Cooling by Design

Model animal temperature regulation to reduce energy use

ZOO.9.4 "Enrichment: Use an engineering design process to model biomimicry of endothermic temperature regulation to meet a sustainable need.*"

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline how the jackrabbit releases or limits heat, and circle the matching features of the window panel. Number the team's design steps from identifying the need through revising the model.

A Window Inspired by Ears

1. At a school with costly air-conditioning, students want a classroom to shed heat without using a fan. They study jackrabbits, which, like other mammals, produce body heat and keep their internal temperature within a working range. A jackrabbit's large ears contain blood vessels near the skin. When the air is cooler than the blood, increased blood flow through the ears helps release heat to the surroundings. Reduced flow limits that heat loss. Ears are not magic coolers: when surrounding air is hotter, exposed surfaces may gain heat instead. The students must account for outside temperature.

2. The team proposes a removable window panel with adjustable vents and a shaded, light-colored outer surface. Moving air through open vents plays the role of circulating blood, while the panel's exposed surface offers a path for heat to leave. On a cool night, opening the vents can carry warmer indoor air out as cooler air enters. When outdoor air is hotter than indoor air, closing the vents limits heat coming in. The design must fit an existing window, let the window lock, and cost less than a powered fan. Mesh keeps insects out but may slow airflow.

3. To test the idea, the students place two identical model rooms under the same lamp. One has a panel with fixed open vents, and the other has adjustable vents. They record indoor and outdoor temperatures at the same times during a warm-air phase and a cooler-air phase. Their goal is for the adjustable model to stay no warmer than the fixed-vent model during the warm phase and become at least 2 °C cooler by the end of the cool phase. If the second goal fails, they will enlarge the openings and repeat the test while keeping the other conditions the same.

2 ANSWER WITH EVIDENCE

Use the passage

1. Why does the jackrabbit release more heat through its ears when cooler air surrounds them, and what limits heat loss?

2. How do the adjustable vents model the jackrabbit's response to temperature? Explain when the students would open and close them.

3. What comparison and temperature results would show that the adjustable panel meets the team's goals?

4. If the cooler-air goal is missed, what change will the team make, and what must stay the same for a fair retest?

3 YOUR TURN

Your own words

Design a passive cooling feature for a bicycle-delivered produce crate using the jackrabbit ear principle. In one paragraph, describe when it changes position, one delivery constraint, a fair comparison and temperature goal, and one change you would make if the goal is missed.

ANSWER KEY

Cooling by Design

HIGH SCHOOL · ZOO.9.4

PART 1 · READ AND MARK

Underline how the jackrabbit releases or limits heat, and circle the matching features of the window panel. Number the team's design steps from identifying the need through revising the model. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Why does the jackrabbit release more heat through its ears when cooler air surrounds them, and what limits heat loss?	**More warm blood flowing near the ear's surface releases heat to cooler surroundings. Reduced blood flow limits that loss.**
2	How do the adjustable vents model the jackrabbit's response to temperature? Explain when the students would open and close them.	**Opening the vents on cool nights lets warm indoor air leave, like increased blood flow releasing heat. Closing them when outdoor air is hotter limits heat coming in, like reduced blood flow limits heat transfer.**
3	What comparison and temperature results would show that the adjustable panel meets the team's goals?	**Compare the adjustable-vent model with the fixed-open-vent model. The adjustable model must be no warmer during the warm phase and at least 2 °C cooler by the end of the cool phase.**
4	If the cooler-air goal is missed, what change will the team make, and what must stay the same for a fair retest?	**They will enlarge the openings. They must keep the other test conditions the same.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would fit an insulated produce crate with mesh-covered vents and sliding shutters, like the adjustable heat-loss path in a jackrabbit's ears. I would close the shutters when outside air is hotter than air inside the crate and open them when it is cooler. The shutters must stay secured during bumpy rides so fruit cannot fall out. I would compare two otherwise identical crates on the same route, one with fixed vents, and measure inside temperatures every 15 minutes. My goal is a peak temperature at least 2 °C lower. If I miss it, I would add a light-colored shade and retest.

Accept designs that use an adjustable path for heat loss and account for the direction of heat transfer. Comparisons should hold conditions constant except for the proposed feature and include a measurable goal.