Chapter 13

Why Ask Y?: The Male Reproductive System

In This Chapter

- Explaining the parts of male reproduction
- Understanding meiosis and what happens to chromosomes

Individually, humans don’t need to reproduce to survive. But to survive as a species, a number of individuals must produce and nurture a next generation, carrying their uniqueness forward in the genetic pool. Humans are born with the necessary organs to do just that.

In this chapter, you get an overview of the parts and functions of the male reproductive system, along with plenty of practice questions to test your knowledge. (We cover the guys first because their role in the basic reproduction equation isn’t nearly as long or complex as it is for their mates. We address the female reproductive system in Chapter 14.)

Identifying the Parts of the Male Reproductive System

On the outside, the male reproductive parts, which you can see in Figure 13-1, are straightforward — a penis and a scrotum. At birth, the apex of the penis is enclosed in a fold of skin called the prepuce, or foreskin, which often is removed during a surgery called circumcision.

![Figure 13-1: The male reproductive system.](Illustration by Imagineering Media Services Inc.)
The scrotum is a pouch of skin divided in half on the surface by a ridge called a raphe that continues up along the underside of the penis and down all the way to the anus. The left side of the scrotum tends to hang lower than the right side to accommodate a longer spermatic cord, which we explain later in this section.

There are two scrotal layers: the integument, or outer skin layer, and the dartos tunic, an inner smooth muscle layer that contracts when cold and elongates when warm. Why? That has to do with the two testes (the singular is testis) inside (see Figure 13-2). These small ovoid glands, also referred to as testicles, need to be a bit cooler than body temperature in order to produce viable sperm for reproduction. When the dartos tunic becomes cold, such as when a man is swimming, it contracts and draws the testes toward the body for warmth. When the dartos tunic becomes overly warm, it slackens to allow the testes to hang farther away from the heat of the body.

A fibrous capsule called the tunica albuginea encases each testis and extends into the gland forming incomplete septa (partitions), which divide the testis into about 200 lobules. These compartments contain small, coiled seminiferous tubules where sperm are produced by spermatogenesis, or meiosis, which we review in the next section.

Distributed in gaps between the tubules are interstitial cells called Leydig cells that produce the male sex hormone testosterone. The tubules of each lobule come together in an area called the mediastinum testis and straighten into tubuli recti before forming a network called the rete testis that leads to the efferent ducts (also called ductules). These ducts carry sperm to an extremely long (about 20 feet), tightly coiled tube called the epididymis for storage.

The epididymis merges with the ductus deferens, or vas deferens, which carries sperm up into the spermatic cord, which also encases the testicular artery and vein, lymphatic vessels, and nerves. Convoluted pouches called seminal vesicles lie behind the base of the bladder and secrete an alkaline fluid containing fructose, vitamins, amino acids, and prostaglandins to nourish sperm as it enters the ejaculatory duct.
From there the mixture containing sperm enters the prostatic urethra that’s surrounded by the prostate gland. This gland secretes a thin, opalescent substance that precedes the sperm in an ejaculation. The alkaline nature of this substance reduces the natural acidity of the female’s vagina to prepare it to receive the sperm.

Two yellowish pea-sized bodies called Cowper’s glands, or bulbourethral glands, lie on either side of the urethra and secrete a clear alkaline lubricant prior to ejaculation; it neutralizes the acidity of the urethra and acts as a lubricant for the penis. Once all the glands have added protective and nourishing fluids to the 400 to 500 million departing sperm, the mixture is known as seminal fluid or semen.

During sexual arousal, two columns of spongy erectile tissue in the penis — the corpus spongiosum penis and the corpus cavernosum penis — swell with blood to make it rigid and capable of entering the female’s vagina. At the time of ejaculation, smooth muscles in the wall of the epididymis force sperm through the ductus deferens, located in the inguinal canal, toward the urinary bladder. After mixing with the secretions from the seminal vesicles and the prostate gland, the semen travels along the urethra and out a vertical slit in the glans penis, or head of the penis.

See how familiar you are with the male anatomy by tackling these practice questions:

1. The cutaneous pouch containing the testes and part of the spermatic cord is the
   a. Scrotum
   b. Ejaculatory pouch
   c. Ductus deferens
   d. Seminal vesicle
   e. Epididymis

2. The scrotum adjusts to surrounding temperatures through the action of the
   a. Testes
   b. Bulbourethral glands
   c. Dartos tunic
   d. Prostatic urethra

3. Spermatogenesis occurs in the
   a. Inguinal cells
   b. Interstitial cells
   c. Seminiferous tubules
   d. Rete testis
   e. Epididymis

4. Testosterone is produced in the
   a. Seminiferous tubules
   b. Epididymis
   c. Adenohypophysis
   d. Subtentacular cells
   e. Leydig cells
5. Select the correct sequence for the movement of sperm:
   a. Seminiferous tubules → Tubuli recti → Rete testis → Epididymis → Ductus deferens → Ejaculatory duct → Urethra
   b. Seminiferous tubules → Tubuli recti → Rete testis → Ejaculatory duct → Epididymis → Duct deferens → Urethra
   c. Epididymis → Ejaculatory duct → Tubuli recti → Rete testis → Seminiferous tubules → Ductus deferens → Urethra
   d. Seminiferous tubules → Ejaculatory duct → Tubuli recti → Rete testis → Epididymis → Ductus deferens → Urethra

6. Which of the following does not add a secretion to the sperm as it moves through the reproductive ducts?
   a. Interstitial cells
   b. Epididymis
   c. Seminal vesicle
   d. Prostate

7. The convoluted tube that stores sperm is called the
   a. Seminiferous tubule
   b. Rete testis
   c. Spermatic cord
   d. Epididymis
   e. Ductus deferens

8. The fluid accompanying the sperm is called the
   a. Stroma
   b. Semen
   c. Prepuce
   d. Inguinal
   e. Perineum

9. An average ejaculation will contain sperm numbering approximately
   a. 40 to 50 million
   b. 400 to 500 million
   c. 400 to 500
   d. 4 to 5 million

10. A thin, milky liquid imparting alkaline characteristics to the seminal fluid is produced by the
    a. Seminal vesicle
    b. Interstitial cells
    c. Sertoli cells
    d. Bulbourethral gland
    e. Prostate gland
Packaging the Chromosomes for Delivery

Sperm, the male sex cell, is produced during a process called *meiosis* (which also produces the female sex cell, or *ovum*). Meiosis involves two divisions.

- The first, a *reduction division*, divides a single *diploid* cell with two sets of chromosomes into two *haploid* cells with only one set each.
- The second process is a division by *mitosis* that divides the two haploid cells into four cells with a single set of chromosomes each.

Review the reproduction terms in Table 13-1.

<table>
<thead>
<tr>
<th>Terms That Vary By Gender</th>
<th>General Term</th>
<th>Male Term</th>
<th>Female Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex organs</td>
<td>Gonads</td>
<td>Testes</td>
<td>Ovaries</td>
</tr>
<tr>
<td>Original cell</td>
<td>Gametocyte</td>
<td>Spermatocyte</td>
<td>Oocyte</td>
</tr>
<tr>
<td>Meiosis</td>
<td>Gametogenesis</td>
<td>Spermatogenesis</td>
<td>Oogenesis</td>
</tr>
<tr>
<td>Sex cell</td>
<td>Gamete</td>
<td>Spermatozoa (Sperm)</td>
<td>Ovum</td>
</tr>
</tbody>
</table>

A *diploid cell* (or 2N) has two sets of chromosomes, whereas a *haploid cell* (or 1N) has one set of chromosomes.

Meiosis, which you can see in Figure 13-3, is a continuous process. Once it starts, it doesn’t stop until gametes are formed. Meiosis is described in a series of stages as follows (for more on the terminology of cells, see Chapter 2):

1. **Interphase:** The original diploid cell — called a *spermatocyte* in a man and an *oocyte* in a woman — is said to be in a “resting stage,” but it actually undergoes constant activity. Just before it starts to divide, the DNA molecules in the chromanemata (chromatin network) duplicate.

2. **Prophase I:** Structures disappear from the nucleus, including the nuclear membrane, nucleoplasm, and nucleoli. The cell’s centrosome divides into two *centrioles* that move to the ends of the nucleus and form poles. Structures begin to appear in the nuclear region, including spindles (protein filaments that extend between the poles) and asters, or *astral rays* (protein filaments that extend from the poles into the cytoplasm). The chromanemata contract, forming chromosomes. Those chromosomes then start to divide into two chromatids but remain attached by the centromere. *Homologous* chromosomes that contain the same genetic information pair up and go into *synapsis*, twisting around each other to form a tetrad of four chromatids. These tetrads begin to migrate toward the equatorial plane (an imaginary line between the poles).

3. **Metaphase I:** The tetrads align on the equatorial plane, attaching to the spindles by the centromere.

4. **Anaphase I:** Homologous chromosomes separate by moving along the spindles to opposite poles. In late anaphase, a slight furrowing is apparent in the cytoplasm, initiating *cytokinesis* (the division of the cytoplasm).
5. **Telophase I**: The contracted and divided homologous chromosomes are at opposite poles. Spindle and aster structures disappear, and a nuclear membrane and nucleoplasm begin to appear in each newly forming cell. Chromosomes remain as chromatids, still contracted and divided. The furrowing seen in anaphase continues to deepen, dividing the cytoplasm. In the male, the cytoplasm divides equally between the two cells. In the female, cytoplasmic division is unequal.

6. **Interkinesis**: The cytoplasm separates. Two genetically identical haploid cells are formed with half the number of chromosomes as the original cell. In the male, the cells are of equal size. In the female, one cell is large and the other is small.

7. **Prophase II**: The cells enter the second phase of meiosis. Once again, structures disappear from the nuclei and poles appear at the ends. Spindles and asters appear in the nuclear region. Chromosomes are already contracted and divided into chromatids attached by the centromere, and they begin to migrate toward the equatorial plane.
8. **Metaphase II:** The chromatids align on the equatorial plane and attach to the spindles by the centromere.

9. **Anaphase II:** The chromatids separate, becoming chromosomes that move along the spindles to the poles. A slight furrowing appears in the cytoplasm.

10. **Telophase II:** With the chromosomes at the poles, spindles and asters disappear while new nuclear structures appear. The chromosomes uncoil, returning to chromanemata and their chromatin network. Cytoplasmic division continues to deepen and each haploid cell divides, forming four cells.

At the end of this process, the male has four haploid sperm of equal size. As the sperm matures further, a **flagellum** (tail) develops. The female, on the other hand, has produced one large cell, the ovum, and three small cells called **polar bodies**; all four structures contain just one set of chromosomes. The polar bodies eventually disintegrate and the ovum becomes the functional cell. When fertilized by the sperm, the resulting **zygote** (fertilized egg) is diploid, containing two sets of chromosomes.

Think you’ve conquered this process? Find out by tackling these practice questions:

**Q.** The metaphase II stage in meiosis involves

- a. The slipping of the centromere along the chromosome
- b. The alignment of the chromosomes on the equatorial plane
- c. The contraction of the chromosomes
- d. The disappearance of the nuclear membrane
- e. The polar migration of the chromosomes

**A.** The correct answer is the alignment of the chromosomes on the equatorial plane. Think “divide and conquer.”

**11.** The process in sexual reproduction involving the union of gametes is called

- a. Fission
- b. Conjugation
- c. Invagination
- d. Fertilization
- e. Pollination

**12.** Gametes are formed by

- a. Interkinesis
- b. Cytokinesis
- c. Meiosis
- d. Mitosis
- e. Photosynthesis
13. A man has 46 chromosomes in a spermatocyte. How many chromosomes are in each sperm?
   a. 23 pairs
   b. 23
   c. 184
   d. 46
   e. 92

14. Synapsis, or side-by-side pairing, of homologous chromosomes
   a. Occurs in mitosis
   b. Completes fertilization
   c. Is followed immediately by the splitting of each centromere
   d. Signifies the end of prophase of the second meiotic division
   e. Occurs in meiosis

15. Anaphase I of meiosis is characterized by which of the following?
   a. Synapsed homologous chromosomes move toward the poles.
   b. DNA duplicates itself.
   c. Synapsis of homologous chromosomes occurs.
   d. Homologous chromosomes separate and move poleward with centromeres intact.
   e. Centromeres split, and chromosomes migrate toward the poles.

16. During ovum production, the three nonfunctional cells produced are called
   a. Diploid cells
   b. Male sex cells
   c. Polar bodies
   d. Somatic cells
   e. Cross-over gametes

17. The stage (or period) in meiosis between the first and second division is called
   a. Anaphase I
   b. Interphase
   c. Metaphase I
   d. Interkinesis
   e. Prophase II

18. After meiosis, each diploid spermatocyte has become
   a. Four haploid sperm of varying sizes
   b. One functional diploid sperm and three cells that eventually will disintegrate
   c. Four haploid sperm of equal size
   d. Two haploid sperm of equal size
   e. Three haploid flagellum and a diploid sperm
19. Complete the following worksheet on the stages of meiosis.

Draw the stages of meiosis:

1. Late Prophase I
2. Metaphase I
3. Anaphase I
4. Telephase I
5. Interkinesis
6. Prophase II

Describe the changes in each stage:
7. Metaphase II

8. Anaphase II

9. Telephase II

10. Sperm

11. Ovum and Polar Bodies
Answers to Questions on the Male Reproductive System

The following are answers to the practice questions presented in this chapter.

1. The cutaneous pouch containing the testes and part of the spermatic cord is the a. scrotum. “Cutaneous” simply means “skin.”

2. The scrotum adjusts to surrounding temperatures through the action of the c. dartos tunic. This is the inner smooth muscle layer of the scrotum.

3. Spermatogenesis occurs in the c. seminiferous tubules. Immature sperm cells line the walls of the tubules.

4. Testosterone is produced in the e. Leydig cells. “Interstitial cells” would also be correct because the word “interstitial” can be translated as “placed between.” But alas, that’s not one of the answer options.

5. Select the correct sequence for the movement of sperm: a. Seminiferous tubules → Tubuli recti → Rete testis → Epididymis → Ductus deferens → Ejaculatory duct → Urethra. The sperm develop in the coiled tubules, move through the straighter tubes (tubuli recti), continue across the network of the testis (rete testis) and into the epididymis (remember the really long tube), and travel past the ductus (or vas) deferens and the ejaculatory duct into the urethra.

6. Which of the following does not add a secretion to the sperm as it moves through the reproductive ducts? a. Interstitial cells. Interstitial cells secrete testosterone, which goes into the blood.

7. The convoluted tube that stores sperm is called the d. epididymis. The other answer options don’t come into play until it’s time to release semen.

8. The fluid accompanying the sperm is called the b. semen.

9. An average ejaculation will contain sperm numbering approximately b. 400 to 500 million. Keep in mind that sperm are microscopically small, so quite a few can fit in a tiny amount of semen.

10. A thin, milky liquid imparting alkaline characteristics to the seminal fluid is produced by the e. prostate gland.

11. The process in sexual reproduction involving the union of gametes is called d. fertilization. Oh, come now — fission? Pollination? Remember that we’re talking human anatomy here!

12. Gametes are formed by c. meiosis. Gametes — sperm and ova — are the end goal of this process.

13. A man has 46 chromosomes in a spermatocyte. How many chromosomes are in each sperm? b. 23. Divide the number 46 in half.

14. Synapsis, or side-by-side pairing, of homologous chromosomes e. occurs in meiosis.

15. Anaphase I of meiosis is characterized by which of the following? d. Homologous chromosomes separate and move poleward with centromeres intact.
During ovum production, the three nonfunctional cells produced are called **c. polar bodies**. They eventually disintegrate.

The stage (or period) in meiosis between the first and second division is called **d. interkinesis**. *Inter*- means "between," and *–kinesis* means "motion," so it’s clear that this phase is “between motions.”

After meiosis, each diploid spermatocyte has become **c. four haploid sperm of equal size**. There’s no such thing as a diploid sperm because as a sex cell, sperm carries only half the regular complement of 46 chromosomes. And because another division takes place after the initial division in meiosis, the final product of the process is four cells, not two.

Following is a summary of what should appear in your drawings and descriptions of the stages of meiosis. For further reference, check out Figure 13-3.

In the drawing for late prophase I, at least two pairs of homologous chromosomes should be shown grouped into tetrads (in truth, there are 23 pairs, but simplified illustrations tend to show just two). The description for prophase I should include reference to the tetrad formation. The drawing for metaphase I should show the equatorial plane (a center horizontal line) with the tetrads aligned along it. The illustration also should show spindles radiating from each pole, with the tetrads attached to them by their centromeres. The description should include reference to the equatorial plane, the poles, and the spindles.

The drawing for anaphase I should show the tetrads moving to the top and bottom of the cell along the spindles and the cytoplasm slowly beginning to divide. In telophase I, the division becomes more pronounced and two new nuclei form. As the process enters interkinesis, the cytoplasm pinches off into two cells.

During prophase II, which also is the start of the second meiotic division, the contracted and divided chromatids migrate toward a new equatorial plane. The drawing of metaphase II should show all chromatids aligned on the equatorial plane. For anaphase II, you should show the chromatids pulling apart into chromosomes and moving toward the poles. In the final stage, telophase II, you should draw new nuclei forming around the chromosomes.