Solutions

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

2.1

- A change in a single DNA base (substitution)

2.2

- An insertion or deletion (frameshift)

2.3

- A base change that does not change the amino acid coded

2.4

- any two of: errors in DNA replication; errors in DNA repair; radiation such as UV light or X-rays; reactive chemicals (mutagens)

3.1 C

- a nonsense mutation

3.2

(a)

- A frameshift (deletion); it shifts the reading frame so all following codons change

(b)

- A substitution changes at most one amino acid, but a frameshift changes every downstream codon, usually ruining the whole rest of the protein

3.3

- Harmful mutations can disrupt a protein and cause disease, but mutations also create new alleles (variation) that natural selection can act on, sometimes benefiting the organism

3.4

(a)

- a point (substitution) mutation: A replaced by U in codon 6 (GAG → GUG)
- a missense mutation: glutamic acid at position 6 is replaced by valine

(b)

- nonpolar valine on the protein's surface makes haemoglobin molecules stick together, forming long fibres when oxygen is low
- the fibres distort the red blood cells into a sickle shape, which can block capillaries and break down early

(c)

- heterozygotes (one sickle-cell allele) are more resistant to malaria, so where malaria is common they survive and reproduce more and the allele is selected for
- where there is no malaria the allele gives no benefit and homozygotes have sickle-cell disease, so it is selected against: whether a mutation is beneficial depends on the environment

3.5

(a)

- nondisjunction

(b)

- 47 chromosomes; aneuploidy, here trisomy 21 (Down syndrome)

3.6 C

- conjugation transfers DNA through a pilus; transformation is uptake of DNA from the surroundings and transduction is transfer by a virus