Unit 2 · Life and Life Process

HARDER PRACTICE QUESTIONS · ANSWER KEY

Full marks 43

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Dal on the kitchen shelf

ANSWER A · 4

i. We need $200 \times 2C > 1{,}000{,}000$, so $2C > 5{,}000$. $2^{12} = 4{,}096$ is too small and $2^{13} = 8{,}192$ is enough, so **$n = 13$**.

ii. $13 \times 20 = 260$ minutes = 4 h 20 min after 11 a.m., which is **3:20 p.m.**

iii. $200 \times 8{,}192 =$ **1,638,400**.

iv. It is 40 minutes later: **4:00 p.m.** (This waiting time is the lag.)

MARKING SCHEME

✓ $2C > 5{,}000$, so $n = 13$.

✓ 260 minutes, so 3:20 p.m.

✓ 1,638,400 bacteria.

✓ 40 minutes later, 4:00 p.m.

2 Work backwards

ANSWER A · 3

i. Noon is 2 hours, or 4 generations, earlier: $12{,}800 \div 2^4 = 12{,}800 \div 16 =$ **800 cells**.

ii. $12{,}800 \div 100 = 128 = 2^7$, so 7 generations earlier: $7 \times 30 = 210$ minutes = 3 h 30 min before 2 p.m., which is **10:30 a.m.**

MARKING SCHEME

✓ 800 cells at noon.

✓ $128 = 2^7$, so 7 generations.

✓ 210 minutes earlier: 10:30 a.m.

3 Check the claim

ANSWER HA · 5

(The counts are made up, to show the stretches the unit describes.)

i. 0–30 minutes, the **lag**; 60–140 minutes, the **log phase**; 200–300 minutes, the **stationary phase**.

ii. 2,000 → 4,000 in 20 minutes, and likewise after: **20 minutes**.

iii. $300 \div 20 = 15$ and $1{,}000 \times 2^{15} = 1{,}000 \times 32{,}768 = 32{,}768{,}000$. Her arithmetic is right.

iv. No. The formula holds only while there is plenty of food and space. The flask's count levels off near 60,000 because food runs out and wastes build up. A formula used outside its stretch gives a wrong number, not a wrong count.

MARKING SCHEME

✓ Lag, log and stationary named in the right places.

✓ Generation time 20 minutes.

✓ 32,768,000 is correct arithmetic.

✓ The count isn't wrong: the formula holds only during steady doubling.

✓ Food runs out and wastes build up, so the number levels off.

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4 Phage against bacteria

ANSWER A · 4

i. After 30 minutes, **1** cell. After 60 minutes, 1 + 100 = **101** cells.
ii. 100 × 100 = **10,000 phages**; 10,000 − 101 = **9,899 cells** left.
iii. There are more phages than cells, so every cell left can be infected, and by 90 minutes all the bacteria are dead.
iv. Nothing: T4's tail fibers fit only the receptors of *E. coli*, so it can't attach, and outside a host it can't multiply.

MARKING SCHEME

✓ 1 and 101 cells killed.
✓ 10,000 phages and 9,899 cells.
✓ All the cells are infected and dead by 90 minutes.
✓ The phage can't attach to a host whose receptors don't fit, so it doesn't multiply.

5 Predict, then explain

ANSWER HA · 3

Batch A: inside the bacteria, because the DNA goes down the tail into the cell.
Batch B: outside, with the empty coats ("ghosts"), because the protein stays outside.
Since new phages are built after only the DNA has entered, the instructions for a whole new phage must be in the DNA, not the protein. (This is how Alfred Hershey and Martha Chase's 1952 work helped prove that genes are made of DNA.)

MARKING SCHEME

✓ Batch A: inside the cells.
✓ Batch B: outside, with the coats.
✓ Only DNA enters, yet complete phages are made, so DNA carries the instructions.

6 Which is it?

ANSWER A · 4

P: *Mucor*: coenocytic hyphae, sporangia on sporangiophores.
Q: **yeast**: eukaryote of the right size, with a bud and bud scars.
R: *E. coli* (a bacterium): prokaryote of the right size, with a septum in binary fission.
S: **a bacteriophage** (a virus such as T4): too small for a light microscope, and multiplies only with a living host.

MARKING SCHEME

✓ P: *Mucor*, from the coenocytic hyphae and sporangia.
✓ Q: yeast, from the nucleus, bud and scars.
✓ R: a bacterium, from no nucleus and the septum.
✓ S: a phage, from its size and need of a host.

7 Correct the misconceptions

ANSWER U · 4

1. *Mucor* has no rhizoids; they belong to *Rhizopus*. Its hyphae run along and into the bread.
2. Its hyphae have no cross walls (except where reproductive parts are cut off): it is coenocytic.
3. Sporangiospores are haploid and are made by mitosis. Meiosis happens when the zygospore germinates.
4. The strains look alike and aren't male and female; the signs mean only "able to mate with the other one".

MARKING SCHEME

✓ No rhizoids in *Mucor*.
✓ No cross walls (coenocytic).
✓ Sporangiospores haploid, by mitosis.
✓ + and − aren't male and female.

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8 Reading pairs of cultures

ANSWER HA · 4

i. A and C are one strain; B and D are the other.
ii. E is in the same strain as B and D. So E with B: **no**. E with C: **yes**. E with D: **no**.
iii. No. The two strains look alike, and nothing shows which is which; + and − are only names, chosen for "able to mate with the other one".
iv. A single spore gives a pure culture of one strain. A culture from many spores could hold both strains and make zygospores on its own, which would hide the pattern.

MARKING SCHEME

✓ A, C in one strain; B, D in the other.
✓ E with B no, with C yes, with D no.
✓ She can't: the names are arbitrary and the strains look alike.
✓ A single spore gives one strain only.

9 Design a fair test

ANSWER A · 4

i. He changes how damp the roti is (sprinkled, not soaked, or left dry) and measures how many days until mold shows, or how much is covered each day.
ii. Any three: the same kind and size of roti; the same box; the same place and temperature; the same time in the air; lids closed the same way.
iii. To collect spores. Both must have the same chance of catching spores, or a difference could come from the number of spores instead of the water.
iv. Never open the box near his face or sniff the mold, since the spores can cause allergies and illness (or: seal the box in a bag to throw it away, and wash his hands).

MARKING SCHEME

✓ Changes the dampness; measures the time or the area of mold.
✓ Any three things kept the same.
✓ The same exposure gives the same chance of spores.
✓ Don't open or sniff; spores can cause allergies or illness.

10 Estimate it

ANSWER A · 3

i. 1 mm = 1,000 µm, so the cube is $1{,}000^3 = 10^9$ µm³. Each cell is 2 µm³, so about $10^9 \div 2 = \mathbf{5 \times 10^8}$ **cells**.
ii. $2^{29} = 536{,}870{,}912$, about 5×10^8, so 29 generations: $29 \times 20 = 580$ minutes, **about 9 hours 40 minutes**. In a real culture, food and wastes stop it long before.

MARKING SCHEME

✓ Cube 10^9 µm³, each cell 2 µm³.
✓ About 5×10^8 cells.
✓ 29 generations, about 9 h 40 min.

11 Think

ANSWER HA · 3

i. No. A heterothallic *Mucor* can mate only with the other strain, and its mycelia are all one strain.
ii. Sporangiospores are copies, with the same genes, so they have the same weakness to the fungicide.
iii. A zygospore mixes the genes of two strains, so its offspring are new combinations, some of which may cope with the fungicide. Its thick wall also lets it rest through bad times.

MARKING SCHEME

✓ No: it needs the other strain.
✓ Sporangiospores have the same genes, so the same weakness.
✓ Zygospores give new combinations, some of which may survive.

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12 Make your own

HA · 2

ANSWER

For example, 10 cells with a generation time of 20 minutes: n = 180 ÷ 20 = 9, and $10 \times 2^9 = 10 \times 512 =$ **5,120**. (Also 80 cells at 30 minutes: $80 \times 2^6 = 5{,}120$.)

With 25 minutes, 180 ÷ 25 = 7.2 generations, which isn't a whole number of doublings, so the cells wouldn't reach exactly that number at 3 hours.

MARKING SCHEME

- ✓ A starting number and generation time that give 5,120, shown.
- ✓ 180 ÷ 25 = 7.2, not a whole number of generations.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	0	4	22	17	**43**

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