Nutrition can be defined as the sum total of the processes by which a living organism receives and utilizes materials necessary for survival, growth and repair of tissues.

Q1: What do you call material that is consumed and is necessary for survival, growth and repair of tissues? _________________

Diet (noun) can be defined as the foods that people, animals or communities habitually eats.

Diet (verb) can be defined as restricting oneself to small amounts or special kinds of foods to lose weight or achieve a desired outcome.

Dietary Reference Intake (DRI) can be defined as the intake which meets nutrient requirements in 97.5% of the population of a specific age and sex, ie, the amount of a nutrient that is two standard deviations above the mean requirement.

Figure. Schematic of normal distribution of nutrient requirements for a population, area under the curve to the left of arrow indicates coverage of population by DRI

Essential nutrients include water, amino acids, fatty acids, vitamins, minerals, trace minerals, electrolytes, water and the energy sources – carbohydrate, fat and protein

Energy sources:
- **Protein** – contains approximately 4 kcal/g
- **Carbohydrate (simple sugars, starches)** – contain approximately 4 kcal/g
- **Fats/lipids** – contain about 9 kcal/g
- **Ethanol** – contains about 7 kcal/g

1 kilocalorie (kcal) is the amount of heat required to raise 1 kilogram of water 1 degree centigrade. We typically refer to kilocalories as calories.

1 joule (J) is the amount of mechanical energy required to displace a mass of 1 kg a distance of 1 meter with an acceleration of 1 meter per second (1 J = 1 kg x 1 m² x 1 sec²). Joules or kilojoules (kJ) are the international standard.
The conversion factors between joules and kilocalories are: 1 kcal = 4.184 kJ, or conversely, 1 kJ = 0.239 kcal.

**Q2:** If the average energy intake (caloric intake) of a 20-year old male is 3200 kcal/day and his diet composition matches recommendations from the American Heart Association (i.e., 15% kcal from protein, 30% kcal from fat & 55% kcal from carbohydrate), how many grams of fat does he consume daily on average?

**Human Energy Requirement** can be defined as the amount of food energy needed to balance energy expenditure in order to maintain body size, body composition and a level of necessary physical activity consistent with long term good health. This includes the energy needed for the optimal growth and development of children, for the deposition of tissues during pregnancy, and for the production and secretion of milk during lactation.

**Energy budget** can be defined as the amount of energy we consume (energy intake) compared to the amount of calories we burn (energy expenditure).

When energy intake equals energy expenditure, individuals are considered in *energy balance* and body weight does not change.

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**Components of the Energy Budget**

- **Resting Energy Expenditure (basal metabolic rate)**: 60-70%
- **Thermic Effect of Food**: ~10%
- **Physical Activity**: ~20-30%
Basal or resting metabolic rate can be defined as the amount of energy required for maintenance of functions essential for life while the body is at rest (e.g., respiration, cardiac functions, maintenance of muscle tone).

Components of Basal Metabolic Rate (or Resting Metabolic Rate)
- Over 60% of BMR in healthy adults from heart (most metabolically active), kidneys, liver and brain
- Skeletal muscle, although low relative metabolic activity at rest, comprises over 25% of total BMR because of sheer volume of tissue
- Within cells, most BMR energy expended in macromolecule turnover, ion transport, and regulatory cycling of intermediary metabolites
- Relationship between BMR (or RMR) and lean mass (metabolically active tissue) is consistent across a wide range of body sizes
- Decreases in BMR (per kg of fat-free mass) can occur:
  - hypothyroidism
  - anorexia nervosa
  - Down syndrome
  - very-low-calorie diets & starvation states – due to loss of lean body mass & down-regulation of BMR to conserve energy
- Increases in BMR can also be observed:
  - hyperthyroidism
  - Parkinson’s disease
  - asthma
  - hypermetabolic state – e.g., burns, sepsis

Thermic effect of food can be defined as the amount of energy required to digest, absorb and store nutrient and energy intake. It is typically about 10% of total daily energy expenditure.

Physical Activity can be defined as any bodily movement produced by skeletal muscle that requires energy expenditure.

Physical activity is
- most variable component of total daily energy expenditure
- very difficult to measure accurately in free-living individuals
- physical activity is very important in decreasing the risk of cardiovascular disease, type 2 diabetes and weight regain (following weight loss)

Q3: What happens when the energy budget is out of balance? _________________________

Q4: What happens if energy intake is significantly less than energy expenditure? _________________________
Fuel Utilization in Fasting (~24 hours)

Figure. General scheme of fuel metabolism in a normal fasted man, showing 2 primary sources of energy (muscle and adipose tissue) & types of consumers (pure glucose: nerve and RBC/WBC; fatty acids & ketones: heart, kidney, muscle, etc)

Fuel Utilization after 5-6 Weeks of Semi-starvation

Figure. General scheme of fuel metabolism after 5-6 weeks starvation showing diminished rate of mobilization of muscle protein and increased use of ketones by the CNS; glycogen stores depleted

Cahill et al. NEJM 1970;282:668. Reprinted with permission. Copyright © 1970 Massachusetts Medical Society. All rights reserved.
Protein Energy Malnutrition (PEM) can result in:
- **Stunting** – chronic, relatively mild PEM; defined as ≥ 2 standard deviations below the mean height-for-age in children
- **Underweight** – result of acute mild PEM; defined in adults as BMI<18.5
- **Wasting** – sign of acute, severe PEM; defined as ≥ 2 standard deviations below mean weight-for-height
  - Marasmus – severe wasting (<60% expected weight) with marked loss of subcutaneous fat and skeletal muscle
  - Kwashiorkor – wasting with edema and impaired renal function (60-80% expected weight) – skin and hair color changes often present; fatty liver which does not progress to cirrhosis

In the United States, PEM can be seen in hypermetabolic states (burns, infection), anorexia nervosa, chronic kidney disease/dialysis, elderly, poorly managed post-bariatric surgery

Q5: What happens if energy intake is significantly more than energy expenditure?

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Lipids and Dietary Fats
- **Lipids** are compounds that are soluble in organic solvents, such as acetone, ether or chloroform
- vary widely in size, polarity and function: from hydrophobic triglycerides & sterol esters to more water-soluble phospholipids
- Dietary lipids include cholesterol and phytosterols

**Triglycerides**
- Largest proportion of human dietary lipid consumption
- Composed of 3 fatty acids attached to glycerol

**The 3 classes of fatty acids are:**

*Saturated Fatty Acids (SFA)*
- No double bonds
- Examples: Palmitic acid (C16:0) CH₃(CH₂)₁₄COOH
  - Stearic acid (C18:0) CH₃(CH₂)₁₆COOH
- Fats high in SFA tend to be solid at room temperature
- Associated with hypercholesterolemia – recommended intake <7% total caloric intake
- Mechanism by which plasma cholesterol raised by SFA not clearly elucidated – may be decreased catabolism of LDL

*Mono-unsaturated Fatty Acids (MUFA)*
- Must be at least 12 carbons long, contain a double bond at the n-9 position.
- Example: Oleic acid (C18:1, n-9 c/s) CH₃(CH₂)₇CH=CH(CH₂)₇COOH
- Found in high concentration in olive & canola oils
- Not associated with increased plasma LDL or decreased HDL concentrations

*Polyunsaturated Fatty Acids (PUFA)*
- Fatty acids with double bonds at the n-3 or n-6 positions that cannot be synthesized by humans
Omega-6 fatty acids found in corn, safflower & soybean oils; omega-3 fatty acids found in oily fish

Omega-3 fatty acids – eicosapentaenoic acid EPA (C20:5) and docosahexaenoic acid (DHA) (C22:6) derivatives of linolenic acid; found to be important for structure & function of membranes in retina & CNS

Oils high in PUFA are liquid at room temperature

Associated with lower plasma LDL concentrations

**Trans Fatty Acids**

- Typically man-made; added to vegetable oils to increase viscosity, i.e., turn a liquid vegetable oil into a solid, such as margarine, also used commercially-produced baked goods (currently make up 2-3% of fats in US diet) – have been banned for the most part in the U.S.

- Associated with higher LDL

- Mechanism for raising plasma cholesterol not known

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**Essential Fatty Acids (EFA)**

- Both are PUFA's

  Linoleic acid (C18:2, n-6,9 all cis) [an omega-6 fatty acid]
  \[ \text{CH}_3\text{(CH}_2)_3\text{CH=CHCH}_2\text{CH=CH(CH}_2)_7\text{COOH} \]

  α-Linolenic acid (C18:3, n-3,6,9 all cis) [an omega-3 fatty acid]
  \[ \text{CH}_3\text{(CH}_2\text{CH=CHCH}_2\text{CH=CHCH}_2\text{CH=CH(CH}_2)_7\text{COOH} \]

- Precursors of specific long-chain fatty acids required for cell membranes

- Classic signs of EFA deficiency: reduced growth rates, scaly dermatitis with increased loss of water, male and female infertility, depressed inflammatory responses; kidney abnormalities, abnormal liver mitochondria, decrease capillary resistance, increased fragility of erythrocytes and reduced contractility of cardia muscle

- EFA deficiency is rare in humans

- Omega-3 fatty acids appear to be required for neural tissue development and visual function

- Preterm infants may be vulnerable to omega-3 deficiency because of immature desaturase and elongase enzyme activities & low fat stores
Dietary Fiber

- Not an energy source
- Defined as plant polysaccharides and lignin resistant to hydrolysis by digestive enzymes
- Two general types of fiber:
  - **Soluble fibers**, ie, water soluble, includes pectins and gums (legumes & fruits); implicated in cholesterol lowering
    - Lower cholesterol by 3 mechanisms:
      - act as bile-acid sequestering agent
      - reduce rate of insulin rise by slowing CHO absorption thereby slowing cholesterol synthesis
      - stimulate production of short-chain fatty acids which are absorbed by portal circulation and inhibit cholesterol synthesis
  - **Insoluble fibers** include cellulose and lignins (whole grains & vegetables); less impact on lowering cholesterol levels

- High fiber diets maintained for long term believed to reduce the incidence of colon cancer; proposed mechanisms include 1) bulking action of fiber speeds transit through the colon reducing absorption of adverse chemicals and 2) fiber adsorbs carcinogenic agents

**What diet to recommend?**

- USDA provides good common-sense diet
- American Heart Association diet for CVD risk reduction
- American Diabetes Association offers diet for type 2 diabetics
- Any number of options for weight reduction – many popular diets are designed by physicians with little training in nutrition and are usually based on anecdotal experience rather than clinical trials
- A comparison between Atkins (low carbohydrate but not as extreme as the Keto Diet), Ornish (very low fat), Weight Watchers (low fat, balanced), and Zone (low fat, low glycemic index) diets found little difference in weight lost or change in CVD risk factors between diets.

- **Biggest predictor of weight loss success is ability to stick with the diet for at least a year.**

**Q6:** Your 26-year old female patient asks your opinion of a gluten-free diet for weight loss and improved well-being. What is your answer?