

RUNNING IN HOT WEATHER - INTRODUCTION

This unit presents a scientific enquiry about thermoregulation in the context of long-distance runners training in a location where weather conditions are sometimes hot and/or humid. The simulation allows students to manipulate the air temperature and air humidity levels, as well as whether or not the simulated runner drinks water. For each trial, data associated with the selected variables are displayed, including: air temperature, air humidity, drinking water (yes/no), sweat volume, water loss and body temperature. The runner's sweat volume, water loss and body temperature are also displayed on the top panel in the simulation panel. When the conditions trigger dehydration or heat stroke those health dangers are highlighted with red flags.

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Running in Hot Weather
Introduction

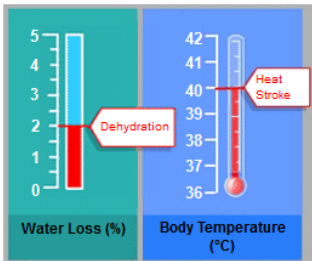
Read the introduction. Then click on the NEXT arrow.

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

RUNNING IN HOT WEATHER - PRACTICE

Before beginning the unit, students are introduced to the simulation controls and asked to practice setting each control. Help messages are displayed if students do not perform the requested actions within 1 minute. If students time-out by not acting within 2 minutes, they are shown what the simulation would look like if the controls were set as specified in the provided instructions. As explained in the orientation that students take before beginning the Science section, reminders about how to use the controls, as well as how to select or delete a row of data are available on each question screen by clicking on the “How to Run the Simulation” tab in the left pane.

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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.

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)

RUNNING IN HOT WEATHER – QUESTION 1

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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.

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

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

Students are asked to use the simulation and the data they generate to identify whether the person running under the specified 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.

Question Type	Complex Multiple Choice
Competency	Interpret Data and Evidence Scientifically
Knowledge – System	Procedural - Living
Context	Personal – Health and Disease
Difficulty	497 – Level 3

Scoring

Full credit

The student selects:

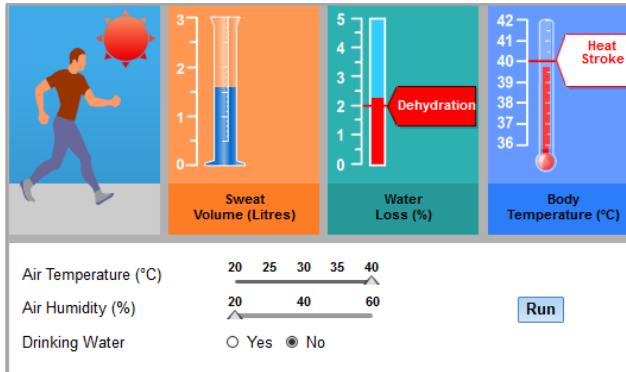
The health danger that the runner encounters is (dehydration/heat stroke).¹

This is shown by the (sweat volume/water loss/body temperature) of the runner after a one-hour run.

¹ Note that underlining indicates the correct response.

Comment

In this question, students are provided with the specific values for each of the variables in the simulation. They must set the controls as specified and run the simulation once. A red flag is displayed indicating that, under these conditions, the runner would suffer from water loss leading to dehydration. This is the easiest question in the unit, requiring students to carry out a straightforward procedure, identify the flagged condition in the display as shown below, and interpret the display to correctly identify water loss as the cause of the runner's dehydration.



RUNNING IN HOT WEATHER – QUESTION 2

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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.

The simulation interface includes four gauges: a runner icon, a 'Sweat Volume (Litres)' gauge (0-3), a 'Water Loss (%)' gauge (0-5) with a 'Dehydration' label, and a 'Body Temperature (°C)' gauge (36-42) with a 'Heat Stroke' label. Below the gauges are sliders for 'Air Temperature (°C)' (20-40), 'Air Humidity (%)' (20-60), and a 'Drinking Water' radio button (Yes/No). A 'Run' button is also present.

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

<i>Question Type</i>	Simple Multiple Choice/Open Response
<i>Competency</i>	Interpret Data and Evidence Scientifically
<i>Knowledge – System</i>	Content – Living
<i>Context</i>	Personal – Health and Disease
<i>Difficulty</i>	580 – Level 4

Scoring

Full Credit

The student selects:

Drinking water would reduce the risk of dehydration but not heat stroke AND selects the following two rows in the data table:

- Air temperature set to 35° C, 60% air humidity and “No” for drinking water AND
- Air temperature set to 35° C, 60% air humidity and “Yes” for drinking water

Partial Credit

The student selects:

Drinking water would reduce the risk of dehydration but not heat stroke AND selects incorrect or incomplete data.

Comment

In question 2, students are asked to run the simulation holding the air temperature and humidity constant using specified values, and they must manipulate the variable of whether or not the runner drinks water. The simulation shows that running under the specified conditions without drinking water leads to both dehydration and heat stroke. In contrast, drinking water reduces the risk of dehydration but not the risk of heat stroke. Students must run the simulation twice in order to collect the data that supports their answer. Because students must manipulate one variable and compare the outcomes of two trials, this question is more difficult than the first question in the unit.

RUNNING IN HOT WEATHER – QUESTIONS 3A AND 3B²

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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) 20 25 30 35 40
 Air Humidity (%) 20 40 60
 Drinking Water Yes No

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

3A

<i>Question Type</i>	Multiple Choice and Open Response (select data) – Computer Scored
<i>Competency</i>	Evaluate and Design Scientific Enquiry
<i>Knowledge – System</i>	Procedural – Living
<i>Context</i>	Personal – Health and Disease
<i>Difficulty</i>	531 – Level 3

3B

<i>Question Type</i>	Open Response – Human Coded
<i>Competency</i>	Explain Phenomena Scientifically
<i>Knowledge – System</i>	Content – Living
<i>Context</i>	Personal – Health and Disease
<i>Difficulty</i>	641 – Level 5

² Note that these two questions are identified as Q03 and Q04 in the item codes.

Scoring

3A

Full Credit

The student selects:

Sweat volume increases

AND

The two selected rows must have air humidity of 60% and two different air temperatures selected (one lower and one higher – such as 20°C in one row and 25°C in the second or 35°C in one row and 40°C in the second, etc.) In addition, drinking water must have the same setting (either “Yes” or “No”) in both of the selected rows.

3B

Note to coders in the coding guide:

Coders will only code the response to the open-response question: What is the biological reason for this effect?

The computer will separately score 0 or 1 for the selection and the rows of data.

Coders should code the written response based on the assumption that the student has selected “Sweat volume increases” even if that is not the student’s selection.

Full Credit

The student’s response indicates or implies the function of sweat in cooling the body and/or regulating body temperature.

- Sweat evaporates to cool the body when temperatures are high.
- Increasing sweat levels in high temperatures keeps the body from getting too hot.
- Sweat helps maintain body temperature at a safe level.

Comment

This set includes two separately coded questions: 3A is a multiple-choice question and also requires the selection of data to support that answer; 3B asks students to explain the reason that sweat volume increases under the specified conditions.

In 3A, one variable is defined – the humidity level – and students must run the simulation using at least two different temperatures to show the impact of an increase in temperature on sweat volume. Students must identify at least two rows of data in the data table that supports their answer. This question falls at Level 3.

Question 3B is the most difficult question in the unit at Level 5. It requires students to draw on their knowledge of biology (content knowledge) to explain that sweating cools the body at higher temperatures.

RUNNING IN HOT WEATHER – QUESTION 4³

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

<i>Question Type</i>	Open Response – Human Coded
<i>Competency</i>	Evaluate and Design Scientific Enquiry
<i>Knowledge – System</i>	Procedural – Living
<i>Context</i>	Personal – Health and Disease
<i>Difficulty</i>	592 – Level 4

Scoring

Full Credit

The student selects **35°C**

AND

The two rows selected have 40% humidity at 35°C air temperature and 40% humidity at 40°C air temperature

AND

The student gives an explanation that indicates or implies that with humidity at 40%, 35°C is the highest air temperature that is safe from heat stroke, since moving the air temperature up from 35°C to 40°C puts the runner into heat stroke.

³ Note that this is identified as Q05 in the item codes.

- As the outdoor temperature goes up from 35° to 40°C, the body temperature goes above 40°C, putting the runner in heat stroke.
- At 40% humidity, running in 40°C air temperature leads to heat stroke, but at 35°C the runner's body temperature remains just below the level of heat stroke.
- When the air temperature is increased, 40°C is the first time the runner gets heat stroke.
- When humidity is 40%, the runner only gets heat stroke at 40°C. The other highest temperature is 35°C.
- 40°C heat stroke, not 35°C. [*Minimum response*]

Partial Credit

The student selects **35°C**

AND

The two rows selected have 40% humidity at 35°C air temperature and 40% humidity at 40°C air temperature

AND

The student's explanation is missing, unclear or incorrect.

OR

The student selects **35°C**

AND

Correct rows are **not** selected

AND

The student gives a correct explanation.

OR

The student selects **40°C**

AND

The two rows selected have 40% humidity at 35°C air temperature and 40% humidity at 40°C air temperature

AND

The student gives an explanation that indicates or implies that with humidity at 40%, 35°C is the highest air temperature that is safe from heat stroke,

[Note: This last combination is given credit because students might simply interpret the question as: "What is the lowest temperature that is *unsafe*?"]

Comment

In this question, one variable is defined. With a set air humidity of 40%, students must run at least two trials in order to determine the highest temperature at which a person can run without getting heat stroke. They must draw on procedural knowledge to explain how the data they have collected supports their answer by indicating that at 40% humidity, an air temperature higher than 35°C results in heat stroke.

RUNNING IN HOT WEATHER – QUESTION 5⁴

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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)

Question Type	Open Response – Human Coded
Competency	Evaluate and Design Scientific Enquiry
Knowledge – System	Procedural
Context	Personal – Health and Disease
Difficulty	598 – Level 4

Scoring

Full Credit

The student selects **Unsafe**

AND

The two rows selected have
 40% humidity at 40°C with Drinking Water=Yes and
 60% humidity at 40°C with Drinking Water=Yes

AND

⁴ Note that this is identified as question 6 in the item codes.

The student gives an explanation that indicates that with the runner suffering from heat stroke at both 40% and 60% humidity, there is a risk of heat stroke at 50% humidity in the same conditions.

- With a temperature of 40°C and the runner drinking water, the runner will experience heat stroke at both 40% and 60% humidity, so the runner will probably experience heat stroke between those two levels of humidity, at 50%.
- 50% is halfway between 40% and 60%, and both those levels involve heat stroke, so 50% probably does as well.
- 40% is unsafe, so higher than that will be worse. [*Minimum response. With a correct selection of data, this response can be read as explaining how the data supports a selection of unsafe for 50%.*]

Partial Credit

The student selects **Unsafe**

AND

The two rows selected have

40% humidity at 40°C with Drinking Water=Yes and

60% humidity at 40°C with Drinking Water=Yes.

AND

The student's explanation is missing, unclear or incorrect.

OR

The student selects **Unsafe**

AND

Correct rows are **not** selected

AND

The student gives a correct explanation referring to results from the simulation.

Comment

This question requires students to extrapolate beyond the data that can be directly collected through the simulation. They must develop a hypothesis about the safety of running at 40°C at 50% air humidity, where only 40% and 60% humidity levels are available in the simulation tools. The correct response is that it would be unsafe, and students must select one row with a humidity level at 40% and one at 60% with temperature and drinking water set as specified in the question in both rows. 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, it is likely that heat stroke would also occur at 50% humidity.

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Bird Migration
Question 1 / 5


Refer to "Bird Migration" on the right. Click on a choice to answer the question.

Most migratory birds gather in one area and then migrate in large groups rather than individually. This behaviour is a result of evolution. Which of the following is the best scientific explanation for the evolution of this behaviour in most migratory birds?

- Birds that migrated individually or in small groups were less likely to survive and have offspring.
- Birds that migrated individually or in small groups were more likely to find adequate food.
- Flying in large groups allowed other bird species to join the migration.
- Flying in large groups allowed each bird to have a better chance of finding a nesting site.

BIRD MIGRATION

Bird migration is a seasonal large-scale movement of birds to and from their breeding grounds. Every year volunteers count migrating birds at specific locations. Scientists capture some of the birds and tag their legs with a combination of coloured rings and flags. The scientists use sightings of tagged birds together with volunteers' counts to determine the migratory routes of birds.



Question Type	Simple multiple choice
Competency	Explain Phenomena Scientifically
Knowledge – System	Content – Living
Context	Global – Environmental Quality
Difficulty	501 – Level 3

Scoring

Full credit

The student selects:

Birds that migrated individually or in small groups were less likely to survive and have offspring.

Comment

In question 1, students are asked to select an explanation for the specified phenomenon that birds migrate in large groups. This question, which is at the very low end of Level 3, requires that students identify an appropriate conclusion about the evolutionary benefit of this behavior.

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Bird Migration
Question 2 / 5

Refer to "Bird Migration" on the right. Type your answer to the question.

Identify a factor that might make the volunteers' counts of migrating birds inaccurate, and explain how that factor will affect the count.

BIRD MIGRATION

Bird migration is a seasonal large-scale movement of birds to and from their breeding grounds. Every year volunteers count migrating birds at specific locations. Scientists capture some of the birds and tag their legs with a combination of coloured rings and flags. The scientists use sightings of tagged birds together with volunteers' counts to determine the migratory routes of birds.



Question Type	Human Coded
Competency	Evaluate and design scientific enquiry
Knowledge – System	Procedural – Living
Context	Global – Environmental Quality
Difficulty	630 – Level 4

Scoring

Full Credit

The student identifies at least one specific factor that can affect the accuracy of counts by observers.

- The observers may miss counting some birds because they fly high.
- If the same birds are counted more than once, that can make the numbers too high.
- For birds in a large group, volunteers can only estimate how many birds there are.
- The observers might be wrong about what kind of bird they are, so the numbers of that kind of bird will be wrong.
- The birds migrate at night.
- Volunteers will not be everywhere the birds migrate.
- The observers can make a mistake in counting.
- Clouds or rain hide some of the birds.

Comment

To correctly answer this question, students must use procedural knowledge to identify a factor that might lead to inaccurate counts of migrating birds and explain how that could affect the data collected. Being able to identify and explain potential limitations in data sets is an important aspect of scientific literacy and locates this question at the top of Level 4.

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Bird Migration
Question 3 / 5

Refer to "Golden Plovers" on the right. Click on one or more boxes to answer the question.

Which statements about the golden plover's migration do the maps support?

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


- The maps show a decrease in the number of golden plovers migrating southward in the past ten years.
- The maps show that northward migratory routes of some golden plovers are different from southward migratory routes.
- The maps show that migratory golden plovers spend their winter in areas that are south and southwest of their breeding or nesting grounds.
- The maps show that the migratory routes of the golden plover have shifted away from coastal areas in the past ten years.


BIRD MIGRATION
Golden Plovers

Golden plovers are migratory birds that breed in northern Europe. In autumn, the birds travel to where it is warmer and where more food is available. In spring the birds travel back to their breeding grounds.


The maps below are based on more than ten years of research on the migration of the golden plover. Map 1 shows the southward migratory routes of the golden plover during autumn, and map 2 shows the northward migratory routes during spring. Areas coloured grey are land, and areas coloured white are water. The thickness of the arrows indicates the size of the migrating groups of birds.

Migratory Routes of the Golden Plover





Map 1: Southward Migratory Routes
During Autumn



Map 2: Northward Migratory Routes
During Spring

Question Type	Complex Multiple Choice
Competency	Interpret data and evidence scientifically
Knowledge – System	Procedural – Living
Context	Global – Environmental Quality
Difficulty	574 – Level 4

Scoring

Full credit

The student selects:

BOTH of the following 2 responses:

The maps show that northward migratory routes of some golden plovers are different from southward migratory routes.

The maps show that migratory golden plovers spend their winter in areas that are south and southwest of their breeding or nesting grounds.

Comment

Question 3 requires students to understand how data is represented in two maps and use that information to compare and contrast migration routes for the golden plover in the autumn and spring. This Level 4 interpretation task requires students to analyse the data and identify which of several provided conclusions are correct.

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Meteoroids and Craters
Question 1 / 3


Refer to "Meteoroids and Craters" on the right. Click on a choice to answer the question.

As a meteoroid approaches Earth and its atmosphere, it speeds up. Why does this happen?

- The meteoroid is pulled in by the rotation of Earth.
- The meteoroid is pushed by the light of the Sun.
- The meteoroid is attracted to the mass of Earth.
- The meteoroid is repelled by the vacuum of space.

METEORIDS AND CRATERS

Rocks in space that enter Earth's atmosphere are called meteoroids. Meteoroids heat up, and glow as they fall through Earth's atmosphere. Most meteoroids burn up before they hit Earth's surface. When a meteoroid hits Earth it can make a hole called a crater.



Question Type	Simple Multiple Choice
Competency	Explain phenomena scientifically
Knowledge – System	Content – Physical
Context	Global – Frontiers
Difficulty	483 – Level 2

Scoring

Full credit

The student selects:
The meteoroid is attracted to the mass of Earth.

Comment

Question 1 requires students to apply simple scientific knowledge to select the correct explanation for why objects speed up at they approach Earth. This content question, which requires the students to explain a phenomenon scientifically, is at the top of Level 2.

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Meteoroids and Craters
Question 2 / 3


Refer to "Meteoroids and Craters" on the right. Select from the drop-down menus to answer the question.

What is the effect of a planet's atmosphere on the number of craters on a planet's surface?

The thicker a planet's atmosphere is, the craters its surface will have because meteoroids will burn up in the atmosphere.

METEORIDS AND CRATERS

Rocks in space that enter Earth's atmosphere are called meteoroids. Meteoroids heat up, and glow as they fall through Earth's atmosphere. Most meteoroids burn up before they hit Earth's surface. When a meteoroid hits Earth it can make a hole called a crater.



Question Type	Complex Multiple Choice
Competency	Explain phenomena scientifically
Knowledge – System	Content – Earth & Space
Context	Global – Frontiers
Difficulty	450 – Level 2

Scoring

Full credit

The student selects:

The thicker a planet's atmosphere is, the *more/fewer* craters its surface will have because *more/fewer* meteoroids will burn up in the atmosphere.

Comment

This Level 2 question requires students to select two responses that explain the relationship between the thickness of a planet's atmosphere, the likelihood that meteoroids will burn up in the atmosphere and, therefore, the number of craters that will be on the planet surface.

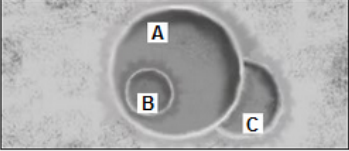
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Meteoroids and Craters
Question 3 / 3

Refer to "Meteoroids and Craters" on the right. Use drag and drop to answer the question.

Consider the following three craters.



Put the craters in order by the size of the meteoroids that caused them, from largest to smallest.


	Largest	→	Smallest
A			C

Put the craters in order by when they were formed, from oldest to newest.

	Oldest	→	Newest
A			C

METEORIDS AND CRATERS

Rocks in space that enter Earth's atmosphere are called meteoroids. Meteoroids heat up, and glow as they fall through Earth's atmosphere. Most meteoroids burn up before they hit Earth's surface. When a meteoroid hits Earth it can make a hole called a crater.



<i>Question Type</i>	Complex Multiple Choice (drag and drop)
<i>Competency</i>	Interpret data and evidence scientifically
<i>Knowledge – System</i>	Content – Earth & Space
<i>Context</i>	Global – Frontiers
<i>Difficulty</i>	3A: 299 – Level 1b 3B: 438 – Level 2

Scoring

3A

Full Credit

The student orders the craters: A, C, B.

3B

Full Credit

The student orders the craters: C, A, B.

⁵ Note that these two questions are identified as Q03 and Q04 in the item codes.

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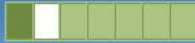
Comment

Question 3A, a basic data interpretation question, was the easiest question in the 2015 science assessment. It requires simple, everyday knowledge that a larger object would cause a larger crater and a smaller one would cause a smaller crater.

Question 3B is somewhat more difficult because students must compare the three craters shown in the image to determine when the craters were formed, from oldest to newest, based on the way they overlap in the image – e.g. crater C must have formed first because crater A overlaps C a bit and crater B must be the most recent crater because it is within A.

SLOPE-FACE INVESTIGATION – INTRODUCTION

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Slope-Face Investigation

Introduction

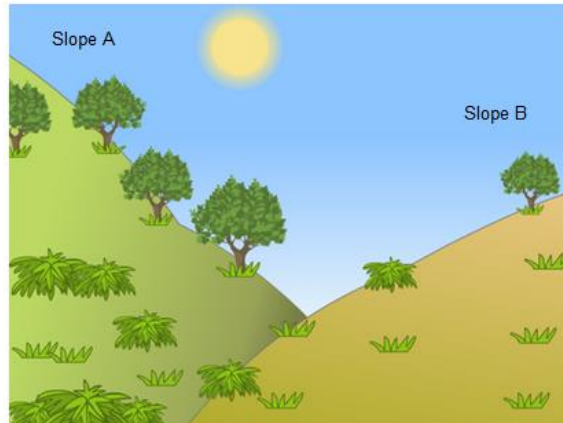
Read the introduction. Then click on the NEXT arrow.

SLOPE-FACE INVESTIGATION

A group of students notices a dramatic difference in the vegetation on the two slopes of a valley: the vegetation is much greener and more abundant on slope A than on slope B. This difference is shown in the illustration on the right.

The students investigate why the vegetation on the slopes is so different from one slope to the other. As part of this investigation, the students measure three environmental factors over a given period of time:

- **Solar radiation:** how much sunlight falls on a given location
- **Soil moisture:** how wet the soil is in a given location
- **Rainfall:** how much rain falls on a given location



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Slope-Face Investigation
Question 1 / 4

Refer to "Data Collection" on the right. Type your answer to the question.

In investigating the difference in vegetation from one slope to the other, why did the students place two of each instrument on each slope?

SLOPE-FACE INVESTIGATION
Data Collection

The students place two of each of the following three instruments on each slope, as shown below.

Solar radiation sensor: measures the amount of sunlight, in megajoules per square metre (MJ/m²)

Soil moisture sensor: measures the amount of water as a percentage of a volume of soil

Rain gauge: measures the amount of rainfall, in millimetres (mm)

<i>Question Type</i>	Open Response – Human Coded
<i>Competency</i>	Evaluate and design scientific enquiry
<i>Knowledge – System</i>	Epistemic – Earth & Space
<i>Context</i>	Local/ National - Natural Resources
<i>Difficulty</i>	517 – Level 3

Scoring

Full Credit

The student gives an explanation that identifies a scientific advantage of using more than one measurement instrument on each slope, e.g. correcting for variation of conditions within a slope, increasing the precision of measurement for each slope.

- So they could determine whether a difference between slopes is significant.
- Because there is likely to be variation within a slope.
- To increase the precision of the measurement for each slope.
- The data will be more accurate.
- In case one of the two malfunctions
- To compare different amounts of sun on a slope [A comparison implies that there may be variation.]

Comment

Question 1 requires students to apply epistemic knowledge to explain the design of the investigation presented in this unit. This Level 3 question allows students to demonstrate their understanding of the underlying rationale for the procedure of taking two independent measures of the phenomena being investigated. Knowledge of this rationale is the aspect of this question that assesses epistemic knowledge.

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Slope-Face Investigation
 Question 4 / 4

Refer to "Data Analysis" on the right. Click on a choice and then type an explanation to answer the question.

Two students disagree about why there is a difference in soil moisture between the two slopes.

- Student 1 thinks that the difference in soil moisture is due to a difference in solar radiation on the two slopes.
- Student 2 thinks that the difference in soil moisture is due to a difference in rainfall on the two slopes.

According to the data, which student is correct?

Student 1
 Student 2

Explain your answer.

SLOPE-FACE INVESTIGATION
Data Analysis

The students take the average of the measurements collected over a given period of time from each pair of instruments on each slope and calculate the uncertainty in these averages. Their results are recorded in the following table. The uncertainty is given following the "±" sign.

	Average Solar Radiation	Average Soil Moisture	Average Rainfall
Slope A	3800 ± 300 MJ/m ²	28 ± 2%	450 ± 40 mm
Slope B	7200 ± 400 MJ/m ²	18 ± 3%	440 ± 50 mm

<i>Question Type</i>	Open Response – Human Coded
<i>Competency</i>	Interpret data and evidence scientifically
<i>Knowledge – System</i>	Epistemic – Earth & Space
<i>Context</i>	Local/ National - Natural Resources
<i>Difficulty</i>	589 – Level 4

Scoring

Full Credit

The student selects **Student 1**

AND

Gives an explanation that indicates that there is a difference in solar radiation between the two slopes **and/or** that rainfall does not show a difference.

- Slope B gets much more solar radiation than slope A, but the same amount of rain.
- There is no difference in the amount of rainfall the two slopes get.
- There is a big difference in how much sunlight slope A gets compared to slope B.

Comment

In this question, students must evaluate two claims by interpreting the provided data, which include confidence intervals around the average of measurements of solar radiation, soil moisture and rainfall. Students are asked to demonstrate an understanding of how measurement error affects the degree of confidence associated with specific scientific measurements, one major aspect of epistemic knowledge.

SUSTAINABLE FISH FARMING - INTRODUCTION

PISA 2015



Sustainable Fish Farming

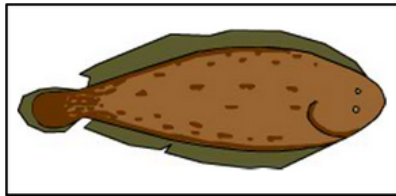
Introduction

Read the introduction. Then click on the NEXT arrow.

SUSTAINABLE FISH FARMING

An increased demand for seafood is placing a greater burden on populations of wild fish. To reduce this burden, researchers are investigating ways to grow fish sustainably in fish farms.

Two challenges to creating a sustainable fish farm include (1) feeding the farmed fish and (2) maintaining water quality. Farmed fish require large amounts of food. A fish farm that is sustainable will grow the food needed to feed the farmed fish. Waste from the fish can build up in the farm to levels that are dangerous to the fish. In a sustainable fish farm, there is a constant flow of ocean water through the farm. Waste and excess nutrients (food that algae and plants need to grow) are removed from the water before it is returned to the ocean.



PISA 2015

Sustainable Fish Farming
Question 1 / 4

Refer to the information below. Use drag and drop to answer the question.

The diagram shows a design for an experimental fish farm with three large tanks. Filtered salt water is pumped from the ocean before flowing from tank to tank until it is returned to the ocean. The primary goal of the fish farm is to grow common sole to be harvested in a sustainable way.

- **Common Sole:** The fish being farmed. Their preferred food is ragworms.

The following organisms will also be used in the farm:


- **Microalgae:** Microscopic organisms that only need light and nutrients to grow.
- **Ragworms:** Invertebrates that grow very rapidly on a diet of microalgae.
- **Shellfish:** Organisms that feed on microalgae and other small organisms in the water.
- **Marsh Grass:** Grasses that absorb nutrients and wastes from the water.

Water is cleaned in this tank. Fish are harvested from this tank.


Water is returned to the ocean. Water enters the farm from the ocean. Nutrients are added to this tank.

Filters that allow only microalgae to move through the farm in the flow of water.


The researchers need to decide in which tank each organism should be placed. Drag and drop each of the organisms below to the appropriate tank above to ensure that the Common Sole is fed and that salt water is returned to the ocean unchanged. The microalgae are already in the correct tank.



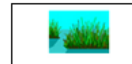
Common Sole



Ragworms



Shellfish



Marsh Grass

Question Type	Complex Multiple Choice
Competency	Explain phenomena scientifically
Knowledge – System	Content – Living
Context	Local/ National – Natural Resources
Difficulty	740 – Level 6

Scoring

Full credit

The student drags Ragworms and Common Sole into Tank 2 (bottom right) and drags Marsh Grass and Shellfish into Tank 3 (left)

Comment

This question requires students to understand a system and the role of several organisms within that system. In order to answer correctly, students must understand the goal of the fish farm, the function of each of the three tanks therein, and which organisms will best fulfill each function. Students must use information provided in the stimulus and the diagram, including a footnote under the diagram. An additional component that adds difficulty is the open-ended nature of the task. Any of the four organisms can be placed in any of the three tanks and there is no restriction on the number of organisms in each tank. As a result, there are multiple ways of getting this incorrect.

PISA 2015

Sustainable Fish Farming
Question 2 / 4

Refer to the information below. Click on a choice to answer the question.

The diagram shows a design for an experimental fish farm with three large tanks. Filtered salt water is pumped from the ocean before flowing from tank to tank until it is returned to the ocean. The primary goal of the fish farm is to grow common sole to be harvested in a sustainable way.

- **Common Sole:** The fish being farmed. Their preferred food is ragworms.

The following organisms will also be used in the farm:

- **Microalgae:** Microscopic organisms that only need light and nutrients to grow.
- **Ragworms:** Invertebrates that grow very rapidly on a diet of microalgae.
- **Shellfish:** Organisms that feed on microalgae and other small organisms in the water.
- **Marsh Grass:** Grasses that absorb nutrients and wastes from the water.

Water is returned to the ocean.

Water enters the farm from the ocean.

Nutrients are added to this tank.

Filter

Filter

Filter

Filter

Water is cleaned in this tank.

Fish are harvested from this tank.

Filters that allow only microalgae to move through the farm in the flow of water.

Researchers have noticed that the water that is being returned to the ocean contains a large quantity of nutrients. Adding which of the following to the farm will reduce this problem?

- More nutrients
- More ragworms
- More shellfish
- More marsh grass

Question Type	Simple Multiple Choice
Competency	Interpret data and evidence scientifically
Knowledge – System	Content – Living
Context	Local/ National – Environmental Quality
Difficulty	456 – Level 2






Scoring

Full Credit

The student selects:
More marsh grass

Comment

For question 2, which is at Level 2, students only need to identify which of the listed organisms will reduce the large number of nutrients being released to the ocean from the fish farm, based on descriptions of each organism. As the question does not require the construction of an explanation, it focuses on the ability to interpret data and evidence scientifically.

PISA 2015     

Sustainable Fish Farming
Question 4 / 4

Click on a choice to answer the question.

Which procedure would make fish farming more sustainable?

- Increasing the rate of water flow through the tanks.
- Increasing the amount of nutrients added to the first tank.
- Using filters that allow larger organisms to move between the tanks.
- Using the wastes produced by the organisms to make fuel to run the water pumps.

<i>Question Type</i>	Simple Multiple Choice
<i>Competency</i>	Explain phenomena scientifically
<i>Knowledge – System</i>	Content – Physical
<i>Context</i>	Local/ National – Environmental Quality
<i>Difficulty</i>	585 – Level 4

Scoring

Full credit

The student selects:

Using the wastes produced by the organisms to make fuel to run the water pumps

Comment

Question 4 asks students to use their understanding of the system provided in this unit and the explanation of what it means to be “sustainable” in this context in order to identify how the system could be modified to be more sustainable.