Biomed: Medical Interventions (PLTW)

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Unit 1- How to Fight Infection

1.1- Mystery Infection

Vocabulary

Medical Interventions	Any measure whose purpose is to improve health or alter the course of disease.
Outbreak	A sudden rise in the incident of disease.
Pathogen	A specific causative agent of disease.
Bioinformatics	The collection, classification, storage, and analysis of biochemical and biological information using computers especially as applied in molecular genetics and genomics.
Genome	The complement of an organism's genes; an organism's genetic material.
BLAST	Basic Local Alignment Search Tool, to compare the nucleotide of the pathogen with the database to determine the matching organism.
GenBank Database	A publicly available molecular database containing nucleotide and amino acid sequences for hundreds of thousands of organisms.
Antibody	A protein secreted by plasma cells (differentiated B cells) that bind to a particular antigen and marks it for elimination.
Antigen	A macromolecule that elicits an immune response by lymphocytes.
Booster	An additional dose of a vaccine used to "boost" the immune system. They boost the levels of antibodies you have.
Concentration	The amount of specified substance in a unit amount of another substance.
Solvent	A substance, usually a liquid, capable of dissolving another substance.
Solution	A homogeneous mixture of 2 or more substances, which may be solids, liquids, gasses, or a combination.

Enzyme- Linked Immunosorbent Assay (ELISA)	A quantitative in vitro test for an antibody or antigen present in the body.
Enzyme	A protein serving as a catalyst, a chemical agent that changes the rate of reaction without being consumed.
Qualitative Results	Indicate whether a patient is positive or negative for the presence of the antigen or antibody.
Quantitative Results	Determine how much of the detected substance is present.

- Medical Intervention categories- Interventional procedures ex. Appendectomy, diagnostic ex. X-ray, assistive devices ex. Wheelchair, drugs ex. Albuterol inhaler, and behavioral ex. Exercise routine.
- Containing Infection- Contact webs help scientists determine how the infection or disease may have been spread and help to contain the outbreak of the disease through isolation and sanitation.
- Human genome project- A project, started in 1990, to map the complete genetic layout of a human being, they determined the complete nucleotide sequence of DNA of each human chromosome. This helps us to identify, treat, and contain diseases.
- DNA Sequencing- How scientists determine the precise order of nucleotides within a DNA Molecule.

Physical Effects- poor coordination, dizziness, memory loss, headaches, weakness, hearing loss, vision problems, damage to membranes on brain and spinal cord.

Meningitis affects the meninges, the membranes surrounding the brain and spinal cord.

Treatment- Intravenous antibiotics, corticosteroids. Treatment must be administered as soon as possible to reduce the risk of permanent damage to the brain and spinal cord.

Antigens are molecules that are foreign to the body and can include bacteria, viruses, and fungi. Antibodies are specific proteins that are produced in response to invading antigens, they seek out and attach to invaders, flagging them for destruction by the immune system.

→ Antibodies are extremely specific to the antigens they attack.

The Immune system is the body's system of fighting off invaders. B-lymphocytes, a type of WBC help to fight infection, they are present in the blood and lymph nodes.

1.2- Antibiotic Treatment

Vocabulary

Antibiotics	A substance produced by or derived from a microorganism and able in dilute solution to inhibit or kill another microorganism.
Zone of Inhibition	The clear area where the bacteria were not able to grow or survive.
Antibiotic Resistant	Resistance to one or more antibiotics usually due to additional genetic information.
Nucleoid	The area of a gene that contains DNA.
Plasmid	A small ring of DNA that carries accessory genes separated from those of the bacterial chromosome.
Conjugation	The one-way transfer of DNA between bacteria in cellular contact.
Transformation	The uptake and expression of foreign DNA by a cell.
Transduction	The transfer of genetic material from one organism to another by a genetic vector.

Gram Negative Vs Gram Positive

- GP has thick cell walls composed of peptidoglycan or murein
- GP stains positive
- GP has cell walls that contain chains of teichoic acid that extend from the plasma membrane through the cell wall
- GN has thin walls of peptidoglycan
- GN stains pink
- GN has an outer membrane of lipopolysaccharide

Antibiotic Types

- Penicillin
    - Stop peptidoglycan cross linking to weaken/ breakdown cell walls
    - Best for Gram positive
    - Kills cells
- Fluoroquinolone
    - Stops DNA replication
    - Prevents untwisting of DNA
    - Broad Spectrum
- Sulfonamides
    - Binds to enzymes that metabolize folate into folic acid
    - Inhibit
    - Broad spectrum
- Tetracycline
    - Stop protein synthesis
    - tRNA cant join with mRNA to make amino acid chain
    - Broad spectrum

Mechanisms of Antibiotic Resistance

- Genetic Mutation

    - A change in DNA that can cause a change in the gene product that is targeted.
- Destruction/inactivation
    - Some bacteria have genes which produce enzymes that chemically degrade the antibiotic, making them ineffective.
- Efflux
    - Efflux pump is a channel that exports materials out of the cell through an active process. Some bacteria can become antibiotic resistant through the efflux pump pumping out antibiotics and preventing it from collecting in the cell.
- Genetic Transfer- Conjugation
    - Aided by circular DNA (plasmids) which replicates without the chromosome. A pillis forms between two cells allowing the plasmid copy to go from one cell to another, transferring the antibiotic resistance.
- Genetic Transfer- Transformation
    - Genes are transferred as naked DNA from one cell with the antibiotic resistant gene to another normal cell.
- Genetic Transfer- Transduction
    - Bacteria DNA is transferred from one to another via a virus that infects the bacteria cell and serves as a vector for the DNA.

1.3- The Aftermath

Vocabulary

Cochlear Implant	An electrical prosthetic device that helps people with sensorineural hearing loss recognize sounds. It is composed of a microphone and speech processor that converts the sound waves into electrical signals that are transmitted into the implanted electrode(s) in the cochlea.
Audiologist	A healthcare specialist in treating patients with hearing loss or related disorders.
Sound	Mechanical energy that is transmitted by longitudinal pressure waves.
Crest	Highest point of a wave.
Trough	Lowest point of a wave.
Amplitude	The measure of how much energy a wave carries.
Wavelength	The distance from one crest to another.
Pitch	Determined by frequency, the degree of highness or lowness of a tone.
Frequency	How rapidly the sound waves vibrate each second.
Hertz	Vibrations per second.
Intensity	Loudness, determined by amplitude.
Amplitude	Amount of energy in a wave.
Decibels	How sound intensity is measured.
Pinna	External structure that directs sound to the inner ear.
Auditory Canal	Transmit sound from pinna to tympanic membrane.
Eustachian Tube	Ventilates the middle ear space, ensuring that its pressure remains at a normal pressure.
Ossicles	Transmits sounds from air to cochlea.
Tympanic Membrane	Thin layer of tissue that receives sound vibrations and transmits them to the ossicle.
Cochlea	Changes the vibrations of the cochlear liquids and structures into a neural signal.

Sensory Hair Cell	Amplify sound waves and convert auditory information to the brain stem.
Cochlear Nerve	Brings auditory information from cochlea to the brain.
Oval Window	A membrane covered opening that leads from the middle ear.
Vestibule	Detect changes in gravity and linear acceleration.
Vestibular Nerve	Transforms vestibular information to an egocentric frame of reference.
Audiometer	Used to measure a subject's hearing sensitivity.
Threshold	The softest sound a subject can hear.
Audiogram	A graphic representation of the relation of vibration frequency and the minimum sound intensity for hearing.

Hearing Tests

- Rinne Test
  - Evaluates hearing loss by comparing air conduction to bone conduction.
- Speech-in-Noise Test
  - Assess sensorineural hearing loss usually in active duty soldiers.
- Pure Tone Test
  - Tests air conduction by finding the quietest sound you can hear at different frequencies.

1.4- Vaccination

Vocabulary

Vaccine	A harmless variant of a pathogen that stimulates a host's immune system to mount defenses against the pathogen.
Vaccination	A procedure that presents the immune system with a harmless variant of a pathogen, thereby stimulating the immune system to mount a long term defense against the pathogen.
Recombinant DNA Technology	The process of cutting and recombining DNA fragments.
Plasmids	A small ring of DNA that carries additional genes that are separate from those in the chromosomes.
Vectors	Carries and moves genetic material.
Genes	A part of DNA that code for a specific protein to be produced.
Restriction Enzyme	An enzyme that recognizes and cuts specific sequences of DNA.
DNA ligase	An enzyme that helps to join the ends of DNA strands.

After the vaccine is administered

- Immune system identifies the antigens
- Immune system develops proteins that circulate the blood to help fight the infection
- Body stockpiles antibodies so they are available to fight off the disease once exposed

Immunities

- Innate- Born with, genetic
- Adaptive/ active- exposed to or vaccinated against
- Passive- passed from mother to baby
- Herd- everyone around you is protected

Characteristics of an Effective Vaccine

- Low levels of side effects and toxicity
- Protect against exposure to natural or wild forms of the pathogen
- Stimulates antibody and cell mediated response
- Have long term, lasting effects producing immunological memory
- Require minimal boosters
- Easy to administer with long shelf life

- Killed or inactive
    - Can't multiply and it contains recognizable antigens on skin but requires a larger dose and possible additional boosters.
- Live Attenuated
    - Long lasting and requires fewer boosters however, small chance of disease agent mutating back to pathogen strain.
- Genetically Modified
    - Provokes an immune response however copy and transfer mistakes can happen.
- Naked DNA
    - Small chance of replication as it is just DNA but it may infect the host.

Case Control Study

- Retrospective
- Looks at old resources
- People are similar

Cohort Study

- Prospective
- Ongoing

Unit 2- How To Screen What is in Your Genes

2.1- Genetic Testing and Screening

Vocabulary

Genes	A discrete unit of hereditary information consisting of a specific nucleotide DNA sequence.
Genetic Counselor	A specialist dealing with the process of communication concerning the occurrence or risk that a genetic disorder will occur in a family.
Genome	The complement of an organism's genes.
Genetic Diseases	Illnesses that originate in the chromosomes and DNA.
Genetic Testing	The use of methods to determine if someone has a genetic disorder, may develop one, or is a carrier for one.
Genotype	The genetic makeup of an organism.
Phenotype	The physical and physiological traits of an organism.
Allele	One of the 2+ forms of a gene.
Single- nucleotide polymorphism	One base pair variation in the genome sequence.
Taq Polymerase	An enzyme taken from a bacteria that is used to copy DNA because it doesn’t break down in high temperatures.
Thermal Cycler	Used to amplify DNA and RNA samples by PCR, raises and lowers the temperature to denature and anneal the sample allowing more copies to be made.
Screening	Tests used to monitor the growth of the fetus and check for chromosomal abnormalities.
Noninvasive	The test has minimal risks or impact on the mother or child.
Diagnostic	Provides a more definitive answer as to weather or not a child will be born with a particular disorder or condition.
Karyotype	A display of the chromosome pairs of a cell arranged by size and shape.
Carrier Screening	Tests if someone has one copy of a defective gene to a recessive disorder but doesn't display traits.

- Single Gene
    - Recessive, dominant, sex-linked disorders
    - Caused by changes or mutations that occur in the DNA sequence of a gene
- Multifactorial
    - Caused by a combination of environmental factors and mutations in multiple genes.
- Chromosomal
    - Caused by missing, extra, or broken chromosomes, deletions, or rejoinings.
- Mitochondrial
    - Mitochrondiral DNA only comes from the mother
    - Caused by mutations in non chromosomal DNA of mitochondria.

Steps of PCR

- Denaturing
    - double stranded DNA is heated up until the hydrogen bonds break, separating the strands.
- Annealing
    - Enabling DNA primers to attach to template DNA at a specific location.
- Extension
    - The temperature is raised and the new strand of DNA is made by the taq polymerase enzyme.

2.2- Our Genetic Future

Vocabulary

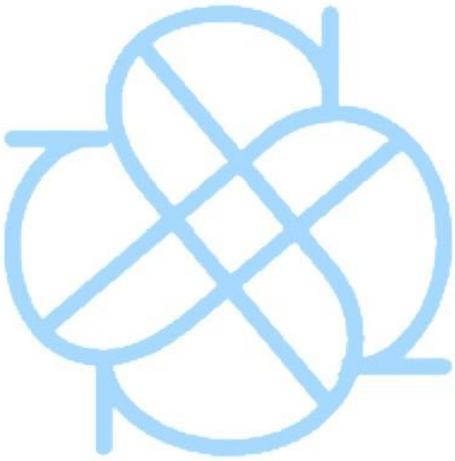
Gene Therapy	The alteration of the genes of a person with a genetic disease.
Vectors	An agent that carries genetic material and can introduce other genes into another organism.
Genome Editing	A technique that uses tools in the cell, the DNA and replaces the mutated genes with healthy ones.
Dominant Negative	Interferes with normal function.
Gain of Function	An abnormal function begins to work.
Improper Regulation	There is too much or too little or something in the cell.
Ovulation Induction	Hormones that stimulate follicle production.
Artificial Insemination	Insertion of sperm into a woman's cervix or uterus.
Donor Conception	Donors eggs or sperm are inserted in the patient.
In-Vitro Fertilization	Gametes are fertilized in a dish in a lab then implanted in the uterus.
Intracytoplasmic Sperm Injection	Direct insertion of sperm into one or more eggs.
Surrogacy	A woman carries another woman's child.

- Gene Therapy Candidates
    - Is the mutation responsible for the condition 1 or more genes?
    - Which gene is involved?
    - What do you know about the biology of the disease?
    - Will adding a normal copy fix the problem?
    - Can the gene be delivered to the affected cells?

Gene Silencing

- Turns the gene expression off to prevent formation of protein from the gene.

- Triple helix forming oligonucleotide gene therapy
    - Delivers single strands of DNA that bind between strands of the mutated genes, preventing it from being transcribed into mRNA.
- RNA interference
    - Introduces a small piece of RNA, complementary to a piece of the mRNA, which attaches and forms a double helix which is killed by the cell.
- Ribosome gene therapy
    - Ribosomes targeted to destroy mRNA with a mutated gene.



Unit 3- How to Conquer Cancer

3.1- Detecting Cancer

Vocabulary

Cancer	A malignant tumor possible of continuous growth that can grow locally and systemically.
Risk Factors	Something which increases a person's risk or susceptibility.
Cell Cycle	An ordered sequence of an eukaryotic cell's life events.
Apoptosis	The changes a cell undergoes as it goes into cell death, brought on by signals triggering suicide proteins.
Oncogenes	A gene that could potentially cause a cancerous change in normal cells.
Tumor Suppressor Genes	Regulates a cell's activity during division and replication.
Biopsy	The removal and examination of tissues, cells, or fluids.
Osteosarcoma	Cancer originating in the bone/ bone tissues.
Proto-oncogenes	A normal gene that corresponds to an oncogene, it can cause cancer but requires an altercation or mutation to become an oncogene.

- Checkpoints in a cell cycle ensure that the cell can continue in the cycle without mutations.
    - Cells that are damaged undergo apoptosis
- Cancer is caused when there is a problem in the oncogenes and tumor suppressor genes.

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- Four main types of cancer:
    - Carcinomas
    - Sarcomas
    - Lymphomas
    - Leukemias
- Cancer can arise from the loss of normal growth control, the balance between new cells and cell death become unbalanced.
- Methods of spreading:
    - Invasion- direct migration of cancer cells into nearby tissue.
    - Metastasis- cancer cells traveling via lymphatic and blood vessels around the body and grow in normal tissues.
- Benign tumors grow locally but can't spread by invasion or metastasis but malignant tumors can only spread by invasion or metastasis.
- DNA repair genes code for proteins that normally correct errors arising when cells replicate DNA before division.

3.2- Reducing Cancer Risk

- Breast Cancer:
    - Mammogram: an x-ray of the breast commonly used to detect early signs of cancer.
    - Breast MRI: Uses magnetic waves to take an image of the breast used for screening when women are at higher risk for developing breast cancer.
    - Clinical breast exam: A healthcare professional palpates to breasts to feel for lumps or bumps.
    - Self Exam: Identifying any changes felt in the breast.
- Cervical Cancer:
    - Pap smear: Examines the vagina and cervix, cells and mucus from the cervix and the area around it are collected and tested for precancerous cell changes.
- Colorectal Cancer:
    - Looks for precancerous polyps ,or signs of them, in the colon to be removed before they become cancerous.
    - Stool tests, flexible sigmoidoscopy, colonoscopy, and CT colonography are used to look for these polyps.
- Lung Cancer:
    - Low Dose Computed Tomography (LDCT): X-ray machine using a low dose (of radiation to create a detailed image of the lungs.
- Prostate Cancer:
    - Blood Test: Measures the amount the levels of prostate-specific antigen proteins in the blood to screen for abnormally high levels which may indicate prostate cancer.

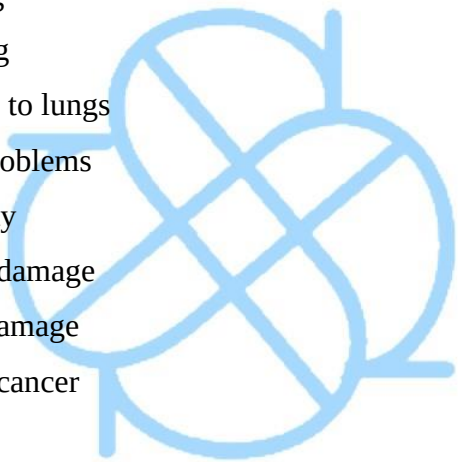
- Maintaining a healthy lifestyle can help to reduce a person's risk of developing cancer from external factors:
    - Not smoking or using tobacco products
    - Maintain a healthy weight
    - Exercise
    - Healthy Diet
    - Limited alcohol consumption

3.3- Treating Cancer

- Surgery:
    - Removing the tumor and surrounding tissues.
    - Surgery is often used to remove all or some of the cancerous tissue after diagnosis, or to ease cancer symptoms or to shrink tumors before other treatments.
    - Side effects:
        - Pain in surgical site
        - Infection
        - Bleeding
        - Damage to surrounding tissues
        - Anesthetic reactions
        - Fatigue
        - Appetite loss
        - Swelling
        - Drainage
        - Bruising
        - Numbness or nerve damage

- Chemotherapy:
    - A type of cancer treatment using powerful chemicals that target and kill fast-growing cells within the body.
    - Often used in combination with other treatments.

- Side effects:
    - Nausea
    - Vomiting
    - Diarrhea
    - Hair loss
    - Loss of appetite
    - Fatigue
    - Fever
    - Mouth sores
    - Pain
    - Constipation
    - Bruising
    - Bleeding
    - Damage to lungs
    - Heart problems
    - Infertility
    - Kidney damage
    - Nerve damage
    - Second cancer



- Radiation Therapy:
    - The radiation makes small breaks in the DNA of exposed cells, the breaks help prevent cancer cells from continuing to grow and divide.
    - Often used in combination with other treatments.
    - Side effects:
        - Hair loss at treatment site
        - Skin irritation
        - Fatigue
        - Dry mouth
        - Difficulty swallowing
        - Sore throat
        - Nausea
        - Mouth sores
        - Tooth decay
        - Cough
        - Shortness of breath
        - Frequent urination
- Immunotherapy:
    - Can be used to teach or boost the immune system to destroy cancer cells.
    - Can be used alone or in combination with other cancer treatments.
    - Side effects:
        - Pain/ swelling/ soreness
        - Rash
        - Fever/ chills
        - Dizziness
        - Nausea and vomiting
        - Muscle/ joint aches
        - Fatigue
        - Headache
        - Shortness of breath
        - Abnormal blood pressure

        - Heart palpitations
        - Risk of infection
        - Organ inflammation
- Targeted therapy:
    - Used to prevent cancer from growing and spreading.
    - Targeted therapy is used for patients with cancers whose tumors have the specific gene mutation that codes for the target.
    - Side effects:
        - Skin problems
        - Delayed clotting
        - High blood pressure
- Hormone therapy:
    - Used to stop or slow the growth of cancer cells that use hormones to grow, such as prostate and breast cancers.
    - May be used in combination with other treatments.
    - Side effects:
        - Tiredness
        - Digestive system problems
        - Hair loss
        - Muscle and bone changes
        - Weight gain
        - Headaches or memory loss

- Stem cell transplant:
    - Used to restore the blood-forming stem cells in patients whose stem cells are damaged.
    - Given with radiation and high dose chemotherapy.
    - Side effects:
        - Mouth/ throat pain
        - Nausea and vomiting
        - Infection
        - Bleeding
        - Interstitial pneumonitis
        - Graft versus host disease
        - Acute GVHD
        - Graft failure

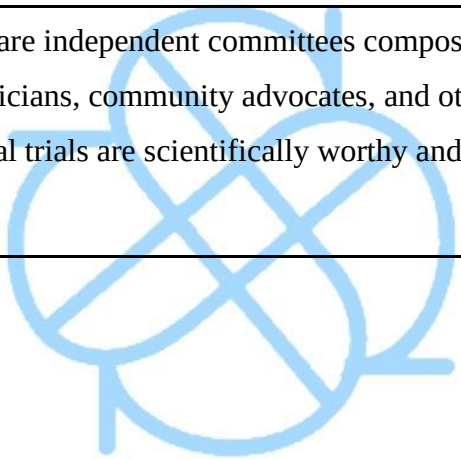
3.4- Building a Better Cancer Treatment

Vocabulary

Phase I	Evaluate safety of drug, determine safe dosage range, identify side effects, test small groups of people.
Phase II	Learn more about safety and side effects, sharpen estimates of proper dosage, determine effectiveness, test larger groups of people.
Phase III	determine effectiveness, determine side effects, test large groups of people.
Phase IV	Collect additional information after the drug enters the market: drug's risks, drug's benefits, optimal use.
Controlled experiment	One group receives the treatment another group does not .

Randomized experiment	Control group and treatment group are chosen at random.
Double-blind experiment	Neither subjects nor scientists know who is assigned to which group until after the data are collected.
Single-blind experiment	Subjects do not know which group they are assigned to but researchers know, this is prone to researcher bias.
Treatment group	Given experimental drugs.
Control group	given standard treatment or a placebo.
Placebo	An inactive pill, liquid, or powder that has no treatment value.
Randomized, double blinds	Neither patients nor researchers know who is in what group, prevents subjects in different groups from behaving different ways, and prevents scientists from introducing any unconscious bias into the data collection process.
Open trials	Set up where researchers and subjects know what treatment is being given, often used to test surgical procedures and medical devices, that by nature, cannot be done without the subject or researcher knowing who is receiving the treatment, however these are more prone to error and bias than double blind studies.
Factorial trials	Used to test medicines in combination.

Crossover trials	Used to test two treatments, set up where each participant gets both treatments being tested. Some participants are assigned at random to receive drug A and when done, receive drug b. Other patients receive drug B and when done, receive drug A.
Orphan drug trials	Used to test drugs designed to treat rare diseases, tested on a small number of participants who are very sick, if drug works, improved health is usually readily available.
Safety and Ethical Regulations	Clinical trials are designed to protect the health of the participants. Clinical trials done in the United States must be approved and monitored by an Institutional review Board.
Institutional Review Boards	IRBs are independent committees composed of physicians, statisticians, community advocates, and others. The IRB assures that clinical trials are scientifically worthy and that ethical guidelines are met.



Clinical Trials

- Clinical trial bias:
    - Double blind trials are the least biased because neither subjects nor scientists know who is assigned to which group until after the data are collected.
    - Single blind experiments are the most prone to biases because the scientists know ahead of time and may influence the results.
- Placebos:
    - In certain trials some patients are given a placebo in place of the drugs to serve as a reference point in results.
    - It may be viewed as unethical to give someone a placebo if they are coming to the clinical trial as a last resort treatment. By giving a patient a placebo, they will not be receiving any treatment at all and therefore the condition will only continue to get worse which is detrimental to the patient and their quality of life.