31. Interpreting Actograms (page 41)

1. Double plotting maintains continuity between the time periods and provides a clearer picture of the pattern of activity.
2. (a) The free-running period is the length of time the organism's biological clock runs for in the absence of environmental cues.
   (b) If the free-running period was shorter than 24 hours, the timing of the activity shifts to the left. If it is longer than 24 hours, it shifts to the right.

32. Activity Patterns in Animals (page 42)

1. (a) 23.5 hours (b) 24.5 hours
2. Circadian (approximating to a 24 hour period).
3. (a) The free-running periods of the rhythms are different.
   (b) A is more regular and less broken than B.
4. (a) 13 hours
   (b) Circatidal (period of ~12.5 hours, with tidal flows).
   (c) To remove any possible effect of temperature changes on toebiter behaviour.
   (d) Synchronises behaviour with tidal flows: forages with incoming tide and burrows to avoid desiccation with the outgoing tide.
   (e) Tidal cycle of high and low tides.
5. The free running period is maintained even in the absence of environmental cues.
6. Daily rhythm with nocturnal activity.
7. Immediately after the onset of darkness.
8. Cockroaches are nocturnal.
9. Approximately 24.5 hours.
10. Entrainment synchronises the free-running endogenous rhythm with an exogenous cue, such as the light-dark cycle. The free-running period is usually slightly shorter or longer than the period of the environmental cycle (its zeitgeber). Entrainment keeps the organism's activity pattern aligned with an appropriate environmental cue ensuring appropriate timing for environmentally dependent behaviours such as foraging.

33. Plant Rhythms (page 44)

1. (a) Dormancy prevents plants expending energy in growth when growing conditions are unfavourable. It allows them to survive periods of cold weather.
   (b) Increasing day length and temperatures.
2. The plant must be exposed to a certain period of very low temperatures (indicating winter to the plant) before it will flower. A warm period in autumn won't be sufficient to promote flowering because it hasn't been preceded by the necessary cold period.
3. Leaf abscission and losing the leaves ensures that the plant conserves as much energy as possible before the winter, when there is insufficient light for much photosynthesis and the cold weather (particularly frosts and snow) might damage leaf structures. Energy is not wasted in maintaining leaf tissue and the plant withdraws as much reusable material from the leaves before losing them.
4. The same hormones control leaf fall and fruit fall because both processes involve severing the fruit or leaf stalk connection with the plant.
5. Cold stratification is an advantage because it ensures that the seeds will not germinate until after the winter has passed. Once they have been exposed to a period of cold wet conditions (i.e. environmental cues relating to winter), subsequent warming will indicate a true spring, the appropriate time to germinate.
6. (a) The flowers begin to open in the morning as the temperature begins to increase and they begin to close in the early evening as temperature drops.
   (b) Closing the flower during the night may prevent flower damage, stop the entry of non-pollinating insects, or stop the pollen becoming wet with dew.
   (c) Nastic response (movements are rapid and the stimulus is not directional). **Teacher's note**: Sleep movements are nyctinasties. The prefix nycti- means darkness referring to the movements being associated with diurnal light and temperature changes.

34. Photoperiodism in Plants (page 46)

1. (a) Pr (660nm) and Pfr (730nm).
   (b) Pfr is the active form. In long day plants it promotes flowering. In short day plants it inhibits flowering.
2. (a) Pr converts rapidly to Pfr in natural light. Pfr coverts more slowly to Pr in darkness. The relative concentrations of Pr and Pfr give the plant the ability to measure day length. Phytochrome also interacts with clock genes, which maintain the plant's biological clock.
   (b) The ability to measure time gives all the plants of a particular species the ability to determine the appropriate time for flowering. All plants will behave the same way and thus flower at the same time.
3. (a) Day length (more importantly, night length).
   (b) Any one of:
   - Flowering at the same time ensures that other flowers will be available to provide/receive pollen.
   - Synchronisation with periods of high insect activity may assist pollination.
4. (a) Short-day plants: Flower only when the day length is short (average: 10 hours).
   (b) Long-day plants: Flower only when the day length exceeds a certain minimum value (average: 14 hours).
5. Short-day plants are really long night plants, requiring a night length of more than a minimum value. In the experiment outlined, a short-day plant failed to flower when a long night was interrupted by a short period of light. The plant interpreted this as a short night irrespective of the short day prior to it.

35. What You Know So Far: Orientation in Time (page 48)

Summary is entirely the student's own.

36. NCEA Style Question: Biological Clocks in Animals (page 49)

1. (a) Circadian and circatidal
   (b) Endogenous
2. The crab is active twice during the day. It shows a higher level of activity during what should be daylight hours (between hours 6-18) and shows lower activity levels during its second activity period (hours 18-24). Both periods of activity occur during low tide, when the crab emerges from its burrow to feed.

   The crab's endogenous rhythm does not perfectly match that of the changing tide at the beach it was collected from. The crab's rhythm runs faster, so by the end of the experiment the crab is active when it would be high tide at the beach the crab was collected from.
3. Biological rhythms are important for maintaining the timing of certain activities, such as feeding or sleeping/waking, especially when there is no strong environmental cue (e.g. for animals living in burrows or caves). Biological rhythms may be exogenous or endogenous in nature. Exogenous (external) rhythms are stimulated in direct response to environmental stimuli (e.g. light/dark, tides). Endogenous (internal) rhythms continue in the absence of environmental cues. They are often controlled by hormones. An internal timing system is called a biological clock.

   Biological rhythms are synchronised to the environment by zeitgebers (time givers). A zeitgeber is an external or environmental cue that resets and synchronises (entrains) an organism's biological rhythm with a particular environmental cycle, e.g. light/dark. Without a zeitgeber, an organism's biological rhythm and activity would not be synchronised to the appropriate environmental conditions.

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