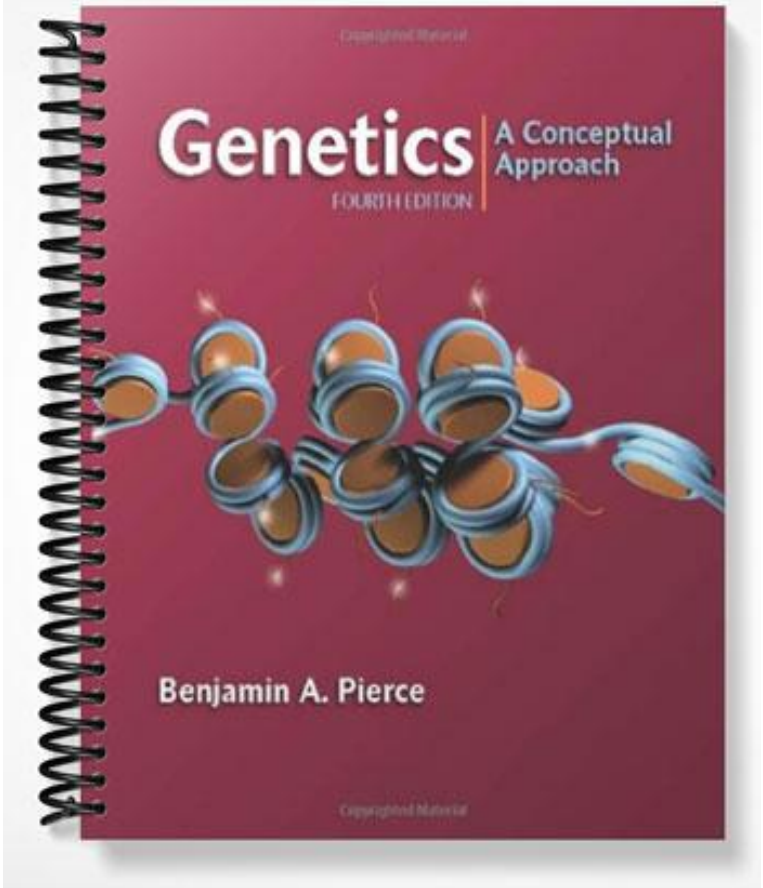
TEST BANK


Genetics
A Conceptual Approach
FOURTH EDITION
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Chapter 2

Chromosomes and Cellular Reproduction

COMPREHENSION QUESTIONS

Multiple Choice

Use the following information for questions 1–3.

A diploid somatic cell from a rat has a total of 42 chromosomes ($2n = 42$). As in humans, sex chromosomes determine sex: XX in females and XY in males.

1. What is the total number of telomeres in a rat cell in G_2?
   a. 21
   b. 42
   c. 84
   d. 126
  *e. 168

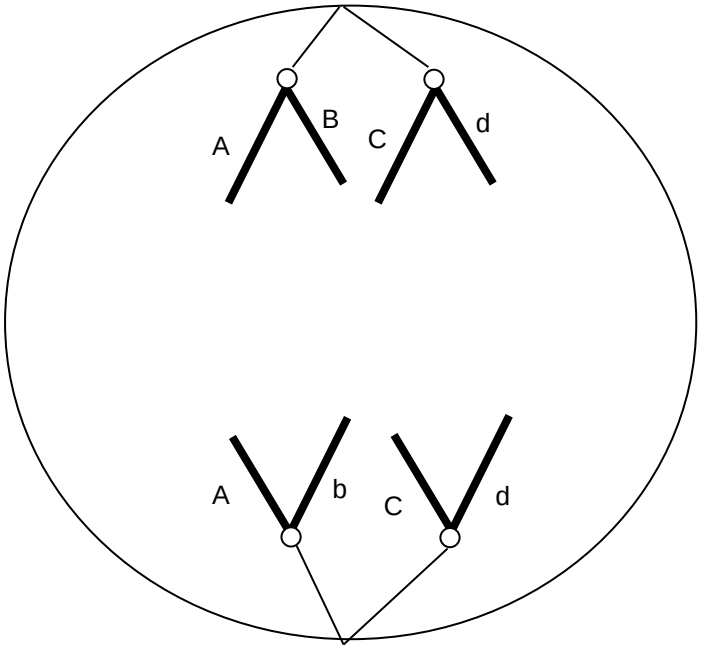
2. What is the total number of chromosomes present in the cell during metaphase I of meiosis?
   a. 21
  *b. 42
   c. 84
   d. 126
   e. 168

3. What is the total number of chromosomes in a polar body cell from a rat?
  *a. 21
   b. 40
   c. 41
   d. 42
   e. 84

4. A dividing eukaryotic cell is treated with a drug that inhibits the molecular motors associated with kinetochores. At which cell cycle stage would it stop?
   a. G_1
   b. S
   c. G_2
  *d. M (anaphase)
   e. M (telophase)

5. The figure shows a chromosomal separation taking place. The letters stand for genes; capital and lowercase stand for different alleles. The diploid chromosome number in this organism is four. What process is shown?
   a. anaphase of mitosis

b. telophase of meiosis I
c. anaphase of meiosis I
d. telophase of mitosis
*e. anaphase of meiosis II



True/False

6. Errors in chromosome separation are rarely a problem for an organism. **(F)**

7. The prokaryotes include both the eubacteria and the archaea. **(T)**

8. Archaea are more closely related to eukaryotes than they are to eubacteria. **(T)**

9. Generally, chromosomes of eukaryotes are circular**. (F)**

10. Cells with a single set of chromosomes are called diploid. **(F)**

Fill in the Blank

11. In a flowering plant, the male part of the flower (the stamen) produces haploid microspores that divide by **mitosis** to produce sperm. A pollen grain that lands on a stigma grows a pollen tube to deliver **2** (how many?) sperm to the ovary. Fusion of a sperm with an egg produces a **2** *n* cell called a **zygote**. To provide

food for the developing embryo, a tissue called endosperm is produced through double fertilization. Endosperm has a ploidy of **3** *n*.

12. In prokaryotes, replication usually begins at a specific place on the chromosome called **the origin of replication**.

13. The **nuclear matrix** is the highly organized internal scaffolding of the nucleus.

14. The attachment point on the chromosome for spindle microtubules is the **centromere**.

15. **Cytokinesis** refers to the splitting of the cytoplasm, separating one cell into two.

Multiple Choice

16. Prokaryotic chromosomes do not have telomeres because:
a. they do not go through mitosis.
b. they do not go through DNA replication.
c. they are in the cytoplasm.
*d. they are circular.
e. they have no centromeres.

17. In eukaryotes, chromosomes do not contain:
*a. ribosomes.
b. chromatin.
c. proteins.
d. histones.
e. DNA.

18. In order to be functional, a eukaryotic chromosome requires all of the following except:
a. a centromere.
b. origins of replication.
*c. a nucleoid.
d. telomeres.

19. What process is unique to plants?
a. meiosis
*b. double fertilization
c. crossing over
d. haploid gametes
e. spermatogenesis

20. Suppose that a diploid cell contains 8 chromosomes (2n = 8). How many different combinations in the gametes are possible?

a. 2
b.4
c. 8
*d. 16
e. 64

Use the following choices for questions 21–25.

a. Meiosis I prophase
b. Meiosis I anaphase
c. Meiosis II prophase
d. Meiosis II anaphase
e. Mitosis prophase
f. Mitosis anaphase

21. Chromosomes are in unseparated, sister-chromatid form, at the end of the phase(s) **a, b, c, e** .

22. The first stage after which a dividing cell that started as a diploid would be haploid **b** .

23. Sister chromatids separate during **d, f** .

24. Chromosomes are randomly partitioned during **b** , contributing to genetic diversity.

25. Crossing over (genetic recombination) occurs in **a** .

Use the following information for questions 26–28.

Pea plants have seven different types of chromosomes.

26. True or False? A diploid pea cell in G_1 has 14 centrioles. **(F)**

27. The nucleus of a megaspore in a pea ovary would contain how many chromosomes? **7**

28. A nucleus in the pea endosperm contains how many chromosomes? **21**

29. A chromosome with a centromere at the very end is called:
a. submetacentric.
b. metacentric.
c. acrocentric.
d. acentric.
*e. telocentric.

Short Answer

30. During prophase I of meiosis, crossing over is indicated by what microscopically visible structure?

Chiasmata (chiasma) or the synaptonemal complex

31. List two differences and two similarities between mitosis and meiosis.

Differences:

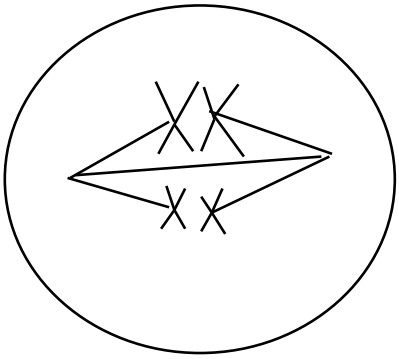
a. Mitosis occurs in somatic (nonsex) cells; meiosis occurs in sex cells to produce gametes.
b. Meiosis involves chromosome pairing (of homologous chromosomes); mitosis does not.
c. Mitosis produces nonsex cells; meiosis produces gametes.
d. Mitosis produces cells of the same ploidy; meiosis produces haploid cells from diploid cells.
e. Meiosis has two consecutive divisions; mitosis has one.
f. Mitosis produces two daughter cells; meiosis produces four daughter cells.
g. Mitosis produces identical daughter cells; meiosis produces four different daughter cells.

Similarities:

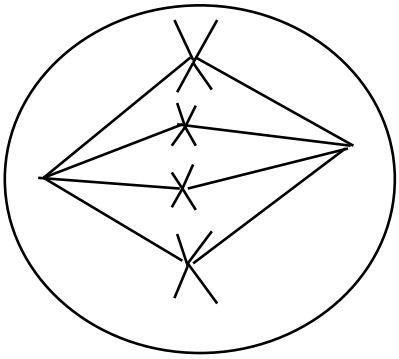
a. Both involve the separation of replicated chromosomes during cell division.
b. Both are processes to ensure that daughter cells in cell division receive a complete set of chromosomes.
c. DNA replication must occur first.
d. Cytokinesis usually occurs at the end of each.

32. The cells illustrated below belong to a species with a diploid chromosome number of four. Each of the cells below is in which stage of mitosis or meiosis?

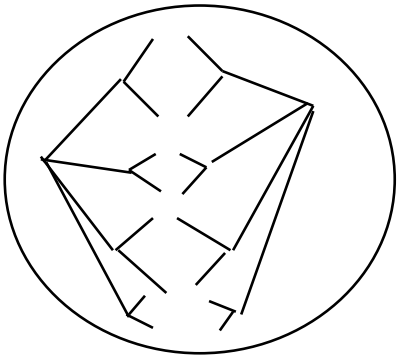
a. **meiosis I metaphase**



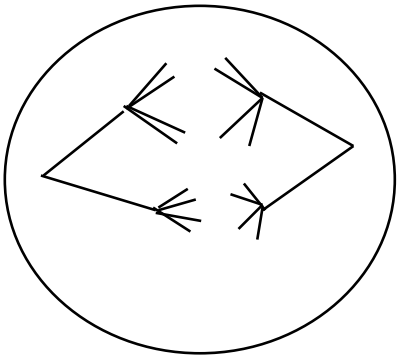
b. **mitosis metaphase**



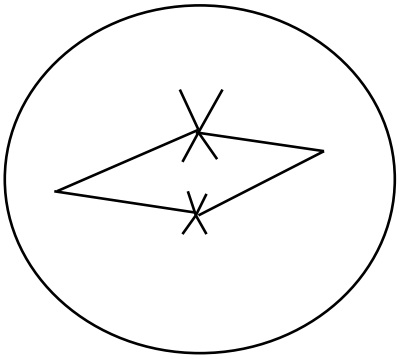
c. **mitosis anaphase**



d. **meiosis I anaphase**



e. **meiosis II metaphase**



For questions 33–37 describe the difference between:

33. centromere and kinetochore

A centromere is the physical location on a chromosome where the kinetochore and spindle microtubules attach. The kinetochore is composed of proteins that assemble on the centromere to provide a site for the spindle microtubules to attach.

34. G_1 and G_2 of the cell cycle

G_1 occurs before S phase and G_2 occurs after S phase. During G_1, cells grow in size, chromosomes are composed of a single chromatid. During G_1, cells pass a critical checkpoint (the G_1/S checkpoint) after which they are committed to undergoing cell division. During G_2, the chromosomes are composed of two chromatids. There is another checkpoint during G_2 that ensures cells are prepared for mitosis. Cells typically spend more time in G_1 than in G_2.

35. homologous chromosomes and sister chromatids

Homologous chromosomes can have different alleles. Sister chromatids are duplicates and (except for errors in replication) are identical in sequence.

36. meiosis I and meiosis II

Homologs pair and segregate in meiosis I. Sister chromatids are paired and segregate in meiosis II. Crossing over occurs in meiosis I, but not in meiosis II.

37. sporophyte and gametophyte

The sporophyte is the diploid phase of a plant life cycle. The gametophyte is the haploid stage.

38. What evidence is there that viruses evolved after, not before, cells?

Viruses can reproduce only within host cells. Thus, they must have evolved after cells.

39. What is *one* feature of meiosis that produces genetic variability in gametes? In two or three sentences, explain how this feature causes genetic uniqueness.

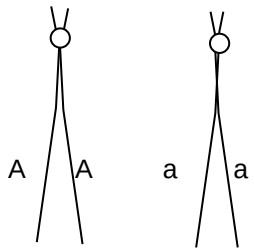
Independent assortment.
In meiosis I—metaphase and anaphase—nonhomologous chromosomes distribute randomly. Alignment and separation of one pair of homologous chromosomes is independent of how a different pair separates. Different gametes have different combinations of the paternally derived and maternally derived chromosomes. These chromosomes can have different alleles for the same genes, so the gametes normally have different combinations of alleles.

OR

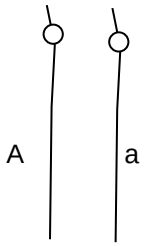
Crossing over.
In meiosis I—prophase—portions of homologous chromosomes exchange, changing combinations of alleles of genes on a single chromosome, so not

even sister chromatids are identical after crossing over. Each gamete has only one copy of each homolog, and each homolog now has a unique combination of alleles.

40. a. Draw a pair of telocentric homologous chromosomes as they would appear in G_2. Indicate centromeres with a small circle, and place the alleles *A* and *a* on each of the chromatids.



b. Draw the same chromosomes as they would appear in G_1. Place the alleles *A* and *a* on each of the chromatids.



41. Why is mitosis important within the cell cycle?

A single cell and all its genetic information is duplicated. Each cell contains a full complement of chromosomes.

42. Explain why mitosis does not produce genetic variation and how meiosis leads to the production of tremendous genetic variation.

Mitosis produces cells that are genetically identical to the parent cell. Meiosis includes two distinct processes that contribute to the generation of genetic variation: crossing over shuffles alleles on the same chromosome into new combinations, whereas the random distribution of maternal and paternal chromosomes shuffles alleles on different chromosomes into new combinations.

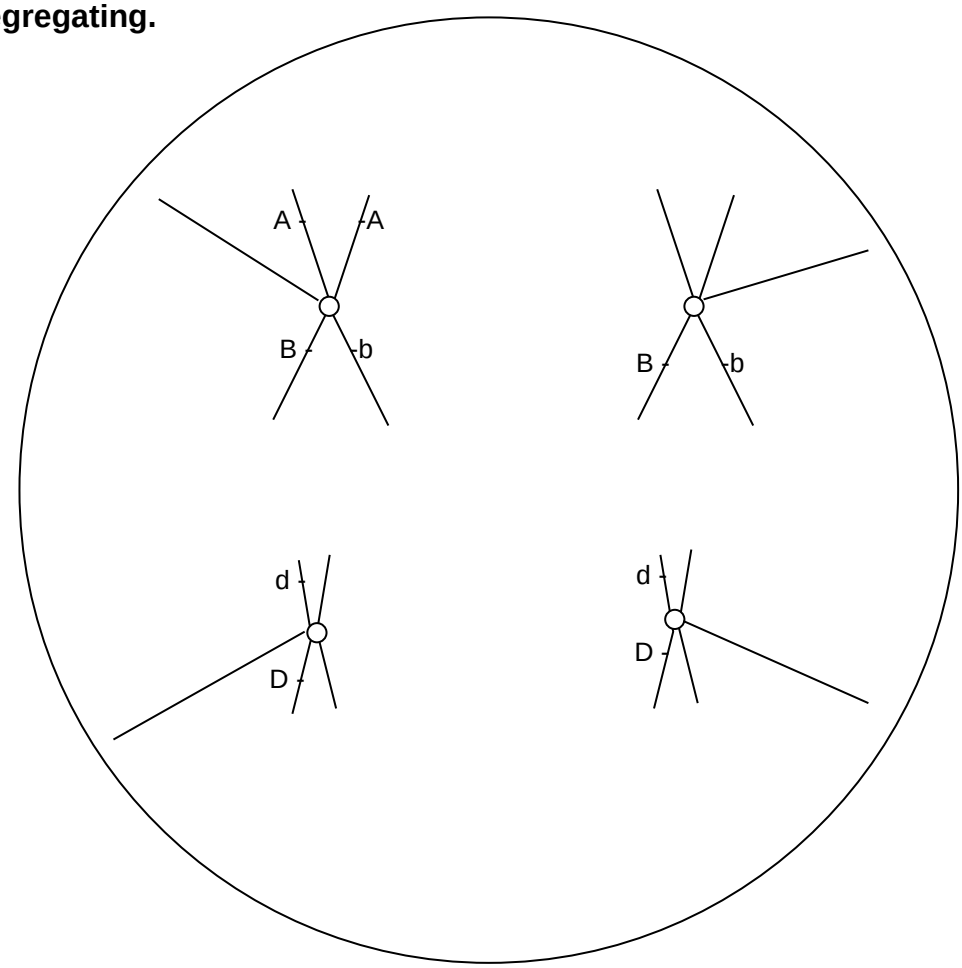
43. Microscopy to look at a cell's chromosomes is often done when the cell is in mitotic metaphase. For example, karyotypes that extract chromosomes from a

single cell and photograph them to look for abnormalities are done on metaphase, rather than interphase, cells. Why?

In metaphase, chromosomes are condensed and are more easily visualized.

44. Find and describe at least four errors in the drawing below of mitotic anaphase**.**

(1) Chromosomes that are separating are still duplicated.
(2) Spindles are not coming from a common spindle-pole body.
(3) Sister chromatids do not have identical alleles for the *B* gene.
(4) Two alleles of the *D* gene are on one chromosome.
(5) No alleles of the *A* gene are on the homologous chromosome.
(6) Homologous chromosomes appear to have paired and to be segregating.



45. What events during sexual reproduction are significant in contributing to genetic diversity?

(1) Crossing over changes allele combinations on chromosomes, so, after meiosis I, even sister chromatids are not genetically identical.
(2) Independent assortment of non-homologous chromosomes ensures each gamete has a different combination of alleles for genes on non-homologs.
(3) Two genetically unique gametes from each parent combine during fertilization to form a novel, genetically unique individual.

46. In tissue from the intestinal epithelium of a frog, the following proportions of cells were found at each stage of the cell cycle:

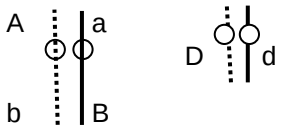
Stage	**Proportion of Cells**
Interphase	0.90
Prophase	0.04
Prometaphase	0.02
Metaphase	0.01
Anaphase	0.02
Telophase	0.01

If the entire cell cycle in frog epithelium cells requires 20 hours for completion, what is the average duration of each stage?

0.9 × 20 = 18 hours, 0.04 × 20 = 0.8 hours, .02 × 20 = .4 hours, etc.

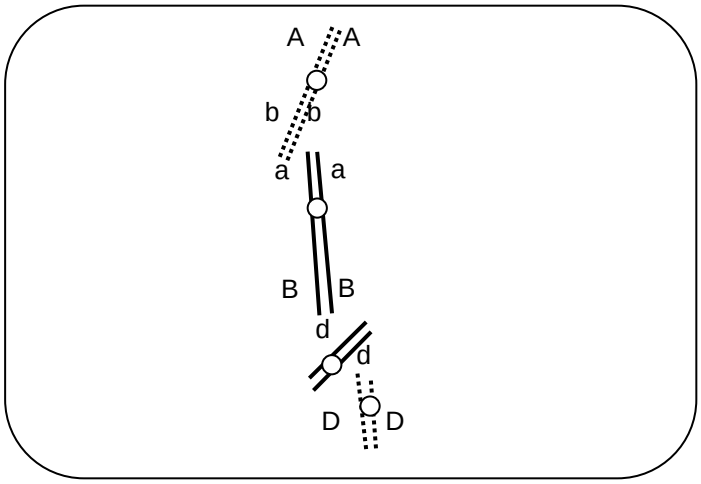
Use the following information for questions 47–48.

A diploid, eukaryotic cell in interphase has these two pairs of homologous chromosomes with the indicated arrangement of alleles:

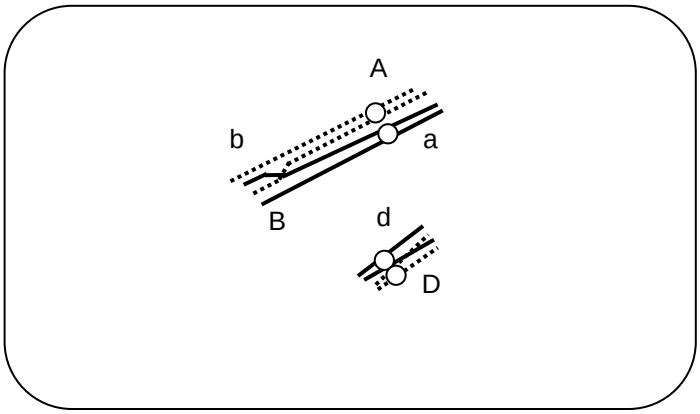


47. Draw the chromosomes at the end of a) prophase of mitosis and b) prophase I (of meiosis I) with the most likely crossing over events. Indicate placement of alleles on the chromosomes.

a)

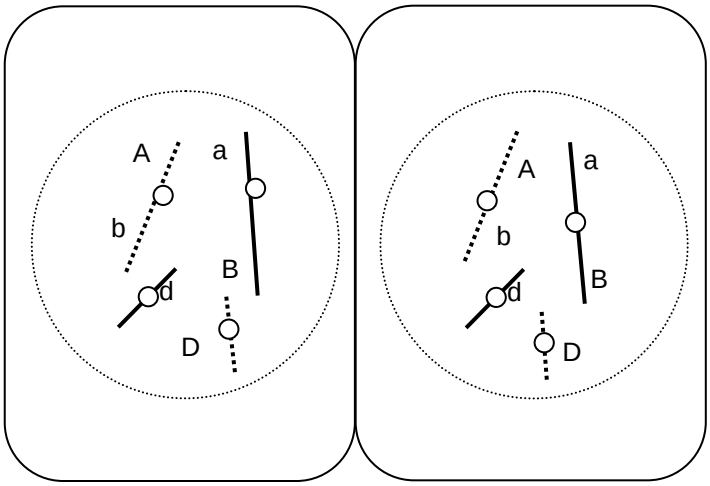


b)

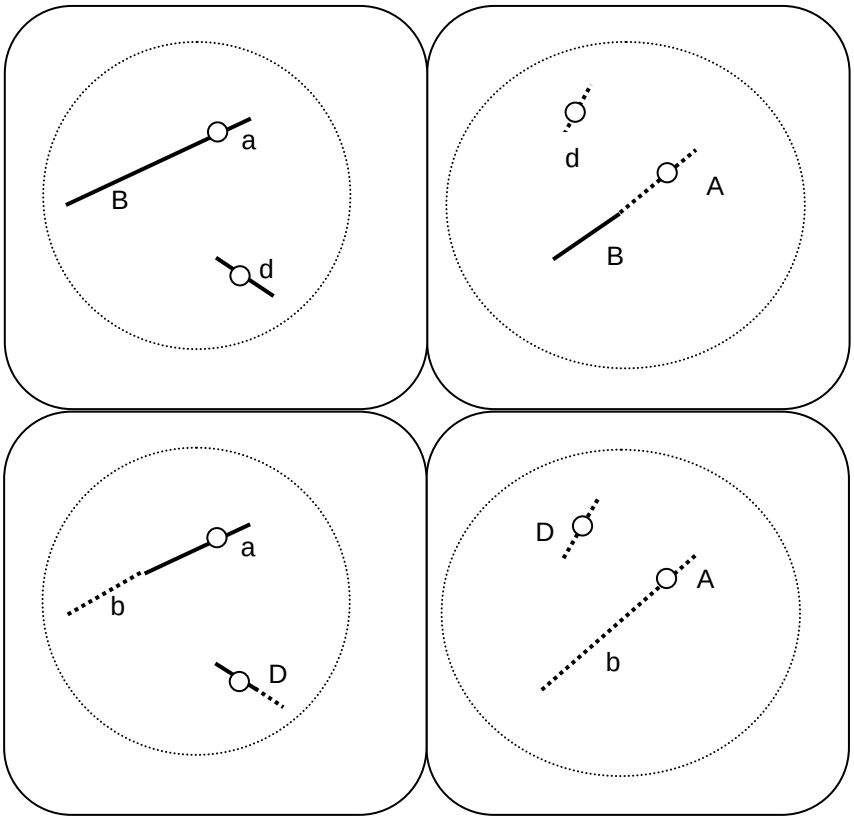


48. Draw the chromosomes at the end of telophase of a) mitosis and b) meiosis II. Indicate placement of alleles on the chromosomes.

a)



b) [One possibility]



49. Write all possible genotypes of each of the cells resulting from a) mitosis and b) meiosis, drawn in the previous question.

Mitosis: A/a B/b D/d or ABD/abd (diploid and heterozygous at all three loci)

Meiosis: ABd, aBd, AbD, abD (haploid at all three loci)

50. a. Compare and contrast spermatogenesis and oogenesis in animals. For each process, be sure to include information about division of the nucleus, allocation of chromosomes to the various products, and division of the cytoplasm.

Division of the nucleus and allocation of the chromosomes to the products are essentially the same in both processes. Starting with a 2n germ cell, nuclear division is by meiosis I and II, and each product of meiosis contains one set of chromosomes (1n). The major difference is that division of the cytoplasm during meiosis I and II is equal in spermatogenesis and unequal in oogenesis. During oogenesis, meiosis I produces a large secondary oocyte with lots of cytoplasm and a polar body with very little cytoplasm. Meiosis II in the secondary oocyte produces a large ovum with lots of cytoplasm and a small second polar body.

Therefore, only one large, functional egg is produced per primary oocyte, whereas four small, functional sperm are normally produced per primary spermatocyte.

b. Why is the difference in cytoplasmic division between spermatogenesis and oogenesis important to reproduction, considering the different roles of sperm and eggs in reproduction?

The small size and other features of sperm structure suit them well to delivery of the haploid nucleus to the egg. The large amount of cytoplasm in the egg suits it well to nourishing development of the embryo after fertilization.

51. a. Describe the changing role of cohesin during the mitotic cell cycle.

Cohesin keeps sister chromatids together after DNA replication during S phase through metaphase of mitosis. The breakdown of cohesin allows the sister chromatids to separate from each other during anaphase.

b. Explain the importance of regulation of cohesin activity to normal cell division.

Cohesin must be active beginning in S phase through metaphase in order to keep the sister chromatids together so that they can be properly aligned at the metaphase plate to ensure equal division of the genetic information to the two daughter cells. Cohesin must be inactivated or broken down in order to allow the sister chromatids to separate during anaphase so that each daughter cell will get one copy of the genes on each chromosome.

52. List and briefly describe the three major cell cycle checkpoints. For each checkpoint, predict the consequences if the checkpoint failed to work properly.

(1) The G_1/S checkpoint holds the cell in G_1 until the cell has all of the enzymes necessary for replication of DNA. If the checkpoint failed, the cell would proceed into S without the necessary enzymes, causing the DNA not to be replicated properly or completely. This might cause the cell cycle to halt at the G_2/M checkpoint. Alternatively, the cell might divide without the genetic material having been replicated, causing the daughter cells to receive incomplete genetic information. (Both predictions are reasonable based on information in the chapter.)

(2) The G_2/M checkpoint is passed only if the cell's DNA is undamaged. If it fails to work properly, division would proceed in the presence of damaged DNA, possibly leading to mutations in the daughter cells and/or death of the daughter cells.

(3) The spindle-assembly checkpoint is during metaphase, and it ensures that each chromosome is aligned at the metaphase plate and attached to spindle fibers from opposite poles. This checkpoint depends on tension at the kinetochores of each chromosome. If the checkpoint fails, anaphase will occur even when the chromosomes are not aligned properly, allowing daughter cells to be produced with extra and/or missing chromosomes.