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Biological Sciences review

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Answers

Ultra-processed foods: what's the problem?

Answers to practice exam questions on pp. 2–6

Martin Rowland

1 Amylase hydrolyses starch into maltose and maltase hydrolyses maltose to glucose. Amylase is released by the pancreas into the lumen of the small intestine. Maltase is in the surface membrane of cells lining the small intestine.

2 Co-transport proteins / SGLT1 proteins in the surface membrane of an intestinal cell allow facilitated diffusion of one glucose molecule with one sodium ion / Na+. Glucose molecules are transported (from epithelial cell) into blood stream by active transport (via GLUT 2 proteins).

Confidence with numbers

Answers questions on pp. 16–19

Martin Rowland

a The magnification is × 10,000

b Golgi body

Plus 1 mark for each of any three from the following:

- Modification / glycosylation of proteins / lipids OR addition of carbohydrate groups to proteins / lipids.
- Sorting / packaging of macromolecules / named macromolecules into vesicles.
- Formation of lysosomes.
- Direction of vesicular transport OR ensures proteins / lipids are delivered to their target sites.
- Synthesis of polysaccharides (for plant cell walls).

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Relics of the Stone Age

Answers to the questions on pp. 27–29

Kevin O'Dell

Question 1

Radiocarbon dating is based on the fact that radiocarbon (carbon-14) is constantly being created in the atmosphere. This can combine with atmospheric oxygen to form radioactive carbon dioxide, which in turn is incorporated into plants during photosynthesis. Animals then acquire carbon-14 by eating the plants. When the animal or plant dies, it stops exchanging carbon with its environment, and from that point onwards the amount of carbon-14 it contains begins to decrease as the carbon-14 undergoes radioactive decay.

Measuring the amount of carbon-14 in a sample from a dead plant or animal can be used to calculate when the animal or plant died. The older a sample is, the less carbon-14 there is to be detected, and because the half-life of carbon-14 (the period of time after which half of a given sample will have decayed) is about 5730 years, the oldest dates that can be reliably measured by radiocarbon dating are around 50,000 years ago.

Question 2

DNA decays more slowly when tissues are frozen or dried soon after death. This is because, after death, most DNA damage is caused by intracellular nucleases and microorganisms, which are inhibited under conditions of desiccation (e.g. in caves) or freezing (e.g. in ice).

Question 3

The two key ways in which DNA decays in favourable environmental conditions are as follows:

- Fragmentation – essentially this involves random breaks in the DNA backbone. For example, depending on the specific conditions, 10,000-year-old DNA might be degraded to fragments averaging 500 bp in length.
- Deamination – for example, the deamination of cytosine to uracil.

Question 4

Archaeological evidence might include evidence supporting the idea that the bodies were buried at the same time (perhaps by studying soil samples, all of which have the same distinguishing pollen grains), or that they appear to be buried in family groups.

Anatomical evidence, using a variety of metrics, will help determine the sex of each individual and estimate their age at death.

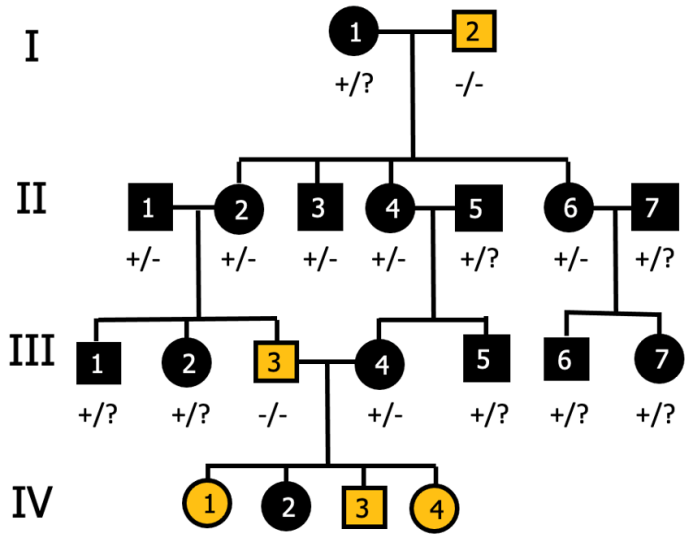
Genetic approaches, using DNA sequencing, will allow the team to determine relatedness between individuals. Such studies not only include determining relatedness by comparing autosomal DNA sequences, but also using mitochondrial DNA to identify relatedness along the maternal lineage, and the Y chromosome DNA to reveal relatedness along the paternal lineage.

Question 5

The family as a whole probably has a relatively high CoI because the Western Isles population at that time would have probably been quite small, so they would have been relatively inbred. Those in generation IV would have a particularly high CoI, because in addition to being part of a relatively inbred population, their parents are also first cousins, so they share one set of grandparents.

Question 6

The redrawn figure should be as follows:



Note that the genotypes of most of the dark-haired individuals are unclear.

Question 7

There are perhaps two approaches for this. The first would be to investigate in a biochemical fashion whether the receptor protein produced by the *melanocortin-1 receptor* (*MC1R*) gene carrying the novel missense mutation is functional or not. The second might be to create a transgenic model of the novel *MC1R* missense mutation, perhaps using CRISPR to create the missense mutation in a dark-haired mouse, and see whether that results in a red-haired phenotype in their offspring.

Question 8

This requires an explanation of how two individuals that are heterozygous (+/–) at the *MC1R* gene can have a child that has the genotype –/–. However, it has to be explained in language that a non-geneticist will understand.

Question 9

If the parents are heterozygous for the MC1R mutation, then the probability of their first-born child being a daughter is a half (0.5), and of her having red hair is a quarter (0.25). Therefore, the probability of having a red-haired daughter is a half multiplied by a quarter (0.5×0.25), which is an eighth (0.125). Therefore, the probability that their first three children are all red-haired daughters is an eighth multiplied by an eighth multiplied by an eighth ($0.125 \times 0.125 \times 0.125$), which is one in 512 (or approximately 0.002).

Question 10

DNA sequencing, whether whole-genome sequences or using a standard paternity test using short tandem repeats (STRs), would be a good starting point, as any child of theirs must have obtained one haploid set of chromosomes from Carrie and the other haploid set from Guy.

Chemical signalling in insects

Answers to practice exam questions on pp. 30–33

Martin Rowland

1 **a** Nymphs of hemimetabolous insects are similar to the adult, while holometabolous insects have larva, pupa and adult stages.

b Different stages of life cycle / larva and adult have different diet so avoid (intraspecific) competition.

2 Pull: a plant (within the crop) that repels insect pests away from a crop plant.

Push: a plant (away from the crop) that attracts insect pests away from a crop plant.