2. During meiosis, double-strand breaks occur in chromatids. The breaks are either repaired by the exchange of genetic material between homologous nonsister chromatids, which is the process known as crossing over (Figure 1A), or they are simply repaired without any crossing over (Figure 1B). Plant breeders developing new varieties of corn are interested in determining whether, in corn, a correlation exists between the number of meiotic double-strand chromatid breaks and the number of crossovers.

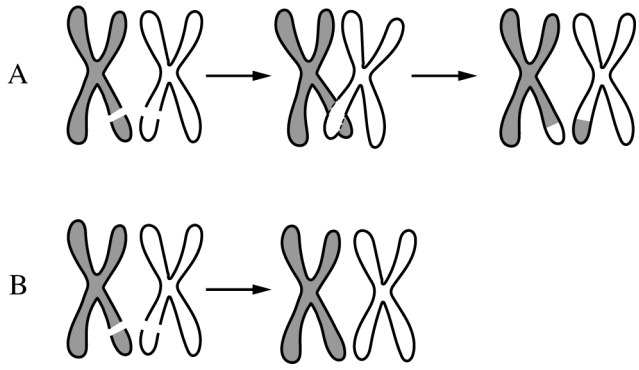


Figure 1. Double-strand breaks in chromatids are repaired with crossing over (A) or without crossing over (B).

Using specialized staining and microscopy techniques, scientists counted the number of double-strand chromatid breaks and the number of crossovers in the same number of meiotic gamete-forming cells of six inbred strains of corn (Table 1).

TABLE 1. NUMBER OF CHROMATID DOUBLE-STRAND BREAKS AND AVERAGE NUMBER OF CROSSOVERS IN INBRED STRAINS OF CORN

| Strain of Corn | Number of Double-Strand Breaks | Average Number of Crossovers ( $\pm 2SE_{\bar{x}}$) |
|---|---|---|
| I | 710 | 19.5 ± 0.5 |
| II | 650 | 18.0 ± 0.7 |
| III | 600 | 17.5 ± 1.0 |
| IV | 510 | 16.0 ± 1.0 |
| V | 425 | 14.0 ± 0.5 |
| VI | 325 | 11.0 ± 1.5 |





GO ON TO THE NEXT PAGE.

(a) The double-strand breaks occur along the DNA backbone. **Describe** the process by which the breaks occur.

(b) Using the template in the space provided for your response, **construct** an appropriately labeled graph that represents the data in Table 1 and allows examination of a possible correlation between double-strand breaks and crossovers. Based on the data, **determine** whether corn strains I, II, and III differ in their average number of crossovers.

(c) Based on the data, **describe** the relationship between the average number of double-strand breaks and the average number of crossovers in the strains of corn analyzed in the experiment.

(d) Crossing over (Figure 1A) creates physical connections that are required for proper separation of homologous chromosomes during meiosis. A diploid cell with four pairs of homologous chromosomes undergoes meiosis to produce four haploid cells. Crossing over occurs between only three of the pairs. **Predict** the number of chromosomes most likely present in each of the four haploid cells. Provide reasoning to **justify** your prediction. **Explain** how plant breeders can use the information in Table 1 to help develop new varieties of corn.

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**Write your responses to this question only on the designated pages in the separate Free Response booklet.**





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## Question 2: Interpreting and Evaluating Experimental Results with Graphing

**9 points**

During meiosis, double-strand breaks occur in chromatids. The breaks are either repaired by the exchange of genetic material between homologous nonsister chromatids, which is the process known as crossing over (Figure 1A), or they are simply repaired without any crossing over (Figure 1B). Plant breeders developing new varieties of corn are interested in determining whether, in corn, a correlation exists between the number of meiotic double-strand chromatid breaks and the number of crossovers.

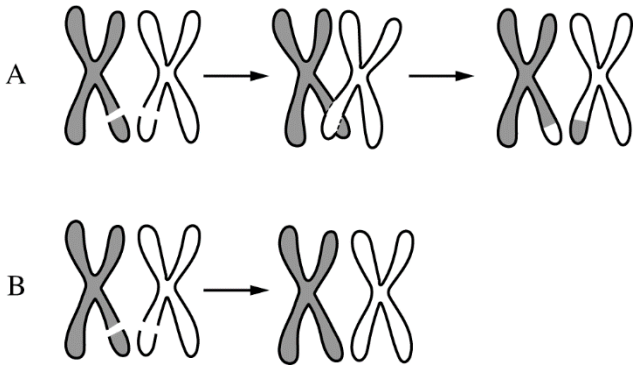


Figure 1. Double-strand breaks in chromatids are repaired with crossing over (A) or without crossing over (B).

Using specialized staining and microscopy techniques, scientists counted the number of double-strand chromatid breaks and the number of crossovers in the same number of meiotic gamete-forming cells of six inbred strains of corn (Table 1).

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| Strain of Corn | Number of Double-Strand Breaks | Average Number of Crossovers ($\pm 2\mathrm{SE}_{\bar{x}}$) |
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| II | 650 | $18.0 \pm 0.7$ |
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| V | 425 | $14.0 \pm 0.5$ |
| VI | 325 | $11.0 \pm 1.5$ |

**(a)** The double-strand breaks occur along the DNA backbone. **Describe** the process by which the breaks occur. **1 point**

Accept one of the following:

- (Enzymatic) hydrolysis occurs between the sugars and phosphates/nucleotides.
- The covalent bonds between the sugars and phosphates/nucleotides are broken.

| | | |
|---|---|---|
| **(d)** | Crossing over (Figure 1A) creates physical connections that are required for proper separation of homologous chromosomes during meiosis. A diploid cell with four pairs of homologous chromosomes undergoes meiosis to produce four haploid cells. Crossing over occurs between only three of the pairs. **Predict** the number of chromosomes most likely present in each of the four haploid cells.<br>• Two cells will have three/n−1 chromosomes; two cells will have five/n+1 chromosomes. | **1 point** |
| | Provide reasoning to **justify** your prediction.<br>• During meiosis I, (three homologous pairs separate normally, and) one pair does not separate/experiences nondisjunction. In meiosis II, the sister chromatids separate normally. | **1 point** |
| | **Explain** how plant breeders can use the information in Table 1 to help develop new varieties of corn.<br>Accept one of the following:<br>• Because crossing over increases genetic diversity, the plant breeders can breed strains with high crossover numbers/double-strand breaks.<br>• They can increase the number of double-stranded breaks, which may lead to more crossovers that increase genetic variation. | **1 point** |
| | **Total for part (d)** | **3 points** |
| | **Total for question 2** | **9 points** |