

University Medicine

Name: _____ Score: _____

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'→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?

7. A tumour of about 10^9 cells grew from one cell. About how many doublings old is it?
_____ doublings
8. A spherical cell is $60\text{ }\mu\text{m}$ 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 $37\text{ }^\circ\text{C}$?
_____ mV
10. A $1.2 \times 10^8\text{ bp}$ 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

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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 $5' \rightarrow 3'$

Antiparallel templates and a $5' \rightarrow 3'$ -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

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

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

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

9. 123 mV

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

10. 333 origins

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