Thermoregulation Lab: NYSSLS Alignment

Teacher guide for the student worksheet at mrsajdak.com/thermoregulation (two pages, 19 questions: Day 1 on the front, Day 2 on the back; a low-write version has the same numbers). Anatomy & Physiology, Hole's Essentials Section 6.4 (skin functions: regulation of body temperature). The answer key is kept off the website; write to rsajdak@buffaloschools.org for it. © 2026 Ryan Sajdak. Free to use, share and change under CC BY-NC-SA 4.0 (creativecommons.org/licenses/by-nc-sa/4.0): give credit, do not sell it, share your version the same way.

The model

Five tabs and a bonus game in one page, no login. Every run gives the same numbers, so the key is exact. **What is real:** in Tab 1 a wet thermometer cools toward the room's wet-bulb temperature, worked out from the humidity with Stull's (2011) formula;. The heat index in Tab 3 is the National Weather Service formula. The watts in Tab 2 use textbook coefficients for radiation, still and moving air, contact, water and evaporation on 1.8 m^2 of adult skin. In Tab 3 the stored heat warms an 80 kg body at 3.47 kJ for each kilogram for each degree, and only sweat that evaporates cools him. A core above about 40°C is heat stroke. **What is made up to show a pattern:** the pulse, cheek colors and temperatures in Tab 4 and the hourly steps of the fever in Tab 5 are chosen to match typical results; they are not measured on a person. The note at the foot of the lab page and the worksheet footer say so.

Tab 3 ends in a collapse when the player wears full pads in humid heat. Preview it if a student in the room plays a fall sport or has had heat illness; it is a good moment to name the warning signs (confusion, stopping sweating, collapse: call 911 and cool the person).

Objectives

The same four statements are printed on the worksheet, two at the top of each side, with a box to tick. They match the lesson objective AP.3.6.8: explain how the skin helps regulate body temperature through a negative feedback loop.

Side	I can	Questions
Day 1	name four ways heat leaves the skin, and show with data that evaporation cools.	1 to 7
Day 1	explain how sweat glands and dermis blood vessels change how fast heat leaves, and why humid heat is dangerous.	8 to 10
Day 2	name the parts of a negative feedback loop and find them in my own data.	11 to 15
Day 2	explain why a fever makes you shiver at a normal temperature and sweat when it breaks.	16 to 19

Performance expectations: building toward

HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. **HS-LS1-3** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Worksheet link: students trace how the nervous system (thermoreceptors, the hypothalamus), the skin (sweat glands, dermis vessels) and the muscles (shivering) work together to hold one number steady (Q9, Q13 to Q15, Q19, HS-LS1-2). They run fair tests (Q1 to Q3, Q8), record a body returning to its set point after exercise and after cold, and name every part of the loop in their own data, including a set point that moves in a fever (Q11 to Q19, HS-LS1-3). This is practice toward both, not a full assessment of either. **DCI LS1.A:** Structure and Function (feedback mechanisms maintain a living system's internal conditions). **PS3.B** (energy moves from warmer to cooler objects) supports Parts 1 and 2.

Part by part

Part	SEP	CCC	What students do
1. Wet and dry Tab 1, Q1 to 4	SEP 3 Planning and carrying out investigations SEP 4 Analyzing and interpreting data	Cause and Effect	Fan a dry and a wet thermometer, then change only the humidity. Every run starts at the room's 21.5°C. A wet bulb drops 6.3°C fanned, 3.2 in still air, 11.1 at 20% humidity and nothing at 100%. Dry, still air is the control. Fridge water is a myth check: it warms to about the 15°C the room-water run reaches, so evaporation cools, not cold water.

2. Four ways out Tab 2, Q5 to 7	SEP 4 Analyzing and interpreting data	Energy and Matter Patterns	Read the watts through radiation, conduction, convection and evaporation in six scenes. Radiation wins at rest; a 64°F lake pulls out 1,152 W by conduction. On a 99°F run, radiation and convection turn negative and only evaporation is left.
3. Football practice Tab 3, Q8 to 10	SEP 4 Analyzing and interpreting data SEP 6 Constructing explanations	Cause and Effect Structure and Function	Same 90°F, three humidities. At 40% all sweat evaporates and the core ends at 37.1°C; at 80% half drips off and the core reaches 39.2°C. In full pads he collapses at minute 40 (minute 53 with water breaks). The skin close-up shows vasodilation.
4. The loop Tab 4, Q11 to 15	SEP 3 Planning and carrying out investigations SEP 2 Developing and using models	Stability and Change Systems and System Models	Record pulse, color, palm temperature and sweat after exercise, and cheek and core at a cold bus stop. Sweat switches off by itself at 4 minutes. The cheek drops 9°C while the core drops 0.2°C. Sort eight cards into stimulus, receptor, control center, effector and response.
5. Fever Tab 5, Q16 to 18	SEP 4 Analyzing and interpreting data SEP 6 Constructing explanations	Stability and Change	Step a flu hour by hour. With the set point at 39°C a 37°C body shivers; when the fever breaks at hour 6 a 39°C body sweats. Medicine at hour 3 drops the set point to 37.8°C.
Wrap it up Q19	SEP 6, SEP 7 Engaging in argument from evidence	Stability and Change	Claim, evidence and reasoning: one negative feedback loop handles too hot, too cold and a moved set point.

Running it

Two 40-minute periods, one device per student or pair. The plan book lists them as Thermoregulation Day 1 of 2 and Day 2 of 2.

Day 1 (heat out): opener slide, why does a fan cool you when it only moves warm air? (5 min) · Part 1, Q1 to 4 (12 min) · Part 2, Q5 to 7 (10 min) · Part 3, Q8 to 10 (11 min) · exit question, why is humid 90°F more dangerous than dry 90°F? (2 min).
Day 2 (the loop): opener slide, why do you shiver with a fever when you are already warm? (5 min) · Part 4, Q11 to 15, two modes and the card sort (20 min) · Part 5, Q16 to 18 (12 min) · Q19, finished for homework if needed; early finishers play **Be the hypothalamus** (3 min).

A link can open a tab directly: mrsajdak.com/thermoregulation/#wetdry (also #routes, #practice, #loop, #fever, #game). Each side stands alone.

Explore, then explain, then apply. Each part starts with data questions (Q1 to 3, Q5 and 6, Q8 and 9, Q11 to 13, Q16 and 17). A READ FIRST line then sends students to the **Learn It** box under the lab drawing, which opens once they have the data, before Q4 (evaporation takes heat; fanning and dry air help), Q7 (the four routes; water conducts 25 times better than air), Q10 (vasodilation, vasoconstriction, sweat glands, the heat index), Q14 and 15 (the set point, the five parts, negative means against the change, the cold side) and Q18 and 19 (pyrogens move the set point). The slideshow has a matching Learn It slide at each point.

Where students get stuck: Q1 (every run starts at 21.5°C; drop = 21.5 minus the reading after 5 minutes); Q2 (Dry, still air is the control; Dry, fanned rules out the fan cooling the thermometer by itself); Q3 (100% humidity: drop 0.0); Q6 (a negative number is heat coming in, which surprises students); Q9 (water breaks do not save the player in full pads at 80%; they only delay the collapse by 13 minutes, a useful discussion); Q11 and 12 (press Record this time at each of the four times, then Next time; the hot mode does not show the core, the loop diagram does); Q15 (the cheek drop is 33.5 – 24.5 = 9.0°C).

Bonus tab: Be the hypothalamus. A 90-second game: keep the core in the green band through shade, a run in the sun, rest and cold rain using only sweat, wide or narrow vessels and shivering. It is not on the worksheet. It makes a good early-finisher task or a whole-class review on the board.

Going further. The NFHS and many state athletic associations publish heat acclimatization guidelines for fall practices, some based on the wet-bulb globe temperature. Students can look up the guideline their school follows and use Tab 3 to argue for or against it (HS-ETS1-3).