Diet & Obesity

Cardiovascular diseases are a #1 killer

- Congenital cardiovascular diseases (from birth) make up only a small proportion

→ How do doctors know whether patients are at risk of cardiovascular disease?

- Medical means: blood tests, imaging (CT scans), etc.
- Cheaper, more accessible: *markers* can be assessed by any individual to discern whether they are at risk
    - Important marker: ***obesity*** (excessive accumulation of body fat) is highly correlated with cardiovascular diseases, diabetes, and many other diseases

Obesity

How doctors view obesity can affect perception of the problem:

1. Obesity as a marker for disease
2. Obesity as a disease, in and of itself

Ways to assess obesity:

1. Waist circumference (40+ in. in males; 35+ in. in females)
    a. Females generally have more fat, but males build fat belly-first (hip-first in females)
    b. WC has been found to be a better indicator than BMI, though BMI is still in use
        i. High WC associated with diabetes, hypertension, dyslipidemia, and other diseases
2. Body fat percentage (25+% in males; 30+% in females; differs based on age) - made easier to measure with technology
    a. Scales send electric currents through the body (after stepping on it barefoot) to calculate proportions of fat
    b. Disadvantage: fat percentage measurement depends on hydration (dehydrated -> higher number); requires repetition multiple times for a more accurate measurement
3. Body mass index (BMI) compares one's weight, height to that of the rest of the population
    a. Is not a measurement of body fat (is: (weight/height)^2

    b. Values: 18.5-24.9 (healthy/not obese); 25-29.9 (overweight; intermediate category between healthy, obese); 30+ (obese)
        i. Overweight indicates risk of becoming obese; need for action (warning sign for obesity)
        ii. Numbers were determined in the 80s, have not been updated (special case: bodybuilders have high BMI w/o being obese, due to high muscle mass)
            1. Not originally designed for women, children
    c. Special means of measuring, terminology for children under 18
        i. Children >2+ y.o.: 85-95 percentile (at risk for overweight); >=95 (overweight) [different, kinder terminology]
        ii. Children < 2 y.o.: weight for length >95th percentile
4. DEXA (dual-energy X-ray absorption) - machine scans a person hand-to-toe, gives a fat percentage for every part of the body
    a. Determines whether fat is visceral or subcutaneous
    b. Originally developed for measuring bone density; used for measuring bone osteoporosis
    c. Requires special machine, but not excessively expensive
5. Visceral (around the organs; correlated with health problem) vs subcutaneous (under the skin; comparatively not as dangerous) fat
    a. Location of fat makes a difference, but requires special procedure

Obesity in 2022: according to BMI:

1. ⅓ of the population is healthy
2. ⅓ of the population is overweight
3. ⅓ of the population is obese

US obesity trends (per CDC): obesity has increased nearly 3x in the past 30 years

- Key to preventing obesity: knowing what to eat, how to live

10/3/23

- Obesity as a marker -
- Diet & exercise
    - Diet - set of habits for life (i.e. not a short-term behavior)
    - Diet is significantly more important than exercise in preventing obesity
        - Society places an undue emphasis on exercise (equates diet and exercise, whereas in reality diet > exercise)
        - Exercise consumes less energy [calories] than people expect
            - An ideal workout burns 500 calories, max (more realistically, 300); at most 25% of daily calories
- Food vs nutrition: food is what people eat; nutrition is the science of food
    - Nutrition is a very recent science (began in the 80s)
        - Discusses how food is digested, e.g.
- Digestion: the process of breaking down the food we eat
    - The longer it takes food to digest, the better
        - The process of digestion sends signals to the brain to stop sending hunger signals, making a person feel less hungry
            - Eating fruits is better than drinking juices, e.g.; the process of eating solids will prevent hunger
                - We can drink much more than we can eat
    - The food molecules that are absorbed enter the bloodstream (absorption), providing food for cells
        - Absorption process takes time (longer to digest = longer to absorb); food is not immediately available to cells upon eating
    - Metabolism - the study of how food is metabolized
        - Food is chemicals, and may be stored differently/in different locations (storage) depending on what type of chemical it is
- Three main locations for storage: liver, muscles, fat cells (meh, good, bad)
    - Once food is stored in fat cells, it is difficult to take out
- Talking about diet: talking nourishment (the food we eat/what cells need), for health purposes (the absence of physiological/psychological diseases), type, and amount

    - Talking about health: type/quality of food is more important than amount
        - Looking at food labels: what kind of calories food has is much more important than how many calories
    - Health - the absence of disease
        - Life expectancy vs quality of life & physiological (health) age
- Diseases partially affected by nutrition: osteoporosis (bone thinning as people age; can be somewhat prevented/mitigated by consuming calcium, vitamin D), heart diseases, diabetes, general lifestyle diseases
    - Affected by nutritional deficiency/toxicity: lack or excess of vitamins (e.g. niacin/B3 deficiency -> pellagra), iron deficiency -> anemia (improper delivery of oxygen to cells -> getting tired easily, e.g.), vitamin C deficiency -> scurvy (unstable skin, skin rashes)
        - Nutritional deficiencies determined by blood test; vitamin intake may vary week-to-week, but needs to be long-term for deficiency
- Healthy People [2030; gov. project]: 10-year objectives to improve health
    - Started as Healthy People 1990 in 1980
    - Current objectives: decrease consumption of added sugars (where are people getting their nutritional information from? e.g. social media), increase consumption of vegetables
        - Health objectives may have additional changes (e.g. political: growing sugar fuels economies, e.g.)

Nutrients

- Nutrients - what are they?
- 3 energy-generating molecules (i.e. Calories/kilocalories [1000 calories]) for humans in food: carbohydrates [carbs], proteins, and lipids
    - Daily values based on 2,000 kilocalories/day (may be too low for athletes, e.g.)
- Essential nutrients:
    - Macronutrients: carbs, lipids, proteins
        - 4-9-4: 1 gram of carbs/proteins = 4 kilocalories, 1 gram of lipids = 9 kilocalories
        - Macro: consume daily in large quantities (in grams)
    - Micronutrients: vitamins, minerals
        - Micro: consume daily in small amounts (in milligrams)
        - Do not generate calories
    - Water - necessary, but does not generate calories
- Carbohydrates - different types of carbohydrates (some good, some bad)
    - Types: sugar, carbohydrates, poison
        - Sugar: may occur in natural form (e.g. in fruits) or as poison (added sugars)
            - Added sugars often inexpensive, loaded with calories, has harmful health effects
        - Natural carbohydrates good to a certain extent, certain types very accessible (e.g. starchy foods [rice])
            - Not good for diabetics
    - Are necessary - primarily function as fuel (1 gram = 4 Cal.)
        - Importance of carbs only recognized in scientific community in recent years
        - Not the only source of fuel (e.g. hypothetical zero-carb diet -> liver converts other molecules into fuel)
    - Food with carbs: grains/wheat, most fruits/vegetables, some animal products (e.g. milk, cheese)
- Lipids (fats) - also different types of lipids/fats (some good, some bad)
    - Have many important functions on top of providing calories
        - Essential fats - certain fats that must be consumed (cannot be produced by the body)

        - Very calorie-dense (1 gram = 9 Cal.)
    - Historically demonized until recent years
        - Ex: Keto diet - healthy high-fat diet
- Proteins - generally good, but most expensive type of carbohydrate/ounce
    - Have a large amount of functions in the body: e.g. building muscles
        - Protein sparing: the body is capable of using proteins as fuel, but typically prefers to save them for other functions
    - Sources of protein: meat [e.g. chicken, fish]
        - Formerly: eggs cheapest, relatively healthy form of protein
        - No other natural source of protein (i.e. no high-protein fruits, vegetables, grains); non-natural alternatives: tofu
    - Proteins are usually good, but are typically consumed with meats (which also contain fats, potentially bad ones)
        - Many types of proteins
- Carbohydrate conversions: all three forms of carbohydrates can be interconverted (e.g. the body can convert carbs to lipids or proteins as needed, and vice versa)
- Vitamins: not a source of energy (i.e. no calories), but very important for metabolism (chemical reactions)
    - Vitamins may be either fat soluble (vitamins A, D, E, and K) or water soluble (vitamins Bs, and C); denotes how we store vitamins
        - Cannot store water-soluble vitamins in the body
    - Are best consumed from natural sources, not supplements/pills
- Minerals: chemical ions
    - Sodium, potassium, magnesium, zinc, iodine, iron (all consumed naturally)
        - Sodium has negative associations (to be consumed in moderation)
- Water - essential inorganic nutrient
    - Involved in many body processes: fluid balance, nerve impulses, body temperature, muscle contractions, nutrient transport, and excretion of waste products
- Food pyramids fell out of favor (mentioned cereals = sugars), changed to MyPyramid/stairs in 2005 (emphasis on grains remains, but no mention of cereals)
    - Modern: food plate (MyPlate)
- The quality of food in a diet supersedes the type of diet

10/9/23

- Lifestyle diseases: heart diseases [#1], cancer [#2], chronic lower respiratory diseases [#3] (and nephritis [#9]) are some of the leading causes of death in the US
    - Cardiovascular diseases have replaced infectious diseases as leading cause of death in the past century
- Acute vs chronic diseases
    - Infectious diseases called “acute”; cardiovascular diseases called “chronic”
        - Acute illness - illness with a clear-defined beginning & end, amenable to solutions (e.g. sanitation of water, vaccinations)
            - Decreased due to improvements in public infrastructure, medicine
        - Chronic (lifestyle) illness - illness that cannot be cured, only managed
            - Often begin early in life, long before clinical symptoms appear (ex: children with fat deposits); require early detection/screening
- Risk factors of cardiovascular diseases:
    - Smoking/tobacco: causes inflammation (overactive immune system chronically releasing potentially damaging chemicals, even during times of health)
        - Inflammation (inflammatory markers) superseded high cholesterol as #1 risk factor for cardiovascular diseases
    - Lipids: trans fat - harmful, artificial “stabilizing” ingredient; omega-6 fat [inflammatory, the bad fats])
    - Hypertension/high blood pressure (140 or above) - chronic hypertension
        - Is affected by physical activity
        - Systonic (heart contracting; blood flowing; higher pressure) vs dystonic (heart relaxing; less pressure)
    - Physical inactivity
    - Diabetes (inability for the body to manage sugar): results in major problems, even blindness (most blindness cases diabetes-related)
        - Body wants a certain level of glucose (sugar) in the blood
    - Obesity
    - Diet - quality & quantity
    - Alcohol - causes damage to the body, can be aggravated by preexisting conditions
- Lowering risk of cardiovascular diseases

- Controlling stress (media awareness)
    - Advertisements - food companies advertise more than health institutes
- Avoiding high energy-dense foods (small quantity, large number of calories/fat)
    - Sugars, especially added sugars, drastically raises level of insulin [hormone] in the blood (insulin spike)

10/10/23

Disc 1

Slides on canvas

iProfile name: "*name*, Discussion *section code*, UID: *UID*"

Indicate activity level one below what you think is correct

Right: "What is my activity level?"

Food journal:

Indicate day

Create new food item

Activity journal

Reports - start & end date; complete view; pdf

Fitness assessments

- Body weight: total body mass (lb./kg.)
  - Pounds to kilograms: pounds * 0.45 = kilograms
  - Limitations: doesn't account for height, body mass type (e.g. muscle vs fat)
- Body composition: proportion of fat to lean mass in the body (percentage)
  - Attempts to measure excess fat
  - General healthy body composition: 15%-25%
    - Determination of what constitutes healthy % differs between genders; percentage tends to be very low for athletes (esp. bodybuilders)
  - Measuring body composition: bio impedance analysis (BIA)
    - Scale sends electrical current through the body
      - Electrical impulse travels differently through fat (insulator) vs muscle/water (conductors)
- Body Mass Index (BMI): measure of body fat based on height and weight (kg/m^2)
  - Equation: (weight in kg)/(height in meters)^2
  - Normal weight: 18.5-24.9
    - Limitation: doesn't account for body mass type (e.g. muscle vs fat)
- Waist circumference: measurement around the waist (inches)
  - Location above hip bone, across navel (not across the hips)

        - Determines subcutaneous (under the skin) vs visceral (around the organs, esp. abdominal - around the abdomen) fat
    - Low risk: below 31.5 inches (women); below 37 inches (men)
- Blood pressure: pressure exerted on blood vessels as blood flows through (mm Hg)
    - Hypertension (high blood pressure) means heart is working too hard; hypotension (low blood pressure)
        - Hypertension: 140/90 mm Hg or more
        - Hypotension: 90/60 mm Hg or below
        - Normal: 120/80 mm Hg
    - Systole (heart/ventricles contracted; pressure high) vs diastole (heart/ventricles relaxed; pressure low) phases of the heart
    - Blood pressure cuff placed over upper arm to be positioned over the brachial artery (brachial artery pressure used as measurement - easy to access, direct extension of/very close to the heart)
        - Placed over left arm - heart slightly shifted to the left
        - Cuff inflating stops blood flow in the arm - cuff then slowly deflates, and measures the pressure at which blood flow resumes

Flexibility hamstring

Lay flat on mat; try to bring legs to 90-degree angle with ground

Flexibility shoulder can touch both

Touch hands over shoulders behind back

Weight 123.4

Body composition % fat mass 4.5 [hydration: 66.2]

Guest->age->male normal->height->wait for beep

Top # - body weight; bottom number: body composition; flash: water%

40s - dehydrated, 50s-okay, 60s-hydrated

Waist circumference 27 in

Bmi 16.7

Blood pressure 117/81

Resting heart rate 70

Smoking: non smoker (no risk)

Carbohydrates

- Sugar - type of carbohydrate
    - Natural vs artificial sugars
        - Most natural sugars come from plants (ex. sugarcane); a small amount from [cow] milk (only animal source of sugars)
- Plant sugars created via photosynthesis [chemical reactions]
- Storing carbohydrates - different types of carbohydrates differ in terms of digestion process
    - Need carbohydrates for energy [carbohydrates as fuel] - every cell in the boody uses carbohydrates as fuel
    - Storing excess carbohydrates - liver and muscles (excess: adipose tissue)
        - Liver has limited [fixed] anatomical capacity for storing carbohydrates; muscle storage capacity is dynamic (store more for more active individuals)
        - Share of excess carbohydrates stored in adipose tissue (fat tissue) increases as weight increases
            - Unlimited capacity (hence obesity)
            - Once carbohydrates enter fat tissue and are converted to fat, removing it is difficult

<u>Types of Carbohydrates</u>

Chemistry of carbohydrates - group of different molecules

- Individual ***monosaccharides*** (smallest unit of carbohydrates) link up to form ***disaccharides*** (2x) and ***polysaccharides*** (3+)

Sugar: chemical term referring to any mono/di/polysaccharides

- Simple sugar (monosaccharides/disaccharides) vs complex carbohydrates (polysaccharides)

3 types of monosaccharides - ***glucose***, ***fructose***, and ***galactose***

- **Glucose** - most abundant type of monosaccharide in natural sugar
    - All other types of monosaccharide are converted into glucose (the metabolic form) once inside the body

- **Fructose** - sweetest type of monosaccharide
    - Commonly used by food companies as a sweetener [high fructose corn syrup]; less common in natural sugar
- **Galactose** - rarest form of monosaccharide
    - Bacteria don't like galactose (does not cause tooth cavities)

3 types of disaccharides - ***lactose***, ***sucrose***, ***maltose***

- **Lactose** (glucose/galactose) - sugar found in milk
- **Sucrose** (glucose/fructose) - sugar commonly found in fruit (incl. sugarcane)
- **Maltose** (glucose/glucose) - fermented sugar; very rare in nature (only in fermented products)

Polysaccharides (containing many units of glucose) - ***starch, fiber, glycogen***

- **Starch** found in corn, wheat, potatoes
- **Fiber** found only in plants; good to consume
- **Glycogen** - stored form of polysaccharides inside the body
    - Stored carbohydrates in liver/muscles are stored as glycogen
    - Not a dietary source - there is no glycogen in food
- Starch, fiber, glycogen all polymers of glucose; differ in terms of digestibility
    - Starch is <u>digestible</u>: can be easily & completely broken down by the body
        - Consequence: full glucose load is absorbed very quickly
    - Fiber is <u>poorly digestible</u>; the body cannot easily break down fiber
        - 30 g. fiber -> 5-15 g. glucose (amount varies between individuals)
        - Benefit of consumption - keeps digestive system busy & feeling full, without consuming the full calorie load

Consuming Carbohydrates

Simple sugars to be taken with caution; complex carbohydrates are better, but still to be taken with caution for some (e.g. people wanting to lose weight, diabetics)

- Fruit sugars vs soda sugars (e.g.): fruits contain other chemicals (e.g. fibers, vitamins) helping processing of glucose; sodas contain only the glucose

Fibers are a generally-agreed good carbohydrate

- Fiber found only in plants; plants have rigid cell walls made of fiber (e.g. bark)
- Two types of fiber: ***soluble*** and ***insoluble fibers***
    - **Soluble fibers** are beneficial for the cardiovascular system (heart health); **insoluble fibers** are beneficial for the digestive system
    - Ex (soluble fibers): oat, pulp (e.g. orange pulp), apple skin
        - Soluble fibers generally come from the outside/skin of plants
- Fiber digestion varies person to person; can be 1-4 calories/gram, depending on the types of bacteria involved

Sugar alcohols are a less common type of carbohydrate (sugar)

- Generally less sweet, contains less calories than glucose
    - Consist of a sugar with an additional attached alcohol group
        - Naturally found in small amounts in fruit (e.g. blueberries, blackberries)
- Common sugar alcohols: ***glycerol, sorbitol, mannitol, xylitol***
    - **Glycerol**: 4 calories/gram; **xylitol**: 2.4 calories/gram (found in sugar gum)
    - **Sorbitol** (2.6 cal/g), **mannitol** (1.6 cal/g) not found in many natural foods
    - **Erythritol**: sugar alcohol with low calorie yield, absorbed and then excreted
- Loophole: since FDA classifies sugars as simple or complex, food companies can load food with large amounts of sugar alcohols and still call it "sugar-free"
    - Bodies are not naturally equipped to handle large amounts of sugar alcohols; health effects are unknown
        - Sweet taste of sugar alcohols trigger hunger signals (psychological effect)

Carbohydrate Digestion

- Digestive organs use enzymes to break down complex foods & sugars
- Glucose digestion: complex sugars (e.g. starch) need to be broken down into glucose
    - Enzymes:
        - Salivary amylase in the salivary glands and the stomach
        - Pancreatic amylase in the pancreas
        - Disaccharidases in the small intestine

    - Fiber slows down the digestion & absorption process
- Glucose absorption & regulation: once carbohydrates are broken down into glucose, it is absorbed in the duodenum (section of the small intestine) and enters the bloodstream

Insulin: hormone to lower the sugar level [glucose] in the blood

- Is released by the ***beta cells*** in the pancreas when sugar levels are high, e.g. after a meal
    - Amount of insulin released is proportional to amount of glucose absorbed
    - Consuming faster-absorbed carbohydrates results in more insulin release
- Insulin prompts storage of glucose in the liver and the muscles
    - Physically "chaperones" glucose into storage areas

Homeostasis: the principle that the body reacts to its surroundings in order to maintain its internal environment

- Ex: sweating when hot, shivering when cold
- ***Hormones*** act as body's homeostatic mechanism for regulating sugar level
    - Blood sugar level usually regulated to 70-100 milligrams/deciliter
    - **Insulin** lowers sugar levels when they are too high
        - Problem: side effects promote weight gain, obesity
            - Promotes fat storage (***lipogenesis***)
            - Prevents fat breakdown (***lipolysis***)
    - **Glucagon** - hormone released by the pancreas to raise sugar levels
        - Retrieves stored glucose from the liver and muscles
- Order of eating: eating salad before pasta, e.g. is very different from [better than] eating pasta before salad (pasta - not a good food, too much starch)

Insulin & Glucose

Every cell in the body takes glucose, but most only take the amount they need (a small amount); no capacity for storage

→ Remainder stored in one of three locations

1. In the **muscles**
2. In the **liver**
3. Any remaining glucose sent to ***adipose tissue*** (**fat cells**)

Insulin is an ***anabolic hormone*** - promotes storage [of muscle, sugar, and fat]

- Amount of insulin released proportional to the amount of glucose in the blood [plasma]; the more insulin in the blood, the more fat is stored
    - Amount of insulin measured in units (proportional to millimeters)
- Eating high-sugar foods can result in an ***insulin spike*** (a lot of insulin released)
    - Note: Glucose in the blood is not always equal to glucose eaten - eating slower-absorbed foods (e.g. fiber) decreases amount of insulin released

Effect of insulin levels on glucose uptake:

- Amount taken by cells independent of insulin levels
    - Used by cells to make energy (ATP)
- Amount taken by liver partially dependent on insulin levels
    - Glucose stored as glycogen
        - Can be broken down, sent into bloodstream as needed
- Amount taken by muscle cells, fat cells mostly dependent on insulin levels
    - Muscles, fat cells use some glucose to make ATP
        - Muscles: excess is stored as glycogen
            - Glycogen in the muscles is used exclusively by the muscles
        - Fat cells: excess (majority) is stored as triglycerides, i.e. as fat
            - Triglyceride significantly harder to break down, released much less readily than glycogen

Diabetes results in insulin dysfunction

- Causes excess glucose to remain in the blood (rather than being stored) and eventually being taken by the liver; muscle cells, fat cells lack glucose
    - Liver reaches glycogen capacity; converts glucose to fat
        - Liver only has limited capacity for fat (and for converting to fat); excess fat is sent from the liver to fat cells, resulting in excess fat
- Fatty liver disease
    - Used to be associated with alcohol in the 80s, and only seen in heavy drinkers middle age and above; now associated with obesity and even occurs in children due to overconsumption of sugar
        - Now distinguished between alcoholic, non-alcoholic fatty liver disease
- Fructose does not trigger the release of insulin
    - Used by food companies as a tagline to portray fructose as healthy
    - Causes excess fructose to be sent to the liver (can cause same issues as above)

- Avoiding insulin spikes
    - Fasting
    - Keto diet - fat does not trigger release of insulin
    - Glycemic index - 1980s metric to classify carbohydrate foods based on glycemic response (change in blood glucose level)
        - Subjects would eat a certain quantity of food; insulin response measured
        - Developed into glycemic load: below 10 low, 11-19 medium, 20+ high
- Carbohydrates in food
    - Wheat: fiber in the bran; fiber + vitamins in the germ; starch in the endosperm
        - Whole wheat - uses the entire kernel (vs white bread - just the endosperm)

10/18/23

- Carbohydrates in food
    - Mostly from wheat, sugarcane, recently: corn (cheap)
- Corn - starch
    - High fructose corn syrup (hfcs) - starch in corn converted into fructose via chemical reactions to make it sweeter
- Names of sugar on food - many different names (64+)

- Types of bread
    - Brown bread - simply added chemicals to change appearance
    - Enriched/stone-ground/unbleached bread - the same as regular bread
    - Refined bread - removing bran (fiber)
    - Whole-grain/whole-wheat - bran has not been removed
        - Still has a lot of carbohydrates (high glycemic index), relatively low fiber
- Carbohydrates on food labels:
    - Polysaccharides not explicitly reported (besides fiber) - to be inferred from total carbohydrates, fiber + sugar listings
        - May be starch or sugars
- High fructose corn syrup - fructose converted to glucose by the liver; constant high exposure to fructose can cause damage to the liver (fatty liver disease)

Proteins

Proteins as Food

All proteins are good (no bad proteins, like carbohydrates/lipids)

- Many functions; also used as fuel (1g -> 4 Cal)
- Are essential for the body to consume
    - No significant negative effects from overconsuming protein

Protein sources:

- Animal meat is majority lipids/proteins (~90% protein)
- Plant sources:
    - Natural plant sources (e.g. beans) have relatively less protein, more carbohydrates
    - Non-natural plant sources: tofu, soy

Disadvantages with protein sources:

- No pure protein foods (meat has lipids; plant has carbohydrates)
- Most expensive type of food per ounce

- Functions of protein
    - Muscles are majority protein

Protein Chemistry

Proteins are polymers made of amino acids

- 20 different types of amino acids
- Amino acids rarely consumed directly (outside of protein powders/shakes); instead consumed as protein polymers, then broken down inside the body
    - Cells then construct any proteins they need from amino acids (many different types of proteins)

Amino acids - made of a central [alpha] carbon surrounded by an amino & carboxyl group, hydrogen group [atom] + an additional R group (variable - different between amino acids)

- All proteins are water-soluble; but only some amino acids are soluble (polar vs nonpolar) depending on their R group

- Not all proteins contain every type of amino acid
    - Essential vs non-essential amino acids - both are equally important
        - Essential amino acids must be consumed (we are deficient if not); non-essential amino acids can be constructed from essential amino acids via transamination reactions
    - Complete proteins - any protein that consumes all 9 essential amino acids

Functions of Proteins

- Functions of proteins: many functions
    - Chemical reactions, signaling, fluid balance, acid-base balance, protection, transport, growth & development, and movement
        - Proteins speed up chemical reactions (proteins as enzymes)
            - Breakdown of triglycerides occurs via lipase protein, e.g.
        - Signaling (messaging - hormones)
            - Insulin made of proteins, e.g.
        - Fluid balance
            - Interstitial fluid - body fluid to carry nutrients to, waste from cells in the body (surrounds the bloodstream - all cells in interstitial fluid)
                - Contains ions, nutrients, water
            - Fluid balance - cells must get the right amount of water (too much -> cell expands, too little -> cells dehydrated)
                - Must obtain the proper osmolarity level; otherwise, results in edema (too much fluid -> tissue becomes swollen)
            - Kwashiorkor disease - extreme starvation results in permanent tissue loss
        - Proteins in the immune system - proteins (antibodies) released by the immune system to fight bacteria in the body
        - Transporters - proteins used for transporting molecules through cell membranes, or as channels
            - Glucose transporters
        - Proteins act in cell growth, maintenance, and repair
        - Proteins in movement: actin and myosin in muscles
    - Proteins called diverse

- Quality of proteins - complete vs incomplete proteins
    - Protein called complete if it contains all 9 essential amino acids
        - Animal meat, some plant products (e.g. soy) are complete proteins
    - Protein called incomplete if it is missing any of the essential amino acids
        - Beans - incomplete protein (missing one essential amino acid)
    - Incomplete proteins need to be supplemented with an additional source of protein containing the missing amino acids
        - Many of the meals we eat, culturally, fulfilled this requirement even before the science was known

Protein Digestion

- Digestion of proteins - proteins are not absorbed as-is, but first broken down into amino acids and then absorbed
    - All proteins consumed are digested (broken down into amino acids) beginning in the stomach
        - Pepsin - enzyme in the stomach that breaks down proteins into smaller molecules (not yet amino acids); requires acid
        - Pancreas releases protease enzymes to continue digesting proteins
        - Proteins eventually broken down into amino acids and absorbed in the small intestine
- Digestion process
    - Bolus in the stomach breaks solid food down into chyme (liquid food)
- Amino acids in the blood also trigger the release of insulin
    - Proteins, once absorbed into the blood, are either taken up by cells or stored in the liver and muscles for later use
- Nitrogen balance - we need to eat an appropriate/balanced amount of proteins (proteins contain nitrogen), relative to how many we consume/excrete
    - Positive nitrogen balance (higher consumption than excretion) needed for growth, building muscles
    - Negative nitrogen balance (higher excretion than consumption) is bad - results from not consuming enough food (starvation)
    - Nitrogen balance (equal consumption, excretion) is desirable for healthy adults

- Overall recommended dietary allowance (RDA) of protein is the minimum amount of [dietary] proteins an individual should consume daily
    - Formula: 0.8 g. of protein / 1 kg. of body weight
- Every cell in the body needs amino acids; applies to every organ
    - Used by pancreas to build insulin; muscles, to build actin; salivary glands to build amylase; liver, to build immune proteins
        - Cells build proteins as instructed by genes (gene expression)
- Protein synthesis
    - Protein shapes, functions are complex
- Insulin index - recently developed index for insulin release
    - Even foods without many carbohydrates may still have a high insulin index (e.g. meat has lots of proteins, triggering insulin release)
- Ketchup is bad

Lipids

- Lipids - commonly associated with fat, fast food
- Lipids are essential - must be consumed
    - Are associated with health risks, but also have vital functions in the body
        - Big difference between dietary fat (not necessarily bad) and lipids in the blood (problematic; health risk of cardiovascular disease)
    - Some types are beneficial, others should be avoided
        - Some lipids are essential
    - Lipids: oils vs fats
- Types of lipids:
    - Triglycerides - most common type of lipid (~99.5%; consumed in grams)
        - Contained in meat, dairy, oils, etc.
    - Cholesterol, phospholipids (~0.5%; consumed in milligrams)
- Triglycerides - molecules made of glycerols and 3 fatty acids
    - Digestion: glycerol becomes glucose in the liver
    - How healthy triglycerides are depends on structure of fatty acids
- Fatty acid chains differ by length (number of carbons) and atomic interactions
    - Fatty acids also called hydrocarbons

- Fatty acids structure
    - Methyl group (omega carbon) on one end; carboxyl group (alpha carbon) on the other end
- Fatty acid lengths
    - Classifications
        - Short fatty acid chains: less than 6 carbons
        - Medium fatty acid chains: 6-12 carbons
        - Long fatty acid chains: 13-21 carbons
        - Extra long fatty acid chains: 22+ carbons
    - Longer fatty acids contain more calories
        - MCT oils - medium-chain triglyceride (marketed as low-calorie)
            - Coconut oil contains excess amount of MCT oils; controversial
    - Most fats eaten in nature are long/extra-long, used for energy storage

        - Body prefers short and medium chains - can be used for other functions
- Fatty acid interactions depend on the types of bonds in the fatty acid chains (single vs double)
    - Level of saturation of fatty acids
        - Saturated fatty acids have only single bonds (linear structure)
            - Contain the maximum amount of hydrogens connected to triglyceride carbon chain
        - Unsaturated fatty acids have at least one double bond (curved structure)
            - Results in a bent/kink structure in the fatty acid
            - Location of double bond described by distance from omega carbon (omega 3, omega 6, etc.)
    - Linear fatty acids (i.e. saturated fatty acids) are more easily/efficiently stackable than curved fatty acids (i.e. unsaturated fatty acids)
        - Stacked linear fatty acids are solid at room temperature (e.g. butter); including curved fatty acids results in liquid (e.g. olive oil)
    - In the body - saturated fatty acids are more easily stored than unsaturated fatty acids
        - Body has difficulty storing unsaturated fatty acids - wants to use them (e.g. by burning them as calories)
- Fats in the diet
    - Location of double bond in unsaturated fatty acids described by distance from omega carbon (omega 3, omega 6, etc.)
        - Omega-3, omega-6 are essential fats - cannot be produced in the body, must be consumed
    - No foods are pure saturated/unsaturated fats
        - Food companies prefer using saturated fats - better shelf life, stability, nicer appearance; public stigma against saturated fats
- Types of unsaturated fatty acids
    - Cis vs trans fatty acids
        - Cis fatty acid - natural form of unsaturated fatty acids (“oily” form)
            - Omega-3, omega-6
        - Trans fatty acid - artificial unsaturated fatty acids that behave like saturated fatty acid in food (i.e. in terms of shelf life, stability)

                - Created by converting cis to trans via hydrogenation process
                - Is harmful in the body - increases risk of cardiovascular diseases, e.g.
        - Monounsaturated vs polyunsaturated fatty acids
            - Monounsaturated - one double bond
                - Generally agreed to be healthy
            - Polyunsaturated - more than one double bond
                - Some polyunsaturated fats are good; others are bad
            - Both types occur naturally; no only mono- or only poly- foods
- Eating
    - Olive oil has high MUFA content, but not to be used for frying
    - Deep frying - no good choices
        - Canola oil is not healthy - high omega-6 content

11/1/23

- Alpha-linolenic acid (omega-3), linoleic acid (omega-6) - essential fatty acids
    - Are anti-inflammatory - stops prolonged immune system overactivity [inflammation]
        - Clot prevention - prevents damage to blood vessels [heart diseases]
    - In Western/American society - modern diets have lots of omega-6 (“fat” on food labels), not enough omega-3
        - Ideal ratio: 2:1, 1:1 omega-6 to omega-3 [almost impossible]
        - In society: 20:1 omega-6 to omega-3
            - Even 8:1 is good
    - Sources of omega-3: green leafy vegetables (some amount), fish [salmon], walnuts
    - Sources of omega-6: vegetable oil
        - Marketed as “healthy”, but are loaded with omega-6
        - Almost everything has vegetable oils
            - Worst oils are also most-used (cheapest): canola and soy
- Common perception: “fat is bad”
    - Meats advertise being lean
        - Assumption: “lean meat” is proteins -> lean meats [in the store] are mostly proteins
        - Reality: some is fat/protein; remainder (majority of serving size) is water

        - "Extra lean" is some amount more proteins, a lot more water
        - Only relevant value: sum of fat (in grams), protein (in grams)
- Phospholipids - typically consumed only in small quantities
    - Have structure similar to glycerol
    - Occur naturally in the body to form cell membranes
        - Are amphipathic - partially water-soluble
    - May be used by food companies as emulsifiers - bridges solubility of oil, water (allows them to mix; used in salad dressings, e.g.)
- Cholesterol
    - Cholesterol functions in the body: functions in fluidity of cell membranes, creating steroid hormones (e.g. testosterone, estrogen), making vitamins (D, K)
        - Is non-essential (can be made by the liver)
    - Liver - cholesterol hub/warehouse
        - Every cell in the body needs some amount of cholesterol; delivered by the liver via vesicles, bloodstream
        - LDL - vesicle for cholesterol
    - Has different structure than triglycerides (glycerol), phospholipids - have more benzene rings, e.g.
    - Two types of sterols: animal cholesterol, plant sterols
        - "Cholesterol" typically refers to animal cholesterol; food companies often omit plant sterols from food labels
    - Sources of animal cholesterol: eggs [egg yolk], meat
    - Big difference between dietary cholesterol, liver-produced cholesterol
        - Many heart diseases due to problems in the liver

11/3/23

- Lipids in the body:
    - Pancreatic lipase (enyzme) released by pancreas, used to break down lipids
    - Liver also releases bile - fragments lipids, breaks large lipid globules down into smaller globules (emulsification)
        - Makes pancreas lipase more effective
    - Lipids broken down into monoglycerides, free fatty acids

        - Since lipids hydrophobic, need to be packaged in chylomicrons (dietary lipid vesicles) by small intestine before sending to liver
- Liver processes lipids, stores lipids, sends them to various locations
    - Uses many different types of vesicles: VLDL [very low-density lipoprotein], LDL [low-density lipoprotein], and HDL [high-density lipoprotein]
        - VLDL primarily carries triglycerides; some cholesterol
            - Triglycerides used as energy by cells in the body (e.g. by muscles, fat)
        - LDL primarily carries cholesterol; some triglycerides
            - Culprit of cardiovascular disease
        - HDL only carries cholesterol
            - Considered "good" cholesterol - want high HDL levels, low VLDL/LDL levels
    - Blood tests measure lipid levels in circulation, by amount of lipid vesicles
- Functions of lipids: all cells in the body need lipids
    - Serves as fuel for making ATP
        - Consequence: exercise burns lipids to create ATP (fat burning)
    - Used in synthesis of phospholipids
        - Phospholipids make cell plasma membranes, vesicle membranes
        - Most phospholipids in the body are synthesized, not consumed
    - Used to create lipoprotein vesicles for transport (e.g. VLDL, HDL, etc.)
    - Used for insulation - maintaining body temperature
        - Subcutaneous [under skin] fat - fat under skin, serving as insulating layer to help maintain temperature
            - Skin - first layer of heat exchange
            - Subcutaneous fat is normal, necessary fat (vs visceral fat - fat under organs [unhealthy])
        - Myelin - fat around the brain cells [nerves], helps speed up conduction of electrical activity in the brain
    - Has other cell-specific functions
        - Lipids, cholesterol used to synthesize steroid hormones (e.g. testosterone, estrogen) in the gonads (testes, ovaries), adrenal gland
            - Majority of cholesterol used for hormone synthesis
        - Lipids used to synthesize vitamins (vitamin D, K) in skin, kidneys

                - Skin uses sunlight to trigger some vitamin D synthesis
- Breakdown of ATP fuel sources:
    - More sedentary lifestyles use more carbohydrates; more active lifestyles use more lipids
        - Sitting: 50/50 carbohydrates, lipids
- Lipid dietary recommendations - lipids are essential, but controversial
    - Unlike carbohydrates, lipids have more functions than just energy
    - Promoted/"official" recommendation: 10-15% of daily intake should be fat
        - Reality: no strict recommendation, as long as lipid consumption is limited to healthy fat
            - Blood tests are best measure of diet quality
    - Unlike carbohydrates/proteins - lipids does not trigger insulin release
- Good & bad fats
    - Good fats: avocado, olive oil, nuts
        - Keto diet - high-fat diet that is beneficial for diabetic patients [under a doctor's supervision]
    - Avoid: omega-6, trans fats
- Reading food labels - total fat, saturated fat, trans fat listed as separate values
    - Unsaturated fat not explicitly listed
        - Unsaturated fat = total fat - saturated fat; type of unsaturated fat depends on ingredients
    - "0 trans fat" just means less than 0.5 grams
        - Ex: if a food item has 2 grams of trans fat, divide into 4 servings -> can say "0 trans fat"
            - Small food items may be listed as having more servings than would be realistically consumed for this reason
        - Ingredients: "hydrogenated oil" = trans fat
    - "0 fat/fat-free"
        - Ingredients: "Glycerol + fatty acids" = triglycerides [fats]

The Body

Digestive System

Three functions of the digestive system - ***digestion***, ***absorption***, and ***excretion***

1. **Digestion**: chemical breakdown of food into small molecules
    a. Breakdown process happens incrementally, through series of steps
        i. Some molecules (water, vitamins) do not need to be broken down; can be absorbed directly
    b. Ex: carbohydrates -> monosaccharides; proteins -> amino acids; lipids -> monoglycerides & fatty acids
2. **Absorption**: passing of food molecules into the bloodstream
    a. Food is not considered "consumed" until it has been fully absorbed into the bloodstream
        i. Consumed food used by cells to sustain basic functions
3. **Excretion**: removed of excess food from the body
    a. Not everything consumed is digestible/absorbable; remainder is excreted

Digestive Organs

Main Digestive Organs

Main digestive organs: organs food physically passes through

Mouth -> throat -> esophagus -> stomach -> small intestine -> large intestine

The **mouth** is the initial point of entry for food + starting point for digestion.

- Two types of digestion (in the mouth): ***mechanical digestion*** and ***chemical digestion***
    - ***Mechanical digestion***: The mouth physically fragments food into smaller pieces
        - Occurs via chewing [masticating]
    - **Chemical digestion**: Breaking down the covalent bonds in food via chemicals
        - Occurs via saliva from the *salivary glands*
            - Mouth glands - parotid gland, sublingual gland, submandibular gland release saliva (simplification)
        - Begins immediately, even within the mouth

Saliva contains ***mucus, lysozymes, amylase, protease, lipase***

- **Mucus**: lubricant to help food pass through narrow organs
    - Mucus is basic -> neutralizes acidic food (prevents acidic damage to inside of mouth)
- **Lysozymes**: immune system chemicals to kill harmful bacteria
    - Bad breath - caused by (benign) digestive bacteria in the mouth
- **Amylase**: enzyme facilitating chemical breakdown of amylose (starch)
    - Starchy foods "melt" on the tongue - amylase
- ***Lipase***, ***protease*** (enzymes for breaking down lipids, proteins) do not contribute significantly to digestion in the mouth (too inefficient); reason for release unclear

Smooth muscles - involuntary muscles in the various digestive organs to gently induce movement of food through the digestive system via rhythmic contractions (*peristalsis*)

- Do not depend on gravity (despite misconceptions)
- Are *involuntary muscles* (as opposed to voluntary skeletal muscles)

The **throat** contains two separate, adjacent tubes: the ***esophagus*** (transports food) and the ***trachea/windpipe*** (transports air)

- **Esophagus** - long, muscular tube composed of smooth muscles; transports food from mouth to stomach
- **Epiglottis** ("guardian of the airways") - a flap above trachea to facilitate routing of food, air
    - Seals airways when swallowing food
    - *Choking* occurs when food enters airways (Adam's apple)
        - Air may also enter food channel behind Adam's apple (inconsequential)

The **stomach** acts as a junction between the esophagus, small intestine

- Is a large J-shaped organ, located directly right below left side of ribs
- Acts a a *temporary hold/processing center* for food
    - Can hold food for 1-2 hours
    - **Sphincter**: rings of smooth muscles between digestive organs, acting as seals to control the movement of food
        - May pass food in small fragments, to prevent any digestive organ from becoming overloaded

        - Ex: The *stomach sphincter* controls the rate of food emptying into the small intestine
- Protein digestion begins in the stomach: proteins begin to be broken down into smaller fragments (but not yet into amino acids)
    - **Pepsin**: potent enzyme in the stomach to break down proteins
        - Is actually released by the stomach in an inactive form (***pepsinogen***); is activated by stomach acid (HCl) upon reaching cavity of small intestine
            - Released in an inactive form to ensure pepsin does not damage other parts of the body
- Notable stomach cells: ***mucous cells, parietal cells, chief cells*** (+ others)
    - **Mucous cells** release mucus to liquify food
    - **Chief cells** release pepsinogen
    - **Parietal cells** release hydrochloric acid (stomach acid - HCl)
- Food in the stomach converted to ***chyme*** - liquified, semi-processed food
    - Contains partially-processed fats, proteins, etc.

The **small intestine** is the location where the final stages of digestion happen (absorption occurs).

- Small intestine-released enzymes: ***maltase, peptidase, sucrase, lactase, enterokinase***
    - **Maltase**, **sucrase**, **lactase** break down carbohydrates
    - **Peptidase** helps break down peptides (protein fragments) into amino acids
    - **Enterokinase** helps activate proteolytic enzymes from the pancreas
        - Ex: trypsinogen -> trypsin
- From other organs: the small intestine receives *chyme* from the stomach, ***pancreatic juice*** from the pancreas, and *secretions* from the liver and gallbladder
    - **Pancreatic juice**: secreted enzymes from the pancreas
        - Also sends bicarbonate - basic chemical to neutralize stomach acid

<u>Accessory Organs</u>

Accessory organs release chemicals into digestive organs (do not physically handle food)

Pancreas, liver, gallbladder, salivary glands

The **pancreas** has both endocrine, exocrine functions

- Exocrine functions - releasing of pancreatic juice

- Endocrine functions - producing various chemicals, enzymes
    - ***Acinar cells*** produce enzymes
        - **Proteolytic enzymes**: series of enzymes for digesting protein
        - ***Pancreatic amylase***, ***pancreatic lipase*** digest amylose, lipids
    - ***Duct cells*** produce bicarbonate

Liver/gallbladder have many different functions

- The ***liver*** produces ***bile*** for digestion
    - **Bile** - substance that promotes emulsification of fat, boosting lipid breakdown by pancreatic lipase
- The ***gallbladder*** stores, releases bile

Not all food is completely digestible; the remainder ends up in the **large intestine**

- Some foods (ex: fiber) may only be partially absorbed; end up in large intestine
- Large intestine contains trillions of bacteria (***intestinal flora***)
    - Intestinal flora exist in a *symbiotic relationship:*
        - Bacteria get food from the body
        - Bacteria release vitamin K, break down MCTs/MCFAs (medium-chain triglycerides)
    - Bacteria contain enzymes for breaking down fiber; amount of fiber digested depends on the amount of bacteria (varies person-to-person)
        - Digestion of fiber by bacteria slower than digestion of other carbohydrates by the body, preventing insulin spike
- Every person has different types of bacteria in their large intestine; determined by diet a person consumes
    - Some bacteria are beneficial (make us less hungry); others harmful (make the brain more hungry, produce inflammatory substances, increase storage of adipose tissue)
    - Probiotics - pills containing gut bacteria
        - Does not truly affect balance of bacteria - without improving the diet, bad bacteria will remain
    - (*) Fecal transplants - transplanting intestinal bacteria

Digestive Disorders

- Not disorders - belching, flatulence
    - Gas for belching due to eating too fast; gas from flatulence related to food consumed, individual metabolism
        - Smell due to bacteria
    - Flatulence common cause: individuals who have not consumed fiber in the past, suddenly starting to consume fiber [temporary]
- ***Heartburn*** occurs when acid from the stomach leaks into esophagus, causes inflammation
    - May happen if sphincter does not fully close
        - Can also occur when eating spicy or hot food
        - Prevented using pills
    - Severe heartburn occurs when acid reaches & enters the trachea, causing the windpipe to spasm & seal
    - **GERD** (*gastro-esophegial reflux disease*) - disease where heartburn occurs regularly
- ***Ulcer*** occurs when helicobacter pylori starts living inside stomach
    - Causes irritation in the stomach; in particular, causes pain whenever the ulcer is touched (notably, when eating)
    - Bacteria surviving inside stomach acid was originally thought to be impossible; was proven by scientists physically drinking helicobacter pylori, developing ulcers
- Celiac disease (celiac sprue)
    - Causes discomfort when consuming food/drink (?)
        - Related to the immune system (?)
    - Caused by gliadin - protein found in certain foods (e.g. wheat, rye)
        - “Gluten-free” - free of gliadin
            - Only significant for people with celiac disease, but marketed as a “healthier choice” for everyone
- ***Crohn’s disease*** causes inflammation in the small intestine
    - Stool movement through inflamed regions can cause additional inflammation, leading to *bloody stool*
        - Severe Crohn’s leads to growth of *polyps* (pockets) in the small intestine
    - Treatment

        - **Colonoscopy** - process of inserting a probe through the anal canal to check for irritation/inflammation in the large intestine
        - Anti-inflammatory medications to mitigate

- Avoiding digestive diseases
    - Watch your diet
    - Consuming fibers may improve digestive health
- Microflora - bacteria in the large intestine help digest food not digestible by the small intestine
    - Type of microflora varies person-to-person; not all types are beneficial
        - Good microflora: produce MCT, vitamin K, vitamin B12, essential amino acids
        - Bad microflora: produce inflammatory chemicals
    - Promoting healthy microflora
        - Leaky gut food - food that irritates the gut (causes microflora to produce chemicals that leak into gut)

Endocrine System

- Endocrine system - system composed of hormone-releasing organs
    - Main functions:
        - Communication - allowing different organs to communicate with each other
        - Homeostasis - balance & regulation of bodily state, chemical levels, etc.
    - Composed of different hormone-producing glands
- Glands scattered across the body
    - Some glands may produce produce multiple hormones
        - Ex: hypothalamus - produces 7 different hormones; pituitary gland: 9
- Hormones - chemical messengers that travel in the blood
    - Hormones generally specific - act on unique areas of the body (target cells/organs)
        - Ex: insulin (tell body to store fat); testosterone/estrogen (sex hormones)
    - May be composed of lipids (steroids), proteins (peptides/amines)
        - Lipids hydrophobic -> steroid hormones travel less easily than peptide hormones
    - Glands vascularized (have many blood vessels surrounding them) to enable release of hormones into bloodstream

Endocrine system gland

- Pituitary gland - small gland located in the brain behind nose/eyes
    - Extremely small - half the size of an almond
        - Composed of two major lobes - anterior and posterior (front & back)
    - Releases 9 hormones
        - Essential for life - 70% of body functions depend on hormones from the pituitary gland
        - Anterior lobe releases 7 hormones; posterior lobe releases 2 hormones
    - Notable hormones (anterior lobe):
        - Growth hormone - promotes growth and maintenance of organs
            - Growth - promotes nutrient availability to organs
                - Promotes muscle growth & strengthening
                - Promotes breakdown of fat in adipose tissue [lipolysis]

                - Inhibits insulin promotion of glucose transport
            - Exercise increases release of growth hormone (both during exercise, and throughout the day)
            - Amount released decreases with age (peaks in 20s/30s)
            - Target organ: liver
                - Promotes release of insulin-like growth factor (IGF-1)
                    - Insulin-like: similar structure, different effects
                - IGF-1 acts on bones, muscles
            - Is controlled - release regulated by hypothalamus in the brain via GHRH [growth hormone-releasing hormone]
- Thyroid gland releases thyroid hormone
    - Two types of thyroid hormone: T3 & T4
        - Simplification: have similar functions
    - Increases metabolism - burning of calories [caloric expenditure]
        - Similar to growth hormone - promotes nutrient availability, lipolysis
        - Increases heat production
    - Thyroid hormone sparked by release of TSH [thyroid-stimulating hormone] from pituitary gland, controlled by TRH from hypothalamus
        - More active lifestyle -> more thyroid hormone released
    - Common diseases
        - Hyperthyroidism - overactive thyroid (too much T3/T4)
            - Results in being skinny, energetic, active
            - Always feel hot
        - Hypothyroidism - underactive thyroid (less T3/T4)
            - Often feel cold; tend to struggle to maintain weight
- Adrenal gland composed of adrenal medulla, adrenal cortex
    - Adrenal medulla produces catecholamines
    - Catecholamines consist of two hormones: epinephrine, norepinephrine
        - Produced by chromaffin cells
        - Are stress-adaptation hormones: released during exercise to help body adapt to exercise
            - Target organs:
                - Lungs: dilates/widens airways

                - Heart: increases heart rate
                - Blood vessels: vasodilation
                - Liver: promotes of glucose [glycogenolysis]
                - Adipose tissue: promotes lipolysis
            - Stress: anything body is not used to
        - Indirect effect of epinephrine: glycogenolysis promotes release of insulin
            - Epinephrine-insulin ratio [E:I ratio] can be increased by exercise, good diet
    - Adrenal cortex produces cortisol - steroid hormone released in stressful situations
        - Has similar effects to epinephrine
            - Epinephrine vs cortisol: immediate vs long-term stress
        - Beneficial in normal levels; harmful at high levels
            - Normal levels: promotes glucose sparing [sends more glucose to the brain, less to other organs]
            - High levels of cortisol promotes breakdown of muscles [proteolysis], decreases effect of immune system
- Homeostasis - body tries to keep bodily state at set points [regulation]
    - Releases hormones to respond to changes in internal environment
        - Ex: 70 mg/dl is the blood sugar set point; >70 causes release of insulin
    - Receptors - cells in the body that measure bodily state
        - Ex: pancreas detects changes in blood sugar
    - Control center - organs that determine set points to regulate at
        - Ex: pancreases acts as control center for blood sugar level
    - Effectors - mechanisms to control bodily state
        - Ex: muscle cells, liver act as effectors to take in excess glucose
            - Ex: glucose transporters - protein gates on muscle cell membranes
                - Allows glucose to enter muscle cells
                - Amount of insulin increases number of transporters
        - Ex: liver acts as effector to release glucagon when blood sugar is low
- Testosterone - male sex hormone
    - Is an anabolic hormone - promotes muscle maintenance, growth
        - Strengthens bones - increases calcium deposits
        - Increases protein synthesis in muscles

    - Factors in testosterone
        - Physical activity causes more testosterone release
- Estrogen - female sex hormone; drives the menstrual cycle
    - Has important protective functions
        - Important for heart health - protects against heart attacks
            - Vasodilator effect - widens blood vessels
        - Promotes bone growth - protects against osteoporosis
    - Drops substantially during menopause
        - Increases risk of osteoporosis
- Both sexes produce both testosterone, estrogen
    - Males produce relatively more testosterone than estrogen (and vice versa)
- Levels of sex hormones (testosterone, estrogen) decrease with age
    - Increases rapidly during puberty, peaks mid-30s
    - Hormone replacement therapy (HRT) - supervised procedure for increasing sex hormone levels
        - TRT [testosterone], ERT [estrogen]
        - Increases risk of certain cancers (ERT - breast/uterine cancer; TRT - prostate cancer)

Cardiovascular System

- Leading cause of death - cardiovascular diseases
    - Many cardiovascular diseases caused by lifestyle
        - Vs congenital diseases (present at birth)
        - Atherosclerosis - hardening of blood vessels
        - Hypertension - high blood pressure
    - Historic boogeyman - cholesterol
- Components of the cardiovascular system - heart, blood vessels, and blood
    - Heart - cardiac muscle
    - Blood vessels - allow movement of substances
        - Arteries & veins span the body
    - Blood composed of plasma (fluid component) and cells
    - Purpose:
        - Provides oxygen, energy [nourishment] to cells
        - Picks up waste from cells
- Heart - organ composed of cardiac muscles
    - Acts as a pump
    - Has four chambers [cavities] - two receiving blood, two sending out blood
        - Blood received in left & right atria
        - Blood sent from atria to left & right ventricles, then sent out to lungs to be oxygenated
    - Process
        - Blood received in right atrium, sent to right ventricle
        - Blood sent from right ventricle to lungs to be oxygenated; is then sent back to left atrium, sent to left ventricle, and finally sent out to body
    - Coronary circulation - circulation inside the heart
        - Major blood vessels - left & right coronary arteries (delivers blood to left & right sides of the heart); left anterior descending artery/LAD (delivers to left ventricle)
    - Heart attack - when heart fails to function (coronary circulation fails)
        - Most common cause - failure of LAD

                - Commonly due to occlusion - fat deposits in blood vessels blocking blood flow
                - Also - instability in blood vessels, causing ruptures
- Heart cycle - heart relaxes to fill up on blood; contracting to sent out blood
    - Diastole - heart is relaxed; systole - heart is contracted
        - Ventricular/atrial systole, diastole
        - Aorta - major/largest blood vessel in the body, starting at the left ventricle
    - Pressure - force on blood vessels
        - Blood pressure - systolic pressure / diastolic pressure
            - Healthy baseline - 120 mmHg / 80 mmHg
- Alternate metric for heart health - heart output
    - Cardiac output = heart rate * stroke volume (amount of blood ejected from the heart - L/min)
        - Heart rate - beats per minute (BPM)
            - Typical rate - 60-100 at rest [lower for fitter individuals]
        - Stroke volume - amount of volume ejected every beat (L/B)
            - Typical - 70-75 mL
    - Typical cardiac output: 5 L/m at rest, 20 L/m (4-5x) during exercise
        - 5-6 L of blood typically circulating through the body at any given point
- Blood vessels (arteries, veins) are hollow - have internal lumen [cavity]
    - Have three layers - tunica intima [inner layer], tunica media, tunica externa
    - Tunica intima extremely smooth/fine to decrease friction
        - Composed of a single thin layer of endothelial cells
            - Produce nitric oxide [NO] - vasodilator [widens blood vessels]
        - Nitric oxide released when tunica intima feels increased pressure, acts on smooth muscles to widen blood vessels
    - Tunica media composed of smooth muscle - acts to increase/decrease diameter of blood vessel to modify amount of blood flow, accommodate changes
        - Smooth muscles are involuntary
            - Performs vasoconstriction, vasodilation
    - Tunica externa flexible/elastic, to account for changes in blood vessel diameter
        - Made of elastic tissue
- Blood vessels are very important

    - Heart attack - problem in coronary artery
    - Stroke - problem in carotid artery
- Major components of blood
    - Cellular components - erythrocytes (red blood cells - carry oxygen), leukocytes (white blood cells - immune system), platelets (prevent blood loss from injury)
    - Blood plasma largely composed of water
        - Also contains - ions (e.g. calcium, magnesium), hormones, proteins, nutrients (glucose, amino acids, lipids)
            - Lipids do not dissolve in water, carried in vesicles (lipoproteins)
            - Lipoproteins - hydrophobic (fat-soluble) core, hydrophilic shell
- Fat vesicles:
    - Chylomicrons - carry dietary lipids (mostly triglycerides) from the small intestine to the liver
    - VLDL carries lipids from liver to tissue
        - VLDL - very low density lipoprotein
        - Produced in the liver; carries mainly triglycerides, some cholesterol
    - LDL carries mainly cholesterol, some triglycerides
        - LDL - low density lipoprotein
        - Formed in the blood; derived from VLDL
            - VLDL gradually converted into LDL as VLDL triglycerides are used up/deposited -> more cholesterol (relative)
        - LDL is not harmful by itself, but has a tendency to break down in the blood
    - HDL produced in the liver, collects/brings cholesterol from tissue back to liver
        - HDL - high density lipoprotein

DIseases of the Blood

- Diseases of the blood (heart diseases = blood diseases)
    - Atherosclerosis - hardening of the blood vessels
        - Blood vessels supposed to be elastic (tunica intima); hardening -> loses vasoconstriction, vasodilation
            - Can lead to myocardial events - heart attack, stroke
        - Caused by buildup of fat deposits in blood vessels
            - Due to breakdown of LDL in the blood (LDL oxidation) releasing cholesterol directly into blood vessels [abnormal]
            - Triggers activation of immune system [inflammation]
        - Stages of atherosclerosis:
            - Initiation - fat building up, blood flow is still normal
            - Inflammation - immune system macrophages (immune cells) are sent to clean up fat deposits
                - If there is too much fat, then macrophages are overwhelmed; start to break down (become foam cells)
                - Diameter of blood vessels begins to decrease
            - Fibrous plaque formation - fat, foam cell buildup continues
                - Diameter of blood vessel continues to decrease; eventually starts to impede blood flow (flow impedance/occlusion)
                    - Consequence: tissue downstream may not receive enough oxygen (blood), begin to die (ischemia)
            - Plaque rupture - fat layer ruptured, spills out into blood vessel -> clotting, severe/total flow impedance
                - May become a heart attack (blood vessel in the heart - coronary artery), stroke (blood vessel in the brain)
        - Possible that no warning signs of atherosclerosis appear until final stage (a heart attack/stroke occurs)
            - Possible sign - feeling of chest pain, arm pain
        - Is a progressive disease - takes years to reach final stage
            - Caused by unhealthy diets resulting in production of more bad LDL

        - High-calorie/high-sugar diets can result in high cholesterol levels; results in production of more LDL, smaller LDL
            - Smaller LDL -> more prone to oxidation
    - HDL has a protective role - helps macrophages clear LDL from circulation
- Diagnosing blood diseases
    - Blood test - cheapest, easiest means of diagnosis
        - Takes a lipid profile - determines what kind of lipids (how many lipid vesicles) are circulating in the blood
            - Measures quantity of LDL, HDL
                - LDL levels: <129 relatively low risk; 130<160 is borderline/early warning; >160 is high-risk
                - HDL: want 60+ mg/dL
                - Want LDL:HDL ratio below 3.5:1
            - Triglycerides:HDL ratio - 1:1, 2:1 ideal
        - Tools to measure size of LDL vesicles in blood vessels
            - Cons: are expensive, relatively inaccessible
            - Smaller vesicles get stuck more easily
        - Can also measure inflammatory markers - CRP, interleukin
            - Insulin, sugar levels
    - ER visits
        - Angina pectoris (chest pain) - early sign of heart attack
            - MI - heart attack
    - Imaging/tests
        - EKG
        - Angiography - imaging technique for monitoring blood vessels (ensuring blood is flowing)
- Surgical options
    - Angioplasty - inserts & inflates an artificial mesh into blood vessels; is expanded where lipids have built up, to widen blood vessel
        - Contains chemicals to slowly break down lipid deposits

    - Coronary artery bypass graft - near a location where lipids have built up, cut open blood vessel upstream & downstream of lipid deposits and sew in another blood vessel between the two
        - Adds a “detour” for blood to travel around the blockage
        - Extra blood vessels can be extracted from patient’s arm/chest/knee
        - Done in cases when angioplasty is too risky
    - Limitations of treatment
        - Statistically - most patients who have heart attacks, have a second one
            - Due to unhealthy behavior (cause of problem) persisting
            - Heart attacks due to progressive disease, years and years of fat buildup (unhealthy behavior)
- Medication
    - Statins - lower LDL cholesterol
        - Reduce and prevent inflammation
        - More than half of the population is on statins [used as preventative medicine]
    - Limited medications for lowering triglycerides

- Diagnosing diabetes
    - FPG
    - Glucometer
    - OGTT [oral glucose test]
    - Blood test
    - HbA1C
        - Glucose in the blood can interact with hemoglobin - results in glycosylated hemoglobin (hemoglobin bound to glucose)
        - Measures average of blood glucose for past 6 months
        - Ranges: Healthy: 4-5.6%; pre-diabetic [borderline]: 5.7-6.4%; diabetic; 6.5+%
- Complications from diabetes - dysfunctional insulin causes excess glucose to remain in the blood
    - Fatty liver disease - occurs when fat deposits build up in the liver
        - Occurs in alcoholics and diabetics [non-alcoholic fatty liver disease]
        - Results from excess glucose in the blood going to the liver, become converted to fat
    - Ketoacidosis [not ketosis] - simultaneously high glucose and high fat in the blood
        - Causes body to use fatty acids as fuel
            - Fatty acid metabolism creates ketone bodies
    - Many other major complications
        - Microvascular diseases - small blood vessels begin to deteriorate
            - Ex: Nephropathy (kidneys), neuropathy (nerves), retinopathy (eyes)
            - Nephropathy - kidneys typically act to filter blood (to produce urine, e.g.); consistently high blood glucose -> blood vessels of the kidneys are damaged over time, can no longer filter out glucose
                - Glucose begins to be discharged in urine; blood pressure increases
                - Many diabetic patients also on kidney medication, high blood pressure medications
                    - Dialysis - “artificial kidney”
            - Neuropathy - nerve damage

            - Causes patients to lose sensation in the legs; may result in injury [toe ulcers], needing amputation
        - Retinopathy - eye damage
            - High blood glucose damages blood vessels in the retina
                - Notable sign: white spots on the retina
    - Macrovascular diseases
        - Atherosclerosis
- Managing diabetes
    - Lifestyle changes
        - Food - foods with low glycemic load (e.g. fibers, vegetables)
            - Most fruits to be avoided
            - Socioeconomics - low glycemic load foods are expensive
                - Ex: brown rice, wheat bread still high
            - Keto diet, fasting
        - Physical activity/exercise help increase glucose uptake
    - Medications used until lifestyle improves
        - Sulfonylureas [glyburide] stimulates pancreas to release beta cells
            - Side effect - causes weight gain
        - Biguanides [metformin] acts on liver to reduce glucose release
            - Also increases insulin sensitivity/functionality