Past-paper walk-through

Meiosis and Genetic Diversity ▪ 5.2

eXercise

Questions in this set

- 2026 Q4
- 2024 Q1
- 2022 Q2
- 2016 Q7
- 2015 Q4
- 2014 Q8

Reading the mark scheme

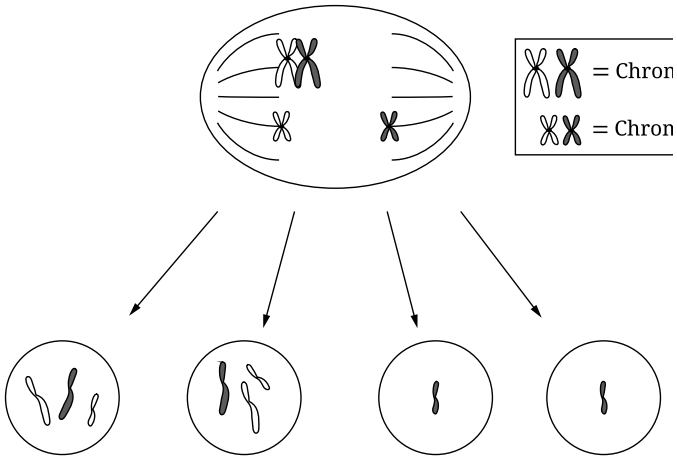
- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner 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 4

2026 ▪ Q4

The process of meiosis enables animals that reproduce sexually to produce gametes.
(a) Describe one characteristic of chromosome movement during Meiosis I.

Question 4



Question 4

2026 ▪ Q4

The process of meiosis enables animals that reproduce sexually to produce gametes.

(b) Explain why chromosomes are more visible when viewed under a microscope during mitosis or meiosis than at any other time in the cell cycle.

Question 4

2026 ▪ Q4

The process of meiosis enables animals that reproduce sexually to produce gametes.

(c) An animal cell with two pairs of homologous chromosomes (a diploid number of four) has undergone meiosis to produce four gametes, and an error occurred at one step, as shown in the figure. One set of chromosomes is represented in white, and the other set is represented in gray.

An Animal Cell Undergoing Meiosis

[Diagram of a dividing cell (undergoing Meiosis II, anaphase-like stage) with spindle fibers, showing an error where chromosomes failed to separate properly on one side. Legend: a white/gray joined pair of sister chromatids = Chromosome 1; a smaller white/gray joined pair = Chromosome 2. In the cell: the left half shows one Chromosome 1 pair (still joined, both chromatids) plus one single Chromosome 2 chromatid; the right half shows one single Chromosome 2 chromatid and one single

Question 4

(unpaired) small chromatid. Four arrows point from the cell to four resulting gamete circles: gamete 1 contains three chromatids (an extra copy of Chromosome 1 plus Chromosome 2 material); gamete 2 similarly contains three chromatids; gamete 3 contains one single small chromatid; gamete 4 contains one single small chromatid. (Net effect: two gametes end up with an extra copy of Chromosome 1, and two gametes are missing a copy of Chromosome 1 - i.e., nondisjunction of Chromosome 1 during Meiosis II.)]

Assume that each gamete produced by the cell shown in the figure is fertilized by a gamete with a complete haploid set of chromosomes. Also assume gene regulation on Chromosome 1 is not affected by the number of copies of Chromosome 1 in the four resulting viable zygotes. **Predict** the difference in mRNA production from genes on Chromosome 1 among the four possible zygotes.

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2026 ▪ Q4

The process of meiosis enables animals that reproduce sexually to produce gametes.

(d) Triploidy describes a condition in which an organism has three complete sets of chromosomes in each cell. Provide reasoning to **justify** the claim that most organisms with triploidy cannot produce gametes with the chromosome number typical of the species.

Question 1

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

Question 1

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

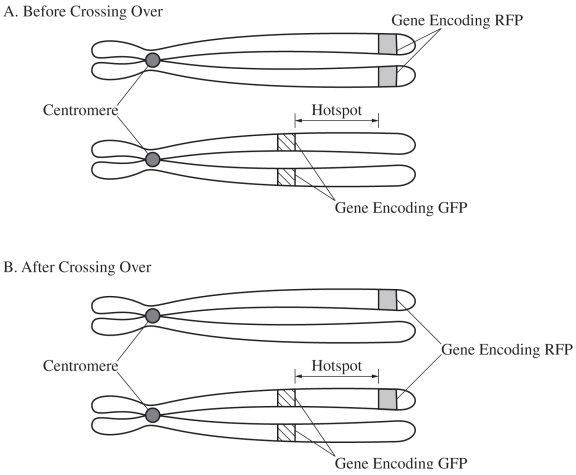
Question 1

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

Question 1

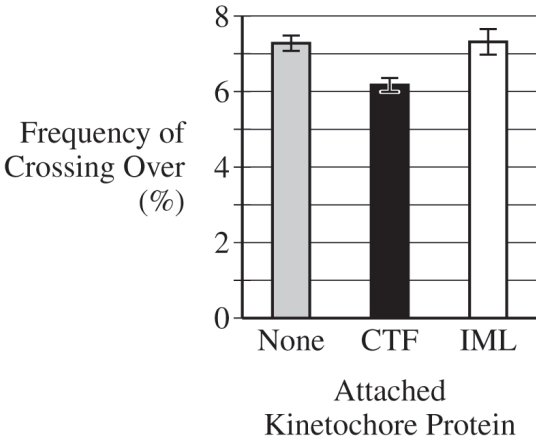
and green light to the number of cells that emitted no light and divided by the total number of cells (Figure 2).
[Figure 2. Bar graph, "The frequency of crossing over in a hotspot on yeast chromosome 8 for cell groups treated with different kinetochore proteins. Error bars represent $\pm 2SE_{\bar{x}}$." 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.

Question 1


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

Question 1

Question 1


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