PHYSIOLOGY

Homeostasis

How the body holds its internal conditions steady through negative feedback, and the systems that fail when it doesn't, with a 10-question practice set and full solutions.

SUBJECT	LEVEL	INCLUDES
Biology	High school and early college	Practice set, answer key, revision sheet

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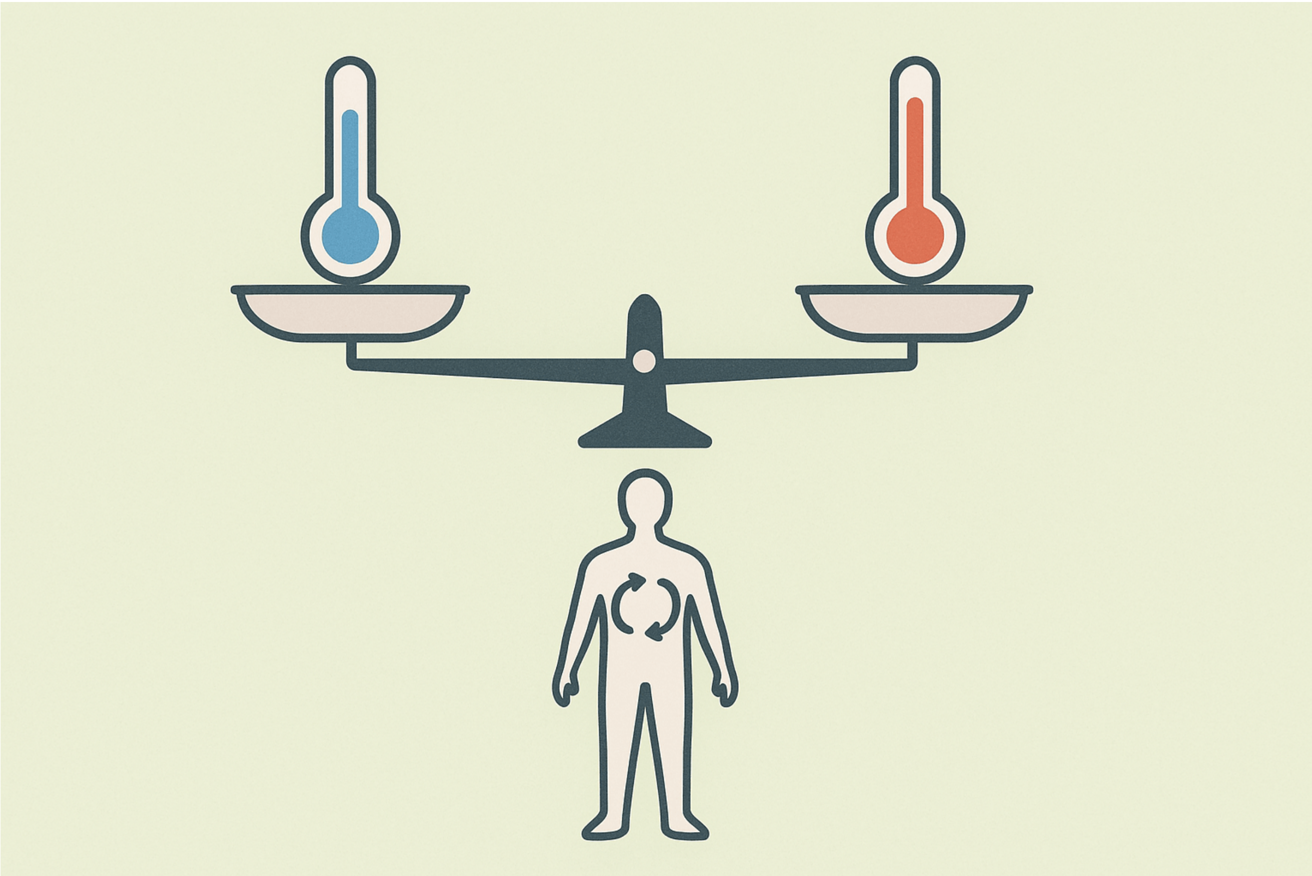
INSIDE

Homeostasis is the maintenance of relatively stable internal conditions inside an organism, even when the outside world changes. Body temperature stays around 37 °C whether you are in Delhi in May or Reykjavik in February. Blood glucose stays within a tight band whether you skipped lunch or just ate a slice of cake. Blood pH stays between 7.35 and 7.45 across nearly every situation. The fact that any of this works is the central organizing principle of physiology.



Homeostasis, the body keeps internal conditions in balance against external variation.

What Homeostasis Is

Homeostasis is the regulation of internal conditions so the body's cells stay close to an optimal operating point. The term was coined by Walter Cannon in 1926, building on Claude Bernard's earlier concept of the milieu intérieur, the internal environment. The principle applies to temperature, blood glucose, blood pH, water balance, salt concentration, blood pressure, oxygen and CO_2 levels, hormone concentrations, and dozens of other variables.

Homeostasis does not mean perfectly constant. Most variables fluctuate within a narrow range around a setpoint. Body temperature varies by about 1 °C through a 24-hour cycle; blood glucose rises after meals and falls between them. What matters is that excursions stay bounded and that mechanisms exist to pull the value back toward the setpoint.

The Components of a Homeostatic Loop

Every homeostatic mechanism has the same four components arranged in a feedback loop.

1. **Setpoint.** The target value the system tries to maintain (e.g., 37 °C body temperature, 90 mg/dL fasting blood glucose).
2. **Sensor.** A receptor that measures the current value of the variable (e.g., thermoreceptors in the skin and hypothalamus, glucose-sensing β cells in the pancreas).
3. **Control center.** The structure that compares the sensor reading to the setpoint and decides whether action is needed (usually the hypothalamus for temperature; the pancreas for glucose).
4. **Effector.** The structure that actually changes the variable back toward the setpoint (sweat glands, blood vessels, liver, muscle, hormones).

Negative Feedback, The Standard Mode

Most homeostatic loops use negative feedback. A change in the variable triggers a response that opposes the change. The classic example is body temperature.

- **If body temperature rises** (e.g., during exercise), the hypothalamus triggers sweating, vasodilation in the skin, and reduced muscle activity. Heat is dissipated. Temperature falls back toward 37 °C.
- **If body temperature falls** (e.g., in a cold room), the hypothalamus triggers shivering, vasoconstriction, and increased metabolic rate. Heat is generated. Temperature rises back toward 37 °C.

The same pattern applies to blood glucose. After a meal, blood glucose rises; the pancreas secretes insulin; cells take up glucose and the liver stores excess as glycogen; blood glucose falls. Between meals, blood glucose drops; the pancreas secretes glucagon; the liver releases stored glucose; blood glucose rises. The two opposing hormones (insulin/glucagon) keep blood glucose in a tight band.

Positive Feedback, The Exception

Positive feedback amplifies a change rather than opposing it. This is destabilizing by definition, so the body uses it only sparingly and only for processes that should run to completion once started.

- **Childbirth.** Uterine contractions stretch the cervix. Stretching triggers oxytocin release. Oxytocin causes stronger contractions. Stronger contractions stretch the cervix more. The loop runs away until the baby is delivered, at which point the trigger disappears.
- **Blood clotting.** An injury exposes collagen. Platelets stick to collagen and release chemicals that activate more platelets. The clot grows rapidly until it seals the wound.
- **Lactation reflex.** An infant suckling triggers prolactin and oxytocin release, which causes milk ejection. Continued suckling sustains the response.

Examples of Homeostatic Variables

VARIABLE	SETPOINT RANGE	SENSOR	EFFECTORS
Body temperature	36.5-37.5 °C	Hypothalamus, skin	Sweat glands, vasculature, muscles (shivering)
Blood glucose	70-110 mg/dL fasting	Pancreatic α and β cells	Liver, muscle, adipose (insulin / glucagon)
Blood pH	7.35-7.45	Chemoreceptors	Kidneys, lungs
Blood pressure	~120/80 mmHg	Baroreceptors in aorta and carotids	Heart rate, vessel diameter, kidneys
Blood O_2 / CO_2	PaO_2 ~95 mmHg, $PaCO_2$ ~40 mmHg	Chemoreceptors	Lungs (breathing rate and depth)
Osmolarity / water	~285-295 mOsm/kg	Hypothalamus	Kidneys (ADH), thirst

When Homeostasis Fails

Disease often is homeostasis failure. **Type 1 diabetes** is loss of the insulin-producing β cells, so the glucose loop loses its main negative-feedback signal. **Hyperthermia and hypothermia** are temperature loops overwhelmed by external conditions. **Hypertension** is sustained failure of the blood-pressure setpoint. **Acidosis and alkalosis** are pH-loop failures. Most chronic disease management is, at heart, augmenting a failing homeostatic mechanism, insulin shots for diabetes, dialysis for kidney failure, beta-blockers for hypertension.

Related study notes: Nervous System, Enzyme, Protein.

Practice Questions

Work each question before reading its solution. The set runs from direct recall and substitution to the applied questions that exams actually use to separate grades.

Q1. Define homeostasis and explain why it is described as a dynamic, not static, equilibrium.

SOLUTION

The maintenance of relatively stable internal conditions (temperature, pH, glucose, water balance) despite a constantly changing external environment. It is dynamic because the body is continuously making small corrections in both directions around a set point, never sitting perfectly motionless; stability emerges from constant active adjustment, not from an absence of change.

Q2. Name the 3 components of every negative feedback loop and their function.

SOLUTION

A RECEPTOR detects a deviation from the set point (a sensor). A CONTROL CENTER (often the brain or a gland) compares the detected value to the set point and decides on a response. An EFFECTOR carries out the response that pushes the variable back toward the set point. Every homeostatic mechanism in the body, thermoregulation, blood glucose, blood pressure, is built from this same 3-part loop.

Q3. Explain the negative feedback loop for body temperature regulation when you get too hot.

SOLUTION

Thermoreceptors in the skin and hypothalamus detect rising temperature above the 37°C set point. The hypothalamus (control center) triggers effectors: sweat glands increase sweating (evaporative cooling) and blood vessels near the skin dilate (vasodilation, releasing heat faster). As temperature falls back toward 37°C, the original stimulus weakens and the response subsides, the defining ”negative” (self-limiting) signature of the loop.

Q4. Why is negative feedback, rather than positive feedback, the dominant regulatory strategy for maintaining stable internal conditions?

SOLUTION

Negative feedback opposes and dampens deviations, actively pulling a variable back toward its set point, which is exactly what stability requires. Positive feedback AMPLIFIES a deviation further in the same direction, useful only for events that need to be pushed rapidly to completion and then explicitly stopped (childbirth contractions, blood clotting, a nerve action potential), never for maintaining a steady baseline, which is why runaway positive feedback in a homeostatic system usually signals dangerous physiological failure.

Q5. Explain blood glucose regulation: what do insulin and glucagon each do, and which glands release them?

SOLUTION

The pancreas releases INSULIN when blood glucose rises (after eating), signaling cells to absorb glucose from the blood and liver to store it as glycogen, lowering blood glucose back toward the set point. When glucose falls too low, the pancreas releases GLUCAGON, triggering the liver to break glycogen back down into glucose and release it into the blood, raising the level back up. The 2 hormones are antagonistic partners bracketing the set point from both sides.

Q6. Type 1 diabetes destroys the pancreatic cells that produce insulin. Trace the homeostatic consequence: what specifically fails, and why does blood glucose rise dangerously after a meal without treatment?

SOLUTION

Without insulin, cells cannot efficiently absorb glucose from the bloodstream and the liver is not signaled to store the excess as glycogen, so glucose from digested food accumulates in the blood with no functioning mechanism to remove it. The negative feedback LOOP itself is intact (the pancreas still detects high glucose), but the EFFECTOR arm is broken, illustrating that a homeostatic failure can arise at any single link in the 3-part chain, not just from a bad sensor or bad control center.

Q7. Give 1 clear example of a POSITIVE feedback loop in the human body, and explain why it must eventually be shut off externally rather than self-limiting.

SOLUTION

Childbirth: uterine contractions push the baby's head against the cervix, triggering oxytocin release, which INTENSIFIES contractions further, which pushes harder against the cervix, escalating the loop. This deliberately amplifying cycle only stops once the baby is delivered, an external endpoint outside the loop's own variables; a positive feedback loop with no external stopping event would simply escalate without limit, which is why unchecked positive feedback is dangerous when it appears in error (such as a fever spiraling out of control).

Q8. Explain osmoregulation: what triggers the release of ADH (antidiuretic hormone), and what effect does it have on urine output?

SOLUTION

Osmoreceptors in the hypothalamus detect rising blood solute concentration (dehydration, or high salt intake). This triggers ADH release from the pituitary gland, which signals the kidneys to reabsorb MORE water back into the blood rather than excreting it, concentrating and reducing urine output. The result dilutes the blood back toward its normal solute concentration, closing the loop, which is exactly why urine becomes darker and more concentrated when you are dehydrated.

Q9. A fever represents a temporary RESETTING of the hypothalamic temperature set point upward (say from 37°C to 39°C), rather than a simple failure of thermoregulation. Explain why the person then feels cold and shivers even though their actual body temperature is already elevated above normal.

SOLUTION

Once the set point is reset to 39°C, the body's own thermoreceptors compare the CURRENT temperature (say, still climbing from 37°C toward 39°C) against the NEW, higher target and detect a deficit, triggering shivering (muscle contraction generates heat) and vasoconstriction, exactly the responses the body uses when genuinely too cold. The regulatory machinery is working correctly; only the target itself has moved, illustrating that "set points" are not fixed forever, they can be deliberately adjusted by the body (often via pyrogens signaling infection).

Q10. Explain calcium homeostasis briefly: name the 2 antagonistic hormones involved and their source glands, paralleling the insulin/glucagon pattern.

SOLUTION

PARATHYROID HORMONE (PTH), from the parathyroid glands, raises blood calcium when it falls too low, by stimulating bone breakdown (releasing stored calcium), increasing kidney reabsorption, and activating vitamin D. CALCITONIN, from the thyroid gland, lowers blood calcium when it rises too high, by promoting calcium deposition back into bone. The antagonistic-hormone-pair pattern (1 hormone raises, 1 lowers, bracketing a set point) recurs across the body's major homeostatic systems, not just glucose.

Answer Key

QUICK ANSWERS

Q1 stable internal conditions via continuous active correction, not stillness **Q2** receptor (detect) → control center (decide) → effector (correct) **Q3** sweating + vasodilation, both shutting off as temperature normalizes **Q4** negative feedback dampens deviations; positive feedback would runaway instead **Q5** insulin lowers glucose (pancreas); glucagon raises it (pancreas), opposing each other

Q6 the effector (insulin release) is missing, so glucose has nowhere to go **Q7** childbirth (oxytocin-contraction loop); stops only when the baby is delivered, not self-limiting **Q8** rising blood solute concentration triggers ADH, which reduces urine output by increasing water reabsorption **Q9** the target itself shifted upward; the body still correctly chases whatever the current set point is **Q10** PTH (parathyroid, raises Ca) vs calcitonin (thyroid, lowers Ca)

Revision Sheet

Definition

Stable internal conditions maintained by continuous active correction: dynamic, not static, equilibrium.

Antagonistic hormone pairs

Insulin/glucagon (glucose), PTH/calcitonin (calcium), ADH governs water balance alone.

The loop

Receptor (detects deviation) → control center (decides) → effector (corrects), always negative feedback for stability.

Where it fails

A broken loop can fail at any link: sensor, control center, or effector (diabetes = broken effector arm).

Negative vs positive

Negative dampens deviations (the default for stability). Positive amplifies, only for self-limiting events with an external stop (childbirth, clotting).

Set points can shift

Fever resets the hypothalamic target upward; the regulatory machinery then correctly chases the NEW target.

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