SUPPORTING SCIENCE AND TECHNOLOGY EDUCATION

BUSINESSTECHNOLOGYSUCCESS

MYSTERY BOX

Nature of Science

TEACHER MANUAL

Contents

Kit Contents

1 Teacher manual

1 Cartesian Diver

1 Hooey Stick

4 Mystery Tubes

5 Mystery Bags

18 Mystery Pots

10 Inquiry Bags

10 student instruction cards: How Scientists Think & Observation / Inference

Learning outcomes and Curriculum links (Nature of Science strand only)

<table>
<tr><th>Activity</th><th>Curriculum Level</th><th>Understanding about Science learning objectives</th><th>Investigating in Science learning objectives</th><th>Communicating in Science learning objectives</th><th>Participating and contributing learning objectives</th></tr>
<tr><td>The Magic and Mystery of Science</td><td>1, 2 and 3</td><td rowspan="4">Students use a range of senses to make observations and use scientific thinking in order to find explanations (inferences).

Appreciate that science is a way of explaining the world and that science knowledge changes over time.

Students distinguish between observations and inferences or interpretations.

Students illustrate how data can be obtained by making non-visual observations.</td><td rowspan="4">Students build on prior experiences, work together to share and examine own and others' knowledge; Ask questions, find evidence, explore simple models, carry out investigations and develop explanations.</td><td>Students build their language and develop their understanding of the many ways the natural world can be represented.</td><td rowspan="4">Students explore various aspects of an issue and make decisions about possible actions.

Students link science learning to daily living.

Students recognise that science is uncertain because it is a human activity and understand that science does not prove or conclude – it is always a work in progress.

Students demonstrate that science is a collaborative enterprise and that scientific uncertainty can be reduced through collaboration.</td></tr>
<tr><td>Inquiry bags</td><td>1, 2 and 3</td><td>Students explore, play, make things and discuss simple models.</td></tr>
<tr><td>How Scientists think</td><td>2 and 3</td><td rowspan="2">Students use a range of scientific vocabulary.</td></tr>
<tr><td>Observation / Inference</td><td>3 and 4</td></tr>
</table>

Background notes for teachers

Nature of Science: What is science and how do scientists work? The Nature of Science strand is described in the science learning area as the overarching and unifying strand.

Students will:

Understand about science

- Appreciate that scientists ask questions about our world that lead to investigations and that open-mindedness is important because there may be more than one explanation. (L1&2)
- Appreciate that science is a way of explaining the world and that science knowledge changes over time. (L3&4)
- Identify ways in which scientists work together and provide evidence to support their ideas**.** (L3&4)

Investigate in science

- Extend their experiences and personal explanations of the natural world through exploration, play, asking questions, and discussing simple models. (L1&2)
- Build on prior experiences, working together to share and examine their own and others' knowledge. (L3&4)
- Ask questions, find evidence, explore simple models, and carry out appropriate investigations to develop simple explanations. (L3&4)

Communicate in science

- Build their language and develop their understandings of the many ways the natural world can be represented. (L1&2)
- Begin to use a range of scientific symbols, conventions, and vocabulary. (L3&4)
- Engage with a range of science texts and begin to question the purposes for which these texts are constructed. (L3&4)

Participate and contribute

- Explore and act on issues and questions that link their science learning to their daily living. (L1&2)
- Use their growing science knowledge when considering issues of concern to them. (L3&4)
- Explore various aspects of an issue and make decisions about possible actions. (L3&4)

Exploring science ideas

Scientists turn their science ideas into questions that can be investigated.
Scientists design investigations to test their predictions.
Scientists' observations are influenced by their science ideas.
Scientists' investigations are influenced by their communities.
Scientists' predictions are based on their existing science knowledge.
Many different approaches and methods are used to build scientific investigations.
When scientists carry out investigations they aim to collect adequate data.
Scientists think critically about the results of their investigations.

Forming scientific explanations

Scientific explanations may involve creative insights.
There may be more than one explanation for the results of an investigation.
Scientific explanations may be in the form of a model.

Inquiry Science Education

Inquiry used within an educational setting is recognised as both a learning objective and a teaching methodology. Inquiry activities are developed to give students ample opportunity to explore, apply prior knowledge, examine, extend understanding toward new learning, and to evaluate their progress of developing new understandings. Inquiry learning involves

- developing questions and making observations,
- doing research to find out what information is already recorded,
- developing methods for experiments,
- developing instruments for data collection,
- collecting, analyzing, and interpreting data,
- outlining possible explanations and creating predictions for future study.

There are four levels of inquiry. The progression seen from level one through four provides an excellent guide for how to scaffold inquiry learning skills for your students.

Level 1: Confirmation Inquiry: The teacher has taught a particular science theme or topic, and then develops questions and a procedure that guides students through an activity where the results are already known. Good for reinforcing concepts taught, to introduce students into learning to follow procedures, collect and record data correctly and to confirm and deepen understandings.

Level 2: Structured Inquiry: The teacher provides the initial question and an outline of the procedure. Students formulate explanations of their findings by evaluating and analysing the data that they collect.

Level 3: Guided Inquiry: The teacher only provides the research question for the students. The students are responsible for designing and following their own procedures to test that question and communicate their results and findings.

Level 4: Open Inquiry: Students formulate their own research question(s), design and follow through with a developed procedure, and communicate their findings and results. This type of inquiry is often seen in science fair contexts where students drive their own investigative questions.

Application of Inquiry-based Science

Inquiry-based learning is fundamental for the development of higher order thinking skills. According to Bloom's Taxonomy, the ability to analyze, synthesize, and evaluate information or new understandings indicates a high level of thinking. Teachers should be encouraging divergent thinking and allowing students the freedom to ask their own questions and to learn the effective strategies for discovering the answers. The higher order thinking skills that students have the opportunity to develop during inquiry activities will assist in the critical thinking skills that they will be able to use in other subjects.

Misconceptions about the nature of science (from the Science Learning Hub)

These are some common misunderstandings about the nature of science – held by students and adults alike. Take any opportunity you can to address these misconceptions in your planning and in your teaching.

Myth: The scientific method
Our students are bound to have been taught at some stage that there is a scientific method. They may well have written up numerous reports with the formulaic aim, hypothesis, method, results and conclusion. We need to show our students that there is no single method of science. Indeed, this would be impossible given the incredible range of different disciplines of science. They may, in fact, decide that there are as many different scientific methods as there are scientists.

Myth: Experiments are the main route to scientific knowledge
If you were to use word association, many of your students would give ‘experiments’ as their association for ‘science’. Science does involve investigation of some sort, but build the understanding in your students that experiments are just one of many different approaches used. In a number of science disciplines, such as geology, cosmology or medicine, experiments are either not possible or are insufficient, unnecessary or unethical. Students will then see that science also relies on many other approaches like basic observations (such as astronomy) and historical exploration (such as paleontology and evolutionary biology).

Myth: Science and its methods can answer all questions
It can be helpful for students to see that there are many questions that science cannot directly answer, such as ethical, moral, aesthetic, social and metaphysical questions. Try a class debate on cloning, stem cell research, the use of sunbeds or any one of a myriad of socio-scientific issues. Students will quickly see that, while science can provide information to inform the debate, it alone cannot provide the answers. Not all questions can be investigated in a scientific manner.

Myth: Science proves ideas
Students may have often heard the media refer to ‘scientific proof’. This myth of proof is especially pervasive in advertising: “Glossylocks shampoo. Scientifically proven to keep your hair shiny for twice as long as regular shampoo.” Take opportunities to show your students that, rather than provide ‘once and for all proof’, a hallmark of science is that it is subject to revision when new information is presented or when existing information is viewed in a new light.

Myth: Science ideas are absolute and unchanging
Some students will hold a view of science as a fixed body of facts that keeps growing as we do more science and have better technology. Yes, there are some ideas in science that are so well established and reliable and so well supported by accumulated evidence that they are unlikely to be thrown out, but even these ideas may be modified by new evidence or by the reinterpretation of existing evidence. You can help your students appreciate this by looking at cutting-edge research in health and medicine and other areas where ideas may change as scientists try to figure out which explanations are the most accurate. It is important that they see the changing of explanations in science as a strength rather than a weakness.

Myth: Science is a solitary pursuit
Ask a class to draw a scientist at work and you are bound to find an over-representation of bald (or wild frizzy-haired), bespectacled, white males working alone in a laboratory with test tubes in hand. This is well researched. You can easily challenge this myth by looking at the profiles of the scientists on the Science Learning Hub. Few work alone, most work collaboratively – and they certainly aren't all male or bald.

Myth: Science is procedural more than creative
If we have a talented artist amongst our students, we are likely to encourage them into some creative endeavour such as photography, architecture or design. But this creativity is needed also in all aspects of scientific research, from coming up with a question, creating a research design, interpreting and making sense of findings or looking at old data in new ways. Remind your students that Leonardo da Vinci was a brilliant artist and was also a leading scientist in aeronautics, anatomy, astronomy, botany, cartography, civil engineering, chemistry, geology, geometry, hydrodynamics, mathematics, mechanical engineering, optics, physics, pyrotechnics and zoology.

When an explanation correctly predicts an event, confidence in the explanation as science knowledge is increased.

Science knowledge

Scientific explanations must withstand peer review before being accepted as science knowledge.
New scientific explanations often meet opposition from other individuals and groups.
Over time, the types of science knowledge that are valued change.
All science knowledge is, in principle, subject to change.

The culture of science

Open-mindedness is important to the culture of science.
Scientific progress comes from logical and systematic work, and also through creative insights.
Science interacts with other cultures.

Cross Curricular Suggestions:

The nature of science communication strand has obvious links to literacy.

Inquiry can lead to investigations: good investigation is a fair test with repeat trials and accurate record keeping, usually involving a range of numeracy skills.

Remember that the nature of science is a process, a skill set or a way of thinking that provides the framework in which the science concepts are taught.

Student Activities

The Magic of Science

TEACHER SUPPORT

Learning Intention

To encourage the use of use scientific thinking in order to find explanations

We are intrigued by apparent discrepancies, the mysterious; the unknown.

In pre-scientific times we might have attributed the explanation to some supernatural power. Science is the attempt to explain natural phenomena.

Through the Nature of Science (NoS) we will observe, use our prior knowledge, gather information, look for patterns to prove (or disprove) possible explanations in order to develop the best answer.

There are 2 'Magic' demonstrations in this kit (see YouTube videos for more info):

- The Hooey Stick http://www.youtube.com/watch?v=nPcOXeBsSiQ
- The Cartesian Diver. http://www.youtube.com/watch?v=ljvp-iR18Ko

Demonstrate both to the class as a whole. After investigating and attempting to master the psychic forces of the demos, answer the following questions:

1. Were you able to make each 'magic' devices respond to your commands?
2. Why is a ***supernatural*** explanation for the motion of the devices not acceptable in a ***science*** class?
3. Why would some cultures actually prefer one type of explanation over another?
4. What is your scientific explanation? How sure are you that your explanation is the correct explanation? What else could you do to increase the confidence in your explanation?
5. If someone were ***unable*** to collect scientific evidence to explain how the devices work, does this absence of evidence provide 'proof' for the claim that the three operate under influence of psychic powers? Explain why or why not?
6. If someone were ***able*** to develop and verify a scientific explanation for how the devices work, does this necessarily eliminate the possibility of a supernatural cause for your teacher's ability to make the diver/propeller move? Explain.

Extension: In a pre-scientific age an appropriate explanation for the Cartesian diver and the Magic Hooey Stick might have focused on their mythical origin and some moral lesson or theistic power. Develop a one paragraph myth that is relevant to some culture (real or fictitious) and does not attempt to be scientific, but is emotionally pleasing, morally instructive, and socially reassuring.

Learning Intention

To use a range of senses to make observations and encourage the use of use scientific thinking in order to find explanations (inferences)

We will observe, use our prior knowledge, gather information, look for patterns to prove (or disprove) possible explanations in order to develop the best answer.

There are several Mystery Objects in the kit:

- 4 mystery tubes (all the same)
- 5 mystery bags (all different, labelled bag 1, 2, 3, 4 & 5)
- 18 mystery pots (6 different ones, 3 of each. Labelled 1, 2, …6)

The purpose of this exercise is to use senses other than sight to observe. Scientists need to be able to observe very carefully, and they need to use all 5 senses (although taste is not often used for health and safety reasons!)
Warn the students that they will not get the 'answer' from you! Scientists spend their lives coming up with possible explanations based on their observations and they may or may not be correct (see over).

Mystery Tubes

The rope passing through the tubes are linked in an interesting way. Pulling the 4 ends in turn will start discussions galore! Encourage the students to draw what they think is happening inside the tube. Ask lots of questions – remember it's OK to not have the answer. Possible homework challenge: make a tube at home that behaves in the same way as these mystery tubes.

Mystery Bags

Pass the bags around the room and get students to write down what they observe by feeling the contents. Try and do this in silence. Observations are FACTS: "The surface feels smooth", "It is smaller than my hand", etc. From here they can work in small groups talking quietly about their inferences:
What do they think is in each bag based on their observations?
How did they come to this conclusion?
What further evidence could be gathered to prove/disprove their inferences?
DO NOT BE TEMPTED TO PROVIDE A 'RIGHT' ANSWER (see over)

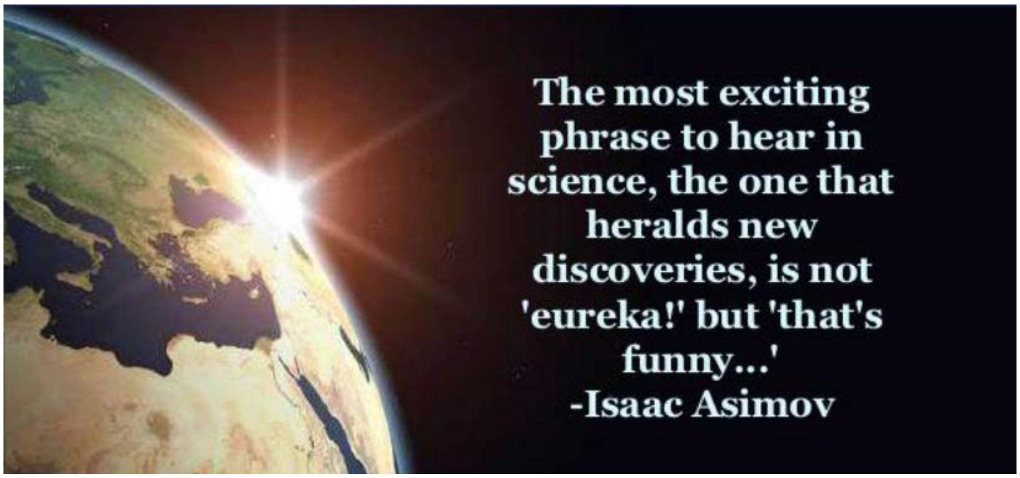
Mystery Pots

In groups, allow the students to examine the pots. THE LIDS DO NOT COME OFF!!!
Again, write down their observations (FACTS), then their inferences (GUESSES of the contents).
Again, do not tell them the answer!

Why it is important not to tell the students the 'right' answer:

Note how frustrated some students feel at not knowing the 'right' answer. Discuss the following:

- How could we gather more information about the contents of the bags/pots?
- What if the pots contained something that you had never heard of? (Like a 'roufy' – our inferences are always based on prior knowledge. This knowledge base is growing all the time and scientists need to make up new names for things that have never been seen before.)
- How does this relate to science? (in 1489, Leonardo da Vinci began a series of drawings showing the human body. Da Vinci dissected around thirty human specimens until he was forced to stop under order of the Pope. His 750 drawings represent studies of bones, skin, muscles and many internal organs, today we are still not sure why humans have an appendix)
- How has technology helped scientists make new discoveries (e.g. X-Rays, Microscopes, etc)?
- What are the limitations of this technology (e.g. X-Rays only show up dense material).



Inquiry Bag

TEACHER SUPPORT

Learning outcomes:

- Students explore, play, make things and discuss simple models
- Students understand that scientists ask questions that lead to experiments
- Students link science learning to daily living
  This task is a wonderful way to help students of any age to start their own inquiry.

There are 10 bags, each filled with random materials, all slightly different.

In small teams construct something together:

- Talk about what is in your bag, what ideas spring to mind?
- Ideas don't have to be scientific; they can be from everywhere, anywhere.
- Discuss ideas with your partners, brainstorm.
- The construction can be imaginary or be a model.

Getting started:
Curr Level 1: as a group, work together to make something using all or some of the stuff in the bag
Curr Level 2: Your group item needs to represent (something topical and science related, in the news?)
Curr Level 3: you must use everything in your bags to make anything that relates to a current science topic in the news. Work together!

Encourage students to discuss what they have made; ask questions like:

- What ideas have you thought about?
- Are there questions you have thought about?
- Would there be anything from this inquiry that you could further investigate?
- Would you tell a story about what you have made?
- Could you share that with the others?
- Finally, from the structure and your ideas, can you write a question from this? This could be a big question, a loaded question, a question that may not have one answer!

How is this Science???

The inquiry process is fundamental to science. Scientists are always coming up with new questions. Good questions are at the beginning of all science experiments.

Application of Inquiry-based Science

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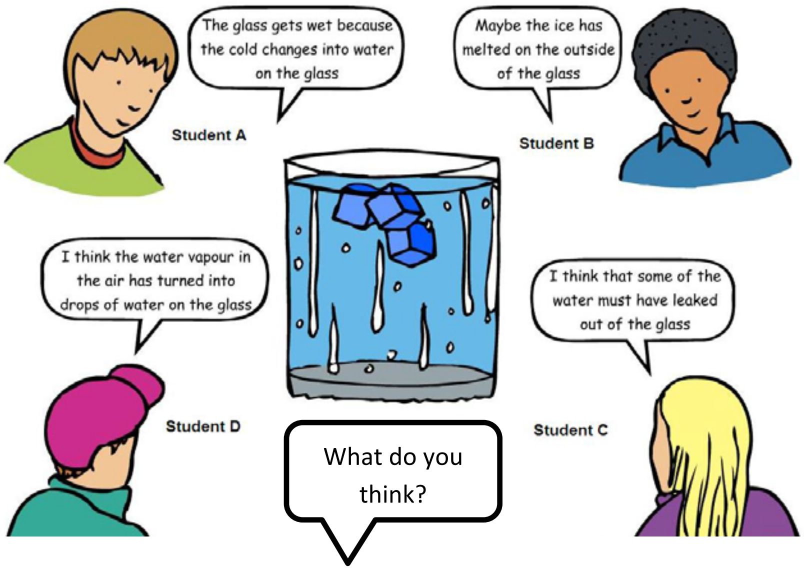
Observation and inference

Science is all about making observations (using all 5 senses) and then trying to come up with explanations for the observations. These explanations are often called inferences and they are a bit like an educated guess.

Here the students are observing that a glass of water and ice gets wet on the outside:



Concept Cartoons

Concept cartoons are useful for encouraging students to formulate explanations. The different ideas presented in this concept cartoon are indicative of responses students might make.

NOTE: In this concept cartoon none of the explanations are scientifically correct. If you want students to choose the best explanation, either add another statement or replace one of the others. (You could choose one from the student examples. Make sure the explanation is not too technical, as students will select it for the wrong reasons.)

Copy this table into your book and complete:

Student	Agree/Disagree	Why
A		
B		
C		
D		
me	*I think that…*	*because…*

What to do

- Present the concept cartoon to small groups or the class.
- Ask students to comment on each statement. This is particularly important for accessing their thinking processes, and for giving them practice in developing explanations.
- Encourage debate between students with different opinions.
- Get each group to then come up with their own explanation. These could then be shared and further refined by the whole class.
- Follow up discussions with students setting up investigations to explore their ideas. This could lead to further refinements of explanations.

Observation / Inference

TEACHER SUPPORT

This is an activity that can be used with classes at all levels. Students can work in pairs or larger groups. They make a list of all the OBSERVATIONS on the left hand side of their page, then make at least one INFERENCE (educated guess) about what this means on the right hand side. IMPORTANT: inferences are never wrong!!!

Link to Science teaching (Nature of Science: Scientific method, communicating)
This is how Scientists work. They make observations, then try and explain those observations using prior knowledge. They may carry on by writing a hypothesis (an inference that can be tested) and proceed to do an experiment (fair test) that proves or disproves the hypothesis.

What's going on in these pictures?
(from 'Science is awesome' facebook page)
In the early 1900s, Swedish tree sculptor Axel Erlandson planted "The Basket Tree." Actually, this is a bit of a misnomer, as it is a collection of six different Sycamore trees that have been grafted together. In the late 1940s, Erlandson opened a roadside oddity attraction containing 20-30 tree sculptures. Today, they have been transplanted and are on display at Gilroy Gardens amusement park in California.

Baloo the bear, Leo the lion, and Shere Kahn the tiger are collectively known as BLT. As cubs, they belonged to a drug dealer who did not properly care for the animals. Eventually, they were rescued by Noah's Ark Animal Sanctuary in Georgia. The three boys had experienced great neglect early in life and had become very dependent on one another as a result. When the staff at Noah's Ark separated them, due to concerns that they would fight, the three became moody and uncooperative. The staff reunited them, and they have been living happily together for the last 12 years.

These beautiful, colourful wisps are actually formed by rocket launches! When the launch occurs within an hour of dusk or dawn, the condensation trail of fuel and water freezes and the minimal amount of sunlight bends through the ice to produce a swirling rainbow in the sky. This is known as the "twilight phenomenon" and launches at dusk are the most colourful.

Don't worry, this reindeer is completely okay. Both male and female reindeer have antlers and shed them every year. When the new antlers grow in, they are covered in a fuzzy fur called velvet, which supplies the growing antlers with blood and nutrients. Once fully grown, the velvet can be sloughed off. This process happens every year and is perfectly harmless, though it does look a bit gruesome.

Resources and Links

Name	Comments	Website
Science Learning Hub	A variety of teaching and learning approaches aimed at illustrating how scientists work.	http://www.sciencelearn.org.nz/Nature-of-Science/Teaching-and-Learning-Approaches
Learner.org	Inquiry learning. Background reading	http://www.learner.org/workshops /inquiry/resources/faq.html
TKI	A lot of background reading about the nature of science, plus some activities as well.	http://scienceonline.tki.org.nz/Nature-of-science
Science is awesome	Facebook page with updates of the latest science news and amazing images	https://www.facebook.com/ScienceIsSeriouslyAwesome

Appendix: Student Worksheets

How Scientists Think

Observation and Inference

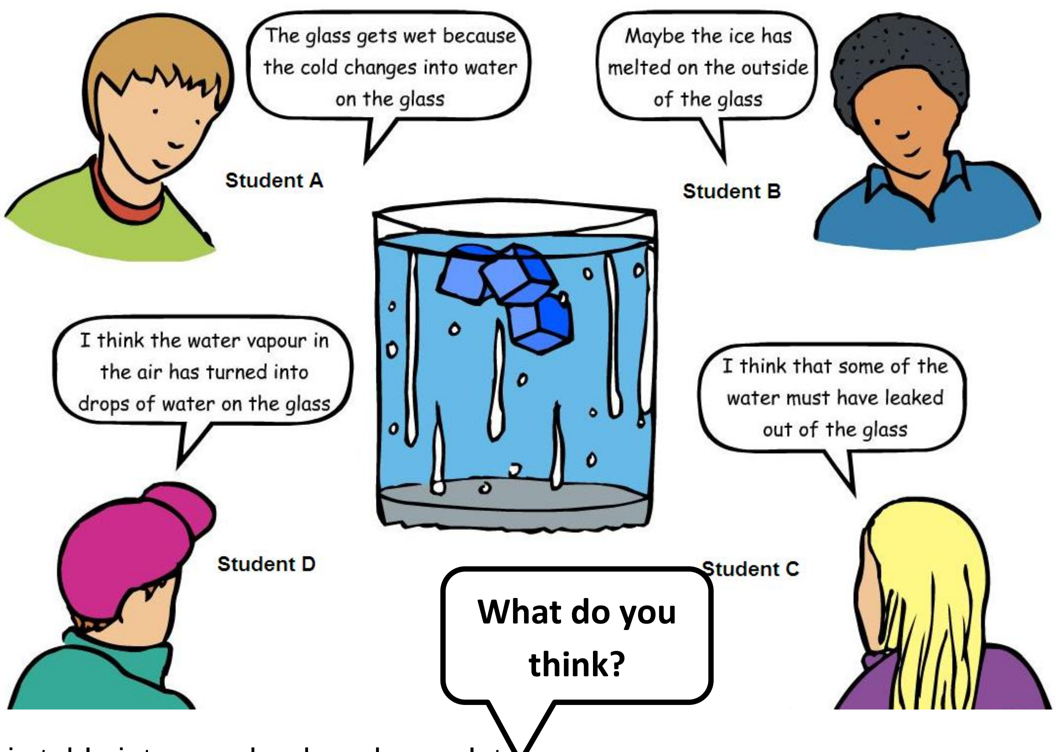
Mystery Box
Nature of Science

How Scientists think
STUDENT INSTRUCTION CARD

Observation and inference

Science is all about making observations (using all 5 senses) and then trying to come up with explanations for the observations. These explanations are often called inferences and they are a bit like an educated guess.

Here the students are observing that a glass of water and ice gets wet on the outside:

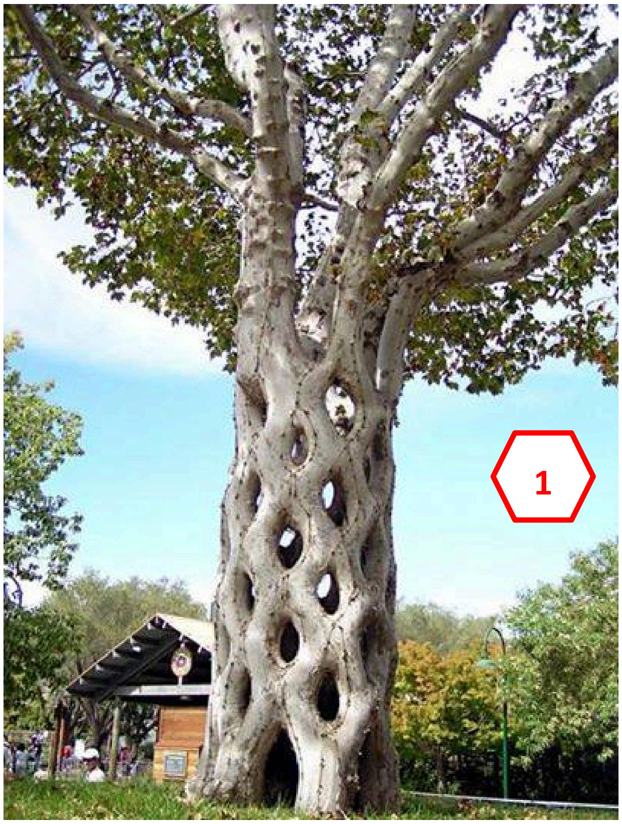


Copy this table into your book and complete.

Student	Agree/Disagree	Why
A		
B		
C		
D		
Me	I think that…	because…

Observation / Inference

STUDENT INSTRUCTION CARD



Choose one of the 4 pictures and in your book list all the **observations** you can make. Now try and write some **inferences**. Inferences are educated guesses and are never wrong until proven wrong with further experiments…