Title: Tensegrity

Topics: tensegrity, in both living organisms and manufactured objects

Objectives:

A. Define tensegrity.
B. Learn how cells maintain their shape.
C. Discuss the importance of physics in living organisms and manufactured objects.

Lesson:

A. Introduction (20 minutes)

Tensegrity is a principle in physics that connects strong, rigid elements and flexible, elements together to make an extremely strong and stable object that can also move. Tensegrity is seen in nature all around us, and a very clear example is in the cells of our own bodies. The cell membrane is very flexible, and if it were on its own, it would not hold any shape… it would lie flat like a deflated balloon. The reason why cells are 3-dimensional is because they have a cytoskeleton. A cytoskeleton is a formation of long rods that stretch every which way across a cell to give it structure. Because of these cytoskeleton rods attached to the cell membrane, our cells are not flat, and they can withstand pressure. However, since they are attached to the membrane that is very fluid and moveable, the cytoskeleton can shift and adjust itself in certain ways to create different shapes for whatever the cell needs to do to survive.

A key component of tensegrity is the connection between tensioned and compressed parts. Tensioned means an object is stretched, and compressed means an object is being pushed inward. Two elements of the cytoskeleton, tubulin and actin, act as the compression and tension, respectively. Tubulin is rigid and is pushed inward and helped into place because it is an inflexible object, and actin is more flexible and is stretched into place. Another example of tensegrity in living organisms is the vertebrate system of bones, muscles, tendons, and ligaments connected together.

B. Class Project (60 minutes)

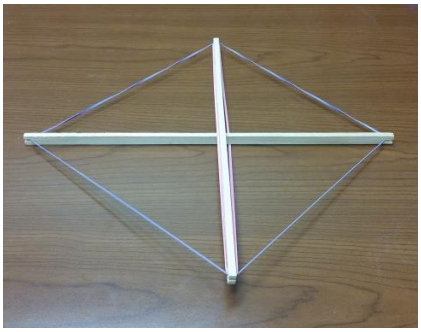
Biomimicry is the method of creating inventions based on naturally occurring designs and processes in living organisms. Living organisms, including you and me, have this clever structure solution of tensegrity, and humans have used the idea of tensegrity in inventions such as suspension bridges and sculptures (and some fun things like tents and trampolines!) to make objects that are extremely strong but still flexible.

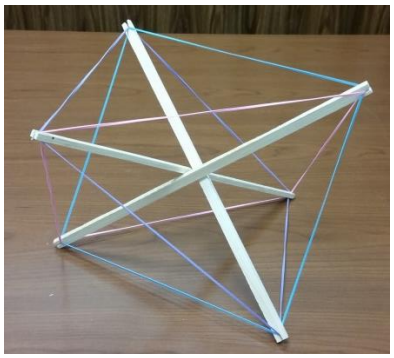
Materials: For this activity, each student should have three wooden 12-inch rods with notches on both ends and three large rubber bands.

Steps:

1. Wrap a rubber band around a rod (rod A) lengthwise so that it rests in both notches. Do the same to another rubber band and another rod (rod B).
2. Take rubber band A, and wrap it around the notches of rod B so that rods A and B lie in an X formation, and rubber band A is stretched in a square shape. One side of rubber band B should then be stretched around to the other side of rod A. In order to do this, rubber band A will need to be removed from one notch of rod A for a moment and then put back on. This may require a friend to come help keep the structure together.
3. Wrap the last rubber band around the last rod (rod C). Repeat the step above with rod C so that X, Y, and Z axes are formed. The notches of rod C should stretch rubber band B into a square shape. Rubber band C should be pulled onto the notches of rod A, forming a square. Once again, for this to work, rubber bands will have to be temporarily removed from their respective notches to let rubber band C be able to stretch around the equator of the piece.


Step 1


Step 2


Step 3

C. Conclusion (10 minutes)

To conclude the class, ask for the students' input on the following questions:

1. Now you know how a tensegrity structure is put together. Out of only two materials, you can create an extremely strong, yet incredibly flexible structure. What's your favorite part about this sculpture? Is there anything about this structure you're surprised by?
2. Was there anything difficult about this project? Was the structure easy to put together?
3. Do the rods move around, or are they held firmly in place? Why? There's no glue, right?
4. Can you think of any advantages to having a structure made up of rigid parts and flexible parts? Are there any disadvantages you can think of?

Homework:

Try to think of another example of tensegrity you see either at home, outside, or in another living organism. Take a picture of it and write three sentences about it. What is the rigid element? What is the flexible element? For what purpose was it designed this way?