Metabolism is the sum total of all chemical reactions that are occurring in the body. It is subdivided into catabolism and anabolism. Catabolic reactions are those reactions that break down or hydrolyze large molecules into smaller subunits. Anabolic reactions are those that build large molecules from smaller ones. For the most part, catabolic reactions are exergonic and anabolic reactions are endergonic. The relative concentrations of fat and muscle tissues in your body, or your body composition, are important factors in determining your body's metabolic rate, and thus, the amount of energy (food) needed on a daily basis.

The balance between anabolism and catabolism is influenced by the intake of energy from foodstuffs and is regulated largely by the endocrine system (we'll talk more about this later in the semester). When more food energy is taken in than is used, anabolism dominates and the body gains weight. When less food energy is consumed than is used, catabolism dominates to release energy from stored energy molecules and the body loses weight. When the body is neither gaining nor losing weight, anabolism and catabolism are in balance.

**EXPERIMENT A: Body Composition Analysis**

Body composition refers to the relative proportion of lean body mass and fat tissue in the body. Although some adipose tissue is essential, an excess of fat is detrimental. Currently, about 31%, or about 59 million people, are obese, which is defined as roughly 30 or more pounds over a healthy weight. Almost 65% are either obese or overweight, 10 to 30 pounds over a healthy weight, which increases their chances of developing diabetes, heart disease, some types of cancer and a host of other health problems. At current rates, 40% of Americans will be obese in 5 years!

For the first half of the lab, we will look at several different methods of determining and measuring body composition – body fat percentage, BMI, and waist-to-hip ratio.

### I. BODY FAT PERCENTAGE

Your body fat percentage is simply the percentage of fat your body contains. If you are 150 pounds and 10% fat, you carry 15 pounds fat (10% of 150 pounds) and the rest (135 pounds) is lean body mass - bone, muscle, organ tissue, blood and everything else. A certain amount of fat is essential to maintain critical physiological functions. Fat regulates body temperature, cushions and insulates organs and tissues, and is the main form of the body's energy storage. However, researchers at the National Institutes of Health report that people with high percentages of body fat have an increased risk of diabetes, elevated blood cholesterol, heart disease, stroke and high blood pressure. Generally, women should fall in the 18 to 25 percent range. The following table describes body fat ranges and their associated categories (from American Council on Exercise):

<table>
<thead>
<tr>
<th>Classification</th>
<th>Women (% Fat)</th>
<th>Men (% Fat)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential Fat</td>
<td>10-12 percent</td>
<td>2-4 percent</td>
</tr>
<tr>
<td>Athletes</td>
<td>14-20 percent</td>
<td>6-13 percent</td>
</tr>
<tr>
<td>Fitness</td>
<td>21-24 percent</td>
<td>14-17 percent</td>
</tr>
<tr>
<td>Acceptable</td>
<td>25-31 percent</td>
<td>18-25 percent</td>
</tr>
<tr>
<td>Obese</td>
<td>&gt; 31 percent</td>
<td>&gt; 25 percent</td>
</tr>
</tbody>
</table>
We will use two common (and easy) methods to determine body fat percentage.

1. **Bioelectrical Impedance**

   Muscles, blood vessels and bones are body tissues having a high water content that conduct electricity easily. Body fat, on the other hand, has little electric conductivity. We can use a device called a Body Fat Analyzer to measure our body fat percentage. This type of device uses a technology called *bioelectrical impedance*. The device sends an extremely weak electrical current through your body to determine the amount of fat tissue based on the different rates of conductivity through different tissues; the signal travels quickly through lean tissue due to its high percentage of water, and more slowly through fat with its lower percentage of water. Bioelectrical Impedance devices use the information from this signal to work out body fat percentage. Today, we will be using a handheld device to determine body fat percentage by bioelectrical impedance.

**PROCEDURE:**

- Select between the Normal and Athlete modes. To determine if you should select Normal or Athlete, you must calculate your FIT index by using the following formula and numbers below. If your FIT index is greater than 60, you should select the Athlete setting; any number below choose the normal setting.

   \[ \text{FIT Index} = \text{Frequency} \times \text{Intensity} \times \text{Time} \]

   - Frequency represents the frequency of exercise. (Daily exercise = 5; 3-4 times/wk = 4; 1-2 times/week = 3; 3-4 times / month = 2; anything less than that = 1.)
   - Intensity represents the intensity at which you exercise. (Vigorous = 5; moderate/light effort = 4)
   - Time represents the duration of your average workout. (45 minutes or more = 4; 30-44 minutes = 3; 15-29 minutes = 2; less than 15 minutes = 1.)

- Lastly, enter your height, weight, age and gender at the appropriate prompts. When all the data is fixed and stored, the analyzer screen will display "Ready," and you'll be ready to take your first body fat measurements.
- Hold the grip electrodes and press the start button. The device will beep when done and display your information.
- Record all data, notes, and observations in your lab notebook.

2. **Caliper method**

   The Skinfold caliper is a device that measures the thickness of a fold of your skin with its underlying layer of fat. By doing this at the key locations can be a quite accurate representative of the total amount of fat that is on your body, it is also possible to estimate the total percent of body fat on your body. Follow the instructions on the pages provided on the tables by the calipers to take your measurements and determine your body fat %.

   **Record your results for both tests in a table.**

   **Note if there was a difference in the values you got for the different methods?**
II. BODY MASS INDEX

Body mass index, or BMI, is the measurement of choice for many physicians and researchers studying obesity, because of its ease of use. BMI uses a mathematical formula that takes into account both a person's height and weight. BMI equals a person's weight in kilograms divided by height in meters squared. (BMI=kg/m²).

<table>
<thead>
<tr>
<th>BMI</th>
<th>Waist less than or equal to 40 in. (men) or 35 in. (women)</th>
<th>Waist greater than 40 in. (men) or 35 in. (women)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.5 or less</td>
<td>Underweight</td>
<td>N/A</td>
</tr>
<tr>
<td>18.5 - 24.9</td>
<td>Normal</td>
<td>N/A</td>
</tr>
<tr>
<td>25.0 - 29.9</td>
<td>Overweight</td>
<td>Increased</td>
</tr>
<tr>
<td>30.0 - 34.9</td>
<td>Obese</td>
<td>High</td>
</tr>
<tr>
<td>35.0 - 39.9</td>
<td>Obese</td>
<td>Very High</td>
</tr>
<tr>
<td>40 or greater</td>
<td>Extremely Obese</td>
<td>Extremely High</td>
</tr>
</tbody>
</table>

Calculate your BMI.

1. Determine your weight in kg (1 pound = 0.45 kg): ________________
2. Determine your ht in meters (1 m = 39.4 inches): ________________
3. Calculate your BMI (weight/ height²): ________________

III. WAIST – TO –HIP RATIO

People with apple-shaped bodies (more fat around the abdominal area) seem to develop cardiovascular disease, hypertension, and diabetes more often than those with pear-shaped bodies (more fat in the hips, buttocks, and thighs). To determine if you have a healthy waist to hip ratio, use a measuring tape to measure the circumference of your hips at the widest part of your buttocks. Then measure your waist at the smaller circumference of your natural waist, usually just above the belly button.

1. Stand and measure your waist at the navel. __________ cm
2. Measure your hips at the greatest circumference. __________ cm.
3. Divide the waist circumference by the hip circumference.

Ratio: __________

If you’re a woman, the waist-to-hip ratio should come out as no more than 0.8. Men have a little more wiggle room: a healthy waist-to-hip ratio for them is 0.95.
BIO 360: Vertebrate Physiology
LAB 4: Metabolism, body composition, and nutrition
BIO 360: Vertebrate Physiology  
LAB 4: Metabolism, body composition, and nutrition

EXPERIMENT B: BMR and Activity

The total energy expended each day includes the energy consumed at rest and during physical activity. The basal metabolic rate (BMR) is a measure of the energy required to maintain the body. We will use two methods to calculate BMR, though each are only estimates and will likely differ considerably.

PROCEDURE

*Calculate your BMR according to the following equations.*

1. The Harris Benedict equation is a formula that uses height, weight, age, and sex to determine basal metabolic rate (BMR). This makes it more accurate than determining calorie needs based on total bodyweight alone. The only variable it does not take into consideration is lean body mass. Therefore, this equation will be very accurate for everyone except those who are extremely muscular, where it may underestimate caloric needs and those who are extremely overweight, where it may overestimate caloric needs.

   **Men:** $BMR = 66 + (13.7 \times \text{wt in kg}) + (5 \times \text{ht in cm}) - (6.8 \times \text{age in years})$

   **Women:** $BMR = 655 + (9.6 \times \text{wt in kg}) + (1.8 \times \text{ht in cm}) - (4.7 \times \text{age in years})$

   Note: 1 inch = 2.54 cm. 1 kilogram = 2.2 lbs.

   BMR: ______________

2. The Katch-McArdle formula calculates your BMR based on lean body weight and is considered the most accurate BMR estimate. This formula from Katch & McArdle takes into account lean mass and therefore is more accurate than a formula based on total body weight. A single formula applies equally to both men and women.

   \[ BMR \text{ (men and women)} = 370 + (21.6 \times \text{lean mass in kg}) \]

   BMR: ______________

We can now calculate the amount of energy required for a single day by multiplying our BMR (the amount of energy for physiological work) by our activity level. This will give us an estimate of our energy expenditure for each day and can be used as a quantitative measure of how much food we need to eat.

**Activity Multiplier**

- **Sedentary** = $BMR \times 1.2$ (lay in bed all day; no exercise)
- **Lightly active** = $BMR \times 1.375$ (normal daily activity no exercise/sports)
- **Mod. active** = $BMR \times 1.55$ (normal daily activity 1 hr exercise/sports)
- **Very active** = $BMR \times 1.725$ (normal daily activity 2 hrs hard exercise/sports)
- **Extremely active** = $BMR \times 1.9$ (normal daily activity 4 hrs rigorous athletic training)
Record the amount of calories you need to consume to maintain your current weight: -

EXPERIMENT C: Nutrient Assessment (Energy Intake and Dietary Record)

Both the chemical energy consumed in foods and the metabolic energy expended by cells are measured in kilocalories (kcal) or Calories (C). The major source of food calories are carbohydrates, lipids, and proteins. Per gram consumed, carbohydrates yield 4 kcal, fat 9 kcal, and protein 4 kcal of energy.

Procedure:
1. Complete a 3-day dietary record (see example below). The three days must be consecutive days, including at least one weekend day. Weigh yourself each day under consistent conditions.
2. Record all foods and fluids consumed each day. Measure or estimate food quantities by weight and fluids by volume.
3. Look up the estimated calories for each food or fluid you consume. The caloric values can be obtained from reference books or several websites (e.g. www.caloriescount.org, http://www.caloriecontrol.org, www.nal.usda.gov/fnic/foodcomp/, www.nutritiondata.com)

Sample Dietary Record

Day # ________ Day of Week ________ Weight (lb) ________

<table>
<thead>
<tr>
<th>Time</th>
<th>Food</th>
<th>Fluid</th>
<th>Calories</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

1. Determine the total Calories consumed for each of the three days.
2. Determine the total Calories expended for each of the three days.
3. For each day of the dietary record, compare the Calories consumed with the Calories expended. Is there a net gain or loss for each day? Over the three day span?
4. If there are 3,500 kcal/ pound, what is the expected weight gain or loss in pounds over this three-day experiment?
5. Compare your calculated weight change with your actual weight change. How are they related?
TYPE and hand in answers to all of the questions above and the following questions.

1. What are the main pros and cons associated with each of the methods of measuring body fat %?
2. Why is there debate in the medical community surrounding the use of BMI as a quantifiable measurement?
3. Many health professionals refer to the “calories in/calories out” model when determining a patient’s caloric requirements. How does this relate to the results of your nutrient assessment and weight? If they differ, why do you think that was?

In addition, please hand in your nutritional diary and all of the recorded information.