1 **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)

2 

3 **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
    - 

- 

4 **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.

5 **Exchange of Energy**

6 **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
- 
- 

7 **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)

8

**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

9 **Nutrient Metabolism**

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

10 **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

11 **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 = $H_2O$
  -

12 **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
-

13 **Metabolism of Nutrients:**
**Lipids**

1 Triglycerides

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

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

3 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
  -

14 **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
-
-

15 **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

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17 **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
-
-

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19 **Glycolysis Video**
- http://scholar.hw.ac.uk/site/biology/activity3.asp
-

20 **Metabolism Regulators**
- Hormones
  - Insulin
  - Glucagon
  - Cortisol
  - Epinephrine

21 **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

22 ***The Body’s Response to Feasting***

23 **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
-

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26 **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

27
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30 **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
-
-

31 **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

32 **Energy Drinks**

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

33 **Energy Drinks**

- Concerns
  - Stimulant
  - Diuretic
  - Alcohol