Chapter 2

Chromosomes and Cellular Reproduction

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

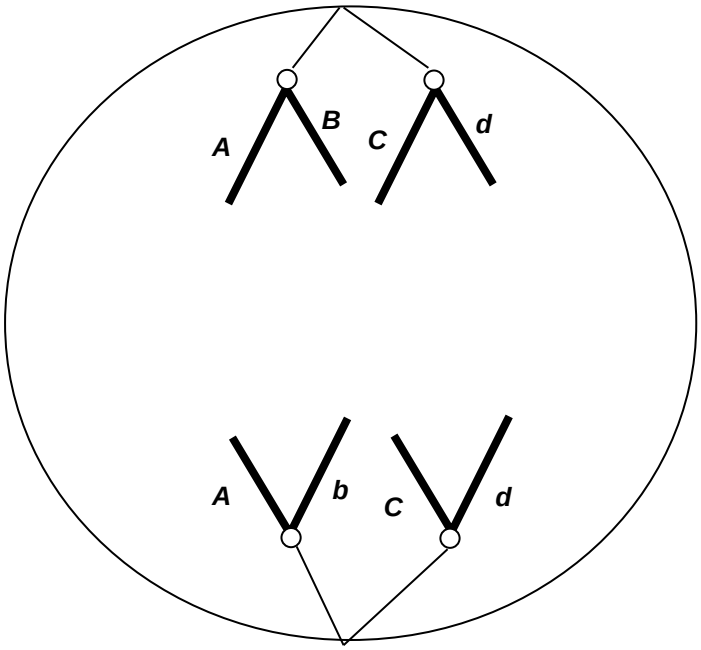
3. What is the total number of chromosomes in a polar body cell from a rat?
  *a. 21
   b. 40
   c. 41
   d. 42
   e. 84

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. A eukaryotic cell in G_1 has a mutation that prevents cyclin B from being made. At which cell cycle stage would this cell stop?
  *a. G_1
   b. S
   c. G_2

d. M (anaphase)
e. M (telophase)

6. 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



7. 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 closed-circular.
e. they have no centromeres.

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

9. In order to be functional, a chromosome requires all of the following except:
a. centromeres.

b. origins of replication.
*c. nucleomeres.
d. telomeres.

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

11. Which stage of meiosis increases genetic variability in the gamete cells?
a. telophase
*b. prophase I
c. anaphase I
d. anaphase II

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

13. If a typical somatic cell has 32 chromosomes, how many chromosomes are expected in each gamete of that organism?
a. 46
b. 64
c. 0
*d. 16
e. 32

Use the following choices for questions 14-17.

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

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

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

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

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

Use the following information for questions 18-19.

Pea plants have seven (7) different types of chromosomes.

18. The nucleus of a megaspore in a pea ovary would contain how many chromosomes?
*a. 7
b. 14
c. 21
d. 28

19. A nucleus in the pea endosperm contains how many chromosomes?
a. 7
*b. 21
c.14
d. 28

True/False

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

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

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

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

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

25. Daughter cells resulting from the completion of a cell cycle always have identical cytoplasmic content. **(F)**

26. Histones are present in all types of organisms including eubacteria, archea, and eukaryotes. **(F)**

27. Progression through the different phases of the cell cycle is regulated by key transition points called checkpoints. **(T)**

Fill in the Blank

28. In a flowering plant, the male part of the flower (the stamen) produces haploid microsporocyte cells 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*.

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

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

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

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

33. Chromatin is a complex structure of DNA and proteins called **histones.**

34. Telomeres are located at the ends of the chromosomes and participate in **limiting** cell division.

Short-Answer Discussion

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

Chiasmata (chiasma) or the synaptonemal complex

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

Differences:

(1) Mitosis occurs in somatic (nonsex) cells; meiosis occurs in sex cells to produce gametes.
(2) Meiosis involves chromosome pairing (of homologous chromosomes); mitosis does not.
(3) Mitosis produces nonsex cells; meiosis produces gametes.
(4) Mitosis produces cells of the same ploidy; meiosis produces haploid cells from diploid cells.
(5) Meiosis has two consecutive divisions; mitosis has one.
(6) Mitosis produces two daughter cells; meiosis produces four daughter cells.
(7) Mitosis produces identical daughter cells; meiosis produces four different daughter cells.

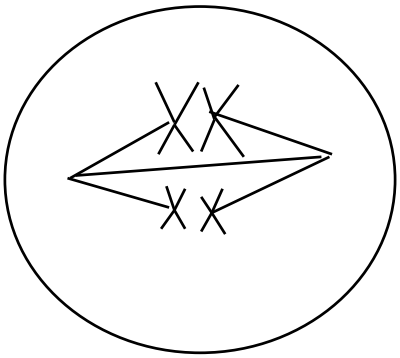
Similarities:

(1) Both involve the separation of replicated chromosomes during cell division.

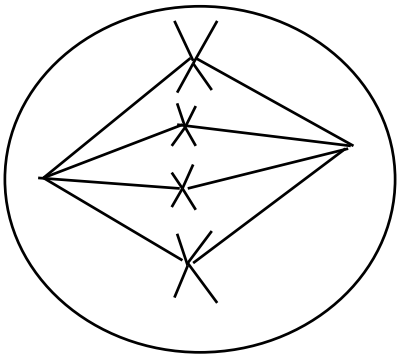
(2) Both are processes to ensure that daughter cells in cell division receive a complete set of chromosomes.
(3) DNA replication must occur first.
(4) Cytokinesis usually occurs at the end of each.

37. 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?

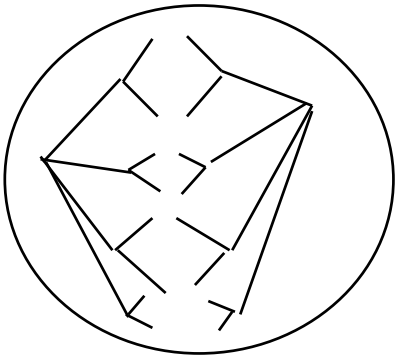
a. **meiosis I metaphase**



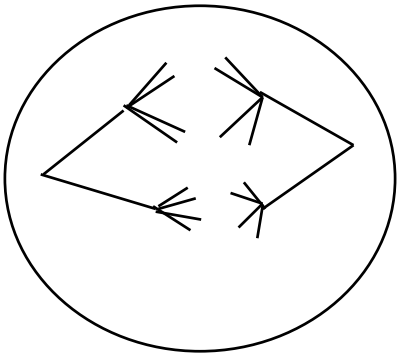
b. **mitosis metaphase**



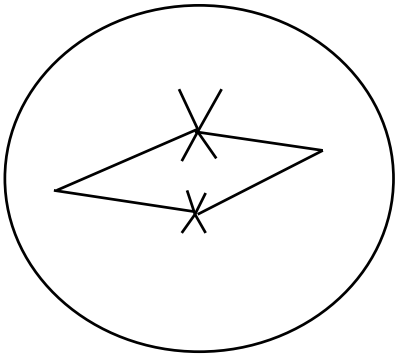
c. **mitosis anaphase**



d. **meiosis I anaphase**



e. **meiosis II metaphase**



Describe the difference between:

38. genome and gene

The complete genetic makeup of any organism is its genome. A gene is a unit of that genome. A gene is a section of a chromosome that encodes an RNA molecule or a single polypeptide (protein).

39. 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.

40. 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, and cyclin B levels are low. 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 and cyclin B levels rise. 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.

41. homologous chromosomes and sister chromatids

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

42. 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.

43. sporophyte and gametophyte

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

44. How many copies of a gene exist in a eukaryotic organism, where are they located, and are they identical?

There are two copies called "alleles" located in the two chromosomes called a homologous pair (paternal and maternal). These copies may not be identical.

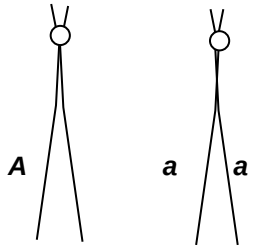
45. What is *one* feature of meiosis that produces genetic variability in gametes? In two or three sentences, explain how this feature causes genetic uniqueness.

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 have different alleles for the same genes, so the gametes have different combinations of alleles.

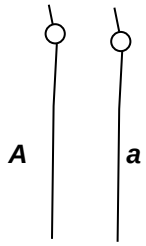
OR

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.

46. 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.



47. 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.

48. 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.

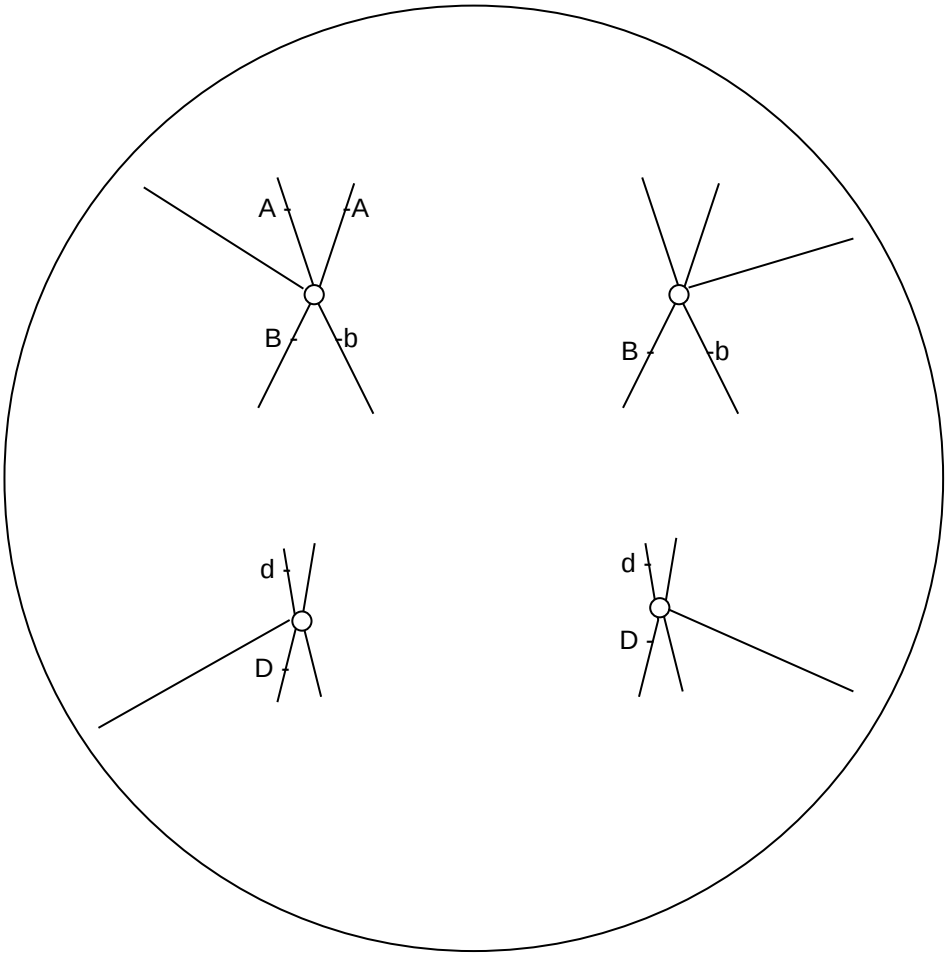
49. Microscopy to look at a cell's chromosomes is often done when the cell is in mitotic metaphase. For example, karyotypes that extract chromosomes from a single cell and photograph them to look for abnormalities are done on metaphase, rather than interphase, cells. Why?

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

50. Find and describe at least four errors in the drawing of mitotic anaphase on the following page**.**

(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.

Chromosomes and Cellular Reproduction



51. 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.

52. Explain the reasons why viruses cannot be characterized as cells or primitive forms of life.

Viruses can reproduce only within host cells, using replication, transcription, and translation machinery of the host cell. From an evolutionary point of view, viruses are closely related to their hosts and they are not a distinct evolutionary group. A virus's genes are similar to those of their host, suggesting they have evolved from their hosts rather than from other viruses.

Problems and Calculations

53. 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.