

**PISA 2015 RELEASED FIELD TRIAL
COGNITIVE ITEMS - SCIENCE**

Doc: CY6_TST_PISA2015FT_Released_Cognitive_Items

Produced by ETS (Core 3 Contractor)



PISA 2015 Contractors



Contents

Scientific Literacy – Released FT Items	
Overview.....	4
Standard Units.....	7
Interactive Units.....	22

Scientific Literacy – Overview

Thirty-five new Science items from the 2015 Field Trial were approved by the Scientific Literacy Expert Group for release as sample items. The items are presented in this document in two groups:

- **Standard units**, which consist of static materials including text, graphics, tables, and graphs and associated questions.
- **Interactive units**, which include interactive stimulus materials and associated questions.

The question intent is provided for each released item, showing how the item was classified according to the construct categories in the 2015 Scientific Literacy draft framework. These categories include: **competencies**, **types of scientific knowledge**, **contexts**, and **cognitive demand**. Each was explained more fully in the draft framework, as shown below.

COMPETENCIES

The boxes below provide an elaborated description of the kinds of performance expected for a display of the three competencies required for scientific literacy. The descriptions, framed as actions, are intended to convey the idea that the scientifically literate person both understands and is capable of undertaking a basic set of practices which are essential for scientific literacy.

1. Explain Phenomena Scientifically
Recognise, offer and evaluate explanations for a range of natural and technological phenomena demonstrating the ability to: <ul style="list-style-type: none">▪ Recall and apply appropriate scientific knowledge;▪ Identify, use, and generate explanatory models and representations;▪ Make and justify appropriate predictions;▪ Offer explanatory hypotheses;▪ Explain the potential implications of scientific knowledge for society.

2. Evaluate and design scientific enquiry

Describe and appraise scientific enquiries and propose ways of addressing questions scientifically demonstrating the ability to:

- Identify the question explored in a given scientific study;
- Distinguish questions that are possible to investigate scientifically;
- Propose a way of exploring a given question scientifically;
- Evaluate ways of exploring a given question scientifically;
- Describe and evaluate a range of ways that scientists use to ensure the reliability of data and the objectivity and generalisability of explanations.

3. Interpret data and evidence scientifically

Analyse and evaluate scientific information, claims and arguments in a variety of representations and draw appropriate conclusions by demonstrating the ability to:

- Transform data from one representation to another;
- Analyse and interpret data and draw appropriate conclusions;
- Identify the assumptions, evidence and reasoning in science-related texts;
- Distinguish between arguments which are based on scientific evidence and theory and those based on other considerations;
- Evaluate scientific arguments and evidence from different sources (e.g., newspaper, Internet, journals).

TYPES OF SCIENTIFIC KNOWLEDGE

The ability of students to demonstrate these competencies is dependent on three types of scientific knowledge. These are defined as:

- **Content knowledge**, knowledge of the content of science (including physical systems, living systems, and earth and space science),
- **Procedural knowledge**, knowledge of the diversity of methods and practices that are used to establish scientific knowledge as well as its standard procedures, and
- **Epistemic knowledge**, knowledge of how our beliefs in science are justified as a result of understanding the functions of scientific practices, their justifications, and the meaning of terms such as theory, hypothesis, and observation

CONTEXTS

The PISA 2015 assessment requires evidence of these competencies and knowledge in a range of contexts including:

- health,
- natural resources,
- the environment,
- hazards, and
- the frontiers of science and technology

in

- personal,
- local/national, and
- global settings.

COGNITIVE DEMAND

A key new feature of the 2015 PISA framework is the definition of levels of cognitive demand within the assessment of scientific literacy and across all three competences of the framework. The difficulty of any item is a combination both of the degree of complexity and range of knowledge it requires and the cognitive operations that are required to process the item. The levels defined for this assessment include:

- **Low**
Carry out a one-step procedure, for example recall of a fact, term, principle or concept or locate a single point of information from a graph or table.
- **Medium**
Use and apply conceptual knowledge to describe or explain phenomena, select appropriate procedures involving two or more steps, organise/display data, interpret or use simple data sets or graphs.
- **High**
Analyse complex information or data, synthesise or evaluate evidence, justify, reason given various sources, develop a plan or sequence of steps to approach a problem.

Unit CS600 Bee Colony Collapse Disorder**Unit Overview**

This released unit deals with the phenomenon known as bee colony collapse disorder. The stimulus materials include a short text introducing the phenomenon and a graph showing results of a study investigating the relationship between the insecticide imidacloprid and bee colony collapse disorder.

Unit CS600 Bee Colony Collapse Disorder**Released Item #1**

PISA 2015

Bee Colony Collapse Disorder
Question 1 / 5


Refer to "Bee Colony Collapse Disorder" on the right.
Type your answer to the question.

Understanding colony collapse disorder is important for people who keep and study bees, but colony collapse disorder also has an effect beyond the bees. People who study birds have identified an impact. The sunflower is a food source for both bees and certain birds. Bees feed on the nectar of the sunflower, while the birds feed on the seeds.

Given this relationship, why might the disappearance of bees result in a decline in the bird population?

BEE COLONY COLLAPSE DISORDER

An alarming phenomenon is threatening bee colonies around the world. This phenomenon is called colony collapse disorder. Colony collapse occurs when bees abandon the beehive. Separated from the hive, the bees die, so colony collapse disorder has caused the death of tens of billions of bees. Researchers believe that there are a number of causes for colony collapse.



To correctly answer this question, students must provide an explanation that states or implies that a flower cannot produce seeds without pollination. The competency for this item is 'Explain Phenomena Scientifically,' as students are asked to recall appropriate scientific knowledge.

<i>Item Number</i>	CS600Q01
<i>Competency</i>	Explain Phenomena Scientifically
<i>Knowledge – System</i>	Content – Living
<i>Context</i>	Local/National – Environmental Quality
<i>Cognitive Demand</i>	Medium
<i>Item Format</i>	Open Response – Human Coded

Unit CS600 Bee Colony Collapse Disorder
Released Item #2

PISA 2015

Bee Colony Collapse Disorder
 Question 2 / 5

Refer to "Exposure to Imidacloprid" on the right. Select from the drop-down menus to complete the sentence.

Describe the researchers' experiment by completing the following sentence.

The researchers tested the effect of
 Select on
 Select .

BEE COLONY COLLAPSE DISORDER
Exposure to Imidacloprid

Scientists believe that there are multiple causes for colony collapse disorder. One possible cause is the insecticide imidacloprid, which may cause bees to lose their sense of orientation when outside the hive.

Researchers tested whether exposure to imidacloprid leads to colony collapse. In a number of hives, they added the insecticide to the bees' food for three weeks. Different hives were exposed to different concentrations of the insecticide, measured in micrograms of insecticide per kilogram of food ($\mu\text{g/kg}$). Some hives were not exposed to any insecticide.

None of the colonies collapsed immediately after exposure to the insecticide. However, by week 14, some of the hives had been abandoned. The following graph records the observed results:

Number of Weeks After Exposure to Insecticide	0 $\mu\text{g/kg}$	20 $\mu\text{g/kg}$	400 $\mu\text{g/kg}$
10	0%	0%	0%
12	0%	0%	0%
14	0%	25%	50%
16	0%	25%	50%
18	0%	25%	100%
20	25%	75%	100%
22	25%	100%	100%

Students are asked to select from among three options in each drop-down menu to demonstrate their understanding of the question being explored in the researchers' experiment. Those options include:

- collapse of bee colonies
- concentration of imidacloprid in food
- bee immunity to imidacloprid

The response that the researchers tested the effect of *concentration of imidacloprid in food* on *collapse of bee colonies* correctly identifies the independent and dependent variables in the experiment.

Item Number	CS600Q02
Competency	Evaluate and Design Scientific Enquiry
Knowledge – System	Procedural
Context	Local/National – Environmental Quality
Cognitive Demand	Medium
Item Format	Complex Multiple Choice – Computer Scored

Unit CS600 Bee Colony Collapse Disorder
Released Item #3

PISA 2015

Bee Colony Collapse Disorder
 Question 3 / 5

Refer to "Exposure to Imidacloprid" on the right. Click on a choice to answer the question.

Which one of the following conclusions matches the results shown in the graph?

- ☐ Colonies exposed to a higher concentration of imidacloprid tend to collapse sooner.
- ☐ Colonies exposed to imidacloprid collapse within 10 weeks of exposure.
- ☐ Exposure to imidacloprid at concentrations below 20 µg/kg does not harm colonies.
- ☐ Colonies exposed to imidacloprid cannot survive for more than 14 weeks.

BEE COLONY COLLAPSE DISORDER
Exposure to Imidacloprid

Scientists believe that there are multiple causes for colony collapse disorder. One possible cause is the insecticide imidacloprid, which may cause bees to lose their sense of orientation when outside the hive.

Researchers tested whether exposure to imidacloprid leads to colony collapse. In a number of hives, they added the insecticide to the bees' food for three weeks. Different hives were exposed to different concentrations of the insecticide, measured in micrograms of insecticide per kilogram of food (µg/kg). Some hives were not exposed to any insecticide.

None of the colonies collapsed immediately after exposure to the insecticide. However, by week 14, some of the hives had been abandoned. The following graph records the observed results:

Number of Weeks After Exposure to Insecticide	0 µg/kg	20 µg/kg	400 µg/kg
10	0%	0%	0%
12	0%	0%	0%
14	0%	25%	50%
16	0%	25%	50%
18	0%	25%	100%
20	25%	75%	100%
22	25%	100%	100%

This question requires interpretation of a graph that presents data related to the relationship between concentrations of the insecticide and the rate of colony collapse over time.

The correct response is the first option (*Colonies exposed to a higher concentration of imidacloprid tend to collapse sooner*) as the graph shows that the percentage of colonies that collapsed is higher when the hives were exposed to a concentration of 400 µg/kg of the insecticide as compared with 20 µg/kg during weeks 14-20 of the experiment.

Item Number	CS600Q03
Competency	Interpret Data and Evidence Scientifically
Knowledge – System	Procedural
Context	Local/National – Environmental Quality
Cognitive Demand	Medium
Item Format	Simple Multiple Choice – Computer Scored

Unit CS600 Bee Colony Collapse Disorder
Released Item #4

PISA 2015

Bee Colony Collapse Disorder
 Question 4 / 5

Refer to "Exposure to Imidacloprid" on the right. Type your answer to the question.

Look at the result in week 20 for the hives that the researchers did not expose to imidacloprid (0 $\mu\text{g/kg}$). What does it indicate about causes of collapse among the studied colonies?

BEE COLONY COLLAPSE DISORDER
Exposure to Imidacloprid

Scientists believe that there are multiple causes for colony collapse disorder. One possible cause is the insecticide imidacloprid, which may cause bees to lose their sense of orientation when outside the hive.

Researchers tested whether exposure to imidacloprid leads to colony collapse. In a number of hives, they added the insecticide to the bees' food for three weeks. Different hives were exposed to different concentrations of the insecticide, measured in micrograms of insecticide per kilogram of food ($\mu\text{g/kg}$). Some hives were not exposed to any insecticide.






None of the colonies collapsed immediately after exposure to the insecticide. However, by week 14, some of the hives had been abandoned. The following graph records the observed results:

Weeks After Exposure	0 $\mu\text{g/kg}$	20 $\mu\text{g/kg}$	400 $\mu\text{g/kg}$
10	0%	0%	0%
12	0%	0%	0%
14	0%	25%	50%
16	0%	25%	50%
18	0%	25%	100%
20	25%	75%	100%
22	25%	100%	100%

Students must provide a hypothesis for the collapses among the control colonies. A correct response indicates either that there must be another natural cause of colony collapse for the studied colonies or that the hives in the control group were not properly protected from exposure.

Item Number	CS600Q04
Competency	Explain Phenomena Scientifically
Knowledge – System	Content – Living
Context	Local/National – Environmental Quality
Cognitive Demand	Medium
Item Format	Open Response – Human Coded

Unit CS600 *Bee Colony Collapse Disorder*
Released Item #5

PISA 2015     

Bee Colony Collapse Disorder
 Question 5 / 5

Click on a choice to answer the question

Scientists have proposed two additional causes for colony collapse disorder:

- A virus that infects and kills the bees.
- A parasitic fly that lays its eggs in the abdomen of the bees.

Which of the following findings supports the claim that bees die because of a virus?

☐ Eggs of another organism were found in hives.

☐ Insecticides were found inside the bees' cells.

☐ Non-bee DNA was found inside the bees' cells.

☐ Dead bees were found in hives.

Students must use appropriate scientific content knowledge about the viral infections to explain the phenomenon described in this item. The correct response is the third option: *Non-bee DNA was found inside the bees' cells.*

<i>Item Number</i>	CS600Q05
<i>Competency</i>	Explain Phenomena Scientifically
<i>Knowledge – System</i>	Content – Living
<i>Context</i>	Local/National – Environmental Quality
<i>Cognitive Demand</i>	Medium
<i>Item Format</i>	Simple Multiple Choice – Computer Scored

Unit CS613 Fossil Fuels

Unit Overview

This released unit explores the relationship between the burning of fossil fuels and CO₂ levels in the atmosphere. The stimulus material includes a diagram illustrating how carbon cycles in the environment and a short text describing strategies for reducing the amount of CO₂ released into the atmosphere, a table comparing the characteristics of ethanol and petroleum when used as fuel, and a graph illustrating the results of a mathematical model that calculates carbon capture and storage at three different ocean depths.

Unit CS613 Fossil Fuels

Released Item #1

PISA 2015

?

◀

▶

Fossil Fuels

Question 1 / 4

Refer to "Fossil Fuels" on the right. Click on a choice to answer the question.

Using biofuels does not have the same effect on atmospheric levels of CO₂ as using fossil fuels. Which of the statements below best explains why?

- ☐ Biofuels do not release CO₂ when they burn.
- ☐ Plants used for biofuels absorb CO₂ from the atmosphere as they grow.
- ☐ As they burn, biofuels take in CO₂ from the atmosphere.
- ☐ The CO₂ released by power plants using biofuels has different chemical properties than that released by power plants using fossil fuels.

FOSSIL FUELS

Many power plants burn carbon-based fuel and emit carbon dioxide (CO₂). CO₂ released into the atmosphere has a negative impact on global climate. Engineers have used different strategies to reduce the amount of CO₂ released into the atmosphere.

One such strategy is to burn biofuels instead of fossil fuels. While fossil fuels come from long-dead organisms, biofuel comes from plants that lived and died recently.

Another strategy involves trapping a portion of the CO₂ emitted by power plants and storing it deep underground or in the ocean. This strategy is called carbon capture and storage.

```

graph TD
    Biofuel[Biofuel] --> PP[Power Plant]
    FossilFuel[Fossil Fuel] --> PP
    PP -- "Power Plant CO2 Emissions" --> Atmosphere[Released to Atmosphere]
    Atmosphere -- "CO2 Used During Photosynthesis" --> Biofuel
    Atmosphere --> Ocean[Stored in Ocean]
          
```

Students must use appropriate scientific content knowledge to explain why the use of plant-based biofuels does not affect atmospheric levels of CO₂ in the same manner as burning fossil fuels. The second option is the correct response: *Plants used for biofuels absorb CO₂ from the atmosphere as they grow.*

Item Number	CS613Q01
Competency	Explain Phenomena Scientifically
Knowledge – System	Content – Physical
Context	Global – Natural Resources
Cognitive Demand	Medium
Item Format	Simple Multiple Choice – Computer Scored

Unit CS613 Fossil Fuels
Released Item #2

PISA 2015

Fossil Fuels

Question 2 / 4

Refer to "Fossil Fuels" on the right. Type your answers to the questions.

Despite the advantages of biofuels for the environment, fossil fuels are still widely used. The following table compares the energy and CO₂ released when petroleum and ethanol are burned. Petroleum is a fossil fuel, while ethanol is a biofuel.

Fuel Source	Energy Released (kJ of energy/g of fuel)	Carbon Dioxide Released (mg of CO ₂ /kJ of energy produced by the fuel)
Petroleum	43.6	78
Ethanol	27.3	59

According to the table, why might someone prefer using petroleum instead of ethanol, even if their cost is the same?

According to the table, what is an environmental advantage of using ethanol instead of petroleum?

FOSSIL FUELS

Many power plants burn carbon-based fuel and emit carbon dioxide (CO₂). CO₂ released into the atmosphere has a negative impact on global climate. Engineers have used different strategies to reduce the amount of CO₂ released into the atmosphere.

One such strategy is to burn biofuels instead of fossil fuels. While fossil fuels come from long-dead organisms, biofuel comes from plants that lived and died recently.

Another strategy involves trapping a portion of the CO₂ emitted by power plants and storing it deep underground or in the ocean. This strategy is called carbon capture and storage.

```

graph TD
    Biofuel[Biofuel] -- "CO2 Used During Photosynthesis" --> Atmosphere[Released to Atmosphere]
    FossilFuel[Fossil Fuel] -- "Power Plant CO2 Emissions" --> Atmosphere
    Atmosphere -- "Power Plant CO2 Emissions" --> Ocean[Stored in Ocean]
  
```

The item asks students to analyse data presented in a table to compare ethanol and petroleum as fuel sources. Students should determine that people might prefer using petroleum over ethanol because it releases more energy for the same cost and that ethanol has an environmental advantage over petroleum because it releases less carbon dioxide.

<i>Item Number</i>	CS613Q02
<i>Competency</i>	Interpret Data and Evidence Scientifically
<i>Knowledge – System</i>	Procedural
<i>Context</i>	Local/National – Natural Resources
<i>Cognitive Demand</i>	Medium
<i>Item Format</i>	Open Response – Human Coded

Unit CS613 Fossil Fuels
Released Item #3¹

PISA 2015

⏻

?

◀

▶

Fossil Fuels
Question 3 / 4

Refer to "Carbon Capture and Storage" on the right.
Type your answer to the question.

Use the data in the graph to explain how depth affects the long-term effectiveness of storing CO₂ in the ocean.

FOSSIL FUELS
Carbon Capture and Storage

Carbon capture and storage involve trapping a portion of the CO₂ emitted by power plants and storing it where it cannot be released back into the atmosphere. One possible place to store the CO₂ is in the ocean, because the CO₂ dissolves in the water.

Scientists have developed a mathematical model to calculate the percentage of CO₂ that continues to remain stored after CO₂ is pumped into the ocean at three different depths (800 metres, 1 500 metres, and 3 000 metres). The model assumes that the CO₂ is pumped into the ocean in the year 2000. The graph below shows the results of this model.

Year	800 m depth (%)	1 500 m depth (%)	3 000 m depth (%)
2000	100	100	100
2050	85	95	98
2100	65	85	95
2150	45	75	92
2200	35	65	88
2250	28	58	82
2300	22	50	75
2350	18	42	68
2400	15	35	62
2450	12	30	55
2500	10	25	50

Students must interpret data presented in a graph to provide an explanation that summarises the overall finding that storing carbon dioxide deeper in the ocean leads to better retention rates over time than storing it at shallower depths.

<i>Item Number</i>	CS613Q03
<i>Competency</i>	Interpret Data and Evidence Scientifically
<i>Knowledge – System</i>	Procedural
<i>Context</i>	Global – Natural Resources
<i>Cognitive Demand</i>	Medium
<i>Item Format</i>	Open Response – Human Coded

¹ Note that the fourth item in this unit, CS613Q04, is not included among the released items.

Unit CS644 *Volcanic Eruptions*

Unit Overview

This released unit focuses on the distribution pattern of volcanoes and the impact of volcanic eruptions on climate and the atmosphere. Stimulus materials include a map showing the location of volcanoes and earthquakes around the globe and graphs illustrating the impact that volcanic eruptions have on the amount of solar radiation that reaches Earth's surface and on carbon dioxide concentrations in the atmosphere.

Unit 644 *Volcanic Eruptions*

Released Item #1

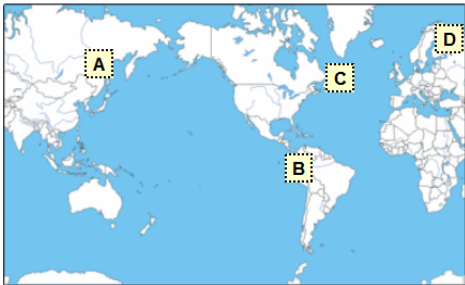
PISA 2015

Volcanic Eruptions

Question 1 / 4

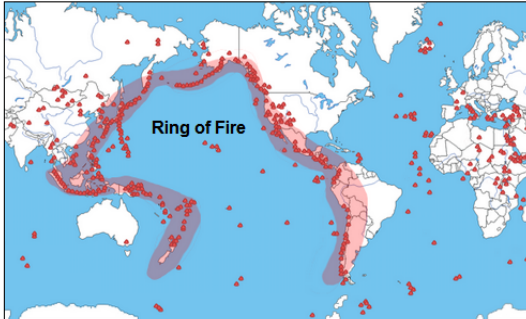
Refer to "Volcanic Eruptions" on the right. Click on a choice to answer the question.

Select the location on the map below that is **least** likely to experience volcanic activity or earthquakes.

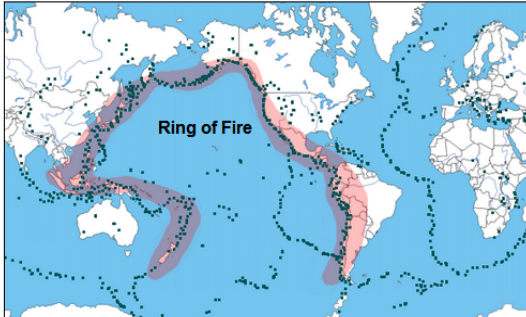


VOLCANIC ERUPTIONS

Volcanic eruptions and earthquakes affect people in many parts of the world. Map 1 shows the location of volcanoes. Map 2 shows the location of earthquakes. A region called the Ring of Fire is shown on both maps.



Map 1 - Volcanoes



Map 2 - Earthquakes

Students must interpret data presented on a map to identify the location least likely to experience volcanic activity or earthquakes. The correct response is map location *D*, over northern Europe.

<i>Item Number</i>	CS644Q01
<i>Competency</i>	Interpret Data and Evidence Scientifically
<i>Knowledge – System</i>	Procedural
<i>Context</i>	Global – Hazards
<i>Cognitive Demand</i>	Low
<i>Item Format</i>	Simple Multiple Choice – Computer Scored

Unit 644 Volcanic Eruptions
Released Item #2²

PISA 2015

?

◀

▶

Volcanic Eruptions
Question 3 / 4

Refer to "Effects on Solar Radiation" on the right. Type your answer to the question.

Why does the percentage of solar radiation that reaches Earth's surface change after volcanic eruptions?

VOLCANIC ERUPTIONS
Effects on Solar Radiation

When volcanoes erupt, they emit volcanic ash and sulphur dioxide into the atmosphere. The graph below shows the effect that these emissions have on the amount of solar radiation that reaches Earth's surface.

Solar Radiation Reaching Earth's Surface Over Time

Year	Percentage of Solar Radiation (%)
1960	92
1970	92
1980	92
1982 (Eruption)	78
1985	92
1990	92
1992 (Eruption)	82
1995	92
2000	92

Students must correctly interpret the graphed data as showing that the percentage of solar radiation reaching Earth's surface is reduced during major volcanic eruptions, and provide an explanation indicating or implying that volcanic emissions reflect or absorb solar radiation.

<i>Item Number</i>	CS644Q03
<i>Competency</i>	Interpret Data and Evidence Scientifically
<i>Knowledge – System</i>	Content – Earth and Space
<i>Context</i>	Global – Hazards
<i>Cognitive Demand</i>	Medium
<i>Item Format</i>	Open Response – Human Coded

² Note that the second item in this unit, CS644Q02, is not included among the released items.

Unit 644 Volcanic Eruptions
Released Item #3

PISA 2015

Volcanic Eruptions
 Question 4 / 4

Refer to "Atmospheric Carbon Dioxide" on the right. Click on a choice to answer the question.

Based on the information provided, what effect do volcanic eruptions have on the concentration of carbon dioxide in the atmosphere?

- ☐ A major effect, because there have been many eruptions.
- ☐ A major effect, because each eruption ejects large amounts of material.
- ☐ A minor effect, because volcanoes release little CO₂ compared to other sources.
- ☐ A minor effect, because CO₂ levels in the atmosphere decrease during eruptions.

VOLCANIC ERUPTIONS
Atmospheric Carbon Dioxide

Volcanoes emit carbon dioxide (CO₂) during eruptions. The graph below shows atmospheric carbon dioxide concentrations that scientists have measured since 1960.

CO₂ in the Atmosphere Over Time

The table below shows the relative contribution of different sources to the carbon dioxide in the atmosphere.

Source	Contribution to CO ₂ in the Atmosphere
Volcanic emissions	< 1%
Human-caused emissions	20%
Plant respiration	40%
Microbial respiration and decomposition	40%

Students must interpret the provided data as supporting the third response which says that volcanoes have a minor effect on the concentration of carbon dioxide in the atmosphere because they release little CO₂ compared to other sources.

Item Number	CS644Q04
Competency	Interpret Data and Evidence Scientifically
Knowledge – System	Procedural
Context	Global – Hazards
Cognitive Demand	Low
Item Format	Simple Multiple Choice – Computer Scored

Unit 655 Groundwater Extraction and Earthquakes

Unit Overview

This unit focuses on natural and human processes that may lead to earthquakes. The stimulus materials include a text and graphic illustrating the relationship of faults to earthquakes, a map showing levels of stress in one region of Earth, and a short text about an earthquake believed to have been caused by groundwater extraction.

Unit 655 Groundwater Extraction and Earthquakes

Released Item #1

PISA 2015

⏻

?

◀

▶

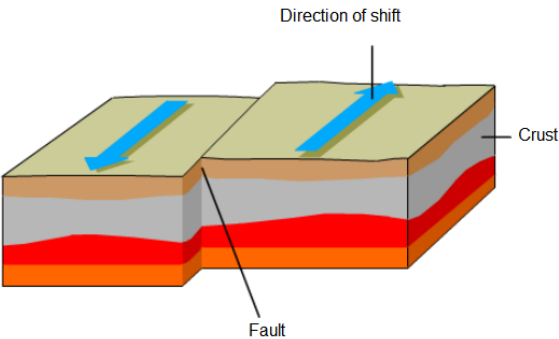
Groundwater Extraction and Earthquakes
 Question 1 / 4

Refer to "Groundwater Extraction and Earthquakes" on the right. Type your answer to the question.

Stress builds up naturally at faults. Why does this happen?

GROUNDWATER EXTRACTION AND EARTHQUAKES

The rocky crust is the uppermost layer of Earth. The crust is broken up into tectonic plates that ride on a layer of rock that is partially melted. The plates contain breaks called faults. Earthquakes happen when stress accumulated along the fault is released, causing parts of the crust to shift. An example of a shift along a fault is shown below.



The diagram shows a cross-section of the Earth's crust. Two blocks of the crust are shown on either side of a vertical fault line. Blue arrows on the top surface of each block point in opposite directions (one left, one right), indicating the direction of potential or actual movement. Labels include 'Direction of shift' pointing to the arrows, 'Crust' pointing to the top layer, and 'Fault' pointing to the break between the two blocks. Below the crust, a layer of red and orange material is visible, representing the partially melted rock mentioned in the text.

Using the description and representation of faults provided in the stimulus, students must provide an explanation that indicates or implies that the movement of tectonic plates leads to the build-up of stress and/or that rock or land moving in different directions is stopped by friction at a fault.

<i>Item Number</i>	CS655Q01
<i>Competency</i>	Explain Phenomena Scientifically
<i>Knowledge – System</i>	Content – Earth and Space
<i>Context</i>	Local/National – Hazards
<i>Cognitive Demand</i>	Medium
<i>Item Format</i>	Open Response – Human Coded

Unit 655 Groundwater Extraction and Earthquakes
Released Item #2

PISA 2015

Groundwater Extraction and Earthquakes
 Question 2 / 4

Refer to "Stress in Earth's Crust" on the right. Use drag and drop to answer the question.

The map on the right shows the levels of stress in Earth's crust in a region. Four locations within the region are identified as A, B, C, and D. Each location is on or near a fault that runs through the region.

Put the locations in order from lowest risk to highest risk of earthquake.

A B C D

Highest risk:

Lowest risk:

GROUNDWATER EXTRACTION AND EARTHQUAKES
Stress in Earth's Crust

Levels of Stress in Earth's Crust

Students must apply their understanding of the relationship between stress in Earth's crust and earthquakes to predict the risk of earthquakes in four specific locations that are near faults. The location with the highest risk is the one labelled "D" on the diagram, followed by "B", "C" and finally "A", which has the lowest risk because it has the lowest level of stress.

<i>Item Number</i>	CS655Q02
<i>Competency</i>	Interpret Data and Evidence Scientifically
<i>Knowledge – System</i>	Procedural
<i>Context</i>	Local/National – Hazards
<i>Cognitive Demand</i>	Low
<i>Item Format</i>	Complex Multiple Choice – Computer Scored

Unit 655 Groundwater Extraction and Earthquakes
Released Item #3

PISA 2015

⏸

?

◀

▶

Groundwater Extraction and Earthquakes

Question 3 / 4

Refer to "The 2011 Earthquake In Lorca" on the right.
Click on a choice to answer the question.

Which observation supports the geologists' hypothesis?

- ☐ The earthquake was felt many kilometres away from Lorca.
- ☐ Movement along the fault was greatest in areas where the pumping created the greatest stress.
- ☐ Lorca has had earthquakes that were of greater magnitude than the May 2011 earthquake.
- ☐ The earthquake was followed by a number of smaller earthquakes felt in the region around Lorca.

GROUNDWATER EXTRACTION AND EARTHQUAKES

The 2011 Earthquake In Lorca

Lorca, Spain, is located in a region that experiences earthquakes relatively often. One earthquake occurred in Lorca in May 2011. Geologists believe that unlike previous earthquakes in the region, this earthquake may have been caused in part by human activity, specifically by the pumping of groundwater. According to the geologists' hypothesis, extracting water from underground contributed to stress on a nearby fault, which triggered a shift that resulted in the earthquake.

Students must identify the one observation that supports the hypothesis presented in the stimulus that groundwater extraction triggered an earthquake by contributing to stress on a nearby fault. The second option (*Movement along the fault was greatest in areas where the pumping created the greatest stress*) is the correct response as it supports an association between the water extraction and the earthquake.

<i>Item Number</i>	CS655Q03
<i>Competency</i>	Explain Phenomena Scientifically
<i>Knowledge – System</i>	Content – Earth and Space
<i>Context</i>	Local/National – Hazards
<i>Cognitive Demand</i>	Medium
<i>Item Format</i>	Simple Multiple Choice – Computer Scored

Unit 655 Groundwater Extraction and Earthquakes
Released Item #4

PISA 2015

Groundwater Extraction and Earthquakes
 Question 4 / 4

Refer to "The 2011 Earthquake In Lorca" on the right.
 Click on one or more boxes to answer the question.

A student who lives in a town in a region far from Lorca learns about the geologists' hypothesis about the 2011 earthquake in Lorca. The student knows that groundwater extraction in the region where he lives has led to a decline in the groundwater level. He is concerned about the possibility of earthquakes in his town. Which of the following questions should the student consider in evaluating the risk that groundwater extraction will trigger an earthquake in his town?

✓ Remember to select **one or more** boxes.

☐ Does the crust in the region contain faults?

☐ Is the crust in the region subject to stress from natural causes?

☐ Is water pumped from the ground in the region polluted?

☐ What are the average daily temperatures in the region?

GROUNDWATER EXTRACTION AND EARTHQUAKES
The 2011 Earthquake In Lorca

Lorca, Spain, is located in a region that experiences earthquakes relatively often. One earthquake occurred in Lorca in May 2011. Geologists believe that unlike previous earthquakes in the region, this earthquake may have been caused in part by human activity, specifically by the pumping of groundwater. According to the geologists' hypothesis, extracting water from underground contributed to stress on a nearby fault, which triggered a shift that resulted in the earthquake.

In this item, students must use their understanding of earthquakes and the provided information about the earthquake in Lorca to identify the question or questions most likely to provide information about the risk of earthquakes in a particular region. Both the first and second questions would provide that information: *Does the crust in the region contain faults?* and *Is the crust in the region subject to stress from natural causes?*

<i>Item Number</i>	CS655Q04
<i>Competency</i>	Explain Phenomena Scientifically
<i>Knowledge – System</i>	Content – Earth and Space
<i>Context</i>	Local/National – Hazards
<i>Cognitive Demand</i>	Medium
<i>Item Format</i>	Complex Multiple Choice – Computer Scored

Unit 639 Blue Power Plant

Unit Overview

This released unit focuses on a power plant that uses the differences in the salt concentration between salt water and fresh water to generate electricity. The stimulus includes text describing this process and an animation showing the movement of water through the plant and the movement of water molecules across a semipermeable membrane.


PISA 2015

Blue Power Plant
Introduction

Read the introduction. Then click on the NEXT arrow.

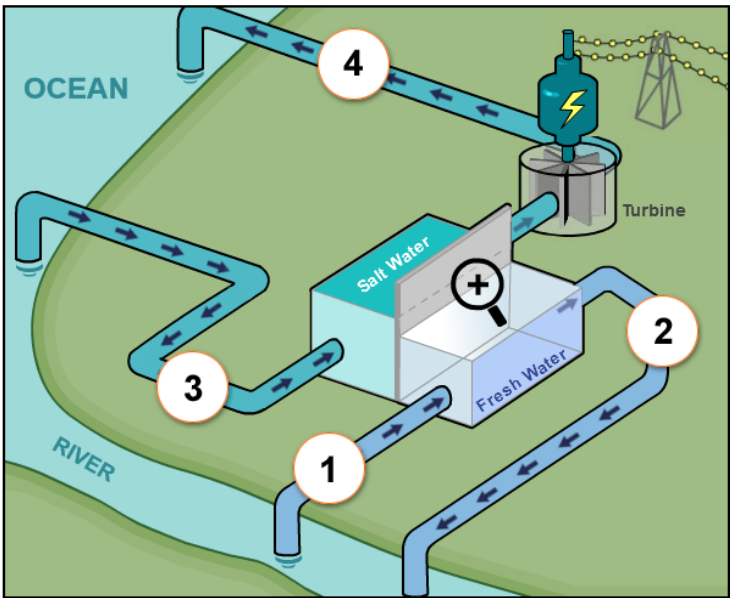
This animation shows a new kind of power plant that is located where a freshwater river and water from the ocean meet. The power plant uses the differences in the salt concentrations in the two bodies of water to produce electricity. In the power plant, fresh water from the river is pumped through a pipe into one container. Salt water from the ocean is pumped into another container. The two containers are separated by a membrane that allows only water molecules to move through it.

Water molecules naturally move through the membrane from the container of low salt concentration to the container of high salt concentration. This increases the volume and pressure of the water in the container of salt water.

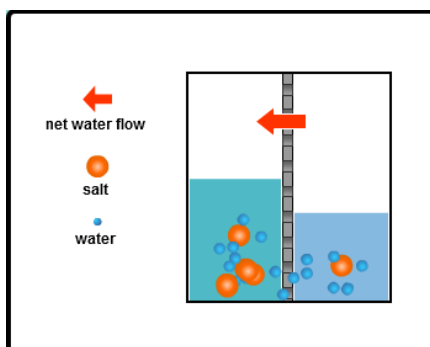
Click on the magnifying glass  to observe this movement of water molecules.

The high pressure water in the salt water container then flows through a pipe, moving a turbine to generate electricity.

BLUE POWER PLANT



View with the magnifying glass:



Unit 639 Blue Power Plant
Released Item #1

PISA 2015

⏻

?

⏮

⏭

Blue Power Plant
 Question 1 / 4

Refer to "Blue Power Plant" on the right. Click on one or more boxes to answer the question.

Four locations in the power plant have been numbered. Water is pumped from the river to location 1, marked on the screen.

✓ Remember to select **one or more** boxes.

In which locations could water molecules that come from the river be found later in the process?

☐ Location 2
☐ Location 3
☐ Location 4

Blue Power Plant

Students must apply their understanding of how water moves through the power plant presented in the diagram to identify *Location 2* and *Location 4* as containing water molecules from the river.

<i>Item Number</i>	CS639Q01
<i>Competency</i>	Interpret Data and Evidence Scientifically
<i>Knowledge – System</i>	Content – Physical
<i>Context</i>	Local/National – Frontiers
<i>Cognitive Demand</i>	Low
<i>Item Format</i>	Complex Multiple Choice – Computer Scored

Unit 639 Blue Power Plant
Released Item #2

PISA 2015

Blue Power Plant
 Question 2 / 4

Click on the magnifying glass to see what happens to the water molecules and dissolved salt in the containers. Select from the drop-down menus to complete the sentence.

River water has a low concentration of salt. As the molecules move through the membrane, the salt concentration in the container of fresh water

Select and the salt concentration in the container of salt water .

Blue Power Plant

The diagram illustrates a Blue Power Plant. It features a central container divided into two sections: 'Salt Water' on the left and 'Fresh Water' on the right, separated by a semi-permeable membrane. A magnifying glass is positioned over the membrane. Arrows indicate the flow of water and salt. Pipe 1 draws water from a 'RIVER' into the 'Fresh Water' container. Pipe 2 draws water from the 'Fresh Water' container to a 'Turbine'. Pipe 3 draws water from the 'Salt Water' container to the 'Turbine'. Pipe 4 draws water from the 'OCEAN' into the 'Salt Water' container. A legend in the bottom right corner shows a red arrow for 'net water flow', an orange circle for 'salt', and a blue circle for 'water'.

Students are asked to use the animation to determine the effect the movement of water across the membrane on the salt concentration of the fresh water and the salt water. The correct response is: As the molecules move through the membrane, the salt concentration in the container of fresh water *increases* and the salt concentration in the container of salt water *decreases*.

Item Number	CS639Q02
Competency	Interpret Data and Evidence Scientifically
Knowledge – System	Procedural
Context	Global – Frontiers
Cognitive Demand	Medium
Item Format	Complex Multiple Choice – Computer Scored

Unit 639 Blue Power Plant
Released Item #3

PISA 2015

Blue Power Plant
 Question 3 / 4

Refer to "Blue Power Plant" on the right. Select from the drop-down menus to answer the question.

Several energy conversions occur within the power plant. What kind of energy conversion occurs in the turbine and generator?

The turbine and generator convert

Select to Select

Blue Power Plant

Each drop-down menu in this item lists four types of energy: gravitational, potential, kinetic and electrical. Students must correctly interpret the animated diagram and specify that the turbine and generator convert *kinetic* to *electrical* energy.

<i>Item Number</i>	CS639Q04
<i>Competency</i>	Interpret Data and Evidence Scientifically
<i>Knowledge – System</i>	Content – Physical
<i>Context</i>	Local/National – Frontiers
<i>Cognitive Demand</i>	Medium
<i>Item Format</i>	Complex Multiple Choice – Computer Scored

Unit 639 Blue Power Plant
Released Item #4

PISA 2015

Blue Power Plant
 Question 4 / 4

Refer to "Blue Power Plant" on the right. Type your answer to the question.

Many electric power plants use fossil fuels, such as oil and coal, as their energy source.

Why is this new power plant considered to be more environmentally friendly than power plants that use fossil fuels?

Blue Power Plant

The diagram illustrates a 'Blue Power Plant' situated on a green landmass between a blue 'OCEAN' and a light blue 'RIVER'. The plant consists of a central desalination unit with two compartments: 'Salt Water' (top) and 'Fresh Water' (bottom). A magnifying glass icon is over the 'Fresh Water' compartment. Four numbered circles indicate the flow of water: (1) Salt water is pumped from the ocean into the desalination unit. (2) Fresh water is pumped from the desalination unit into a turbine. (3) Salt water is pumped from the desalination unit back into the ocean. (4) The turbine generates electricity, indicated by a lightning bolt symbol and a power line tower.

Students must provide an explanation that identifies a way in which plants that burn fossil fuel are more harmful to the environment than the new power plant illustrated in this unit, or identify a feature of the new power plant that makes it more environmentally friendly.

<i>Item Number</i>	CS639Q05
<i>Competency</i>	Explain Phenomena Scientifically
<i>Knowledge – System</i>	Content – Physical
<i>Context</i>	Global – Frontiers
<i>Cognitive Demand</i>	Medium
<i>Item Format</i>	Open Response – Human Coded

Unit 621 Adjustable Glasses**Unit Overview**

This released unit describes an innovative type of eyeglasses that use fluid to adjust the shape of the lenses. The interactive portion of the unit first allows students to investigate the effect of adjusting the amount of fluid in the lens on the shape of the lens. Students are then able to investigate the effect of the lens adjustments on the vision of three different people: one with normal vision, one with farsighted vision, and one with nearsighted vision.


PISA 2015

Adjustable Glasses
Introduction

Read the introduction. Then click on the NEXT arrow.

ADJUSTABLE GLASSES

A new technology, called **adjustable glasses**, has been developed to help people without access to eye doctors to correct their vision. The lenses of these glasses contain a fluid. The shape of the lens changes as the amount of fluid in the lens is adjusted.



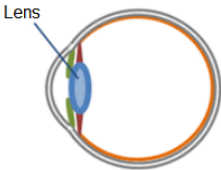
Unit 621 Adjustable Glasses
Released Item #1

PISA 2015

Adjustable Glasses
 Question 1 / 5

Click on a choice to answer the question.

The idea of adjustable lenses is not new. The human eye also has a lens that is adjustable.



The shape of the eye's lens is adjusted by muscle action. Why is it important for the eye's lens to change shape?

- ☐ To facilitate seeing objects that have different brightnesses
- ☐ To facilitate seeing objects that have different colours
- ☐ To facilitate seeing objects that are at different distances
- ☐ To facilitate seeing objects that have different sizes

Students must use content knowledge to correctly identify the third option, that the eye's lens must change shape *to facilitate seeing objects at different distances*.

<i>Item Number</i>	CS621Q01
<i>Competency</i>	Explain Phenomena Scientifically
<i>Knowledge – System</i>	Content – Living
<i>Context</i>	Personal – Health and Disease
<i>Cognitive Demand</i>	Low
<i>Item Format</i>	Simple Multiple Choice – Computer Scored

Unit 621 Adjustable Glasses
Released Item #2

PISA 2015

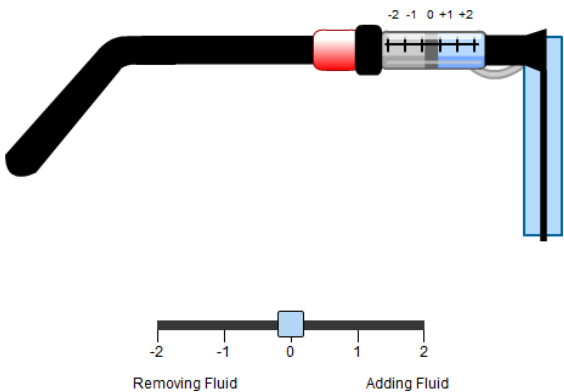
Adjustable Glasses
 Question 2 / 5

Use the slider to change the amount of fluid in the lens.
 Select from the drop-down menus to answer the question.

How does adding fluid affect the shape of the glasses' lens?

When fluid is added to a flat lens, the sides of the lens curve
 select because the net force exerted by the fluid
 on the lens sides is select .

A side view of a pair of adjustable glasses is shown below. The initial shape of the lens is flat.



The diagram shows a side view of a pair of adjustable glasses. A slider is located on the right side of the frame, with a red and white knob. The slider has tick marks and labels for -2, -1, 0, +1, and +2. Below the slider is a horizontal scale from -2 to 2. The left side of the scale (from -2 to 0) is labeled 'Removing Fluid' and the right side (from 0 to 2) is labeled 'Adding Fluid'. The glasses' lens is shown as a vertical blue rectangle on the right side of the frame.

The options in the drop-down menus are outward and inward for the first menu and more and less for the second. Using the simulated adjustable glasses, students are asked to determine that when fluid is added to a flat lens, the sides of the lens curve *outward* and then interpret the simulation to specify that this is because the net force exerted by the fluid on the lens is *more*.

<i>Item Number</i>	CS621Q02
<i>Competency</i>	Interpret Data and Evidence Scientifically
<i>Knowledge – System</i>	Content – Physical
<i>Context</i>	Personal – Frontiers
<i>Cognitive Demand</i>	Low
<i>Item Format</i>	Complex Multiple Choice – Computer Scored

Unit 621 *Adjustable Glasses*

Introduction to second simulation

The introduction provides information about the vision of three students, each of whom will be investigated using the simulation.

The screenshot shows the PISA 2015 software interface. At the top, there is a blue header bar with the text "PISA 2015" on the left, a series of five small colored squares (green, white, green, green, green) in the center, and a power button icon on the right. To the right of the header bar are three navigation icons: a question mark, a left arrow, and a right arrow.

Below the header bar is a light blue rectangular box containing the text "Adjustable Glasses" in bold and "Investigations" below it. Underneath this box, a line of text reads: "Read the information below. Then click on the NEXT arrow."

The main content area is a large white rectangle with a thin green border. Inside this area, the title "ADJUSTABLE GLASSES INVESTIGATIONS" is centered at the top. Below the title, a line of text states: "Three students with different vision experiment with a pair of adjustable glasses."

Below this text are three entries, each consisting of a small square icon with a silhouette and a line of text:

- The first entry has an orange icon and the text: "Anna sees both near and distant objects **in focus**."
- The second entry has a blue icon and the text: "Daniel sees distant objects **in focus** but near objects appear **out of focus**."
- The third entry has a purple icon and the text: "Maria sees near objects **in focus** but distant objects appear **out of focus**."

Unit 621 *Adjustable Glasses*

How to Run the Simulation

Before beginning this part of the unit, students are provided with a brief introduction to the controls in the simulation and are allowed to practice setting each control. Help messages display if students do not take the requested actions within 1 minute. If students time out by not acting at all within 2 minutes, they are shown what the simulation would look like if the controls were set as specified. As explained in the orientation, reminders about how to use the controls are available on subsequent screens by clicking on the “How to Run the Simulation” tab.

PISA 2015

?

◀

▶

Adjustable Glasses

Running the Simulation

In this simulation, you will be able to see how the amount of fluid in the lens affects the students' ability to see a tree clearly from each of the three distances shown below.

near
midway
distant

To see how all the controls in this simulation work, follow these steps:

1. Move the slider for **amount of fluid in lens**.
2. Select the **distance from tree**.
3. Click the "Run" button to see whether the tree will appear in focus or out of focus to the student. The results will be recorded in the table.

in focus

out of focus

?

▶

▶

Anna's View

Amount of Fluid in Lens

0

-2
-1
1
2

Distance from Tree

☐ near

☒ midway

☐ distant

Run

		Amount of Fluid in Lens				
		-2	-1	0	+1	+2
Distance from Tree	Near					
	Midway					
	Distant					

Unit 621 Adjustable Glasses
Released Item #3

PISA 2015

Adjustable Glasses
 Question 3 / 5

► **How to Run the Simulation**

Run the simulation to collect data based on the information below. Select from the drop-down menu to answer the question.

Anna sees both near and distant objects in focus.

How do adjustments to the glasses affect Anna's vision?

Adding fluid to the lens makes objects appear out of focus.

Removing fluid from the lens makes objects appear out of focus.

Anna's View

Amount of Fluid in Lens

-2 -1 0 1 2

Distance from Tree

near midway distant

Run

		Amount of Fluid in Lens				
		-2	-1	0	+1	+2
Distance from Tree	Near					
	Midway					
	Distant					

The two drop-down menus have the same options: distant and near. Students are asked to use the simulation and the data they generate to identify that adding fluid makes *distant* objects appear out of focus for Anna and removing fluid makes *near* objects appear out of focus.

<i>Item Number</i>	CS621Q03
<i>Competency</i>	Interpret Data and Evidence Scientifically
<i>Knowledge – System</i>	Procedural
<i>Context</i>	Personal – Frontiers
<i>Cognitive Demand</i>	Medium
<i>Item Format</i>	Complex Multiple Choice – Computer Scored

Unit 621 Adjustable Glasses
Released Item #4

PISA 2015

Adjustable Glasses
 Question 4 / 5

► **How to Run the Simulation**


Run the simulation to collect data based on the information below. Click on one or more boxes to answer the question.

Daniel sees distant objects in focus but near objects appear out of focus.


What adjustments to the glasses allow Daniel to see near objects in focus?

✓ Remember to select **one or more** boxes.

☐ +2 Adding the full amount of fluid
☐ +1 Adding some fluid
☐ -1 Removing some fluid
☐ -2 Removing the full amount of fluid



Daniel's View






Amount of Fluid in Lens

-2 -1 0 1 2

Distance from Tree

near midway distant

Run

		Amount of Fluid in Lens				
		-2	-1	0	+1	+2
Distance from Tree	Near					
	Midway					
	Distant					

Students are asked to use the simulation to identify the adjustments that will improve Daniel's near vision. There are two correct responses: +2 *Adding the full amount of fluid* and +1 *Adding some fluid*.

Item Number	CS621Q04
Competency	Interpret Data and Evidence Scientifically
Knowledge – System	Procedural
Context	Personal – Frontiers
Cognitive Demand	Medium
Item Format	Complex Multiple Choice – Computer Scored

Unit 621 Adjustable Glasses
Released Item #5

PISA 2015

Adjustable Glasses
 Question 5 / 5

How to Run the Simulation

Run the simulation to collect data based on the information below. Click on a choice to answer the question.

Maria sees near objects in focus but distant objects appear out of focus.

What adjustment to the glasses will allow Maria to see in focus at all three distances?

☐ +2 Adding the full amount of fluid
☐ +1 Adding some fluid
☐ -1 Removing some fluid
☐ -2 Removing the full amount of fluid

Maria's View

Amount of Fluid in Lens

-2 -1 0 1 2

near midway distant

Run

		Amount of Fluid in Lens				
		-2	-1	0	+1	+2
Distance from Tree	Near					
	Midway					
	Distant					

Students are asked to use the simulation and the data they generate to identify the adjustments that will improve Maria's distant vision. In this case there is one correct response: *-1 Removing some fluid*

Item Number	CS621Q05
Competency	Interpret Data and Evidence Scientifically
Knowledge – System	Procedural
Context	Personal – Frontiers
Cognitive Demand	Medium
Item Format	Simple Multiple Choice – Computer Scored

Unit 623 *Running in Hot Weather*

Unit Overview

This released unit presents a scientific enquiry related to thermoregulation using a simulation that allows students to manipulate the air temperature and air humidity levels experienced by long-distance runners, as well as whether or not the simulated runner drinks water. The student selects the air temperature, air humidity, and whether the runner is drinking water (yes/no). After running the simulation the runner's sweat volume, water loss and body temperature are displayed. When the conditions trigger dehydration or heat stroke, those health dangers are highlighted in the display.

PISA 2015

Running in Hot Weather
Introduction

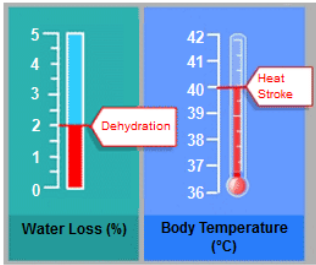
Read the introduction. Then click on the NEXT arrow.

RUNNING IN HOT WEATHER

During long-distance running, body temperature rises and sweating occurs.

If runners do not drink enough to replace the water they lose through sweating, they can experience dehydration. Water loss of 2% of body mass and above is considered to be a state of dehydration. This percentage is labeled on the water loss meter shown below.

If the body temperature rises to 40°C and above, runners can experience a life-threatening condition called heat stroke. This temperature is labeled on the body temperature thermometer shown below.



Meter Type	Scale	Current Value	Warning Label
Water Loss (%)	0 to 5	2	Dehydration
Body Temperature (°C)	36 to 42	40	Heat Stroke

Unit 623 *Running in Hot Weather*

How to Run the Simulation

Before beginning the unit, students are provided with a brief introduction to the controls in the simulation and are allowed to practice setting each control. Help messages display if students do not take the requested actions within 1 minute. If students time out by not acting at all within 2 minutes, they are shown what the simulation would look like if the controls were set as specified. As explained in the orientation, reminders about how to use the controls, as well as how to select or delete a row of data, are available on subsequent screens by clicking on the “How to Run the Simulation” tab.

PISA 2015


Running in Hot Weather
Introduction

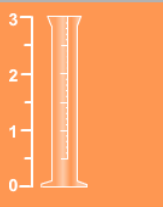
This simulation is based on a model that calculates the volume of sweat, water loss, and body temperature of a runner after a one-hour run.

To see how all the controls in this simulation work, follow these steps:

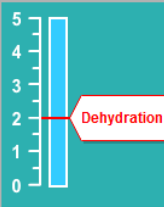
1. Move the slider for **Air Temperature**.
2. Move the slider for **Air Humidity**.
3. Click on either "Yes" or "No" for **Drinking Water**.
4. Click on the "Run" button to see the results. Notice that a water loss of 2% and above causes dehydration, and that a body temperature of 40°C and above causes heat stroke. The results will also display in the table.

Note: The results shown in the simulation are based on a simplified mathematical model of how the body functions for a particular individual after running for one hour in different conditions.

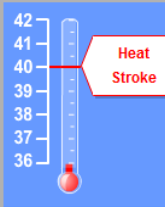




Sweat Volume (Litres)



Water Loss (%)



Body Temperature (°C)

Air Temperature (°C)

20 25 30 35 40

Air Humidity (%)

20 40 60

Drinking Water

☒ Yes
 ☐ No

Run

Air Temperature (°C)	Air Humidity (%)	Drinking Water	Sweat Volume (Litres)	Water Loss (%)	Body Temperature (°C)

Unit 623 Running in Hot Weather
Released Item #1

PISA 2015

Running in Hot Weather

Question 1 / 6

How to Run the Simulation


Run the simulation to collect data based on the information below. Select from the drop-down menus to answer the question.

A runner runs for one hour on a hot, dry day (air temperature 40°C, air humidity of 20%). The runner does not drink any water.

What health danger does the runner encounter by running under these conditions?

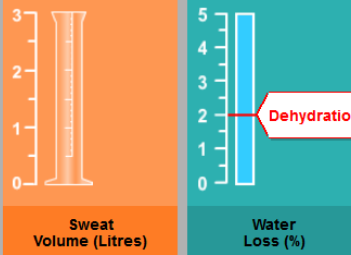
The health danger that the runner encounters is .

This is shown by the of the runner after a one-hour run.



Sweat Volume (Litres)

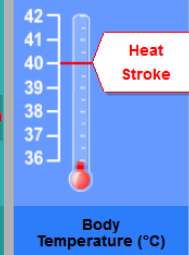
0 1 2 3



Water Loss (%)

0 1 2 3 4 5

Dehydration



Body Temperature (°C)

36 37 38 39 40 41 42

Heat Stroke

Air Temperature (°C)

Air Humidity (%)

Drinking Water ☒ Yes ☐ No

Run

Air Temperature (°C)	Air Humidity (%)	Drinking Water	Sweat Volume (Litres)	Water Loss (%)	Body Temperature (°C)

Students are asked to use the simulation to determine whether the person running under the described conditions is in danger of either dehydration or heat stroke. They are also asked to specify whether this is shown by the runner's sweat volume, water loss or body temperature. The available options in the drop-down menus are: dehydration/heat stroke and sweat volume/water loss/body temperature.

The correct response is that the health danger is *dehydration* as shown by the runner's *water loss*.

Item Number	CS623Q01
Competency	Interpret Data and Evidence Scientifically
Knowledge – System	Procedural
Context	Personal – Health and Disease
Cognitive Demand	Low
Item Format	Complex Multiple Choice – Computer Scored

Unit 623 *Running in Hot Weather* Released Item #2

PISA 2015

Running in Hot Weather

Question 2 / 6

How to Run the Simulation


Run the simulation to collect data based on the information below. Click on a choice and then select data in the table to answer the question.

A runner runs for an hour on a hot and humid day (air temperature 35°C, air humidity of 60%) without drinking any water. This runner is at risk of both dehydration and heat stroke.

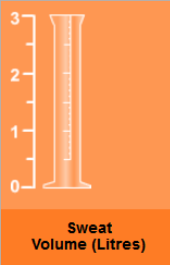
What would be the effect of drinking water during the run on the runner's risk of dehydration and heat stroke?

- ☐ Drinking water would reduce the risk of heat stroke but not dehydration.
- ☐ Drinking water would reduce the risk of dehydration but not heat stroke.
- ☐ Drinking water would reduce the risk of both heat stroke and dehydration.
- ☐ Drinking water would not reduce the risk of either heat stroke or dehydration.

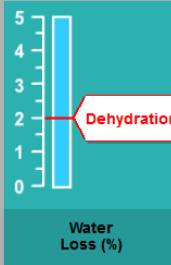
★ Select two rows of data in the table to support your answer.



Sweat Volume (Litres)



Water Loss (%)



Body Temperature (°C)

Air Temperature (°C) 20 25 30 35 40

Air Humidity (%) 20 40 60

Drinking Water ☒ Yes ☐ No

Run

Air Temperature (°C)	Air Humidity (%)	Drinking Water	Sweat Volume (Litres)	Water Loss (%)	Body Temperature (°C)

Students are asked to run the simulation holding the air temperature and humidity constant while varying whether or not the runner drinks water. They must use the data they generate to identify that the second option is correct: *Drinking water would reduce the risk of dehydration but not heat stroke*. In support of their response, they must also select two rows of data where drinking water is set to “No” in one case and “Yes” in the other, with an air temperature of 35°C and air humidity of 60% for both rows.

Item Number	CS623Q02
Competency	Explain Phenomena Scientifically
Knowledge – System	Content – Living
Context	Personal – Health and Disease
Cognitive Demand	Low
Item Format	Simple Multiple Choice and Open Response - Computer Scored

Unit 623 Running in Hot Weather
Released Item #3

PISA 2015

Running in Hot Weather
 Question 3 / 6

► **How to Run the Simulation**

Run the simulation to collect data based on the information below. Click on a choice, select data in the table, and then type an explanation to answer the question.

When the air humidity is 60%, what is the effect of an increase in air temperature on sweat volume after a one-hour run?

☐ Sweat volume increases
☐ Sweat volume decreases

★ Select two rows of data in the table to support your answer.

What is the biological reason for this effect?

Air Temperature (°C)
 Air Humidity (%)
 Drinking Water ☒ Yes ☐ No

Run

Air Temperature (°C)	Air Humidity (%)	Drinking Water	Sweat Volume (Litres)	Water Loss (%)	Body Temperature (°C)

Illustrations: A runner, a sweat volume scale (0-3 Litres), a water loss scale (0-5%), and a body temperature scale (36-42°C) showing a 'Heat Stroke' warning at 40°C.

This item includes two separately coded questions: CS623Q03 includes the multiple-choice question and selection of data to support that answer; CS623Q04. asks students to explain the reason that sweat volume increases under the specified conditions. Unlike the previous questions, only humidity is specified. Students must investigate how varying air temperatures impact sweat volume.

The correct response for CS623Q03 is that *sweat volume increases* when air temperature increases at 60% humidity and the selected rows of data must include one row with a temperature set to a lower number and one to a higher number, with both at a 60% humidity level (e.g., 20°C at 60% and 25°C at 60% or 35°C at 60% and 40°C at 60%)

For CS623Q04, students must explain that sweating is a mechanism used by the body to lower body temperature as the biological reason for this increase in sweat volume at higher temperatures.

<i>Item Number</i>	CS623Q03 and CS623Q04
<i>Competency</i>	Q03: Evaluate and Design Scientific Enquiry Q04: Explain Phenomena Scientifically
<i>Knowledge – System</i>	Q03: Procedural Q04: Content – Living
<i>Context</i>	Personal – Health and Disease
<i>Cognitive Demand</i>	Medium
<i>Item Format</i>	Q03: Simple Multiple Choice and Open Response – Computer Scored Q04: Open Response – Human Coded

Unit 623 Running in Hot Weather
Released Item #4

PISA 2015

Running in Hot Weather
 Question 4 / 6

► **How to Run the Simulation**

Run the simulation to collect data based on the information below. Click on a choice, select data in the table, and then type an explanation to answer the question.

Based on the simulation, when the air humidity is 40%, what is the highest air temperature at which a person can run for one hour without getting heat stroke?

☐ 20°C
☐ 25°C
☐ 30°C
☐ 35°C
☐ 40°C

★ Select two rows of data in the table to support your answer.

Explain how this data supports your answer.

Air Temperature (°C) 20 25 30 35 40
 Air Humidity (%) 20 40 60
 Drinking Water ☒ Yes ☐ No

Run

Air Temperature (°C)	Air Humidity (%)	Drinking Water	Sweat Volume (Litres)	Water Loss (%)	Body Temperature (°C)

Students are asked to use the simulation to identify the highest temperature at which a person can run without getting heat stroke when the humidity is 40%. The correct response is 35°C and students must select the following two rows of data to support their response: 35°C air temperature - 40% humidity and 40°C air temperature - 40% humidity. They must further explain how the selected rows of data support their answer by indicating that at 40% humidity moving the air temperature up from 35°C to 40°C causes heat stroke.

<i>Item Number</i>	CS623Q05
<i>Competency</i>	Evaluate and Design Scientific Enquiry
<i>Knowledge – System</i>	Procedural
<i>Context</i>	Personal – Health and Disease
<i>Cognitive Demand</i>	Medium
<i>Item Format</i>	Open Response – Human Coded

Unit 623 Running in Hot Weather

Released Item #5³

PISA 2015

Running in Hot Weather

Question 5 / 6

► How to Run the Simulation

Run the simulation to collect data based on the information below. Click on a choice, select data in the table, and then type an explanation to answer the question.


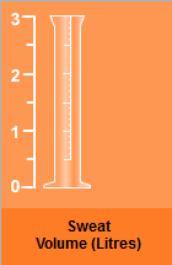
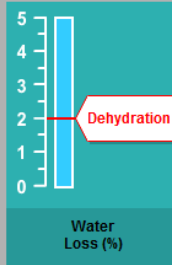
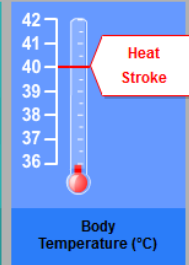
The simulation allows you to choose 20%, 40% or 60% for air humidity.

Do you expect that it would be safe or unsafe to run while drinking water with the air humidity at 50% and air temperature of 40°C?

☐ Safe
☐ Unsafe

★ Select two rows of data to support your answer.

Explain how this data supports your answer.

Air Temperature (°C) 20 25 30 35 40

Air Humidity (%) 20 40 60

Drinking Water ☒ Yes ☐ No

Run

Air Temperature (°C)	Air Humidity (%)	Drinking Water	Sweat Volume (Litres)	Water Loss (%)	Body Temperature (°C)

Students use the simulation to develop a hypothesis about the safety of running at 40°C at 50% humidity (a humidity value that cannot be set on the slider). By testing the humidity levels below and above 50% at 40°C, students can conclude that it would be *unsafe* to run at 40°C, even while drinking water. To support this response, they must select one row with 40% humidity at 40°C with drinking water set to “Yes” and a second with 60% humidity at 40°C with drinking water set to “Yes”. The explanation must indicate that, given that the runner would suffer from heat stroke at both 40% and 60% humidity at 40°C while drinking water; there is a risk of heat stroke at 50% humidity under those same conditions.

Item Number	CS623Q06
Competency	Evaluate and Design Scientific Enquiry
Knowledge – System	Procedural
Context	Personal – Health and Disease
Cognitive Demand	High
Item Format	Open Response – Human Coded

³ Note that the last item in this unit, CS623Q08, is not included among the released items.

Unit 633 *Energy-Efficient House*

Unit Overview

This released unit focuses on how different roof colours affect energy consumption. The simulation allows students to investigate the effect of roof colour on the amount of energy needed to heat or cool a house to a constant temperature of 23°C. For each trial, the student selects a roof colour and outside temperature. After pressing “Run,” the simulation displays energy consumption at the selected colour and temperature.

PISA 2015

?

◀

▶

Energy-Efficient House
Introduction

Read the introduction. Then click on the NEXT arrow.

ENERGY-EFFICIENT HOUSE

There is a growing interest worldwide in building energy-efficient houses. A reduction in energy consumption can save money for owners and can reduce greenhouse gas emissions to the atmosphere. Architects can use simulations to investigate the effect on energy consumption of different choices made in the design of a house.



Unit 633 *Energy-Efficient House*

How to Run the Simulation

Before beginning the unit, students are provided with a brief introduction to the controls in the simulation and are allowed to practice setting each control. Help messages display if students do not take the requested actions within 1 minute. If students time out by not acting at all within 2 minutes, they are shown what the simulation would look like if the controls were set as specified. As explained in the orientation, reminders about how to use the controls, as well as how to select or delete a row of data, are available on subsequent screens by clicking on the “How to Run the Simulation” tab.

PISA 2015

Energy-Efficient House

Introduction

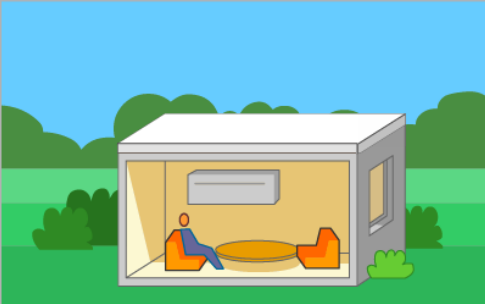
This simulation allows you to explore how different roof colours affect energy consumption. Some solar radiation hitting the roof will be reflected. Some solar radiation will be absorbed and heat up the house.

The simulated house will consume energy both for heating and for cooling in order to maintain the house at a comfortable indoor temperature of 23°C across a range of outdoor temperatures.

To see how all the controls in this simulation work, follow these steps:

1. Click on a **roof colour**.
2. Click on an **outdoor temperature**.
3. Click on the “Run” button to see what happens to energy consumption. The results will display in the table.

Note: Energy consumed is measured in watt-hours. A watt-hour is equal to one watt of power supplied for one hour.



Energy Consumption

Watt-hours

Roof Colour

Indoor Temperature 23 °C
Outdoor Temperature (°C)

0 10 20 30 40

Run

Outdoor Temperature (°C)	Roof Colour	Energy Consumption (watt-hours)

Unit 633 Energy-Efficient House
Released Item #1

PISA 2015

Energy-Efficient House




Question 1 / 4

How to Run the Simulation

Run the simulation to collect data based on the information below. Use drag and drop and then select data in the table to answer the question.




Some houses will be built in an area that has a very hot climate, with outdoor temperatures often at 40°C and above. You have been asked to help decide which roof colour is best to use on the houses.

Put the three roof colours in order of **decreasing** energy consumption for a house being cooled to 23°C in a very hot climate.

Energy Consumption

Highest → Lowest


★ Select three rows of data in the table to support your answer.

Roof Colour

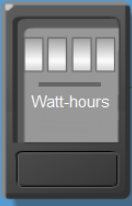
Indoor Temperature 23 °C
 Outdoor Temperature (°C) ● 0 ○ 10 ○ 20 ○ 30 ○ 40

Run

Outdoor Temperature (°C)	Roof Colour	Energy Consumption (watt-hours)



Energy Consumption



Watt-hours

Students are asked to select an outside temperature of 40°C and use the simulation results to put the roof colours in order from highest to lowest in terms of energy consumption as well as identify the data that support their selections. The correct response is: *black* (highest energy consumption at this temperature), *red* (middle), *white* (lowest) and the 3 supporting rows of data include ones with the outdoor temperature set to a constant 40°C and each of three roof colours selected (red, black and white).

<i>Item Number</i>	CS633Q01
<i>Competency</i>	Interpret Data and Evidence Scientifically
<i>Knowledge – System</i>	Procedural
<i>Context</i>	Local/National – Natural Resources
<i>Cognitive Demand</i>	Low
<i>Item Format</i>	Open Response – Computer Scored

Unit 633 Energy-Efficient House
Released Item #2

PISA 2015

Energy-Efficient House

Question 2 / 4

How to Run the Simulation


Run the simulation to collect data based on the information below. Select from the drop-down menu, select data in the table, and then type an explanation to answer the question.

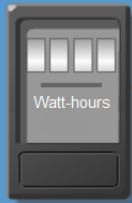
When the outdoor temperature is at 10°C, what is the difference in energy consumption between a house with a white roof and a house with a black roof?

At 10°C, a house with a white roof uses energy than a house with a black roof.

★ Select two rows of data in the table to support your answer.

Explain the difference in energy consumption by describing what happens to solar radiation when it hits these two different colours of roof.



Energy Consumption


Roof Colour: ☒ White ☐ Red ☐ Black

Indoor Temperature 23 °C
 Outdoor Temperature (°C): ☒ 0 ☐ 10 ☐ 20 ☐ 30 ☐ 40

Run

Outdoor Temperature (°C)	Roof Colour	Energy Consumption (watt-hours)

Students are asked to use the simulation to compare the energy consumption of a house with a white roof versus one with a black roof at 10°C. This item includes two separate coded questions: CS633Q02 includes the multiple-choice question and the selection of data to support that answer; CS633Q03 asks students to explain the how roof colour affects the reflection and absorption of solar radiation.

CS633Q02 includes both a drop-down selection and data selection. The white roof uses *more* energy than the black roof to heat the house to 23°C when the outdoor temperature is 10°C. The supporting data include two rows with the outdoor temperature of 10°C – one with a white roof selected and the other with a black roof selected.

To explain this phenomenon in CS633Q03, students must indicate or imply that sunlight is a source of energy, or heat, and that the black roof absorbs more solar radiation than the white roof.

Item Number	CS633Q02 and CS633Q03
Competency	Q02: Interpret Data and Evidence Scientifically Q03: Explain Phenomena Scientifically
Knowledge – System	Q02: Procedural Q03: Content – Physical
Context	Local/National – Natural Resources
Cognitive Demand	Medium
Item Format	Q02: Open Response – Computer Scored Q03: Open Response – Human Coded

Unit 633 Energy-Efficient House
Released Item #3

PISA 2015

Energy-Efficient House

Question 3 / 4

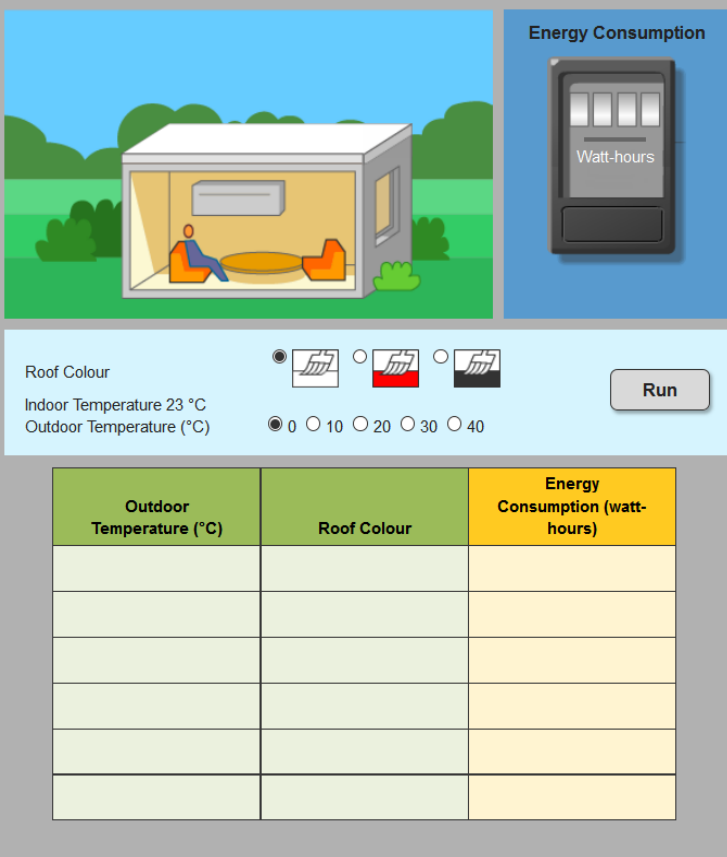
► How to Run the Simulation

Run the simulation to collect data based on the information below. Select from the drop-down menus to answer the question.

According to the simulation, how does the energy consumption of a house with a red roof compare to the energy consumption of a house with a white roof?

At 10°C and below, a house with a red roof has
 Select energy consumption than a house with a white roof.

At 20°C and above, a house with a red roof has
 Select energy consumption than a house with a white roof.



Energy Consumption

Watt-hours

Roof Colour

Indoor Temperature 23 °C
 Outdoor Temperature (°C)

Run

Outdoor Temperature (°C)	Roof Colour	Energy Consumption (watt-hours)

Students are asked to run the simulation to compare the energy consumption of a house with a red roof versus one with a white roof first at 10°C and then at 20°C. Students should determine that a house with a red roof has *lower* energy consumption than one with a white roof at temperatures of 10°C or below, but *higher* energy consumption at temperatures of 20°C or above.

Item Number	CS633Q04
Competency	Interpret Data and Evidence Scientifically
Knowledge – System	Procedural
Context	Local/National – Natural Resources
Cognitive Demand	Medium
Item Format	Complex Multiple Choice – Computer Scored

Unit 633 Energy-Efficient House
Released Item #4

PISA 2015

Energy-Efficient House
 Question 4 / 4

► **How to Run the Simulation**

Run the simulation to collect data based on the information below. Click on a choice to answer the question.

Based on the simulation, what can you conclude about the relationship between the outdoor temperature and energy consumption for the full range of temperatures for all three roof colours?

- ☐ When the outdoor temperature increases, energy consumption increases.
- ☐ When the outdoor temperature decreases, energy consumption increases.
- ☐ When the difference between the outdoor temperature and the indoor temperature increases, energy consumption increases.
- ☐ When the difference between the outdoor temperature and the indoor temperature decreases, energy consumption increases.

Roof Colour

Indoor Temperature 23 °C
 Outdoor Temperature (°C) ☒ 0 ☐ 10 ☐ 20 ☐ 30 ☐ 40

Run

Outdoor Temperature (°C)	Roof Colour	Energy Consumption (watt-hours)

Energy Consumption

Watt-hours

Students are asked to select a statement about the relationship between outdoor temperature and energy consumption that is supported by the simulation. The correct response is the third option: *When the difference between the outdoor temperature and the indoor temperature increases, energy consumption increases.*

Item Number	CS633Q05
Competency	Interpret Data and Evidence Scientifically
Knowledge – System	Content – Physical
Context	Local/National – Natural Resources
Cognitive Demand	High
Item Format	Simple Multiple Choice – Computer Scored