Year 13 Science: Biological rhythms: clocks, zeitgebers and photoperiodism

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. In constant darkness a hamster's activity onset moves 3 h later over 6 days. Calculate its free-running period.

2. A mouse has $\tau = 23.8$ h. In constant darkness, how much earlier will its onset be after 10 days?

3. Name the most common zeitgeber.

4. A short-day plant with a critical night length of 10 h gets 14 h of darkness, interrupted in the middle by a red flash. Will it flower?

5. Why do tidal animals need a clock period of about 12.4 h rather than 12 h?

Exam-style question: a shore crab in a tank

Shore crabs were collected from a beach and kept in a laboratory tank with no tides, in constant dim light and temperature. For the first four days they were most active at the times high tide occurred on their home beach; after that their peaks became later each day and less sharp.

6. Describe a circatidal rhythm and state what evidence shows the crabs' rhythm is endogenous.

7. Explain why the peaks drifted and became less sharp, and what would bring them back in time.

8. Discuss the selective advantage of an endogenous tidal rhythm for a crab on the shore.

Fix the mistake

9. Correct this statement: "Short-day plants flower when the days are short."

10. Correct this statement: "The rhythm stopped drifting when the lights came back, so it is exogenous."

11. Correct this statement: "Onset moved 2.5 h over days 5 to 10, so $\tau = 24 - 2.5 \div 6$."

12. Correct this statement: "Pfr builds up in the dark."

Answer key (for parents and tutors)

1. In constant darkness a hamster's activity onset moves 3 h later over 6 days. Calculate its free-running period.
   3 h ÷ 6 = 0.5 h later per day, so τ = 24 + 0.5 = 24.5 h.
2. A mouse has τ = 23.8 h. In constant darkness, how much earlier will its onset be after 10 days?
   24 − 23.8 = 0.2 h per day; 0.2 × 10 = 2 h earlier.
3. Name the most common zeitgeber.
   Light.
4. A short-day plant with a critical night length of 10 h gets 14 h of darkness, interrupted in the middle by a red flash. Will it flower?
   No: the red flash converts Pr back to Pfr, so the plant reads two nights of 7 h, each shorter than the 10 h critical night length, and Pfr stays high.
5. Why do tidal animals need a clock period of about 12.4 h rather than 12 h?
   High tide comes about 50 minutes later each day, because tides follow the Moon, so the cycle is about 12 h 25 min.
6. Describe a circatidal rhythm and state what evidence shows the crabs' rhythm is endogenous.
   A circatidal rhythm repeats about every 12.4 h, matching the tides. The rhythm continued in a tank with no tides, so it is generated by an internal clock, not by the water itself (Achieved).
7. Explain why the peaks drifted and became less sharp, and what would bring them back in time.
   Without tides as a zeitgeber the clock free-runs with its own period, slightly different from the real tidal cycle, so each peak falls a little later; different crabs drift at different rates, so the group's peaks spread out. Returning them to the shore, where wave action and immersion reset the clock, would entrain them again (Merit).
8. Discuss the selective advantage of an endogenous tidal rhythm for a crab on the shore.
   The clock lets a crab become active and leave shelter just before the tide covers it, when it can feed and is hidden from shorebirds, and retreat before the tide leaves, when it would dry out and be exposed to birds and gulls. Crabs that anticipate the tide feed longer and are eaten less than ones that only react to it, so they survive and breed more, and entrainment keeps that timing right as the tide shifts each day (Excellence links clock, zeitgeber and niche).
9. Correct this statement: "Short-day plants flower when the days are short."
   They respond to an uninterrupted night longer than the critical length; a short flash of light at night stops them flowering even in short days.
10. Correct this statement: "The rhythm stopped drifting when the lights came back, so it is exogenous."
    Drift in constant conditions shows it is endogenous; the lights coming back simply entrain it again.
11. Correct this statement: "Onset moved 2.5 h over days 5 to 10, so τ = 24 − 2.5 ÷ 6."
    Days 5 to 10 is 5 intervals, not 6 rows, so the shift is 0.5 h per day and τ = 23.5 h.
12. Correct this statement: "Pfr builds up in the dark."
    Pfr is made in red light; in the dark it slowly reverts to Pr, which is how the plant measures the night.