Activity Introduction:
How do you know if you are overweight? It sounds like a simple question, but actually, measuring body fat is not as simple as you might think. In this activity, you will use Bottle Bodies, Pop and Bev, to investigate some of the ways body fat can be measured. You will learn how to use BMI (Body Mass Index), calipers, and Hip/Waist Ratio.

Activity Background:
In our modern day lives we are reminded to live a healthy life-style and watch our weight. Television, technology, and magazines remind us of watching our weight and staying active. While fat is necessary for insulation and energy, unhealthy accumulation of fat around our waist, hips or abdomen could be precursors to diseases, such as diabetes and heart disease.

Abdominal obesity is fat (adipose) accumulation around the abdomen and can be measured with a tape measure, which is the simplest way to do this type of measuring. Waist circumference may be the best overall predictor of abdominal visceral obesity. Body Mass Index (BMI), skin fold measurement, and waist circumference can all be used to estimate the amount of body fat.

BMI is a ratio of weight to height. You can calculate BMI using one of the following formulae:

English Units of Measurement:
\[
BMI = \frac{\text{weight (pounds)} \times 703}{\text{height (inches)} \times \text{height (inches)}}
\]

Metric Units of Measurement:
\[
BMI = \frac{\text{weight (Kilograms)}}{\text{height (meters)} \times \text{height (meters)}}
\]

When determining the BMI (Body Mass Index) for adolescents, it is important to use tables designed for that age group, see Appendices 1 and 2 in the Activity Appendix. (Note: Make class copies of these tables for students to use during the activity). The BMI number is different for children and teens and is age and sex specific. Amount of body fat changes with age and amount of body fat differs between girls and boys.

Once the weight and height of a child or adolescent are known, BMI for Age Growth Charts can be used to obtain a percentile ranking. These charts are available on the Centers for Disease Control website referenced in this activity and other sources as well. The percentile ranking shows how a child’s height and weight compares to other children in the United States. Table 1 shows weight categories of underweight, healthy weight, at risk of being overweight, and overweight.
Table 1 BMI Weight Status Categories

<table>
<thead>
<tr>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>Less than the 5th percentile</td>
</tr>
<tr>
<td>Healthy weight</td>
<td>5th percentile up to the 85th percentile</td>
</tr>
<tr>
<td>At risk of Overweight</td>
<td>85th to less than the 95th percentile</td>
</tr>
<tr>
<td>Overweight</td>
<td>Equal to or greater than the 95th percentile</td>
</tr>
</tbody>
</table>

Our body is made up of water, protein, fat, carbohydrates, vitamins and minerals. Some measures of body composition simplify the definition to consider the distribution of fat and fat-free mass (muscle, bone, air cavities, etc.) in the body. Two people weighing 150 pounds can have very different body compositions and thus very different health risks. A person weighing 150 pounds with a large percentage of muscle and a small percentage of fat has a much healthier body composition than a person weighing 150 pounds with a large amount of body fat and less muscle. Adolescents put on weight as their muscle, fat, and bone changes as they grow and develop; monitoring body composition during this critical developmental period may help them become aware of maintaining healthy body composition later in life.

The amounts of muscle, fat, and bone need to establish general fitness. An athlete has more muscle and less fat while a less fit person has less muscle and more body fat. In terms of body composition, the amount of bone is relatively stable in adults, although a person with serious osteoporosis will have lower than normal bone mass, which can cause the amount of body fat to be overestimated.

Calipers, see Figure 1, are often used to measure skin folds. Skin folds in the waistline (found above the hip bone), below the shoulder blade, biceps, and triceps are areas that can easily be measured with calipers. To use the calipers, the skin is lifted with your thumb and forefinger; the “skinfold” created by this action is then measured with the caliper. This method can give a general estimate of percent body fat, but is not the most reliable method of measuring body fat.

Pear and Apple shapes have also been used to describe general body shape. Pear shapes store fat below the waistline on hips, thighs and gluteals. People who are pear shaped are commonly labeled “bottom heavy” but have a well-defined waist. Apple-shaped people have fat concentrated around the abdomen. This kind of
central fat is associated with weight related disorders such as *Heart Disease*, *Diabetes* and *Sleep Apnea*. Women with apple shapes have wide torsos and have a “top heavy” appearance, prominent abdomen and a flat derriere.

Determining *pear shape* or *apple shape* is done by calculating *waist to hip ratio*. This ratio is calculated by dividing the *waist circumference* by the *hip circumference*. If the ratio is greater than 0.8 a person is an apple shape; below 0.8 is a pear shape. *Body type (somatotype)* is determined primarily by genetics and there are 3 body type classifications, see *Figure 2*.

**Figure 2 Body Types**

<table>
<thead>
<tr>
<th>ENDOMORPH</th>
<th>ECTOMORPH</th>
<th>MESOMORPH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typically has:</strong></td>
<td><strong>Typically has:</strong></td>
<td><strong>Typically has</strong></td>
</tr>
<tr>
<td>• round face</td>
<td>• small muscles</td>
<td>• muscular build</td>
</tr>
<tr>
<td>• wide hips</td>
<td>• low body fat</td>
<td>• wide shoulders</td>
</tr>
<tr>
<td>• large bones</td>
<td>• narrow hips, shoulder and waist</td>
<td>• small waist</td>
</tr>
<tr>
<td>• slow metabolism</td>
<td>• low number of fat cells</td>
<td>• low body fat</td>
</tr>
<tr>
<td>• high number of fat cells</td>
<td>• low number of fat cells</td>
<td>• athletic build</td>
</tr>
<tr>
<td>• low waist</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Activity Materials:** (per group)
- 1 plastic soda or water bottle with cap (per student)
- 1 c clay to simulate muscle
- 1 c wax to simulate fat
- 1 measuring tape (metric)
- 1 permanent marker
- 1 metric ruler
- 1/2 c measuring cup
- large container for water
- 1 graduated cylinder
- 1 triple beam balance
- Sand (optional)
- 1 copy *BMI Nomogram for Age*, male and female (Appendices A & B)
- 1 copy *Student Information Page*
- 1 copy *Student Data Page* (per student)
Activity Procedure:
Part 1 Bottle Body Measurements

1. You will work with a partner and each of you needs to bring in an empty soda or water bottle, including the cap, with which to make your Bottle Bodies. One Bottle Body will be named Bev and the other Pop.

2. Find the height, neck, shoulders, waist, and hips on your bottle as follows:
   a. Measure from the “neck” to the base of the bottle, in centimeters. Divide that measurement by 2. The answer will be the distance between the Bottle Body neck and waist. Measure and mark the waist on your Bottle Body with a permanent marker, see Figure 3.
   b. Measure from the waist to the base in cm, divide by 2. This distance is the distance of the hips from the base. Mark the hips on your Bottle Body with a permanent marker, see Figure 3.

3. Pour sand or water into the Bottle Body #1 up to the waist.

4. Place Bottle Body #1 on the balance; measure the mass and record it on your Student Data Page in Table 1. Decide whether this is Bev or Pop.

5. Pour sand or water into Bottle Body #2 either below or above the waist.

6. Place Bottle Body #2 on the balance; measure the mass and record it on your Student Data Page in Table 1.

7. Measure the height of each Bottle Body in centimeters and record the height on your Student Data Page in Table 1.
8. Look at Figure 2, decide whether your Bottle Body represents an Ectomorph, Endomorph or Mesomorph and record your classification on your Student Data Page in Table 1. Hint: An Ectomorph has narrow hips, waist and shoulders; an Endomorph has wide hips, low waist; and a Mesomorph has wide shoulders and small waist.

9. Using a measuring tape, measure the circumference of the Bottle Body waist in centimeters. Repeat, measuring the circumference of the hips. Record your measurements on your Student Data Page in Table 1.

10. Use the formula provided on your Student Data Page to calculate the BMI and waist to hip ratio for both Bottle Bodies. Record your answers in Table 1 on your Student Data Page.

Part 2 Bottle Body Density

1. Obtain a container large enough to submerge the Bottle Bodies. Measure their volume by displacement as follows:
   
a. Place the large container in a dry aluminum pan and pour water into the large container to the top - as full as possible, without overflowing into the pan.

b. Carefully, place one of the Bottle Bodies into the large container. Using your finger, push the Bottle Body under water, making sure your fingers do not go below the surface of the water.

   c. Remove the large container from the pan, taking care NOT TO SPILL any water in the pan.

   d. Collect the water that spilled into the pan in a graduated cylinder. Measure the volume of displaced water in milliliters. This volume will equal the volume of the Bottle Body. Record your measurement on your Student Data Page in Table 2.

   e. Repeat steps a – d for the second Bottle Body.

f. Calculate the density of each Bottle Body using the formulae provided on your Student Data Page.
Part 3 Altering Bottle Body Composition
Remember, in this activity, clay represents muscle and wax represents fat.

1. Add 1/2 of the clay in your materials to Bev by wrapping it around her Bottle Body.
2. Measure the new mass and volume of Bev and record in Table 2 on your Student Data Page.
3. Calculate Bev’s new density and record in Table 2 on your Student Data Page.
4. Add 1/2 of the wax in your materials to Pop by wrapping it around his Bottle Body.
5. Repeat steps 2-3 for Pop.

Part 4 Bottle Bodies and Lifestyle Choices
Remember, in this activity, clay represents muscle and wax represents fat.

1. Remove the clay and wax from your Bottle Bodies and place them in the material bins.
2. Using the clay and wax in your materials bin, place equal volumes of clay and wax on each Bottle Body. Use 1/4 cup wax and 1/4 of the clay to make the modified Bottle Bodies that will be used in this section of the activity.
3. Each partner will work with one of the modified Bottle Bodies.
   a. Bev has gone on a fitness routine, reducing the amount of excess fat and calories in her diet and exercising regularly. After 3 months of her new routine, Bev is seeing some results. Remove some wax to represent the fat loss Bev has experienced, and add the remaining clay to represent the muscle she has added by exercising. Re-measure Bev and complete Table 4 on your Student Data Page.
   b. Pop has also changed his routine, but he has become much more sedentary, sitting for long periods of time at his new computer, exercising much less than he used to and eating more junk food snacks than he used to. Remove some of the clay from Pop and add wax to simulate the change in body composition that has resulted from Pop’s lifestyle change. Re-measure Pop and complete Table 4 on your Student Data Page.