- The atomic number represents the number of protons in an element.
- The mass number is the sum of the protons and neutrons in an element's nucleus.
- Isotopes are atoms that have the same number of protons but different numbers of neutrons.
- Radioactive isotopes release energy when they degrade and can be used for nuclear energy.
- The atomic weight is the sum of the mass numbers of all the isotopes that exist for an element.
- Electrons are arranged in shells around the nucleus of an atom.

Chemical Bonding and Molecules

Chemical bonding involves the sharing, donating, or accepting of electrons between two or more atoms. The octet rule states that elements will bond together so that they both have eight electrons in their outer shell to make it stable. Noble gases have eight electrons in their outer shell and are inert. Most other elements are missing one electron or have extra electrons, which they want to get rid of by bonding with another element to fill their outer shell to eight.

Molecules are chemical substances that result from the combination of two or more atoms, which can be of the same or different elements. Compounds are molecules or combinations of two or more different elements. Covalent bonds are formed when two or more atoms share electrons, resulting in strong and stable bonds. Nonpolar covalent bonds have equal sharing of electrons, while polar covalent bonds have an unequal sharing of electrons, resulting in a partial charge.

Covalent Bonds

Most molecules are covalently bonded together, and there are two types: nonpolar and polar covalent bonds. Nonpolar covalent bonds have equal sharing of electrons, while polar covalent bonds have unequal sharing of electrons, resulting in a partial charge. Polar molecules have a positive and

Inspection and Identification

Inspection involves observing the microbe under a microscope or looking at its growth patterns. Identification involves various tests such as biochemical and immunologic tests, or even DNA analysis, to determine the type of microbe.

Overall, these methods make it possible to study microorganisms and identify pathogens.

Lab Techniques: Sterilization and Culturing Microbes

In the lab, it is important to ensure that all instruments used are sterile. This is achieved through techniques such as heating a loop until it is white hot to kill any living organisms on it before dipping it into the sample and streaking it across a plate. Clinical specimens can be blood, cerebrospinal fluid, urine, feces, or diseased tissue. Incubators are used to provide a warm, dark environment for the specimens to grow, with temperatures ranging from 20 to 40 degrees Celsius. Atmospheric gases like oxygen and carbon dioxide may also be required. The incubation period varies depending on the bacterium being grown, and it can take from a day to several weeks to obtain a pure culture.

Types of Cultures

- **Pure culture:** contains only one species of microbe, allowing for the study of its reaction to different stimuli.
- **Mixed culture:** contains two or more easily differentiated species of microorganisms.
- **Contaminated culture:** contains a known bacterium contaminated with an unknown organism, which can occur through various means such as touching unsterilized equipment or airborne transmission.

Media

Media is the food and environment in which microbes grow. Some microbes require host organisms to grow, while others require artificial

right. Enzymes do not alter or destroy themselves permanently in reactions and can be used again and again until they fall apart.

Enzyme Structure
Enzymes are proteins, but not all proteins are enzymes. Enzymes have a protein portion, called the apoenzyme, and non-metallic or co-enzymes, called cofactors, which are added to the enzyme to make it work even better. Enzymes only have one role in life, and that is to do the one thing they are made to do.

Enzyme Function
Enzymes have specific functions and are named with the suffix "ace." For example, catalase breaks down hydrogen peroxide, oxidase adds electrons to oxygen, and hexokinase transfers phosphate to glucose. Enzymes require cofactors to function properly.

How Enzymes Work
Enzymes work by binding to specific substrate molecules at the active site, which is a special region on the enzyme. The interactions between the substrates and the enzyme stress or weaken some of the chemical bonds in the substrates, leading to the formation of a different molecule. The product is released from the active site, and the enzyme assumes its original shape, ready to work again.

Enzyme Function and Importance of Cofactors

An enzyme facilitates a reaction, where a substrate fits in the enzyme and is broken apart into two products. Cofactors play a role in binding and assisting in enzyme activity, acting as battery packs for proteins to work.

Xo enzymes are secreted outside by bacteria, while endo enzymes stay inside the cell. Constitutive enzymes are constantly made, while regulated enzymes are turned on and off. Synthesis reactions involve two substrates forming one product, while degradation reactions involve one substrate forming two products.

Genetics: Understanding DNA, Transcription, Translation, and Replication

Basics of Genetics

The study of heredity, genetics, involves the transmission of biological traits. In bacteria, this involves passing on their genes to their offspring. We will look at the structure of the bacterial chromosome, which is a single circular piece of DNA. We will also examine genes, genotype, and phenotype.

Overall, genetics is the study of heredity and the transmission of biological traits. By understanding the basics of genetics, DNA, transcription, translation, and replication, we can gain a better understanding of how bacteria pass on their genes to their offspring and how mutations can affect them.

Protein Synthesis and Genes

Protein synthesis involves DNA as the blueprint, RNA as the messenger, and protein as the product. There are three types of genes: structural genes, which make proteins; genes that code for RNA; and regulatory genes, which control gene expression. Genotypes refer to the genetic makeup, while phenotypes refer to the appearance of an organism. Bacteria have only one genotype and one phenotype, making it easier to study.

Size Comparison

Viruses have the smallest genome size, with about 100 to a couple thousand base pairs. E. coli has about 4,000 genes, which is equivalent to about 4-5 million base pairs. Human cells have 30,000 genes, with 46 chromosomes packed inside each cell.

DNA Structure

Transcription and Translation

Transcription is involved with making proteins and takes place all the time. DNA is converted to RNA in transcription, and the RNA is then changed into protein in translation. The proteins determine the phenotype, and the DNA is the blueprint that tells you what the cell is going to do, how it's going to function, and what it's going to make. There are two different languages to read the two different biomolecules, nucleic acids, and proteins.

The central dogma of biology states that DNA is converted to RNA, which then builds the protein. The triplet of DNA or RNA codes for specific amino acids, and the protein's primary structure is the amino acid organization. The DNA tells you what the protein is going to look like by telling you what amino acid is going to go in what order.

RNA

RNA is different from DNA in that it has a different sugar (ribose instead of deoxyribose) and does not have thymine. Instead, it has uracil. The three types of RNA are messenger RNA (mRNA), transfer RNA (tRNA), and ribosomal RNA (rRNA).

mRNA makes the message from the DNA, transcribes the DNA code into RNA, and then binds to the ribosome so that it can be made into protein. tRNA brings amino acids to the ribosome to build the protein. rRNA is a part of the ribosome.

RNA and Transcription

Ribosomal RNA (rRNA) is responsible for building the subunits, while transfer RNA (tRNA) brings amino acids to the party. Messenger RNA (mRNA) carries the DNA message and is used to make a copy from the DNA in the transcription process. The final type of RNA is the ribosome RNA (rRNA), which is responsible for subunits in both prokaryotes and eukaryotes.

- B cells leave the bone marrow once they become mature and go to lymph nodes, where they wait.
- T cells leave the bone marrow before they get receptors and go to the thymus, where they become mature and then go to lymph nodes to wait.
- B and T cells set up in different parts of the body, waiting to respond to antigens.
- When an antigen comes in contact with a B or T cell, it gets activated.
- An activated B cell produces memory cells and plasma cells, which produce antibodies to bind and eliminate the antigen.
- An activated T cell can become a memory cell, cytotoxic T cell, or helper T cell to help the B cells respond.

The immune system has unique markers, such as the MHC, that tell it what is self and what is foreign. MHC class 1 is found on all cells and tells the immune system that this is "you." MHC class 2 is found on antigen-presenting cells and is used to present foreign antigens to T cells.

Understanding B and T Cells

There are two types of cells in the immune system: B cells and T cells. B cells attack invaders found outside the body while T cells attack pathogens that are inside the cells. B cell receptors bind to antigens while T cells help present and bind to other cells to attack and kill cells.

To understand how these cells are made, we need to look at the bone marrow where undifferentiated lymphocytes undergo a series of divisions and genetic changes that cause millions of unique cells to be produced. This is known as the clonal selection theory, where one stem cell can produce different types of cells, resulting in millions of unique cells that recognize a million different receptors.

B Cells and T Cells

B Cell Specificity and Memory

- B cells are specific to outside things outside the cells.
- The B cell receptor is called an antibody and is shaped like a Y with four polypeptide chains.
- The constant region always binds to the cells, and the variable region changes and gives specificity to the antigen.
- Once B cells gain receptors, they leave the bone marrow and go to specific sites to wait for the next antigen to come in contact with.
- The B cells become activated once they come in contact with the specific antigen, and the response takes place.

Antigen and Antibody Specificity

- The antigen and antibody need a specific lock-and-key mechanism to fit perfectly and trigger an immune response.
- Anything that can cause a response is called an antigen.
- An antigen is any foreign substance that provokes an immune response in specific lymphocytes.
- Properties that can cause an immune response include foreignness, size, shape, accessibility, and how it can bind.
- Antigens can be found in microbial cells or viruses, human or animal cells, plant molecules, pollen, food, dust, and spores in the air.

Understanding Antigens and Epitopes

An antigen is any foreign substance that the body recognizes and responds to. Characteristics of an antigen include being perceived as foreign and not a normal constituent of the body. Antigens that are large and over 10,000 molecular weight are the most energetic. The body looks for a specific spot or epitope on a specific antigen. Each antigen can have multiple epitopes, and the more epitopes an antigen has, the more

However, the effectiveness of each method depends on the type of material and microorganism involved.

Moist Heat Method

The most common method of sterilization is moist heat, which involves the use of steam under pressure in an autoclave. This method is suitable for most materials and takes about 10 to 40 minutes at 121 degrees Celsius and 15 psi. The steam penetrates the material and denatures proteins, membranes, and DNA, killing microorganisms effectively, including bacterial spores.

Thermal Death Time

Thermal death time is a test that determines the amount of time required to kill a particular microbe at a constant temperature. For example, using a temperature of 100 degrees Celsius, different tubes are set up with varying boiling times from 1 to 20 minutes. After boiling, the solution is plated to determine the time required to kill all the bacteria. The smallest time that eliminates all bacteria on the plate is the thermal death time.

Thermal Death Point

Thermal death point is a test that determines the temperature required to kill a particular microbe in a constant time, typically 10 minutes. For example, tubes are set up with varying temperatures from 95 to 115 degrees Celsius, and each solution is kept at the temperature for 10 minutes. The solution is then plated to determine the temperature that kills all bacteria within the time limit, and that temperature is the thermal death point.

Both thermal death time and thermal death point tests are essential in identifying the appropriate sterilization method for a particular material.

Free-Flowing Steam

Free-flowing steam is an intermediate sterilization method used for substances that cannot withstand autoclaving, such as canned foods. The

Incineration is used to sterilize bacteria by killing everything, including vegetative and endospores.

Ionizing Radiation

Ionizing radiation penetrates materials and eliminates even surfaces. This method destroys DNA and is used in ultraviolet levels, x-ray, and gamma rays. It's being introduced into food and is used to radiate food to keep it for a longer shelf life. If you see a symbol on your fruit, it means that it has been irradiated. Mail also goes through ionizing radiation to eliminate spores.

Non-Ionizing Radiation

Non-ionizing radiation is based on UV rays. Although it destroys and nicks the DNA, it doesn't penetrate surfaces. For instance, if you hold a piece of paper over a UV light, none of the UV rays will get through. It's great for air and surfaces but doesn't penetrate deeply.

UV radiation is used in clean rooms and is effective in controlling microorganisms in the air and on surfaces. Hospitals use blue light robots to sterilize the air and surfaces.

acquired or specific immunity. The first line of defense includes mechanical barriers such as skin and mucous membranes, respiratory, general and digestive tracts. The second line of defense is located under all the tissues and includes fluids and connective tissue.

The First Line of Defense

The first line of defense is any mechanical barrier around the portal of entry. The outermost layer of skin sheds itself every few days, and this helps eliminate microbes that get on us. Sweating also helps eliminate microbes by washing them away. The blinking and tearing up of eyes is a natural reaction that helps clean out the eyes. Stomach acid is another barrier that kills most microbes that enter our body. Mucus membranes, nasal hairs, and cilia in the trachea help filter the air we breathe and trap microorganisms. Chemicals like sebaceous secretions, lysozyme in tears and saliva, high lactic acid and electrolyte concentration in sweat, skin's acidic pH, hydrochloric acid, digestive juices and bile in the intestines, fluids like semen and the vagina's acidic pH are some of the other mechanical barriers that keep microbes from getting into our body.

Genetic Defenses

Some people are genetically more viable than others. There is an idea of the good genes surviving because some people are more resistant to microbes than others. This could be due to not having certain receptors that allow viruses to enter the body. For example, about 1% of the population can't get infected with HIV because they lack the right receptor for the virus to bind to. This could be considered a mutation, but it is potentially good because it prevents the person from getting infected with HIV.

Genetics plays a huge role in determining our health, as some individuals have a better combination of genes that allow them to be healthier and more resistant to microbes. The first line of defense against microbes includes the sneeze reflex, lysozyme, and hydrochloric acid in the stomach. However, if microbes penetrate this line of defense, the second line of defense takes over. This line of defense includes four main subdivisions,

The secondary lymphoid organs are where white blood cells go to hang out and include lymph nodes, tonsils, spleen, and other areas around the intestinal system that act as a surveillance system.

How White Blood Cells Work

Inflammation

Inflammation is an innate immune response where white blood cells attack anything that enters the body. This response results in redness, warmth, swelling, and pain due to vasodilation, blood leaking out, and white blood cells fighting off infection. Neutrophils are the first responders and eat bacteria, resulting in swelling and pus formation. Eventually, large macrophages come in to clean up and stimulate the T and B cell response.

Other Functions

White blood cells can also leave blood vessels on their own without injury.

Regulation, Mutations and DNA Exchange

Regulation of Bacterial Genes

Bacteria organize their genes into multiple sets and can turn them on or off based on their needs. This is achieved through operands, which means having multiple genes on one transcript. Inducible operands can be turned on when certain substrates are present, while repressible operands are turned off when they are not needed.

Mutations

Mutations in DNA can affect the overall protein produced by changing the three-letter words that make up the genetic code. We will discuss the various types of mutations and how they can be fixed.

DNA Exchange Between Bacteria

Bacteria can exchange DNA through conjugation, transformation, and transduction. These methods are important in molecular biology and can be used to manipulate and control microorganisms.

Operons and Gene Regulation

In bacteria, operons play a crucial role in regulating gene expression. There are two types of operons: inducible and repressible. Inducible operons are usually off but can be turned on when needed, while repressible operons are normally on but can be turned off when the process is not needed. Let's take a closer look at these types of operons.

Lactose Operon

The lactose operon is an example of an inducible operon. It has three segments: the regulator, control, and structural locus. The regulator codes for the repressor protein, which is bound to the DNA and prevents RNA polymerase from binding and making mRNA. The control segment has a promoter and an operator, where the repressor binds. The structural locus has the genes that code for the three enzymes needed to break down

Common Pathogens and Diseases

There are several common pathogens and diseases that affect people globally. Some of them include:

- **Bacteria**
  - **Rickettsia:** This is a type of bacteria that causes diseases such as Rocky Mountain spotted fever. It is easily treatable with doxycycline.
  - **Anthrax:** This is a bacterial organism known as Bacillus anthracis that can infect different areas of the body such as the skin, lungs, gastrointestinal tract, and brain. It is treatable with ciprofloxacin.
- **Protozoa**
  - **Malaria:** This is the most widespread protozoan disease in the world. It is transmitted through the Anopheles mosquito and caused by Plasmodium falciparum or Plasmodium bynes. It can be prevented by using a bed net and controlled by vector control or chloroquine.
- **Viruses**
  - **HIV:** This is a retrovirus that targets CD4 cells and weakens the immune system causing AIDS. It is thought to have originated from a mutation in a monkey virus and is treated with antiretroviral therapy.

Malaria

Malaria is transmitted through the Anopheles mosquito and is characterized by symptoms such as malaise, fatigue, diarrhea, fever, and sweating every 48-72 hours. It can cause anemia and is treated with chloroquine. It has both an asexual and sexual phase, and reproduces within the liver and red blood cells.

Anthrax

Anthrax is caused by Bacillus anthracis, a gram-positive rod that is a prolific spore former and difficult to kill in the environment. It is treatable with ciprofloxacin and is primarily found in cattle. It can infect different

areas of the body, with cutaneous and pulmonary forms being the most common.

HIV and AIDS

HIV weakens the immune system by targeting CD4 cells and causing AIDS. It is thought to have originated from a monkey virus and is treated with antiretroviral therapy. The symptoms associated with HIV are directly tied to the amount of virus present in the body and the amount of CD4 T cells that have been lost due to infection.

Understanding HIV and AIDS

HIV is a retrovirus that infects cells expressing CD4, such as helper T cells and macrophages, which are crucial for immune response. Once infected, the virus replicates by integrating into the host cell's genome and releasing RNA that reverse-transcribes into DNA. The DNA can then become very stable, making it difficult to cure HIV.

The initial symptoms of HIV infection are vague and may not appear for years, but as the virus replicates and destroys T cells, the immune system becomes weakened, leading to AIDS. AIDS is characterized by a severely weakened immune system that makes individuals susceptible to opportunistic infections, which can become life-threatening. HIV is primarily transmitted through direct contact with contaminated bodily fluids, such as blood, semen, vaginal fluid, and breast milk.

HIV Replication Process

- HIV binds to CD4 cells and enters them
- RNA is released and reverse-transcribed into DNA
- The DNA integrates into the host cell's genome
- In most cells, the DNA is transcribed and translated into HIV proteins and viruses, which are then released

Influenza Virus

The influenza virus is an RNA virus that causes seasonal circulation and spikes every winter with varying virulence. Five to twenty percent of the world population gets the flu each year, and it is fatal one percent at a time. The virus is transmitted through respiratory droplets or fomites, and its virulence factors include its ability to mutate rapidly, especially its hemagglutinin and neuraminidase spikes on its surface. Infected tissues are the respiratory mucosa or respiratory mucous membranes, and the virus is good at binding to those cells coated in cilia along the respiratory tract. Signs and symptoms of the flu include headaches, chills, dry cough, body ache, fever, stuffy nose, sore throat, and fatigue. To diagnose the flu, several rapid influenza tests can be completed in less than 24 hours, including PCR tests, ELISA, and immunofluorescence. Prevention and treatment include the flu vaccine and antiviral drugs such as Tamiflu.

Conclusion

Understanding the anatomy of the respiratory tract and the microorganisms that can cause infectious diseases is crucial in preventing and treating respiratory illnesses. Streptococcus pyogenes and the influenza virus are two microorganisms that can cause respiratory diseases and have specific virulence factors that make them dangerous. Proper prevention and treatment methods can help reduce the spread and severity of these diseases.

Flu and Mycobacterium Tuberculosis

Flu is caused by two types of viruses, influenza A and influenza B. Influenza A has two important surface proteins, hemagglutinin (H) and neuraminidase (N), which allow the virus to enter a host cell. The virus can undergo two types of genetic changes: antigenic shift and antigenic drift. Antigenic shift occurs when a flu virus found in ducks and a flu virus found in humans recombine in a pig, creating an entirely different virus. Antigenic drifts are smaller changes in the H or N spikes that are caused by point mutations in the RNA genome.

Prevention and treatment of flu and tuberculosis include limiting exposure, vaccination, and drug treatment. Flu vaccination is recommended every year. A vaccine for tuberculosis is available but not commonly used in the United States. Treatment for tuberculosis involves antibiotics for six months, and in the case of drug resistance, longer antibiotic treatment or fewer effective treatments.