Metabolism

- Transfer of food energy to chemical energy
- Energy for chemical reactions comes from the bonds of the macronutrients
- Includes anabolic and catabolic reactions
- Goal: meet body's need for energy (ATP)

Where Does Metabolism Occur?

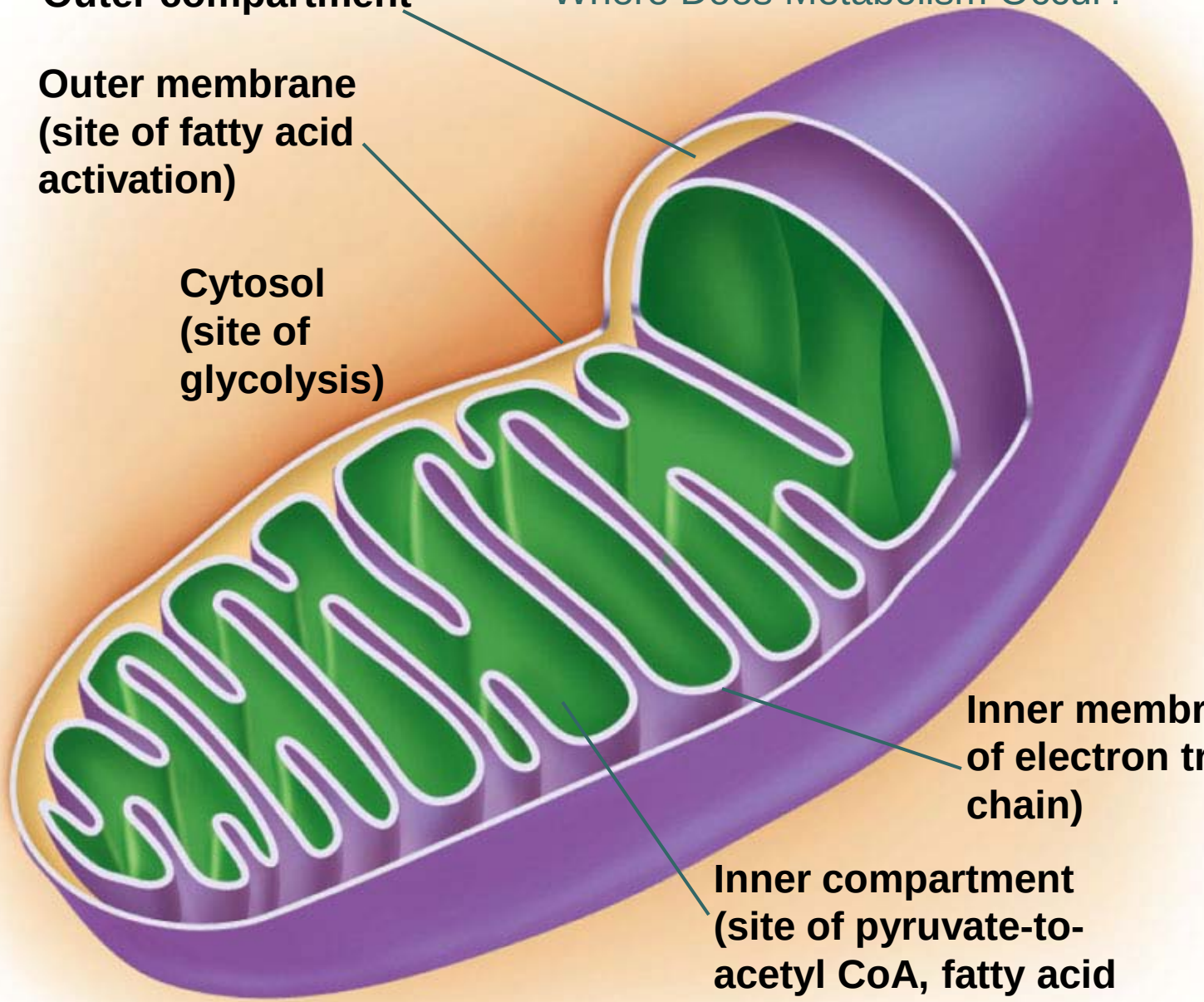


Fig. 7-1b, p. 214

Chemical Reactions in Metabolism

- Catabolic:
  - Breakdown reactions that release energy
    - Glycogen → Glucose
    - Triglycerides → Fatty Acids + Glycerol
    - Proteins → Amino Acids
- Anabolic:
  - Building reactions that require energy
    - Glucose → Glycogen
    - Fatty Acids + Glycerol → Triglycerides
    - Amino Acids → Proteins

Anabolic or Catabolic

A cracker becomes glucose

Glucose becomes glycogen

You consume more energy than your body expends.

Fasting.

A piece of ham becomes amino acids.

Amino acids become your muscles.

A cookie becomes fatty acids

Fatty acids become body fat.

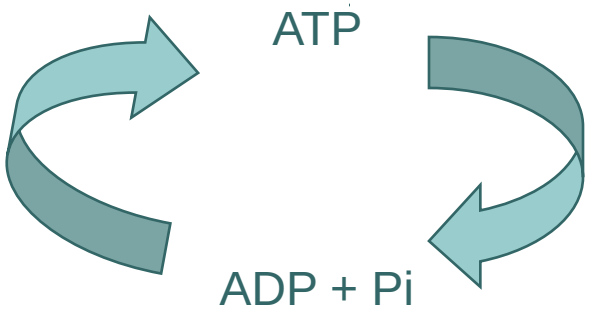
Fatty acids provide energy.

Exchange of Energy

Simple Molecules: Glucose, Amino Acids, Glycerol, Fatty Acids

Catabolic Reactions

Energy released from stores to make ATP



Anabolic Reactions

Transferring energy to form molecules

Complex Molecules: Glycogen, Proteins, Triglycerides

Key Energy Players

- ATP
  - Energy molecule used to power cellular functions
  - Provides energy for:
    - Protein synthesis
    - Muscle contractions
    - Active transport
    - Nerve transmission
    - All other energy requiring reactions
  - Comes from the bonds hold food molecule together

Key Energy Players

- NADH and FADH
  - During metabolism, high energy elections are released
  - These electrons need to transfer to ATP
  - Carriers are coenzymes
    - NADH and FADH
    - From B Vitamins (niacin and riboflavin)

Foodstuffs and ATP Production

- Not all are treated the same
- Carbs
  - Oxidized to Glucose --- ATP
    - RBC have no mitochondria only source of energy is glycolysis
- Lipids
  - Cell membranes, myelin sheaths, insulation
  - Main source of energy to make ATP if inadequate carbs consumed; can be limited
- Protein
  - Generally conserved

Nutrient Metabolism

- During metabolism, the body separates atoms from energy yielding nutrients
- Net result:
  - Carbs → glucose
  - Lipids → glycerol + fatty acids
  - Proteins → amino acids

Carbon Backbones of Energy Yielding Nutrients

- 3 carbon compounds can make glucose
- 2 carbon compounds cannot make glucose

  - Glucose → 3 carbon
  - Glycerol → 3 carbon
  - Fatty Acids → 2 carbon
  - Amino Acids → 2 and 3 carbon

Stages Of Metabolism

- Digestion
  - Macronutrients to individual components
  - Absorbed into cells
- Glycolysis (cytosol of the cell)
  - Anaerobic
  - Creates 2, 3 carbon units
- Citric Acid Cycle (mitochondia of the cell)
  - Aerobic
  - Reaction produces CO_2 and electrons, NADH
  - Extracts most energy to power generation of ATP
- Electron Transport Chain (inner mitochondria of the cell)
  - Most ATP produced here
  - NADH and FADH deliver high energy electrons
  - At the end of the chain, O_2 + electrons + H = H_2O

Metabolism of Nutrients: Carbohydrates

- Cells extract energy from carbs in 4 ways
  - Glycolysis (anaerobic)
  - Pyruvate to Acetyl-CoA (anaerobic)
  - Krebs (Citric Acid or TCA cycle) (aerobic)
  - Electron Transport Chain (aerobic)
- End products CO2, H2O, ATP

Metabolism of Nutrients: Lipids

Triglycerides

can only be used as energy source if broken down to glycerol and fatty acids

Glycerol

- can make glucose
- can enter TCA cycle
- *3 Carbon Unit*
- 5% of TG can make glucose

Fatty acids:

- Beta oxidation
  - Cleave f/a 2 C's at a time
  - Each 2C combines with Acetyl CoA
  - 95% of TG cannot make glucose

Metabolism of Nutrients: Proteins

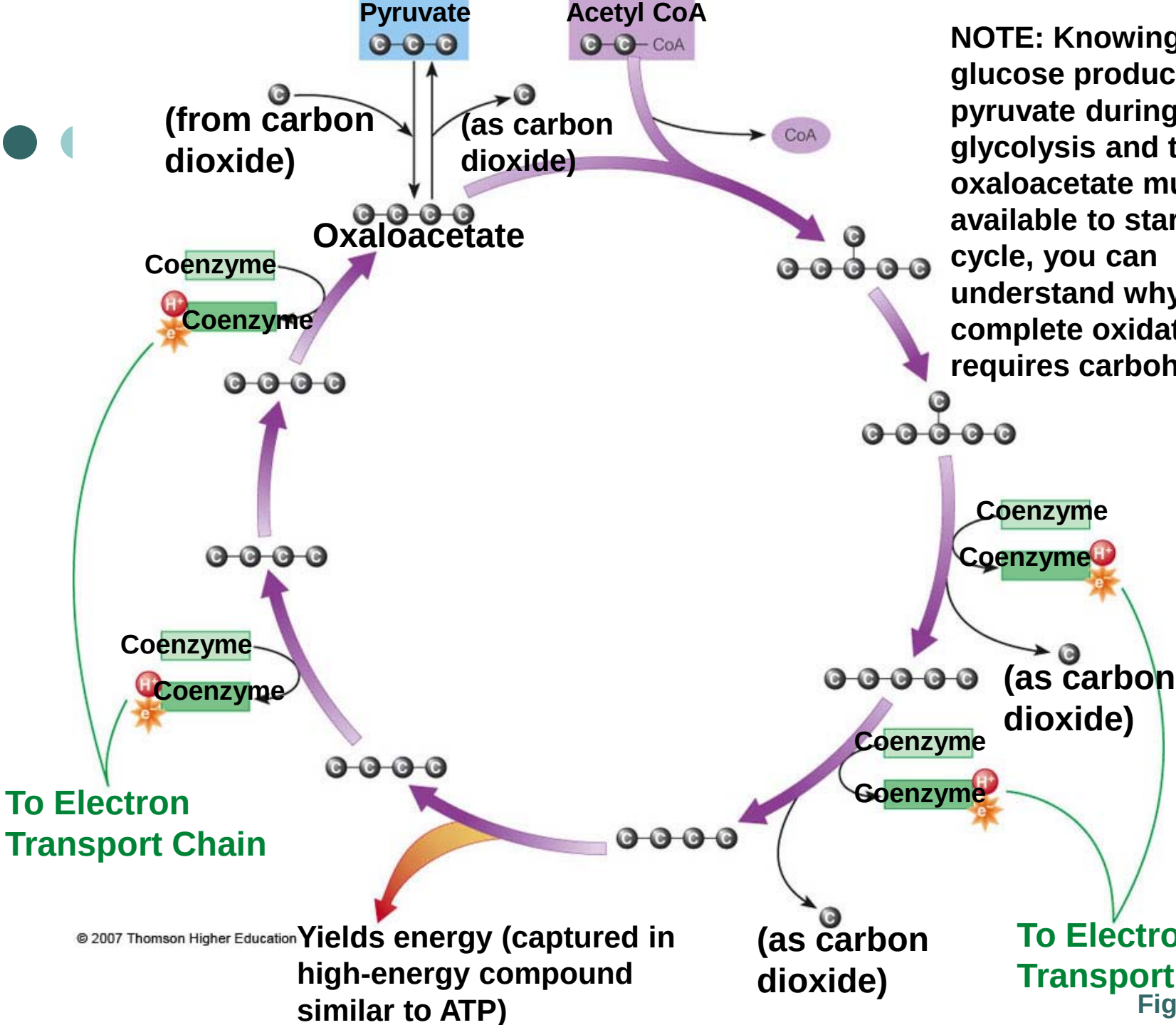
- Deamination – Nitrogen removed
  - Liver converts ammonia to Urea
  - Carbon skeletons provide energy, glucose or convert to fat
    - 2 carbon units: directly into AcetylCoA
    - 3 carbon units: can make glucose
    - 3 carbon units: directly into TCA cycle
  - Kidney excretes Urea from body

Krebs/Citric Acid/TCA Cycle

- Acetyl CoA----- TCA/Krebs/Citric Acid
  - Acetyl CoA (2 carbon) combines with Oxaloacetate
  - Oxaloacetate = 4 C compound
  - Makes 6 carbon compound called Citrate (citric acid)
  - Reactions continue to pull off carbons and expel as CO2

- This cycle extracts most of the energy that powers ATP generation.

- This cycle important building blocks of amino acids and fatty acids
  - If alternate use depletes supply of oxaloacetate, the cycle can slow or stop, made directly from pyruvate so readily available



NOTE: Knowing that glucose produces pyruvate during glycolysis and that oxaloacetate must be available to start the TCA cycle, you can understand why the complete oxidation of fat requires carbohydrate.

Fig. 7-18, p. 228

Electron Transport Chain

- Coenzymes deliver electrons from the TCA cycle, glycolysis and beta oxidation to a carrier
- Inner membrane of the mitochondria
  - Carrier passes them to another carrier
    - Oxygen accepts electrons combines with hydrogen = water
  - During electron transfer energy released to move H to outer compartment of mitochondria
  - Hydrogen ions float “downhill” – inner compartment
  - ATP synthesized
- ATP leaves mitochondria, enters cytoplasm, used for energy

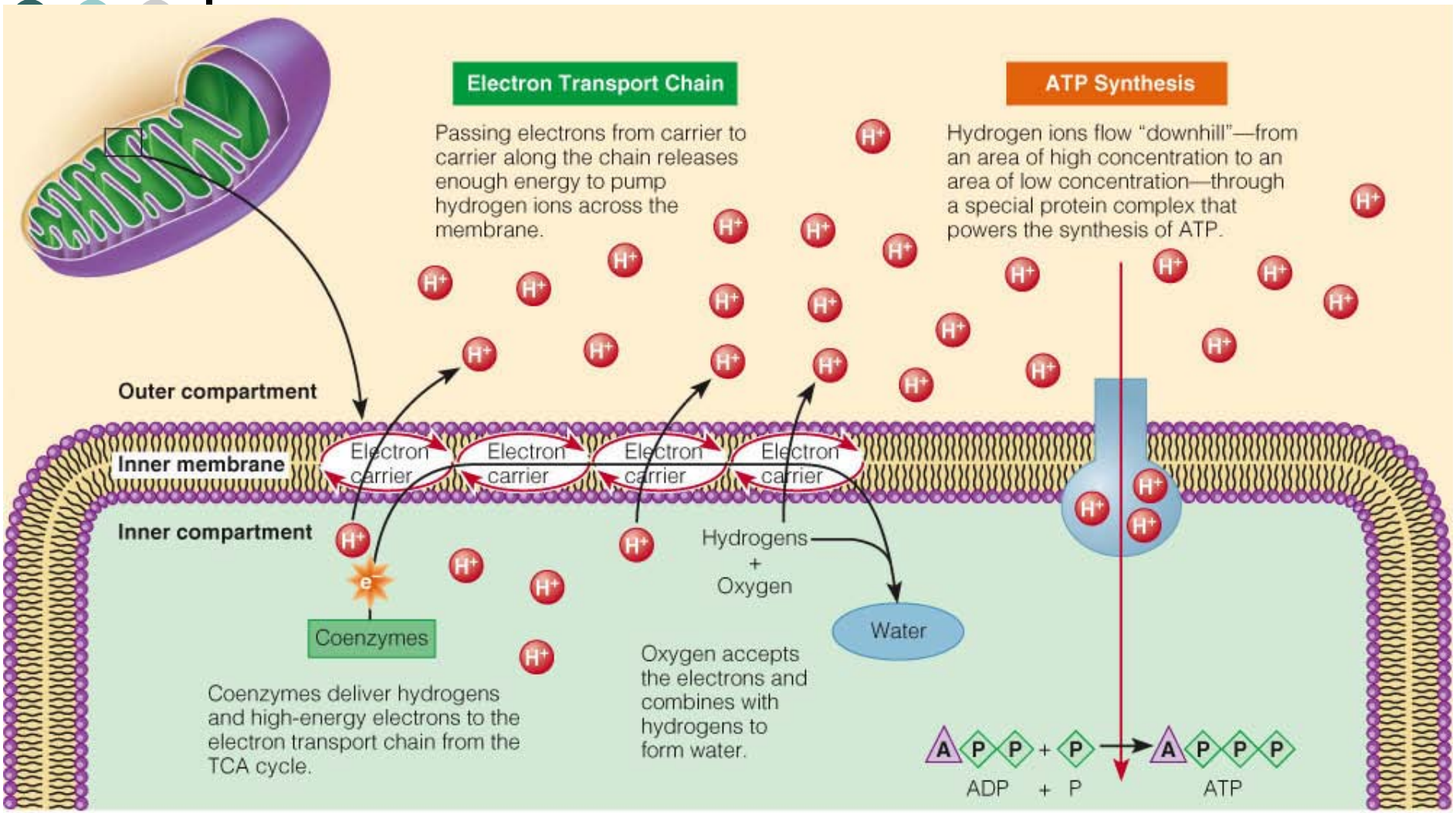


Fig. 7-19, p. 229

Glycolysis Video

- http://scholar.hw.ac.uk/site/biology/activity3.asp

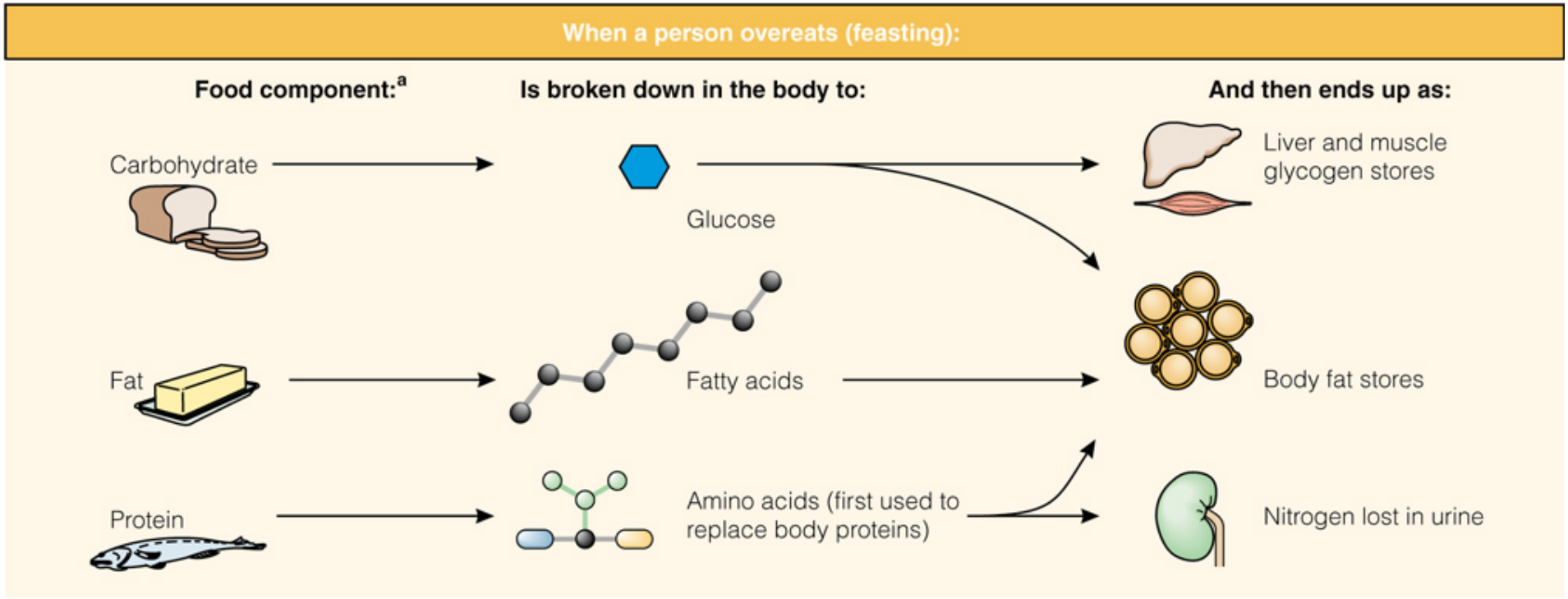
Metabolism Regulators

- Hormones
  - Insulin
  - Glucagon
  - Cortisol
  - Epinephrine

Feasting

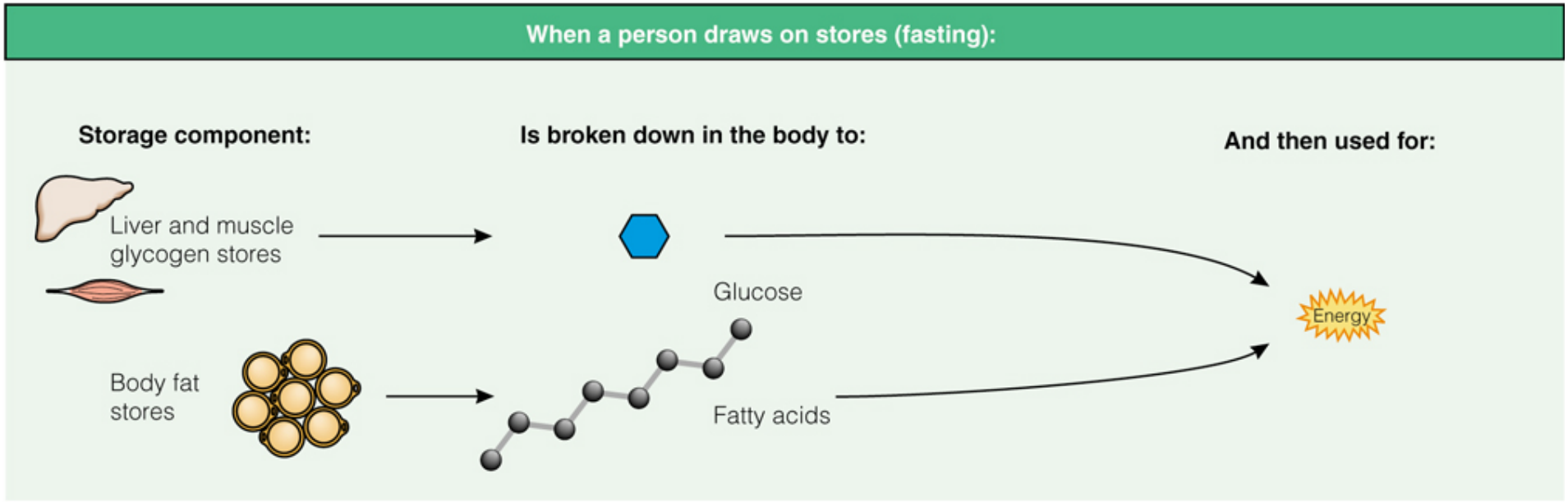
- Anabolic state
- Food consumption triggers hormone release
- Insulin inhibits release of other hormones and stores byproducts of nutrient digestion
  - Carbs --- glycogen
  - Fatty Acids ---- glycerol and fatty acids – t/g
  - Amino Acids --- amino acid pool or fat stores

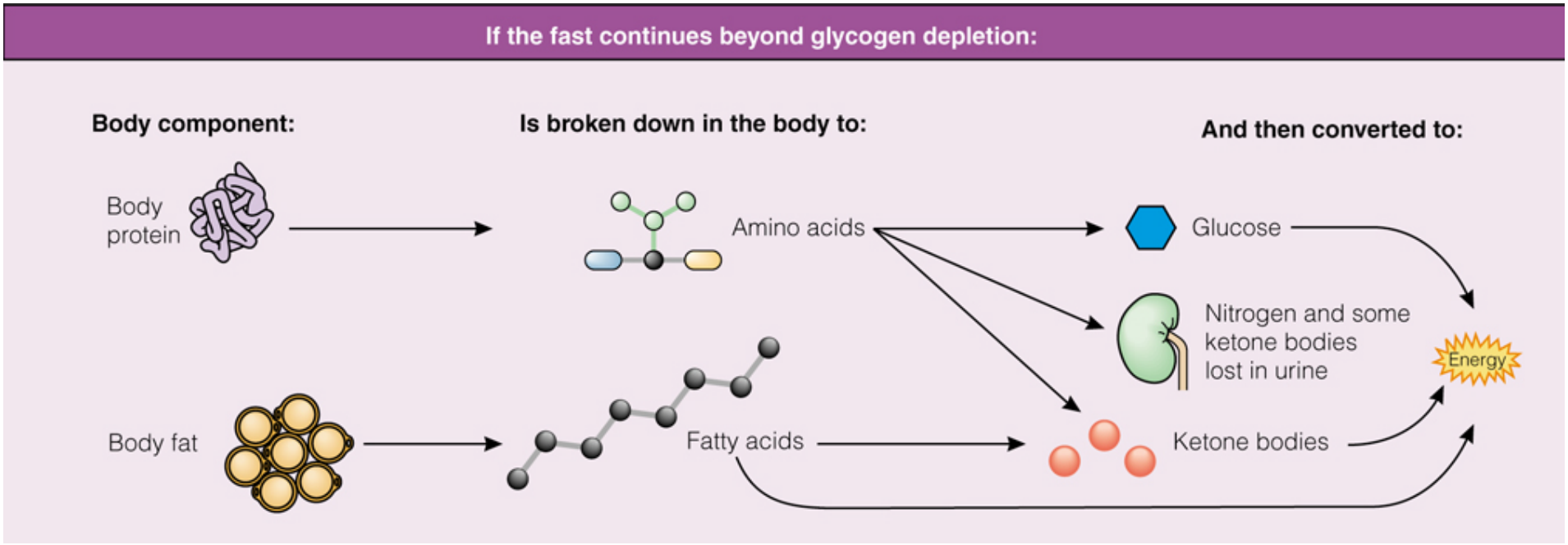
The Body's Response to Feasting



Fasting

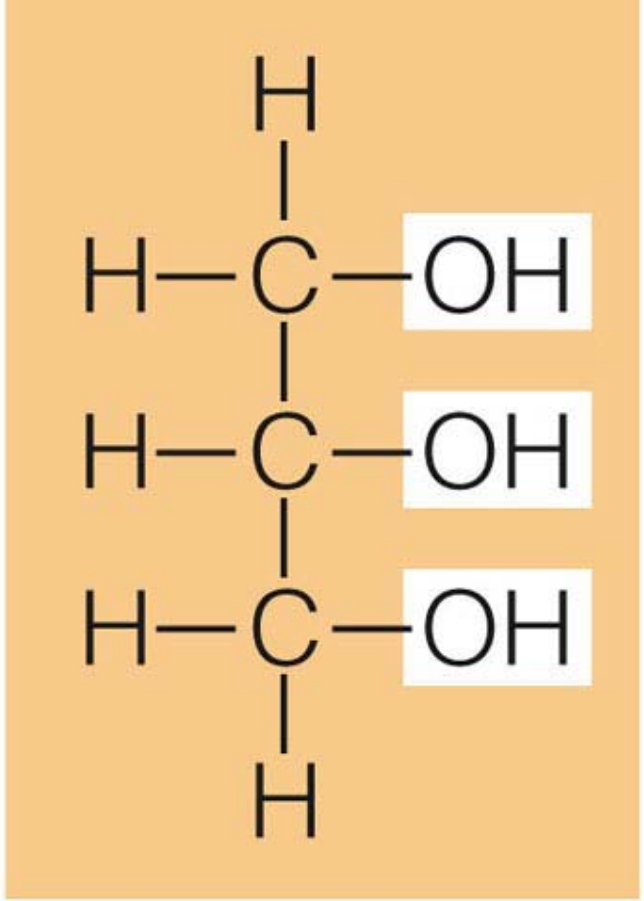
- Catabolic State
- All nutrients eventually used for energy
- Glycogen from liver and fatty acids from adipose tissue yield Acetyl CoA and provide energy for cells
  - Glucose – needed for brain, RBC and nerves
  - Protein – 3 carbon can provide glucose – body protein must be broken down to provide these
  - Ketosis – produced by Acetyl CoA fragments
    - Can provide fuel for some brain cells
    - Suppresses appetite
    - Changes acid/base balance of body
- Metabolism slows – lean tissue shrinks – muscles do less work - less calorie demands


When a person draws on stores (fasting):
Storage component:
Is broken down in the body to:
And then used for:
Liver and muscle glycogen stores
Glucose
Energy
Body fat stores
Fatty acids

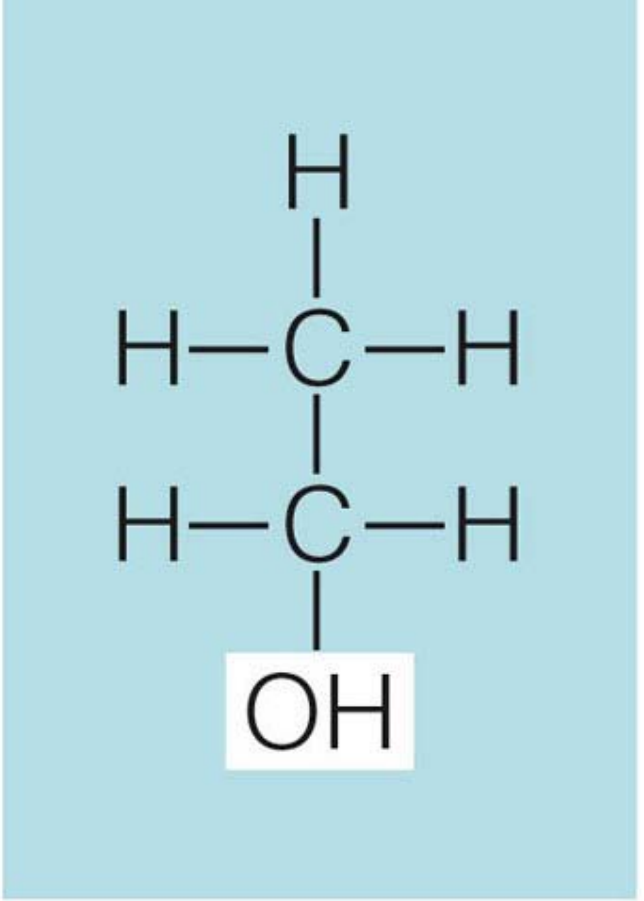

If the fast continues beyond glycogen depletion:
Body component:
Is broken down in the body to:
And then converted to:
Body protein
Amino acids
Glucose
Nitrogen and some ketone bodies lost in urine
Energy
Body fat
Fatty acids
Ketone bodies

Alcohol Metabolism

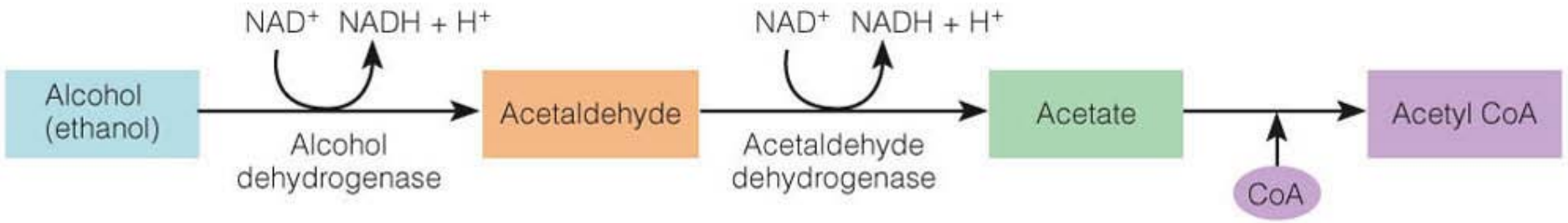
- Immediately absorbed in the mouth, esophagus and small amts into bloodstream
- 80-95% absorbed unchanged
- Quickly metabolized by liver to remove from blood and prevent damage
- Metabolized like a fat
  - ETOH – acetaldehyde (toxic)
  - Acetaldehyde – acetate and Acetyl CoA
  - Acetyl CoA – citric acid cycle or made into fatty acids
- Small Amounts of Alcohol Consumption
  - Alcohol Dehydrogenase metabolizes alcohol to Acetyl CoA
  - Little converts to energy – more stored as fat in liver
- Large Amounts of Alcohol Consumption
  - Overtax Alcohol Dehydrogenase
  - Alternate System – MEOS takes over
  - Energy utilized to support MEOS system
- Alcohol Clearance from the body
  - Liver can metabolize a set amount per hour
  - Absorption exceeds livers capacity to breakdown, into circulation
    - Oxygen deprivation to the brain
    - Placental crossing to the fetus if pregnant



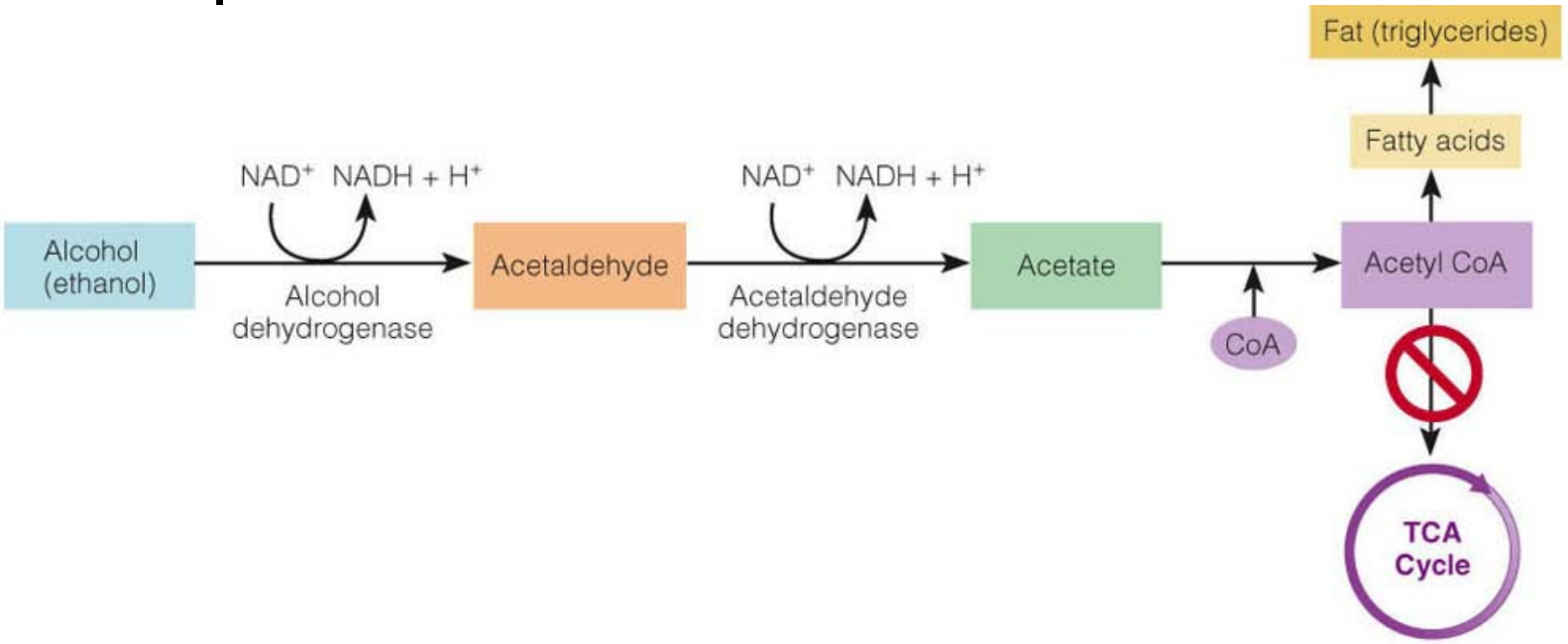
Glycerol is the alcohol used to make triglycerides.



Ethanol is the alcohol in beer, wine, and distilled liquor.



The conversion of alcohol to acetyl CoA requires the B vitamin niacin in its role as the coenzyme NAD. When the enzymes oxidize alcohol, they remove H atoms and attach them to NAD. Thus NAD is used up and NADH accumulates. (Note: More accurately, NAD+ is converted to NADH + H^+.)



Acetyl CoA molecules are blocked from getting into the TCA cycle by the high level of NADH. Instead of being used for energy, the acetyl CoA molecules become building blocks for fatty acids.

Alcohol Problems

- Alcohol Poisoning
  - If passed out from excess, still absorbed and levels in bloodstream rise
  - Overdose can cause irreversible brain damage
- Poor Diet
- Vitamin Deficiencies
- Fatty Liver
- Elevated Triglycerides
- Body Weight

Alcohol Benefits

- U shaped curve for mortality rates
  - 1-2 drinks per day same as nondrinkers
  - >3 increased death rate
- Heart Disease
  - Beer, wine, spirits all equal in protection
  - Raise HDL
  - May inhibit blood clots
- Cancer

Energy Drinks

- Beverages marketed to enhance or boost energy
- General Contents of many energy drinks
  - Caffeine
  - Guarana
  - Ginseng
  - Taurine
  - B Vitamins
  - Glucuronolactone
  - Sugar

Energy Drinks

- Concerns
  - Stimulant
  - Diuretic
  - Alcohol