

Chapter 3

Reproduction, Heredity and Genetics, and Prenatal Development

INTRODUCTION

Whereas Chapters 1 and 2 examined the major developmental perspectives and theories, Chapter 3 illuminates the biological foundations of development. The chapter presents current research findings about the beginning of human development. Chapter 3 examines such important topics as the reproductive systems of males and females; the remarkable process of fertilization, growth and health factors crucial to prenatal development; the birth process; and possible complications of pregnancy and birth for mother, father, and child. Within this context, the following topics are covered:

- **Reproduction.** This includes a detailed section on how human beings are able to reproduce. Also explained and critically evaluated are the genetic testing and counseling methods available to assess development before birth.
- **Heredity.** This involves looking at the cellular level in order to understand the role that chromosomes, genes, and DNA play in passing on inheritances.
- **Genetics.** This section covers the Human Genome Project, principles of genetics such as dominant and recessive characteristics, and phenotypes and genotypes. Also covered is genetic counseling and testing, and the methods of fetoscopy, amniocentesis, and ultrasonography.
- **Cell division.** This portion of the chapter examines the differences between mitosis and meiosis as well as the difference between autosomes and sex chromosomes.
- **Prenatal development.** The three stages of prenatal development—germinal, embryonic, and fetal—are highlighted.
- **Other factors in development.** Environmental and teratological influences that can affect the developing organism are examined. These include drugs, disease, stress, HIV/AIDS, maternal age, and the Rh factor.

LEARNING OBJECTIVES

After completing Chapter 3, you should be able to:

1. Describe some facts about a typical:

male's sperm production (location, locomotion, amount, when produced).

female's ova production (location, locomotion, amount, when produced).

2. Name and identify the function of the two male androgens.

3. Name and identify the function of the two female sex hormones.

4. Explain the journey of a mature ovum from where it is produced and the role of each body part through menstruation or fertilization (if that occurs).

5. Describe the process of fertilization.

Where does it take place? (i.e., natural vs. assisted reproductive technologies [ART])

How does conception occur?

How does the uterus prepare for pregnancy?

6. Discuss different methods for conception.

In vitro fertilization (IVF)

Gamete intra-fallopian transfer (GIFT)

Zygote intra-fallopian transfer (ZIFT)

Intracytoplasmic sperm injection (ICSI)

cytoplasm transfer

7. Discuss different forms of birth control.

8. Describe the Human Genome Project.

9. Explain the difference between genotype and phenotype.

10. Describe each of the following diagnostic tests:

amniocentesis

ultrasonography

fetoscopy

chorionic villus biopsy

blood tests

11. Name the three stages of the *prenatal period*, identify the time period within which each occurs, and describe the main characteristics that define each stage.

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12. Describe the development of the zygote during the early *germinal period*, and define the following:

mitosis

cleavage

blastocyst

endometrium

13. Identify what the layers of the cell wall mass of the *blastocyst* will eventually become.

ectoderm

mesoderm

endoderm

14. Discuss the growth and development of the embryo from the end of the second week until the end of the eighth week during the *embryonic period*, making use of the following terms

growth

placenta

umbilical cord

early structure for all organs

recognizable human body

15. Define cephalocaudal and proximodistal development

16. Cite the impact of infectious and noninfectious diseases that might harm a fetus:

rubella

syphilis

genital herpes

AIDS (HIV)

diabetes

WEB SITES

The following Web sites deal with some of the major concepts and issues presented in Chapter 3. Additional resources can be found at the text's Web site at <http://www.mhhe.com/crandell8>.

American Fertility Association

<http://www.theafa.org/>

American Social Health Association

<http://www.ashastd.org/>

American Society for Reproductive Medicine

<http://www.asrm.org/>

The International Society for Stem Cell Research

<http://www.isscr.org/public/ethics.htm>

National Campaign to Prevent Teen Pregnancy

<http://www.teenpregnancy.org>

Reproductive Technologies Web at Harvard

<http://www.hsph.harvard.edu/Organizations/healthnet/contra/info.html>

Research Ethics and Stem Cells: National Institutes of Health

<http://stemcells.nih.gov/info/ethics.asp>

SELF-TESTS

Matching

Match the key terms with their definitions:

- | | | |
|------------------------------|--|---------------------------------|
| a. abortion | t. fallopian tube | mm. miscarriage |
| b. allele | u. fertilization | nn. mitosis |
| c. amniocentesis | v. fetal period | oo. multifactorial transmission |
| d. amnion | w. fetoscopy | pp. ovaries |
| e. ARTs | x. fetus | qq. ovulation |
| f. autosomes | y. gametes | rr. ovum |
| g. blastocyst | z. genes | ss. phenotype |
| h. cephalocaudal development | aa. genetics | tt. placenta |
| i. chorion | bb. genotype | uu. polygenic inheritance |
| j. CVS | cc. germinal period | vv. proximodistal development |
| k. chromosomes | dd. heterozygous | ww. recessive character |
| l. clone | ee. homozygous | xx. sex chromosomes |
| m. DNA | ff. human genome | yy. sex-linked traits |
| n. dominant character | gg. implantation | zz. teratogen |
| o. embryo | hh. in vitro fertilization | aaa. ultrasonography |
| p. ectoderm | ii. maternal serum alpha-fetoprotein (MSAFP) | bbb. uterus |
| q. ectogenesis | jj. meiosis | ccc. zygote |
| r. embryonic period | kk. menstruation | |
| s. endoderm | ll. mesoderm | |

- | | |
|--|---|
| 1. ____ a characteristic formed by different alleles | 7. ____ a process that takes place in a dividing cell by which each new cell has the same number of chromosomes as the parent cell |
| 2. ____ a characteristic made up of alleles that are the same from both parents | 8. ____ a single fertilized egg |
| 3. ____ a gene at a given location on a chromosome | 9. ____ a trait determined by a gene located on a sex chromosome |
| 4. ____ a hollow, thick-walled, muscular organ that will house and nourish the developing embryo | 10. ____ an invasive procedure whereby the physician inserts a thin catheter through the vagina and cervix and into the uterus, removing a small plug of villous tissue |
| 5. ____ a map of the genetic makeup of each chromosome | 11. ____ any agent that contributes to birth defects or anomalies |
| 6. ____ a noninvasive scanning procedure that allows physicians to determine the size and shape of the fetus and placenta, the amount of amniotic fluid, and the appearance of fetal anatomy | 12. ____ development that commences with the brain and head areas and then works its way down the body |

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13. ____ development that occurs when tissues grow in opposite directions away from the axis of the primitive streak
14. ____ fertilization outside the body in a medical lab environment in an attempt to accomplish pregnancy
15. ____ long, threadlike structures made of protein and nucleic acid that contain the hereditary materials found in the nuclei of all cells
16. ____ one allele (gene) that completely masks or hides the other allele
17. ____ one commonly used invasive procedure conducted normally between the fourteenth to twentieth week of gestation to determine if the fetus is normal
18. ____ scientific technological options used to increase a woman's chance of becoming pregnant when conception does not occur through normal sexual activity
19. ____ term used when the cell division converts the zygote into a hollow ball of cells
20. ____ the 22 pairs of chromosomes similar in size and shape that each human being normally possesses
21. ____ the twenty-third pair of chromosomes—one from the mother and one from the father—that determine the baby's sex
22. ____ the active biochemical substance of genes that programs the cells to manufacture vital protein substances
23. ____ the actual genetic makeup of an organism
24. ____ the discharge of the ovum from the follicle in the ovary
25. ____ the first stage of prenatal development, which extends from conception to the end of the second week
26. ____ the maturing of an ovum and ovulation, and eventual expulsion of an unfertilized ovum from the body through the vagina
27. ____ the observable (or expressed) characteristics of an organism
28. ____ the organ formed from uterine tissue and the trophoblast of the blastocyst; it functions as an exchange terminal that permits entry of food materials, oxygen, and hormones and the exit of carbon dioxide and metabolic wastes
29. ____ the process by which the number of chromosomes in gamete-producing cells are reduced by one-half
30. ____ the recognition that environmental factors interact with genetic factors to produce traits
31. ____ the scientific study of biological inheritance
32. ____ the second stage of prenatal development, which covers the period from the end of the second week to the end of the eighth week
33. ____ the term used when the zygote, embryo, or fetus is expelled from the uterus before it can survive outside the mother's womb
34. ____ the transmission of characteristics or traits for which a single gene is not responsible, but rather are determined by a large number of genes in combination
35. ____ the two kinds of mature sex cells that are involved in human reproduction
36. ____ the union (fusion) of a sperm and an ovum; it occurs in the upper end of the fallopian tube
37. ____ tubes leading from each ovary to the uterus; the location that fertilization occurs if sperm are present
38. ____ units on the chromosome that transmit inherited characteristics passed from biological parents to children
39. ____ when one allele (gene) is completely masked or hidden by the other allele
40. ____ the third stage of prenatal development extending from the end of the eighth week until birth

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41. ____ a procedure that allows a physician to examine the fetus directly through a lens after inserting a very narrow tube into the uterus
42. ____ spontaneous or induced expulsion of the fetus
43. ____ an organism grown from a single somatic cell
44. ____ a closed protective sac around the embryo filled with watery fluid
45. ____ a membrane that surrounds the amnion and links the embryo to the placenta
46. ____ the organism in the stage between implantation and fetus
47. ____ outer layer of the embryonic cell mass that will form the nervous system, skin, and sensory organs
48. ____ fetal development outside the womb
49. ____ inner layer of the embryonic cell mass that will form the digestive tract and respiratory system
50. ____ term for organism between the eighth week of life and birth
51. ____ process whereby the blastocyst buries itself in the uterine wall
52. ____ blood sampling method to detect defects
53. ____ middle layer of the embryonic cell mass that gives rise to the skeletal, muscular, and circulatory systems
54. ____ primary female reproductive organs
55. ____ female gamete or egg

Multiple Choice

Circle the letter of the response that best completes or answers each of the following statements and questions.

Factual Questions

1. Sex cells (sperm and ova) are called
 - a. alleles
 - b. genes
 - c. gametes
 - d. zygotes
2. A normal adult male's sperm production can be affected by
 - a. health
 - b. work
 - c. temperature
 - d. all of the these
3. A female produces immature ova in her ovaries while developing in her mother's womb. Between puberty and menopause, usually one ovum per month matures and is released. How many ova ultimately reach maturity?
 - a. 40 to 50
 - b. 400 to 500
 - c. 400,000
 - d. 400 million

4. The principal male sex hormones are
 - a. estrogen and progesterone
 - b. estrogen and testosterone
 - c. testosterone and androsterone
 - d. testosterone and semen

5. Sperm are produced in the man's body in winding tubules within the
 - a. epididymis
 - b. urethra
 - c. testes
 - d. fallopian tubes

6. During ejaculation, as the sperm pass out of the man's body through the penis, secretions that fuel and protect the sperm are also released from the
 - a. seminal vesicles and prostate gland
 - b. androgens and prostate gland
 - c. prostate gland and urethra
 - d. seminal vesicles and urethra

7. The primary female reproductive organs, the ovaries, produce mature ova and the female sex hormones
 - a. estrogen and testosterone
 - b. estrogen and progesterone
 - c. progesterone and testosterone
 - d. androsterone and progesterone

8. The journey of a mature ovum, if not fertilized, is
 - a. ovaries, oviduct, uterus, cervix, vagina, vulva
 - b. ovaries, oviduct, cervix, vagina, uterus, vulva
 - c. ovaries, uterus, vagina, vulva, oviduct, cervix
 - d. uterus, ovaries, oviduct, cervix, vagina, vulva

9. The optimal time for fertilization (conception) to occur within the menstrual (ovarian) cycle is
 - a. at the beginning of the cycle
 - b. at the middle of the cycle
 - c. at the end of the cycle
 - d. any time during the cycle

10. If unfertilized, the ovum degenerates after about how much time?
 - a. 24 hours
 - b. 5 days
 - c. 14 days
 - d. 28 days

11. Fertilization actually takes place in what female reproductive structure?
 - a. ovaries
 - b. fallopian tube
 - c. uterus
 - d. vagina

12. According to your text, the newly fertilized ovum is now called a(n)
- embryo
 - fetus
 - conceptus
 - zygote
13. About what percent of zygotes die shortly after fertilization?
- 10 percent
 - 23 percent
 - 33 percent
 - 43 percent
14. If pregnancy fails to take place, the decreasing level of hormones leads to menstruation, about _____ days after ovulation.
- 2
 - 5
 - 7
 - 14
15. During menstrual flow, what body structure secretes hormones into the bloodstream to “direct” another ovarian follicle to begin rapid growth?
- ovary
 - pituitary gland
 - uterus
 - thyroid gland
16. Which of these is not an assisted reproductive technology (ART)?
- ZIFT
 - GIFT
 - PAVI
 - ICSI
17. The womb “tank” is an example of:
- cytoplasm transfer
 - cryopreservation
 - embryo adoption
 - ectogenesis
18. Long, threadlike structures made of protein and nucleic acid containing hereditary materials are known as _____.
- genomes
 - chromosomes
 - DNA
 - genes
19. The first step in cloning is
- creating stem cells
 - creating a denucleated egg
 - creating a clonote
 - nuclear transplantation

20. Humans have ____ genes in each cell.
- 20,000 to 25,000
 - 90,000 to 100,000
 - 6-7 million
 - none of these
21. A medical diagnostic procedure, used by physicians to identify hereditary defects before an infant's birth, that draws fluid from the sac surrounding the fetus is called
- amniocentesis
 - ultrasonography
 - chorionic villus biopsy
 - fetoscopy
22. Gametes are formed through:
- embriosis
 - mitosis
 - endotosis
 - meosis
23. Gametes differ from other cells in the body because they
- contain no chromatids
 - contain one-half the number of chromosomes that other cells have
 - contain twice the number of genes that other cells have
 - all of these
24. Your mother and father are both Bb (dominant brown, recessive blue) concerning eye color. This difference in alleles is called:
- polygenic
 - heterozygous
 - homozygous
 - multifactorial
25. The growth of the zygote and the establishment of a linkage with the support system of the mother is identified as what period?
- germinal
 - embryonic
 - fetal
 - uterine
26. An absolutely essential growth process that begins within a few hours of fertilization and is a division of cells into identical cells (1 to 2, 2 to 4, 4 to 8, 8 to 16, 16 to 32, etc.) is called
- embriosis
 - mitosis
 - endotosis
 - meiosis

27. As a result of cleavage, the zygote becomes transformed into a hollow ball of cells called the
- mitosis
 - blastocyst
 - chorion
 - ectoderm
28. Normally the blastocyst “digests” its way through the rich lining of the uterine cavity called the _____ and gradually burrows into the wall of the uterus.
- oviduct
 - cervix
 - endometrium
 - vagina
29. The outer layer of cells that compose the blastocyst, called the inner cell mass, produces the
- embryo
 - amnion
 - chorion
 - trophoblast
30. During prenatal growth and development, the end of the second week to the eighth week is what period?
- germinal
 - embryonic
 - fetal
 - uterine
31. The placenta is the organ that
- transfers maternal nutrients to the fetus
 - protects the fetus against shock or adhesion
 - directly connects the fetal and maternal blood supplies
 - connects the embryo to the vaginal wall
32. The principle that describes development as starting with the head and brain areas and moving downward is called
- cephalocaudal development
 - proximodistal development
 - teratology development
 - progressive development
33. In which stage during prenatal development do the organs of the fetus assume their specialized functions?
- germinal
 - embryonic
 - fetal
 - critical

34. During the fifth prenatal month, the mother generally begins to feel the spontaneous movements of the fetus (a sensation like a fluttering butterfly in the abdominal region) known as
- neuromuscular movement
 - quickening
 - embryonic activity
 - prenatal movement
35. Which layer of the inner cell mass gives rise to the skeletal, muscular, and circulatory systems?
- ectoderm
 - mesoderm
 - embryoderm
 - endoderm
36. Most pregnancies end with the birth of a normal, healthy baby. However, about what percent of all conceptions result in spontaneous abortion?
- 0.5 to 1 percent
 - 10 to 15 percent
 - 5 to 10 percent
 - 22 to 28 percent
37. Rh-negative disorder is one in which the infant may be given intrauterine transfusion because
- the mother develops a fever and a slight rash
 - the mother forms antibodies that destroy the baby's incompatible blood cells
 - the baby is born with an abnormally low white blood cell count
 - the baby is separated from the placenta

Conceptual Questions

1. Ovum is to _____ as sperm is to _____.
- gamete; zygote
 - estrogen; androgen
 - prostate gland; uterus
 - fertilization; gamete
2. You see a photograph of the largest human cell. What are you looking at?
- epididymis
 - sperm
 - ovum
 - urethra
3. A woman is experiencing a sharp, constant pain near her left ovary in her lower abdomen. She had sexual intercourse about two weeks ago, and she suspects a pregnancy. She should see her doctor immediately because the blastocyst might be developing in the thin tubular structure that leads away from the ovary and *not* in the uterus (called an ectopic pregnancy). If this is the case, where is the blastocyst found?
- vulva
 - vagina
 - cervix
 - oviduct

4. One of Janet's ovum was discharged 14 days ago and she has not had sexual intercourse in the past month. What can she expect will happen in the next few days?
- fertilization
 - menstruation
 - conception
 - ovulation
5. A woman's obstetrician suggests to her that he needs to get a sample of amniotic fluid from her fetus. The obstetrician
- is performing in vitro fertilization
 - intends to inseminate a surrogate mother
 - may suspect that the fetus is genetically defective
 - is looking at the shape and size of the fetus
6. A friend of yours thinks that she is pregnant because her period is two weeks overdue. If she is pregnant, she is probably at the
- end of the germinal period
 - beginning of the fetal period
 - middle of the embryonic period
 - beginning of the germinal period
7. Regina, a first-time mother, tells you she is expecting quintuplets. What does this suggest to you?
- she is very fertile
 - she is not very fertile and probably used assisted reproductive technology
 - she has misused the contraceptive Depo Provera
 - she has more than two ovaries
8. You find yourself looking at two cells and count 69 total chromosomes. What are you looking at?
- two gametes
 - one gamete and one other cell
 - two other cells
 - process of meiosis
9. Evelyn is informed by her pediatrician that her son has congenital deafness. She feels this probably occurred because she
- married a man who had served in the Vietnam war and who handled Agent Orange containers
 - smoked heavily throughout her pregnancy even though her doctor advised her to quit smoking
 - shared intravenous needles with a friend
 - used quinine when serving as a missionary in equatorial Africa
10. A pregnant woman's body produces antibodies that attack the baby's blood cells. Which of the following conclusions is most likely?
- The mother is Rh positive.
 - The mother is affected by toxemia.
 - The mother is a diabetic.
 - The mother is hypertensive.

11. Which of the following statements most accurately represents your text's discussion of toxins in the workplace?
- The female's ova are more susceptible to damage from environmental cause than the male's sperm.
 - The male's sperm are more susceptible to damage from environmental toxins than the female's ova.
 - It makes sense to clean up the workplace not only for mothers but for fathers as well.
 - Hazards in the workplace rarely contribute to reproductive problems.
12. Most spontaneous abortions will take place before which period of development?
- prenatal
 - germinal
 - embryonic
 - cephalocaudal
13. Looking at a single human's hair and eye colors allows you to point out the
- genotype
 - phenotype
 - allele
 - polygenetic inheritance
14. If you become interested in teratology, your studies might include
- rubella
 - chlamydia
 - syphilis
 - all of these
15. Which prenatal sequence is correct?
- germinal, fetal, embryonic
 - fetal, germinal, embryonic
 - germinal, embryonic, fetal
 - embryonic, germinal, fetal

Essay Questions

1. Give arguments for why and how a couple would “plan” when they were going to have a baby. What lifestyle changes might they consider?
2. Your best friend wants to have children, but is infertile. Write a letter explaining to her the various ARTs, cloning, and stem cell research, including the pros and cons of each.
3. Someone writes a letter to the editor saying, “We should start practicing eugenics in order to create a better race of humans. After all, look what it’s done for tomatoes.” Having read the section on heredity and genetics, write a response that synthesizes both positive and negative aspects of “playing God.”

ANSWERS FOR SELF-TESTS

Matching

- | | | | |
|--------|--------|--------|--------|
| 1. dd | 15. k | 29. jj | 43. l |
| 2. ee | 16. n | 30. oo | 44. d |
| 3. b | 17. c | 31. aa | 45. i |
| 4. bbb | 18. e | 32. r | 46. o |
| 5. ff | 19. g | 33. mm | 47. p |
| 6. aaa | 20. f | 34. uu | 48. q |
| 7. nn | 21. xx | 35. y | 49. s |
| 8. ccc | 22. m | 36. u | 50. x |
| 9. yy | 23. bb | 37. t | 51. gg |
| 10. j | 24. qq | 38. z | 52. ii |
| 11. zz | 25. cc | 39. ww | 53. ll |
| 12. h | 26. kk | 40. v | 54. pp |
| 13. vv | 27. ss | 41. w | 55. rr |
| 14. hh | 28. tt | 42. a | |

Multiple Choice

Factual

- | | | | |
|-------|-------|-------|-------|
| 1. c | 11. b | 21. a | 31. a |
| 2. d | 12. d | 22. d | 32. a |
| 3. b | 13. c | 23. b | 33. c |
| 4. c | 14. d | 24. b | 34. b |
| 5. c | 15. b | 25. a | 35. b |
| 6. a | 16. c | 26. b | 36. b |
| 7. b | 17. d | 27. b | 37. b |
| 8. a | 18. b | 28. c | |
| 9. b | 19. b | 29. d | |
| 10. a | 20. a | 30. b | |

Conceptual

- | | | | |
|------|------|-------|-------|
| 1. b | 5. c | 9. b | 13. b |
| 2. c | 6. d | 10. a | 14. d |
| 3. d | 7. b | 11. b | |
| 4. b | 8. b | 12. b | |

