Achieve

SCIENCE TASK ANNOTATION

ANNOTATION KEY

EQUITY
Supporting a wide range of diverse students.

SCENARIOS
Information provided to elicit performances.

SEPs
Opportunities to demonstrate science and engineering practices.

DCIs
Opportunities to demonstrate understanding of disciplinary core ideas.

CCCs
Opportunities to demonstrate understanding of crosscutting concepts.

SENSE-MAKING
Opportunities for reasoning about phenomena and problems.

ASSESSMENT PURPOSE
Highlights how the task features connect to intended assessment use.

Targeted Performance Expectation:

HS-LS-4-3: Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

[Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.]

[Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.]

EVOLUTION OF SWALLOWS

In the 1970's along the I-80 highway in Keith County, Nebraska, drivers started noticing large numbers of dead swallows on the road. This led to a 45-year long study on swallow roadkill to figure out why this was happening.

Cliff Swallows traditionally built their nests on vertical cliff faces. However, with the expansion of roads, they have adopted many bridges, overpasses, and culverts as their colonial nesting sites. Their nests are grey or brown with openings at one end. Cliff Swallows zoom around in complicated aerial patterns to catch insects for food.

Image source: http://www.cell.com/cms/attachment/2021743115/2041577164/gr1_lrg.jpg

Source of data: Brown, C. R., & Brown, M. B. (2013). Where has all the road kill gone? *Current Biology*, 23(6), 233-234.

This is a specific, puzzling phenomenon that grounds student thinking. The phenomenon is set up to be comprehensible to a wide range of students, with limited words and sufficient detail to help students visualize what is going on. The images are helpful, and the scenario could be improved if it included videos of swallows' aerial behavior, so that students could more easily visualize this—especially as the aerial behaviors are most relevant to explaining the phenomenon as set up by the task.

The scenario text includes:
1) the specific observation that a large number of dead swallows were observed on the road,
2) some cuing that this is unusual and relevant to a community (language like "started noticing" and "45-year-long study to figure out why this is happening", and
3) identification of a "gap" or uncertainty [why this is happening] that students need to fill with their understanding of science SEPs, DCIs, and CCCs.

SCENARIOS **EQUITY**

EVOLUTION OF SWALLOWS (CONTINUED)

Question 1. What do you think are some of the challenges for cliff swallows living in this new environment that did not exist before the highway was built?

This question provides some scaffolding to help students connect their own ideas to the relevant DCIs to begin engaging in the task—this is an example of appropriate on-ramping.

EQUITY

Question 2 Short Answer Version. The table below shows some disadvantages and advantages of shorter and longer wings for bird flight.

Consider the kind of flight the cliff swallows who live under highway bridges might need to get food from the road.

Do you think birds with longer wings or shorter wings are more likely to have an advantage that allows them to survive better in this new environment? Explain your answer.

To successfully answer this question, students need to use reasoning about the way swallows fly (provided) to identify advantageous traits. This is another example of a scaffold, rather than a question that requires the DCI, because the knowledge students need to have to answer this is what "advantageous" means—and the colloquial definition is sufficient. Beyond that, students need to use logical reasoning, supported with evidence.

Students are making a claim based on evaluating given evidence, but this does not reach the level of sophistication expected for HS across analyzing and interpreting data or engaging in argument from evidence. In HS, both practices emphasize complex, valid sources of evidence and interpreting information in light of increasing uncertainty.

EQUITY DCIs SEPs

This might be difficult for some students to visualize; it would be particularly helpful to include a video or some other support, given the nature of questions 2 and 3.

EQUITY SCENARIOS

Longer wings	Shorter wings
• Require less energy to use because there's less drag • Harder to change directions quickly, turning is slow • Take off speed is slow	• Require more energy to use • Easier to change direction quickly • Allow birds to take off quickly

EVOLUTION OF SWALLOWS (CONTINUED)

QUESTION 4 POSSIBLE POINTS = 3

Points	Required Components of Answer	Examples
+1	Correct trait: Shorter wings	Shorter wings are more advantageous for survival Birds with shorter wings are more likely to survive.
+1	Shorter wings allow the birds to maneuver quickly to avoid cars on the highway	With shorter wings, birds can more easily avoid cars
+1	States why (compared to what) shorter wings are advantageous in the population	This is an advantage over birds with longer wings who cannot change directions as quickly and are therefore more likely to get killed by a car

Alternate Multiple-Choice Version

Birds with which wing length are more likely to have an advantage that allows them to survive better in this new environment?

a) Shorter wings, because they allow swallows to take off quickly after getting food.

b) Shorter wings, because there is more drag on their wings.

c) Longer wings, because they require less energy for flight.

d) Longer wings, because they can fly farther with them.

This is an interesting way to contrast multiple approaches to eliciting student thinking. The multiple choice version of this question requires students to

1) select the appropriate claim(longer or shorter), and

2) logically connect it to the reason the trait would be advantageous in this scenario described.

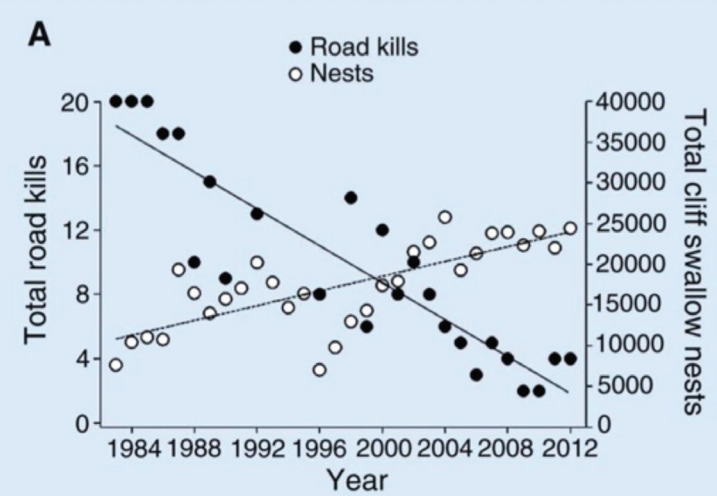
Based on the understanding of "advantageous", students can eliminate answer choice B; students have to use their understanding of the scenario and the evidence as a whole to choose among A, C, and D. It should be noted that if students really evaluate the given information and the scenario, it is clear that shorter wings are advantageous as they enable swallows to more easily engage in the "type of flight" cliff swallows need to get food from the road—then students really just need to eliminate B.

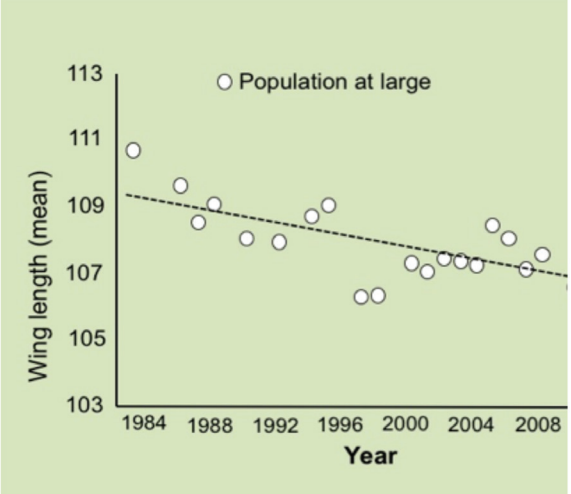
DCIs

EVOLUTION OF SWALLOWS (CONTINUED)

Question 3. As shown in the picture above, cliff swallows use human-made structures like bridges and overpasses as nest building sites.

Complete the table below using the pattern of data in the graph to explain what is happening in the cliff swallow population from 1984 to 2012. *Note: Wing length is a heritable trait*.





In chart A, The Y axis on the left side shows the total number of swallows killed by cars (road kill). The black dots show the number of swallows killed each year from 1984–2012. There is a second Y axis that shows the total number of cliff nests. The white dots show how many nests were observed each year from 1984–2012.

This component of the scenario includes several supports and cues for students to support sense-making around the targeted SEPs and DCIs. The question asks students to consider complex graphs, but still provides them with the necessary information (X and Y axis, secondary Y axis) such that not knowing the mechanics of the graphs used should not limit their ability to engage in the task.

SCENARIOS EQUITY SENSE-MAKING

EVOLUTION OF SWALLOWS (CONTINUED)

Question:	Your answer:
1. What is happening to the average wing length over time?	Choose one correct answer: a. Individual swallows' wings are getting shorter. **b. The proportion of swallows with shorter wings is increasing in the population.** c. Individual swallows' wings are getting longer. d. The proportion of swallows with longer wings is increasing in the population.

Question 3 is nicely scaffolded to help all students on ramp to the question and build their explanation. The question breaks down the various pieces of evidence and reasoning students need to bring to the table.

This is an example of integration of dimensions that are below grade-level, and provides a scaffold for future questions.

To successfully respond to this multiple choice question, students need to:
1) recognize that the green graph above shows changes to wing length at the population-level,
2) identify that population-level changes connects to the proportion of swallows with shorter wing length as the result of heritable traits rather than individual swallows' wings growing or shrinking (to distinguish between a/c and b/d), and
3) identify that the data shows that wing length is decreasing (to distinguish between b and d).

This question requires students to connect parts of the MS DCIs 4.B and 4.C and the MS SEP "analyze and interpret data".

SEPs **DCIs**

EVOLUTION OF SWALLOWS (CONTINUED)

Question:	Your answer:
2. Describe the survival advantage of shorter versus longer wings for cliff swallows. Support your answer with a pattern you observe in the data.	

This prompt requires students to connect their understanding of the data provided to reasoning they used earlier to make the claim that shorter wings provide a survival advantage over the long wings. To support this, students need to:
1) integrate information across both graphs provided to show that wing length is on average shortening as the number of deaths of swallows decreases and/or the number of nests increases, and
2) understand what a survival advantage is and be able to apply this here.

This is an example of more sophisticated data analysis and interpretation, approaching HS-level sophistication. With the exception of the term "survival advantage," the DCI understanding is most closely connected to the MS level (MS4.B: "Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.")

SEPs DCIs

EVOLUTION OF SWALLOWS (CONTINUED)

Question:	Your answer:
3. How could the total road kills go down, as the nests are going up? (Nests are something scientists use to estimate the size of adult swallows surviving long enough to reproduce.)	
4. What about the environment contributes to a change in the average wing length in the cliff swallow population over generations?	

Answering this question (as expected by the scoring guidance) requires that students use reasoning to interpret the given observation to the population-level shifts in the proportion of shorter winged swallows and the survival of a larger proportion of the population to be able to reproduce. This connects most closely to the HS-level DCI LS4.B "The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population."

It should be noted that, as written, this question could be answered using logical reasoning without science ideas or practices—that as the number of swallows killed decreases, the population of swallows living to form nests increases. This would reflect a misunderstanding of the question rather than limited student understanding of the related concept.

SENSE-MAKING DCIs

EVOLUTION OF SWALLOWS (CONTINUED)

Question:	Your answer:
5. What is the role of natural selection in explaining the change in average wing length in the population over generations?	

This question most clearly targets the DCIs about natural selection and adaptation at the middle school level.
The distinguishing characteristics between MS4.B/C and HS4.B/C are:

1) a focus on proportion of individuals with advantageous and disadvantageous traits, and

2) that these changes can be driven by an environmental change that causes a new selection advantage or disadvantage if traits are heritable.

Because the question can be answered using the less sophisticated understanding that "traits that support successful survival and reproduction in the new environment become more common [short wings, for the reasons noted above]; those that do not become less common [change in population]. Thus, the distribution of traits in a population changes.", this question assesses the MS DCI understanding, building toward but not completely assessing the HS expectation.

Students are engaged in sense-making when they connect the DCI to the observation that average wing length is decreasing in the population over time and to their reasoning about specific pressures in the environment described that might lead to this change.

SENSE-MAKING DCIs

EVOLUTION OF SWALLOWS (CONTINUED)

QUESTION 2.2 POSSIBLE POINTS = 2

Points	Required Components of Answer	Examples
+1	Describes at least one advantage of shorter wings	The shorter wings help the birds be able to fly faster.
+1	Provides a piece of evidence about wing length based on the graph	The data show that most of the roadkill victims have larger wings. There are more birds in the population with shorter wing length over time.

QUESTION 2.3 POSSIBLE POINTS = 2

Points	Required Components of Answer	Examples
+1	Mentions the population of swallows becoming adapted to its new environment, as evidenced by increased nesting sites	There are more swallows surviving, because there are more with shorter wings.
+1	Mentions the population of swallows becoming adapted to its new environment, as evidenced by decreased road kills	There are more swallows surviving, because the long-winged swallows were all killed off early on, and those that remain were better adapted.

QUESTION 2.4 POSSIBLE POINTS = 1

Points	Required Components of Answer	Examples
+1	Mentions a specific pressure of the environment (e.g., cars, predators) and relates that to wing length	Smaller wings may allow the bird to fly faster, especially when flying away from an incoming car. Birds with shorter wings can make more evasive maneuvers to escape oncoming traffic.

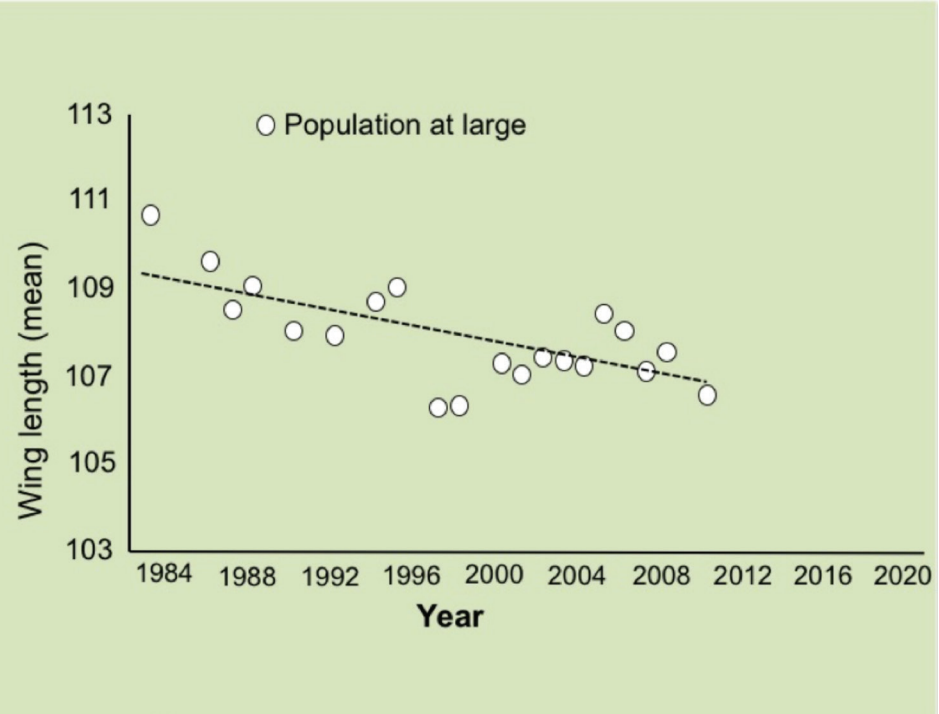
EVOLUTION OF SWALLOWS (CONTINUED)

QUESTION 2.5 POSSIBLE POINTS = 3

Points	Required Components of Answer	Examples
+1	Refers to survival of swallows with shorter-wings and/or death of those with longer wing	
+1	Refers to reproduction or passing on advantageous traits	The threat of the cars causes natural selection by killing off long-winged birds & leaving the short-winged birds to reproduce. The pressure from the highway environment has allowed swallows with shorter wings to live more and reproduce, passing on their hereditary trait through natural selection.
+1	Correctly discusses adaptation (If the student discusses adaptation in any of the above responses, give a point here)	The swallow population is somehow adapting to the different conditions of the nests underneath the highways. The swallows are adapting to their new environmental home. Over time, the swallows learn of the dangers of the highway and adapt accordingly to avoid those dangers.

EVOLUTION OF SWALLOWS (CONTINUED)

Question 4. Draw a dot on the chart below to indicate what you predict the average wing length will be in 2020. How did you estimate where to place the dot? What do you assume in the environment was changing or staying the same in the future?



This question requires that students understand that the line of best fit indicates a trend, and that the line will continue its trajectory if there are no major environmental changes that would result in a different selection pressure. This question, with both parts, requires that students use the SEP "analyze and interpret data" and DCI LS.4B.

These elements are approaching high school appropriateness because:
1) the DCI requires that students understand that "Adaptation also means that the distribution of traits in a population can change when conditions change" (HS.LS.4C), and
2) the HS SEP element asks students demonstrate that they can "apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems…"
When students interpret the population information and line of best fit, they are using more advanced statistical thinking than mean, median, mode that is called out in middle school, and begins to support "determining function fits to data".

SEPs DCIs SENSE-MAKING

EVOLUTION OF SWALLOWS (CONTINUED)

QUESTION 3 POSSIBLE POINTS = 3

Points	Required Components of Answer	Examples
+1	Explain that estimate uses the line of best fit. Student does not have to use the actual term "best fit", but must describe the action of following line or pattern	I followed the line of best fit from the previous data to determine how many short-winged birds there would be Extending the line to 106 counts
+1	Estimate is roughly 106 (Roughly = within 1 point of 106)	The threat of the cars causes natural selection by killing off long-winged birds & leaving the short-winged birds to reproduce. The pressure from the highway environment has allowed swallows with shorter wings to live more and reproduce, passing on their hereditary trait through natural selection.
+1	Assumption that the environment didn't change, selection pressures remain the same	I assumed shorter wings remained an advantageous trait. I assumed that cars would still be a danger to the swallows