MUSCLE MODEL ACTIVITY GUIDE

What factors affect the strength of muscle?

APPLICATIONS IN:

LIFE SCIENCES – Structure and Function/Physiology

PHYSICAL SCIENCES – Forces and Motion/Elasticity

MATHEMATICS – Graphing

NGSS* ALIGNMENT:

<table>
<thead>
<tr>
<th></th>
<th>Elementary School</th>
<th>Middle School</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PS2.A</strong> Force and Motion</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>PS3.B</strong> Conservation of Energy and Energy Transfer</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>PS3.C</strong> Relationship Between Energy and Forces</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>LS1.A</strong> Structure and Function</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>ETS1.A</strong> Defining and Delimiting Engineering Problems</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>ETS1.B</strong> Developing Possible Solutions</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

*Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the NGSS was involved in the production of, and does not endorse, this product.

Presented by the Field Museum education department
MUSCLE MODEL / THE MACHINE INSIDE: BIOMECHANICS ACTIVITY GUIDE
MUSCLE EXPERIMENT-
Introduction for Educators

OVERVIEW
A handshake from a chimp can generate up to 50 pounds per square inch (psi) of pressure, but an adult human barely makes it up to 20 psi. Chimps achieve this strength despite having similar sized hands because of a higher density of muscle fibers. Humans have a set number of muscle fiber when they are born, but can increase their strength by increasing the size of their fibers through exercise. In these activities, students use rubber bands as models for muscle fibers and test their strength against the rubber bands by stretching them.

LEARNING GOALS
- Students explore how an increase in muscle density (number) or size (width) means the rubber bands “get stronger,” making them more difficult to stretch
- Students discuss the validity of various models.
- Students design their own arm models or catapult designs.

HOW TO USE
The materials are segmented specifically for you to use what you need. You can have students simply explore ideas or follow a more quantitative approach. You can do everything either as a demo or experiment. We have provided pre-made “concept overview,” “record sheets,” “questions to think about” to use and hand out.

TIPS
For Activities:
- This activity uses rubber bands as models for muscle fibers. Have students discuss the pros and cons of this model.
- When stretching their own rubber bands, difficulty will increase with density and size. The distance they can stretch the rubber bands decreases because their strength remains the same. This idea may be counterintuitive for some students.
- It may be useful set this activity up as stations in your classroom.

For Design Challenge:
- It may be useful to create a “teacher” design and ask students to improve or manipulate aspects of your design.
- Discuss how the designs are models for muscles, including its strengths and weaknesses.
ACTIVITY – Exploring Muscle Density

Chimps are much stronger than you’d expect considering they have hand size similar to a human’s. With this activity you will use an increasing number of rubber bands as a model for increasing muscle density.

PREDICT
Will it get harder or easier to stretch the rubber bands as you increase the number?

SUPPLIES
- Multiple Rubber Bands of the same width (0.5 inch band width is recommended)
- Meter Stick

WHAT TO DO
1) Using one rubber band, stretch it as far as you can without breaking it over a yardstick, lining your left thumb over the “zero” point on the ruler. Record how far you could stretch the rubber band by recording where your right thumb is against the ruler.
2) Double the number of rubber bands of the same width and repeat step 1. Measure how long you were able to stretch them. Record this information.
3) Repeat step 2 until you can’t stretch the rubber bands anymore.
**ACTIVITY –**
**Exploring Muscle Size**

Most animals, including humans, are born with the exact number of muscle fibers they will have their entire lives. This means they cannot increase their density, but they can change the size of muscle fibers. Explore how fiber size affects strength in this activity.

**PREDICT**

*Will it get harder or easier to stretch the rubber bands as you increase the size?*

**SUPPLIES**

- Multiple Rubber Bands of different widths (make sure they are of similar length, just different widths)
- Meter Stick

**WHAT TO DO**

1) Take one rubber band, measure the width in centimeters. Record this information.

2) Stretch the rubber band as far as you can without breaking it over a meter stick. Line your left thumb up with the “zero point” on the ruler and measure how far you stretched your right thumb over the ruler. Record this information.

3) Repeat step 1 using rubber bands of different widths. Record this information.
# RECORD SHEET – Muscle Density

<table>
<thead>
<tr>
<th>Number of Rubber Bands</th>
<th>Distance Stretched (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Be sure to label axes*
# RECORD SHEET – Muscle Size

<table>
<thead>
<tr>
<th>Size of Rubber Bands (cm)</th>
<th>Distance Stretched (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Be sure to label axes*
QUESTIONS TO THINK ABOUT

1) How is the distance you can stretch the rubber band affected by the number (density) of rubber bands and by the width (size) of your rubber band? How does that impact strength?

2) Who was able to stretch the rubber bands the farthest and what does that say about their own muscle fibers?

3) How are rubber bands a model of muscle fibers? How was strength being measured/modelled?

4) What are some factors that could have made your experiment produce different results? How can you control those factors?

5) Is there a different way of demonstrating the idea of muscle size and muscle density? How would it be different?

6) How does your data compare to other students’ data?

Notes:
1) Arm Model
Design an arm model that uses rubber bands as a model for muscles. Figure out a means of testing strength.

2) Catapult
Design a catapult that uses rubber bands. Compare how far your catapult can toss a penny or similarly small object to other designs.

Check out our other design challenges at http://biomechanics.fieldmuseum.org/explore/educational-resources/design-challenges
ADDITIONAL RESOURCES

Simple Arm Model Designs
Make a Model Arm – Kids Activities Blog:
http://kidsactivitiesblog.com/1800/arm-lesson

A Popsicle-Stick Arm – Krieger Science:
http://kriegerscience.wordpress.com/2010/10/11/a-popsicle-stick-arm/

How to a Muscle Model – eHow:
http://www.ehow.com/how_6762730_build-muscle-model.html

Simple Catapult Design Ideas on the Web
Catapult Designs for Kids – Spaghetti Box Kids:
http://spaghettiboxkids.com/blog/catapult-designs-for-kids/

How to Make a Catapult out of Paper Towel Rolls – eHow:

SPECIAL THANKS:

The Machine Inside: Biomechanics was developed by The Field Museum, Chicago, in partnership with the Denver Museum of Nature & Science.

Funded by: The Chicago Community Trust The Searie Funds of The Chicago Community Trust

Lead Sponsor: ITW
The design challenges are meant to fit into your curriculum as a project for students to complete related to their study of biomechanics. Each design challenge connects to The Field Museum traveling exhibition *The Machine Inside: Biomechanics*. The exhibition can be a great resource to help inspire your students, and the challenges can act as a post-visit activity. However, you can also easily use these challenges on their own by having students investigate ideas online.

**Top tips for teaching through design include:**
- Holding multiple feedback sessions for your students to present their ideas to you and their peers for refinement,
- Encouraging students to take on the perspective of a particular stakeholder to help focus their ideas,
- Having students take a devil’s advocate position to their own ideas in order to improve their design.

We also encourage educators to check out [http://www.designlearning.us/](http://www.designlearning.us/) for more information on teaching through design.

When your students have completed their designs, we encourage them to submit a photo or a video to us with a written explanation of their design, which problem it solves, and how nature was an inspiration. They can submit their projects here: [http://fieldmuseum.fluidsurveys.com/surveys/fieldmuseum/biomechanics-education-design-challenge/](http://fieldmuseum.fluidsurveys.com/surveys/fieldmuseum/biomechanics-education-design-challenge/)

If they submit we may choose their design to be featured on our Biomechanics tumblr site. Check out what others have done or see if your student’s design has been published here: [http://biomimicrytfm.tumblr.com](http://biomimicrytfm.tumblr.com)

**NGSS Alignment**
- MS-ETS1-1 Define criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment.
- MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
- HSET1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
BE A BIOMECHANIC!
Locomotion

THE TASK
Humans can live under a diverse set of circumstances, largely because we are able to create tools and technology that help us do so. Throughout the rest of nature, animals and plants have adapted to have a particular set of unique traits that take advantage of physics and allow survival in the most extreme environments. Scientists often get inspiration for new technologies by observing and copying animals in a field called biomimicry. Now it’s your turn! Use what you can find in nature to design something that can help humans continue to thrive and leave a better tomorrow for future generations.

THE CHALLENGE
Animals can move through water, air, trees, vines, and so many other places. Humans...well, we’re stuck on the ground and require technologies to help us travel anywhere else. Many of our current technologies that allow us to fly or swim come from wanting to be more like the animals. Use how animals move as an inspiration to design a new vehicle for traversing varied land, water, and airspace.

THE PROCEDURE
Use video resources provided to inspire you and start brainstorming ideas. Sketch out a design or build a prototype or model of what you propose. Gather feedback from teachers, peers, parents, siblings, or anyone else who will listen to help refine your ideas.

OTHER TOOLKIT RESOURCES: MUSCLE MODEL ACTIVITY, LEVER ACTIVITY

NGSS ALIGNMENT:
- MS-PS2-2 Plan an investigation to provide evidence that change in an object’s motion depends on the sum of the forces on the object and the mass of the object.

SPECIAL THANKS:

The Machine Inside: Biomechanics was developed by The Field Museum, Chicago, in partnership with the Denver Museum of Nature & Science.

Funded by: The Searle Funds of The Chicago Community Trust  Lead Sponsor: TWC

PRESENTED BY THE FIELD MUSEUM EDUCATION DEPARTMENT
DESIGN CHALLENGE / THE MACHINE INSIDE: BIOMECHANICS