Answers to Unit 4 Review: Viruses, Archaea, Bacteria and the Immune Response

Great review at: http://www.youtube.com/watch?v=vAR47-g6tlA (Crash Course Biology, you don't need to know protists, yet;)

1. List three diseases caused by viruses and three diseases caused by bacteria.

a) diseases caused by viruses include: **influenza**, **HIV/AIDS**, **ebola**, **polio**, **chicken pox**, **cold sores**, **herpes** etc. (you should know these ones but you can list any viral diseases)

b) diseases caused by bacteria include: **strep throat**, **gonorrhea** and **syphilis**, also food poisoning caused by **E.coli** and **salmonella** (you should know these ones but you can list any bacterial diseases)

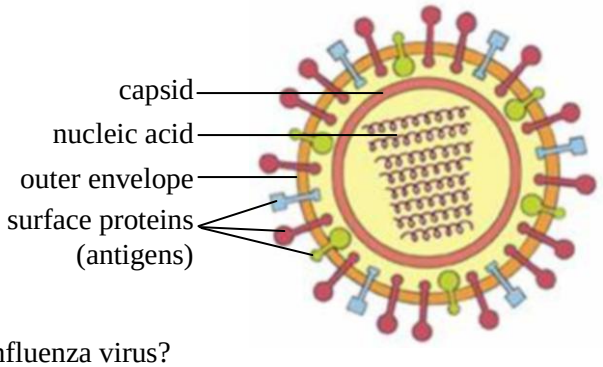
2. Identify three different ways that each of the following can be classified:

a) viruses can be classified by any of:
- if they have DNA or RNA as their nucleic acid
- the shape of their capsid
- if they have an outer envelope
- by the types of proteins on their outer envelope (eg influenza H1N1 or H5N1)
- what type of cells they infect
- if they are pathogenic

b) Archaea can be classified by any of:
- if they are extremophiles, mesophiles or methanogens
- if they are extremophiles, they can be sub-divided into halophiles, acidophiles, thermophiles etc.
- their source of energy: are they autotrophs (producers) or heterotrophs (consumers)?
- where they live: oceans, soil, volcanoes, intestines

c) bacteria can be classified by any of:
- the shape of the bacterial cells (coccus, bacillus or spirillum)
- the arrangement of the bacterial cells (single, diplo, strepto, staphylo)
- the shape of the bacterial colony (circular, irregular, rhizoid, filamentous)
- Gram negative or Gram positive
- aerobic or anaerobic
- does it form endospores or not, and the position of the endospore within the bacteria
- pathogenic or not

3. Label the key parts of the influenza virus shown to the right.



4. HIV is a retrovirus but influenza is not.

a) What additional item does HIV have that is not found in the influenza virus?
- retroviruses have the enzyme "reverse transcriptase" (converts viral RNA into viral DNA)

b) Describe how HIV reproduces when it is infectious and causing disease.
- HIV is most infectious and active when it is in the lytic cycle
- HIV specifically infects white blood cells
- during the lytic cycle, the viral RNA/DNA stays separate from the white blood cell's DNA
- the viral DNA is copied (transcribed) to make mRNA which is then translated to make viral protein by the white blood cell's ribosomes
- the white blood cell also replicates the viral RNA
- the viral RNA, capsid proteins and reverse transcriptase enzyme are assembled to make viruses within the white blood cell
- when the white blood cell is full of viruses (about 200 in one cell), the white blood cell ruptures (is lyzed), releasing the viruses which can then infect other cells

c) Describe how HIV could form a "provirus"
- if HIV forms a provirus, its RNA is first translated into DNA by the enzyme 'reverse transcriptase'
- the viral DNA is then integrated into the white blood cell's DNA by the enzyme 'integrase'
- as long as the viral DNA is part of the host cell's DNA, it is a provirus and it does not cause disease

5. Smallpox was caused by a DNA virus but influenza is an RNA virus. Why was a vaccine able to completely eradicate smallpox on Earth (as far as we know) while a new vaccine must be made for influenza every year?
   - DNA viruses such as smallpox virus have double-stranded DNA, so the DNA is very stable and does not mutate (change) very often. The smallpox capsid proteins (antigens) do not change significantly for many years so the same vaccine remains effective for a long time.
   - RNA viruses are usually single-stranded RNA, which is less stable and more likely to mutate, creating new capsid or surface proteins (antigens) that the host cell must learn to recognize
   - also, RNA viruses usually convert their RNA to DNA within the host cell, using the enzyme 'reverse transcriptase'
   - this enzyme has a high error rate, so there are many changes (mutations) to the viral DNA as it is copied
   - the mutations in the viral DNA/RNA are passed on to the 'daughter viruses'
   - if the mutations change the viral capsid or surface proteins (antigens), our immune system may not have antibodies and T-cells that recognize this new protein so they must create new ones
   - new vaccines must be made to the new viral antigens to protect against the mutated viruses

6. Use the characteristics of living things to explain why viruses are not considered to be alive.
   - the characteristics of life (MRS GREN: independent movement, reproduction, sensitivity and response to the environment, growth, respiration, excretion and nutrition) are not exhibited by viruses
   - viruses are incapable of INDEPENDENT movement and reproduction – they require their host cells to do these functions for them
   - viruses also do not take in nutrients, perform any kind of respiration (chemical reactions to generate energy), excrete wastes or grow
   - because viruses do not have the characteristics of living things, they are not considered to be alive

7. The Archaea are incredibly diverse. What are three types of Archaea and how is each unique?
   - Archaea are distinct from bacteria because they have different types of ribosomes, different types of molecules in their cell membranes and unusual metabolisms (chemical reactions)

   - there are a huge number of types of Archaea and still more are being discovered
   - some Archaea are extremophiles – they live and thrive in extreme conditions such as:
     thermophiles that can live at temperatures above the boiling point of water
     acidophiles that can live at very low pH levels
     thermoacidophiles that can survive at high temperatures and very low pH
     halophiles that can live in very concentrated salt solutions without losing water by osmosis
   - some Archaea are mesophiles and grow in 'normal', non-extreme conditions such as ocean water or soil
   - some Archaea are Methanogens which use carbon dioxide and hydrogen gas as their energy source, creating methane gas as their waste product (they live in cows' stomachs and peoples' intestines)

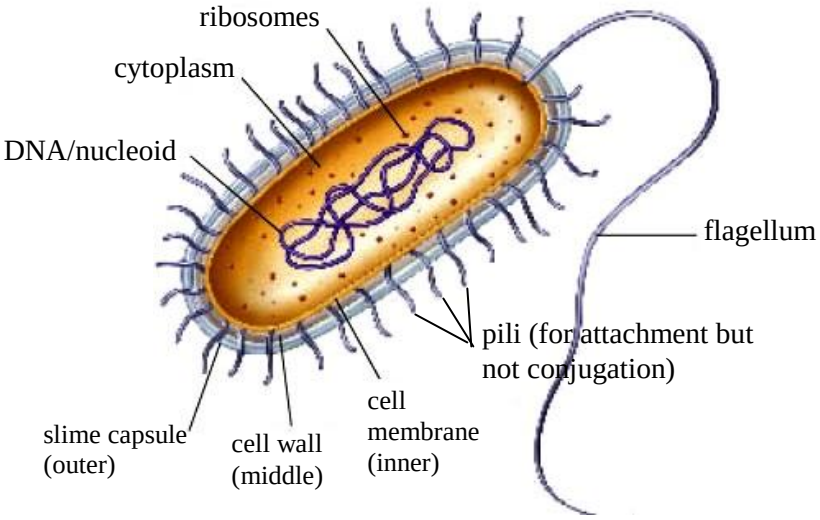
8. Why is it believed that Archaea were the earliest living things?
   - Archaea have specialized metabolisms and molecules that allow them to survive in anaerobic conditions (when no oxygen is present), in high temperatures, high acidity (low pH) and high salt environments
   - these are the same conditions that probably existed when the Earth was very young, suggesting that Archaea arose and adapted to the conditions of the very young Earth, making them incredibly ancient

9. What are three significant similarities between Archaea and bacteria? What are four significant differences that resulted in Archaea and bacteria being split from one Kingdom into two separate Domains?

Archaea and bacteria both:
- are prokaryotes – they have no membrane-bound organelles
- are single-celled (unicellular) organisms – each cell lives independently of the others
- are about the same size (very small)
- have a single loop of DNA
- have ribosomes
- are surrounded by a cell wall
- reproduce asexually by binary fission

Archaea and bacteria are different because:
- they have different types of macromolecules in their cell membranes and cell walls
- they have different proteins in their ribosomes (ie. different ribosomes)
- they have very different metabolisms and chemical reactions that they use for energy production
- Archaea live anaerobically (there may be a few exceptions), while bacteria can live either anaerobically or aerobically (there are many examples of both)
- also, Archaea are not known to cause diseases, while many types of bacteria are pathogenic

10. Refer to the diagram of a typical bacterial cell shown to the right:



a) Label its key parts.

b) Does this bacterium have a plasmid that you can see? Explain.
- no, this bacterium does not have a plasmid (a small simple loop of DNA which is separate from the main chromosome). It has only its full, large piece of DNA. If it had a plasmid, we would see both the large piece and a small circular loop

c) What is the function of the little "tubes" on the bacteria's surface?
- the little 'tubes' are called pili (singular is pilus)
- these small pili are used to help the bacteria adhere (stick) to surfaces, in a similar way to how the hooks on burrs help burrs stick to our hair and clothes

d) What is the shape of this bacteria? it is a bacillus (rod shape)

e) Which part of the bacteria is made of peptidoglycan? the cell wall (the middle layer)

f) Is it a prokaryote or a eukaryote? How do you know?
- this cell is a prokaryote (all bacteria are prokaryotic) because it does not have a membrane-bound nucleus or any other membrane-bound organelles
- prokaryote literally means 'before kernel', which means 'before a nucleus' had developed

g) Describe how this bacteria reproduces asexually.
- bacteria reproduce asexually by binary fission
- the chromosome loop attaches itself to the inner cell membrane of the bacteria
- the chromosome replicates (copies itself) and both chromosomes remain attached to the membrane
- the bacteria grows and elongates. As the cell elongates, the distance between the chromosome loops increases
- when the cell gets long enough, the cell membrane and cell wall begin to grow inward, dividing the bacteria into two separate cells, each with one loop of DNA
- when the cell membrane and cell wall are complete, two identical daughter cells have been created

h) Describe how this bacteria reproduces sexually.
- bacteria reproduce sexually by conjugation
- a bacteria grows a specialized pilus called a 'sex pilus', 'conjugation tube' or 'conjugation pilus'
- the pilus attaches to another bacteria of either the same, or a different, species
- the donor bacteria makes a copy of some or all of its DNA, usually it is a small loop of DNA with just a few genes called a 'plasmid'
- the plasmid or DNA passes through the conjugation pilus into the recipient cell
- the recipient cell accepts the plasmid and may integrate it into its chromosome
- when the recipient cell divides by binary fission, the plasmid is passed to its daughter cells, along with its original chromosome

i) What is the main advantage of sexual reproduction?
- sexual reproduction increases genetic diversity by mixing and blending the DNA from two different bacteria
- if the DNA that is passed to the recipient cell enables it to grow and divide more effectively, then more of the bacteria will survive to pass on its genes

j) Describe how this bacteria could develop antibiotic resistance.
- antibiotic resistance can develop in the following two ways (there are more, but these two are enough for this course): random mutation and conjugation
- a random mutation in the bacteria's DNA may give the bacteria new proteins (perhaps a new enzyme) which allows it to grow and survive even when the antibiotic is present
- a resistant bacteria can pass its 'resistance gene' to other bacteria by conjugation, enabling the recipient bacteria to make a protein (perhaps an enzyme) so it can grow in the presence of the antibiotic
- once the bacteria has the genes that make it resistant, it will pass them to its offspring so they will also be resistant and the antibiotic will no longer work on these bacteria

k) This bacteria has a thick cell wall and thin slime capsule.
- Is it Gram positive or Gram negative? Gram positive (the thick cell wall absorbs the Gram stain)
- What colour will it be after Gram staining? purple (blue)

11. Compare and contrast the following:

a) the replication of RNA viruses and DNA viruses

Similarities:
- both replicate by binding to a receptor on the outside of a host cell and inserting their nucleic acid inside the host
- the viral nucleic acid (RNA or DNA) takes over the cell, making copies of the viral nucleic acids and proteins to make new viruses

Differences:

DNA viruses	RNA viruses
• the viral DNA is transcribed into mRNA and used for viral protein synthesis	• the viral RNA may be used as mRNA and translated directly to make viral proteins, OR • RNA retroviruses must first change their RNA into DNA using the enzyme reverse transcriptase, then the DNA is used for viral protein production
• DNA viruses have double-stranded DNA which is more stable than RNA. These viruses are less prone to mutations, so it is easier to make a long-lasting vaccine for DNA viruses	• RNA viruses are much more prone to mutations than DNA viruses, so it is harder to make long-lasting vaccines for RNA viruses

b) the lytic cycle and the lysogenic cycle

Similarities:
- both are methods of viral replication inside host cells

Differences:

Lytic Cycle	Lysogenic Cycle
▪ viral nucleic acids remain separate from the host cell's DNA ▪ the viral DNA is rapidly transcribed and translated into viral protein • viruses are produced inside the cell, until the cell is so full that it bursts (lyses), releasing the viruses • the lytic cycle kills the host cell	• viral nucleic acids are integrated into the host cell's DNA as a pro-virus • the viral DNA is copied along with the rest of the host cell's DNA • very little, if any, viral protein is produced and the host cell is not harmed. When the host cell reproduces, it copies the viral DNA along with its own DNA and passes the viral DNA to its daughter cells. • the lysogenic cycle does not kill the host cell

c) viruses and bacteria

Similarities:
- both contain nucleic acid and protein
- both can mutate and change must faster than eukaryotic cells
- both have antigenic proteins on their surfaces which can trigger the immune response in plants or animals
- both can be either pathogenic or harmless

Differences:

Viruses	Bacteria
• are not alive • can not reproduce independently • do not contain any ribosomes, are simply nucleic acid and a protein capsule • may have DNA or RNA as their genetic material • may have an outer envelop of proteins and lipids	• are one of the earliest forms of life • reproduce independently, usually by binary fission • contain ribosomes • their genetic material is DNA but they have RNA in their ribosomes and for protein production • may have an outer slime capsule that contains proteins and lipids

d) Archaea and bacteria

Similarities:
- both are prokaryotes (do not contain a nucleus or any other membrane-bound organelles)
- both are very early forms of life and are unicellular (each cell is an individual living thing)
- both have a single loop of DNA
- both reproduce by binary fission
- both are incredibly diverse and have adapted to live in many different types of conditions
- both have their own Domain and Kingdom

Differences:

Archaea	Bacteria
• different types of ribosomes from bacteria • different materials in their cell membranes, do not contain peptidoglycan • many unusual and unique biochemical reactions (metabolisms)	• different types of ribosomes from Archaea • different materials make up their cell membranes, cell walls contain peptidoglycan • less unusual biochemical reactions (metabolisms), but still quite diverse

• are autotrophs ("self-feeding" using light or chemical energy from inorganic material) • none are known to be pathogenic • can be extremophiles eg. acidophiles, halophiles • can not form endospores • all (?) are anaerobes (not sure anymore, we are discovering new ones all the time)	• can be autotrophic (producers) or heterotrophic (consumers) • some (the minority) are pathogenic • are not extremophiles • can form endospores • can be anaerobes or aerobic, depending on the bacteria

e) eukaryotes and prokaryotes

Similarities:
- both are living things and have the characteristics of living things (MRS GREN)
- both use DNA as their genetic material
- both include a huge diversity of organisms adapted to live in a huge variety of environments

Differences:

Prokaryotes (Archaea and Bacteria)	Eukaryotes (Protists, Fungi, Plants and Animals)
• do not contain a nucleus or any other membrane-bound organelles • can be anaerobic or aerobic • different types ribosomes and biochemical reactions than eukaryotes • cells are very small, about 1/10 to 1/100th the size of eukaryotes • very early forms of life • are unicellular (each cell is an individual living thing) • have a single loop of DNA • reproduce asexually by binary fission • may share genetic information by conjugation, no meiosis	• contain a nucleus and many other membrane-bound organelles • all are aerobic (some can live for a short time under anaerobic conditions) • different types ribosomes and biochemical reactions than eukaryotes • cells are larger, about 10x to 100x the size of prokaryotes • later forms of life • can be unicellular or multi-cellular • have linear chromosomes, not loops • reproduce asexually by mitosis • various types of sexual reproduction including meiosis

f) viruses and endospores

Similarities:
- both are "stripped down" to the basics: nucleic acids inside a protective outer shell, maybe with some enzymes (endospores also have ribosomes which viruses do not have)
- both are in "suspended animation" (dormant) and not carrying out the processes of life
- both are very small
- both are formed inside living cells

Differences:

Viruses	Endospores
• do not contain ribosomes • may contain either DNA or RNA as their genetic material • must 'hi-jack' cells to reproduce, are never able to become a living thing on their own	• contain ribosomes • contain DNA as their genetic material • are a survival mechanism which are formed by bacteria under adverse conditions. They are not a method of reproduction. Endospores revert to their bacterial cell form when conditions improve

g) binary fission and mitosis

Similarities:
- both are methods of cellular reproduction
- both are asexual and produce two daughter cells that are identical to the parent cell

Differences:

Binary Fission	Mitosis
• method of reproduction used by prokaryotes (Archaea and bacteria) • these cells have no nucleus, so the loop of DNA replicates within the cytoplasm • these cells do not form spindle fibers; the replicated DNA (chromosome loops) are attached to the cell membrane and pulled apart as the bacterial cell grows and elongates • there are no phases (prophase, metaphase, anaphase or telophase) • the cell membrane and cell wall grow from the outside of the cell in towards the centre, dividing the cytoplasm in two	• method of reproduction used by eukaryotes (plant and animal cells, protists and fungi) • these cells have a nucleus. The DNA is replicated inside the nucleus during interphase and then spread out into the cytoplasm during prophase • these cells form spindle fibers which pull the chromosomes to opposite poles of the cell • in plant cells, the cell plate starts in the middle of the cell and grows outward toward the cell wall, dividing the cytoplasm and cell • in animal cells, the cell membrane pinches at the cleavage furrows, dividing the cytoplasm

h) binary fission and conjugation

Similarities:
- both are methods of cellular reproduction in prokaryotes (Archaea and bacteria)

Differences:

Binary Fission	Conjugation
• most common method of reproduction in prokaryotes, especially under favourable growth conditions • produce two identical daughter cells • does not require a conjugation pilus	• happens less commonly, especially when growth conditions are unfavourable • transfers DNA from one cell to another, creating a new combination of genes in the recipient. The recipient cell then divides • requires the formation of a conjugation pilus between the donor and the recipient cell

i) pili and flagella

Similarities:
- both are appendages that are attached to bacterial cell walls

Differences:

Pili	Flagella
• small, short tubes that are attached to the outside of some bacteria • may be used for attachment (holding the bacteria on to a surface) or for conjugation (DNA transfer)	• may be found attached to the outside of prokaryotic or eukaryotic cells • are used for locomotion

j) endospore and provirus

Similarities:
- both are formed inside cells
- both are intended as temporary structures that form in between stages of active growth or reproduction

Differences:

Endospores	Provirus
• are survival structures formed by bacteria during adverse conditions • are formed within bacterial cells only • are bacteria in "suspended animation", waiting for good conditions for growth • the endospore contains the mother cell's DNA wrapped in a spore coat • the endospore can remain inside the mother cell and this does not damage the mother cell	• are "waiting" structures formed by viruses within cells • may be found in prokaryotic or eukaryotic cells • are viruses in "suspended animation', between lytic cycles • the provirus is integrated into the cell's DNA and is not surrounded by a capsid, capsule or coat • the viral DNA is copied along with the cell's DNA and this does not damage the host cell

k) coccus and bacillus

Similarities:
- both are shapes of prokaryotes (Archaea or bacteria)

Differences:

coccus	bacillus
• these are round bacteria or Archaea • the round shape helps the bacteria resist drying out	• these are rod-shaped bacteria or Archaea • the rod shape gives bacilli a relatively large surface area to volume ratio, so it is a good shape for absorbing nutrients (but this also means that they dry out more quickly)

l) Gram negative and Gram positive

Similarities:
- both are types of staining used to identify and categorize bacterial cells
- both are based on the presence/absence of a thick peptidoglycan cell wall

Differences:

Gram negative	Gram positive
• these bacteria have a thin peptidoglycan cell wall and/or a thick outer slime capsule • these bacteria are coloured pink by the Gram stain	• these bacteria have a thick peptidoglycan cell wall and/or a thin outer slime capsule • these bacteria are coloured purple/blue by the Gram stain

m) Thermophiles and acidophiles

Similarities:
- both are types of Archaea called 'extremophiles', these are prokaryotes that can live and thrive under extreme growth conditions that would kill any other type of living thing
- they are both very primitive types of life
- both were discovered relatively recently and have very unique ribosomes and cell membranes that can withstand these extreme conditions
- neither causes any known diseases
- Archaea can have both characteristics at once, and are called thermoacidophiles

Differences:

Thermophiles	Acidophiles
• these Archaea thrive in extremely hot environments, even over the boiling point of water (boiling mud, volcanoes, hot springs)	• these Archaea thrive in extremely acidic (low pH) conditions such as acid hot springs and acidic ocean vents

n) Extremophiles and mesophiles

Similarities:
- both are types of Archaea, these are prokaryotes that can live and thrive under a wide range of growth conditions
- they are both very primitive types of life
- both were discovered relatively recently and have very unique ribosomes and cell membranes
- neither causes any known diseases

Differences:

Extremophiles	Mesophiles
• these Archaea thrive in extreme conditions such as extreme heat (thermophiles), extreme acid (acidophiles), extremely concentrated salt solutions (halophiles), extreme cold (psychrophiles) • these are incredibly difficult to study, because they are killed by normal lab conditions	• these Archaea thrive in fairly normal conditions of temperature, pH, salt etc • are found in the oceans, guts of animals, soil etc • these are relatively easy to study because they can be grown under normal lab conditions

o) Fomites and vectors

Similarities:
- both are ways that pathogens can be passed from one host to another

Differences:

Fomites	Vectors
• these are non-living objects that can carry pathogens on their surface and transfer pathogens from one organism to another Examples: door handles, light switch, contaminated tissues, bed sheets etc	• these are living things that can harbour (host) pathogens and transmit them from one organism to another Examples: mosquitoes that carry the pathogen that causes malaria, ticks that carry Lyme disease, fleas that live on rats and carry the bacteria for the black plague

p) specific and non-specific immune defenses

Similarities:
- both are parts of our immune response that can prevent or limit infection by a pathogen

Differences:

Specific Immune Defenses	Non-specific Immune Defenses
• these are specific to one antigen (one surface protein) • can be antibodies that stick to one certain type of surface protein. Antibodies are made by B-cells (a type of white blood cell) • can be T-cells that respond to one specific type of antigen (surface protein) • after the first exposure to an antigen, specific immune defenses have memory – they remember specific antigens so that antibodies or T-cells can be made very quickly	• these are not specific to any one antigen (surface protein) • can be the first line of defense, such as physical barriers (intact skin or sticky mucous) or they can be chemical barriers such as the acid in our stomachs, acidic sweat or lysozyme (an enzyme in tears and saliva that breaks down cell membranes) • can be the second line of defense once a pathogen gets inside the body, such as the inflammatory response (increased blood flow, swelling and heat), non-specific immunoglobulins (antibodies that stick to a variety of antigens) or immune cells such as phagocytes and macrophages that engulf and destroy any pathogens or cell debris that they encounter

q) active vs. passive immunity

Similarities:
- both are parts of the immune response that can prevent or limit infection by a pathogen

Differences:

Active Immunity	Passive Immunity
• this is the type of immunity that is created in response to a specific antigen • it is highly specific to one antigen (one surface protein) • can be antibodies that stick to one certain type of surface protein. Antibodies are made by B-cells (a type of white blood cell) • can be T-cells that respond to one specific type of antigen (surface protein) • after the first exposure to an antigen, specific immune defenses have memory – they remember specific antigens so that antibodies or T-cells can be made very quickly • it is permanent – once you have made the antibodies or T-cells, they can quickly be made again in response to the antigen	• this is immunity that is passed from one organism to another, it can be specific or non-specific • mothers pass non-specific antibodies to their babies across the placenta before birth • mothers can pass antibodies to their babies after birth in their milk or colostrum (colostrum is the first milk made by a mother, it contains large amounts of immunoglobulins/antibodies) • antibodies from a person who has been exposed to a pathogen can be extracted from their blood and given to another person to protect them • passive immunity is temporary – it will help protect the recipient until their own immune system can make antibodies and T-cells

12. How can bacteria survive during adverse conditions? Describe this process.

Some bacteria form endospores which can survive during adverse conditions (heat, dryness, acidity etc.)
- endospores are formed within the bacteria (endo means 'within')
- when conditions become adverse (too dry, too acidic, lacking nutrients), the bacteria replicates its DNA
- it then forms a spore coat which surrounds one copy of the DNA, some ribosomes and enzymes
- the spore dries and "matures"
- the spore waits inside the mother cell until it is released when the mother cell dies and is broken down
- the spore can wait millions of years until favourable conditions return. At that point, it will grow into a bacterial cell and start all life processes again

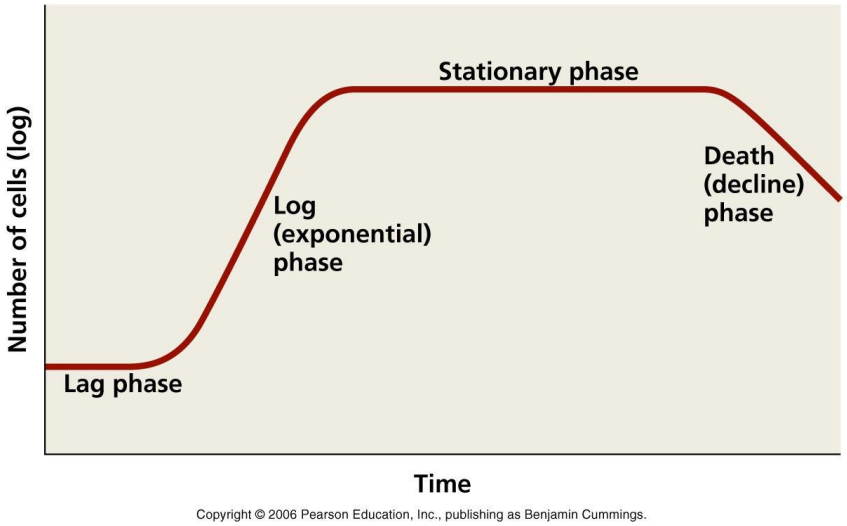
13. Bacteria have an undeserved "bad rap". What are three indispensable (critical) roles of bacteria in:

a) ecosystems:
- nitrogen-fixing bacteria convert nitrogen gas (N_2) to ammoni/ammonium (NH_3/NH_4^{1+})
- decomposing bacteria break down and recycle organic material and nutrients
- autotrophic bacteria (producers) use energy from light or inorganic chemicals and convert this energy to food for themselves and the consumers who eat them

b) animals' bodies
- a healthy flora (mixture of bacteria) in the intestines can "out-compete" pathogenic bacteria and keep the host animal healthy
- bacteria in the guts (stomachs and intestines) of termites and ruminant animals (cows, goats, sheep, camels etc) help break down plant material and release its energy so it can be used by the host animal
- bacteria living in the intestines of many animals produce vitamins which are absorbed and used by the host animal, for example, vitamin B12 and vitamin K
- E. coli bacteria in the large intestines of many animals are important in helping to reabsorb water from the gut (when people take antibiotics, they often get diarrhea because the antibiotics kill their E. coli, so they can not reabsorb the water from their large intestines, giving them 'the runs')

14. For bacterial populations:

a) Sketch a typical "growth curve" for bacterial populations and describe what is happening in each region



- during the lag phase, there are very few bacteria and they are adjusting to a new environment, so they reproduce very slowly
- during the log phase, the bacteria have adjusted to their new environment and there are unlimited resources available (food, light etc) so their numbers increase exponentially
- during the stationary (steady state) phase, resources are becoming scarce and wastes are accumulating. The bacteria are reproducing more slowly. Their death rate equals their reproduction rate.
- during the death (decline) phase, resources are very scarce and so many wastes have accumulated that they are starting limit cell growth and health. Bacteria are dying more quickly than they are reproducing. Bacteria which can form endospores may do so during this phase.

b) Describe three ways to limit bacterial growth without the use of antibiotics, antiseptics or disinfectants. Describe how each of these methods works.
- keep things clean – this limits the food and nutrients that are available for bacteria
- keep things dry – this removes a source of moisture for the bacteria, so they dry out (by osmosis) and die (drying can also denature the bacterial enzymes)
- add salt or sugar – this removes water from the bacteria by osmosis, so the bacteria dry out and die (this can also denature the bacterial enzymes)
- add acid – the low pH denatures the bacterial enzymes so they no longer work and the cell dies

c) Identify five different features or characteristics of bacterial colonies that can be used to classify or identify the bacteria.
- bacterial colonies can be classified by their: form or shape (eg. circular or irregular), their margin or edge (eg. entire/smooth or undulate), their elevation or profile (looking from the side) which can be flat, concave, crateriform etc. You do NOT need to know all the names of the shapes – just the idea that shape, margin and elevation can be used for classification
- colonies can be also be classified by the colour, opacity (are they opaque?), the appearance of their surface (shiny, dull, wrinkled etc) and their size

15. Regarding antibiotics:

a) What are three ways that different antibiotics can kill bacteria without harming eukaryotic cells?
Antibiotics work by slowing down or stopping the bacterial cell from:
1. replicating its DNA, so the bacteria can not reproduce. This will not hurt the cells of the body for the short time that antibiotics are taken.
2. making peptidoglycan, so the cell wall weakens and the bacteria ruptures. This will not hurt eukaryotic cells because they do not make peptidoglycan.
3. making proteins, so the bacteria can not produce needed enzymes, structural proteins etc. Bacterial cells have different ribosomes than eukaryotic cells, so drugs can block protein synthesis in bacteria without affecting the eukaryotic cells.

b) Describe how bacterial resistance arises.
- bacterial resistance arises when bacteria are exposed to an antibiotic. Some bacteria have genes which make them naturally resistant to the effect of that antibiotic, so these bacteria survive while the 'weaker' (susceptible) bacteria are killed
- the surviving resistant bacteria reproduce, passing on their resistance genes
- the resistant bacteria can also pass the gene that gives them resistance to other bacteria through conjugation, so now other species of bacteria can also become resistant

c) What is a 'super-bug'?
- a 'super-bug' is a bacteria that is resistant to one or more types of antibiotics
- the most well known is MRSA – methicillin resistant Staphylococcus aureus (if you aren't squeamish, you can Google images for MRSA – yuck!)

d) What factors have contributed to the formation of 'super-bugs'?
- over-use and mis-use of antibiotics in people
- over-use and mis-use of antibiotics in farm animals
- people not completing their full prescription of antibiotics
- people using antibacterial soaps and lotions – these contain low levels of antibiotics that kill some bacteria, but not the resistant or slightly resistant ones (eg. triclosan in some dish detergents)

e) What three things can you do to help slow down the development of resistant bacteria?
- only use antibiotics when they are ABSOLUTELY necessary! (not for viruses)
- follow the doctor's orders and finish the full prescription, even if you start to feel better after a few days
- do not use antibacterial soaps or lotions – good old plain soap is every bit as effective and will not cause resistance
- get your vaccinations so your immune system is as strong as possible

16. Regarding the immune system:

a) What is its overall purpose?
- to prevent infection by keeping the right bacteria growing in the right places (E. coli are healthy and good when they live in your intestines, but they cause infections (UTIs) if they start to grow in your urinary tract (bladder or urethra)

b) Describe two types of non-specific **physical** immune defenses and where in the body each is used.
- non-specific physical immune defenses work by keeping bacteria out of the body
- unbroken skin (all over our body) keeps pathogens out
- the sticky mucous lining the nasal passages and respiratory tract traps bacteria and other pathogens. We can cough up or blow out the mucous and the pathogens are removed from the body

c) Describe two types of non-specific **chemical** immune defenses and where in the body each is used.
- the enzyme lysozyme in our tears and saliva breaks down bacterial cell walls, killing bacteria in our eyes and mouths
- the hydrochloric acid in our stomachs kills many kinds of bacteria (but not Helicobacter pylori – way to go Drs. Barry Marshall and Robin Warren, The Nobel Prize winners in Physiology or Medicine for 2005!!)

d) Describe two types of active, acquired immunity.
- active, acquired immunity refers to the production of specific antibodies and T-cells in response to a specific antigen (often a protein on the surface of a virus or bacteria)
- white blood cells called B-cells produce antibodies that recognize one specific antigen
- white blood cells called T-cells recognize antigens on the pathogen and engulf the pathogen
- B-cells and T-cells also "remember" each antigen and can quickly be produced if these antigens are present

e) Describe two types of passive immunity. What is one advantage and one disadvantage of passive immunity?
- passive immunity is immunity that is 'passed' from one organism to another
- mothers pass immunoglobulins (antibodies) across the placenta to their babies before they are born
- mothers pass immunoglobulins (antibodies) in their colostrum (the earliest milk) and breast milk
- antibodies can be purified from the blood of people who have survived a disease. These antibodies can be given to people who have the disease and this may help them fight off the pathogen while they are waiting to make their own antibodies and T-cells

Advantage: the antibodies from other people can protect someone while they are waiting to make their own antibodies

Disadvantage: passive immunity is temporary – it only lasts a short time

17. Explain how viruses and bacteria are used together in genetic engineering, for example, to make human insulin.

One way to do genetic engineering is using both viruses and bacteria: (the following description is greatly simplified but enough detail for this course)

- first, a working copy of the gene (DNA) for the desired human protein must be isolated (eg. the gene for human insulin)
- this gene is integrated into a virus's DNA
- the virus is used to insert the DNA into an appropriate bacterial cell (one that has a receptor for this virus and will accept the new DNA)
- once the virus has injected the DNA into the bacterial cell, the bacteria accepts the new DNA as its own. The bacteria now has 'recombinant DNA' because it is a combination of DNA from two sources)
- when the bacteria reproduces, all of the offspring will have the inserted DNA
- the bacteria transcribe and translate the insulin gene, making human insulin
- huge vats of bacteria are grown and insulin can be purified from them

18. What is recombinant DNA? Give **ONE** example of a situation in which recombinant DNA is formed.
- recombinant DNA is created in the lab – it is an artificial combination of DNA from two (or more) different species created by genetic engineering
- for example, when the human insulin gene is inserted into the DNA of an E. coli, it creates recombinant DNA in the E.coli (it now has some human genes in it)

19. Complete the following chart to compare Archaea and bacteria:

Criteria	**Archaea**	**Bacteria**
Prokaryote or Eukaryote	prokaryote	prokaryote
Unicellular or multicellular?	unicellular	unicellular
Type of nucleic acid	DNA	DNA
Haploid or diploid?	haploid (has one chromosome)	haploid (has one chromosome)
Shape/form of their nucleic acid	a loop of DNA (may be condensed in a nucleoid region)	a loop of DNA (may be condensed in a nucleoid region)
Main type of reproduction	asexually by binary fission	asexually by binary fission
Aerobic/anaerobic or both?	usually anaerobic	anaerobic or aerobic
Three ways they are classified	extremophiles (halophiles, acidophiles, thermophiles, barophiles, psychrophiles etc.) mesophiles Methanogens	• aerobic or anaerobic • Gram negative or Gram positive • autotroph (producer) or heterotroph (consumer) • shape of cell (coccus etc.), presence of flagella, endospores etc. etc