Principles of Biomedical Sciences Review
Unit 1: The Mystery
Steps for Processing a Crime Scene

1. Interview
2. Examine
3. Photograph
4. Sketch
5. Collect Evidence

Note: The crime scene should already be protected and secured to prevent contamination or tampering.
Personal Protective Equipment

Definition

“specialized clothing or equipment worn by an employee for protection against infectious materials” (OSHA)
Steps of Experimental Design

1. Identify the problem.
2. Formulate a hypothesis.
3. Design the procedure to be used to test the hypothesis.
4. Carry out the experimental procedure.
5. Analyze the data and observations.
6. Draw conclusions.
DNA Structure

- Double helix
- Building block: nucleotide
- Backbone: sugar/phosphate
- Steps: bases held together by hydrogen bonds
- Base pairing rules: A/T and C/G
- Sugar=deoxyribose
- Purines: adenine and guanine
- Pyrimidines: thymine and cytosine
DNA Structure
Nucleotide

- Phosphate group
- Sugar - deoxyribose
- Nitrogen base:
  - Adenine
  - Guanine
  - Cytosine
  - Thymine

![Diagram of nucleotide structure](image-url)
Size of DNA

- How does such a large molecule fit into the nucleus?
• Chromosomes are found in the nucleus of a cell.
• Chromosomes are made up of DNA.
• DNA is made up of millions of genes.
• Genes code for proteins that cause our traits.
Unit 2: Diabetes
Macromolecules

Proteins:
• Antibodies
• Contractile Proteins
• Enzymes
• Hormonal Proteins
• Structural Proteins
• Storage Proteins
• Transport Proteins
Macromolecules

Lipids: Energy storage
- Structuring cell membranes
- Lipid hormones
- Cellular metabolism
Macromolecules

• Carbohydrates: energy
  – Monosaccharides
  – Disaccharides
  – Polysaccharides
Macromolecules

- Dehydration Synthesis
- Hydrolysis

- Anabolism: synthesis reactions
- Catabolism: decomposition (or breaking apart)
Enzymes (protein)

- Catalysts
- facilitates or helps a reaction to occur more readily by reducing the energy required for the reaction to occur
- Lock and Key model
- Induced Fit model
- Substrate
- Active Sites
<table>
<thead>
<tr>
<th>Type 1 Diabetes</th>
<th>Type 2 Diabetes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Young onset</td>
<td>Older onset</td>
</tr>
<tr>
<td>(less than 35 years)</td>
<td></td>
</tr>
<tr>
<td>2. Rapid onset of symptoms (eg. ketoacidosis)</td>
<td>No obvious symptoms in the early stage</td>
</tr>
<tr>
<td>3. Non-obese</td>
<td>Obese</td>
</tr>
<tr>
<td>4. Body cannot produce insulin</td>
<td>Insulin secretion can be normal or abnormal, Body cells are resistant to insulin</td>
</tr>
<tr>
<td>5. Managed by insulin injections, with diet and exercise control</td>
<td>Managed by oral medications or insulin injections, with diet and exercise control</td>
</tr>
</tbody>
</table>
Food

- RDA (recommended daily allowance)
- Use DRI instead
- DRI (daily reference intake): is the daily intake level of a nutrient that is considered to be sufficient to meet the requirements of 97–98% of healthy individuals in every demographic in the United States
Feedback

- **Negative feedback loop** - The body senses an internal change and activates mechanisms that reverse, or negate, that change.
  - body temperature regulation

- **Positive feedback loop** - a process in which the body senses a change and activates mechanisms that accelerate or increase that change
  - blood clotting
Unit 3: Sickle Cell Anemia
What is Blood?

- Blood is a the major transport mechanism for substances that must be distributed through the body, including gases, molecules, nutrients, and hormones.
Blood Cells

• Red cells: carry oxygen
• White cells: fight invaders
• Platelets: blood clotting
Blood Plasma

- liquid part of blood, mostly water, has many things dissolved in it (sugars, salts, etc)
Sickle Cell Disease

- Normal hemoglobin:
- 2 alpha globins and 2 beta globins
Sickle Cell Disease

• For SCD, there is a mistake in the beta globin that causes the wrong amino acid to be used, making the rbc shape wrong and causes them to be sticky.

• Glutamic acid (hydrophilic) is replaced by valine (hydrophobic).
Sickle Cell Disease

- Found in high numbers in Africa because those with the trait show resistance to malaria
Amino acids and proteins

- Amino acids are the building blocks of proteins
- Therefore, proteins are chains of amino acids
- The sequence of amino acids determine the shape of the protein
RNA
Sugar: ribose
Bases: uracil replaces thymine
RNA

- tRNA: carry in the amino acids during translation (protein synthesis)
- rRNA: along with proteins, makes up the ribosomes
- mRNA: is a “copy” of DNA that leaves the nucleus and is the template from which amino acids chains are made
Protein Synthesis

- **Transcription:** The synthesis of RNA from a DNA template

- **Translation:** The synthesis of a poly-peptide using the genetic information encoded in an mRNA molecule. There is a change of language from nucleotides to amino acids.
Sickle Cell

• Disease: ss, have 2 sickle cell genes
• Trait: Ss, heterozygous, only a carrier
Karyotype: 47, XY, +21
Confidentiality

Healthcare provider must treat patient information confidentially and protect its security.
Unit 4: Heart Attack
The Heart

- Aorta
- Pulmonary trunk
- Left atrium
- Pulmonary veins
- Left ventricle
- Inferior vena cava
- Superior vena cava
- Right atrium
- Right ventricle
Blood Flow

Blood from the body flows:
- to the superior and inferior vena cava,
- then to the right atrium
- through the tricuspid valve
- to the right ventricle
- through the pulmonary valve
- to the pulmonary artery
- to the lungs

The blood picks up oxygen in the lungs, and then flows from the lungs:
- to the pulmonary veins
- to the left atrium
- through the mitral valve
- to the left ventricle
- through the aortic valve
- to the aorta
- to the body
Measurements of Heart’s Condition

• Heart rate: Number of heart contractions per unit of time

• EKG

• Blood Pressure
Fight or Flight Response

- The "fight or flight response" is our body's primitive, automatic, inborn response that prepares the body to "fight" or "flee" from perceived attack, harm or threat to our survival.
- adrenaline, noradrenaline and cortisol are released into our bloodstream
- respiratory rate increases
- Blood is shunted away from our digestive tract and directed into our muscles and limbs
- heart rate and blood pressure increase
Blood Pressure

• Measure of the force put on the vascular walls by the blood as it is pushed by the cardiac muscle through the vascular system

• **Systolic** The top number, which is also the higher of the two numbers, measures the pressure in the arteries when the heart beats (when the heart muscle contracts).

• **Diastolic** The bottom number, which is also the lower of the two numbers, measures the pressure in the arteries between heartbeats (when the heart muscle is resting between beats and refilling with blood).
Blood Pressure

• Blood pressure changes from minute to minute and is affected by activity and rest, body temperature, diet, emotional state, posture, and medications.

• Changes: higher when laying down (why?)

• Having high blood pressure puts someone at a higher risk for stroke, heart attack, kidney failure, loss of vision, and atherosclerosis (hardening of the arteries).
EKG

• P wave: represents the depolarization & contraction of the atria
• QRS complex: represents the depolarization & contraction of the ventricles
• T wave: represents the repolarization & relaxation of the ventricles
Cholesterol
Why We Need Fats

- Strengthen our immune system.
- Help calcium absorption and so give stronger bones.
- Are important for brain functioning.
- They waterproof and isolate the human body.
- They are the major constituent of the cell membranes.
- They function as energy reserves.
- They are indispensable for the absorption and use of the fat soluble vitamins A,D,E,K.
- They contribute to the production of many hormones.
- They contribute to the maintenance of many of our systems.
Saturated vs. Unsaturated Fats

Saturated

Unsaturated
(a) Fat molecule (triacylglycerol)

(b) Hard fat (saturated): Fatty acids with single bonds between all carbon pairs

(c) Oil (unsaturated): Fatty acids that contain double bonds between one or more pairs of carbon atoms
Why Unsaturated Healthier

• Found foods such as nuts, avocados, and olives.
• They are liquid at room temperature and differ from saturated fats in that their chemical structure contains double bonds.
• Additionally, studies have shown that unsaturated fats are also heart-healthy fats - they have the ability to lower LDL cholesterol and raise HDL cholesterol ("good" cholesterol).
• Does individual 2 in generation I have sickle cell disease? Is this individual male or female?

• Do individuals 3 and 4 in generation II have sickle cell disease?

• Based on the information given about the children in generation III, what can you predict about their parents?
LDL and HDL
LDL and HDL

• In order to travel around the body, cholesterol combines with protein, forming a lipoprotein (lipid + protein). The protein actually coats the cholesterol.

• LDL molecules contain more cholesterol than protein, making them low-density
LDL and HDL

• LDL binds to cholesterol in the liver to carry it to cells in the body. The lack of density allows excess LDL to remain in the blood vessels.

• When blood vessel walls become damaged, due to the effects of oxygen reactions or conditions like high blood pressure, the LDL binds to and accumulates along the walls of the blood vessels.
LDL and HDL cont.

- HDL is denser than LDL. This occurs due the higher amount of protein in HDL and a lower amount of cholesterol and fat.
- The high density of HDL keeps it moving through the blood vessels. As it goes it picks up excess cholesterol from tissues and the blood vessels. HDL then carries cholesterol back to the liver for breakdown and excretion.
Pedigrees

• Each row of the pedigree diagram indicates one generation
• The connecting lines indicate a direct relationship between individuals
• The generations are listed using Roman numerals
• The individuals within each generation are indicated by Arabic numerals.
• The order of birth within a generation is indicated by placing the first born at the far left and progressing from left to right with each subsequent child.
• If a symbol is filled in, that individual showed the trait the pedigree is tracking.
How is individual 4 in generation II related to individual 1 in generation II?
PCR

The polymerase chain reaction (PCR) is a biochemical technology in molecular biology to amplify a single or a few copies of a piece of DNA across several orders of magnitude, generating thousands to millions of copies of a particular DNA sequence.
Restriction enzymes

• an enzyme that cuts DNA at specific recognition nucleotide sequences

• Such enzymes, found in bacteria are thought to have evolved to provide a defense mechanism against invading viruses.
Figure S-2: Gel Electrophoresis

1. Restriction enzymes cleave DNA into smaller segments of various sizes.

2. DNA segments are loaded into wells in a porous gel. The gel floats in a buffer solution within a chamber between two electrodes.

3. When an electric current is passed through the chamber, DNA fragments move toward the positively-charged cathode.

4. Smaller DNA segments move faster and farther than larger DNA segments.
Medical Interventions

• An intervention is some action that is taken to change an outcome.
• A medical intervention is something that is done to treat or prevent an illness or injury.
• The medical procedures and interventions that we take for granted today have not always been available.
• Not all patients respond the same way to a medical intervention, and the physician should carefully select the best treatment for each patient.
Unit 6: Infectious Diseases
Bacteria

• One bacterial cell is capable of dividing itself into two new bacterial cells by a process called *binary fission*.

• Bacteria are living organisms and need to have an energy source. Some bacteria are capable of converting sunlight or chemicals into energy; others must convert food to energy just like humans.
Bacteria

• Bacteria can damage human tissue in three ways.
  – the bacteria directly attack and digest human cells
  – Bacteria produce toxins or other proteins that travel in the blood stream and damage cells that are not near the site of the actual bacterial infection
  – bacterial cells trigger a response by the immune system; as a result, the immune cells or their products damage surrounding body cells during the ensuing battle to kill the bacteria
Bacteria

• are very small, much smaller than a human cell
• can only be observed using a microscope and magnifying them at least 1000x
• Bacteria are divided into two main groups depending on how they react to a specific set of dyes called the *Gram stain* and it remains the first step in classifying or identifying bacteria.
  • Purple: Gram positive.
  • Pink: Gram negative
Gram Stain Notes

- Crystal Violet dye stains all bacterial cells
- Iodine fixes the crystal violet so that it will stay in the gram positive (purple)
- Alcohol washes the crystal violet out of the gram negative bacteria
- Safranin is used to stain the gram negatives (pink)
**Gram-positive**

- Retain crystal violet dye and stain dark violet or purple
- Peptidoglycan layer = Thick (multilayered)

**Gram-negative**

- Can be decolorized to accept counterstain (safranin); stain red
- Peptidoglycan layer = Thin (single-layered)
Viruses

- Viruses are not cells
- leads many scientists to consider them non-living
- they attach to, take over, and use cells
- overtaken cell is called a host cell
- A virus will get its genetic material into a cell, completely take over all the cell processes, and force the host cell to produce new viruses.
Viruses

- Because viruses are non-living, they do not require food and do not make any products without the help of a host cell.
- Are much smaller than cells
- Until the electron microscope was invented in the 1940’s, it was impossible to see a virus.
- The structure of a virus determines which cells it can attach to and invade.
Unit 1: Human Body Systems
Immune

protects against disease
Circulatory

blood, blood vessels, heart, lymph

transport of nutrients, metabolic wastes, water, salts, and disease fighting cells
Respiratory

intake of oxygen and removal of carbon dioxide from body
Nervous control of body activities and the reaction to stimuli
Digestive break down of food and absorption for use as energy
Excretory

controls water and salt balance
Endocrine

production of hormones and body regulation