Muscle tissues maintain electrical imbalances, or potentials, across cell membranes by concentrating positive or negative charges on opposite sides of those membranes. These potentials are a form of stored energy. With activation (such as from a nerve impulse), the ions are allowed to cross the muscle cell membranes, generating electrical activity and resulting in muscle contraction. An electromyogram, or EMG, is a graphical recording of electrical activity within muscles. Electrical activity is correlated with the strength of muscle contraction, and is dependent on the quantity of nerve impulses which are sent to the muscle. This is easily visible in large muscles such as the biceps muscle in the arm and the quadriceps muscle in the leg, but can also be demonstrated in smaller, less visible muscles, such as the masseter muscle in the jaw.

In this experiment, you will examine the electrical activity in several groups of muscles. First, we will look at the muscles in the jaw generated by chewing to see how food texture influences the strength of contraction in the masseter muscle of the jaw (Figure 1). Next, we will analyze electrical activity in the extensor muscles of the forearm. These muscles originate in tendons of the proximal dorsal forearm in the region of the lateral epicondyle and attach distally to tendons, which control extension of the hand and fingers (Figure 2). Inflammation of the tendons at the elbow is common and can result from repetitive motions used in sports, hobbies, and in the workplace.

**LAB OBJECTIVES**
- Obtain graphical representation of the electrical activity of a muscle.
- Associate amount of electrical activity with strength of muscle contraction.
- Compare masseter muscle function during different types of chewing activity.
- Associate muscle activity with movement of joints.
- Correlate muscle activity with injury.
BIO 360: Vertebrate Physiology
Lab 8b: Electrical activity of muscular contractions

MATERIALS
- Laptop, Logger Pro, EKG Sensor
- Antibacterial wipes
- Electrode tabs
- Ruler
- Various soft foods
- 2-5 pound weight
- Various hard foods
- Various chewy foods

PROCEDURE
You will work in groups of 4-5 students, and each person should perform each of the tests. The subject should perform parts I and II back to back and III and IV back to back. You can either switch partners and finish the jaw portion of the lab or move the electrodes to the same subjects' forearm.

Part 1 Electrical activity of the jaw muscles during conscious clenching
1. Connect the EKG Sensor to the Vernier computer interface. Open the file “13 Introduction to EMG” from the Human Physiology with Vernier folder.
2. Instruct the subject to be seated. Remove excess oil from the skin with antibacterial wipes to improve the adhesion of the electrode tabs to the skin. Position the upper electrode tab facing the ear so that the electrode wire may be looped over the ear (Figure 3). Position the lower tab so it faces downward and the wire hangs down. Attach the EKG electrodes to the tabs; in this experiment red and green leads are interchangeable. Place a third electrode tab on some other area of the body, such as the left or right forearm, and attach the black EKG electrode to this tab.
3. The subject should sit with his or her jaw relaxed. Click \(\text{Collect}\) to begin data collection. If your graph has a stable baseline for 5 s (Figure 4), click \(\text{Stop}\) and continue to Step 4. If your graph has an unstable baseline, click \(\text{Stop}\) and try again until you have a stable baseline for 5 s.
4. Click \(\text{Collect}\). After recording 5 s of stable baseline with the jaw relaxed, begin to clench your jaw for 5 s, and then relax. Repeat this process of clenching for 5 second and relaxing for 5 s to obtain several events. Data will be collected for 30 s
5. Click and drag to highlight the first period during which the subject’s jaw was relaxed (approximately 0–5 s). Click the Statistics button, \(\square\). Record the minimum and maximum values in Table 1, rounding to the nearest 0.01 mV.
6. Move the Statistics brackets to frame the next 5 s interval (5–10 s), during which the subject was clenching his/her jaw. Record the minimum and maximum values in Table 1, rounding to the nearest 0.01 mV. Repeat this for the three clenching intervals. To close the Statistics box, click the \(\times\) in the corner of the box.
Part II: Comparison of Muscle Action in the Chewing of Different Foods
7. Gather 1 each of the following foods: soft, hard, chewy
8. Click \[ \text{Collect} \] to begin data collection. After recording 5 s of stable baseline, instruct the subject to take a bite of the soft food and chew for the next 15–20 s. After chewing and swallowing has been accomplished, have the subject relax his/her jaw to return to baseline for the last 5–10 s of data collection.
9. Click and drag to highlight the first period during which the subject’s jaw was relaxed (approximately 0–5 s). Click the Statistics button, \[ \text{\textsuperscript{Stat}} \]. Record the minimum and maximum values in Table 1, rounding to the nearest 0.01 mV.
10. Move the brackets to frame the data recorded during the chewing interval of Run 2, and record the minimum and maximum values for this interval in Table 1, rounding to the nearest 0.01 mV. To close the Statistics box, click the \( \times \) in the corner of the box.
11. Repeat Steps 8–10 with the subject chewing a hard food. If chewing and swallowing has not been completed by 25 s, subject should cease chewing and relax the jaw to return to baseline for the final 5 s of data collection. Be sure to select the correct run when you are obtaining statistics for the data.
12. Repeat Steps 8–10 with the subject chewing on chewy food. The subject should cease chewing and relax the jaw to return to baseline for the final 5 s of data collection.
13. Calculate the difference between each minimum and maximum value and record this value in the data table under the column marked \( \Delta \) mV.

| Table 1 |
|---------|---------|----------|----------|----------|
| Condition          | Interval | Minimum mV | Maximum mV | \( \Delta \) mV |
| Jaw relaxed        | 0-5 s    |           |           |           |
|                    | 5-10 s   |           |           |           |
| Jaw clenching      | 15-20 s  |           |           |           |
|                    | 25-30 s  |           |           |           |
| Chewing soft food  | 0-5 s    |           |           |           |
|                    | chewing interval |           |           |           |
| Chewing hard food  | 0-5 s    |           |           |           |
|                    | chewing interval |           |           |           |
| Chewing chewy food | 0-5 s    |           |           |           |
|                    | chewing interval |           |           |           |

Part III: Muscle activity during forearm extension
1. Open the file “15 Muscle Function Analysis” from the Human Physiology with Vernier folder.
2. Attach three electrode tabs to your dominant arm. Two tabs should be placed on the dorsal forearm, and a third electrode tab should be placed on the upper arm, as shown in Figure 5.
3. Connect the EKG clips to the electrode; the red and green leads are interchangeable for this experiment. Stand facing your table or lab bench so that your arm is angled down toward the surface (Figure 5).
4. Rest your fingertips on the table, with your palm above the surface and in line with your forearm, as shown in Figure 5. Click \[\textbf{Collect}\] to begin data collection. If your graph has a stable baseline (Figure 4), click \[\textbf{Stop}\] and continue to Step 5. If your graph has an unstable baseline, click \[\textbf{Stop}\] and try again until you have a stable baseline for 5 s.

5. Collect data while flexing and relaxing the extensor muscle.
   1. Click \[\textbf{Collect}\]. After recording a stable baseline for 5 s, gently cock your hand back as far as you can (Figure 6). Hold this position for 5 s.
   2. Return your hand to its relaxed position, fingertips resting on the table surface, for 5 s.
   3. Repeat the extension and relaxation action for one more full cycle—5 s with the hand cocked, followed by 5 s with the hand in a resting position. Data will be collected for 25 s.
   4. Store this run by choosing Store Latest Run from the Experiment menu.
   5. Click and drag to highlight the first 5 s of data collected. Click the Statistics button, \[\textbf{S}\], click the box in front of Run 1 to obtain statistics for this run, and click \[\textbf{OK}\]. Record the minimum and maximum values displayed in Table 2, rounding to the nearest 0.01 mV.
   6. Drag the Statistics brackets to highlight each of the next 5 s intervals until you reach 20 s (5–10 s, 10–15 s, 15–20 s). Record the minimum and maximum values displayed in the Statistics boxes in Table 2. When you are finished, close the Statistics box by clicking the \[\times\] in the corner of the box.

Part IV: Ergonomics and Muscle Protection

7. Obtain a 2-5 lb weight from your instructor. Place your relaxed hand on the weight, with your palm facing downward. Click \[\textbf{Collect}\] to begin data collection.

8. Collect data to examine the effect of lifting a weight using your extensor muscles:
   a. Click \[\textbf{Collect}\]. After recording a stable baseline for 5 s, grip the weight with your hand. Using only the action of your wrist, lift the weight to a height of 5–10 cm off the surface of the table (Figure 7). Hold this position for 5 s.
   b. Gently lower the weight onto the table and rest for 5 s
   c. Repeat extension and relaxation action for one more full cycle—5 s with hand cocked, followed by 5 s with the hand in a resting position. Data will be collected for 25 s.

9. Click and drag to highlight the first 5 s of data collected. Click the Statistics button, \[\textbf{S}\], click the box in front of Run 2 to obtain statistics for this run, and click \[\textbf{OK}\]. Record the minimum and maximum values displayed in Table 2, rounding to the nearest 0.01 mV.

14. Drag the Statistics brackets to highlight each of the next 5 s intervals until you reach 20 s (5–10 s, 10–15 s, 15–20 s). Record the minimum and maximum values displayed in the Statistics boxes in Table 2, as you did in step 7.
15. Collect data while lifting a weight using your **flexor** muscles:
   a. Click [Collect]. After recording a stable baseline for 5 s, using only the action of your wrist, lift the weight to a height of 5–10 cm off the surface of the table (Figure 8). Hold this position for 5 s.
   b. Gently lower the weight onto the table and rest for 5 s.
   c. Repeat the flexation and relaxation action for one more full cycle–5 s of flexing upward with weight, followed by 5 s with the hand in a resting position.

16. Click and drag to highlight the first 5 s of data. Click the Statistics button, ![Statistics](image), click the box in front of Run 3 to obtain statistics for this run, and click ![OK](image). Record the minimum and maximum values in Table 1, rounding to the nearest 0.01 mV.

17. Drag the Statistics brackets to highlight each of the 5-second intervals until you reach 20 s (5–10 s, 10–15 s, 15–20 s). Record the minimum and maximum values in Table 2, as above.

18. Calculate the difference between each minimum and maximum value and record this value in Table 2.

<table>
<thead>
<tr>
<th>Table 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
</tr>
<tr>
<td>Fingers resting on table</td>
</tr>
<tr>
<td>Hand cocked back</td>
</tr>
<tr>
<td>Fingers resting on table</td>
</tr>
<tr>
<td>Hand cocked back</td>
</tr>
<tr>
<td>Fingers resting on weight–overhand</td>
</tr>
<tr>
<td>Hand cocked back with weight</td>
</tr>
<tr>
<td>Fingers resting on weight–overhand</td>
</tr>
<tr>
<td>Hand cocked back with weight</td>
</tr>
<tr>
<td>Fingers loosely gripping weight–underhand</td>
</tr>
<tr>
<td>Hand flexed upward with weight</td>
</tr>
<tr>
<td>Fingers loosely gripping weight–underhand</td>
</tr>
<tr>
<td>Hand flexed upward with weight</td>
</tr>
</tbody>
</table>
LAB REPORT  Answer the following questions, and turn in, along with the tables above, in a SINGLE WORD document.

Parts I and II:
1. Compare the amplitude (strength) of muscle activation during mastication (chewing) of the three food items tested.
   a. Make a graph showing the class averages (in the amplitude of muscle activation) for each of the three food items. (Be sure to make the graph that is the most appropriate.)
   b. Rank, in order (from greatest to least), the amplitude of EMG electrical activity for each of the foods tested: soft, hard, and chewy.
   c. How did your averages compare to the averages of the class?

2. On the basis of the findings in this experiment what recommendation would you make to a friend with a temporomandibular disorder (TMD) regarding his/her food choices?

3. The “Iron Jaw Trick” is a popular circus act in which a performer (or two performers) hang from a trapeze by his/her teeth. What exercises might someone do to strengthen the masseter muscles of the jaw so that a trick of this type could be performed successfully?

4. Reviewing your data, what conclusion can you reach regarding the relationship between the strength of muscle contraction and the amplitude of electrical activity generated?

Parts III and IV
5. Compare the amplitude (strength) of muscle activation during muscle activation in the three tests (unweighted, weighted-underhand, weighted-overhand).
   a. Make a graph showing the class averages (in the amplitude of muscle activation) for each of the three movements. (Be sure to make the graph that is the most appropriate.)
   b. Rank, in order (from greatest to least), the amplitude of EMG electrical activity for each of the movements.
   c. How did your averages compare to the averages of the class?
   d. What do the results in Table 2 show about the relationship between hand position and muscle activity when lifting an object?

6. What advice would you give to a friend with tennis elbow about how she should lift a frying pan onto the stove or a can of paint onto a workbench? Using what you have learned in this experiment, explain why a wrist brace is effective treatment for tennis elbow.

7. Some people keyboard with their wrists resting on the table or on a wrist support. In light of what you have learned from this experiment, would you recommend this practice as a way of preventing injury to the extensor muscles of the forearm? Why or why not?

8. Based on this experiment, what advice would you give to a beginning piano player about proper hand position?