**Unit 4**

Cell Structure, Metabolism and the Nutrients that Support Metabolism

The Cell

Cell is basis of human _____

Function of the cell

Requires energy, _____ (_____)

Requires _____

_____ major areas of cell

Parts of the Cell

**Cell (_____) Memebrane**

_____ and _____ (little organs)

Organelles

_____: Powerhouse of cell

_____: Factory of the cell

_____ (rER): contains ribosome

Participates in _____ synthesis

_____ (sER): does not contain ribosomes

Participates in _____ sysnthesis and _____

_____: Packaging site for protiens and lipids

_____: cell's digestive system, contains enzymes

_____: Control center of Cell

**Nuclear membrane**:

**DNA**:

_____: Where RNA and ribosomes are made

Metabolism: From Food to Life

What is Metabolism?

**Metabolism** is

The specifice types of metabolic reactions _____ or _____ energy

For example

Anabolism

**Anabolism** is the process

Critical for growth, repair, maintenance and synthesis of body tissue

_____ Energy

Catabolism

**Catabolism** is the

Occurs during digestion of macromolecules

Old tissues or cells are broken down for repair or replacement

_____ Energy

Metabolic reactions are usually linked.

What are the molecules important for these chemical reactions?

Adenosine Triphosphate (ATP)

**ATP** is

How is it used?

Enzymes, cofactors and coenzymes

***Enzymes***

Is it simply just speeding up these chemical reactions?

Enzyme Action

What about the cofactors and coenzymes?

**Cofactors**

**Coenzyme**

We will get into more detail with their functions later in this unit.

Metabolic Pathways

**Metabolic pathways** are

Occur in specific types or parts of the cell

May be limited to specific organs or tissues

_____ is the site of energy production in the nucleus of the cell

Additional chemical reactions

_____ is an anabolic process

Water is released as a by-product

A—OH + H—B → A—B + $H_20$

_____ is usually a catabolic process

A large molecule is broken apart with the addition of water

A—B + $H_20$ → A—OH + H—B

_____ is the addition of phosphate group to a compound

When the 2 high-energy phosphate bonds in ATP are hydrolyzed

**Oxidation-Reduction Reactions**

Molecules exchange electrons (_____)

**Oxidation** –

**Reduction** –

Exchange reactions occur together

Ex. electron transport chain

Since most chemical reactions or pathways will involve the use of energy how do we exact make our energy currency?

What is our energy currency?

Energy from Carbohydrates

When glucose is transported to the liver, it is

Phosphorylated and metabolized for energy or stored as _____

Released into circulation for other cells to use as fuel or stored as glycogen (muscle tissue)

Converted to fatty acids, if glucose exceeds caloric needs, and stored as triglycerides in adipose tissue

Let's first focus on how to extract energy from the carbs we eat.

Summary of Glucose Oxidation

**Aerobic Pathway**

Requires _____

3 Major Stages

**Glycolysis**

Breaks down glucose (6-C) to two pyruvate (3-C)

Occurs in the _____

Requires 2 ATPs

Produces a total of 4 ATPs and 2 _____

In the *Absence* of Oxygen…

In the *Presence* of Oxygen…

**Intermediate Step**

Convert Pyruvate to _____

Loss of _____ from the pyruvates

_____ is produced in the process

Occurs in the _____

**Tricarboxylic Acid Cycle**

a.k.a. **Krebs Cycle**

Acetyl CoA is broken down completely to _____.

cells use carbon skeletons of intermediates to produce other organic molecules (amino acids).

energy harvested per acetyl CoA:

1 ATP

3 NADH

1 $FADH_2$

**Electron Transport Chain**

Series of proteins & electron carriers embedded in the inner mitochondrial membrane.

_____ is the final electron acceptor

_____ is the final product

Summary of Glucose Oxidation

What about Energy from Fat?

Dietary and adipose triglycerides are broken down by _____ to yield one glycerol and 3 free fatty acids

*Free fatty acids* are used for _____ or _____

_____ is converted to pyruvate, then to acetyl CoA for entry into the TCA cycle

What about Energy from Proteins?

The body prefers using _____ and _____ for energy

Protein is reserved for metabolic functions that cannot be performed by others

building and repairing body tissues

Protein are used for fuel primarily during _____ total energy or carbohydrate _____

Energy from Protein

_____ dietary protein

used for energy or converted to _____ for storage as triglycerides

Now let's look at metabolism during feeding, fasting, and starvation

But before we do so let look at Synthesizing Macronutrients

Synthesizing Macronutrients

**Gluconeogenesis**:

Primarily from _____

Vital tissue proteins (skeletal and heart muscles and organ proteins)

Small amount from _____ (triglyceride)

Fatty Acids _____ form Glucose

There is _____ to convert acetyl CoA to pyruvate

Since acetyl CoA cannot be converted to glucose, fatty acids cannot be converted to glucose

Therefore you get _____

**Ketoacidosis**

Body defends against that by excreting the _____

Causes _____

Coma or _____

**Lipogenesis** or **de novo synthesis***:*

Occurs when consuming _____ calories

Acetyl CoA units assemble into fatty acid chains

Fatty acids combine with glycerol to form _____

Mostly occurs in liver cells

Amino acid synthesis (_____)

The body makes the carbon skeleton of _____ amino acids (NEAA)

Synthesis of NEAA occurs only when the body has enough energy and nitrogen

Since essential amino acids cannot be synthesized, they must be _____

Metabolism during **Feeding**

Bloodstream is _____ with glucose, fatty acids, and amino acids

Glucose is _____ as liver and muscle _____

When glycogen stores are saturated, glucose is stored as _____

Fatty acids are stored as triglycerides mostly in _____ tissues

Amino acids are _____ and carbon skeleton are converted to fatty acids for storage as triglycerides

Metabolism during **Fasting**

Liver glycogen is _____ releasing glucose into the blood

Most cells can switch to using _____ as fuel to conserve glucose for brain and other cells that rely on glucose as fuel

_____ form as acetyl CoA units are blocked from entering TCA cycle

_____ from muscle protein breakdown and glycerol

Metabolism during **Starvation**

The body switches to _____

Blood glucose is _____ to support brain and red blood cells

Activity, body temperature, metabolism _____

Fatty acids become the primary _____

Brain cells start to use _____ bodies as fuel

_____ protein supplies glucose

Nutrients Involved in Energy Metabolism

Vitamins vs Minerals

Vitamins

_____ molecules that assist in regulating body processes

_____

Minerals

_____ substances required for body processes

_____

Vitamins and Metabolism

Are required for proper _____

Do not directly _____ energy

Are necessary for _____ energy from the macronutrients

Let's first focus on Vitamins and Minerals

_____: a protein that accelerates the rate of a chemical reaction. Enzymes are required for all metabolic reactions.

_____: a molecule that combines with an enzyme to facilitate enzyme function.

B-complex Vitamins

The B-complex vitamins are

thiamin ($B_1$), riboflavin ($B_2$), niacin, vitamin $B_6$, folate, vitamin $B_{12}$, pantothenic acid, biotin

_____ (**vitamin _____**)

Food Source:

Good sources: whole grains, enriched foods, pork products

Function:

Coenzyme thiamin pyrophosphate (_____) required for metabolism of carbohydrate and branched-chain amino acids and production of DNA and RNA

Deficiency

**Beriberi** –

Occurs where polished rice is the only _____

_____

Impaired sensory, motor and reflex

Have difficulty rising from squatting position

Occurs within ___ days on a thiamin deficient diet

Toxicity

_____

_____ (**vitamin _____**)

Food Source:

Good source: milk, enriched foods, meat

Light sensitive (use opaque milk cartons)

Function:

component of 2 coenzymes involved in oxidation-reduction reactions in metabolism

_____ and _____

part of _____ enzyme glutathione peroxidase

Deficiency

**Ariboflavinosis**

Toxicity

N/A

_____

Nicotinamide and nicotinic acid

Food Source:

Good sources: meat, fish, poultry, enriched bread products

Can be made from amino acid tryptophan

Function:

Deficiency

_____ – severe niacin deficiency

Occurs in 50-60 days

Prevented with an adequate _____ diet

Consequences of deficiency

Toxicity

Toxicity can result from _____

Flushing of skin, Itching, Nausea, and Liver damage

**Vitamin $B_6$ (pyridoxine)**

Food Source:

Good sources: enriched cereals, meat, fish, poultry, starchy vegetables

Function:

Group of 3 related compounds

Coenzyme for over _____ enzymes in amino acid metabolism

Decarboxylation of amino acid

Transamination reaction

Deficiency

_____ anemia

Seborrheic dermatitis

Convulsion, depression, confusion

Toxicity

Toxicity from supplements can result in _____ damage, skin lesions

_____ (_____)

Food Source:

Good sources: Liver, fortified breakfast cereals, grains, legumes, foliage vegetables

Function:

Coenzyme tetrahydrofolate (_____) involved in DNA synthesis and amino acid metabolism

Involved in the metabolism of _____

Deficiency

_____ anemia

Similar signs and symptoms of vitamin B-12 deficiency

_____ defects

Toxicity

A masking of symptoms of vitamin B-12 deficiency

_____ damage

_____ (_____)

Food Source:

Good sources: Organ meat, Seafood, Eggs, Hot dogs, Milk

Function:

Deficiency

_____ **anemia**

Nerve degeneration, weakness

Tingling/numbness in the extremities (parasthesia)

Paralysis and death

Toxicity

_____

_____

Food Source:

Good sources: chicken, beef, egg yolk, potatoes, oat cereals, tomato products

Function:

Component of coenzymes for fatty acid metabolism

_____

Required for synthesizing cholesterol, steroids

Deficiency

_____

Listlessness, fatigue, headache, sleep disturbance, nausea, abdominal distress

_____ at risk

Usually in combination with other deficiencies

Toxicity

N/A

_____

Food Source:

Biotin content has been determined for very few foods

Cauliflower, yolk, liver, peanuts, cheese

_____ synthesis of biotin

Function:

Part of coenzymes involved in metabolism of carbohydrates, fat, and proteins

Important for _____

Deficiency

Deficiency seen in large consumption of raw _____ over time

Symptoms: hair thinning, hair color loss, red rash

Toxicity

N/A

_____ is a vitamin-like substance

Food Source

Good sources: milk, liver, eggs, peanuts

Function

Assists in homocysteine metabolism

Accelerates the synthesis of acetylcholine, a _____

Deficiency

Deficiency can lead to fat accumulation in the _____

Toxicity
Toxicity can result from supplements
Fishy body odor
Vomiting
Excess salivation
Sweating
Diarrhea
Low Blood Pressure

Minerals and Metabolism

_____ (___)

Iodine is a _____ mineral.
Food Source
Good sources: saltwater fish, shrimp, iodized salt, milk and dairy products
Function
Critical for the synthesis of _____ hormones
Thyroid hormones

Important for healthy

Deficiency
Iodine deficiency disorders (IDDs)
_____ –thyroid enlarges to capture more iodine
_____ – mental retardation from iodine deficiency during embryonic development
_____ – low thyroid hormone results in low body temperature, cold intolerance, weight loss, fatigue
Toxicity
_____ with thyroid function
Over consumption of _____

_____ (_____)

Chromium is a _____ mineral.
Food Source
Good sources: mushrooms, prunes, dark chocolate, nuts, whole grains
Function
Assists insulin to transport glucose from the bloodstream into the cells
Important for RNA and DNA metabolism
Supports normal growth and immune function
Deficiency
Chromium deficiency uncommon
Induced in labs: raises blood glucose and insulin
Toxicity
High-dose supplementation safety is unknown

_____ (_____)

Manganese is a _____ mineral.

Food Source

Good sources: whole-grain foods, brown rice, pineapple, pine nuts, okra, spinach

Function

Coenzyme involved in energy metabolism

Part of the antioxidant enzyme _____

Deficiency

_____

Toxicity

Toxicity _____ the nervous system causing spasms and tremors

_____ (___)

Sulfur is a _____ mineral.

Food Source

Function

Required for _____ of alcohol and drugs by the liver

Deficiency

Sufficient sulfur is synthesized from the protein in our diets

Toxicity

B-vitamin Status

Diets high in unenriched processed foods provide inadequate levels of B-vitamins

Some B-vitamins lost in milling of grains are replaced by the enrichment process

Poor B-vitamin status impacts exercise

Limited studies show poor work performance: lower intensity and duration