

Energy Metabolism

Module 8



Objectives

- Define metabolism, catabolism, and anabolism.
- Describe oxidation and reduction reactions.
- Explain how the body metabolizes alcohol.
- Explain the factors that regulate energy metabolism.
- Summarize how fed and fasted states affect metabolism.
- Describe common inborn errors of metabolism.



Metabolism

- Metabolism refers to the chemical processes involved in maintaining life
 - Enable us to release energy from carbohydrate, fat, protein, and alcohol
 - Permit us to synthesize new substances and excrete waste products
- A metabolic pathway is a group of reactions that occur in a progression



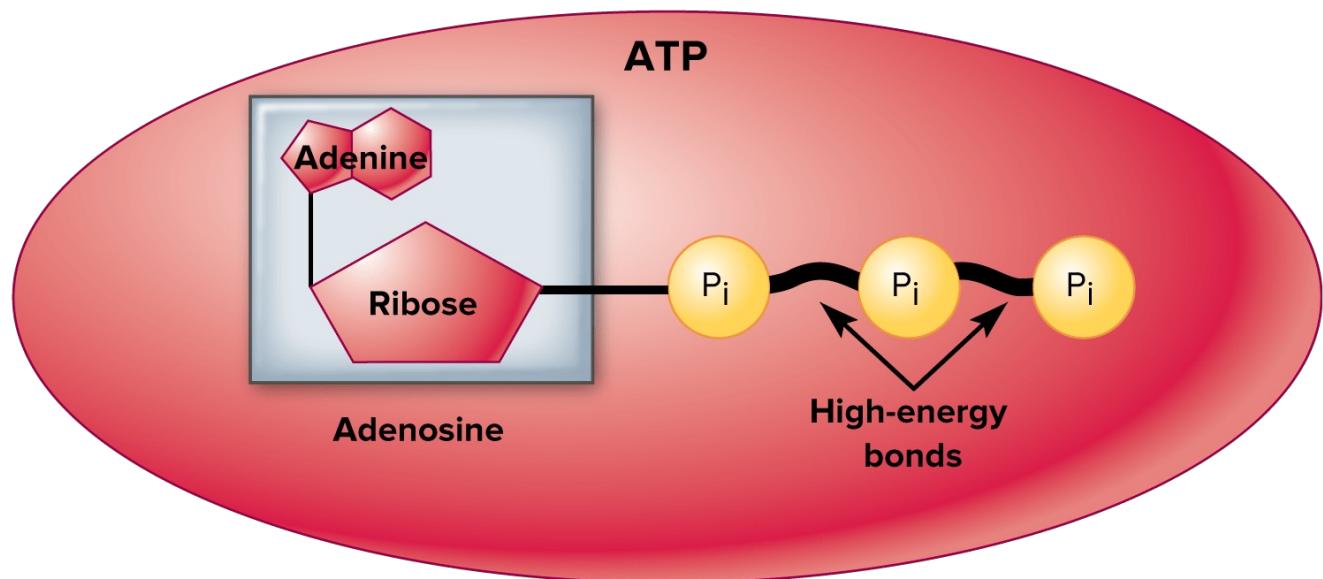
Metabolism

- **Anabolic** pathways use small compounds to build larger, more complex ones
 - Glucose, fatty acids, cholesterol, and amino acids are building blocks to create glycogen, hormones, enzymes, other proteins
 - Requires energy
 - More prominent during growth
- **Catabolic** pathways break down compounds into smaller units
 - Glycogen is broken down to make glucose when energy needed
 - Results in the release of CO₂, H₂O, and energy (ATP)
 - More prominent during weight loss or wasting disease



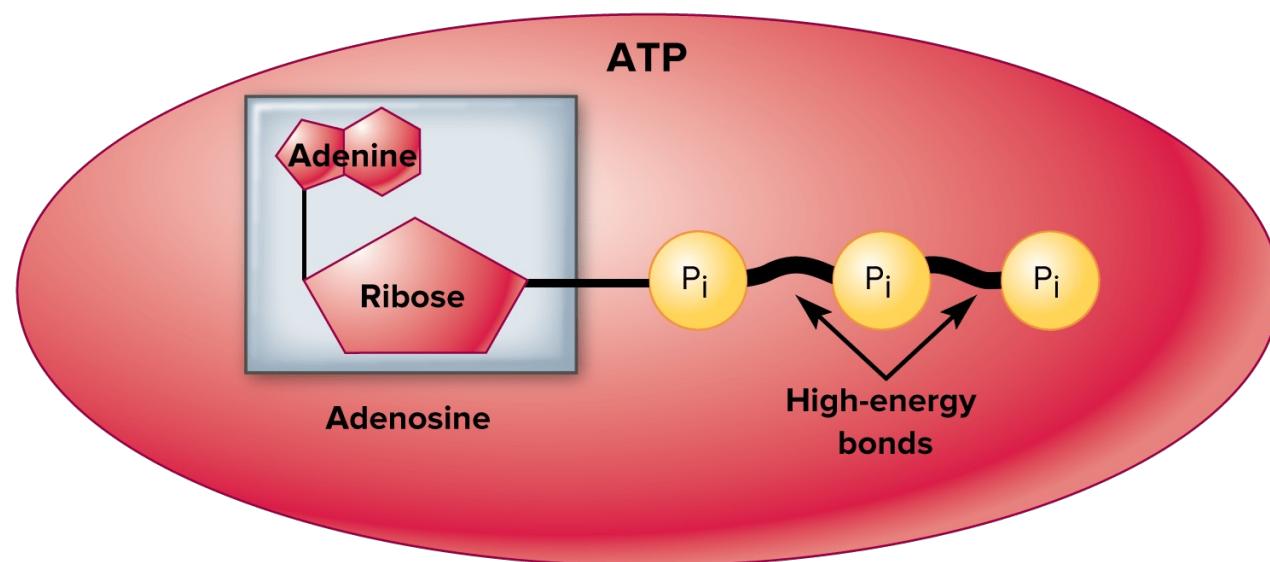
ATP

- Adenosine triphosphate (ATP) (ah-DEN-o-scene tri-FOS-fate)
- Chemical that supplies energy for many cellular processes and reactions.
- **The main form of energy the body uses**



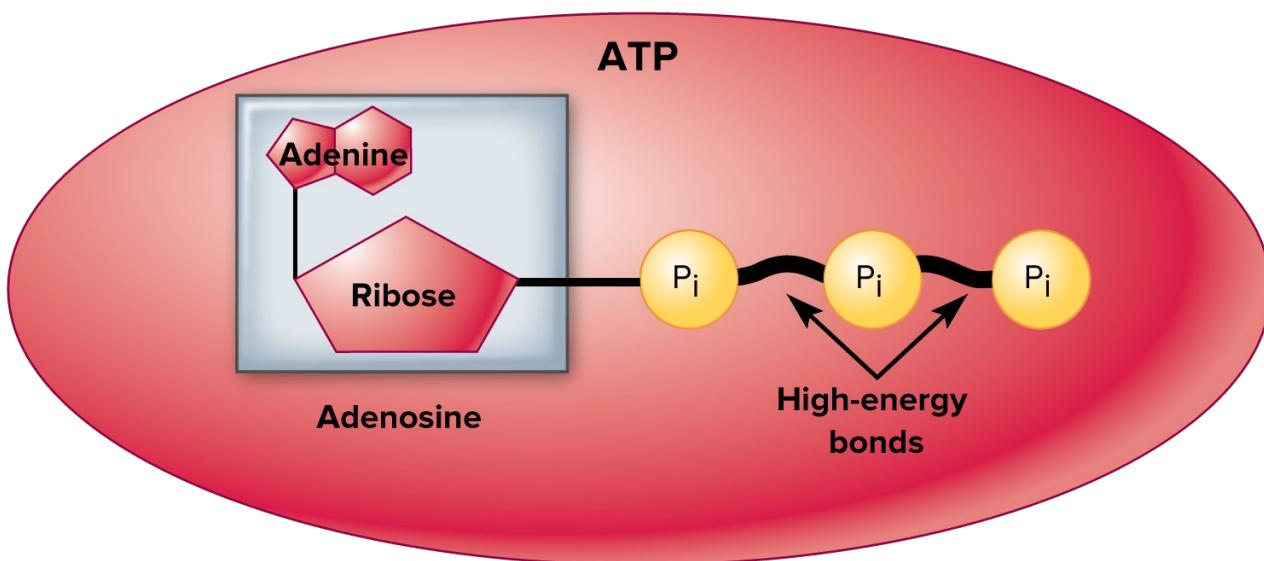
ATP

- A molecule of ATP consists of the organic compound adenosine bound to 3 phosphate groups
- The bonds between the phosphate groups contain energy and are called high-energy phosphate bonds.
- Hydrolysis of the high-energy bonds releases this energy.



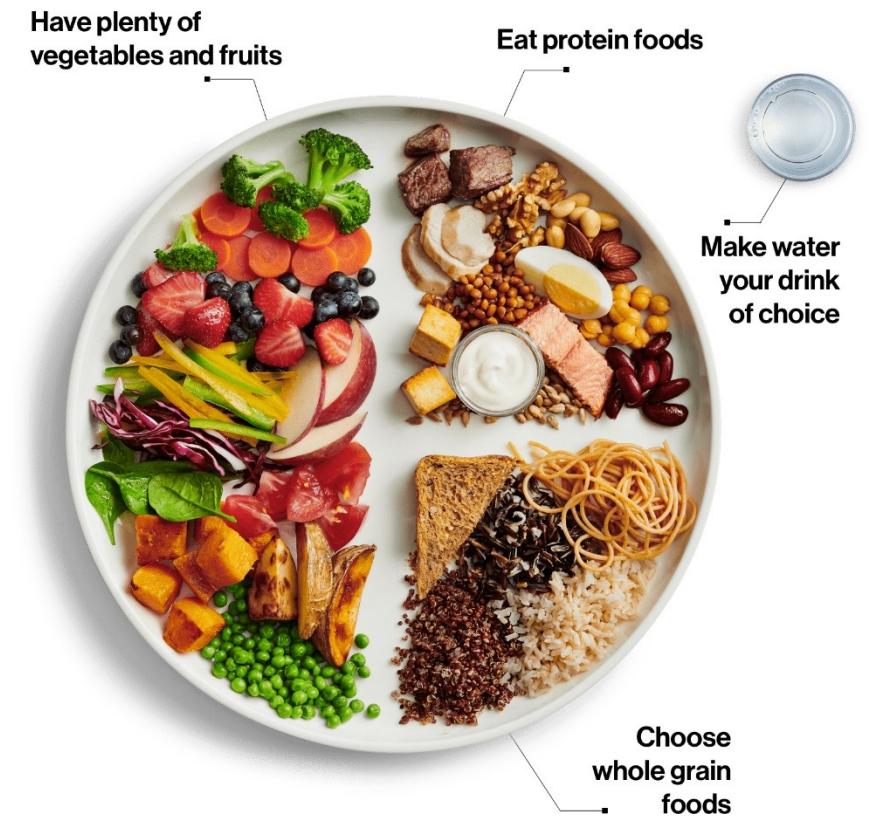
ATP

- Only the energy in ATP and related compounds can be used directly by the cell to synthesize new compounds (anabolic pathways), contract muscles, conduct nerve impulses, and pump ions across membranes

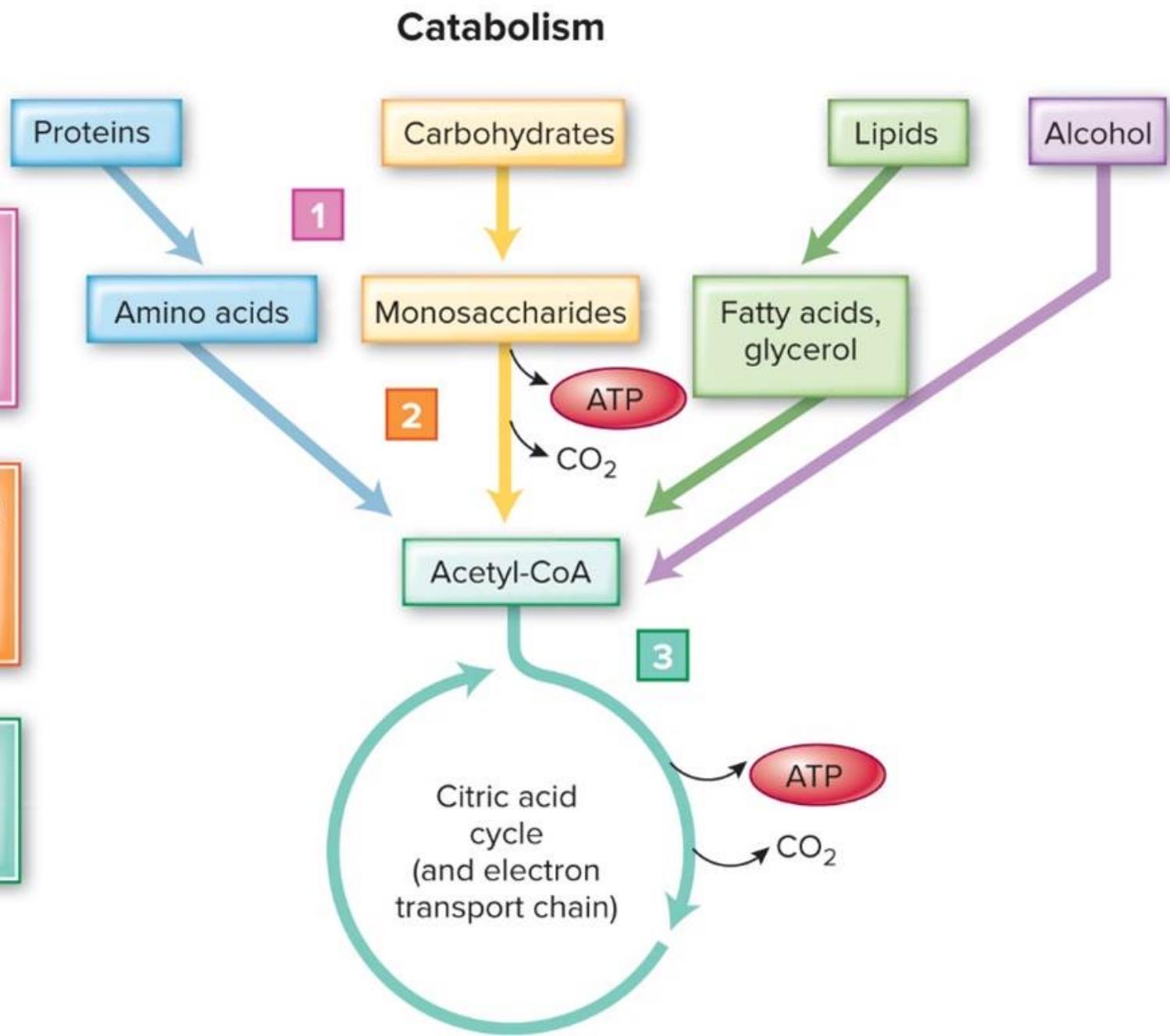
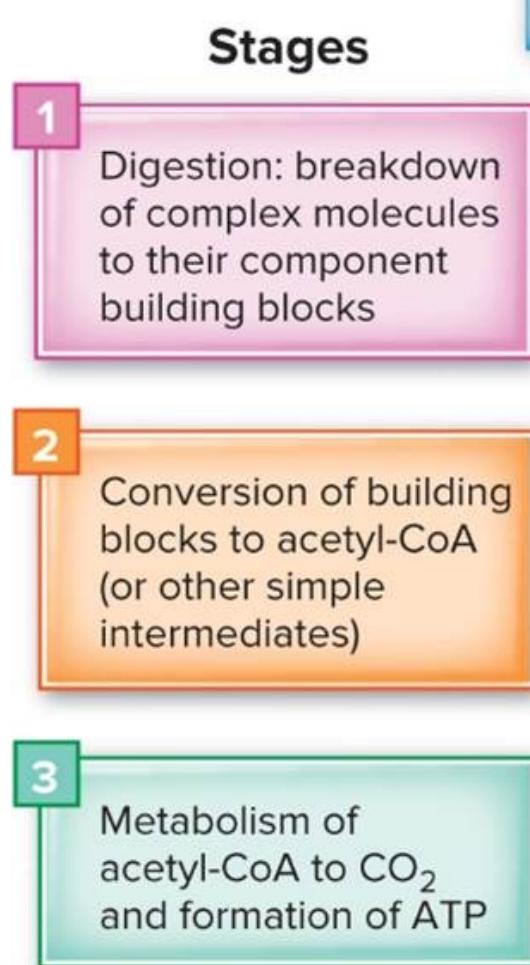


Converting Food into Energy

- The series of catabolic reactions that produce energy for cells begins with digestion
 - Continues when monosaccharides, amino acids, fatty acids, glycerol, and alcohol are sent through metabolic pathways
 - Captures energy as adenosine triphosphate (ATP, aka cellular energy)
 - Heat, carbon dioxide, and water are also released

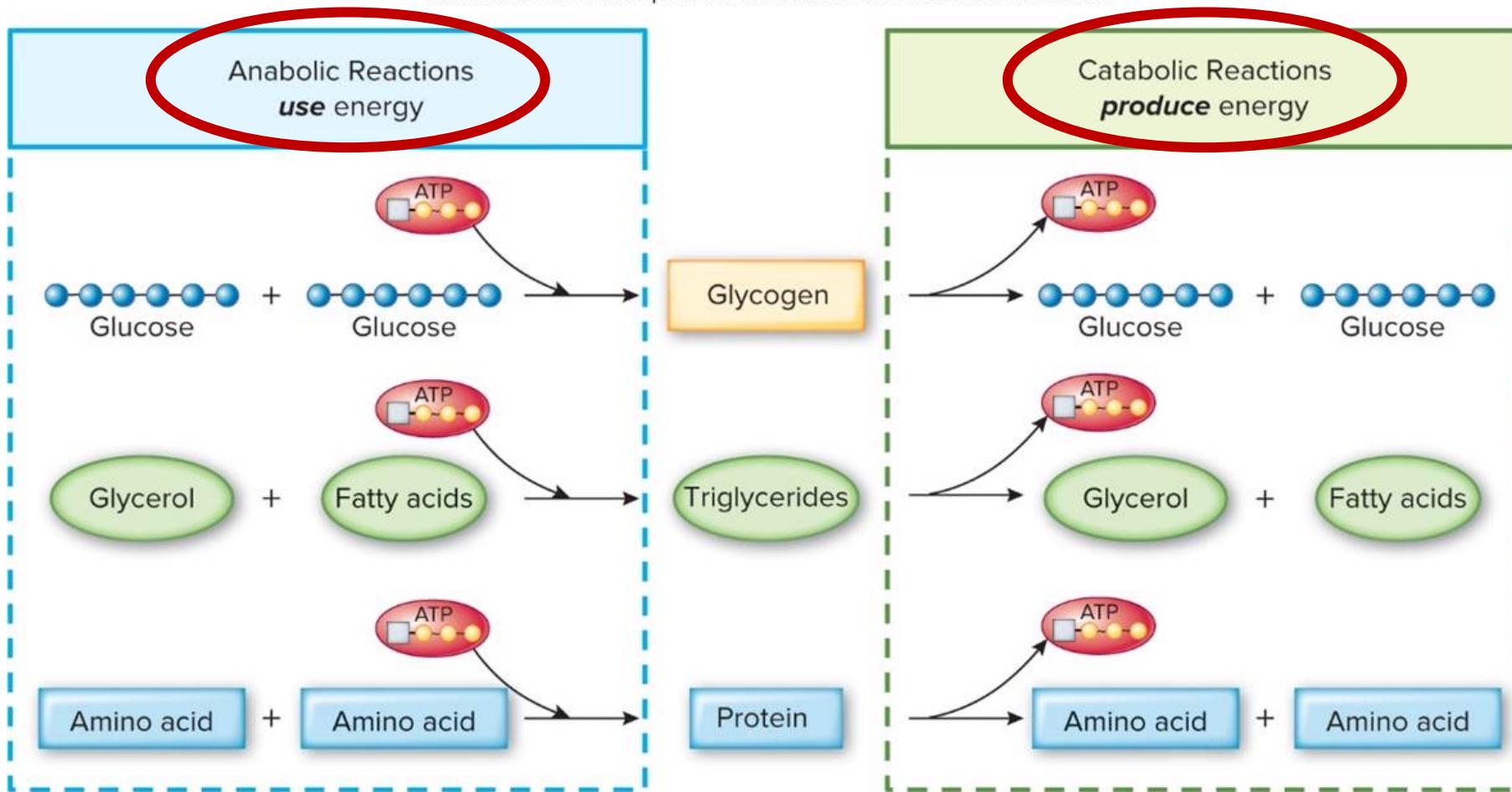


The 3 Stages of Catabolism



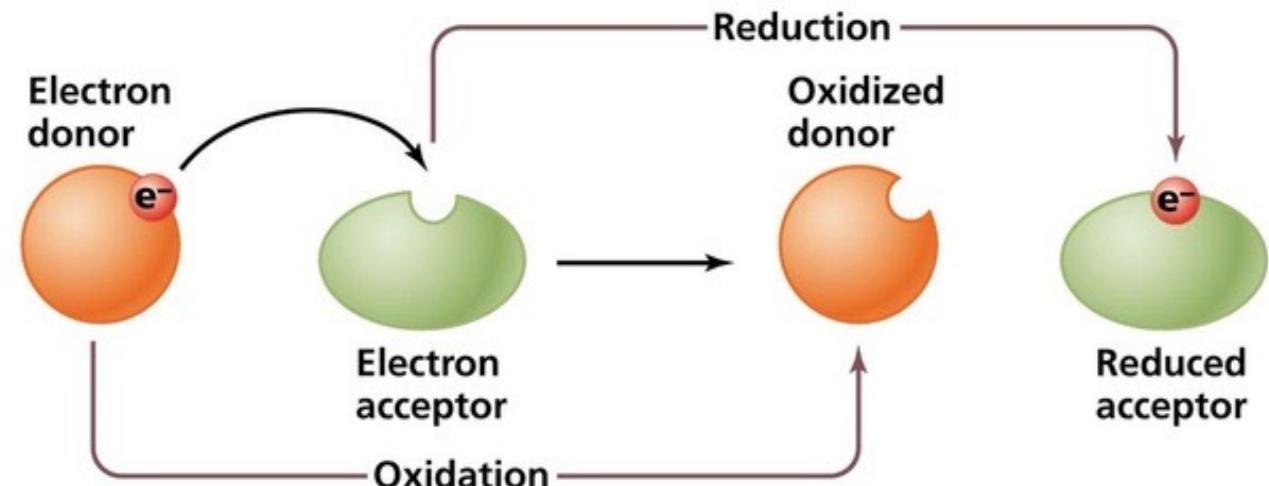
Anabolic and Catabolic Reactions

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Oxidation-Reduction Reactions

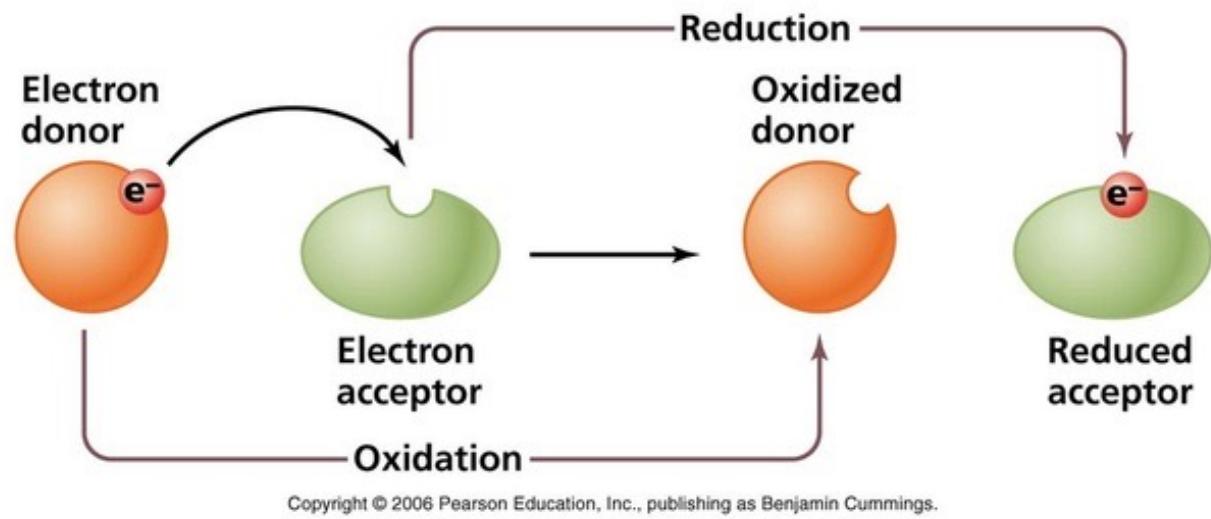
- Key processes in energy metabolism
 - A T P synthesis involves the exchange of ions in the form of hydrogen ions from energy-yielding compounds.
 - Oxidation-reduction reactions are used
 - Electrons are transferred eventually to oxygen
 - Form water and release energy used to produce A T P



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Oxidation-Reduction Reactions

- A substance is *oxidized* when it:
 - Loses electrons or hydrogen
 - Gains oxygen
- A substance is *reduced* when it:
 - Gains electrons
 - Loses oxygen
- Enzymes control oxidation-reduction reactions.
- Niacin and riboflavin

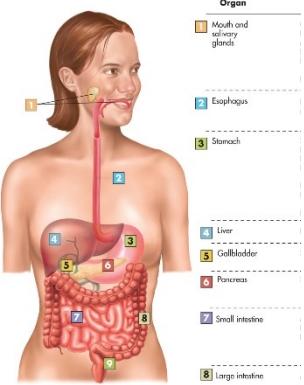
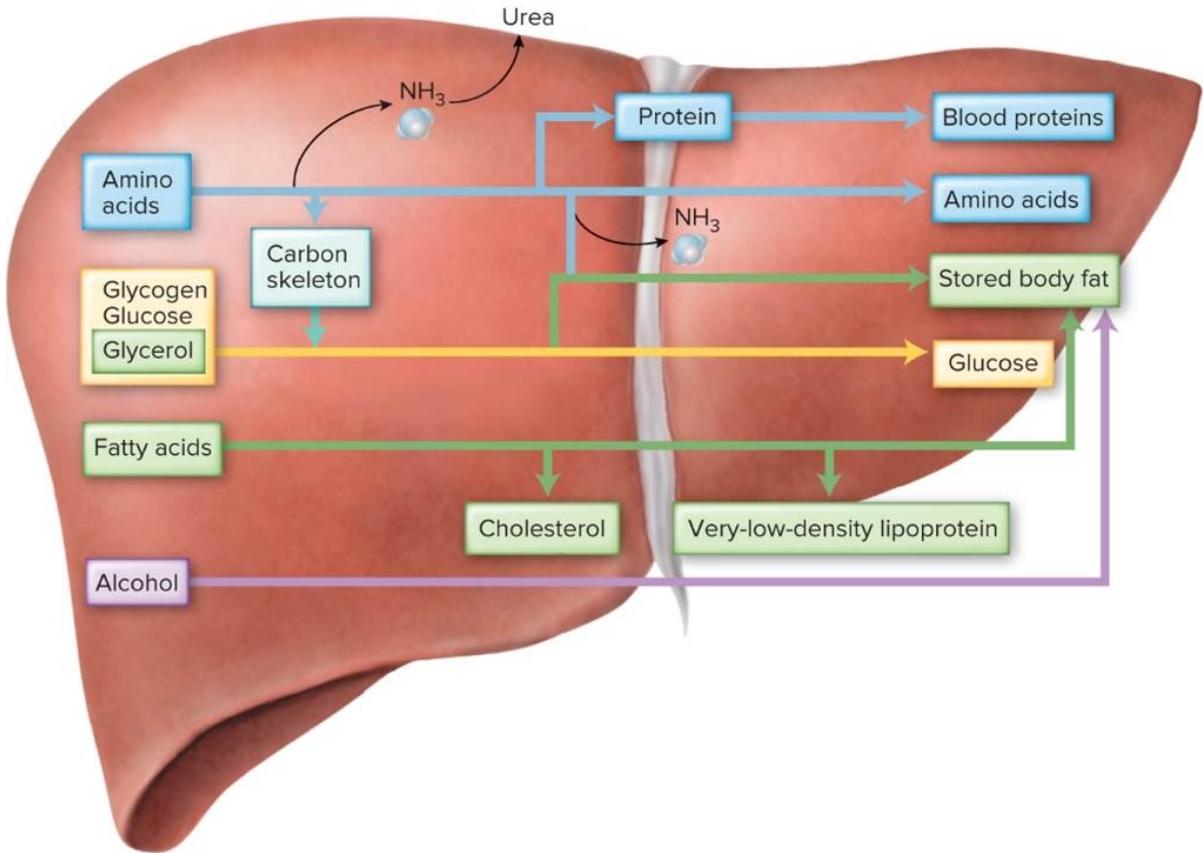


Regulation of Energy Metabolism

- Liver

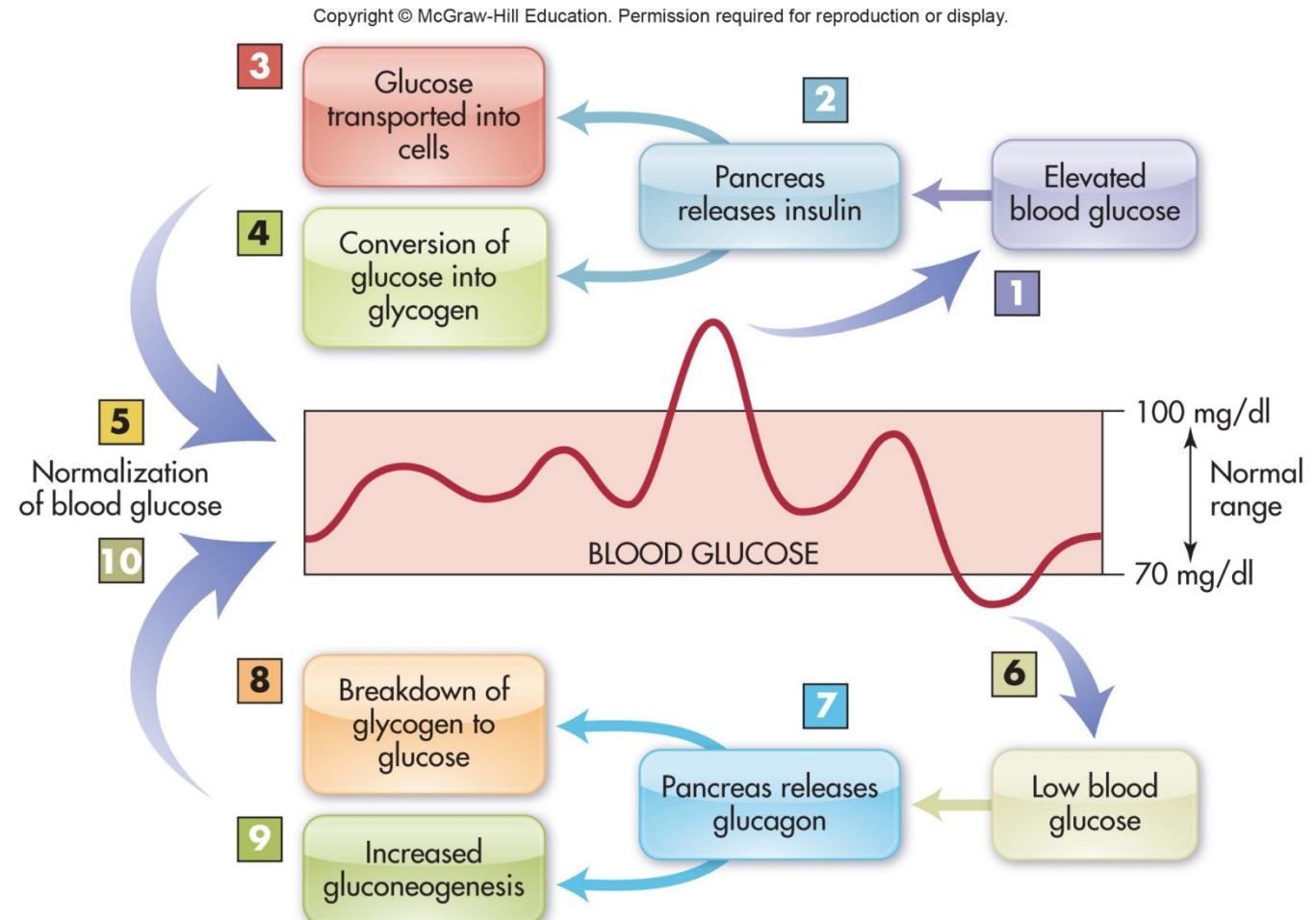
- Most nutrients first pass through the liver after absorption
- Key metabolic functions include:
 - Conversions between forms of simple sugars
 - Fat synthesis
 - Production of ketone bodies
 - Amino acid metabolism
 - Urea production
 - Alcohol metabolism
 - Nutrient storage

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Regulation of Energy Metabolism

- Enzymes
- Hormones
 - Low levels of insulin promote:
 - Gluconeogenesis
 - Protein breakdown
 - Lipolysis
 - Increased insulin promotes synthesis of:
 - Glycogen
 - Fat
 - Protein



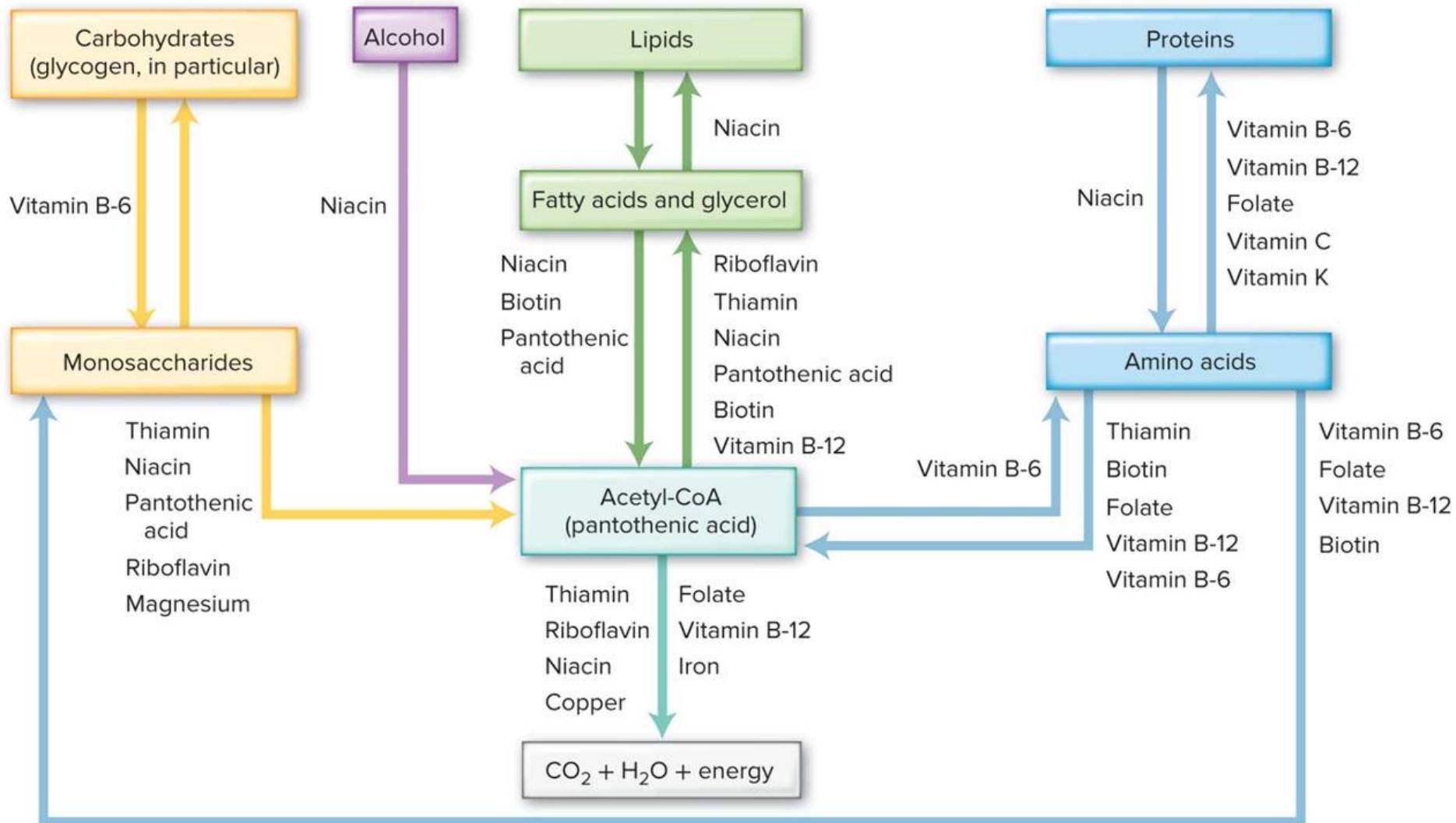
Regulation of Energy Metabol

- Many vitamins and minerals are needed for metabolism:
 - Thiamin
 - Riboflavin
 - Niacin
 - Pantothenic acid
 - Vitamin B-6
 - Biotin
 - Folate
 - Vitamin B-12
 - Iron
 - Copper



Vitamins and Minerals Involved in Metabolic Pathways

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Fasting and Feasting

- Both affect metabolism.
- The form of each macronutrient and the rate at which it is used varies when calorie supplies are insufficient or exceed needs.

-> [Watch feasting and fasting video lecture](#)

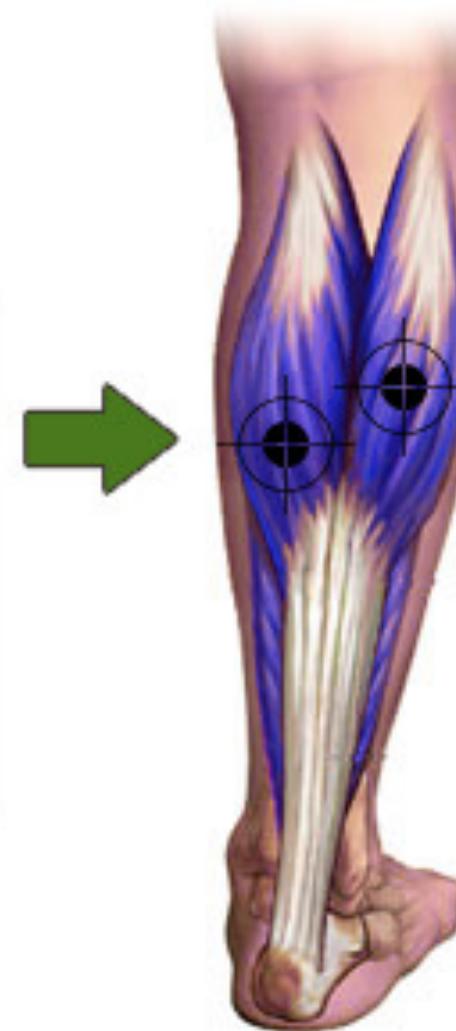


Fasting

- During initial fasting, the body fuels itself with glycogen and fatty acids from adipose tissue.
- If fast continues:
 - Fats continue to be broken down and cannot be used to fuel nervous system or red blood cells
 - Glycogen stores are depleted
 - Body tissue is broken down to make glucose from glucogenic amino acids

Glycogen
stored carbohydrate

LARGE
fuel tank



Fasting

- During prolonged fast:
 - Body protein is depleted
 - Fatty acids cannot be used for gluconeogenesis
 - Sodium and potassium are depleted (lost in urine with ketone bodies)
 - Blood urea levels increase b/c of breakdown of protein



Fasting

- Body adapts to survive fasting:
 - Slows metabolic rate
 - Reduces energy requirements
 - Slows breakdown of lean body tissue for gluconeogenesis
 - Allows nervous system to use more **ketone bodies**
 - Still, proteins are needed to make some glucose
- After 50% of lean body mass is lost (7-10 weeks), death occurs.



Fasting - ketones

- Occur in hormonal imbalances or during starvation/fasting
- How are ketones formed?
 - usually our body functions best when oxaloacetate is supplied from glucose to citric acid cycle.
 - But when on low CHO diet, oxaloacetate becomes inadequate, causing citric acid cycle activity to decrease.
 - However, lipolysis continues which means acetyl-coA production from fatty acids continues and results in a build up of Acetyl-coA because oxaloacetate not available to allow acetyl-co to enter the citric acid cycle.
 - Because it cannot enter the cycle, these molecules join together and form ketone bodies.

Feasting

- Feasting's most obvious result is fat tissue.
- Also increases:
 - Insulin production by pancreas
 - Burning of glucose for energy
 - Production of glycogen
 - Synthesis of protein and fat



Feasting

- Fat consumed in excess is stored in adipose tissue
 - Little energy required; high fat, high energy diets promote body fat production
- Protein consumed in excess does not promote muscle development
 - Some amino acids will stay in pool or form fatty acids



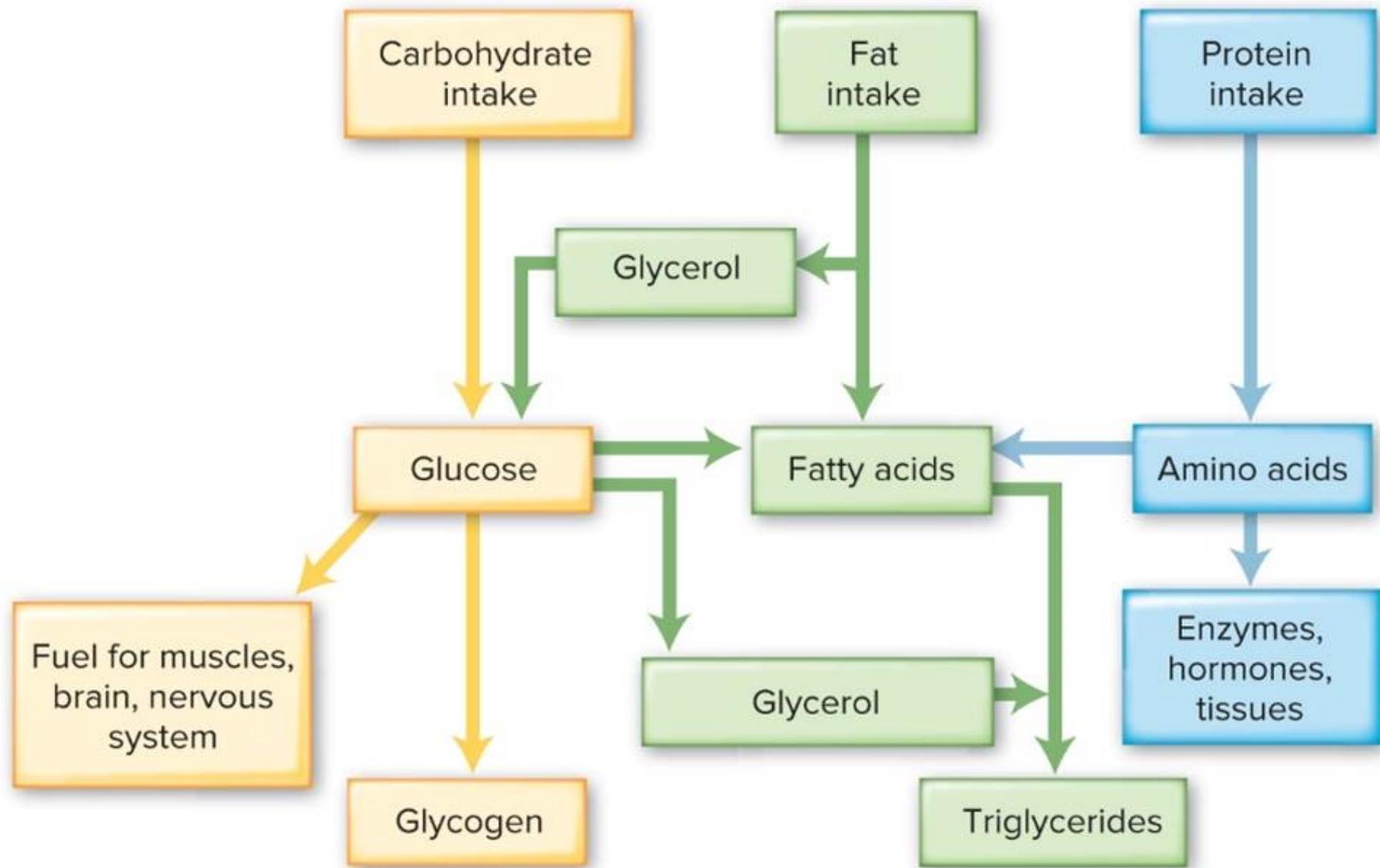
Feasting

- Carbohydrates consumed in excess:
 - First build glycogen stores
 - Once filled, can use glucose for energy, fat synthesis
 - Reduces fat catabolism (fat burning)
- ***Anyone who consumes more calories from any of the energy-yielding nutrients than what the body can use will gain weight.***



Effects of Feasting

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Clinical Perspective: Inborn Errors of Metabolism

- Some people lack enzymes to perform normal metabolic functions
 - Inborn error of metabolism
 - Metabolic pathway does not function normally
 - Causes formation of alternative metabolic products
 - Occurs from inheriting a defective gene from both parents



Clinical Perspective: Inborn Errors of Metabolism

- Characteristics:
 - Appear soon after birth
 - Newborn screens, determined by state
 - Very specific for 1 or few enzymes
 - No cure is possible but condition can be controlled
- Commonly seen are:
 - Phenylketonuria (P K U)
 - Galactosemia
 - Glycogen storage disease
 - trimethylaminuria

Clinical Perspective: Inborn Errors of Metabolism

- Phenylketonuria (P K U)
 - Phenylalanine hydroxylase does not convert phenylalanine to tyrosine
 - Accumulated phenylalanine can lead to toxic by-product buildup and irreversible mental retardation

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CARBONATED WATER, CARAMEL COLOR, ASPARTAME, PHOSPHORIC ACID, POTASSIUM BENZOATE (TO PROTECT TASTE), NATURAL FLAVORS, CITRIC ACID, CAFFEINE.

PHENYLKETONURICS: CONTAINS PHENYLALANINE

CAFFEINE CONTENT: 46 mg/12 fl oz



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Inborn Errors of Metabolism

- Phenylketonuria
 - Treated with phenylalanine-restricted diet
 - Special formula at birth
 - Fruits, vegetables, and breads are OK
 - Dairy products, eggs, meats, nuts, and aspartame are not

FREE METABOLIC NUTRITION SAMPLES



FOUND BY  YoFreeSamples

Inborn Errors of Metabolism

- Galactosemia
 - Reduction is the metabolism of galactose to glucose
 - Galactose buildup may lead to bacterial infections, mental retardation, and cataracts
 - Must switch to soy formula at infancy
 - Throughout life, must avoid:
 - Dairy products
 - Butter
 - Organ meats
 - Some fruits and vegetables



Inborn Errors of Metabolism

- Glycogen storage disease
 - Liver cannot convert glycogen to glucose
 - Causes:
 - Poor physical growth
 - Low blood glucose levels
 - Liver enlargement
 - Must consume frequent meals and cornstarch in between meals
 - Monitor and maintain blood glucose levels

