MCAP Maryland Comprehensive Assessment Program

# MISA

Maryland Integrated Science Assessment

## January 2019 Released Items and Answer Key

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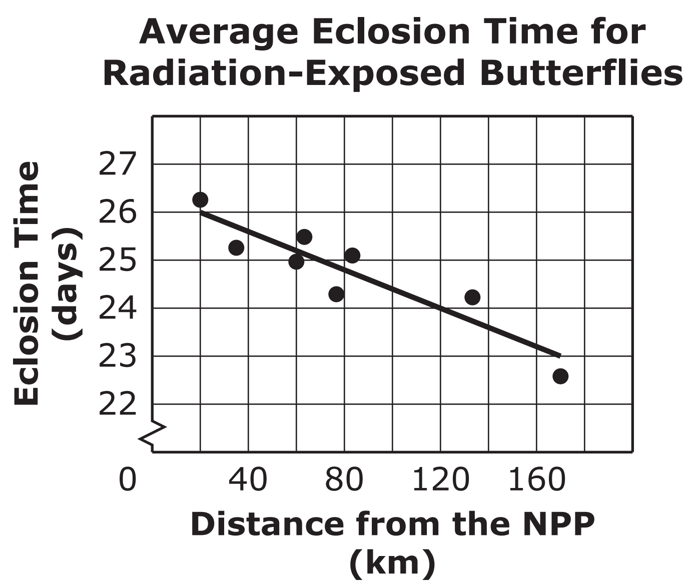
Read the information. Use the information to answer the questions.

**Butterflies Near the Power Plant**

The pale grass blue butterfly (*Zizeeria maha*) has small, blue-colored wings. The distance the butterfly can fly is limited by the size of its wings. The butterfly begins its life cycle as an egg. The egg hatches into a larva, or caterpillar. Next, the pupa forms a chrysalis and eventually the adult emerges as a butterfly. The typical life cycle is about twenty-two days.

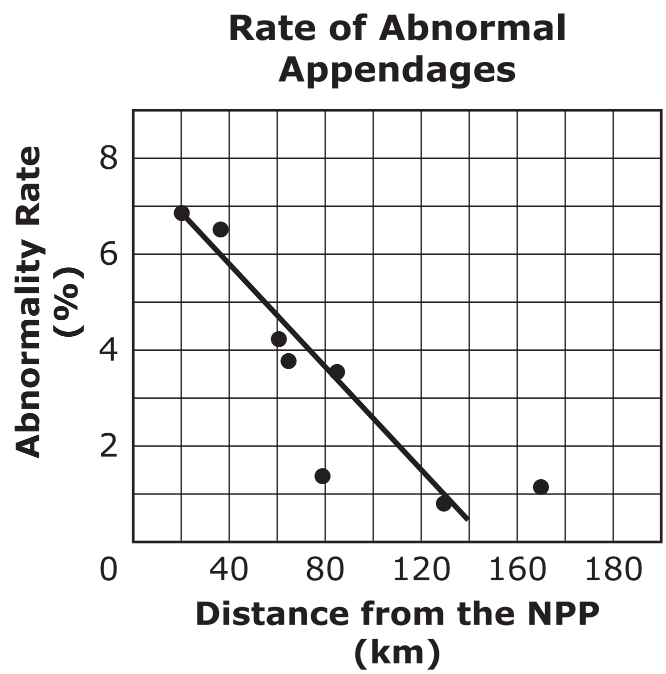
Pale grass blue butterflies are found throughout Japan. This includes areas near the Fukushima Nuclear Power Plant (NPP). An accident at the nuclear power plant on March 11, 2011, released a large amount of nuclear radiation into the surrounding area. Radiation exposure decreased as the distance from the nuclear plant increased. A group of scientists claimed that the pale grass blue butterflies were a model organism to evaluate the environmental and biological effects of the radiation. Two months after the accident, the scientists captured adult pale grass blue butterflies at different distances from the nuclear power plant. This was the first generation of butterflies exposed to the radiation from the accident.

In a laboratory, the scientists bred the collected adult butterflies to create two generations. The eclosion time is the time it takes the butterfly to go from egg to adult. The eclosion time of each generation was recorded by the scientists. The graph shows the data collected.

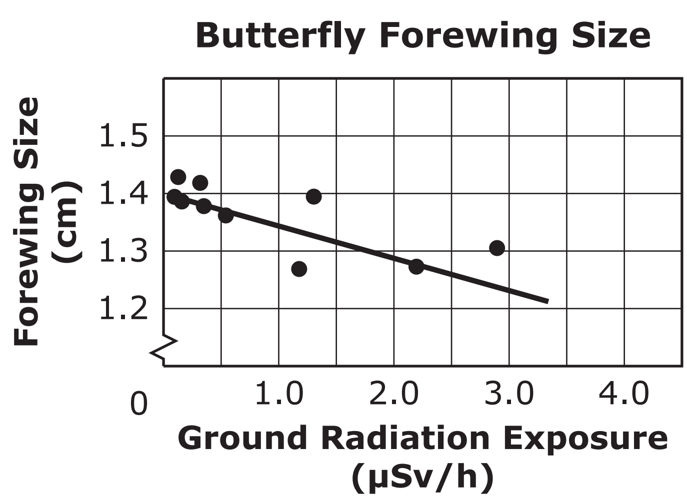


**Abnormalities**

The scientists observed the new generations of butterfly for abnormalities in their wings, eyes, and appendages. The graph shows some of the data the scientists collected during their observations.




A butterfly's forewings are its two front wings. The graph shows the changes in forewing size as the butterflies' exposure to radiation increased. The risk of health effects from exposure to radiation are measured in microsievert units (μSv) in the graph.



## Radiation Impact

In butterflies, the genes that control the development of wings, eyes, and appendages are located on the same chromosome. The scientists performed another experiment to determine the impact of the radiation on the butterflies. The scientists collected a second sample of adult butterflies two months and six months after the nuclear accident. In a laboratory, the scientists grew two new generations of the butterflies from the adult butterflies they had collected.

The data table shows a comparison of the butterflies collected two months and six months after the accident and their offspring.

**Abnormalities in Several Generations of Butterflies**

| Generation | 2 Months after Nuclear Accident (%) | 6 Months after Nuclear Accident (%) |
|---|---|---|
| Parent population (P) | 13.2 | 28.1 |
| 1st generation produced (F1) | 18.3 | 51.9 |
| 2nd generation produced (F2) | 33.5 | Data not collected |

**1** How did the wings of the pale grass blue butterfly help explain the increased rate of abnormalities seen in the butterfly population six months after the nuclear accident at the nuclear power plant?

**A** The pale color of the wings made it easier to detect abnormalities the radiation caused in the wing DNA.

**B** The small size of the wings made detecting abnormalities in the wing proteins of the butterfly easier after the nuclear accident.

**C** The small size of the wings made flying far from the nuclear accident difficult so the butterfly DNA was exposed to radiation that caused abnormalities in the proteins formed.

**D** The wings provided additional areas for the butterfly to capture nuclear radiation after the accident and led to increased levels of abnormalities seen in butterfly proteins.

**2** Based on the data shown in the Rate of Abnormal Appendages and Butterfly Forewing Size graphs, which conclusion can **most likely** be made?

**A** The development of the appendages and forewings in butterflies is controlled by the same cell.

**B** The development of the appendages and forewings in butterflies is controlled by different groups of specialized cells.

**C** The DNA and the proteins involved in the development of butterfly appendages and forewings were affected by radiation.

**D** The DNA in the cells of butterfly appendages and forewings was affected by the radiation, but it had no effect on the proteins formed.

**3** Which evidence supports the claim that genes that control the life cycle and development of pale grass blue butterflies were affected similarly by the accident at the nuclear power plant? Select the two that apply.

**A** The abnormalities seen in offspring generations of butterflies were greater than in the parent generation.

**B** The abnormality rate in appendages for the butterflies increased closer to the site of the nuclear accident.

**C** The abnormalities caused by the radiation were only seen in the eyes and wings of pale grass blue butterflies.

**D** The average eclosion time was longer for radiation-exposed butterflies that were closer to the site of the nuclear accident.

**E** The pale grass blue butterflies fed on plants that grew near the nuclear power plant, which caused mutations in the butterfly DNA.

**F** The abnormalities seen in the butterfly population six months after the nuclear accident were greater than the abnormalities seen two months after the accident.

**4** Which claim is supported by the data in the Abnormalities in Several Generations of Butterflies table?

**A** Exposure to radiation only resulted in abnormalities in butterfly wings.

**B** Exposure to radiation affected the DNA in butterfly cells and was passed on to the offspring.

**C** Pale grass blue butterflies were more affected by radiation exposure than other butterfly species.

**D** Larger doses of radiation led to more butterfly deaths in the parent (P) generation.

**5** Which claims explain the increased abnormality rate seen in the F1 generation of butterflies that were caught two months and six months after the nuclear accident? Select the two that apply.

**A** Each generation of offspring produced by adults that were exposed to nuclear radiation randomly mutated.

**B** The scientists collected adult butterflies for the study from areas with the highest levels of nuclear radiation.

**C** The parent populations of butterflies that produced offspring were those with the largest number of genetic abnormalities.

**D** Nuclear radiation caused genetic damage in the adult butterflies that was inherited by the offspring generation.

**E** Mutations that occurred during meiosis led to offspring generations with more mutations than the parent generation.

**F** The offspring that survived the nuclear accident were those that inherited the most mutations from the parent butterflies.

**6** Use evidence to support the claim that the nuclear accident at the nuclear power plant caused changes that resulted in the abnormalities seen in the pale grass blue butterfly population for the next several generations.

Write your answer on the lines on your Answer Sheet.

Read the information on each tab. Use the information to answer the questions.

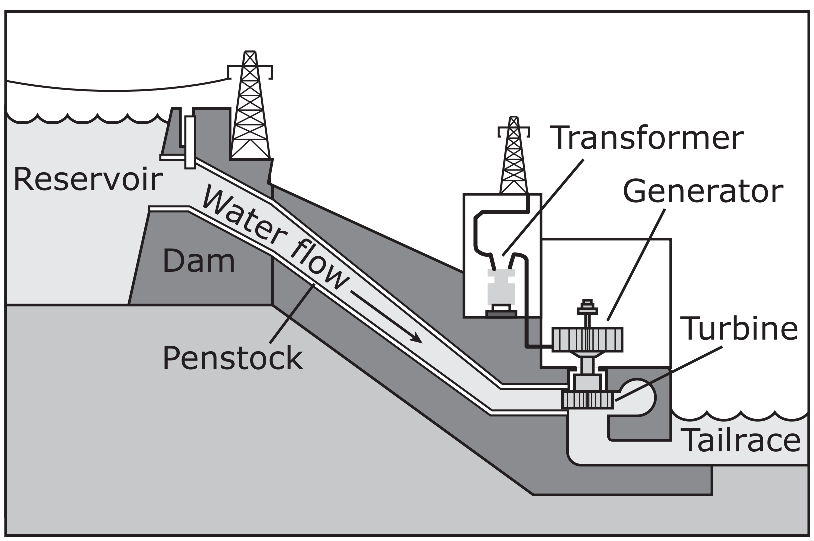
**Hydroelectric Station**

The Deep Creek Hydroelectric Station is located in Garrett County, Maryland. It has two turbines that drive generators to produce 20 megawatts (MW) of electricity. The dam built for this hydroelectric station formed Deep Creek Lake.

The description and model shows how a typical hydroelectric station works.

- Water enters the penstock, a large pipe running from the reservoir above the dam to the turbines near the base.
- At the end of the penstock, the water turns the turbine, a wheel or rotor with blades.
- The turbine is connected to a generator, which has several electromagnets inside many coils of copper wire.
- When the water spins the turbine, the moving electromagnets within the generator produce electricity.
- The transformer sends the electricity to the power station.
- The water flows out of the penstock and turbine at the tailrace.

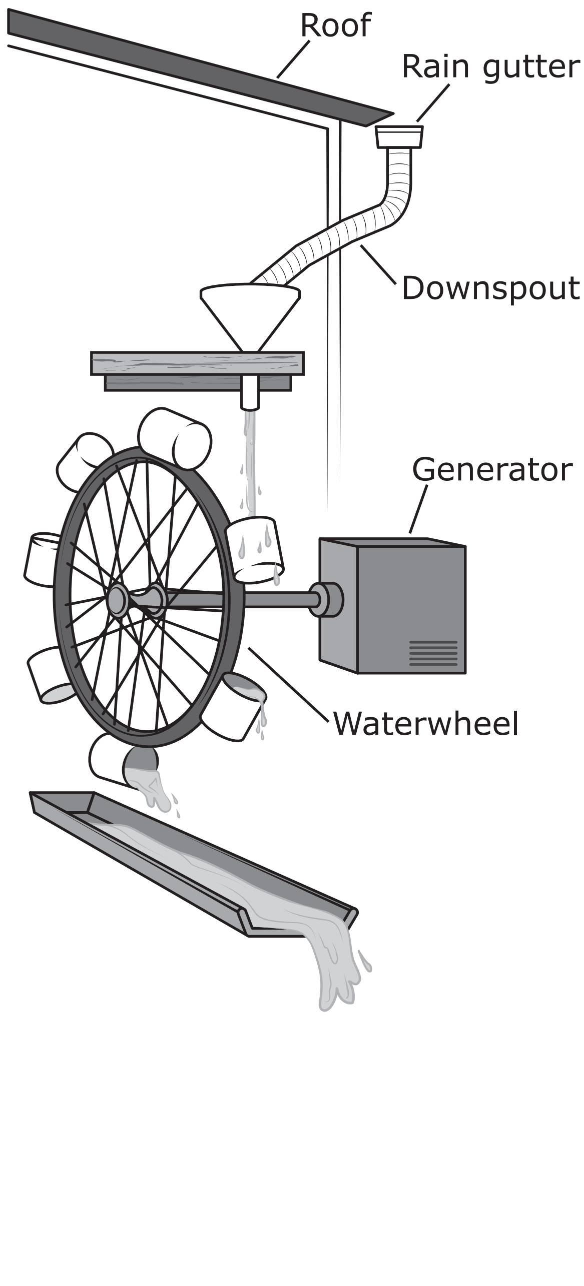
**Hydroelectric Station Model**



## Downspout Generator

Students use the hydroelectric station model to build a downspout hydroelectric generator. A downspout is a pipe that carries rainwater down from a roof or rain gutter. Using materials from a local hardware store, the students build the waterwheel prototype shown.

### Downspout Waterwheel



The waterwheel prototype uses rain as its source of water.

- Rainwater falling on the roof collects in the rain gutter and flows into the downspout.
- Rainwater in the downspout flows into the containers attached to the waterwheel, making the waterwheel turn.
- The greater the volume of rainwater flowing into the container, the faster the waterwheel turns.
- As the waterwheel spins, it rotates the shaft attached to the electromagnets producing electricity.

The students gathered information on the average yearly rainfall for several states.

**Annual Precipitation**

| State | Average Yearly Rainfall (mm) | Average Number of Rain Days/Year |
|---|---|---|
| Florida | 1572 | 128 |
| Maryland | 1131 | 111 |
| Nevada | 244 | 13 |
| Texas | 1150 | 106 |
| Utah | 310 | 94 |
| Washington | 943 | 147 |

The students researched data on the flow rates of water based on the amounts of rainfall, the roof area drained, and the distance between the roof and the waterwheel. The flow rate is the rate at which water is falling from the roof onto the waterwheel. The students calculated the estimated power ($P$) in watts (W) of the waterwheel by using the formula, $P = \rho q g h \eta$, where

Density of water ($\rho$) = 1000 kg/m$^3$

Flow rate ($q$) = Rate of water flowing in the downspout (penstock) in m$^3$/s

Acceleration due to gravity ($g$) = 9.81 m/s$^2$

Height ($h$) = Change in the height of water in m

Efficiency ($\eta$) = Efficiency of the system

The students predicted the performance of a downspout waterwheel from a roof height of 5 m with different flow rates, and assuming 100% efficiency. The table shows the data calculated by students.

**Calculated Downspout Power Generation**

| Downspout Flow Rates (m$^3$/s) | Power Generation (watts) |
|---|---|
| $5.8 \times 10^{-3}$ | 284.5 |
| $4.7 \times 10^{-3}$ | 230.5 |
| $3.15 \times 10^{-3}$ | 154.5 |
| $1.6 \times 10^{-3}$ | 78.5 |

To check if the waterwheel generator was producing enough power to run a small household appliance, the students connected an incandescent light bulb to the generator.

**Effect of Flow Rate on Light Bulb**

| Downspout Flow Rates ($m^3/s$) | Power Generation (watts) | Effect on Light Bulb |
|---|---|---|
| $8.3 \times 10^{-4}$ | 30.5 | no light |
| $1.67 \times 10^{-3}$ | 61.4 | no light |
| $2.5 \times 10^{-3}$ | 92.0 | flickering yellow light |
| $4.1 \times 10^{-3}$ | 150.8 | dim yellow light |

**7** Which statement **best** describes the energy of the water molecules as they move through a hydroelectric station?

**A** The potential energy of the water molecules in the reservoir is equal to the kinetic energy of the water molecules being discharged from the tailrace.

**B** The potential energy of the water molecules in the reservoir is equal to the electrical energy produced by the hydroelectric station.

**C** The potential energy of the water molecules in the reservoir is equal to the kinetic energy of the water molecules discharged from the tailrace combined with the kinetic energy of the moving turbine.

**D** The potential energy of the water molecules in the reservoir is equal to the kinetic energy of the water molecules discharged from the tailrace combined with the electrical energy produced by the hydroelectric station.

**8** Select the phrases that **best** show the inputs and outputs of the turbines in a hydroelectric station while the turbines are in motion, and drag them into the appropriate boxes. Each phrase can be used once.

| Energy Inputs | Energy Outputs |
|---|---|
| | |

- Kinetic energy of water
- Electrical energy
- Thermal energy
- Gravitational potential energy of water
- Sound energy

**9** Different hydroelectric stations have different distances between their reservoirs and their tailraces.

Which statement **best** describes how the power generated from a hydroelectric station with a greater distance between its reservoir and tailrace compares to the power generated from Deep Creek Hydroelectric Station?

**A** The power output is less due to less initial kinetic energy.

**B** The power output is less due to less initial gravitational potential energy.

**C** The power output is greater due to greater initial kinetic energy.

**D** The power output is greater due to greater initial gravitational potential energy.

**10** Select the words that **best** complete the statements to demonstrate how energy is transformed by the downspout waterwheel prototype.

Rainwater on the roof has <chemical/gravitational/mechanical> energy, which is converted to <electrical/gravitational/mechanical> energy when it flows to the downspout and spins the waterwheel. As the waterwheel spins, the generator converts the energy to <chemical/electrical/gravitational> energy.

**11** The students want to power a fan that uses 350,000 W of electricity. At what distance below the roof would the waterwheel prototype have to sit in order to generate enough power when the flow rate is 5.0 $m^3$/s, assuming the efficiency of the system is 100%?

**A** 5.0 m

**B** 7.1 m

**C** 9.5 m

**D** 350 m

**12** Use evidence from the waterwheel prototype to explain how the performance of the prototype could be improved. Be sure to note any trade-offs in the suggested modifications.

Write your answer in your Answer Sheet.

STOP

# 2019 Released Items ANSWER KEY
## MISA

| Item Number | Key | Evidence Statements |
|---|---|---|
| 1 | C | **HS-LS1-1/2.a** Students identify and describe the evidence to construct their explanation, including that: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. |
| 2 | C | **HS-LS1-1/3.a.iii** Students use reasoning to connect evidence, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to construct the explanation. Students describe the following chain of reasoning in their explanation: proper function of many proteins is necessary for the proper functioning of the cells. |
| 3 | B, D | **HS-LS1-1/2.a.iii** Students identify and describe the evidence to construct their explanation, including that: the sequence of genes contains instructions that code for proteins. |
| 4 | B | **HS-LS3-2/4.a.ii** Students use reasoning to describe links between the evidence and claim, such as: genetic variations produced by mutation and meiosis can be inherited. |
| 5 | D, E | **HS-LS3-2/4.a.i** Students use reasoning to describe links between the evidence and claim, such as: genetic mutations produce genetic variations between cells or organisms. |
| 6 | CR-2 | **HS-LS3-2/4.b** Students use reasoning and valid evidence to describe that new combinations of DNA can arise from several sources, including meiosis, errors during replication, and mutations caused by environmental factors. |
| 7 | C | **HS-PS3-2/2.a.iii** Students describe the relationships between components in their models, including: the total energy of the system and surroundings is conserved at a macroscopic and molecular/atomic level. |
| 8 | TEI* | **HS-PS3-2/1.a.i** Students develop models in which they identify and describe the relevant components, including: all the components of the system and the surroundings, as well as energy flows between the system and the surroundings. |
| 9 | D | **HS-PS3-2/2.a.i** Students describe the relationships between components in their models, including: changes in the relative position of objects in gravitational, magnetic or electrostatic fields can affect the energy of the fields (e.g., charged objects moving away from each other change the field energy). |
| 10 | TEI* | **HS-PS3-3/1.b.ii** Students develop a plan for the device in which they: identify the forms of energy that will be converted from one form to another in the designed system. |
| 11 | B | **HS-PS3-3/3.b** Students systematically and quantitatively evaluate the performance of the device against the criteria and constraints. |
| 12 | CR-3 | **HS-PS3-3/4.a** Students use the results of the tests to improve the device performance by increasing the efficiency of energy conversion, keeping in mind the criteria and constraints, and noting any modifications in tradeoffs. |

■ = Written response.

* Technology Enhanced Item – Correct responses shown on the following pages.

Item 8. TEI correct response:

Select the phrases that **best** show the inputs and outputs of the turbines in a hydroelectric station while the turbines are in motion, and drag them into the appropriate boxes. Each phrase can be used once.

| Energy Inputs | Energy Outputs |
| --- | --- |
| Kinetic energy of water | Electrical energy |
| Gravitational potential energy of water | Thermal energy |
| | Sound energy |

Item 10. TEI correct response:

Rainwater on the roof has <chemical/**gravitational**/mechanical> energy, which is converted to <electrical/gravitational/**mechanical**> energy when it flows to the downspout and spins the waterwheel. As the waterwheel spins, the generator converts the energy to <chemical/**electrical**/gravitational> energy.