Teacher Resource Package

STRUCTURES, MATERIALS AND MORE

Background Information, Hands-on Activities, Teacher and Student Resources

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BACKGROUND INFORMATION

Crack! A wicked thunderstorm is passing through this morning. How are you going to stay dry? Will you slip on your rubber boots and rain jacket? Will you grab your umbrella out of the car? Will you huddle under a structure until the storm passes? We use objects and structures every day in our lives. Look closely – did you notice how many different materials are used to make the umbrella and how the materials are held together to make it strong and stable in a windy storm?

How is our environment affected by the production and the use of materials and objects? Let's look closer at that rubber boot you slipped on this morning to keep your toes dry. The rubber for the boot was either synthesized or harvested naturally from tree sap. It was then processed and produced into rubber boots. Once the rubber boots are worn through, they end up in landfill sites. We have to consider all the possible effects on the environment during the different stages of the "life cycle" of that boot.

Materials

Objects are made for a specific purpose and can be made of one material or a combination of materials. The materials used to make an object are chosen based on specific properties such as flexibility, absorbency, hardness and elasticity. An example is a bird which selects twigs and grass to build her nest. The materials are easy to transport to a tree and they provide a safe and soft place to lay and incubate eggs, as well as raise fledgling birds. Humans make a car frame using steel and reinforcements to ensure it has strong structural integrity in case of a collision. Some common materials used in objects include:

- metal (e.g. bicycle, tin foil, screw)
- plastic (e.g. water bottle, computer keyboard, jug of juice)
- fabric (e.g. hat, blanket, backpack)
- paper (e.g. tissue box, book, gift wrap)
- wood (e.g. dresser, bookcase, kitchen cabinet)
- rubber (e.g. rain boot, eraser, tire)
- glass (e.g. window, mirror, light bulb)

Upon closer investigation, the source of all material is natural in origin. Human made materials start with natural substances that are processed and transformed into a material with new or different characteristics. For instance, some fabric is made from cotton plants, while steel is manufactured with iron mined from the ground. There are environmental impacts which result from harvesting, processing and producing these materials. Natural habitats may be affected, resources may be depleted, and pollution may result from the process of converting natural substances into a human made material.

Fasteners

Objects are often designed with fasteners that bind or join materials together. Examples of fasteners include glue, tape, velcro, buttons, staples, screws and nails. Sometimes more than one type of fastener can be used to do the same job. A jacket uses buttons or a zipper to fasten it together. Two or more different materials and objects can be joined or connected using fasteners. A wooden table top fastened to the metal legs using screws is one example of this. There are a multitude of tools that can be used to apply fasteners to join materials or objects together such as screwdrivers, hammers, staplers and wrenches.

Structures

A structure is an object that has a definite size and shape and serves a definite function or purpose. The form of the structure can be natural (e.g. beaver dam, mountain, ant hill) or human made, and use multiple materials and fasteners (e.g. school, fence, running shoe). Human made structures often take design elements from naturally forming structures. A tree's root system and the deep, wide foundation of a tall building are similar as they both anchor the object to make it more stable.

Structures serve a purpose and do one or more of the following: contain, span or support an object. A basket, nest and a house are structures that contain, enclose or hold something. A bridge, spider web or stairs are structures that span and connect a space or a gap. A chair, tree and swing are structures that support and hold up an object. Structures may often have more than one purpose. Monkey bars, in a playground, are an example of a structure that span a distance as well as support a person. A tunnel is a type of structure that serves all three purposes. A tunnel contains a roadway for cars to pass through, it supports the earth above and it also spans a distance, connecting one side of a mountain to another.

Once the purpose of a structure is determined, then the design and the appropriate materials are chosen. When the purpose of a structure changes, the design may stay the same, yet different materials and fasteners could be chosen. A shelf that is to hold small toys could be built from cardboard and tape. If a shelf is needed to hold heavy textbooks, then the shelf could be constructed from wood fastened together with screws.

When engineers design a structure, they ensure that it meets the requirement for strength and stability. The design for a tall building may include concrete walls and a solid, wide base that has a low centre of gravity. This will help the structure be both strong and stable. Other factors that are considered in designs include the use of two dimensional (squares, triangles, rectangles, circles) and three dimensional (cubes, prisms, cylinders, pyramids) shapes within the structure which will enhance strength and stability. Triangles are a useful two-dimensional shape as they hold their form when forces are applied to them. Columns are an important three-dimensional shape so they are often used to support a structure. The columns transfer the forces of the load above to the supporting structure below and therefore help to keep a structure stable. Columns, in a cylindrical shape, tend to be the strongest because they have no corners that are prone to buckling and they transfer the load evenly along the structure.

The Environment

There is a direct effect on the environment when engineers make choices about the types of materials they use to construct objects and structures. The depletion of natural resources (e.g. cutting down forests) and the pollution emitted during processing of those materials are just two examples. The effects can be minimized if communities look for ways to re-use or recycle materials and objects instead of sending them to landfills. For example, clothes that are outgrown could be donated or passed to younger siblings. Researching materials that are sustainable can help to reduce damage done to the earth. Fast growing bamboo regenerates and replenishes quickly which makes it a very sustainable option compared to other hardwoods.

ACTIVITY ONE

Time: 30-60 minutes

Other Application: Language

Key Terms: materials, natural, human made

Group Size: Individual

Materials:
Pencils

Where did it come from? Worksheet per student

Metal samples (e.g. Pop can, stapler)

Plastic samples (e.g. Container, toy)

Wood samples (e.g. Pencil, wooden ruler)

Paper samples (e.g. Book, tissue box)

Fabric samples (e.g. T-shirt, jacket)

Glass samples (e.g. Jar, marble)

Rubber samples (e.g. Eraser, rain boots)

If available, provide a variety of books illustrating material sources

WHERE DID IT COME FROM?

Learning Goal: Students will learn where human made materials come from in nature and how we use the materials we manufacture.

Common everyday materials come from various natural sources. Paper is processed from the wood fibres of trees. Cotton is harvested from the fibres around the seeds of cotton shrubs and then processed and woven into fabric. Many plastic materials are derived from oil or petroleum that is pumped from deep below the earth's surface. Glass comes from sand that has been heated and melted. Rubber originally came from the latex in sap that was collected from rubber trees but most rubber today is produced synthetically. Most metal comes from ore that is mined from the earth.

Procedure:

1. Show samples of metal, plastic, glass, rubber, fabric paper and wooden objects.
2. Ask students if any of these materials are found in nature (for example, does it grow on a tree, do we find it in the ground?) or are they human made. Review each type of sample and the material that it came from.
3. Hand out the "Where Did It Come From?" worksheet.
4. Have students draw a line to match the "Natural Source" with the "Human Made Material". Students may need to research in books to discover the origin of materials.
5. Ask students to write or draw an example of an object that is made from each type of human made material. A jar is an example for glass material.
6. Have students draw a line(s) to connect the "Human Made Material" to where they go when they are no longer needed or used (e.g. Recycle, Reuse, Landfill).
7. Have students answer the question "Where do all human made materials come from?" at the bottom of their worksheet and fill in the blanks (*nature*).

Observations:

Students should be able to identify where the human made material comes from in nature:

trees → wood/paper	cotton plant → fabric
petroleum (oil) → plastics	sand → glass
rubber tree → rubber	earth/mining → metal

Today, about 30% of the rubber is harvested from natural trees. Most rubber is actually synthesized.

Discussion:

Discuss how the environment is affected when these natural resources are extracted (e.g. cutting down forests, pollution from processing plants, mining). Discuss what happens to the human made materials/structures once they are no longer useful. By researching the municipal rules for your area, students will understand relevant recycling information for their households. Recycling and reusing products saves a significant amount of energy in producing new products as well as a reduction in pollution and emissions. Some of the ways products are reused/recycled are described here:

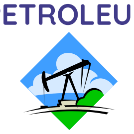
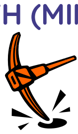
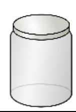
- **Wood** – A large amount of wood still ends up in landfills. Wood can be reused by re-purposing it into other wooden objects as well as recycled into sawdust, wood chips and kindling. Paper is commonly recycled to reduce the number of new trees that need to be cut down as well as reducing the level of air and water pollution and energy involved in producing new paper. Recycled paper is commonly made into newsprint, cardboard, paper towels and gift wrap.
- **Fabric** - Most fabric items such as clothing, bedding and towels can be either reused or recovered/recycled into other items. Generally, textiles are reused by donating to charities that may resell or distribute to those in need. The remainder of textiles can be processed through textile recovery plants that produce insulation and stuffing.
- **Plastic** - Approximately 80% of plastics can be recycled. Plastic labelled "1" is polyethylene or PET and is most often used for water bottles. It can be recycled into carpet, fleece material, floor tiles, automotive parts and ropes. Plastic labelled "2" is high density polyethylene or HDPE and is used in shampoo bottles and yoghurt containers. It can be recycled into pipes and toys.
- **Rubber** - Recycling rubber is now more common although in the past it usually went into landfills. Rubber can be turned into crumb rubber that is used as aggregate in paving (concrete, asphalt), playground ground cover, sporting flooring, rubber tiles and bricks.
- **Glass** – Glass can be recycled indefinitely without degrading in quality. Approximately 90% of glass is crushed into glass pellets called cullets, melted and remolded into new containers for food and beverages. Glass from windows can not be recycled and it goes to landfills.
- **Metal** - Metals have been recycled since the time of ancient civilizations when forgers would melt metals to make swords, armour and coins. Steel is the most commonly recycled metal as it does not lose its properties. Scrap metal such as food cans, old cars, industrial scrap and railways are recycled to make new metal product. Aluminum, such as from beverage cans, are commonly recycled into bicycles, cookware and cars.

Extension:

Students can bring objects from home or use other objects they see around the classroom. They can identify what material it uses, where it is derived from in nature and the environmental effects that result from extracting natural resources and discarding human made materials.

Name:____

WHERE DID IT COME FROM?

NATURAL SOURCE	HUMAN MADE MATERIAL	WHERE DO THE MATERIALS GO WHEN YOU ARE DONE WITH IT?
SAND 	WOOD/PAPER	RECYCLE 
COTTON PLANT 	FABRIC	
TREES 	PLASTIC	REUSE 
PETROLEUM 	RUBBER	
EARTH (MINING) 	GLASS jar 	LANDFILL 
RUBBER TREE 	METAL	

Where do all human made materials come from?______________________________

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ACTIVITY TWO

Time: 30-60 minutes

Other Applications: Art, Language

Key Terms: fasteners, function, material properties

Group Size: Small groups (2-4 students)

Materials:
8.5 x 11" or 11 x 14" construction paper (for sturdier pouch, use craft foam sheets)

Stapler

Twist ties

Masking tape (approx length 5cm)

String (cut to approx 15cm)

Metal fasteners (brass, suggested size 2.5cm)

Paper clips (suggested size 2.5cm)

Velcro strips (one with adhesive backing)

Extension: Write, on the pouch, the name of each fastener used.

USE THOSE FASTENERS!

Learning Goal: Students will learn how different fasteners attach paper together. Students will make a pouch by fastening paper together using different fasteners. The purpose of the pouch may be to collect their schoolwork or store holiday cards.

Procedure:

1. Instruct students that they will be creating a pouch and to identify what the specific purpose of their structure is (e.g. what will it contain).
2. Ahead of time, punch 2-3 holes on three sides of the construction paper or foam in the same place each time.
3. Hand out two pieces of paper to each student and have them line up the holes on the three sides.
4. Group students and provide them with materials to create their pouch:

paper clips	masking tape
pieces of string	metal fasteners (brass)
twist ties	pieces of mating velcro
stapler	

5. Students will choose different fasteners to bind their papers together. They may use the holes on the sides for strings, twist ties, metal fasteners or paper clips.
6. Once three sides are securely fastened, have the students test their structures. If they are not strong enough, they may need to attach more or different fasteners.
7. Students may decorate the front with their names.

Observations: Students should be able to identify different kinds of fasteners and how they work to hold materials together.

Discussion: Have students discuss what fasteners worked well and which fasteners did not. The best fasteners are the staples, tape and brass fasteners. Some challenges that may arise include the paper ripping when twist ties are not properly used, damage to the holes when the string is tied too tightly and ensuring the proper placement of velcro (the mating pieces should be on opposite sides and facing each other). In order for certain fasteners to work, it is important that holes are punched in correct places. Have students identify other types of fasteners they see on the objects they use and see around them (e.g. zippers, buttons, velcro, etc.). Discuss with students the most common fasteners: nails, screws, nuts and bolts and staples.

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ACTIVITY THREE

Time: 1 – 2 hours

Other Application: Art, Language, Math

Key Terms: natural & human made structures, purpose, stability, strength, materials

Group Size: Small groups (2-4 students)

Materials:
Look Around Us! Datasheet per group

Clay or play dough

Classroom building materials such as building blocks or straws

Extension: Students can apply this activity to a variety of different structures such as a desk, bus, magnetic board on wheels, nest, tree, or pond.

LOOK AROUND US!

Learning Goal: Students will learn to identify structures, materials and fasteners in their playground.

Procedure:

1. In small groups, walk outside and observe the playground.
2. Have each group complete the "Look Around Us!" datasheet for a specific structure of the playground (e.g. slide, monkey bar) or the entire structure.
3. Have each group record the name of the structure they are observing. Have students identify the following: whether their structure is human made or natural; what materials and fasteners are used in the structure; and what 2-D shapes they see.
4. Once the students return to the classroom, have each group create a model of their structure using either clay or classroom materials such as building blocks or straws.
5. Have the groups present their structure and discuss what materials and fasteners they used in their model compared to the one they saw in real life.

Observations:
If the slide was examined, students should notice that it spans a distance and is constructed of human made materials of metal and plastic. It has screws and nuts/bolts for fasteners that are recessed so there will not be any injuries. The overall shape of the slide is triangular with cylindrical columns for the posts.

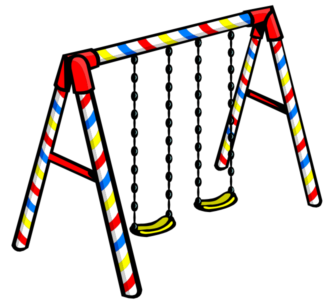
Discussion:
Discuss with students whether their structure has a strong wide base so it can stand on its own. Have students consider what the structures are used for (purpose) and what it does: contain/enclose, span and/or support. What shapes did the students observe? Were the shapes 2-D (triangle, square, rectangle, circle) or 3-D (column, pyramid, cone, cube).

Ask if the materials on their structure were flexible or rigid, absorbent or repellent, strong or weak. What other material characteristics are important? Why? If the structure was built with different materials, what would happen to the structure?

What happens to the structure when we are done using it? Does it affect the environment?

Name:____

LOOK AROUND US!



My structure is______________________________________

Observations	**Circle all that applies**		
Who made it?	Human		Natural
What materials were used?	Wood	Metal	Plastic
What types of fasteners were used?	Screws	Nuts/Bolts	Nails
What shapes do you see?			

ACTIVITY FOUR

Time: 60-90 minutes

Other Application: Math

Key Terms: materials, fasteners, stability

Group Size: Small groups (2-4 students)

Materials:
Empty cardboard boxes such as cereal, cracker boxes

Tetra boxes

Rolls of masking tape

Tape measure or metre stick

FUN FACT!

Amazing Spiders!
A spider web is a structure? This natural structure is made of spider silk which is 5x stronger than steel thread of the same thickness! It is also very elastic and has some unique characteristics. For example, if a thread breaks, the rest of the web gets stronger!

HOW HIGH CAN IT GO?

Learning Goal: Students will learn how to create a free-standing structure by using recyclables.

Procedure:
1. Ask students to collect empty cardboard boxes and tetra boxes for the experiment.
2. Tape all boxes closed so that they are sturdy.
3. Group students in small groups and give them approximately 10-15 boxes.
4. Ask students to build the tallest tower they can in approximately 15-20 minutes.
5. Measure the height of each group's tower and chart the results.
6. Stop the class and have all the students observe each group's tower.
7. Ask students which one is the most stable? Why? (shape of base, columns, etc.)
8. Students should take their tower apart, ensuring they do not damage the materials.
9. Provide each group with a roll of masking tape and ask them to build a tower again using the masking tape as a fastener and challenge them to build it even higher.
10. Allow students to build for another 15-20 min and measure each structure for their tallest height and chart the results.
11. Stop the class and allow students to observe each group's structure. How are they different from their first structures?
12. Review the chart of the structures' height.

Observations: Students can observe their own structure and compare to other groups and see if they included important elements such as using columns and having a wide base. The second time around, the students can compare how the use of fasteners improved the different structures.

Discussion: Discuss what factors are important elements in building and how else they could have made their structure stronger (different fasteners, different material, wider base, using columns). As well, discuss what could happen if their structure was outside: could it withstand the environment and what could they change to make it last.

ACTIVITY FIVE

Time: 2-4 hrs

Other Application: Math, Language, Art, Social Studies

Key Terms: natural & human made structures, function, environment, community

Group Size: Class project, assign small groups or individuals to build individual structures

Materials:

Plastic containers, bottles

Milk / juice cartons

Tetra boxes

Pizza boxes

Small cardboard boxes

Paper towel rolls

Foil

Glue

Tape

Paint & brushes

Construction paper

Markers

IT'S OUR COMMUNITY

Learning Goal: Students will learn about the different structures found in their community. Discuss with students what types of structures are in their community. Identify which ones are human made, which are naturally occurring and list on a chart. For example:

a. human made - school, house, hospital, fire/police station, skyscraper, park, road
b. natural - mountain, nest, beaver dam, ant hill

Students will work together, and model chosen structures from their community using recyclable materials of different shapes and decorating it to make it look realistic.

Procedure:

1. Ask students to collect cleaned recyclables for the project.
2. Assign students individually or in small groups to build different structures by using the recyclable materials. A group of students can work on the school which would include the building, playground and school buses. Other ideas may include:

tetra boxes – cars, buses
milk cartons – houses
paper towel rolls / paper – trees
boxes – buildings
plastic – lake, pools, playground

3. Have students paint or use construction paper and markers to make the structures more realistic.
4. Have students use a few pizza boxes laid flat and taped together to form a base. Attach all the structures to the base to create a community.
5. Have students draw or paint roads, rivers, and grass on the base.
6. Collect each group's work and place it on the base to create the community. Secure each structure with tape.
7. Display their masterpiece in the classroom to show their knowledge of different structures in their community.

Observations: Students will observe the different structures around us, what shapes they are and how they fit together to make a community.

Discussion: Students can discuss how each structure they find in the community functions. Do they contain, support or span? Are the materials in the structure natural or human made? How are each of the structures connected (roadways, waterways, etc.)? Discuss what other structures may not be in their community but may exist in other communities.

TEACHER RESOURCES

Literary Resources

Megastructures. Ian Graham. 2012. Firefly Books. ISBN 978-1-77085-111-5.0000000
All types of structures.

Skyscrapers: Super Structures to Design and Build. Carol A. Johmann. 2001. Williamson Publishing. ISBN 1-885593-50-3.
The history, planning and construction of skyscrapers and experiments.

Website Resources

http://d21na5cfk0jewa.cloudfront.net/bedrock/event-kit/peep-event-structures.pdf *(11/06/15)*
The file at this site offers a number of experiments for building structures.

http://www.reachoutmichigan.org/funexperiments/quick/plastic.html *(18/10/13)*
A great description as to how plastics are made as well as classroom activity comparing materials.

http://www.sda-uk.org/materials/popups/metals/where_do_metals_come_from.htm (*14/07/15)*
Where metal comes from.

http://www.straightdope.com/columns/read/2231/how-is-paper-made (*14/07/15)*
A detailed look at how paper is made.

http://www.britglass.org.uk/about-glass *(11/06/15)*
A detailed look at how glass is made.

http://www.etrma.org/rubber-goods *(11/06/15)*
A description of rubber history and properties.

Multi Media

http://www.youtube.com/watch?v=u3HUmgxk6X0 2:01 min *(11/06/15)*
An interesting video and description of 5 current Mega construction projects around the world.

http://www.youtube.com/watch?v=7DP_ws_dPjE 4:17 min *(11/06/15)*
Life cycle of material.

http://www.youtube.com/watch?v=UeB5XhQ2FL4 6:00 min *(11/06/15)*
Paper book tower experiment.

STUDENT RESOURCES

Literary Resources

How Tall is Tall? – Comparing Structures. Vic Parker. 2010. Heinemann Library. ISBN 978-1-4329-3955-7.
A book that compares heights of different well-known structures.

Skyscrapers- Building Amazing Structures. Chris Oxlade. 2000. Heinneman Library. ISBN 1-4034-7904-6.
A book on how to build skyscrapers.

Earth Friendly Buildings, Bridges and more. Etta Kaner. 2012. Kids Can Press Ltd. ISBN 978-1-55453-570-5.
A book that reviews foundations, bridges, tunnels, domes and dams.

FUN FACT!

About the Concrete You Walk On!

Concrete is a common material that is used for building large structures. As with all materials, it also comes from nature and is made from lime, sand and gravel. It was first discovered among ancient Egyptian and Roman civilizations. In fact, many of their concrete structures are still standing today, like the Roman Coliseum! These days, it is the most used material besides water. It is even more widely used than metals, plastics, and glass!

REFERENCES

In addition to resources listed above, the following websites were also used to develop this package:

http://www.pbs.org/wgbh/buildingbig/index.html (18/10/13)

http://www.exploratorium.edu/structures/index.html (18/10/13)

http://greenliving.lovetoknow.com/Facts_About_Recycling_Paper (12/12/13)

http://www.epa.gov/osw/conserve/materials/ (12/12/13)

http://www.rethinktires.ca/#sthash.3VDOvr8I.dpbs (12/12/13)

http://www.gpi.org/recycling/glass-recycling-facts (12/12/13)

FUN FACT!

Why Recycle?

It takes one million years for a glass bottle to break down in a landfill! Sorting aluminum cans for recycling will save 95% of the energy that would be needed to make new cans. Recycling one aluminum can saves enough energy to run a television for 3 hours!

A registered Canadian educational charity that has inspired over 10,000,000 kids to get excited about STEM (science, technology, engineering and math) since 1989.

Science Education through Partnership

Scientists in School is a leading science education charity that has reached over 10 million young scientists since our founding in 1989. Through our hands-on, inquiry-based STEM classroom and community workshops, we strive to ignite scientific curiosity in children so that they question intelligently; learn through discovery; connect scientific knowledge to their world; get excited about STEM; and have their interest in careers in those fields piqued.

None of this would be possible without the support of our corporate, community, government and individual donors who provide funding that is used to subsidize the cost of all workshops, provide complimentary workshops to schools and organizations in marginalized and under-resourced communities, develop new programs and improve existing programs, and expand to new communities across Canada.

Our Partners

Catalyst

Natural Sciences and Engineering Research Council of Canada • Ontario Trillium Foundation

Innovation

John and Deborah Harris Family Foundation
Nuclear Waste Management Organization • Ontario Power Generation
TD Friends of the Environment Foundation

Imagination

ArcelorMittal Dofasco • Canadian Nuclear Safety Commission • MilliporeSigma, the U.S. and Canada Life Science Business of Merck KGaA, Darmstadt, Germany • Nissan Canada Foundation

Discovery

Alectra • AMD Canada • ATB Financial • Burns Memorial Fund • City of Hamilton, City Enrichment Fund • CST Inspired Minds Learning Project • Edith H. Turner Foundation - Hamilton Community Foundation • Edmonton Community Foundation
G. Murray and Edna Forbes Foundation Fund at the South Saskatchewan Community Foundation • General Motors Canada • Hunter Family Foundation • Kiwanis Club of Ottawa • Municipality of Clarington • Municipality of South Bruce (South Bruce Community Liaison Committee) • Ottawa Community Foundation • Pendle Fund at the Community Foundation of Mississauga • Sifton Family Foundation • S.M. Blair Family Foundation • Superior Glove Works Ltd.
Syncrude • Syngenta Canada Inc. • Systematix Inc. • The Arthur and Audrey Cutten Foundation • The Catherine & Maxwell Meighen Foundation • The Gordon & Ruth Gooder Charitable Foundation • The Lorne and Evelyn Johnson Foundation at the South Saskatchewan Community Foundation • The McLean Foundation • The Saint John's Legacy Foundation • The Township of Tiny • Thomas Sill Foundation Inc • Vesta Energy

Exploration

Ajax Community Fund at Durham Community Foundation • Cajole Inn Foundation • Cambridge & North Dumfries Community Foundation • Canadian Association for the Advancement of Science • Canadian Federation of University Women Owen Sound and Area • Community Foundation Grey Bruce • Community Foundation for Lennox & Addington The Community Foundation of Orillia and Area • Durham Community Foundation • Elexicon • Huronia Community Foundation • Martin Foundation Fund at Hamilton Community Foundation • Niagara Community Foundation • Perth and District Community Foundation • Scarborough Garden & Horticultural Society • Smart and Caring Children and Youth Fund at the Community Foundation of Mississauga • Town of Whitby, Mayor's Community Development Fund Wellington County Medical Society

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