ScAnnotated Kentucky Science Summative Assessment (SSA) Prototype

Please note that an answer key is intentionally not provided with this cluster. The pilot is not intended as an example of individual question types on the upcoming summative field test, nor is it intended to be used as a practice test with students.

Background:

In 2015 the Kentucky Department of Education contracted with WestEd to act as a "thinking partner" in the development of a summative assessment for science. A component of this development included the development and piloting of a summative prototype that would be used in a future RFP (request for proposal) to demonstrate to a potential testing vendor how Kentucky may assess science. As a result, this cluster of items is larger than would typically be seen in an operational test.

Conceptually, the idea explored by the prototype was to assess science through a phenomenon-based approach. Students were asked to engage with a cluster of related items focused around a central idea, or phenomenon.

Process:

Two related standards were bundled. Once bundled, a phenomenon was identified and a storyline exploring that phenomenon was developed. At key points within the storyline a question would be asked that would further the explanation of the phenomenon. In addition, these questions would be used to measure at least two of the dimensions identified in the standards within the bundle. The process of cluster development can be approached in different ways. Item writers can begin with selecting standards to bundle and then identify a phenomenon related to those standards. Writers may also approach cluster development by first identifying a phenomenon and then selecting the standards that best help students make sense of it.

Prototype Details:

<u>Standards assessed:</u>

> **7-PS3-5:** Develop a model to describe the cycling of water through Earth's systems driven by energy form the sun and the force of gravity.
>
> **6-ESS2-4:** Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to and from the object.

It should be noted that full alignment to the standards is intended through the entirety of the item cluster, not through individual questions within the cluster.

<u>Phenomenon:</u> Renewable Energy (hydroelectric power)

<u>Storyline:</u> Hannah visits a museum found along a stream. At a museum display she learns that it has generated its own electricity for the last 15 years. This item cluster explores how the museum was able to generate this electricity and how the river is continually supplied with water through earth processes.

Question annotations:

The assessment pilot is reproduced in unmodified form, followed by a table of annotations.

Pilot Test:

Once a prototype was developed, KDE wished to learn how students would react to this different format. In April 2016, 26 schools were requested to participate in a pilot of the prototype. In addition, 10 of these were asked to participate in a cognitive lab, in which individual students interacted with an observer to gain insight into how students cognitively approached the sense-making required by the cluster.

Four different versions of the cluster based on the same storyline were administered during the pilot. Some forms were delivered in a technology-enhanced format, using technology to support reading, including additional graphics and adding video. The 13 questions presented to students were essentially the same across all versions. 1300 7th grade students in 26 classrooms participated in the pilot. Students were given one class period (40-70 minutes) to complete the cluster.

Findings: In general, students were very positive about the storyline approach to assessment design. The large majority appreciated that the items were related to each other in an understandable way, as opposed to traditional assessments where each item is independent of those preceding and following it. Students expressed that this approach allowed them to think more deeply about a focused set of ideas rather than being "scattered" across multiple topics and domains.

The reading load of the storyline did add to the challenge

For findings related to the individual questions, please see the individual question annotations that follow the cluster.

Instructional Implications: The most obvious implication for instruction is the idea of basing instruction around understanding and explaining phenomena. In the case where engineering design standards (ETS) are part of the bundle, solving problems would also be a focus. Rather than teaching the standards sequentially or as isolated ideas, teachers might consider bundling standards and designing lessons around phenomena. Both the SSA and the Through Course Tasks (TCT) will utilize this approach. The TCT especially may give teachers ideas for a phenomena-based approach to instruction and assessment.

Key Terms:

a. **Phenomenon-** something that can be observed, studied and potentially explained.
b. **Bundle-** the combination of standards selected to be assessed through the lens of a particular phenomenon.
c. **Item Cluster-** the collection of related items written to assess student understanding of the bundled standards.
d. **Storyline-** the text through which the phenomenon is presented to the students. The item cluster is organized through the use of this "story."

Cautions and concerns:

This cluster represents a first step in moving toward a phenomenon-based assessment design. It is most useful as an example of the storyline/cluster approach to assessing student knowledge and understanding through the lens of making sense of a phenomenon. ***It is not intended as an example of specific item types or configurations students might see on the 2017 field test, nor on an operational assessment in following years.*** It is also important to note that the science standards, not the assessment phenomena define the curricula for schools. The same standards assessed in this cluster could be assessed equally well by several different phenomena. Teachers should resist the temptation to include a "waterwheel" unit in their curriculum based on this sample cluster, or on the clusters included in the 2017 field test.

Grade 7 SSA Item Cluster Prototype Alignment Overview

Level:		Grade 7
Primary Target Domain:		Physical Sciences, Earth and Space Sciences
Science Phenomenon:		When water moves in a river, it transfers energy to turn a water wheel.
Target PEs:		06-ESS2-4, 07-PS3-5
Crosscutting Concept(s) Focus:		Energy and Matter
Science and Engineering Practice(s) Focus:		Developing and Using Models, Engaging in Argument from Evidence, Scientific Knowledge is Based on Empirical Evidence
Allowable Item Types:		SR, TE, CR

	06-ESS2-4	07-PS3-5
Performance Expectations:	Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.	Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
Target Clarifications:	Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.	Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.
Assessment Boundaries:	A quantitative understanding of the latent heats of vaporization and fusion is not assessed.	Assessment does not include calculations of energy.

Disciplinary Core Idea(s):	ESS2.C: The Roles of Water in Earth's Surface Processes • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. • Global movements of water and its changes in form are propelled by sunlight and gravity.	PS3.B: Conservation of Energy and Energy Transfer • When the motion energy of an object changes, there is inevitably some other change in energy at the same time.
Science and Engineering Practice(s):	Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe unobservable mechanisms.	Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds. • Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. *Connections to Nature of Science* Scientific Knowledge is Based on Empirical Evidence • Science knowledge is based upon logical connections between evidence and explanations.
Crosscutting Concept(s):	Energy and Matter • Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.	Energy and Matter • Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).

Kentucky Science

Grade 7 SSA Item Cluster Prototype
Paper and pencil version of KDE Phase I cognitive labs

April 2016

Developed by WestEd in collaboration with
the Kentucky Department of Education.

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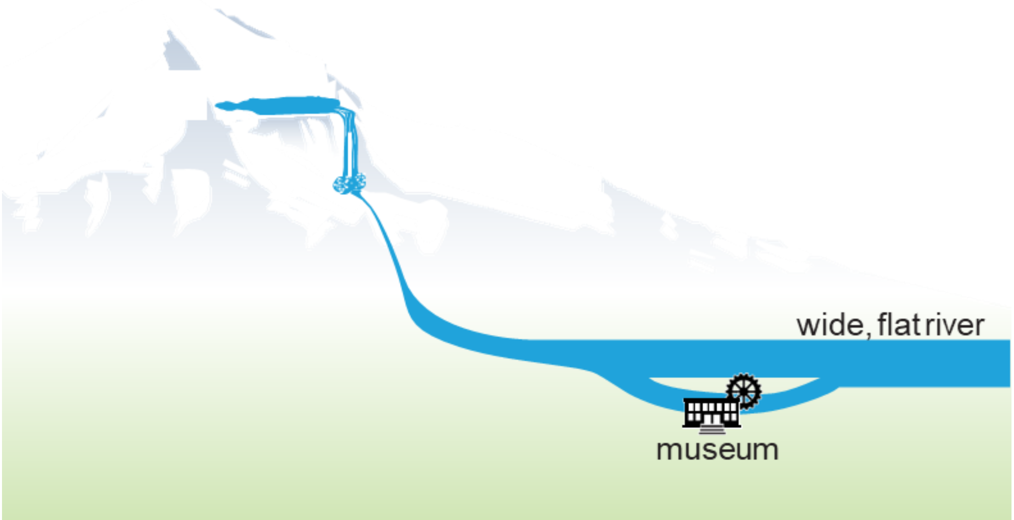
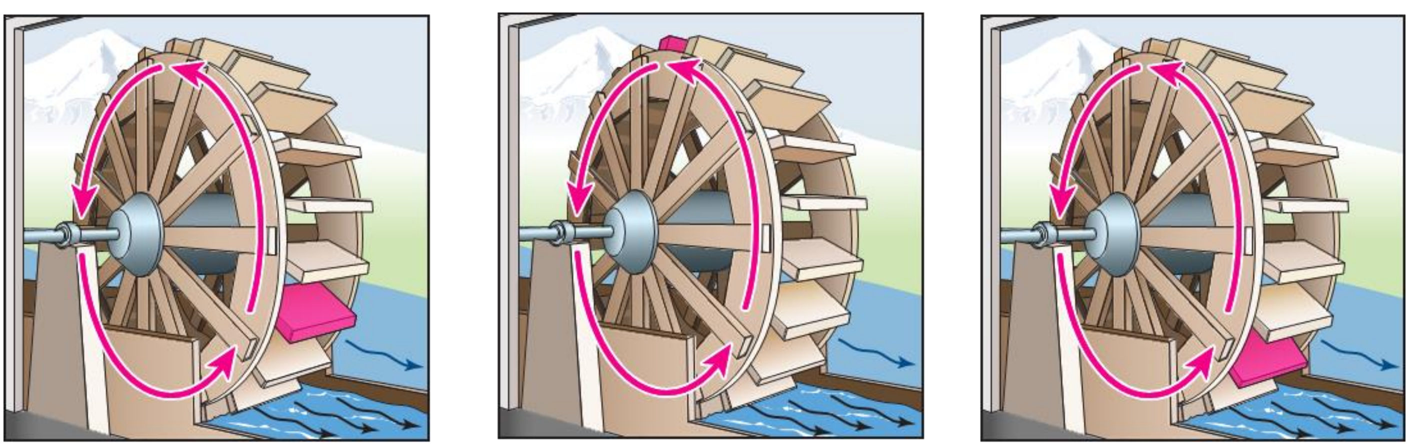
Hannah and her family visit a museum that is located along a wide, flat stretch of river.



Hannah notices that a canal has been built next to the river. Some of the water from the river is diverted into the canal and is being used to turn an old-fashioned water wheel. Review the pictures below to see how the water wheel moves.



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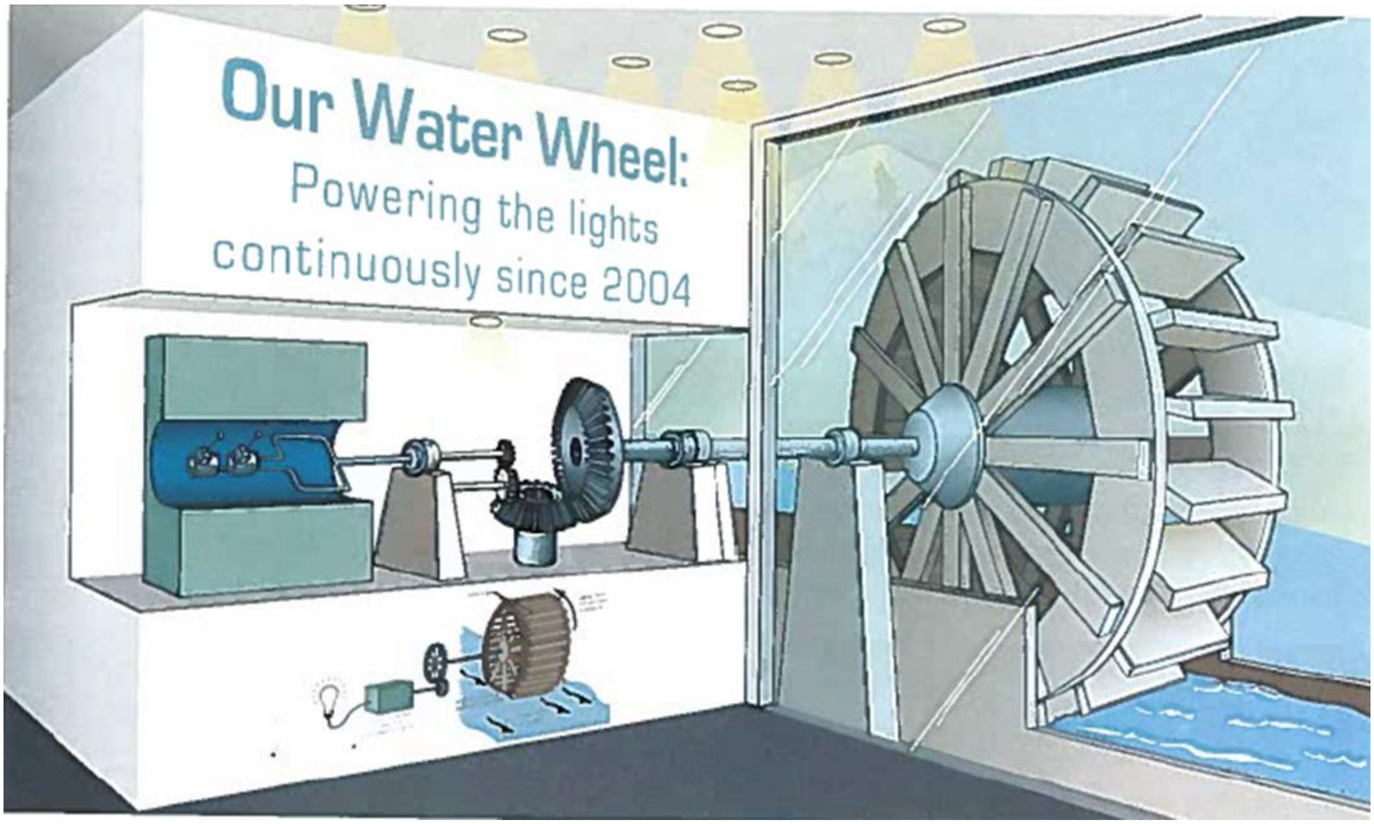
Once inside the museum, Hannah learns that the water wheel is used to power the lights inside the museum. An exhibit shows how the water wheel is connected to different components that are used to power the lights. Hannah can hear the sounds made as the different components move, and she can feel that the air in the area that surrounds the components is warmer than in other parts of the exhibit.



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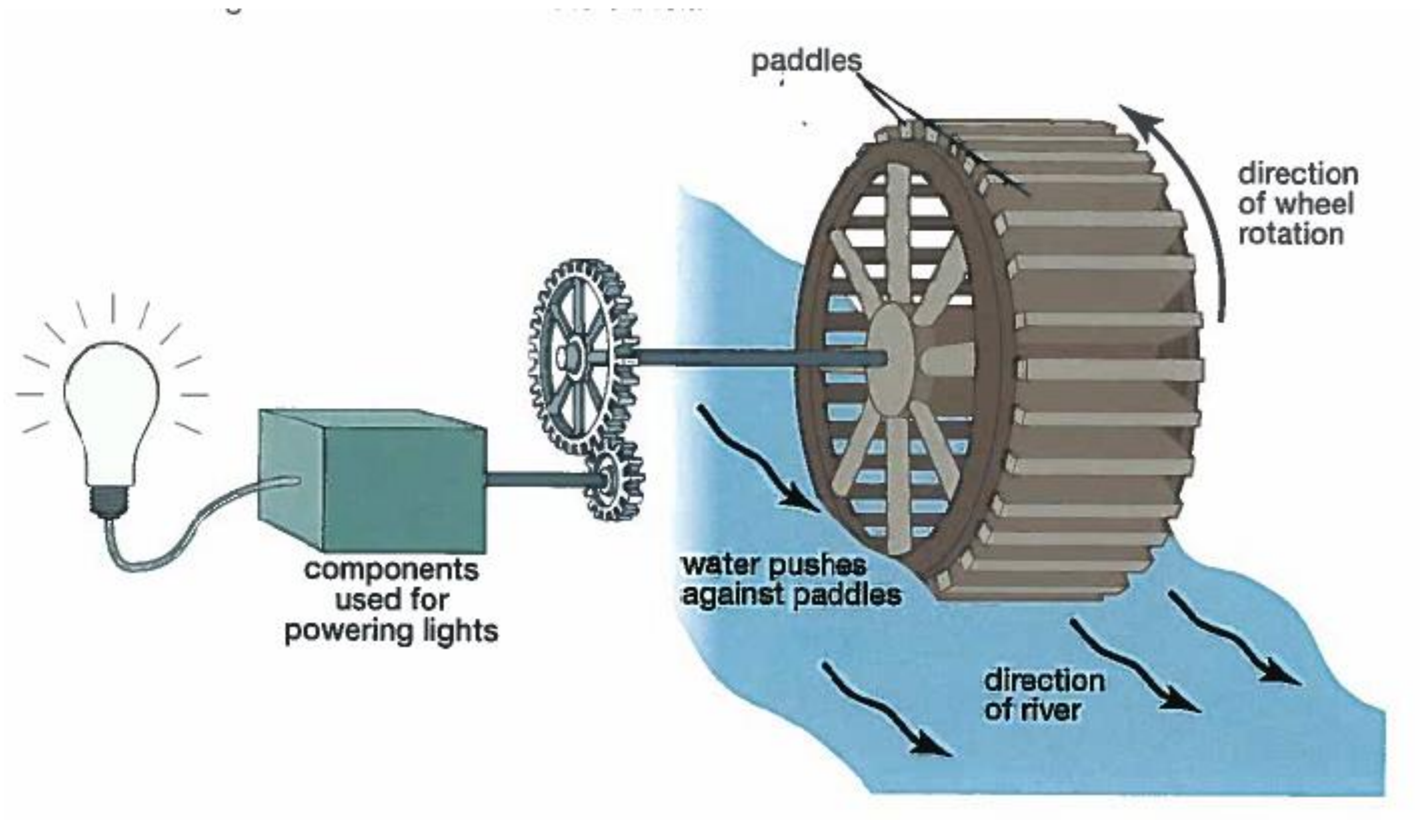
Hannah wonders how the water wheel could be powering the lights continuously since 2004. She notices the diagram on the bottom of the exhibit.



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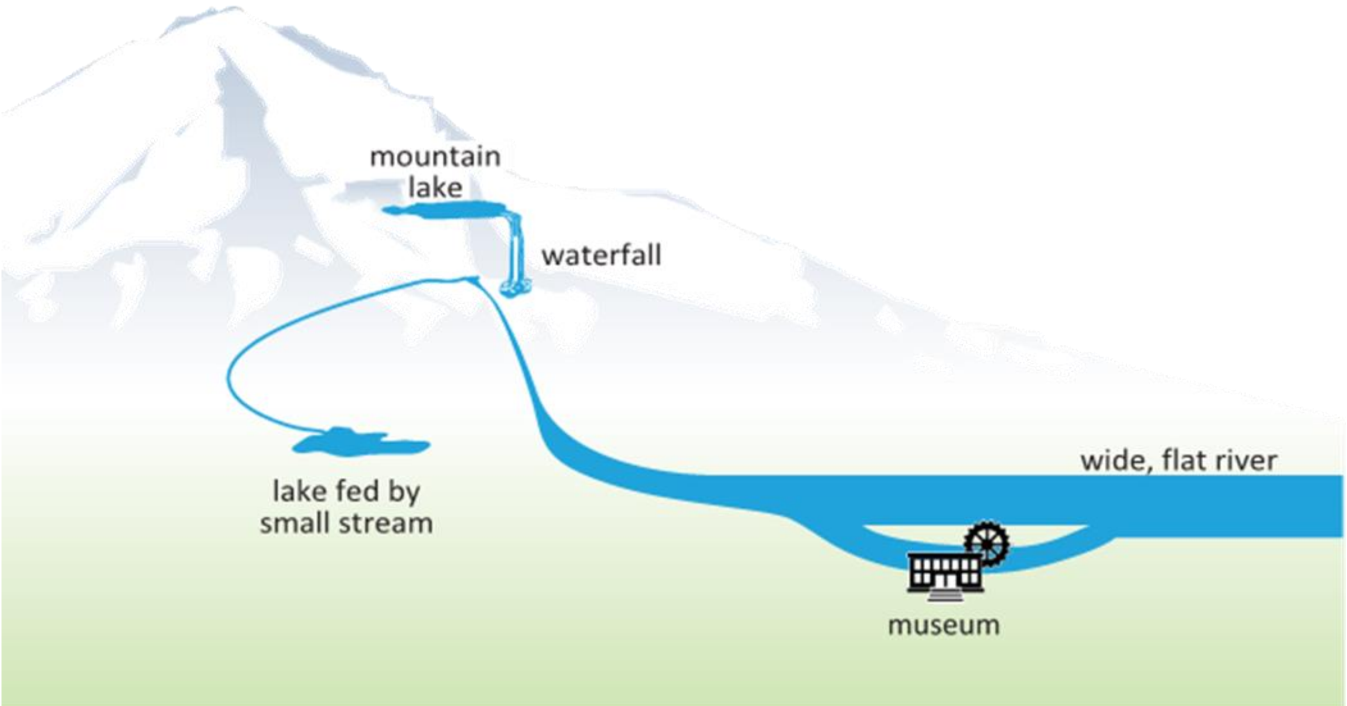
1. The diagram below shows the system that causes the water wheel to move.



In which part of the system is the kinetic energy of the water greatest?

A mountain lake

B waterfall

C lake fed by small stream

D wide, flat river

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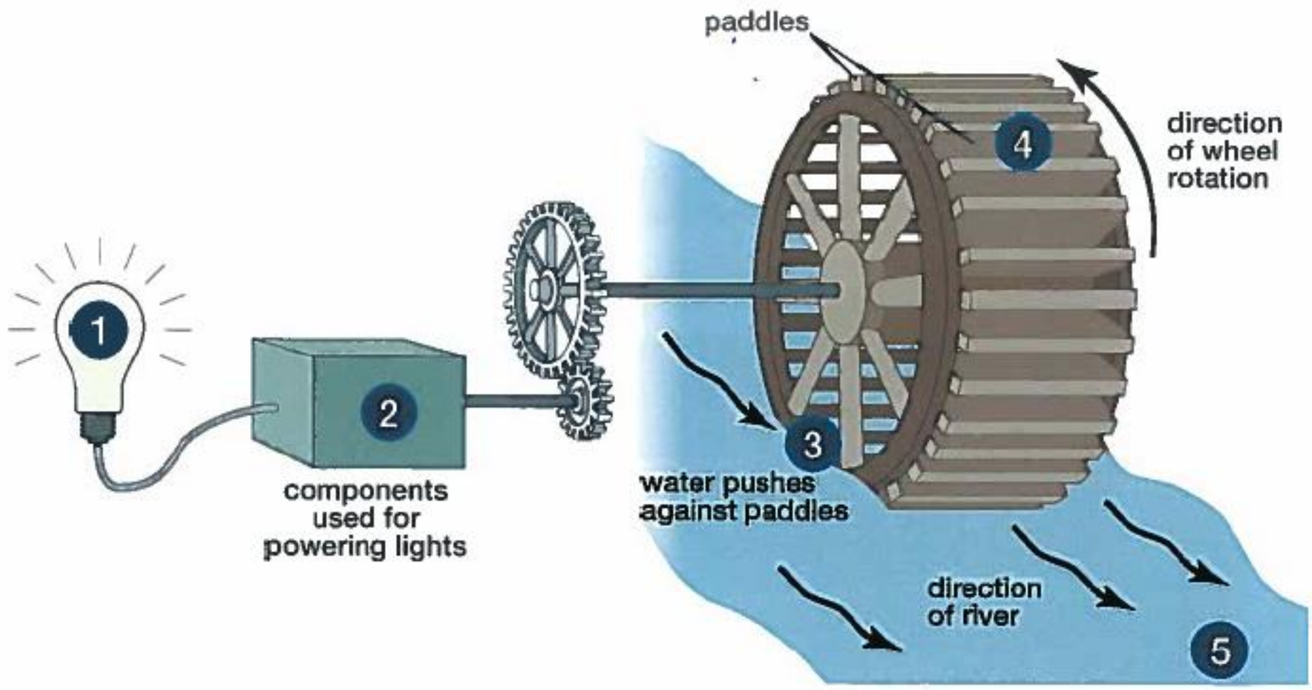
2. The diagram below shows the water-wheel system used to power the lights in the museum's exhibit.



Which location(s) in the diagram show where kinetic energy is transformed into another form of energy? Select all that apply.

A location 1

B location 2

C location 3

D location 4

E location 5

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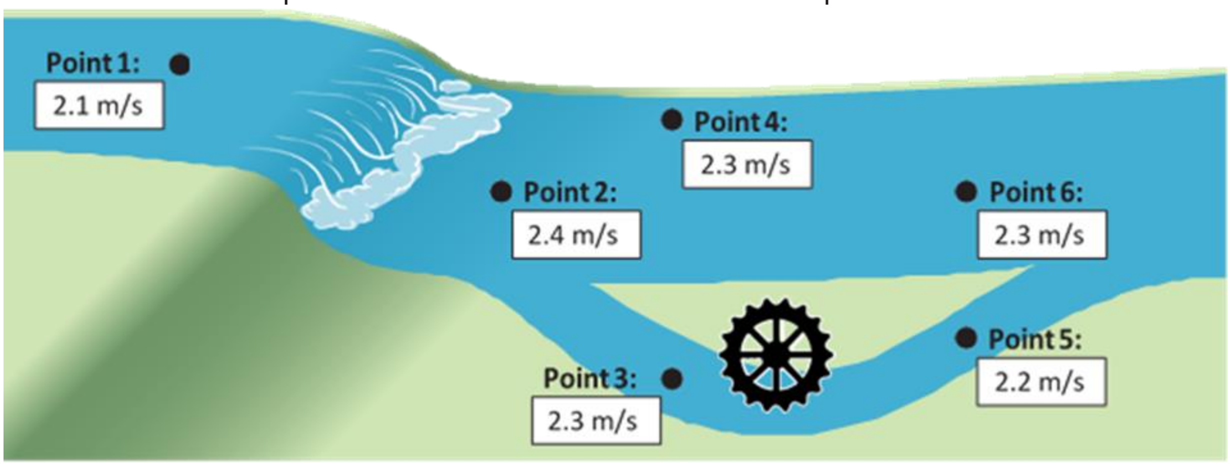
Because the water wheel is so important to powering the lights in the museum, the museum monitors the speed of the water, in meters per second (m/s), in the river at the six different points shown below. There is a change in elevation[1] between points 1 and 2, but there is no change in elevation in the section of river located between points 2 and 6.

How fast does the water in the river flow?

The average speed of the water in the river changes all the time due to various factors. The real-time speed of the water as measured in meters per second is shown.



Hannah looks at the average speed of the river flowing at each point. She wonders why the speed of the river is different at different points along the river.

[1] elevation: the height of an object or location above a given level, especially sea level

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3. Using the information presented about the water wheel and the data provided, which of the following claims about kinetic energy and the water wheel is best supported by the data in the diagram?

   A Some of the kinetic energy of the river is destroyed by the water wheel.

   B Some of the kinetic energy is transferred from the river to the water wheel.

   C Some of the kinetic energy of the water wheel is used to slow the flow of the river.

   D Some of the kinetic energy produced by the water wheel is transferred to the river.

4. What data can be used as evidence to support the claim you made in question 3?

   A The speed of the water is slower at point 5 than at point 3.

   B The speed of the water is slower at point 6 than at point 2.

   C The speed of the water is slower at point 5 than at point 4.

   D The speed of the water is the same at points 3 and 4.

   E The speed of the water is the same at points 3 and 6.

5. Which provides the best reasoning for why the data you selected can be used as evidence to support the claim you made in question 3?

   A Energy is destroyed, because the speed of the water slows down.

   B Energy is conserved, so the speed of the water in the river stays the same.

   C Energy is created, so the water wheel transfers kinetic energy to the water in the river.

   D Energy is conserved, so the kinetic energy lost by the river is gained by the water wheel.

   E Energy is conserved, because some of the kinetic energy of the wheel goes back into the river.

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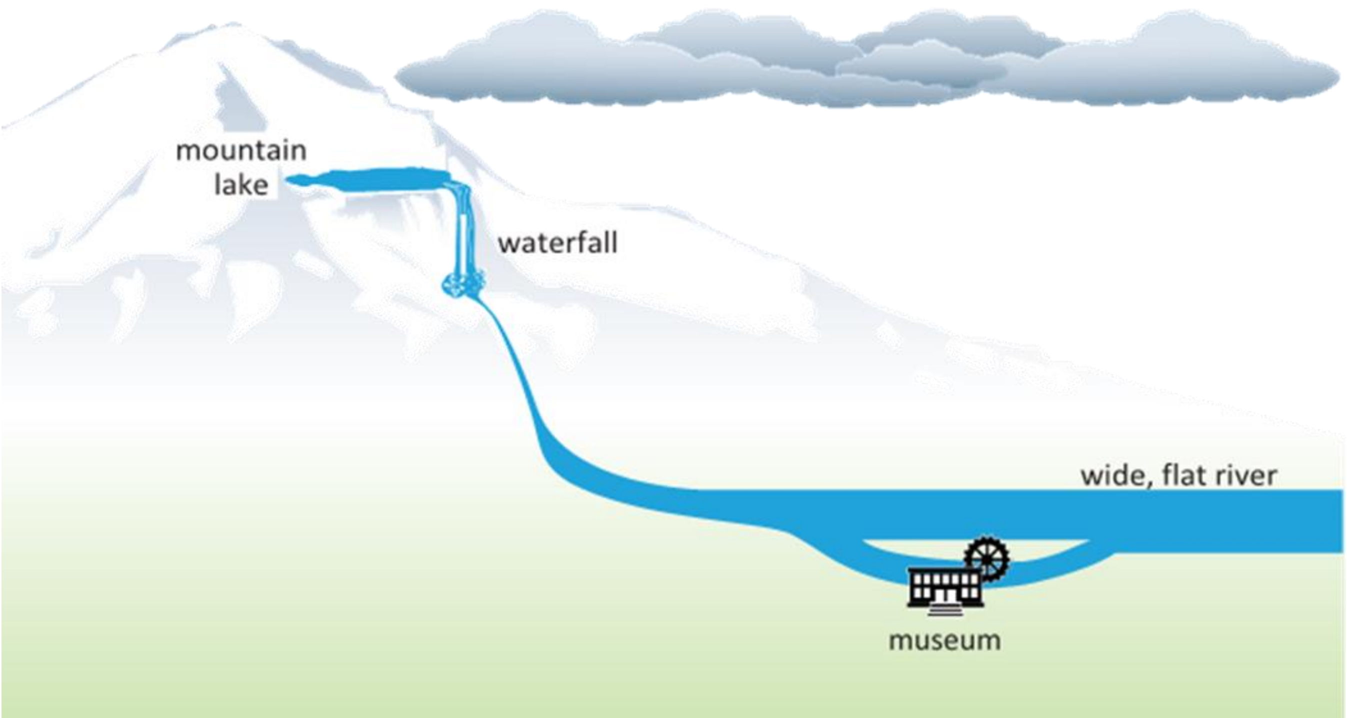
The next day, Hannah tells her class about what she saw at the museum and shares the diagram of the river system with her class. She explains that the river has kinetic energy, which is then transferred to the water wheel when the water flows past the wheel. One student asks where the energy in the river comes from to power the lights continuously. The teacher explains that it takes energy to move water within a system. She asks students to think about what causes the movement of water within the system shown in the diagram below.



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6. Using what you know about energy transfer and the processes that move water within a system, explain what causes water to move to the mountain lake and then flow down the mountain to move the water wheel. In your explanation, discuss what drives each process, including any transfer of energy that is required to move water through the system.

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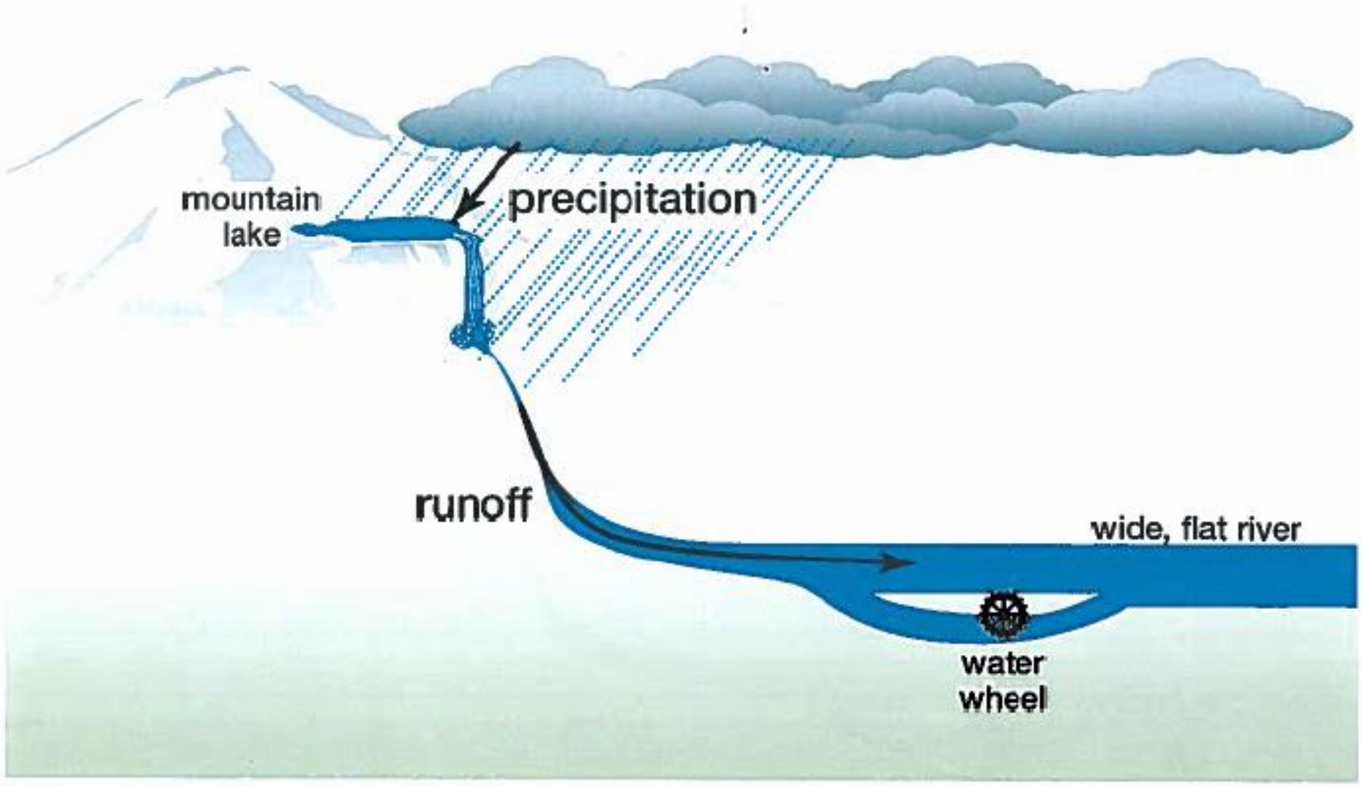
As Hannah's classmates think about how water moves in this system, they decide to change the diagram into a model. First, the students model precipitation and runoff, as shown. The arrows represent the direction in which the water moves.



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7. Which of the following causes precipitation to fall, and causes runoff in the river to flow to the water wheel?

A energy transfer from sunlight to water molecules

B energy transfer from water molecules to the environment

C the force of gravity between Earth and the water molecules

D the force of gravity between water molecules and the water wheel

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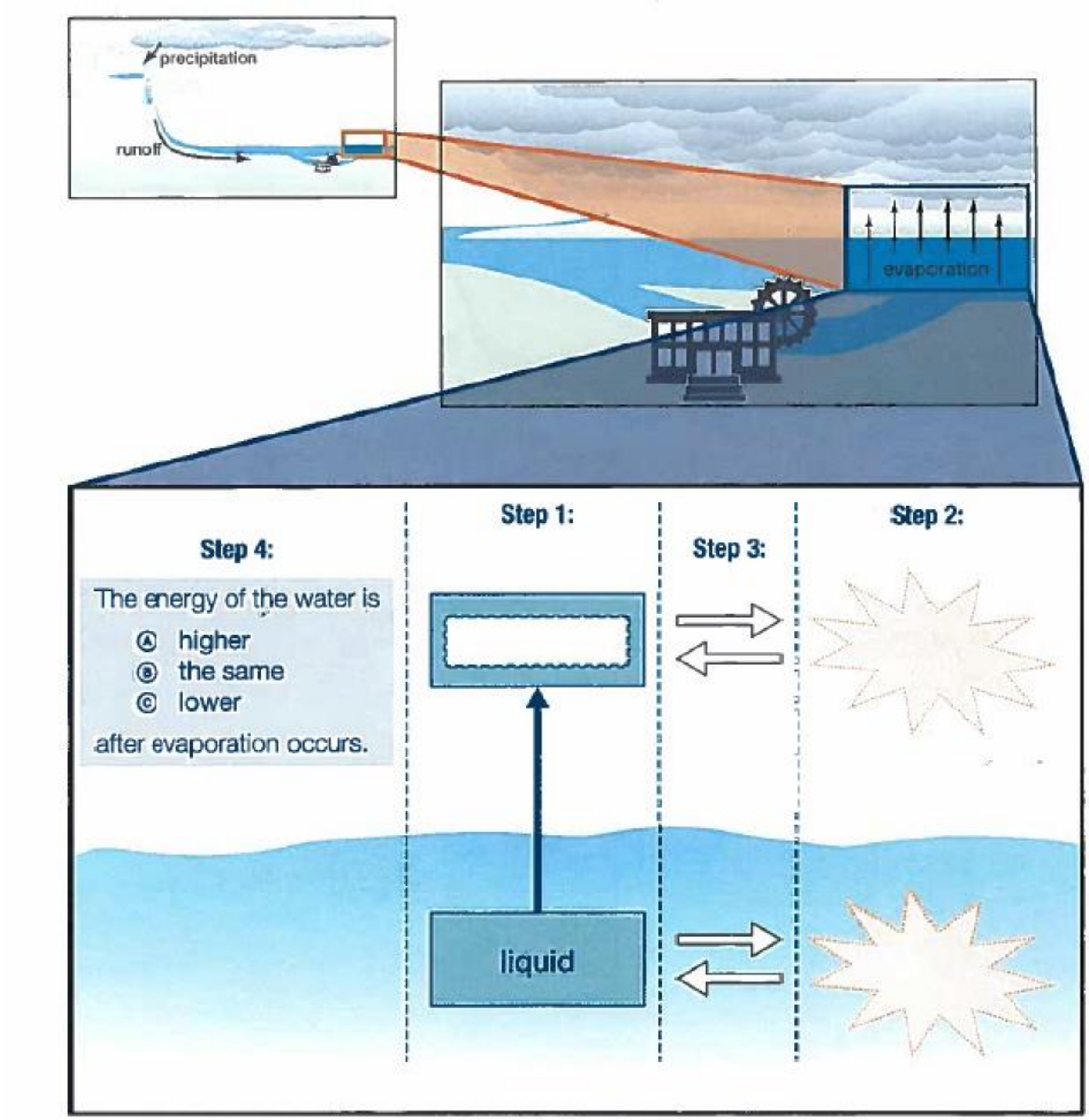
Next, the students attempt to better model the unobservable processes that result in evaporation.

The students model the unobservable processes that result in the evaporation of water by creating the series of images shown below.



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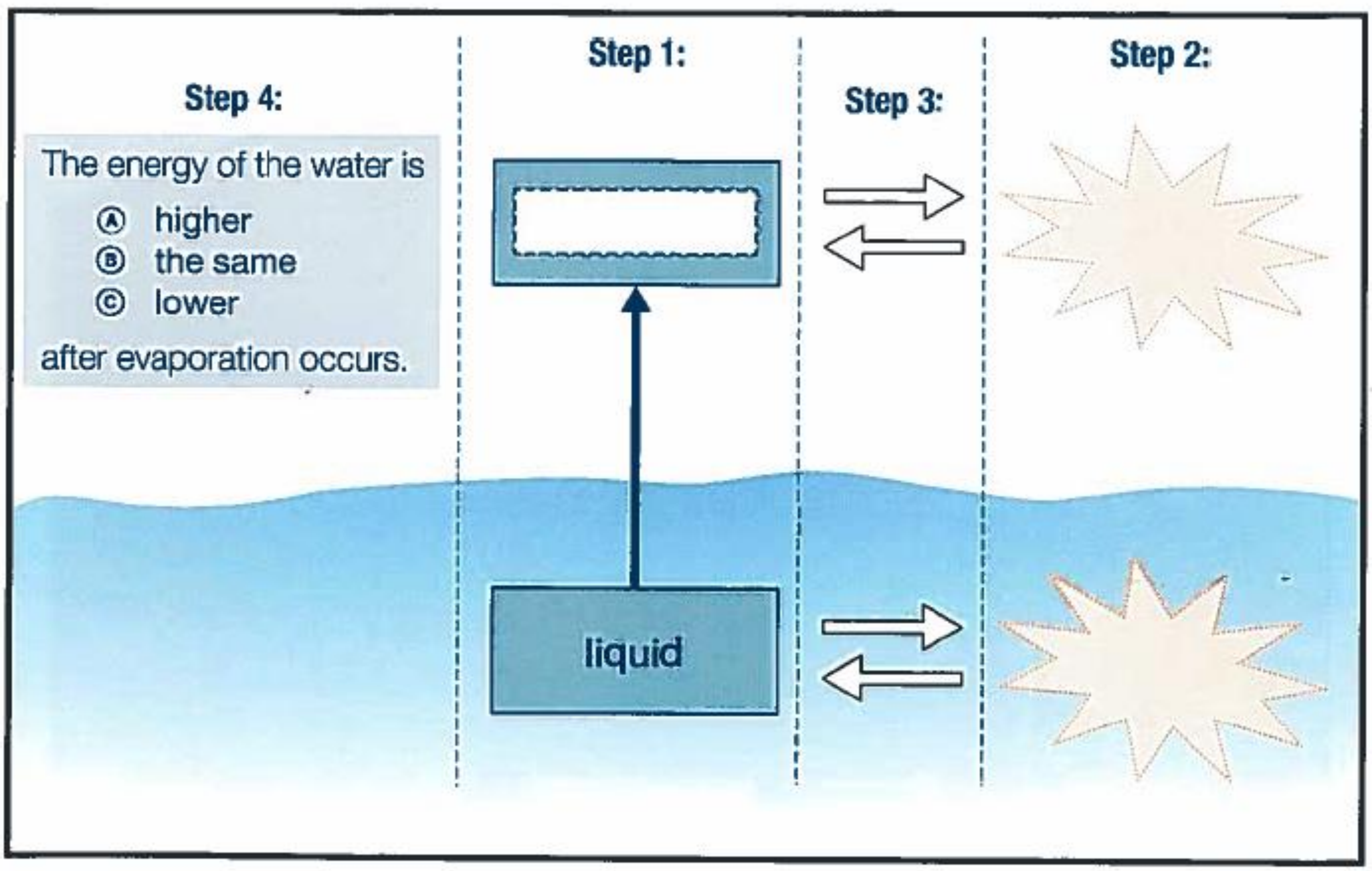
8. Complete the model of evaporation, beginning with the water in the river, by following the steps below.

Step 1: In the box labeled Step 1, write the state of matter (gas, liquid, or solid) of water after evaporation occurs.

Step 2: Write "energy" into ONE of the  icons to show where energy is transferred in this system.

Step 3: Color in ONE of the four arrows in the model to show how energy is transferred during evaporation.

Step 4: Which word(s) complete the sentence to make a comparison of the energy in the water before and after evaporation occurs?



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9. What causes the change in the state of matter during evaporation?

A the force of gravity between water molecules

B energy transfer from sunlight to water molecules

C the force of gravity between Earth and water molecules

D energy transfer from water molecules to the environment

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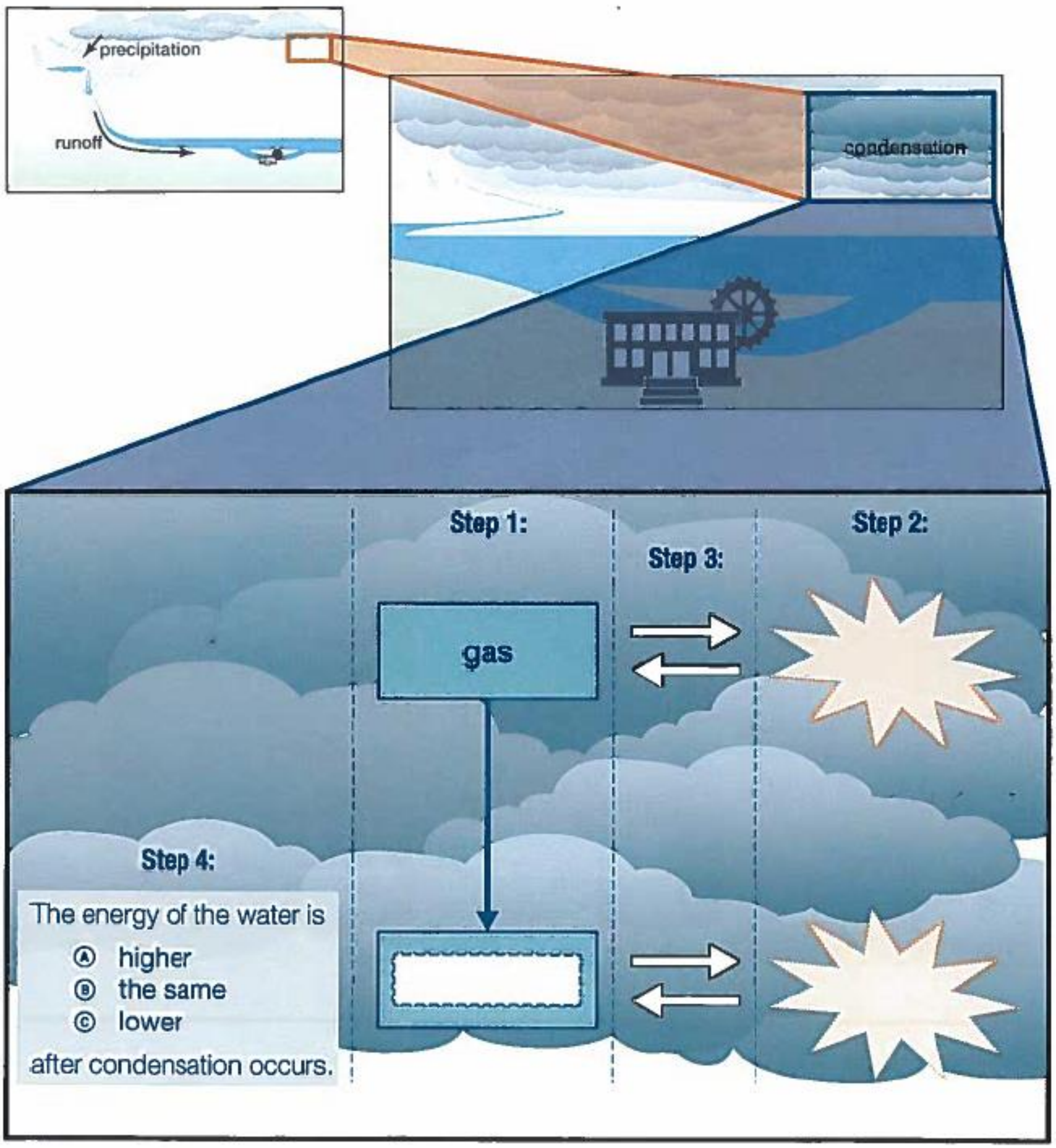
Next, the students want to better model the unobservable processes that result in condensation.

The students model the unobservable processes that result in the condensation of water, by creating the series of images shown below.



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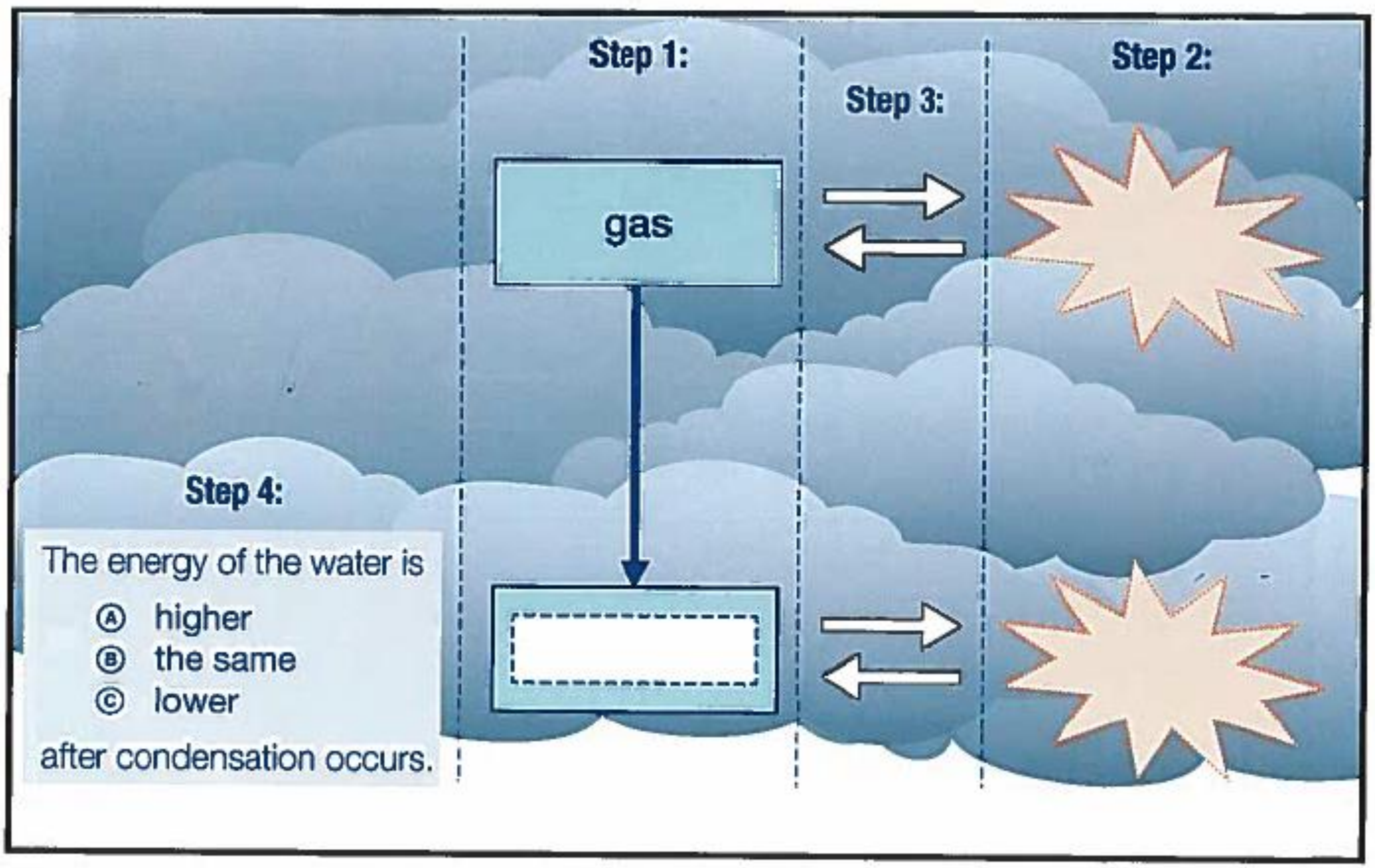
10. Complete the model of condensation, beginning with the water in the atmosphere, by following the steps below.

Step 1: In the box labeled Step 1, write the state of matter (gas, liquid, or solid) of water after condensation occurs.

Step 2: Write "energy" into ONE of the icons to show where energy is transferred in this system.

Step 3: Color in ONE of the four arrows in the model to show how energy is transferred during condensation.

Step 4: Which word(s) complete the sentence to make a comparison of the energy in the water before and after condensation occurs?



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11. What causes condensation?

A the force of gravity between water molecules

B energy transfer from sunlight to water molecules

C the force of gravity between Earth and water molecules

D energy transfer from water molecules to the environment

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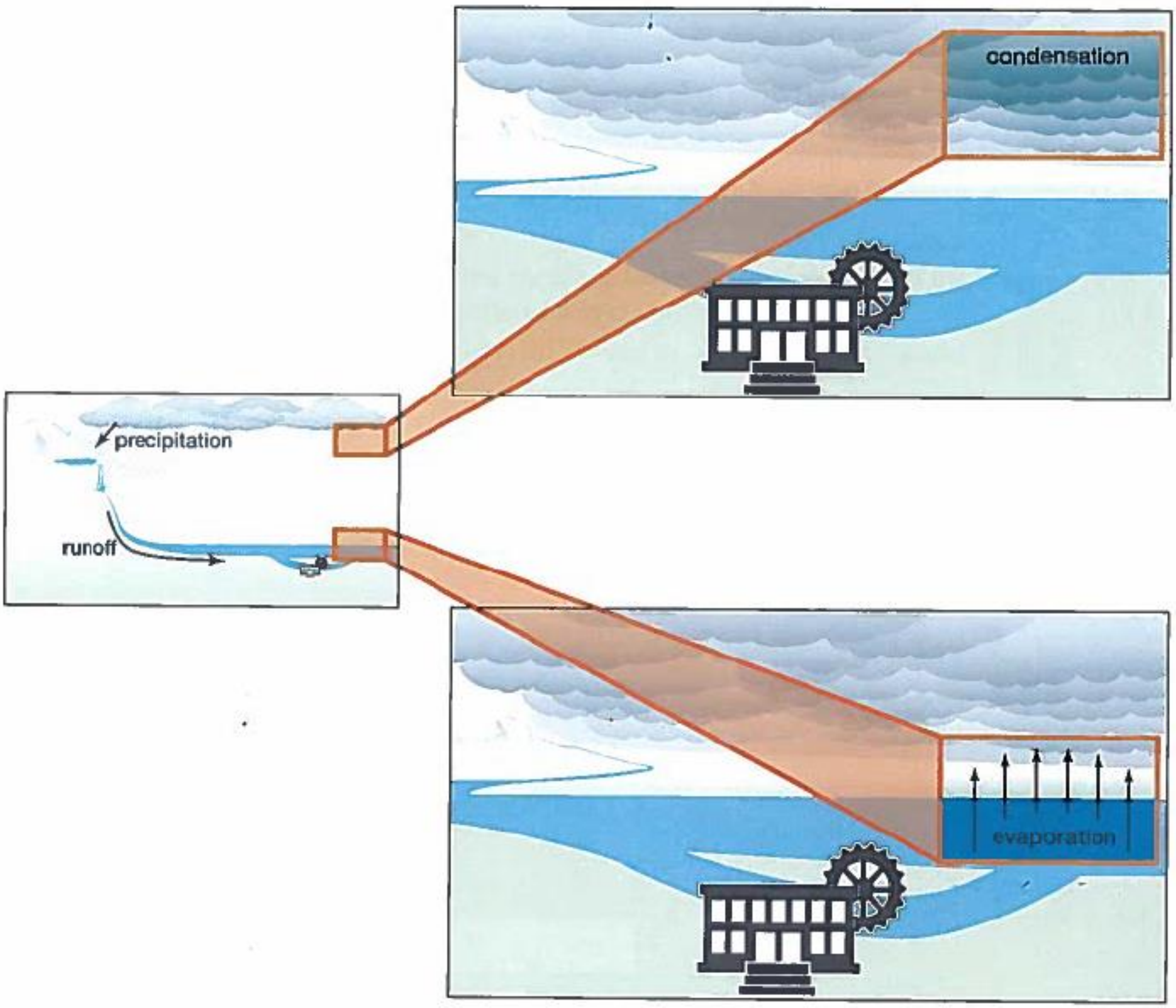
The teacher asks the students to use the model below to describe how the water wheel can be used to power the lights in the museum continuously.



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Two students explain their thinking, as shown below.

Student 1

- The model shows that water molecules in a river or lake absorb energy from the sun. The energy absorbed supplies all the necessary energy for the rest of the water cycle.
- Some of the absorbed energy causes the water molecules to rise up into the air and evaporate.
- Some energy is released by the water molecules as they cool and condense to form clouds.
- The rest of the energy stored in the water molecules is transferred into kinetic energy as gravity pulls on water molecules, causing them to fall as precipitation and collect in the river.
- Some of the remaining kinetic energy in the river is then transferred to the water wheel.

Student 2

- The model shows that water molecules in the river or lake absorb energy from the sun. This supplies the energy necessary for water molecules to evaporate from the lake's surface and rise into the atmosphere.
- The water molecules lose energy as they rise and cool in the atmosphere, condensing to form water droplets in clouds.
- Gravity pulls on the water droplets in clouds, which gain kinetic energy as they fall as precipitation.
- Water in the river has kinetic energy due to the pull of gravity as the water travels down the mountain.
- Some of the kinetic energy of the water in the river is then transferred to the water wheel.

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12. Which student's explanation shows a greater understanding of the processes needed for the water wheel to power the lights continuously? Circle your response.

Student 1 **Student 2**

13. Explain why the student's explanation you identified shows a greater understanding than the other student's explanation.

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Page	Question #	Purpose	Alignment/Dimensions	Lessons Learned
1-3		Sets the stage for the storyline, providing some background that tells		Students reacted positively to the storyline approach to assessment construction
4	1	This is designed to be a foundational question in which students apply their knowledge of the DCI that kinetic energy is the energy of motion.	DCI PS3.B—Conservation of Energy and Energy Transfer	
5	2	Students are applying energy transfer to the model presented in the museum. It asks students to identify more than one response.	DCI PS3.B—Conservation of energy and Energy Transfer CCC Energy and Matter	In the future, questions that ask students to identify more than one response will specific how many answer choices to select.
6-7	3-5	There is a continuation of the storyline, providing further information about the role of energy. The questions are an assessment of argumentation (claim, evidence, reasoning) via a multiple choice format.	DCI PS3.B—Conservation of Energy and Energy Transfer SEP Engaging in Argument from Evidence CCC Energy and Matter	It is possible to assess concepts such as argumentation trough one or more multiple choice questions. Previously such concepts have primarily been assessed through extended response questions. A greater number of students successfully completed the claim, evidence, reasoning questions when presented as multiple choice as opposed to questions requiring a written response.
8-9	6	There is a continuation of the storyline, with Hannah sharing with her class what she learned. The story now moves into exploring/explaining energy that results in electricity being produced. The constructed response is an opportunity for students to first reflect on before exploring in more detail.	DCI ESS2.C—The roles of Water in Earth's Surface Processes DCI PS3.B—Conservation of Energy and Energy Transfer CCC Energy and Matter	Students often did not understand this question. As they continued through the cluster, they would go back and make adjustments to this constructed response. This question intrudes into the answer space. The extended response questions on the field test will be presented on a preceding page so the student is given the entire page to construct his/her response.

Page	Question #	Purpose	Alignment/Dimensions	Lessons Learned
10-11	7	Students begin to explore the role of energy within the water cycle to maintain the energy production within the museum	DCI ESS2.C—The roles of Water in Earth's Surface Processes CCC Energy and Matter	
12-13	8	Students are asked to complete a model, with guidance, demonstrating energy transfer during the process of evaporation	DCI ESS2.C—The roles of Water in Earth's Surface Processes SEP Developing and Using Models CCC Energy and Matter	Students had difficulty understanding the model. Some found it confusing while others stated they had little to no experience with modeling. The steps, being labelled "out of order" caused issues for some students. Teachers have expressed a concern that students were unsure if the question in Step 4 referred to the water that had evaporated or to the water left behind.
14	9	Students are asked to demonstrate an understanding of the role of energy in the evaporative process	DCI ESS2.C—The roles of Water in Earth's Surface Processes CCC Energy and Matter	
15-16	10	Students are asked to complete a model, with guidance, demonstrating energy transfer during the process of condensation	DCI ESS2.C—The roles of Water in Earth's Surface Processes SEP Developing and Using Models CCC Energy and Matter	Students had difficulty understanding the model. Some found it confusing while others stated they had little to no experience with modeling. The steps, being labelled "out of order" caused issues for some students. Similar issues with Step 4 were expressed as with Question 8. When discussing these items with students after the assessment, several students were able to verbally explain the model correctly even though they did not complete it correctly in their booklet.
17	11	Students were asked to demonstrate an understanding of the role of energy in the condensation process.	DCI ESS2.C—The roles of Water in Earth's Surface Processes CCC Energy and Matter	

Page	Question #	Purpose	Alignment/Dimensions	Lessons Learned
18-20	12-13	After working through how energy transfers in water, students are presented with two explanations as to how the water wheel can be used to power the museum lights. They are asked to argue which student has the better explanation. This provides an example of how a Science and Engineering Practice (argument) can be emphasized in a question while still remaining focused on the core science ideas within the cluster.	DCI ESS2.C—The roles of Water in Earth's Surface Processes PS3.B—Conservation of Energy and Energy Transfer SEP Engaging in Argument from Evidence CCC Energy and Matter	The question intrudes into the answer space. The extended response questions on the field test will be presented on a preceding page so the student is given the entire page to construct his/her response.