Past-paper walk-through

Natural Selection ▪ 7.2

eXercise

Questions in this set

- 2026 Q5
- 2024 Q1
- 2024 Q5
- 2022 Q4
- 2021 Q4
- 2019 Q1
- 2018 Q1
- 2018 Q4
- 2016 Q1
- 2016 Q3

Questions in this set

- 2015 Q1
- 2014 Q8

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 5

2026 ▪ Q5

Anole lizards throughout the Caribbean islands and Central and South America have pads of varying sizes on the bottom surfaces of their toes. The sizes of the toe pads are genetically determined and not the result of phenotypic plasticity. During storms with high winds, anoles cling to trees with the help of their toe pads. In recent years, an increase in both the number and intensity of storms has occurred across the range of anole habitats.

In 2017, two very intense storms occurred in the Caribbean islands within a month. In 2019, scientists investigated the relationship between the intense storms and the average toe pad size of the offspring of lizards that survived the storms. The scientists determined the average toe pad size of the surviving offspring and grouped their measurements into three categories: small, medium, and large toe pads. The scientists

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then compared the 2019 toe pad measurements with measurements recorded prior to 2017. Their data are represented in the figure.

A Map Representing Toe Pad Size Distributions Prior to 2017 and in 2019

[Two side-by-side maps of the Caribbean islands and northern South America, labeled "Prior to 2017" and "2019". Symbols mark average toe pad size at various island/mainland locations: circle = Small, triangle = Medium, diamond = Large.

Prior to 2017 map: Caribbean islands region shows small circles and medium triangles (two small circles near the northern islands, two medium triangles near the central islands, one medium triangle further east/south near a smaller island). Mainland South America shows small circles at several locations (one near the northern coast, one further inland, two further south).

2019 map: Caribbean islands region shows the same island locations now marked with medium triangles (hatched, labeled "1") near the northern islands, and large diamonds

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(solid black, labeled “2”) near the central islands, and a large diamond (labeled “3”) near the smaller southeastern island. Mainland South America shows darker-shaded circles at the same locations as before (one near the northern coast marked with a dark circle, region labeled “4” near an inland dark circle, two further south with dark circles). Legend: “Average Toe Pad Size” - open diamond = Large, open triangle = Medium, open circle = Small. “Storm Intensity” - a vertical gradient bar from black (Greatest) through hatched/gray shades down to gray (Least) and white (No storms), corresponding to the shading/fill of each map symbol.]

(a) Describe the role that changes in abiotic factors have in natural selection.

(b) Based on the figure, **explain** the relationship between storm intensity and average toe pad size.

(c) Identify the region on the 2019 map, by indicating the number, that experienced the least storm intensity.

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(d) Based on the information provided, **explain** how continued differences in storm intensity can apply different selective pressures on anole populations living on the Caribbean islands, eventually leading to speciation.

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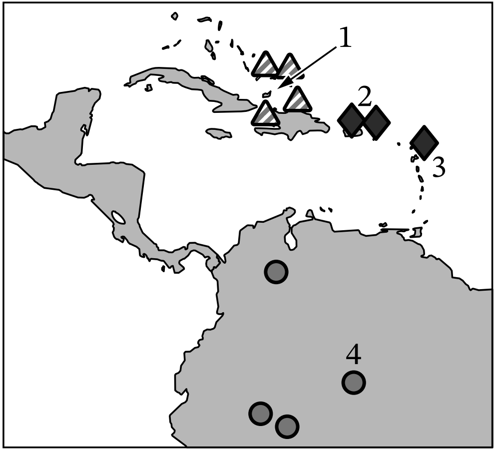

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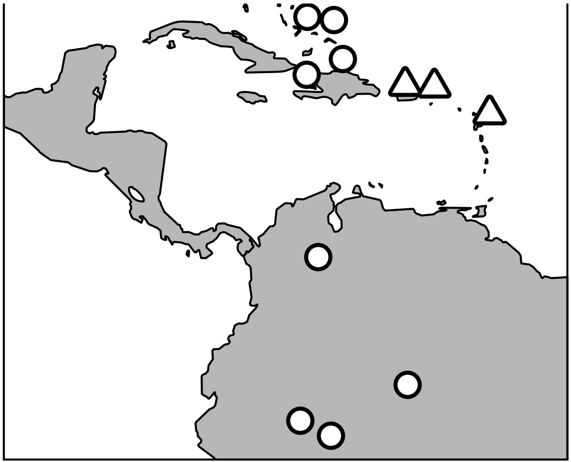

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2024 ▪ Q1

Crossing over in meiosis I is required for homologous chromosomes to properly align during metaphase and segregate during the first cell division.

Some regions of a chromosome called hotspots display a higher frequency of crossing over than other regions do. Crossing over is suppressed in chromosomal regions near the centromeres. The centromere region of a duplicated chromosome includes a collection of proteins that form a structure called the kinetochore. Scientists hypothesized that one or more of these kinetochore proteins are responsible for suppressing crossing over around the centromere.

To investigate their hypothesis, scientists modified chromosome 8 in yeast such that, in each cell, one chromosome from the pair of homologous chromosome 8s contained the gene encoding red fluorescent protein (RFP), while the other chromosome from the pair contained the gene encoding green fluorescent protein (GFP). Cells expressing

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RFP emit (give off) red light, and cells expressing GFP emit green light. Models of the modified chromosome 8 both before and after crossing over are shown in Figure 1. [Figure 1. Models of modified chromosome 8 used in the experiment (A) before and (B) after crossing over occurs at the hotspot. Panel A "Before Crossing Over": two homologous chromosome 8 pairs are drawn, each as a pair of sister chromatids joined at a Centromere. On the upper homolog, the region near one end is labeled "Gene Encoding RFP" (shown as a filled gray box on both sister chromatids near the tip). On the lower homolog, the corresponding region is labeled "Gene Encoding GFP" (shown as a hatched/striped box on both sister chromatids). A "Hotspot" region is marked between the centromere and the RFP/GFP genes with double-arrow brackets. Panel B "After Crossing Over": the same two homologous chromosomes are shown after a crossover has occurred at the hotspot, so that one chromatid of the upper homolog now carries the "Gene Encoding GFP" marker (hatched box) instead of RFP, and one

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chromatid of the lower homolog now carries the "Gene Encoding RFP" marker (filled gray box) instead of GFP — i.e., the fluorescent markers have been exchanged between one chromatid of each homolog. Centromere and Hotspot are again labeled.] The scientists then investigated whether attaching individual kinetochore proteins to a specific DNA sequence present in a known crossing-over hotspot on chromosome 8 affected the frequency of crossing over at this location. In their first experiment, they examined three groups of yeast cells containing the modified chromosome 8. Group 1 contained no kinetochore proteins attached to the hotspot, group 2 contained the kinetochore protein CTF attached to the hotspot, and group 3 contained the kinetochore protein IML attached to the hotspot. For each group, the scientists determined the frequency of crossing over between the RFP and GFP genes. To determine the frequency, the scientists added the number of cells emitting both red

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and green light to the number of cells that emitted no light and divided by the total number of cells (Figure 2).
[Figure 2. Bar graph, "The frequency of crossing over in a hotspot on yeast chromosome 8 for cell groups treated with different kinetochore proteins. Error bars represent $\pm 2\mathrm{SE}_{\bar{x}}$." Y-axis: Frequency of Crossing Over (
(a)(i) Describe the function of S phase of interphase.
(a)(ii) Explain why some haploid cells formed after meiosis in this experiment will have only one fluorescent marker.

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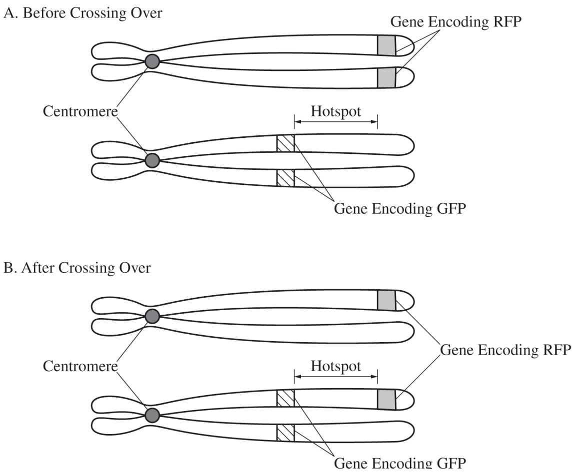
A. Before Crossing Over
Gene Encoding RFP
Centromere
Hotspot
Gene Encoding GFP
B. After Crossing Over
Gene Encoding RFP
Centromere
Hotspot
Gene Encoding GFP

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Gene Encoding GFP

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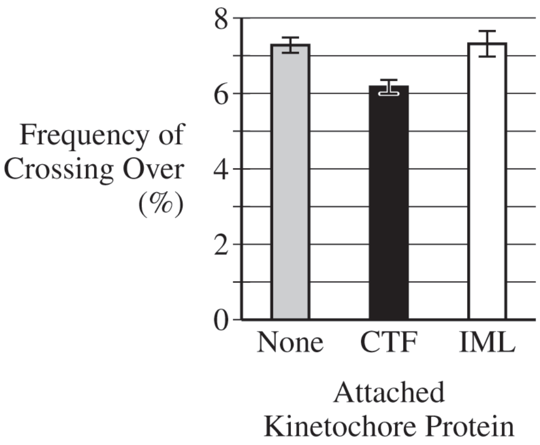

Frequency of Crossing Over (%)
8
6
4
2
0
None
CTF
IML
Attached Kinetochore Protein