Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

pairs: TTACGGCA, read $3' \to 5'$ under the strand

written $5' \to 3'$: `5′-ACGGCATT-3′`

2.2

polymerase can only add to a $3'$ end, so new DNA grows $5' \to 3'$

on one template that is towards the fork (continuous); on the other it is away from the fork, so short fragments are made and joined

2.3

polymerase alone: $\mathbf{6.4 \times 10^4}$

with proofreading: **640**

with mismatch repair: about **6**

2.4

one origin: $6.4 \times 10^9 / 100 = 6.4 \times 10^7$ s ≈ 2 years

30 000 origins: ≈ 2100 s, about 36 min, well inside 8 h

3.1

(a) $2^{30} \approx \mathbf{1.07 \times 10^9}$

(b) primers give a $3'$ end to start from and mark the region to copy; a heat-stable polymerase survives 95 °C in every cycle; 95 °C separates the strands, 55 °C lets primers bind, 72 °C is for copying

(c) $1000 \times 10^{-4} = \mathbf{0.1}$: about 1 copy in 10 has an error

(d) a cloned gene must have exactly the right sequence, and proofreading cuts errors about 100 times

3.2

(a) thymine dimers: two neighbouring T bases joined together

(b) proteins cut the damaged strand on both sides and remove a short piece; polymerase fills the gap using the other strand, and ligase seals it

(c) every sun exposure leaves unrepaired dimers that become mutations when copied; mutations soon hit the genes that control division, such as p53

3.3

(a) $6.4 \times 10^9 \times 10^{-7} = \mathbf{640}$: 100 times the normal 6

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(b) the lining is renewed every few days, so its stem cells divide very many times and gather mutations fast

(c) in any one cell, a single new hit on the working copy is enough; with billions of dividing cells this second hit happens early in life

(d) genetic testing for relatives, so carriers are known; regular colonoscopy from an early age for carriers, which finds and removes growths before they become cancer