

Post-visit
resource
for teachers



The Structures Show



Supplementary information for teachers whose classes have experienced the Shell Questacon Science Circus Shows

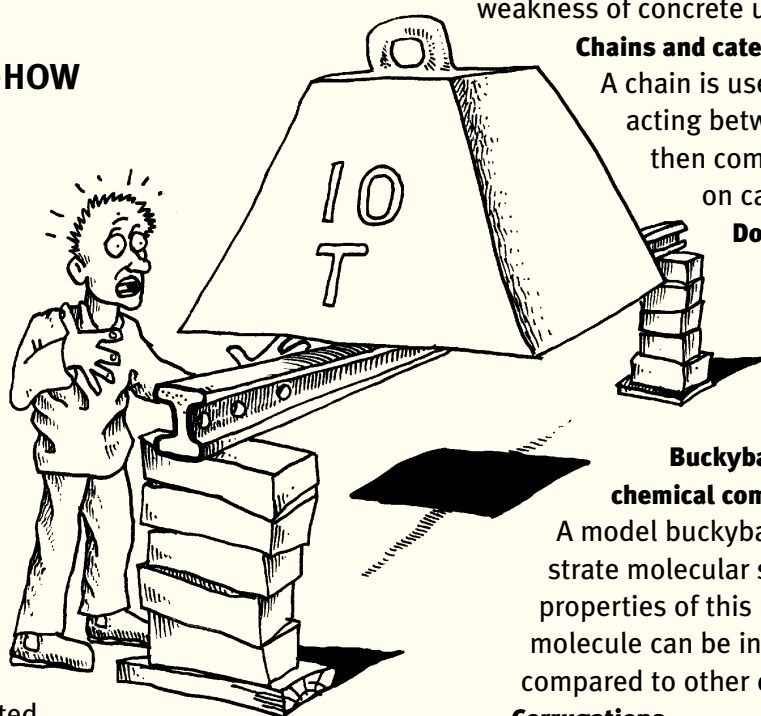
Thank you for hosting a team from the Shell Questacon Science Circus. We hope you enjoyed our visit.

Our science shows are designed to educate and entertain. Did they spark your students' curiosity?

If so, you may be keen to extend the show with more activities. Enclosed is information to supplement your own ideas and resources with which to follow-up our visit.

THE STRUCTURES SHOW

This show aims to excite curiosity about structures, such as buildings, bridges and tunnels, that we often take for granted. The show delves into the useful and unusual properties of different materials and how they are arranged to make useful, safe structures. Demonstrations are used to show that seemingly complex structures and concepts used by civil engineers can be investigated with very simple materials. The presenter experiments with the forces exerted on structures and to show how they are designed to be stronger and lighter.



I-beams are designed to have maximum strength but use a minimal amount of steel.

Show summary

The content of the Structures Show varies considerably according to the presenter's choice of demon-

strations and the age of the audience. Our favourite Structures Show demonstrations are summarised here, but you may find that your show contained a range of different demonstrations.

Pushing and pulling forces

A selection of items is used to demonstrate the main forces acting on structures. The various materials respond to pushing and pulling forces in different ways.

Reinforcing concrete

This demonstration uses a model to investigate how steel rods can be used to counteract the weakness of concrete under tension.

Chains and catenary arches

A chain is used to show the forces acting between links. This is then compared to forces acting on catenary arches.

Domes

The strength of dome-shaped structures under compression is demonstrated using eggs and light bulbs.

Buckyballs and chemical compounds

A model buckyball is used to demonstrate molecular structure. The properties of this unusually strong molecule can be investigated and compared to other carbon compounds.

Corrugations

The effect of changing the shape of a material is demonstrated using a simple piece of paper.

I-beams

This demonstration investigates which forces act upon a beam and how this can be used to make lighter and cheaper I-beams.



Cylinders

A number of demonstrations showing the strength of cylinders when compressed. This also shows that columns can be hollow and still withstand a strong force.

Bend and twist

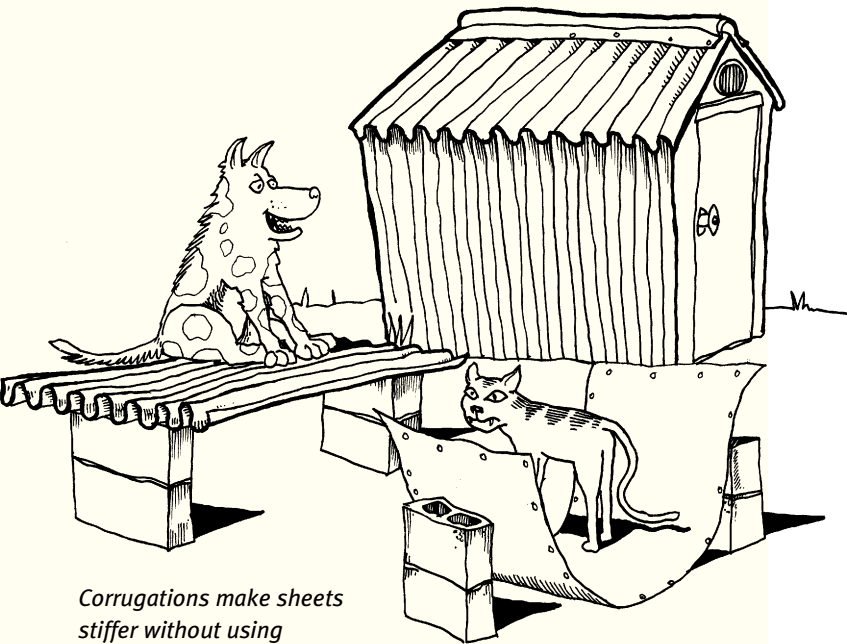
These models demonstrate how the arrangement of strengthening columns affects strength and flexibility.

Safety caution and disclaimer

This show has been developed to be presented by scientists with technical training. It is not implied by the provision of these notes or the show performance that the demonstrations are safe for students or teachers to perform. Teachers should carry out their own health and safety assessments of materials and techniques before using them

Scientific principles demonstrated in the Structures Show

- the easiest way to think of a force is as a push or a pull. Forces can't be seen, but you can observe their effects. Different forces produce different effects. Similarly, different materials or structures respond to forces in different ways.
- combining materials in a structure can help to compensate for weaknesses under particular forces. (eg. Reinforced concrete.)
- a hanging catenary has only tension forces while a catenary arch only experiences compression forces.
- because of the symmetry of a dome, a force applied from the top is spread down evenly over the whole dome. Domes are like three dimensional arches, and so are capable of supporting weight above them and holding a structure together beneath them.
- the molecular structures of diamond, graphite and buckyballs demonstrate how shape can alter the properties of these three carbon compounds.
- corrugations add rigidity to paper. The paper is not stronger, but stiffer or more difficult to bend. A similar principal is used in trusses, scaffolding and corrugated iron.
- beams have compression forces acting along their top and tension forces acting along the bottom edges. In the middle of the beam the two forces cancel each other out. I-beams take advantage of this to remove weight from the beam whilst still retaining the strength of the denser shape.
- thicker columns withstand greater downward pushing forces. Hollow columns or cylinders are also extremely strong when forces are applied along their axis and so can be used to reduce weight or costs on materials.
- columns with fibres in the middle are designed to be flexible while those with fibres on the outside are designed for strength.



Corrugations make sheets stiffer without using additional material.

Suggested follow-up activities

1 Review the show by having students describe their favourite demonstration from the Structures Show and explain what it showed.

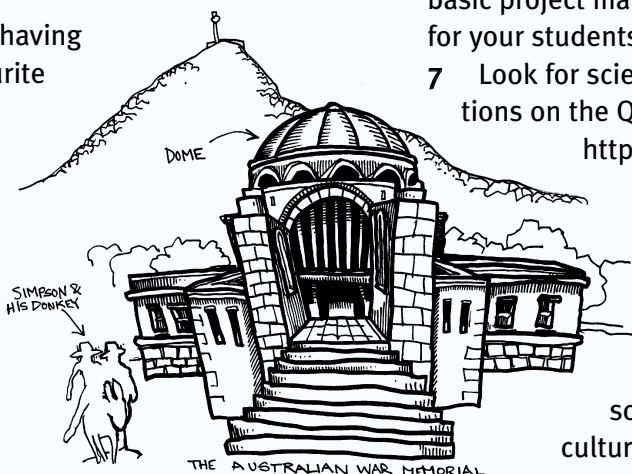
2 Ask students to explain and discuss other examples (from their own experiences) where they have seen or used the strength of different structures for a certain purpose.

3 Discuss or indicate products, industries or natural phenomena from your local area which exemplify any of the specific science in the show. For example, the Sydney Harbour Bridge is the widest long-span bridge in the world; many human bones are hollow, partly to reduce weight but also for strength; the design of water tanks and other household features.

4 Bridges are made using different structures and materials, and often for different purposes. Set a design project for your students to devise and perhaps build a model bridge to span 30cm and support a toy truck. Get them to consider different bridge shapes and materials used.

5 Provide time and materials for students to extend their knowledge of some of the phenomena, concepts and inventions mentioned in the show. Examples include different forces and their effects, general properties of various materials or elements.

6 Ask students to devise and carry out their own experiments on structures. Divide your class into groups (research teams) of 3 for experiment planning. You may like to allocate specific roles eg recorder, equipment manager, communicator within each group. Emphasise the cooperative nature of laboratory work. Teamwork is essential in science, as is safety! Include a good reader in each group. Textbooks and the Internet are useful starting points. Encourage students to gather as much



The dome roof of the Australian War Memorial in Canberra directs the load downward.

information as they can before they begin to do anything. Before any practical work begins, provide a few basic project management guidelines for your students.

7 Look for science activities and demonstrations on the Questacon Web site. Visit <http://www.questacon.edu.au>

8 (For senior secondary students) Extend studies of forces or molecular structures

9 Initiate discussion on the general contribution of science and scientists to our culture, economy and environment.

For example:

- Discuss or find examples of how science and technology have improved our standard of living. There are numerous examples including more productive crop plants; more effective medicines; new and better materials and processes; faster and more reliable communication and information technology; more effective ways of identifying and treating environmental problems; better food production, processing and storage; cleaner and more efficient mineral extraction methods.
- Discuss past and present examples of people being curious about nature and how scientific study is one way of satisfying our curiosity.

For example, compare ancient and modern ways of designing and building bridges and buildings.

- Discuss the skills we need to develop for doing experiments. For example, observing, imagining, recording, discussing, interpreting, and designing are a few of the things we need to practice in science. Model building is one of these skills.

- Research the lives and achievements of some of Australia's past and present outstanding scientists. There are numerous people who could be included. eg Macfarlane Burnet; Carolyn Mountford; Gustav Nossal; Peter Doherty; John Eccles; Mark Oliphant; Don Metcalfe; Frank Fenner; William Farrer; Peter Medawar; Kate Helms; Helen Newton Turner; Howard Florey; Nancy Millis; Ernest Titterton; Bede Morris; Nancy

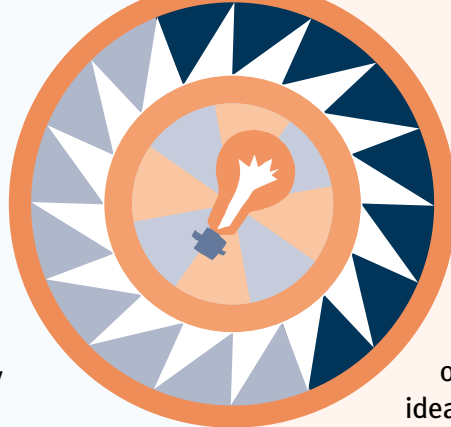
Did you know?

Buckyballs are carbon molecules of 60 -70 atoms linked together in a form similar to a soccer ball. Within a year of the discovery of buckyballs in 1985, Dr Bill Burch at the Australian National University designed a commercial use for them. Buckyballs are used in a vapour known as Technegas for lung scans in Australian hospitals. Dr Burch later managed the Design and Development department at Questacon.

Burbidge; Paul Wild; Susan Serjeantson; Peter Bishop; Elizabeth Truswell; and Kerin O'Dea.

10 Arrange an excursion to Questacon: Australia's leading interactive Science and Technology Centre is Questacon in Canberra.

Exhibitions are constantly changing. There a number of remarkable exhibits which are exciting examples of forces. At Questacon there is an entire gallery devoted to forces, including an earthquake machine! There are numerous other fascinating exhibits which model scientific concepts, natural phenomena and inventions. Tel. (02) 6270 2893 for group bookings.



Student and teacher resources

There are many resources available for inspiration and information. Some of our favourites which contain up to date ideas are:

- *Questacon Exsciter Science kits*. These contain numerous tried and tested ideas and materials for hands-on activities. Tel (02) 6270 2807 for details.
- *Questacon's award winning web site*: <http://www.questacon.edu.au/>
- *Ingenious CD* Tel. (02) 6270 2807 for details
- *Questacon Mag* Tel. (02) 6270 2855 for subscription details
- *Australian Science (incorporating Search)* Tel. (03) 9824 1699 for subscription details
- *Science Australia* by the Curriculum Corporation (national secondary science texts) Tel 1800 337 405
- *Primary Investigations* by the Australian Academy of Science (national primary science texts) Tel (02) 6247 5777 for a free information package.
- *New Scientist* Tel 1300 360127 for subscription details
- *Scientriffic magazine* Tel. (02) 6276 6643 for subscription details
- *The Helix magazine* Tel. (02) 6276 6643 for subscription details
- *Australian Innovation Magazine* Department of Industry, Science and Resources GPO Box 9389 Canberra ACT Australia 2601 Tel. (02) 6213 6304 or fax (02) 6213 6818
- *Australian Academy of Science web site*: <http://www.science.org.au/nova/>
- Contact ASTA, PO Box 334 Deakin West ACT 2600 Tel (02) 6282 9377 email: asta@asta.edu.au for information about professional associations.
- An extensive range of kits, books and fascinating science teaching resources are available from the Questacon shop in Canberra or by mail order from Questacon, King Edward Terrace, Canberra ACT 2600 Request a catalogue by Fax (02) 6273 5100 or Tel (02) 6270 2807.

Try this!

Hard boil two eggs and carefully score around their centres using a small triangular file.

Cut the eggs in half without cracking the shells and scoop out the egg. Strengthen the edges with sticky tape. Place the four egg shells, dome side up, evenly under a board and gently add small objects (approx. 10g) at a time. Try to estimate how much force the egg shells will withstand before they break.

National curriculum links

Presenters vary the show according to the age and level of audience. Accordingly, curriculum links will also differ on each occasion. The following table indicates which outcomes can be achieved with the Structures Show depending on the level and content that is emphasised.

STRAND	Energy and Change	Life and Living	Natural and Processed Materials	Working Scientifically
OUTCOMES* linked to The Structures Show	5.6	1.8, 2.8, 3.8	1.10, 2.10, 3.10, 2.11, 3.11, 4.11	1.13, 1.15, 2.15, 3.15, 1.16, 2.16, 1.17, 2.17, 2.18

*Source: Science – a curriculum profile for Australian schools (1994), Curriculum Corporation.

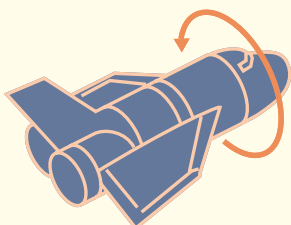
Key scientific words and concepts

structure, material, shape, arches, domes, triangles, cylinders, force, pull, push, tension, tensile force, compression, shearing force, strength, stability, stiffness, rigidity, corrugations, flexibility, weight, molecules, carbon, diamond, graphite, buckyballs

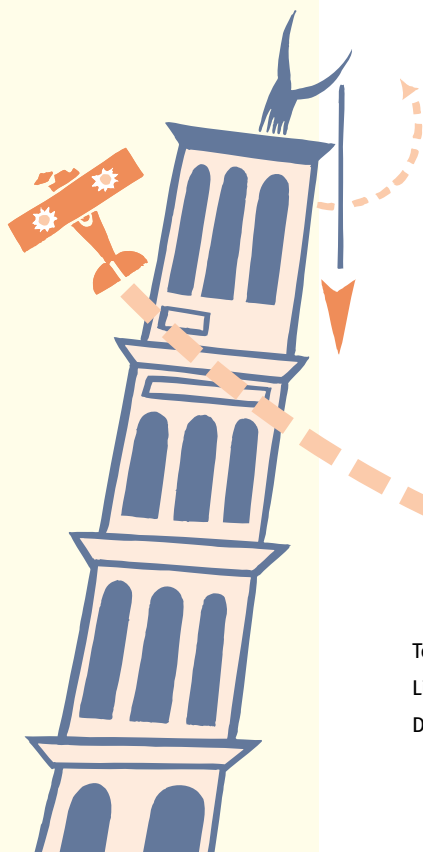
The Shell Questacon Science Circus

The Shell Questacon Science Circus is one of several national Outreach Programs of Questacon–The National Science and Technology Centre. It is staffed by science graduates who are completing a Graduate Diploma in Scientific Communication at the Australian National University. The Science Circus takes the fascination and enjoyment of science throughout Australia by exhibiting in public venues and presenting shows in schools and other community places. Our other Outreach Education Programs include the Questacon Science Squad, Questacon Maths Centre, Starlab and NRMA RoadZone. Information about our Outreach Programs can be obtained by phoning (02) 6270 2820 or by visiting our Internet site <http://questacon.edu.edu.au>

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The Sydney Harbour Bridge was designed with arches and triangles for structural strength.



Text: Graham Smith and Danielle-Louise Quinn

Line drawings: Ed Radclyffe

Design: Stephen Cole