Nutrition

A. Nutrients – a substance in food that is used by the body to promote normal growth,

maintenance, and repair

1. Macronutrients – those which must be consumed in relatively large quantities

A) Include carbohydrates, lipids, proteins, and water

2. Micronutrients – those which are required in small quantities

A) Include vitamins and minerals

3. Essential nutrients – any nutrient that cannot be made by the body and must be

provided by the diet

A) Include minerals, most vitamins, 8-9 amino acids and 1-2 fatty acids

B. Summary of Macronutrients

1. Carbohydrates

A) Sources

1) Complex carbohydrates (starches) – bread, cereal, flour, pasta, nuts, rice, and

potatoes

2) Simple carbohydrates (sugars) – carbonated drinks, candy, fruits, and yogurts

3) Both complex and simple – pastries

B) Uses in the body

1) Short-term energy source used to make ATP

2) Used to synthesize nucleic acids, glycolipids, glycoproteins, ATP, cAMP

and many cell surface receptors

C) Locations in the body

1) Adults generally have about 375-475g

a) ~325g = muscle glycogen

b) 90-100g = liver glycogen

c) 15-25g = blood glucose

i) Blood glucose is usually measured in mg/dl with normal levels in the low

to mid 100’s

D) Problems

1) Excess – obesity, cavities & upset stomach

2) Deficits – tissue wasting & metabolic acidosis

2. Lipids

A) Sources

1) Saturated fatty acids – meat, egg yolks, and dairy products

2) Unsaturated fatty acids – nuts, seeds, and most vegetable oils

3) Essential fatty acids – corn, cottonseed & soy oils, and vegetable shortening

4) Cholesterol – organ meats and egg yolks

B) Uses in the body

1) Protect and cushion organs

2) Insulate body and organs

3) Long-term energy source; most calories (energy) per gram of all nutrients

4) Stabilize cell membranes

5) Precursor for bile salts, steroid hormones, and vitamin D

6) Necessary for fat-soluble vitamin absorption

7) Thromboplastin (blood clotting factor), prostaglandins and eicosanoids are all

derived from lipids

C) Serum lipoproteins

1) Tiny droplets with a core of cholesterol and triglycerides surrounded by a protein

and phospholipid coating

2) Allows lipids to be transported in the blood to be recognized by the body’s cells

3) 4 categories

a) Chylomicrons

i) Absorbed in the digestive system and ultimately stored in adipocytes as

triglycerides

b) High-density lipoproteins (HDLs)

i) Formation primarily occurs in the liver

ii) Act as a vehicle to remove excess cholesterol from the body

c) Low-density lipoproteins (LDLs)

i) Mostly cholesterol

ii) Transport cholesterol to cells that require it

d) Very low-density lipoproteins (VLDLs)

i) Produced in the liver

ii) Transport lipids around the body for use or storage

iii) Converted to LDLs

4) Desirable Cholesterol Levels

a) Total cholesterol = <200mg/dl

b) HDL = 40-56mg/dl for males & 50-60mg/dl for females

c) LDL = <100mg/dl

D) Problems

1) Excess – obesity, cardiovascular disease, & Type 2 diabetes

2) Deficits – weight loss, poor growth, skin lesions, increased risk of strokes,

& slower metabolic rate

3. Proteins

A) Sources

1) Complete proteins – egg whites, milk, meat, fish, and poultry

2) Incomplete proteins – legumes, nuts, seeds, vegetables, grains, and cereals

B) Uses in the body

1) Structural proteins such as keratin, collagen, elastin, and muscle fibers

2) Functional proteins such as enzymes, hemoglobin, hormones & receptors, and

membrane proteins

C) Problems

1) Excess – obesity and kidney & liver problems

2) Deficits – weight loss and tissue wasting, growth retardation, anemia, edema,

premature birth & miscarriage

4. Vitamins

A) Fat soluble vitamins

1) Vitamin A

a) Antioxidant; required for skin & mucus structure and normal bone

development

b) Found in green leafy vegetables, egg yolk, liver, and fortified milk &

margarine

2) Vitamin D

a) Increases blood Ca++ levels

b) Produced in the skin exposed to UV light, also found in egg yolk and

fortified milk

3) Vitamin E

a) Antioxidant that prevents oxidation of fatty acids preventing damage to cell

membranes by free radicals

b) Found in vegetable oils, nuts, whole grains, and dark leafy vegetables

4) Vitamin K

a) Essential in clotting protein formation

b) Found in green leafy vegetables, broccoli, cabbage, cauliflower, and pork

liver

c) Is also produced by bacteria normally present in the large intestine

B) Water soluble vitamins

1) Vitamin C (ascorbic acid)

a) Antioxidant, necessary for the formation of most connective tissues and the

conversion of cholesterol to bile salts, aids iron absorption

b) Found in fruits (especially citrus) and vegetables

2) B-complex Vitamins

a) Thiamine (B1) – helps convert pyruvic acid to acetyl CoA and is necessary for

the synthesis of ACh; found in lean meats, eggs, and green leafy vegetables

b) Riboflavin (B2) – acts as FAD; found in egg whites, fish, and milk

c) Niacin (B3) – acts as NAD; found in poultry, fish, and meat

d) B6 – necessary for amino acid metabolism and the formation of antibodies

and hormones; found in meat, poultry, fish, whole grains, and bananas

e) Folic acid (B9) – essential for RBC formation and embryonic neural tube

development; found in liver, orange juice, deep-green vegetables, lean beef,

eggs, and whole grains

f) B12 – necessary for proper metabolism in the GI tract, nervous system, and

bone marrow; found in liver, meat, poultry, and eggs

5. Minerals

A) Major minerals

1) Calcium (Ca) – necessary for bone density, impulse conduction, and muscle

contraction

2) Phosphorus (P) – required for the production of nucleic acids, proteins, and ATP

3) Potassium (K) – necessary for impulse conduction and muscle contraction

4) Sulfur (S) – a component of some amino acids & vitamins; vital for tertiary

protein structure

5) Sodium (Na) – necessary for maintaining osmotic pressure, impulse conduction,

muscle contraction, and acid-base balance

6) Chloride (Cl) – required for CO2 transport and HCl production

7) Magnesium (Mg) – a coenzyme (NAD & FAD) component

B) Trace minerals

1) Iron (Fe) – component of hemoglobin

2) Manganese (Mn) – required for the synthesis of fatty acids, cholesterol, urea, &

hemoglobin

3) Copper (Cu) – required for the production of hemoglobin, melanin, & myelin

4) Iodine (I) – required for the formation of thyroid hormones

5) Zinc (Zn) – enzyme/protein component, required for normal growth, wound

healing, taste, smell, & sperm production

C. Food Intake Regulation

1. Hypothalamus – hunger center

A) Releases a number of chemicals

1) Orexins – appetite enhancers

2) Neuropeptide Y – increases cravings for carbs

3) Galanin – increases cravings for fats

4) Serotonin – promotes feeling of fullness & satisfaction

B) Also binds to chemicals

1) Leptin

a) Released from fat tissue in response to increased fat deposits

b) Inhibits hunger and increases metabolism

2) Ghrelin

a) Released from cells in the stomach lining

b) Stimulates hunger

Metabolism

A. Metabolism – sum of all the chemical processes in the body

B. Types of Metabolic Reactions

1. Anabolic reactions – energy-requiring reactions that build organic compounds

2. Catabolic reactions – energy-releasing reactions that break organic compounds and

often generate ATP

3. Oxidation reaction – any reaction where a molecule gains oxygen or loses a hydrogen

4. Reduction reaction – any reaction where a molecule loses oxygen or gains a hydrogen

A) Oxidation and Reduction (Redox) reactions are always coupled

C. Carbohydrate Metabolism

1. Glucose catabolism is the breakdown of CHO to release energy (cellular respiration)

A) It is accomplished in four steps: Glycolysis, Pre-Krebs, the Krebs cycle, and the

Electron Transport Chain

2. Glycolysis – “sugar splitting” occurs in the cytoplasm of the cell and does not require

oxygen

A) 1 glucose molecule is broken down into 2 molecules of pyruvic acid

B) 4 ATP are produced during the process. However, 2 ATP are used during the

process. Therefore, the net result is only 2 ATP for glycolysis

C) 2 H atoms are removed (oxidation) and are picked up by 2 NAD+ to form 2

molecules of NADH (reduction)

D) The fate of pyruvic acid depends on the oxygen availability

1) No oxygen present – acidic fermentation

a) H from NADH is transferred to pyruvic acid resulting in lactic acid

2) Oxygen present – Krebs cycle

3. Pre-Krebs

A) As each pyruvic acid enters the mitochondria, a C and H are removed and

coenzyme A is added resulting in 2 molecules of acetyl CoA

B) The 2 carbon atoms that were removed bind with O2 forming 2 molecules of CO2

C) The 2 H atoms that were removed bind with NAD+ forming 2 molecules of NADH

D) No ATP are formed during this step

4. Krebs Cycle – occurs in the matrix of the mitochondria

A) Acetyl CoA enters the Krebs cycle where it combines with oxaloacetic acid to

create citric acid

B) As the cycle moves around, citric acid is rearranged to produce different

intermediate molecules called keto-acids

C) At the end of the cycle, the resulting molecule is oxaloacetic acid, which is now

available to attach to another acetyl CoA

D) Totals for the Krebs cycle

1) 4 C atoms are removed and combine with O2 forming 4 molecules of CO2

2) 10 H atoms are removed and added to NAD+ (6) or FAD (4) resulting in 6

NADH and 2 FADH2

3) 2 molecules of ATP are synthesized per cycle

E) All NADH (10; 2 from glycolysis, 2 from pre-Krebs, 6 from Krebs) & FADH2 (2

from Krebs) produced up to this point will enter the electron transport chain

5. Electron Transport Chain (ETC) – occurs on the cristae of the mitochondria

A) Involves membrane proteins acting as H+ pumps that will release energy as an

electron is transferred from one to another

B) NADH and FADH2 drop off their hydrogen atoms to the chain of electron

acceptors (pumps)

C) As the H are dropped off they lose their electrons which travel “down the chain”

(from one pump to the next)

D) The energy from the electrons is used to pump H+ into the intramenbranous space,

creating a H+ gradient

1) The electrons ultimately end up forming the bond between O and H resulting in

the eventual formation of H2O

a) Oxygen is considered the final electron acceptor for cellular (aerobic)

respiration

F) Intramembranous H+ then moves through ATPsynthase creating the energy to

combine ADP + P resulting in ATP

1) Each NADH stores enough energy to create 2.5 molecules of ATP

2) Each FADH2 stores enough energy to create 1.5 molecules of ATP

G) Results in the production of 28 ATP; therefore the entire process from glycolysis

thru ETC yields a net of 32 ATP

6. Carbohydrate Anabolism

A) When cellular ATP reserves are high or when glucose is in excess, glucose has to

be stored

1) Glucose catabolism is inhibited

2) Glucose conversion to glycogen (glycogenesis) or to fat (lipogenesis) is

stimulated

B) When ATP or glucose levels drop the body can then convert glycogen back to

glucose

1) Glycogenolysis – production of glucose from glycogen

2) Gluconeogenesis – formation of glucose from non-carbohydrate molecules (such

as fat and protein)

3) Both processes occur in the liver

D. Lipid Metabolism

1. The end products of lipid digestion (lipolysis) and cholesterol digestion are transported

in the blood as chylomicrons

2. The glycerol is converted to glucose (which enters into glycolysis) or G3P

(which eventually enters the Krebs cycle)

3. The fatty acids are broken down into fragments which bind to coenzyme A creating

acetyl CoA which enter the Krebs cycle

4. Dietary fats not needed for energy or structural materials are stored in adipose tissue

5. When carbohydrates are scarce, the breakdown of fats for energy results in the

formation of keto-acids (ketones) which can be deadly in high amounts because they

lower the blood pH resulting in a condition known as ketoacidosis.

E. Protein Metabolism

1. To be used for energy, amino acids are converted into pyruvic acid or keto-acids that

can then enter into Krebs

A) This process involves the following events:

1) One of any number of amino acids transfers their amine group to -ketoglutaric

acid resulting in the formation of glutamic acid

a) This process is known as transamination

2) In the liver, the amine group from glutamic acid is removed in the form of

ammonia (NH3) and combined with CO2 to form urea

a) This process is known as deamination

b) The urea is then excreted into the blood where it is filtered out by the kidneys

and released in urine

c) Deaminated amino acids may also be converted to fatty acids or glucose

2. Protein anabolism requires essential amino acids

A) If any of them are lacking, amino acids are used as energy fuels

F. Role of the Liver in Metabolism

1. The liver is the body’s main metabolic organ and it plays a crucial role in processing or

storing virtually every nutrient group

2. The liver has several metabolic functions:

A) Packages fatty acids to forms that can be stored or transported

B) Synthesizes plasma proteins

C) Forms non-essential amino acids and converts ammonia to urea

D) Stores glucose as glycogen and regulates blood sugar homeostasis

E) Stores fat-soluble vitamins

F) Conserves Fe+3 from phagocytized RBC

G) Degrades hormones

H) Detoxifies drugs, alcohol, & other substances

Metabolic Rate and Body Heat Production

A. Body temperature reflects the balance between heat production and heat loss and is

normally 96-100oF (37oC) which is optimal for physiological activities

B. At rest, most body heat is produced by the liver, brain, heart, kidneys, and endocrine

organs

1. Activation of skeletal muscles causes dramatic increases in body heat production

(thermogenesis)

2. The body core generally has the highest temperature whereas the shell (the skin) has the

lowest temp

3. Blood serves as the major heat-exchange agent between the core and the shell

A) When blood is deep in the organs, heat loss is minimal

B) When blood is in the skin capillaries, heat loss is at its maximum

4. Heat-exchange mechanisms include:

A) Radiation – the transfer of heat from a warmer object to a cooler object (not in

direct contact) in the form of “heat waves”

1) Accounts for about half of all body heat loss

2) Examples include your skin warming while sunbathing or a room warming as it

fills with people

B) Conduction – the transfer of heat from a warmer object to a cooler object that is in

direct contact with the warmer one (including the air in direct contact with your skin)

1) Examples include the seat beneath you warming as you sit in it or your skin

warming as a heating pad sits on it

C) Convection – the transfer of heat energy by air currents

1) Warm air rises away from the body and cool air replaces it therefore increasing

conduction

2) Fans and wind can speed up convection therefore making us feel cooler

D) Evaporation – heat is absorbed by water molecules that become so energized that

they escape as water vapor taking heat with it

1) Sweating is the best example but there is a small amount of water loss that

occurs without sweating at all times, even in cold weather

5. Heat-promoting mechanisms

A) Vasoconstriction

B) Increase in metabolic rate

C) Shivering

D) Behavioral modifications/conscious actions

6. Body’s Thermostat

A) The hypothalamus acts as the body’s thermostat

1) Its heat-promoting and heat-loss centers receive input from peripheral and

central thermoreceptors

2) It then integrates these inputs and initiate responses leading to homeostasis