**Muscle Contraction**

Prior Knowledge Needed
- Anatomy of a muscle from organ to sarcomere

Materials Needed:
- Students will need a ruler or tape measure to answer the Model 2 questions

Student Content Outcomes
1. The students will identify the anatomical structures of a sarcomere
2. The students will explain length relationships between relaxed and contracted sarcomeres.
3. The students will describe the overlapping of myofilaments.

**Model 1 – Anatomy of a Sarcomere**

Examine the above model, then answer the following questions:

1. Label the thick horizontal filament “THICK”.
2. Label the thin horizontal filament “THIN”

3. How many sarcomeres are shown in the above model?

4. Based on your observations of the location of thick and thin filaments, describe
   - A band
   - I band
   - H zone
   - Z disc

5. Describe how the H zone differs from the A band. (Use grammatically correct sentences)
6. How many sarcomeres do you think are in a muscle cell found in your quadriceps?

Model 2 – Comparing Relaxed and Contracted Sarcomeres

Figure 1. Relaxed sarcomeres.

Figure 2. Contracted sarcomeres.

1. In Figures 1 and 2 above, label the A-bands, I-bands, and H-zones. Measure the lengths of these structures (in mm) as well as the thick and thin filaments and record the measurements in the chart below:

<table>
<thead>
<tr>
<th>Structure</th>
<th>Length in Relaxed Sarcomere (mm)</th>
<th>Length in Contracted Sarcomere (mm)</th>
<th>Did the length change between Figures 1 and 2? (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thick filament</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thin filament</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A band</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I band</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H zone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sarcomere</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Using the data from the above table, describe what happens to thick and thin filaments when muscles contract.
3. Observe the diagram in Model 2 and describe possible reasons why there is a limit to the amount of shortening that can occur in a sarcomere during muscle contraction.

Model 3 – Cross Sections Through a Sarcomere

The diagrams in Model 3 are cross sections of a sarcomere that show the filaments at various locations within a sarcomere.

Fig. A  Fig. B  Fig. C

1. Label the thick and thin filaments in Figs. A, B, and C above.

2. In the diagram below, draw three vertical lines showing the locations within a sarcomere of the cross sections indicated by Figures A, B, and C. Label each of the lines.

3. Which of the figures (A, B, or C) represents a cross section in the H zone?

4. Which of the figures (A, B, or C) represents a cross section in the I band?

5. Which of the figures (A, B, or C) represents a cross section in the ends of the A band?
6. On the figure below, shade in the area of the A band. Identify the location of the I band.

7. When viewing skeletal muscle through a microscope, you can easily see the dark and light striations of the muscle fiber. Based on the shading in the figures above and below, hypothesize what forms the dark and light bands in the muscle fiber as seen through a microscope.

8. On the figure above label the A band and I band.

9. The *sliding filament* theory is used to explain the physiology of skeletal muscle contraction. On your own, using what you have learned from this activity, predict what the sliding filament theory states. Next, discuss your predictions with your group members and develop a definition of the sliding filament theory with regard to thick and thin filaments. (Use grammatically correct sentences)
Notes to instructors:

• Provide a measuring device (metric ruler) for measuring in Model 2.
• Instructors may need to provide additional guidance on how to draw the location of cross sectional diagrams.
• Instructors should advise the students to answer all questions using grammatically correct sentences.

Prior Knowledge Needed

• Anatomy of a muscle from organ to sarcomere

Student Content Outcomes

1. The students will identify the anatomical structures of a sarcomere.
2. The students will explain length relationships between relaxed and contracted sarcomeres.
3. The students will describe the overlapping of myofilaments.

Model 1 – Anatomy of a Sarcomere

1. Label the thick filament “THICK”.
2. Label the thin filament “THIN”

3. How many sarcomeres are shown in the above model? three

4. Based on your observations of the location of thick and thin filaments, describe

   A band – extends the length of the thick filament and includes a portion of the thin filament

   I band – area between the ends of the thick filaments; contains only thin filaments

   H zone – areas between the ends of the thin filaments; contains only a portion of the thick filaments
Z disc – vertical line at each end of the sarcomere located in the middle of the I band

5. Describe how the H zone differs from the A band. (Use grammatically correct sentences)

The H zone is located in the middle of the A band. The H zone contains only thick filaments. The A band consists of thick and thin filaments. The H zone is a subset of the A band.

6. How many sarcomeres do you think are in a muscle cell found in your quadriceps? millions

Model 2 – Comparing Relaxed and Contracted Sarcomeres

<table>
<thead>
<tr>
<th>Structure</th>
<th>Length in Relaxed Sarcomere (mm)</th>
<th>Length in Contracted Sarcomere (mm)</th>
<th>Did the length change between Figures 1 and 2? (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thick filament</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Thin filament</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>A band</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>I band</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>H zone</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Sarcomere</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>
2. Using the data from the above table, describe what happens to thick and thin filaments when muscles contract.
   *A sarcomere shortens when the thin filaments and thick filament overlap to a greater extent. The filaments do not shorten, but overlap, causing a shortening of the sarcomere as a whole.*

3. From the diagram in Model 2, describe possible reasons why there is a limit to the amount of shortening that can occur in a sarcomere during muscle contraction. (Use grammatically correct sentences)
   *Answers may vary. Possible answer:
   - Depending upon the length of the thin filaments, there is a limit to the amount of overlapping.*

**Model 3 – Cross Sections Through a Sarcomere**

The diagrams in Model 3 are cross sections of a sarcomere that shows the filaments at various locations.

1. Label the **thick** and **thin** filaments in Figs. A, B, and C above.

2. In the diagram below, draw three vertical lines showing the locations within a sarcomere of the cross sections indicated by Figures A, B, and C. Label each of the lines.
3. Which of the figures (A, B, or C) represents a cross section in the H zone?  \( B \)

4. Which of the figures (A, B, or C) represents a cross section in the I band?  \( A \)

5. Which of the figures (A, B, or C) represents a cross section in the ends of the A band?  \( C \)

6. On the figure below, shade in the area of the A band. Identify the location of the I band.

7. When viewing skeletal muscle through a microscope, you can easily see the dark and light striations of the muscle fiber. Based on the shading in the figures above and below, hypothesize what forms the dark and light bands in the muscle fiber as seen through a microscope.

   The dark bands consist of the A band which has the thick filaments and portions of the thin filaments. The light bands consist of the thin filaments of the I band.

8. On the figure above label the A band and I band.

9. The sliding filament theory is used in anatomy and physiology to describe the way a skeletal muscle contracts. On your own, using what you have learned from this activity, predict what the sliding filament theory states. Next, discuss your predictions with your
When a skeletal muscle contracts, thin filaments slide past the thick filaments. In this process, the H bands and I bands get smaller; the zones of overlap get larger; the Z lines move closer together, and the width of the A band remains constant. This explanation is known as the sliding filament theory (Martini and Ober, 2011).

Source