Metabolism

The catabolism of complex organic molecules to release energy for body’s active processes

Byproducts used for synthesis (anabolism) of new molecules (require energy)

Some molecules destined for storage & later use

Coupling of catabolic and anabolic reactions through ATP

Regulation of Food Intake

Two control centers in hypothalamus

– feeding center which is always active and inhibited by satiety center

Input to both include:

– Chemicals - glucose, amino acids, lipids
– Body temperature
– Physical distention of GI tract
– Hormonal - CCK

Metabolic Rate

BMR - measure of metabolic rate at rest

– no exercise for 30 min prior, body awake, comfortable room temp., fasting for 12 hours

BMR is a measure of the minimum amount of energy required for body maintenance, partially related to amount of thyroxine produced (thyroid gland) which regulates rate of ATP use and is not altered by rest

Measured as kilocalories/kg body weight

Indirectly measured by oxygen consumption

Energy Molecules

Oxidation/reduction reactions (loss/gain of electrons) - energy transferring reactions

– Biological RedOx reaction usually also involve transfer of H atoms
  • H atoms are not freed but temporarily bond to coenzymes
  • Nicotinamide adenine dinucleotide (NAD)
  • Nicotinamide adenine dinucleotide phosphate (NADP)
  • Flavin adenine dinucleotide (FAD)

ATP formed by substrate level phosphorylation (direct) or by oxidative phosphorylation (through intermediates like NAD or electron transport system)

Carbohydrate Metabolism

During digestion, most saccharides converted to monosaccharides (primarily glucose)

Non-glucose polysaccharides (fructose & galactose) converted to glucose by liver

Destiny of glucose
– Catabolism/Energy use
  • Cells absorb glucose by facilitated diffusion which is enhanced by insulin
    (ex. neurons and hepatocytes which continually absorb glucose)
– Anabolic synthesis - amino acids, triglycerides (lipogenesis - also a form of
  storage)
– Storage - glycogen (glycogenesis)
– Excess excreted

**Glucose Catabolism**
• Also known as cellular respiration
• Yields CO₂, H₂O and energy
• Four general steps in process
  – Glycolysis
  – Formation of Acetyl CoA
  – Krebs cycle
  – Electron Transport Chain

**Glycolysis**
• Breakdown of 6-C molecule (glucose) to two 3-C molecules (pyruvic acid)
• In most cells first step of glycolysis quickly occurs
  – Phosphorylation to glucose-6-phosphate (keeps glucose in cell)
• Pyruvic acid can be used anaerobically or aerobically
  – If anaerobically, one glucose produces 2 ATP
    • Lactic acid is produced
  – If aerobically, one glucose produces 36 ATP
    • Catabolism of glucose is complete
• Pyruvic acid carried into mitochondrial matrix via transporter protein
• 2 ATP plus 2 NADH net for every glucose molecule

**Formation of Acetyl CoA**
• Decarboxylation reaction producing 2-C acetyl molecule
  – CO₂ given off
• Addition of CoA enzyme (derived from a B vitamin)
• 2 NADH net for every glucose molecule

**Krebs Cycle**
• Also known as citric acid cycle or tricarboxylic acid cycle
• Cycles that returns to oxaloacetic acid with each turn plus
  – Two decarboxylations (CO₂ formation)
    • Several RedOx reactions forming NADH and FADH₂
  – Phosphorylation forming ATP
• 2 ATP, 6 NADH & 2 FADH₂ net for every glucose molecule

**Electron Transport Chain**
• Sequence of electron carriers, electrons are passed to lower energy
configurations

- As energy is released from NADH and FADH₂, H⁺ is pumped across inner mitochondrial membrane (proton pump) to intermembranous space
- Last electron acceptor is oxygen; to produce H₂O
- H⁺ concentration gradient utilized to produce ATP (chemiosmosis)
  - 32-34 ATP produced per glucose molecule

**Glucose Anabolism**

- Glycogenesis - glucose $\rightarrow$ glycogen
  - Takes place in liver & stimulated by insulin
  - Body can store about 500 grams of glycogen (25% liver, 75% muscle)
  - Glycogenolysis - catabolism of glycogen
- Gluconeogenesis - protein (certain AA’s) or fat (glycerol) $\rightarrow$ glucose
  - Occurs when starving, eating low carbo meals, or hormonal stimulation

**Lipid Metabolism**

- Chylomicron - form of lipids after absorption
- May be catabolized (lipolysis) to produce ATP, stored in adipose tissue, or used in structural molecules (phospholipids, lipoproteins, cholesterol, etc.)
- Lipolysis - triglycerides are broken into fatty acids & glycerol
  - Catabolism yields more than twice the energy of carbohydrates
  - Fatty acids catabolized two carbons at a time (beta oxidation) which bond with CoA to form acetyl CoA (entry into Kreb’s cycle)

**Lipid Anabolism**

- Known as Lipogenesis
- Glucose or amino acids $\rightarrow$ lipids
- Stimulated by insulin

**Protein Metabolism**

- Amino acids absorbed by active transport
- May be catabolized (including deamination) to produce ATP, used to synthesize a variety of proteins, or converted to other types of molecules (e.g. glucose, fatty acids)
- Of the 20 amino acids, 10 cannot be synthesized - essential amino acids

**Protein Anabolism**

- Formation of peptide bonds between amino acids
- Stimulated by human growth hormone, thyroxine, and insulin

**Absorptive/Postabsorptive States**

- Time after eating affects the body’s metabolic reactions
- 4 hours usually required to absorb a meal during which many needed molecules are available in the blood
- During the other times, molecules must be pulled from storage when blood glucose level drops (normal is 70-110mg/100 ml of blood)
• See diagrams 25.15 & 25.16
• Insulin (released from pancreas due to GIP and increase blood glucose) stimulates absorptive state
  – GIP = glucose-dependent insulinotropic peptide
  – Increases activity of anabolic and storage molecule enzymes
  – Decrease activity of catabolic enzymes
  – Increases entry of glucose and AA into cells
• Anti-insulin hormones (e.g. glucagon) and sympathetic ANS stimulate postabsorptive state
  – Glucagon increases gluconeogenesis and glycogenolysis in liver
  – Neurons in hypothalamus detect low blood glucose; ANS release of norepi and adrenal release of epi and norepi
    • Epi increase glycogenolysis, epi and norepi increase lipolysis
    • Muscles use the fatty acids, nerve cells use the glucose

Food requirements
• Calories
• Minerals
• Vitamins (water soluble and fat soluble)