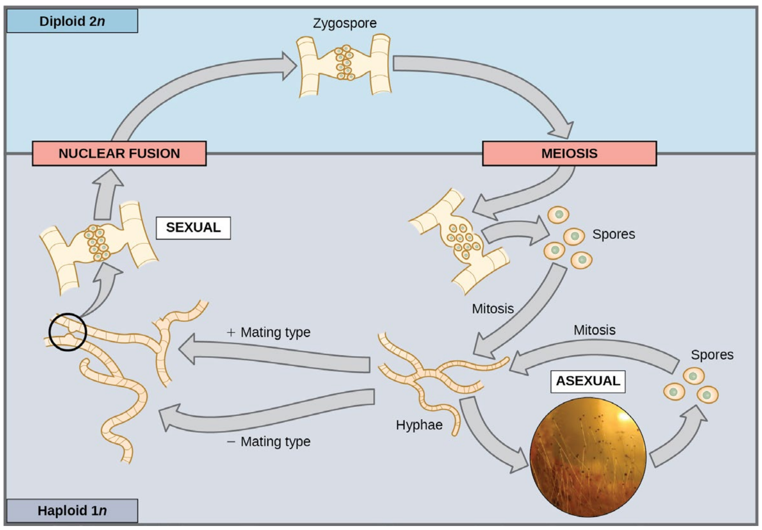
Biology 2e
Unit 3: Genetics
Chapter 11: Meiosis and Sexual Reproduction

Visual Connection Questions

1. If a mutation occurs so that a fungus is no longer able to produce a minus mating type, will it still be able to reproduce?



Yes, it will be able to reproduce asexually.

Review Questions

2. Meiosis usually produces ________ daughter cells.
c. four haploid

3. What structure is most important in forming the tetrads?
b. synaptonemal complex

4. At which stage of meiosis are sister chromatids separated from each other?
d. anaphase II

5. At metaphase I, homologous chromosomes are connected only at what structures?
a. chiasmata

6. Which of the following is *not* true in regard to crossover?
a. Spindle microtubules guide the transfer of DNA across the synaptonemal complex.

7. What phase of mitotic interphase is missing from meiotic interkinesis?
c. S phase

8. The part of meiosis that is similar to mitosis is ________.
c. meiosis II

9. If a muscle cell of a typical organism has 32 chromosomes, how many chromosomes will be in a gamete of that same organism?
b. 16

10. Which statement best describes the genetic content of the two daughter cells in prophase II of meiosis?
b. haploid with two copies of each gene

11. The pea plants used in Mendel's genetic inheritance studies were diploid, with 14 chromosomes in somatic cells. Assuming no crossing over events occur, how many unique gametes could one pea plant produce?
b. 128

12. How do telophase I and telophase II differ during meiosis in animal cells?
d. Chromosomes can remain condensed at the end of telophase I, but decondense after telophase II.

13. What is a likely evolutionary advantage of sexual reproduction over asexual reproduction?
c. Sexual reproduction results in variation in the offspring.

14. Which type of life cycle has both a haploid and diploid multicellular stage?
d. alternation of generations

15. What is the ploidy of the most conspicuous form of most fungi?
b. haploid

16. A diploid, multicellular life-cycle stage that gives rise to haploid cells by meiosis is called a ________.
a. sporophyte

17. Hydras and jellyfish both live in a freshwater lake that is slowly being acidified by the runoff from a chemical plant built upstream. Which population is predicted to be better able to cope with the changing environment?
a. jellyfish

18. Many farmers are worried about the decreasing genetic diversity of plants associated with generations of artificial selection and inbreeding. Why is limiting random sexual reproduction of food crops concerning?
c. Larger portions of the plant populations are susceptible to the same diseases.

Critical Thinking Questions

19. Describe the process that results in the formation of a tetrad.

During the meiotic interphase, each chromosome is duplicated. The sister chromatids that are formed during synthesis are held together at the centromere region by cohesin proteins. All chromosomes are attached to the nuclear envelope by their tips. As the cell enters prophase I, the nuclear envelope begins to fragment, and the proteins holding homologous chromosomes locate each other. The four sister chromatids align lengthwise, and a protein lattice called the synaptonemal complex is formed between them to bind them together. The synaptonemal complex facilitates crossover between non-sister chromatids, which is observed as chiasmata along the length of the chromosome. As prophase I progresses, the synaptonemal complex breaks down and the sister chromatids become free, except where they are attached by chiasmata. At this stage, the four chromatids are visible in each homologous pairing and are called a tetrad.

20. Explain how the random alignment of homologous chromosomes during metaphase I contributes to the variation in gametes produced by meiosis.

Random alignment leads to new combinations of traits. The chromosomes that were originally inherited by the gamete-producing individual came equally from the egg and the sperm. In metaphase I, the duplicated copies of these maternal and paternal homologous chromosomes line up across the center of the cell. The orientation of each tetrad is random. There is an equal chance that the maternally derived chromosomes will be facing either pole. The same is true of the paternally derived chromosomes. The alignment should occur differently in almost every meiosis. As the homologous chromosomes are pulled apart in anaphase I, any combination of maternal and paternal chromosomes will move toward each pole. The gametes formed from these two groups of chromosomes will have a mixture of traits from the individual's parents. Each gamete is unique.

21. What is the function of the fused kinetochore found on sister chromatids in prometaphase I?

In metaphase I, the homologous chromosomes line up at the metaphase plate. In anaphase I, the homologous chromosomes are pulled apart and move to opposite poles. Sister chromatids are not separated until meiosis II. The fused kinetochore formed during meiosis I ensures that each spindle microtubule that binds to the tetrad will attach to both sister chromatids.

22. In a comparison of the stages of meiosis to the stages of mitosis, which stages are unique to meiosis and which stages have the same events in both meiosis and mitosis?

All of the stages of meiosis I, except possibly telophase I, are unique because homologous chromosomes are separated, not sister chromatids. In some species, the chromosomes do not decondense and the nuclear envelopes do not form in telophase I. All of the stages of meiosis II have the same events as the stages of mitosis, with the possible exception of prophase II. In some species, the chromosomes are still condensed and there is no nuclear envelope. Other than this, all processes are the same.

23. Why would an individual with a mutation that prevented the formation of recombination nodules be considered less fit than other members of its species?

The chromosomes of the individual cannot cross over during meiosis if he cannot make recombination nodules. This limits the genetic diversity of the individual's gametes to what occurs during independent assortment, with all daughter cells receiving complete maternal or paternal chromatids. An individual who cannot produce diverse offspring is considered less fit than individuals who do produce diverse offspring.

24. Does crossing over occur during prophase II? From an evolutionary perspective, why is this advantageous?

Crossing over does not occur during Prophase II; it only occurs during Prophase I. In Prophase II there are still two copies of each gene, but they are on sister chromatids within a single chromosome (rather than homologous chromosomes as in Prophase I). Therefore, any crossing over event would still produce two identical chromatids. Since it is advantageous to avoid wasting energy on events that will not increase genetic diversity, crossing over does not occur.

25. List and briefly describe the three processes that lead to variation in offspring with the same parents.

a. Crossover occurs in prophase I between non-sister homologous chromosomes. Segments of DNA are exchanged between maternally derived and paternally derived chromosomes, and new gene combinations are formed.
b. Random alignment during metaphase I leads to gametes that have a mixture of maternal and paternal chromosomes.
c. Fertilization is random, in that any two gametes can fuse.

26. Animals and plants both have diploid and haploid cells. How does the animal life cycle differ from the alternation of generations exhibited by plants?

Nearly all animals employ a diploid-dominant life-cycle strategy; only the gametes are haploid. Once the haploid gametes are formed, they lose the ability to divide again. There is no multicellular haploid life stage. Plants, in contrast, have a blend of the haploid-dominant and diploid-dominant cycles -- they have both haploid and diploid multicellular organisms as part of their life cycle. The diploid plant is called a sporophyte because it produces haploid spores by meiosis. The spores develop into multicellular, haploid plants that are called gametophytes because they produce gametes.

27. Explain why sexual reproduction is beneficial to a population but can be detrimental to an individual offspring.

Sexual reproduction increases the genetic variation within the population, since new individuals are made by randomly combining genetic material from two parents. Since only fit individuals reach sexual maturity and reproduce, the overall population tends toward increasing fitness in its environment. However, there is always a possibility that the random combination creating the offspring's genome will actually produce an organism less fit for the environment than the parents were.

28. How does the role of meiosis in gamete production differ between organisms with a diploid-dominant life cycle and organisms with an alternation of generations life cycle?

Organisms with a diploid-dominant life cycle make haploid gametes by meiosis, while all their somatic cells are diploid. Organisms with an alternation of generations life cycle make gametes during their haploid life stage, so the chromosome number does not need to be reduced and meiosis is not involved.

29. How do organisms with haploid-dominant life cycles ensure continued genetic diversification in offspring without using a meiotic process to make gametes?

Haploid-dominant organisms undergo sexual reproduction by making a diploid zygote. The cells that make the gametes are derived from haploid cells, but the + and – mating types that produce the zygote are randomly combined. The zygote also undergoes meiosis to return to the haploid stage, so multiple steps add genetic diversity to haploid-dominant organisms.