# Lesson 1: Structures Around the City

## LESSON OBJECTIVES

- The students will use prior knowledge to discuss functions of various architectural structures.
- The students will learn about the forces that affect structures by completing hands-on activities.
- The students will work in collaborative groups on design challenges.

## MATERIALS

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| Popsicle Sticks | Chart Paper | Pencils | Scissors |
| Straws | Cardboard | Clay | Clothespins |
| Paper | Paperclips | Tape | Rulers |
| Glue | Brads | Push Pins | Paper Plates |
| Cling Wrap | Tissue Paper | Mini Stapler | Popsicle Sticks |
| Rubber Bands | Sponges | Pictures | |
| Decks of Cards | String | | |

## LESSON PLAN

### 1. Introduction

- Welcome the group to the Science Club. Explain to them that over the next few weeks they are going to be working in teams on several science projects. Have the students get into small groups of 3-5.
- Ask the group: *What makes up a city?* Have them share their ideas. Tell them (if they haven't already said it) that, in addition to people, businesses and trees, buildings are a major part of a city. Tell the group that they will be taking a closer look at the different types of buildings that make up a city.

**10 minutes**

### Helpful Websites Sites

Building Big Website: illustrates different forces that act upon buildings

http://www.pbs.org/wgbh/buildingbig/lab/forces.html

Brian Berg's Website: builder of the world's tallest house of cards

http://www.cardstacker.com/

## 2. City Streets

- Tell your participants that you are going to compare and contrast some buildings in the city of Chicago.
- Give each group at least five pictures of different types of buildings and ask them to categorize them. Tell them to take a few minutes to look over the pictures and make a list of the types of buildings represented.
- They may write down specific building names (i.e. the Willis Tower and the Art Institute) or they may think more generally (i.e. office building, museum). After a few minutes of brainstorming, have each group share their list. Write down their ideas on a chalk board or chart paper.
- After each group has shared their ideas, work together to create a general list of the types of buildings found. For example, if they say the Willis Tower, have them categorize it as an office building or skyscraper.
- Also guide them to think of other types of buildings that may not be represented in the pictures: grocery stores, schools, train stations, etc.
- Once they have created a fairly large list, ask them: *Why do you think there are so many different types of buildings? Why is a house so different from a skyscraper?* Encourage the students to think about the purpose of these different kinds of buildings. A house has a very different purpose than a skyscraper, and so they look different. A house also has different things inside it compared to a skyscraper. Ask the group to make comparisons between the two.
- Typically, the inside and general look of a house and a skyscraper are very different. But, ask the group, are there any similarities in how they are constructed?

**15 minutes**

## 3. Going Camping!

- Ask the group: *What do you think buildings like houses and skyscrapers are made of?* Have them share what they think. They may list materials like brick, wood, steel. They might say structures like beams or columns. If they need help, encourage them to think structurally.
- All buildings have a frame, which holds up the floors and walls. Frames can be made out of different types of materials, and

### Things To Think About

**Roles:** It is recommended that you have the students in each group pick roles for themselves. This way each student can share the fun and responsibility of the work, and a more introverted student can have equal access to the materials.

*Materials Coordinator*-collects and distributes materials for the group

*Instruction Supervisor*– reads out loud the directions to the activity

*Diplomat*-visits other groups to exchange ideas

*Presenter*-presents team's work to the overall group

*Data Collector*-writes down and documents all the team's data

**Supplies**: The students may have a tendency to just grab whatever supplies are available to them. You may want to set up parameters for how many of each material the students can use. For example, each group can only get 2 dowels, 4 paper clips, and 5 straws, etc. Or you can allow the students to make their own supply choices.

some frames are very simplified models. Ask the students if they have ever been camping before, and what is one of the most important supplies to have when going camping? A tent! A tent is a good example of a simple structural frame.

- Show the group a picture of a tent and tell them that they will be given a few minutes to create their own model of a tent. The only criteria is that the tent has to stand on its own. Have them choose roles and tell them to begin. They only have 10 minutes so they should use their time wisely.
- As the groups construct their tents, walk around visiting each table. Observe the students working in a team and make note of their designs. Make sure to give them a 1 minute warning. After the 10 minute time limit is up, tell them to put down all the supplies. Have the students walk around the room to look at each other's tent models.
- Ask the students to share similarities and differences they noticed about the tent structures. Write down their ideas.
- Although some of the design elements may be different, common components should include: being connected to or having a base, having supports inside the tent (poles, columns) and having a frame that helps the tent stand up.
- Use one tent model as an example and ask: *What would happen if I removed the pole inside the tent? What would happen if I cut one of the strings/straws connected to the pole?* In both cases, the tent would collapse. Tell the group that the key to construction is support. With the tent, the poles are supporting strings and the strings are supporting the poles.

**25 MINUTES**

### 4. Forces of Nature: Pushing and Pulling

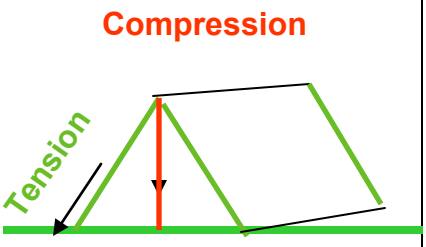
- Explain to the students that in any building, from a house to a skyscraper, there are forces acting upon it. Ask the students if they know what a force is. When talking about structures, a force can be defined as a push or a pull. There are two main forces that act upon every structure.
- Give each student a rubber band. Tell them to pull the rubber band with their hands. Ask them: *What happens?* It stretches out, gets longer and the material gets thinner. The rubber band is being pulled; this is called **tension**. Ask them: *What part of the tent is in tension?* The sides of the tent frame are in tension. They are being pulled towards the top/middle.

#### Additional Information

**Force**: the capacity to do work or cause physical change.

The red pole in the tent is being forced downwards by gravity. This is an example of compression.

The green pole is being stretched because one end is attached to the ground and the other end is attached to the red pole. This is an example of tension.



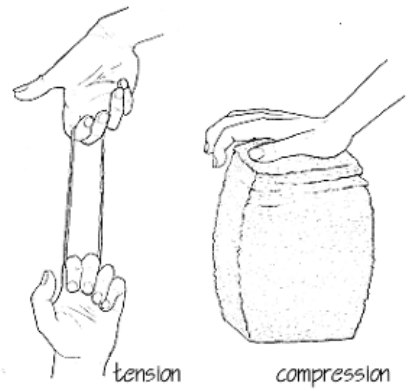
- Now show the group a large sponge. Pass the sponge around and have a few students push down on top of the sponge.Ask them: *What happens?* The sponge gets smashed down, it gets shorter, and it bulges in the middle. The sponge is being pushed or being **compressed**. Have the students identify which part of the tent is in compression. The tent poles are being compressed because they are being pushed down into the foundation.
- Show the students pictures that represent tension and compression, and have the group guess which force the photo is illustrating. They can also act out the actions in some of the photos so that they can experience these two forces.
- For example if they push on a wall, they can feel their arm muscles getting shorter, or compressing. And if they pull on a door knob, they can feel their arm muscles stretching, which is tension.
- Explain that every structure, from a tall building to our bodies, is affected by tension and compression. Some structures experience more or less tension and compression due to the shape and material of that particular structure. Our arms and legs can experience both forces depending on how we position them.

**15 MINUTES**

**POTENTIAL LESSON DIVIDER:**
**50 ADDITIONAL MINUTES**

### 5. Card Construction Challenge

- Most structures have to withstand both tension and compression, and so engineers design buildings that are perfectly in balance. This can be difficult to achieve sometimes!
- Ask the group: *But what happens if a structure is under too much tension or compression?* Show the students a piece of clay, and as you gently pull on it ask them to identify if the clay is experiencing tension or compression. (Tension) Ask them: *What happens to the clay if there is too much tension?* Pull on the clay so it stretches and eventually breaks.
- Then take a small piece of clay and mold it into a small tower that can stand up. Ask the group: *What would happen to the clay tower if there is too much compression*? Use your hand to smash down onto the piece of clay so it becomes flat. Tell the students that it is important to keep structures in balance so they are not experiencing too much of one force, and this is




### Additional Information

**Tension:** is known as a pulling force. This is a force that pulls or stretches an object.

Tension can be found when:

**You hang from a jungle gym** - your arms are stretched

**An elevator hangs on its cables -** the cables stretch out

**A suspension bridge has cables (the Golden Gate Bridge) -** the cables are stretched from the ground to the top of the bridge

something that engineers have to deal with when designing a building.

- Let the students know that they will get to attempt this balance of forces by building a structure. Explain that they will get 30 minutes to work as a group to build the tallest building they can, but the only material they have to work with is a deck of playing cards.
- Give each group a deck of cards and start the clock. Tell them when there is one minute remaining. When time is up walk around to each group with a ruler, measuring the height of their structure. Have each team explain their construction strategy and what they noticed when building. Some of the teams may have folded or torn their cards, and if so have them share why they did this and the outcome.

**35 MINUTES**

### QUESTIONS TO ASK

- How stable is your building?
- Where in your building is there tension or compression?
- Did you follow your original construction plan? Or did you have to change it as you started building?
- What could make your building stronger? Could you use more/ different materials?

- Tell the students that you are giving each group 10 pieces of masking tape, and they are going to get 5 more minutes to construct a new (hopefully more stable) structure. Hand out the tape and start the clock.
- After the 5 minutes are up, walk around again and measure the structures. Ask the groups to share their experiences using the cards and tape to build a structure.

**10 MINUTES**

### QUESTIONS TO ASK

- What did you notice?
- Did you have more success using the tape? Why or why not?
- Did the tape help overcome the tension or compression?
- What could make your building even stronger?

**Compression:** is a pushing force. This kind of force pushes down and shortens an object.

Compression can be found when:

**You sit down in a chair -** the chair legs are pushed downwards

**A statue sits on a pedestal -** the weight of the statue compresses the pedestal

**A building has columns-like the Parthenon -** the columns are pushed down by the weight of the roof

## 6. Conclusion

- Ask the students: *What shapes did you use when building your house of cards?* They should respond by saying shapes like squares, rectangles, and triangles. Point out some of their examples and identify different shapes they created.
- Tell the group that during the next session they will be looking at some of the common shapes used in construction. They will also be taking a closer look at some of the structures in their own neighborhood.

**5 MINUTES**

**End of Lesson One**

## Additional Information

A house built out of cards relies completely on balance and compression.

Each layer of cards has to be very balanced in order to support the weight of the other layers. At the same time the weight of the upper stories compresses (pushes down on) the bottom layers, which also helps stabilize the entire structure.

Forces (like tension and compression) that work on a building need to be equally distributed throughout the structure. This means the building must have a strong foundation and use strong shapes throughout.

Shapes like triangles are very strong because they distribute weight evenly from the points to the base. Triangles also keep their shape even under enormous pressure.

The world record for the tallest house of cards was set in 1999 by Brian Berg. His house stood 25.29 feet tall. He uses only cards, in their usual state, to construct his buildings (no glue, tape, staples, folding, etc.).