

1. Doubling a cell's radius changes its surface-to-volume ratio how?

- ☐ It stays the same
- ☐ It quarters
- ☐ It halves ($SA/V = 3/r$)
- ☐ It doubles

2. For K^+ (140 mM in, 5 mM out), E_K at 37 °C is about –

- ☐ –67 mV
- ☐ –45 mV
- ☐ +67 mV
- ☐ –89 mV

3. Why is there a lagging strand?

- ☐ The template strands are antiparallel and polymerase builds only $5' \rightarrow 3'$
- ☐ The lagging strand is copied from RNA
- ☐ One strand is damaged and must be repaired first
- ☐ Helicase unzips only one strand at a time

4. Why are codons triplets?

- ☐ Ribosomes have three binding sites
- ☐ DNA has three kinds of base
- ☐ Two bases give only 16 codons, fewer than 20 amino acids; three give 64
- ☐ There are 3 stop codons

5. How does an enhancer differ from a promoter?

- ☐ It works only on the template strand
- ☐ It is always inside the first exon
- ☐ It can act from far away, in either orientation, by DNA looping
- ☐ It codes the transcription factor

6. One receptor activates 20 G-proteins; each turns on one cyclase making 1000 cAMP per second for 3 seconds. How many cAMP molecules result?

_____ doublings

8. A spherical cell is 60 μm across. What is its surface-to-volume ratio, in "per μm "?

_____ per μm

9. Ca^{2+} is 100 nM inside and 1.0 mM outside. What is E_{Ca} at 37 °C?

_____ mV

10. A 1.2×10^8 bp chromosome must be copied by forks moving at 50 bp/s each. With 2 forks per origin, how many origins are needed to finish in 1 hour of pure copying?

_____ origins

1. **It halves (SA/V = 3/r)**

Area grows as r^2 , volume as r^3 , so $SA/V = 3/r$: doubling r halves the ratio. This is the argument that caps cell size.

2. **−89 mV**

$E = 61.5 \times \log_{10}(5/140) = 61.5 \times (-1.447) = -89.0 \text{ mV}$.

3. **The template strands are antiparallel and polymerase builds only 5′→3′**

Antiparallel templates and a 5′→3′-only enzyme mean one strand must be made in short pieces, backwards from the fork.

4. **Two bases give only 16 codons, fewer than 20 amino acids; three give 64**

Two bases cannot name 20 amino acids; three give 64 with spare codons spent on third-base degeneracy, which tolerates damage.

5. **It can act from far away, in either orientation, by DNA looping**

Enhancers loop to the promoter from up to about 100 kb away, in either orientation; the promoter sits at the start site.

6. **60000**

$20 \times 1000 \times 3 = 60\,000$ molecules from one hormone molecule.

7. **30 doublings**

$2^{30} = 1.07 \times 10^9$. A tumour you can just detect has been growing silently for years, which is why screening intervals matter.

8. **0.1 per μm**

$r = 30 \text{ μm}$, so $SA/V = 3/30 = 0.1$ per μm : a third of a 20 μm cell's 0.3.

9. **123 mV**

The ratio is $1.0 \text{ mM} / 100 \text{ nM} = 10^4$, so $E = (61.5/2) \times 4 = 123 \text{ mV}$. Forget $z = 2$ and you get 246 mV.

10. **333 origins**

Each origin copies 100 bp/s, so 3.6×10^5 bp per hour. $1.2 \times 10^8 / 3.6 \times 10^5 \approx 333$ origins.