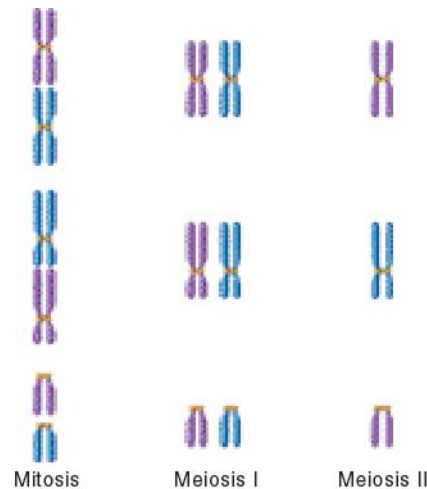C1. They are genetically identical, barring rare mutations, because they receive identical copies of the genetic material from the mother cell.

C2. The term *homologue* refers to the members of a chromosome pair. Homologues are usually the same size and carry the same types and order of genes. They may differ in that the genes they carry may be different alleles.

C3. Sister chromatids are identical copies derived from the replication of a parental chromosome. They remain attached to each other at the centromere. They are genetically identical, barring rare mutations and crossing over with homologous chromosomes.

C4. Metaphase is the organization phase and anaphase is the separation phase.

C5. In G_1, there should be six linear chromosomes. In G_2, there should be 12 chromatids that are attached to each other in pairs of sister chromatids.

C6. In metaphase I of meiosis, each pair of chromatids is attached to only one pole via the kinetochore microtubules. In metaphase of mitosis, there are two attachments (i.e., to both poles). If the attachment was lost, a chromosome would probably be lost and degraded because it would not migrate to a pole. Therefore, it would not become enclosed in a nuclear membrane after telophase. If left out in the cytoplasm, it would eventually be degraded.

C7. A. During mitosis and meiosis II

B. During meiosis I

C. During mitosis, meiosis I, and meiosis II

D. During mitosis and meiosis II

C8. The reduction occurs because there is a single DNA replication event but two cell divisions. Because of the nature of separation during anaphase I, each cell receives one copy of each type of chromosome.

C9.

Mitosis   Meiosis I   Meiosis II

C10. It means that the arrangement of the maternally derived and paternally derived chromosomes is random during metaphase I. Refer to Figure 3.17.

C11. Mitosis—two diploid cells containing 10 chromosomes each (two complete sets)

Meiosis—four haploid cells containing 5 chromosomes each (one complete set)

C12. There are three pairs of chromosomes. So the possible number of arrangements equals 2^3, which is 8.

C13. $(1/2)^n = (1/2)^4 = 1/16$

C14. It would be much lower because pieces of maternal chromosomes would be mixed with the paternal chromosomes. Therefore, it is unlikely to inherit a chromosome that was completely paternally derived.

C15. Bacteria do not need to sort their chromosomes because they only have one type of chromosome. The attachment of the two copies of the chromosomes to the cell membrane prior to cell division ensures that each daughter cell receives one copy.

C16. During interphase, the chromosomes are greatly extended. In this conformation, they might get tangled up with each other and not sort properly during meiosis and mitosis. The condensation process probably occurs so that the chromosomes can easily align along the equatorial plate during metaphase without getting tangled up.

C17. To produce identical quadruplets, fertilization begins with one sperm and one egg cell. This fertilized egg then could divide twice by mitosis to produce four genetically identical cells. These four cells could then separate from each other to begin the lives of four distinct individuals. Another possibility is that mitosis could produce two cells that separate from each other. These two cells could then divide by mitosis to produce two pairs of cells, which also could separate to produce four individual cells.

C18. During prophase II, your drawing should show four replicated chromosomes (i.e., four structures that look like Xs). Each chromosome is one homologue. During prophase of mitosis, there should be eight replicated chromosomes (i.e., eight Xs). During prophase of mitosis, there are pairs of homologues. The main difference is that prophase II has a single copy of each of the four chromosomes whereas prophase of mitosis has four pairs of homologues. At the end of meiosis I, each daughter cell received only one copy of a homologous pair, not both. This is due to the alignment of homologues during metaphase I and their separation during anaphase I.

C19. The products of meiosis have only one copy of each type of chromosome. For example, one human gamete may contain the paternally derived copy of chromosome 11, whereas a different gamete may contain the maternally derived copy of chromosome 11. These two homologues may carry different alleles of the same genes and therefore are not identical. In contrast, mitosis produces genetically identical daughter cells that have both copies of all the pairs of homologous chromosomes.

C20. DNA replication does not take place during interphase II. The chromosomes at the end of telophase I have already replicated (i.e., they are found in pairs of sister chromatids). During meiosis II, the sister chromatids separate from each other yielding individual chromosomes.

C21.

Prophase	Telophase
Nuclear membrane vesiculates.	Nuclear membrane re-forms.
Spindle forms.	Spindle disassembles.
Chromosomes condense.	Chromosomes decondense.
Chromosomes attach to spindle.	Chromosomes detach from the spindle.

C22. A. 20

B. 10

C. 30

D. 20

C23. The hybrid offspring would have 44 chromosomes (i.e., 25 + 19). The reason for infertility is because each chromosome does not have a homologous partner. Therefore, the chromosomes cannot properly pair during metaphase I. The gametes do not receive one copy of each homologue. Gametes will be missing certain chromosomes, which makes them inviable.

C24. A. Dark males and light females; reciprocal: all dark offspring

B. All dark offspring; reciprocal: dark females and light males

C. All dark offspring; reciprocal: dark females and light males

D. All dark offspring; reciprocal: dark females and light males

C25. Male gametes are usually small and mobile. Animal and some plant male gametes often contain flagella, which make them motile. The goal of the male gamete is to locate the female gamete. Female gametes are usually much larger and contain nutrients to help the growth of the embryo after fertilization occurs.

C26. To produce sperm, a spermatogonial cell first goes through mitosis to produce two cells. One of these remains a spermatogonial cell and the other progresses through meiosis. In this way, the testis continues to maintain a population of spermatogonial cells.

C27. During oogenesis in humans, the cells are arrested in prophase I of meiosis for many years until selected primary oocytes progress through the rest of meiosis I and begin meiosis II. If fertilization occurs, meiosis II is completed.

C28. A. *A B C, A B c, A b C, A b c, a B C, a b C, a B c, a b c*

B. *A B C, A b C*

C. *A B C, A B c, a B C, a B c*

D. *A b c, a b c*

C29. A. X-linked recessive (unaffected mothers transmit the trait to sons)

B. Autosomal recessive (affected daughters and sons are produced from unaffected parents)

C30. The outcome is that all the daughters will be affected and all the sons will be unaffected. The ratio is 1:1.

C31. Duchenne muscular dystrophy is inherited as an X-linked recessive disorder. Affected individuals are males. Their mothers are related to males who have the disorder. The mothers of affected males are heterozygous carriers. Note: This pedigree is also consistent with autosomal recessive inheritance, although the pattern is more suggestive of X-linked inheritance.

C32. First set up the following Punnett Square:

A. 1/4

B. (3/4)(3/4)(3/4)(3/4) = 81/256

C. 3/4

D. The probability of an affected offspring is 1/4 and the probability of an unaffected offspring is 3/4. For this problem, you use the binomial expansion where $x = 2$, $n = 5$, $p = 1/4$, and $q = 3/4$. The answer is 0.26, or 26%, of the time.

C33. The genotypes of the parents are that the mother is a heterozygous carrier and the father is hemizygous color-blind. By constructing a Punnett square, the probability of producing a color-blind offspring (male or female) is 1/2, or 50%. We use the product rule to compute ordered events. So, (1/2)(1/2) equals 1/4, or 25%.

C34. A. No. A male inherits the Y chromosome from his father, so he could not inherit an X chromosome from his paternal grandfather.

B. Yes. A male could inherit a maternal X chromosome from his maternal grandfather. It would first be transmitted from his grandfather to his mother, and then from his mother to him.

C. Yes. A female could inherit a maternal X chromosome from her maternal grandmother. It would first be transmitted from her grandmother to her mother, and then from her mother to her.

D. Yes. A female could inherit a maternal X chromosome from her maternal great-great-grandmother. It would first be transmitted from her great-great-grandmother to a maternal great-grandparent (male or female). It could then be transmitted to a grandparent, and then to the mother, and then from her mother to her.

Note: Parts B-D assume there is no crossing over between homologous X chromosomes.

C35. 1 affected daughter : 1 unaffected daughter : 1 affected son : 1 unaffected son

C36. A. The woman's mother must have been a heterozygote. So there is a 50% chance that the woman is a carrier. If she has children, 1/4 (i.e., 25%) will be affected sons if she is a carrier. However, there is only a 50% chance that she is a carrier. So we multiply 50% times 25%, which equals $0.5 \times 0.25 = 0.125$, or a 12.5% chance.

B. If she already had a color-blind son, then we know she must be a carrier, so the chance is 25%.

C. The woman is heterozygous and her husband is hemizygous for the color-blind allele. This couple will produce 1/4 offspring that are color-blind daughters. The rest are 1/4 carrier daughters, 1/4 normal sons, and 1/4 color-blind sons. Answer is 25%.

C37. There is a 1/2 chance that the mother will transmit her abnormal chromosome and a 1/2 chance that the father will. We use the product rule to calculate the chances of both events happening. So the answer is $1/2 \times 1/2 = 1/4$, or 25%. The probability that such a child will pass both chromosomes to an offspring is also 25% because that child had a 1/2 chance of passing either chromosome.

C38. A. The fly is a male because the ratio of X chromosomes to sets of autosomes is 1/2, or 0.5.

B. The fly is female because the ratio is 1.0.

C. The fly is male because the ratio is 0.5.

D. The fly is female because the ratio is 1.0.

C39. A. Female; there are no Y chromosomes.

B. Female; there are no Y chromosomes.

C. Male; the Y chromosome determines maleness.

D. Male; the Y chromosome determines maleness.