D. as cells are adapting to growth in a new medium
- E. when nutrients are constantly added to a culture

27. You suspect a patient has a blood infection caused by a bacterium, and you need to get a titer of bacteria from the patient's blood. How would you do that most effectively?

- A. Centrifuge the blood and weigh the pellet
- B. Examine the optical density of the blood
- C. Use a Coulter Counter to obtain the titer
- D. Use a Petroff-Hausser chamber to estimate the titer
- E. Spread plate the blood and count the number of colonies

28. You have developed a new way to enumerate the bacteria in a culture. It involves covalently adding a fluorescent label to peptidoglycan monomers so that newly synthesized peptidoglycan becomes fluorescent. Then a special device counts only fluorescent cells. This method _____.

- A. will count all live cells, whether or not they are growing
- B. will count both dead cells and live cells
- C. is a type of direct cell count
- D. is a type of viable cell count
- E. will produce a higher titer than a Coulter Counter will

29. The luciferase reaction is not routinely used to obtain an accurate bacterial titer. Why not?

- A. Luciferase is not a bacterial enzyme.
- B. Dead cells do not produce ATP.
- C. The amount of ATP produced per cell is not constant.
- D. You do not see a reaction with fewer than 10^7 bacteria per mL.
- E. It is only based on a statistical estimate of growth.