Solutions

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

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

2.1

no lactose: off, the repressor blocks the operator

lactose, no glucose: on, high

lactose and glucose: on but low, because glucose keeps the activator away

2.2

$4^6 = 4096$

$3.2 \times 10^9 / 4096 \approx \mathbf{7.8 \times 10^5}$ times

2.3

a promoter is at the start of the gene; an enhancer can be far away, up to 100 kb, on either side

an enhancer works in either direction and raises the rate; the promoter is where polymerase starts

2.4

methyl groups block the binding of transcription factors

proteins that bind methylated DNA pack the chromatin tightly

after replication, an enzyme copies the methyl marks onto the new strand

3.1

(a) two: $4^{12} \approx 1.7 \times 10^7$, $3.2 \times 10^9 / 1.7 \times 10^7 \approx \mathbf{190}$; three: $4^{18} \approx 6.9 \times 10^{10}$, $\approx \mathbf{0.05}$: almost certainly only the real site

(b) one short site is found almost everywhere; requiring several factors side by side makes the combined site long and rare, so only the right genes respond

(c) it can strengthen or weaken binding and change how much of the gene is made, with no change to the protein

3.2

(a) the change creates a stronger binding site in an enhancer; the enhancer keeps the lactase gene transcribed after weaning; the gut keeps making lactase, so milk sugar is digested

(b) the change is outside the gene's coding sequence

(c) lactose stays in the gut, draws water in by osmosis, and is fermented by bacteria

3.3

(a) a heritable change in gene activity without a change in the DNA sequence

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(b) twin A has 4 times the methylation of twin B and about a third of the expression

(c) twin A: the methylated promoter silences the protective gene, so less protection

(d) it can switch on many other genes that should be silent

(e) the DNA sequence and a methylation test of the gene's promoter, with a note that the same sequence does not mean the same severity