MODULE 3 – ENERGY BALANCE

Objectives

- Understand internal and external cues that help the body regulate food consumption
- Describe how the body expends energy to maintain physiological functions, process food, and power physical activity
- Explain methods to assess overweight and obesity

From Atoms to Organisms

Atoms → Molecule → Cells → Tissues → Organ → Organ systems → Organism
Energy In

- Regulation of intake
  - Hunger
    - Prompts eating; physiological desire, unpleasant physical and psychological sensations that lead people to acquire and ingest food
  - Satiation
    - Signals to stop eating
  - Satiety
    - Lack of hunger, a feeling of fullness or of having had enough to eat
  - Appetite
    - Psychological desire, the desire to eat; a pleasant sensation that is aroused by thoughts of the taste and enjoyment of food
ENERGY ⇒ THE ABILITY TO DO WORK

- Calories are a unit of measure
  - Used to express the amount of energy produced by foods in the form of heat
  - Calories are actually kilocalories or kcals
- 1 kcal or Calorie = 1 kilojoule / 1000 calorie
- 1 calorie is the amount of energy required to heat 1g water by 1°C
- 1 kcal is the amount of energy to raise 1 kg of water by 1 degree Celsius
- 1 kilocalorie = 4.184 (4.2) kilojoules

How do they determine the caloric value of foods?

- Bomb calorimeter
- Burn the food entirely and measure the increase in temperature of the surrounding water
- Heat released by the food is approximately the same as the energy it supplies for the body

**Bomb Calorimeter**

- Water in which temperature increase from burning food is measured
- a sample of food is burned
- with oxygen (mimics oxidation in the body)
- amount of heat released = temp. rise
- represents amount of energy in that food sample
**How is fuel stored?**

- **FAT** as Triglyceride in adipose tissues
- **CARBOHYDRATE** as Glycogen in skeletal muscle and liver
- **PROTEIN** is NOT stored
- **ALCOHOL** is NOT stored

**Types of energy use (Energy Out/Expenditure)**

1. **Basal Metabolism**
   - Maintain basic physiological functions:
     - Breathing, blood circulation etc
   - Energy required to maintain normal body functions while at rest
   - Affected by body size, composition, age, gender

2. **Physical activity**
   - To power physical activity
   - Energy needed for muscular work
   - Affected by body size, fitness level, type of activity

**Energy Out: Fuel Uses**

- **Dietary thermogenesis (Thermic effect of food (TEF))**
  - Energy used to chemically process foods (process gives off heat)
  - Energy to digest, absorb, metabolize food
Components of Energy Expenditure

- 25-35% physical activity
- 5-10% thermic effect of food
- 60-65% BMR

Factors that Increase RMR Decrease RMR

- Fever* Stress
- Total body weight
- Smoking * Caffeine
- High Lean Body Mass
- Rapid growth
- Hot & cold ambient temp
- Pregnancy, lactation
- Hyperthyroidism
- Rapid growth
- Hot & cold ambient temp
- Pregnancy, lactation
- Hyperthyroidism

Factors that Increase RMR Decrease RMR

- Aging
- Female
- Fasting/Starvation
- Sleep
- Hypothyroidism

Estimating Total Energy Expenditure

- Estimating REE from body weight, gender, and age
- Estimating Total energy expended from REE and physical activity

A) Harris-Benedict Equation

- w: 655.1 + 9.56 (wt:kg) + 1.85(ht:cm) - 4.68 (age:yrs)
- m: 66.47 + 13.75 (wt:kg) + 5.0 (ht:cm) - 6.76 (age:yrs)
• Measure of the energy used when a body is in a state of complete rest.

• B) Estimate your basal metabolic rate
  - Men: body weight (lbs) x 11
  - Women: body weight (lbs) x 10.1
  - Eq.: 
    170 lb man X 11 = 1870 kcals/day
    135 lb woman X 10.1 = 1350 kcals/day

• C) Resting Energy Expenditure (REE)
  - Men: body weight (kg) x 24hrs/day x 1.0
  - Women: body weight (kg) x 24hrs/day x 0.9

### Basal Metabolic Rate (BMR)

<table>
<thead>
<tr>
<th>FACTOR</th>
<th>EFFECT ON BMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>The BMR is higher in youth as lean body mass declines with age. Physical activity may prevent some of this decline.</td>
</tr>
<tr>
<td>Height</td>
<td>Tall people have a larger surface area, so their BMIs are higher.</td>
</tr>
<tr>
<td>Growth</td>
<td>Children and pregnant women have higher BMIs.</td>
</tr>
<tr>
<td>Body composition</td>
<td>The more lean tissue, the higher the BMR. A typical man has greater lean body mass than a typical woman, making his BMR higher.</td>
</tr>
<tr>
<td>Fever</td>
<td>Fever raises the BMR.</td>
</tr>
<tr>
<td>Stress</td>
<td>Stress hormones raise the BMR.</td>
</tr>
<tr>
<td>Environmental temperature</td>
<td>Adjusting to either heat or cold raises the BMR.</td>
</tr>
<tr>
<td>Fastig/Tharzav</td>
<td>Fastig/Tharzav hormones lower the BMR.</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>Malnutrition lowers the BMR.</td>
</tr>
<tr>
<td>Thyroxine</td>
<td>The thyroid hormone thyroxine is a key BMR regulator, the more thyroxine produced, the higher the BMR.</td>
</tr>
</tbody>
</table>

• Amount spent depends on activity level
  - Inactive 30% of basal metabolism calories
  - Average 50% of basal metabolism calories
  - Active 75% of basal metabolism calories

• Example: if basal metabolism = 1500
  - Inactive person 1500 X .30 = 450 calories
  - Average person 1500 X .50 = 750 calories
  - Active person 1500 X .75 = 1125 calories

### Physical Activity
Total daily need for calories =
- Basal metabolic rate 1500
- Activity (inactive) 450
- Dietary thermogenesis +195
Total = 2145 calories

Adding it all up!
Most foods are a mixture!

EER, or estimated energy requirement, is a method to determine how much energy intake your body requires on a daily basis.
The formula to find out includes the following variables: sex, height, weight and the amount of physical activity you do.
As such, by finding out your EER, you can determine how much activity you need to perform on a daily basis to lose weight, gain weight or maintain your current weight.
The formulas in this handout use weight in kilograms and height in meters.

**ESTIMATED ENERGY REQUIREMENT (EER)**

**MALE** (For 19 years old and above)

\[
EER = 662 - (9.51 \times \text{age}) + \text{PA} \times (15.91 \times \text{weight}) + (539.6 \times \text{height})
\]

**FEMALE** (For 19 years old and above)

\[
EER = 354 - (6.91 \times \text{age}) + \text{PA} \times (9.36 \times \text{weight}) + (726 \times \text{height})
\]

A = age (years)
PA = physical activity coefficients
Wt = weight (kg)
Ht = height (meters)

**FORMULA**
### Activity/Gender Coefficients

<table>
<thead>
<tr>
<th>Activity/Gender</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Low active, at least 30 minutes of moderate activities</td>
<td>1.11</td>
<td>1.12</td>
</tr>
<tr>
<td>Active, at least 60 minutes of moderate activities</td>
<td>1.25</td>
<td>1.27</td>
</tr>
<tr>
<td>Very active, at least 2 1/2 hours of moderate activities</td>
<td>1.48</td>
<td>1.45</td>
</tr>
</tbody>
</table>

**PA COEFFICIENTS**

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### Energy IN = Energy OUT

To Maintain Weight

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**Measures of Body Composition and Fat Distribution**

- Techniques for estimating body fatness include these:
  - Anthropometry
    - Skinfold test
    - Waist circumference
  - Density
    - Underwater weighing
    - Air displacement methods
  - Conductivity
    - Bioelectrical impedance
  - Radiographic techniques
    - Dual energy X-ray absorptiometry (DEXA)
Measuring Body Composition

Skinfold thickness

Underwater weighing

Air displacement

Dual energy X-ray absorptiometry

Bioelectric impedance

Average Body Composition

45% muscle

25% organs

15% fat

15% bone

36% muscle

24% organs

27% fat

13% bone

Body Fat Distribution Patterns
Body fat distribution

- Android
  - greater health risk
  - high blood lipids, glucose intolerances, insulin resistance, and high blood pressure
- Gynoid
  - Waist circumference
    - assess abdominal fatness
  - BMI 25–34.9, waist >40 inches in men and >35 inches in women is sign of increased health risk
Nutrient Groups

- There are six groups of nutrients your body needs
  - **Energy Producing**
    - Carbohydrates
    - Fats
    - Proteins
  - **Non Energy Producing**
    - Vitamins
    - Minerals
    - Water
- These are obtained through the foods you eat
- Each nutrient has specific jobs
- Each is vital to good health

More Nutrients

- A healthy diet contains nutrients from all six groups in the right proportion
- Failure to meet nutrient needs results in a
  - **Deficiency Disease**: illness caused by lack of sufficient amounts of a nutrient
- To meet nutrient needs
  - Variety of fruits, Vegetables, Carbohydrates, Fats, Proteins and Water
  - **Dietary supplements**: purified nutrients that are manufactured or extracted from natural substances
Carbohydrates

- **Carbohydrates**: Body’s main source of ENERGY!
- Most come from plant foods - photosynthesis
- **Two Categories**
  - Simple
  - Complex
- **Three Main Types**
  - Sugars
  - Starches
  - Fiber

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**CLASSIFICATION OF CARBOHYDRATE**

<table>
<thead>
<tr>
<th>CARBOHYDRATE</th>
<th>Monosaccharide</th>
<th>Disaccharide</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Simple Carbohydrate</strong></td>
<td>Glucose</td>
<td>Glucose + Fructose</td>
</tr>
<tr>
<td></td>
<td>Galactose</td>
<td>Lactose</td>
</tr>
<tr>
<td></td>
<td>Fructose</td>
<td>Maltose</td>
</tr>
<tr>
<td><strong>Complex Carbohydrate</strong></td>
<td>Amylose</td>
<td>Amylopectin</td>
</tr>
</tbody>
</table>

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**Simple Carbohydrates**

- **Sugars**
- **Six Types**: glucose, fructose, galactose, sucrose, lactose, maltose
  - **Single Sugar Units**
    - Glucose: (blood sugar) form of sugar carried in the bloodstream for energy use in the body
    - Fructose: fruit sugar, sweetest of all sugars
    - Galactose: found attached to glucose to form the sugar in milk
  - **Pairs of Sugar Units**
    - Sucrose: table sugar
    - Lactose: milk sugar; found in the milk of mammals
    - Maltose: malt sugar; found in grain products
Complex Carbohydrates

- Starches and Fibers
- Made from many glucose sugar units bonded together
- **Starch**: storage form of energy in plants
  - Most abundant carbohydrate in the diet
- **Fiber**: form of complex carbohydrates from plants that humans cannot digest
  - Does NOT provide the body with energy
  - Provides bulk in the diet (helps you feel full)
  - Promotes normal bowel function (helps you poop)

Carbohydrate Functions

- Main Function of Starches and Sugars
  - Furnish the Body with Energy
- **Fiber**:
  - Stimulates muscles in the digestive tract which prevents some types of cancer;
  - Helps lower cholesterol levels which helps prevent heart disease

Carbohydrate Sources

- Simple Carbohydrates
  - Sugars, syrups, soft drinks, jams, jellies, candies and other sweets
- Complex Carbohydrates
  - Starches
    - Breads, cereals, pasta products, rice, corn, potatoes, dry beans and peas
  - Fiber
    - Whole grain cereal products, fresh fruits and vegetables
Carbohydrate Excess

- Can be a health concern
- Foods high in sugars tend to low in other nutrients
- May deprive your body of other needed nutrients
- Increases the risk of unhealthy weight gain
- Can lead to tooth decay and gum disease

Carbohydrate Deficiency

- Rare!
- May cause the body to use protein as an energy source
- Which can interfere with normal growth and repair of body tissues
- Can create chemical imbalance
- If fiber is lacking constipation can occur

Fats

- **Fats**: important energy sources.
- Belong to a large group of compounds called lipids
- **Lipids**: include fats and oils
  - All lipids contain **Fatty Acids**: chemical chains that contain carbon, hydrogen and oxygen atoms
  - **Saturated Fatty Acid**: fatty acids that have as many hydrogen atoms as they can hold
  - **Unsaturated Fatty Acid**: have fewer hydrogen atoms than they can hold. Two types
    - **Monounsaturated Fatty Acid**: missing one hydrogen atom
      - Found in Olive, Canola, Peanut oil
    - **Polyunsaturated Fatty Acid**: missing two or more hydrogen atoms
      - Found in Safflower, corn, soybean and some fish oils

CARBOHYDRATE & HEALTH

- WEIGHT CONTROL
- HEART DISEASES
- CANCER
- BLOOD GLUCOSE LEVEL
- LACTOSE INTOLERANCE
- GI HEALTH
- DENTAL CARIES
Chemical Structure of Fats

Glycerol + 3 fatty acids

The Length of the Carbon Chain

Short-chain Fatty Acid
(less than 6 carbons)

Medium-chain Fatty Acid
(6-10 carbons)

Long-chain Fatty Acid
(12 or more carbons)

Triglycerides

- Structure
  - Glycerol + 3 fatty acids
- Functions
  - Energy source
    - 9 kcals per gram
  - Form of stored energy in adipose tissue
  - Insulation and protection
  - Carrier of fat-soluble vitamins
  - Sensory properties in food
Triglycerides

- Food sources
  - fats and oils
    - butter, margarine, meat, baked goods, snack foods, salad dressings, dairy products, nuts, seeds
  - Sources of omega-3 fatty acids
    - Soybean, canola, walnut, flaxseed oils
  - Sources of omega-6 fatty acids
    - Vegetable oils

Phospholipids

- Structure
  - Glycerol + 2 fatty acids + phosphate group
- Functions
  - Component of cell membranes
  - Lipid transport as part of lipoproteins
  - Emulsifiers
  - Phosphatidylcholine
- Food sources
  - Egg yolks, liver, soybeans, peanuts

Sterols: Cholesterol

- Functions
  - Component of cell membranes
  - Precursor to other substances
    - Sterol hormones
    - Vitamin D
    - Bile acids
- Synthesis
  - Made mainly in the liver
- Food sources
  - Found only in animal foods
More Fats
- Most Fats high in saturated fatty acids are solid at room temperature.
- Oils high in unsaturated fatty acids are liquid at room temperature.
- Margarine
- Shortening
- Trans Fatty Acids: fatty acids with odd molecular shapes. When oils are partially hydrogenated trans fatty acids are created.
  - Creates health concern. Causes risk for heart disease!! Lowers Good HDL's and raises Bad LDL.

Some common food sources of trans-fatty acids:
- Most hardened margarines and shortenings.
- Salad dressing, mayonnaise.
- Biscuits, rolls, cakes, cookies, crackers.
- Corn snacks and chips.
- Other fried snacks and chips.
- Cookies, doughnuts.
- French fries, fried chicken or fish.
- Fried fast foods, even those fried in commercial "vegetable oils."

Even More Fats
- Cholesterol: fat like substance found in every cell of the body.
- Serves several important functions:
  - Part of skin tissue
  - Aid in transport of fatty acids
  - Body needs it to produce hormones
- 2 types: Dietary Cholesterol and Blood Cholesterol.
  - Dietary cholesterol: occurs when you eat "animal" foods.
  - Blood Cholesterol: circulates through your blood stream.
    - A high blood cholesterol level can lead to heart disease.
Fat Sources

- Fats can be visible or invisible
- Visible Fats
  - Butter, Margarine, Fat on Meat and in Chicken and Turkey Skin
- Invisible Fats
  - Eggs, whipped cream, baked products, fried foods
- Foods High in Fat
  - Butter, margarine, most salad dressings, oils, vegetable shortening, Egg yolks, many dairy products, meats and avocados
Fat Deficiencies
- RARE!
- Loss of weight
- Loss of energy
- Deficiencies in fat soluble vitamins

Fat Excesses
- Can cause weight problems
- Diet high in fat = Diet high in calories
- Higher risk for heart disease
- Increased risk of some types of cancer

Fats and Health

<table>
<thead>
<tr>
<th>Type of Fatty Acid</th>
<th>Found in</th>
<th>Possible Effects on Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal fats (especially those from red meat and poultry, butter, and other high-fat dairy products)</td>
<td>Causes high blood cholesterol and triglycerides, contributing to heart disease and cancer risk.</td>
<td></td>
</tr>
<tr>
<td>Trans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>French fries and other deep-fat fried foods, cakes, and cookies, chocolate, partially hydrogenated fats</td>
<td>Higher risk of heart disease and breast cancer.</td>
<td></td>
</tr>
<tr>
<td>Monounsaturated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Olive, canola, and palm kernel oils, avocados, nuts, and seeds</td>
<td>Lower blood cholesterol and triglycerides, lower risk of heart disease and breast cancer.</td>
<td></td>
</tr>
</tbody>
</table>
| Polyunsaturated (Even-numbered)
| Canola, corn, and safflower oils, walnuts, flaxseeds, sunflower seeds, and peanuts | Lower blood cholesterol and triglycerides, lower risk of heart disease and breast cancer. | |
| Polyunsaturated (Odd-numbered)
| Cod liver oil, flaxseed, and walnuts | Lower blood cholesterol and triglycerides, lower risk of heart disease and breast cancer. | |

Proteins
- **Proteins:** Chemical compounds that are found in every body cell
  - Needed for growth, maintenance and repair of body tissues
  - Made up of small units called **Amino Acids:** building blocks of proteins
  - 9 amino acids are essential
    - Body cannot make essential amino acids
  - 11 amino acids are non essential
- **Complete protein:** contains all 9 essential amino acids
  - Support growth and normal maintenance of body tissue
- **Incomplete Protein:** missing one or more of the essential amino acids
Nonessential Amino Acids:
--body can synthesize for itself
--food often deliver
--more than 1/2 of a.a. are nonessential

Essential Amino Acids:
--body cannot make
--there are nine
--must be supplied in foods

Conditionally Essential Amino Acids:
--an a.a. normally nonessential but must be supplied in diet in special circumstances

<table>
<thead>
<tr>
<th>Essential</th>
<th>Nonessential</th>
<th>Conditionally Essential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threonine</td>
<td>Tryptophan</td>
<td>Tyrosine</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>Valine</td>
<td>Phenylalanine</td>
</tr>
<tr>
<td>Leucine</td>
<td>Tyrosine</td>
<td>Phenylalanine</td>
</tr>
<tr>
<td>Lysine</td>
<td>Threonine</td>
<td>Tryptophan</td>
</tr>
<tr>
<td>Methionine</td>
<td>Lysine</td>
<td>Methionine</td>
</tr>
<tr>
<td>Arginine</td>
<td>Methionine</td>
<td>Arginine</td>
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<tr>
<td>Asparagine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspartic acid</td>
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<td></td>
</tr>
<tr>
<td>Cysteine</td>
<td></td>
<td></td>
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<tr>
<td>Cysteine</td>
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</tbody>
</table>

Functions of Body Protein

- Structural and mechanical functions
  - Collagen
  - Keratin
  - Motor proteins

- Enzymes
  - Catalyze reactions

- Hormones
  - Regulate body processes
Protein Sources

- Complete Proteins
  - Animal Foods
    - Meat, poultry, fish, milk, cheese, eggs
  - Soybeans
    - Only plant food source of a complete protein
- Incomplete Proteins
  - Plant Foods

Protein Excesses

- Excess protein is stored as fat — increased risk heart disease, DM, some cancers
- Can cause weight gain
- May cause calcium loss — osteoporosis
- May overwork kidneys & lead to poor kidney function

Protein Deficiency

- Protein Energy Malnutrition (PEM): Condition resulting from a diet that does not contain enough protein
  - In Adults
    - Weight Loss
    - Fatigue
  - In Children
    - Stunted Growth
    - Diarrhea

Protein Deficiency

- Protein-energy malnutrition (PEM) is a term that covers a range of protein deficiency conditions that may include only protein deficiency or protein deficiency plus energy deficiency.
- Kwashiorkor is a pure protein deficiency.
- Marasmus is an energy deficiency.
### Types of Vegetarian Diets

<table>
<thead>
<tr>
<th>Diet</th>
<th>What it excludes and includes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semivegetarian</td>
<td>Excludes red meat but may include fish and poultry, as well as dairy products and eggs.</td>
</tr>
<tr>
<td>Pescetarian</td>
<td>Excludes all animal flesh except fish.</td>
</tr>
<tr>
<td>Lacto-ovo vegetarian</td>
<td>Excludes all animal flesh but does include eggs and dairy products such as milk and cheese.</td>
</tr>
<tr>
<td>Lacto vegetarian</td>
<td>Excludes animal flesh and eggs but does include dairy products.</td>
</tr>
<tr>
<td>Vegan</td>
<td>Excludes all food of animal origin.</td>
</tr>
</tbody>
</table>

### Nutrient Needs with a Vegan Diet

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Source in Vegan Diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>Soy-based products, legumes, seeds, nuts, grains, and vegetable protein isolates</td>
</tr>
<tr>
<td>Vitamin B₁₂</td>
<td>Products fortified with vitamin B₁₂, such as soy beverages and some corn, wheat, and rice</td>
</tr>
<tr>
<td>Calcium</td>
<td>Fortified milk, cheeses, yogurt, and vegetable and grain products fortified with calcium</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>Sunshine or products fortified with vitamin D, such as soy beverages, breakfast cereals, and margarine</td>
</tr>
<tr>
<td>Iron</td>
<td>Legumes, rice, dark green leafy vegetables, dried fruit, whole grains, and plant-based protein products (e.g., tofu, tempeh, seitan, seitan-based foods)</td>
</tr>
<tr>
<td>Zinc</td>
<td>Whole grains, wheat germ, legumes, nuts, seeds, and fortified breakfast cereals</td>
</tr>
<tr>
<td>Omega-3 fatty acids</td>
<td>Canola oil, flaxseed and flaxseed oil, walnut oil, and canola, rice, and other vegetable sources, and plant-based milk shakes</td>
</tr>
</tbody>
</table>