Anterior Pituitary Gland Contains Several Different Cell Types That Synthesize and Secrete Hormones. Usually, there is one cell type for each major hormone formed in the anterior pituitary gland. With special stains attached to high-affinity antibodies that bind with the distinctive hormones, at least five cell types can be differentiated.

Table 75-1 Cells and Hormones of the Anterior Pituitary Gland and Their Physiological Functions

Cell	Hormone	Chemistry	Physiological Action
Somatotropes	Growth hormone (GH; somatotropin)	Single chain of 191 amino acids	Stimulates body growth; stimulates secretion of IGF-1; stimulates lipolysis; inhibits actions of insulin on carbohydrate and lipid metabolism
Corticotropes	Adrenocorticotropic hormone (ACTH; corticotropin)	Single chain of 39 amino acids	Stimulates production of glucocorticoids and androgens by the adrenal cortex; maintains size of zona fasciculata and zona reticularis of cortex
Thyrotropes	Thyroid-stimulating hormone (TSH; thyrotropin)	Glycoprotein of two subunits, α (89 amino acids) and β (112 amino acids)	Stimulates production of thyroid hormones by thyroid follicular cells; maintains size of follicular cells
Gonadotropes	Follicle-stimulating hormone (FSH)	Glycoprotein of two subunits, α (89 amino acids) and β (112 amino acids)	Stimulates development of ovarian follicles; regulates spermatogenesis in the testis
	Luteinizing hormone (LH)	Glycoprotein of two subunits, α (89 amino acids) and β (115 amino acids)	Causes ovulation and formation of the corpus luteum in the ovary; stimulates production of estrogen and progesterone by the ovary, stimulates testosterone production by the testis
Lactotropes Mammotropes	Prolactin (PRL)	Single chain of 198 amino acids	Stimulates milk secretion and production

IGF, insulin-like growth factor.

About 30 to 40 percent of the anterior pituitary cells are somatotropes that secrete growth hormone, and about 20 percent are corticotropes that secrete ACTH. Each of the other cell types accounts for only 3 to 5 percent of the total; nevertheless, they secrete powerful hormones for controlling thyroid function, sexual functions, and milk secretion by the breasts.

Specific Areas in the Hypothalamus Control Secretion of Specific Hypothalamic Releasing and Inhibitory Hormones. All or most of the hypothalamic hormones are secreted at nerve endings in the median eminence before being transported to the anterior pituitary gland. Electrical stimulation of this region excites these nerve endings and, therefore, causes release of essentially all the hypothalamic hormones. However, the neuronal cell bodies that give rise to these median eminence nerve endings are located in other discrete areas of the hypothalamus or in closely related areas of the basal brain.

Table 75-2 Hypothalamic Releasing and Inhibitory Hormones That Control Secretion of the Anterior Pituitary Gland

Hormone	Structure	Primary Action on Anterior Pituitary
Thyrotropin-releasing hormone (TRH)	Peptide of 3 amino acids	Stimulates secretion of TSH by thyrotropes
Gonadotropin-releasing hormone (GnRH)	Single chain of 10 amino acids	Stimulates secretion of FSH and LH by gonadotropes
Corticotropin-releasing hormone (CRH)	Single chain of 41 amino acids	Stimulates secretion of ACTH by corticotropes
Growth hormone-releasing hormone (GHRH)	Single chain of 44 amino acids	Stimulates secretion of growth hormone by somatotropes
Growth hormone inhibitory hormone (somatostatin)	Single chain of 14 amino acids	Inhibits secretion of growth hormone by somatotropes
Prolactin-inhibiting hormone (PIH)	Dopamine (a catecholamine)	Inhibits synthesis and secretion of prolactin by lactotropes

ACTH, adrenocorticotropic hormone; FSH, follicle-stimulating hormone; LH, luteinizing hormone; TSH, thyroid-stimulating hormone.

For most of the anterior pituitary hormones, it is the releasing hormones that are important, but for prolactin, a hypothalamic inhibitory hormone probably exerts more control.

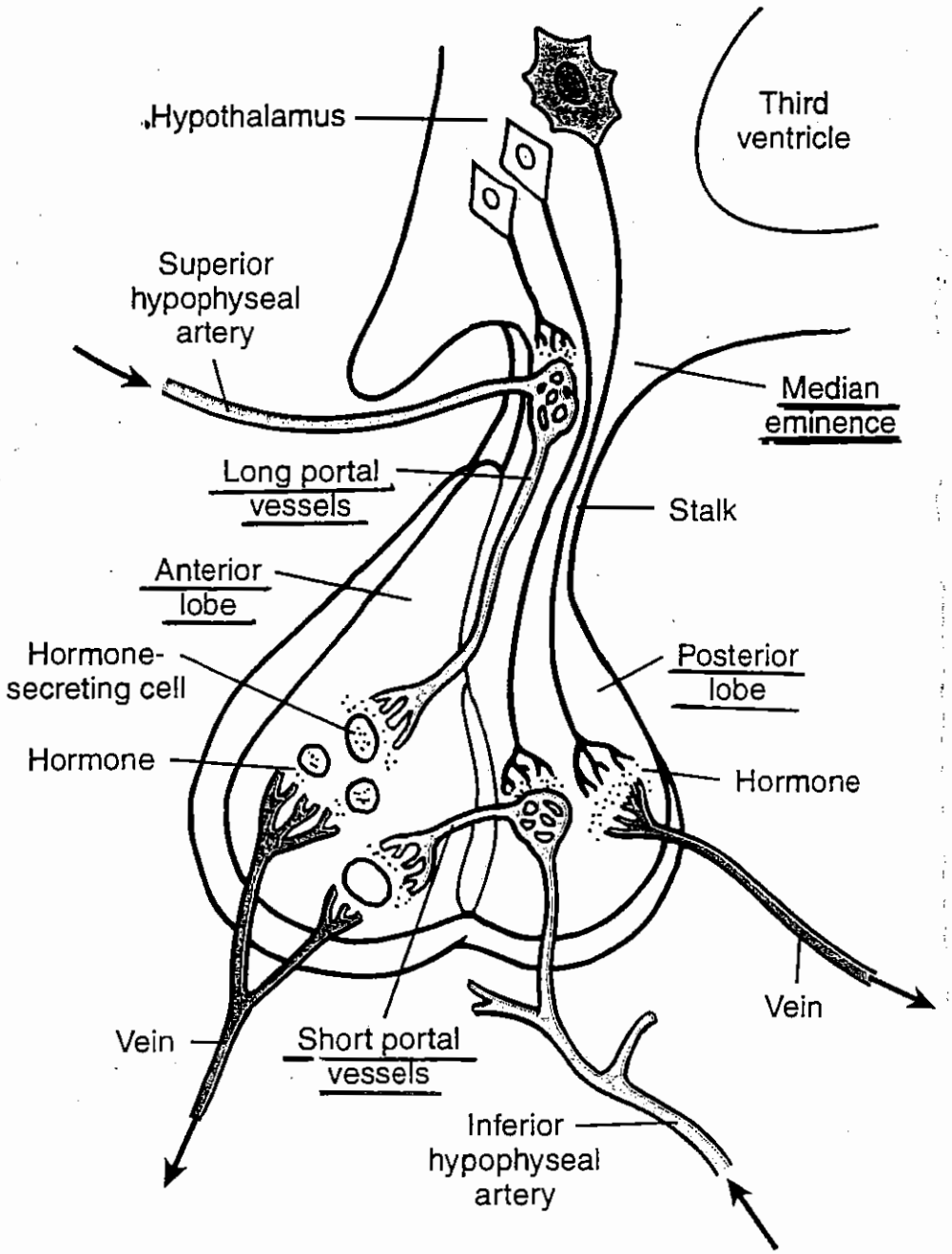


FIGURE 31.2 The blood supply to the anterior pituitary. This illustration shows the relationship of the pituitary blood supply to hypothalamic magnocellular neurons and to hypothalamic neurosecretory cells that produce releasing hormones. The magnocellular neuron (larger, dark blue cell body) releases AVP or oxytocin at its axon terminals into capillaries that give rise to the venous drainage of the posterior lobe. The neurons with smaller, light blue cell bodies are secreting releasing factors into capillary networks that give rise to the long and short hypophyseal portal vessels, respectively. Releasing hormones are shown reaching the hormone-secreting cells of the anterior lobe via the portal vessels.

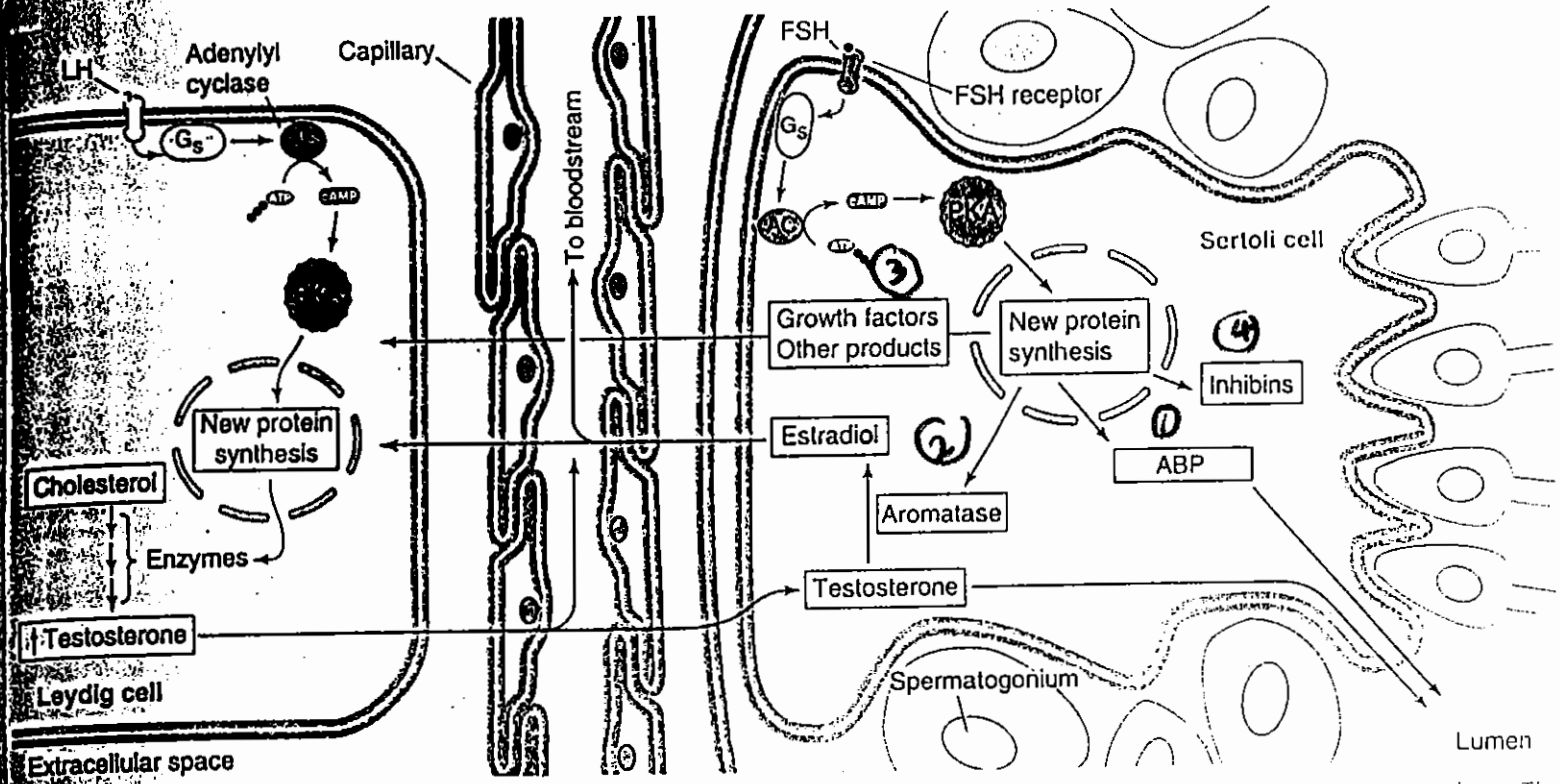


FIGURE 53–3. Leydig- and Sertoli-cell physiology. The Leydig cell (*left*) has receptors for LH. The binding of LH increases testosterone synthesis. The Sertoli cell (*right*) has receptors for FSH. (Useful mnemonics: "L" for LH and Leydig, "S" for FSH and Sertoli.) FSH promotes the synthesis of androgen-binding protein (ABP), aromatase, growth factors, and inhibin. There is crosstalk between Leydig cells and Sertoli cells. The Leydig cells make testosterone, which acts on Sertoli cells. Conversely, the Sertoli cells convert some of this testosterone to estradiol (because of the presence of aromatase), which can act on the Leydig cells. Sertoli cells also generate growth factors that act on the Leydig cells. ATP, adenosine triphosphate; cAMP, cyclic adenosine monophosphate; FSH, follicle stimulating hormone; PKA, protein kinase A.

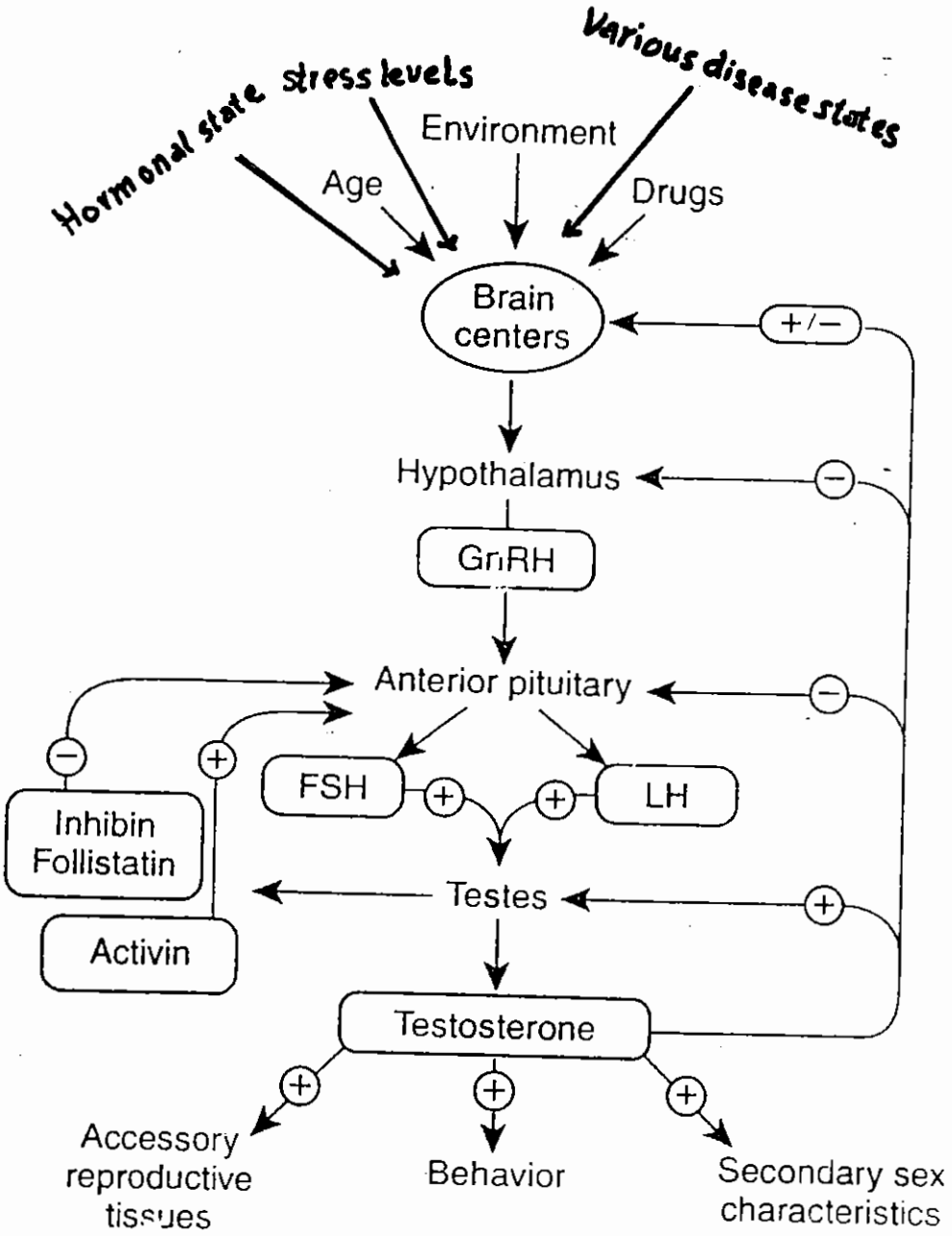
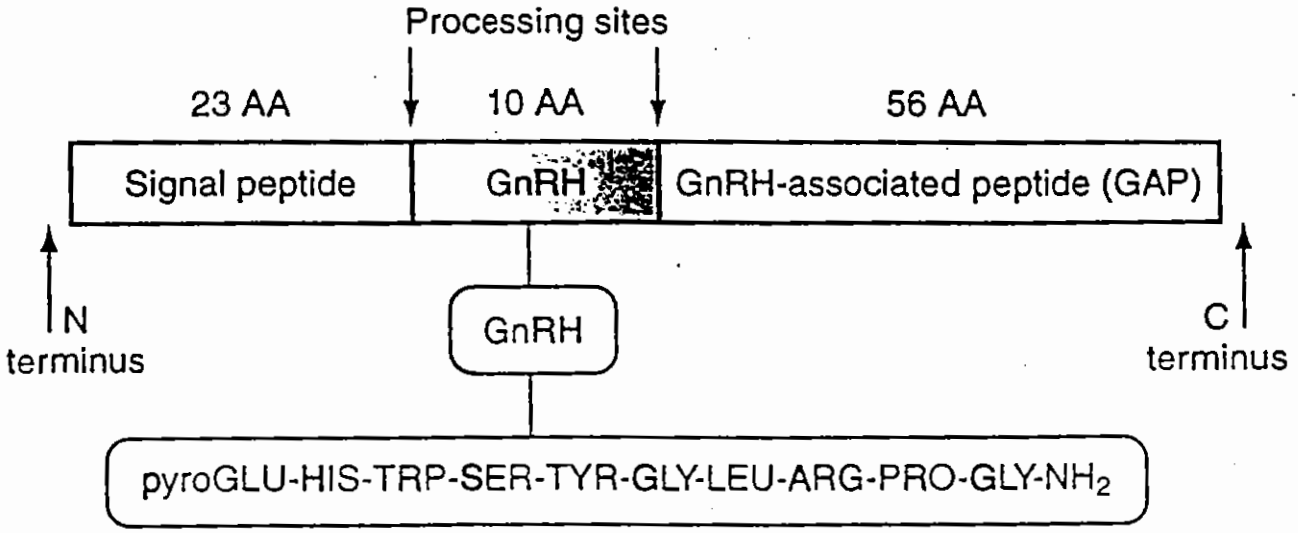


FIGURE 37.1 **Regulation of reproduction in the male.** The main reproductive hormones are shown in boxes. Positive and negative regulations are depicted by plus and minus signs, respectively.

* Testosterone, estradiol, inhibin, activin, and follistatin are major testicular hormones that regulate the release of the gonadotropins LH and FSH. Generally, testosterone, estradiol, and inhibin reduce the secretion of LH and FSH in the male. Activin stimulates the secretion of FSH, whereas follistatin inhibits FSH secretion.

Inhibin acts directly on the anterior pituitary and inhibits the secretion of FSH but not LH.

FIGURE 36.2 The precursor molecule, preproGnRH, that contains GnRH. The amino acid sequence of GnRH, a decapeptide, is indicated at the bottom.



→ GnRH originates from a large precursor molecule called preproGnRH (Fig. 36.2). PreproGnRH consists of a signal peptide, native GnRH, and a GnRH-associated peptide (GAP). The signal peptide (or leader sequence) allows the protein to cross the membrane of the rough endoplasmic reticulum (ER). However, both the signal peptide and GAP are enzymatically cleaved at the rough ER prior to GnRH secretion.

The neuron transports both GnRH and GAP down into the portal circulation. GAP may inhibit prolactin secretion.

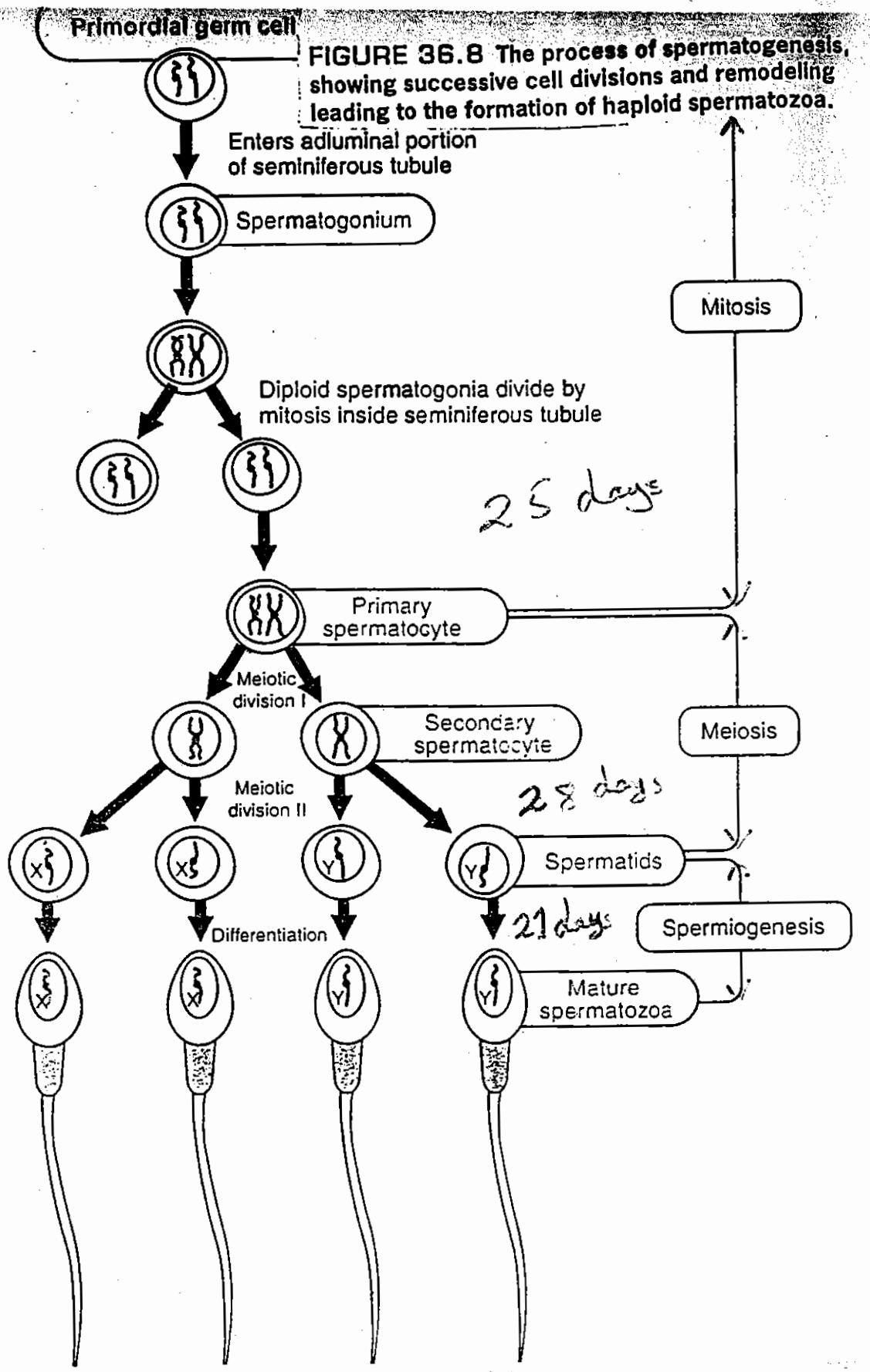
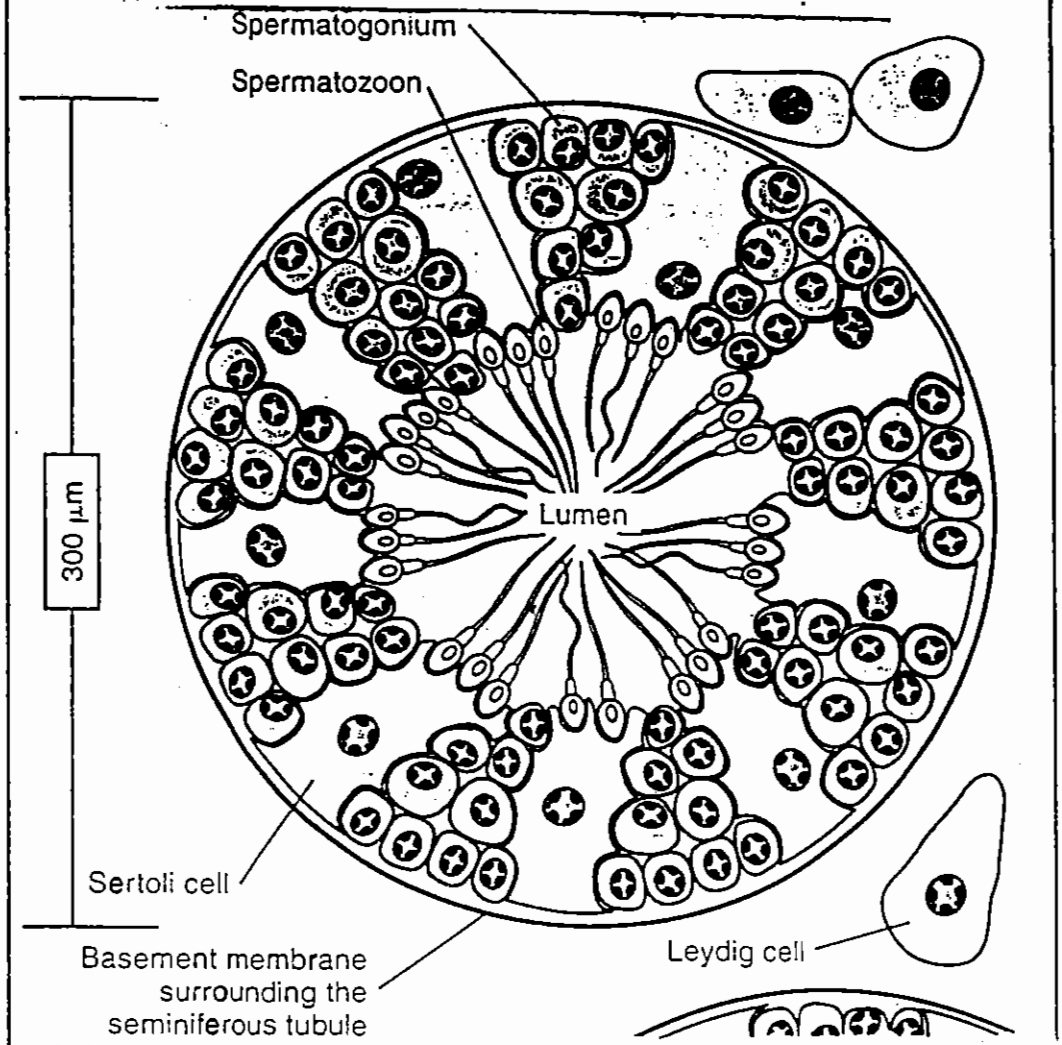


FIGURE 36.8 The process of spermatogenesis, showing successive cell divisions and remodeling leading to the formation of haploid spermatozoa.

→ Because sperm cells are rapidly dividing and undergoing meiosis, they are sensitive to external agents that alter cell division. Chemical carcinogens, chemotherapeutic agents, certain drugs, environmental toxins, irradiation, and extreme temperatures are factors that can reduce the number of replicating germ cells or cause chromosomal abnormalities in individual cells.

FIGURE 36.4 The testis. This cross-sectional view shows the anatomic relationship of the Leydig cells, basement membrane, seminiferous tubules, Sertoli cells, spermatogonia, and spermatozoa.



Sertoli Cells Have Multiple Functions

Sertoli cells are critical to germ cell development, as indicated by their close contact. As many as 6 to 12 spermatids may be attached to a Sertoli cell. Sertoli cells phagocytose residual bodies (excess cytoplasm resulting from the transformation of spermatids to spermatozoa) and damaged germ cells, provide structural support and nutrition for germ cells, secrete fluids, and assist in spermiation, the final detachment of mature spermatozoa from the Sertoli cell into the lumen. Spermiation may involve plasminogen activator, which converts plasminogen to plasmin, a proteolytic enzyme that assists in the release of the inature sperm into the lumen. Sertoli cells also synthesize large amounts of transferrin, an iron-transport protein important for sperm development. Sertoli cells also produce glycoprotein hormones—inhibin, activin, and follistatin—that regulate the secretion of FSH.

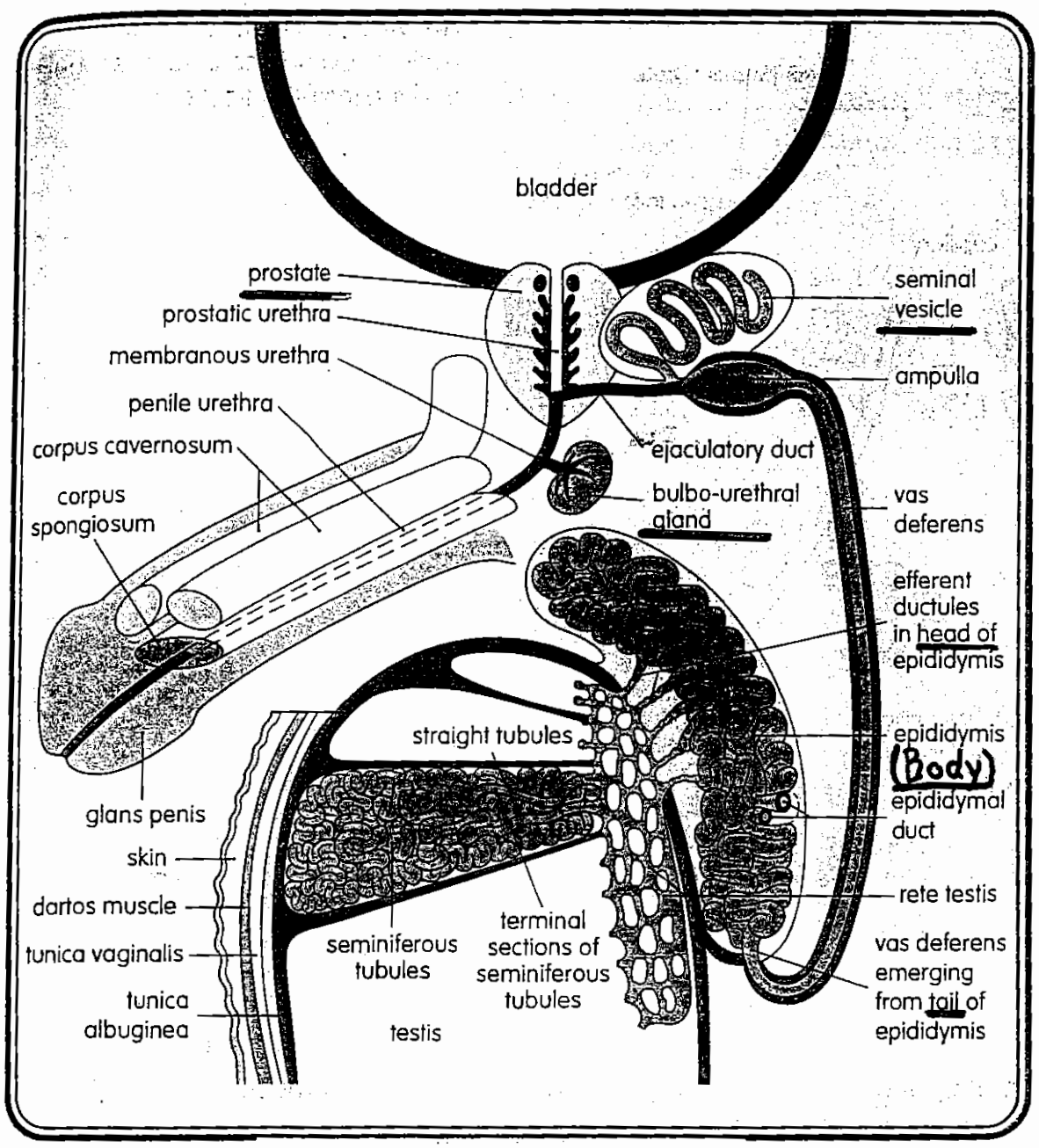


Fig. 10.16 Schematic representation of the male reproductive tract.

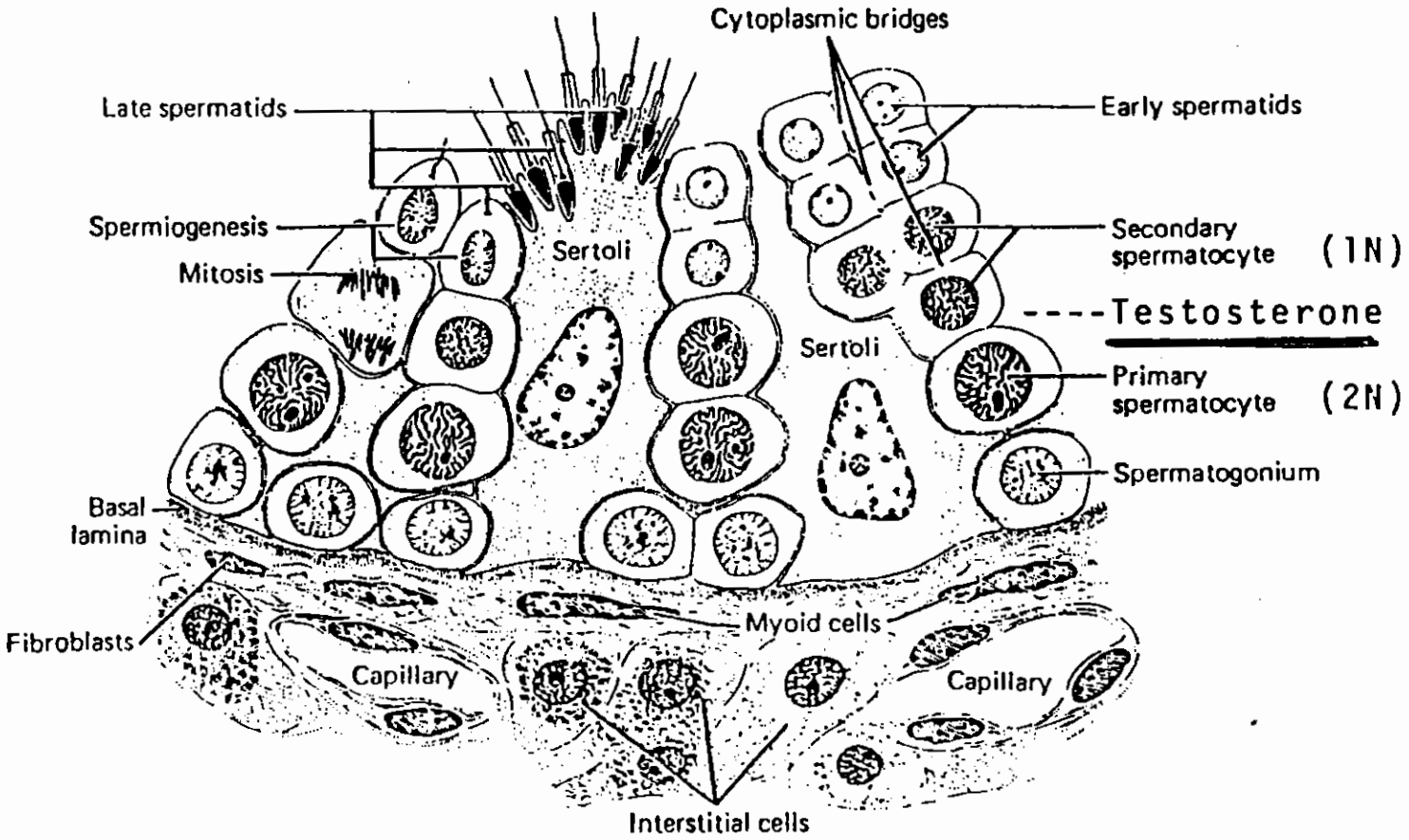
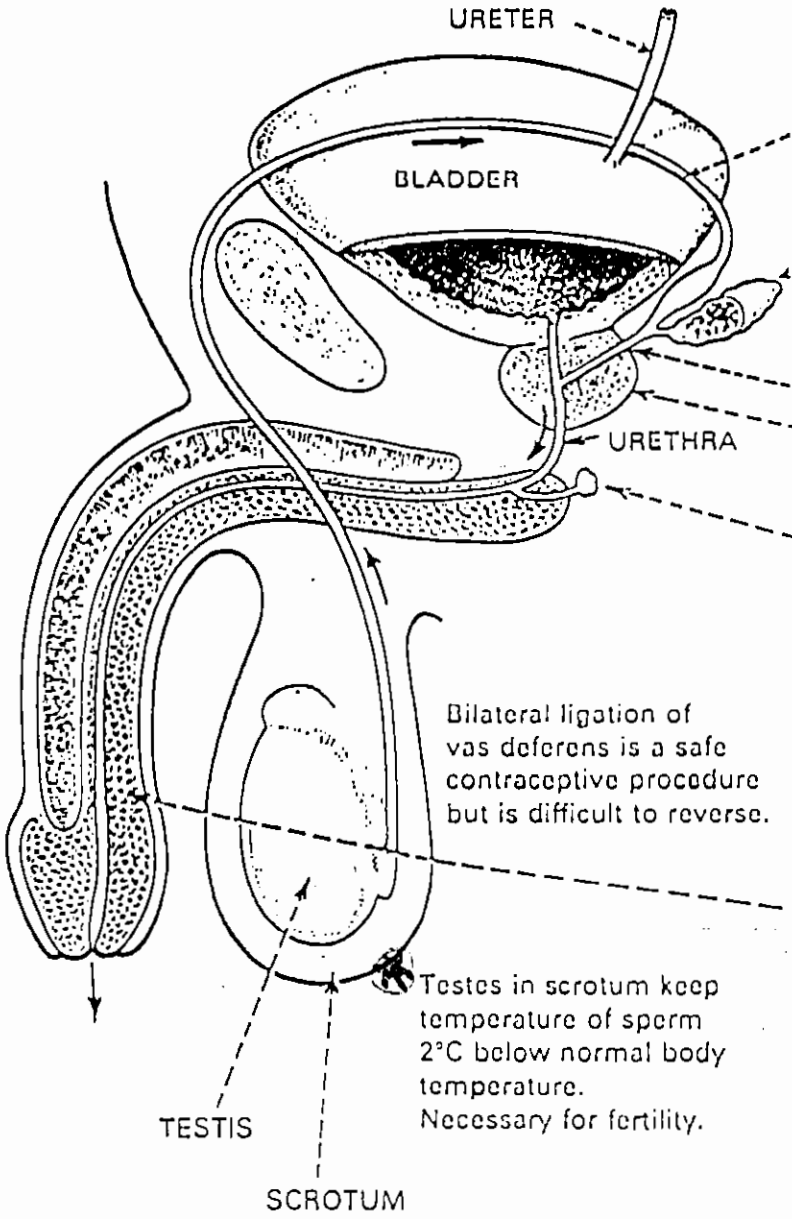


FIGURE 6-6: Diagram of the testis illustrating the cytological changes during spermatogenesis. In man, this process requires approximately 64 days to transform a spermatogonium into a mature spermatid. An additional month may pass before these sperm are ejaculated. (*Adapted from:* Junqueira and Carneiro, 1980.)

MALE ACCESSORY SEX ORGANS

These are the organs adapted for transfer of live spermatozoa from male to female.



Smooth muscle wall of VAS DEFERENS contracts to propel spermatozoa into URETHRA.

SEMINAL VESICLES (two) expel a viscous fructose-containing secretion to keep spermatozoa alive and motile, and prostaglandins to increase uterine and Fallopian tube motility.

EJACULATORY DUCT

PROSTATE GLAND neutralizes acidic vas deferens and vaginal fluids, enhancing sperm motility.

BULBO-URETHRAL GLANDS (two) add a thin lubricant secretion.

During ejaculation the bulbocavernosus muscle – a striated muscle – contracts to eject this SEMINAL FLUID (semen) from the urethra.

Bilateral ligation of vas deferens is a safe contraceptive procedure but is difficult to reverse.

Erection occurs by dilatation of the arterioles of the PENIS – the meshwork of blood sinuses fills with blood. Venous outflow is thus compressed and the penis becomes firm and erect. Arteriolar dilatation is produced by parasympathetic nerves releasing acetylcholine and VIP and nonadrenergic–noncholinergic nerves releasing the powerful vasodilator nitric oxide (EDRF). 2–4 ml of SEMINAL FLUID containing several hundred million spermatozoa are deposited in the female vagina.

Testes in scrotum keep temperature of sperm 2°C below normal body temperature. Necessary for fertility.

Sperm must remain in female tract for several hours to acquire ability to penetrate ovum – capacitation.

When the testes do not descend, the condition is called CRYPTORCHIDISM. The condition occurs in about 3% of full-term infants and about 30% of premature infants.

In the last three months of pregnancy, testosterone and Insulin like hormones from Leydig cells promote the descent of the testes into the scrotum

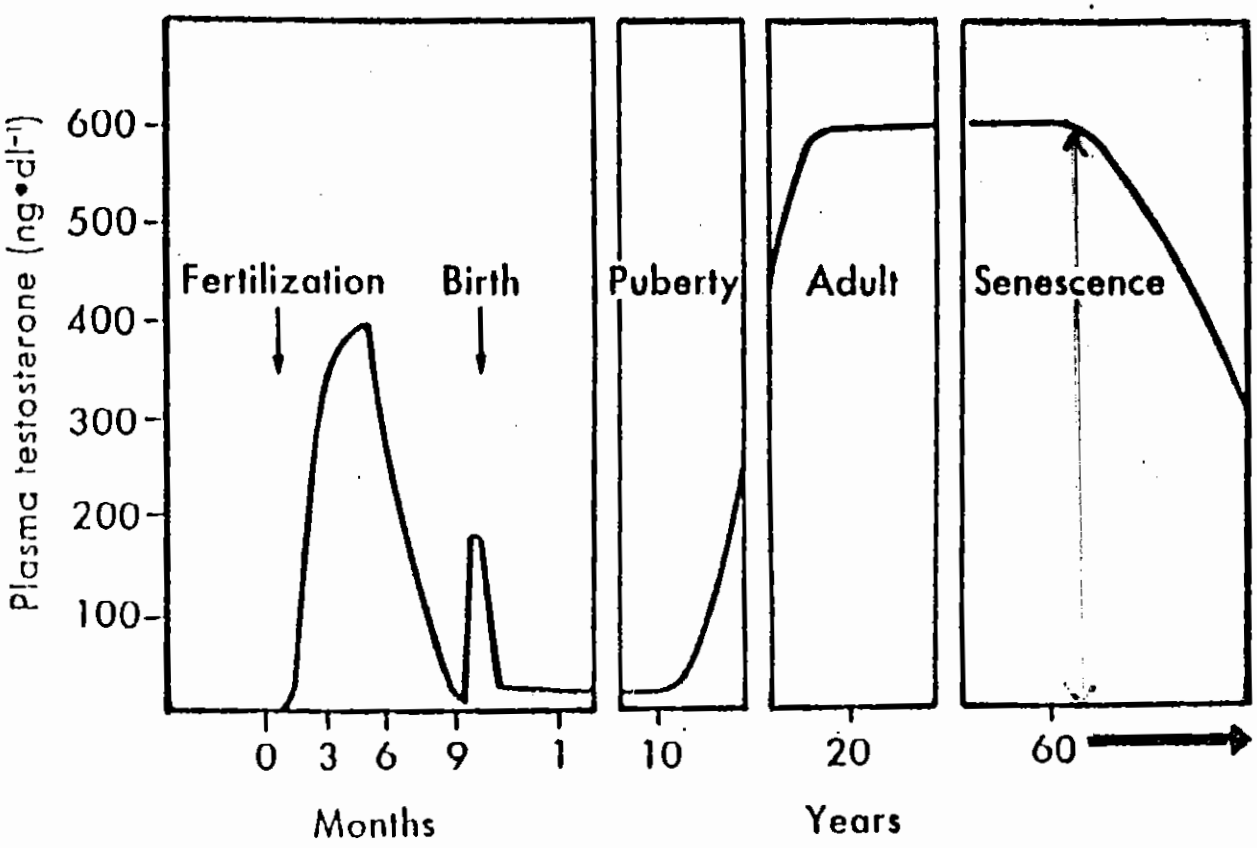


FIGURE 44-5 Plasma testosterone profile during the life span of a normal male. (Redrawn from Griffin JE et al. In Bondy PK and Rosenberg LE: Metabolic control and disease, Philadelphia, 1980, WB Saunders Co; and Winter JSD et al: J Clin Endocrinol Metab 42:679, 1976. Copyright 1976. Reproduced by permission.)

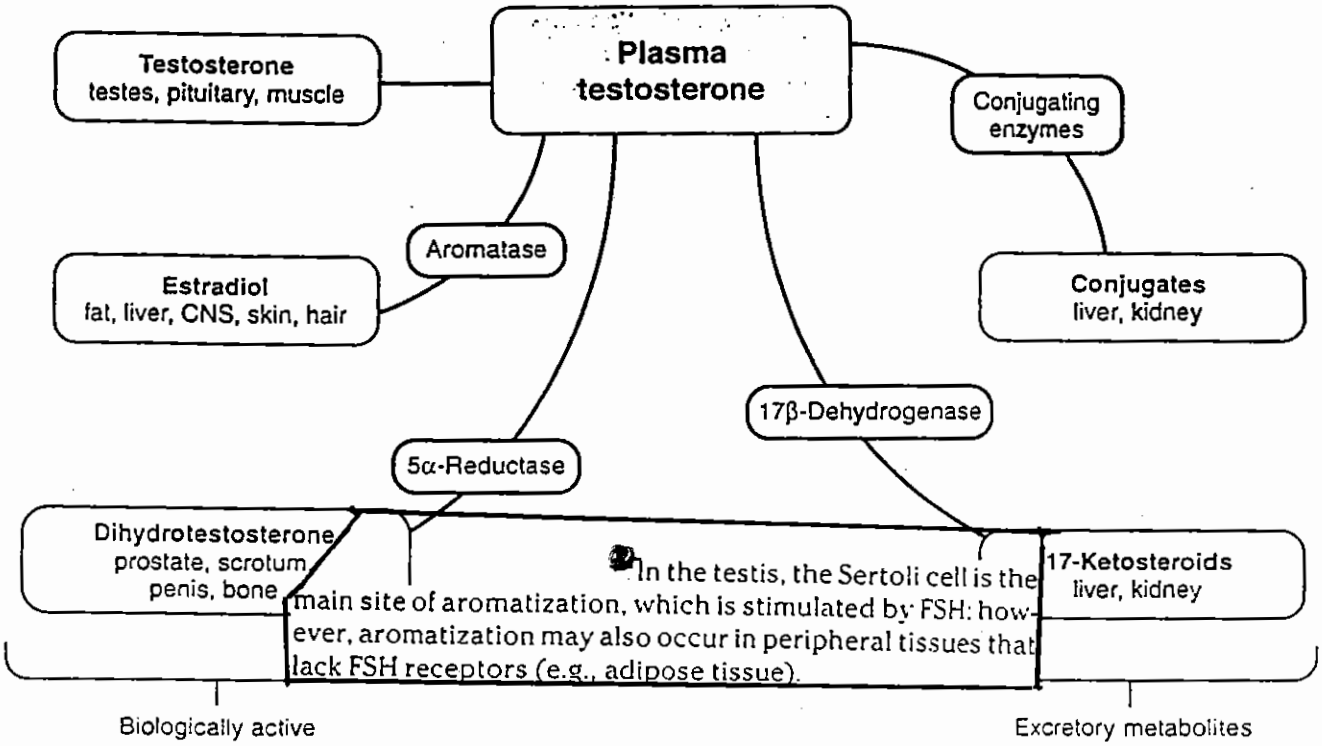


FIGURE 36.11 Conversion of testosterone to different products in extratesticular sites. CNS, central nervous system.

- Drugs that inhibit 5α-reductase are currently used to reduce prostatic hypertrophy because DHT induces hyperplasia of prostatic epithelial cells.
- The biologic activity of DHT is 30 to 50 times higher than that of testosterone.
- Several tissues besides the testes—including adipose tissue, brain, muscle, skin, and adrenal cortex—produce testosterone and several other androgens. These substances may be synthesized de novo or produced by peripheral conversion of precursors.

TABLE 53–2

ANDROGEN PRODUCTION AND TURNOVER

STEROID	BLOOD PRODUCTION RATE—HORMONE DELIVERED TO THE BLOOD (μg/day)	PLASMA CONCENTRATION (μg/liter)
Testosterone	6500	6.5
Androstenedione	2000–6000	1.5
Dihydrotestosterone	300	0.5

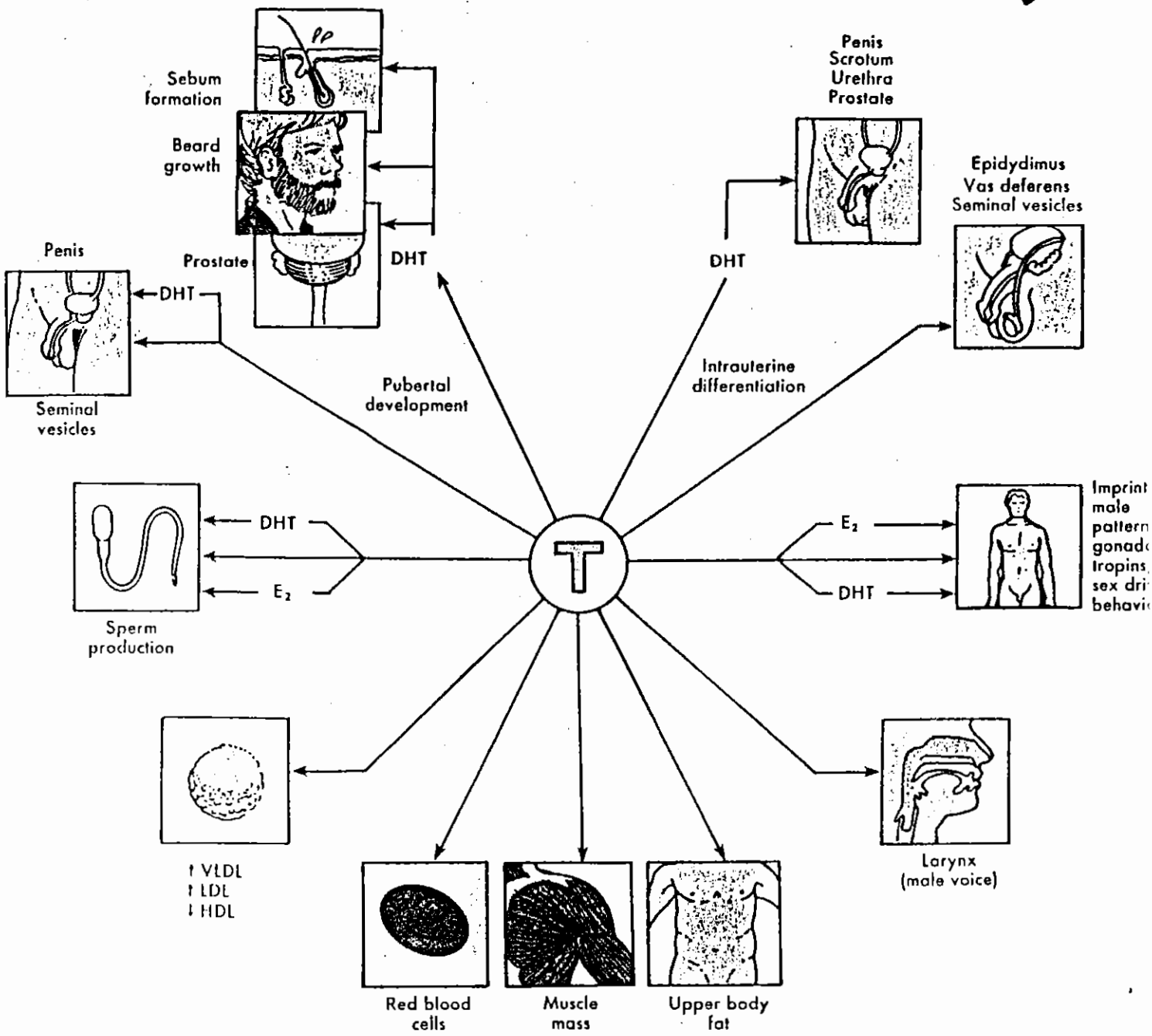


FIGURE 44-6 The spectrum of androgen effects. Note some effects result from the action of testosterone (*T*) itself, whereas others are mediated by dihydrotestosterone (*DHT*) and possibly estradiol (E_2) after they are produced from testosterone. *VLDL*, *LDL*, and *HDL* are very-low-density, low-density, and high-density lipoproteins.

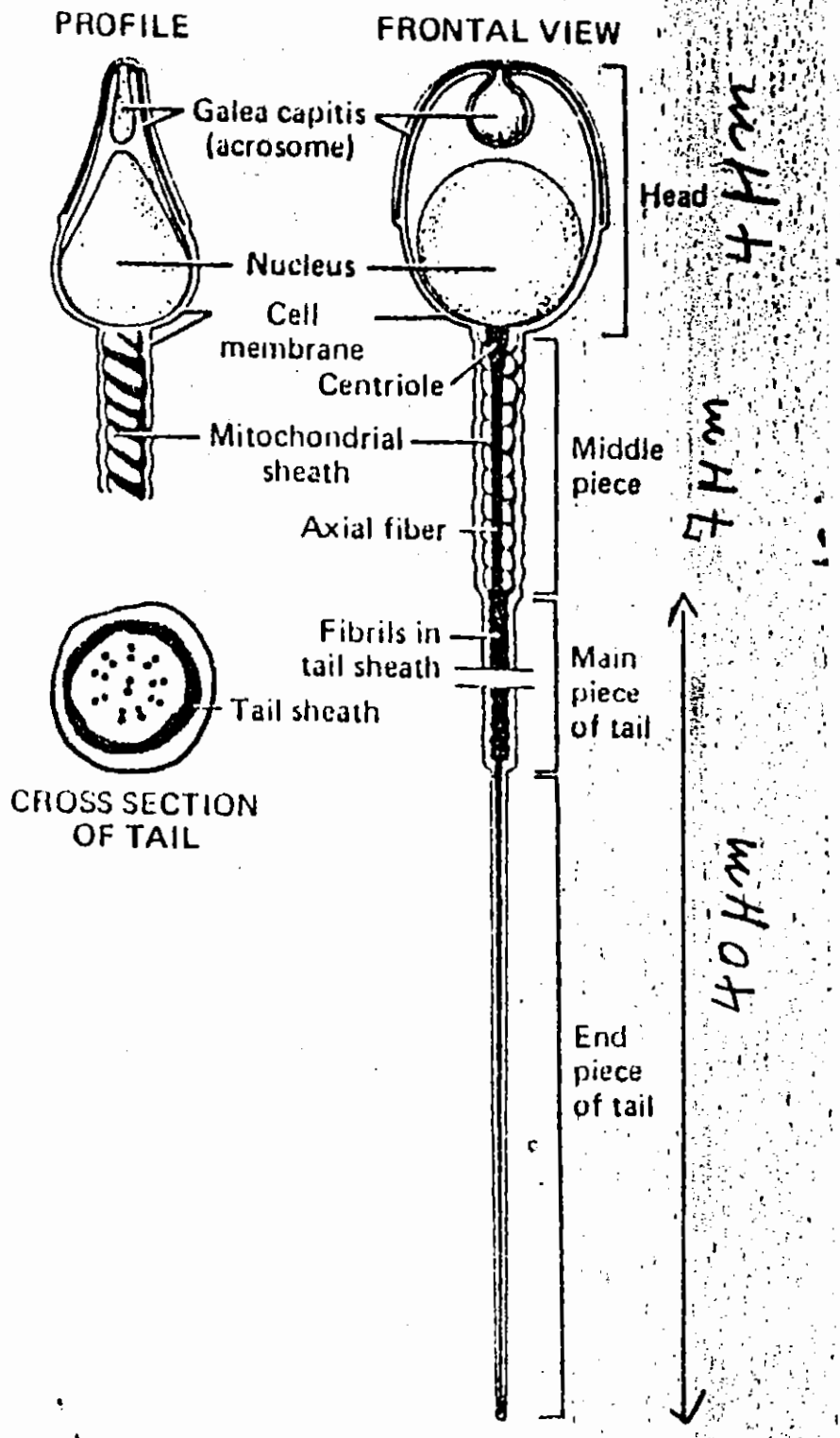


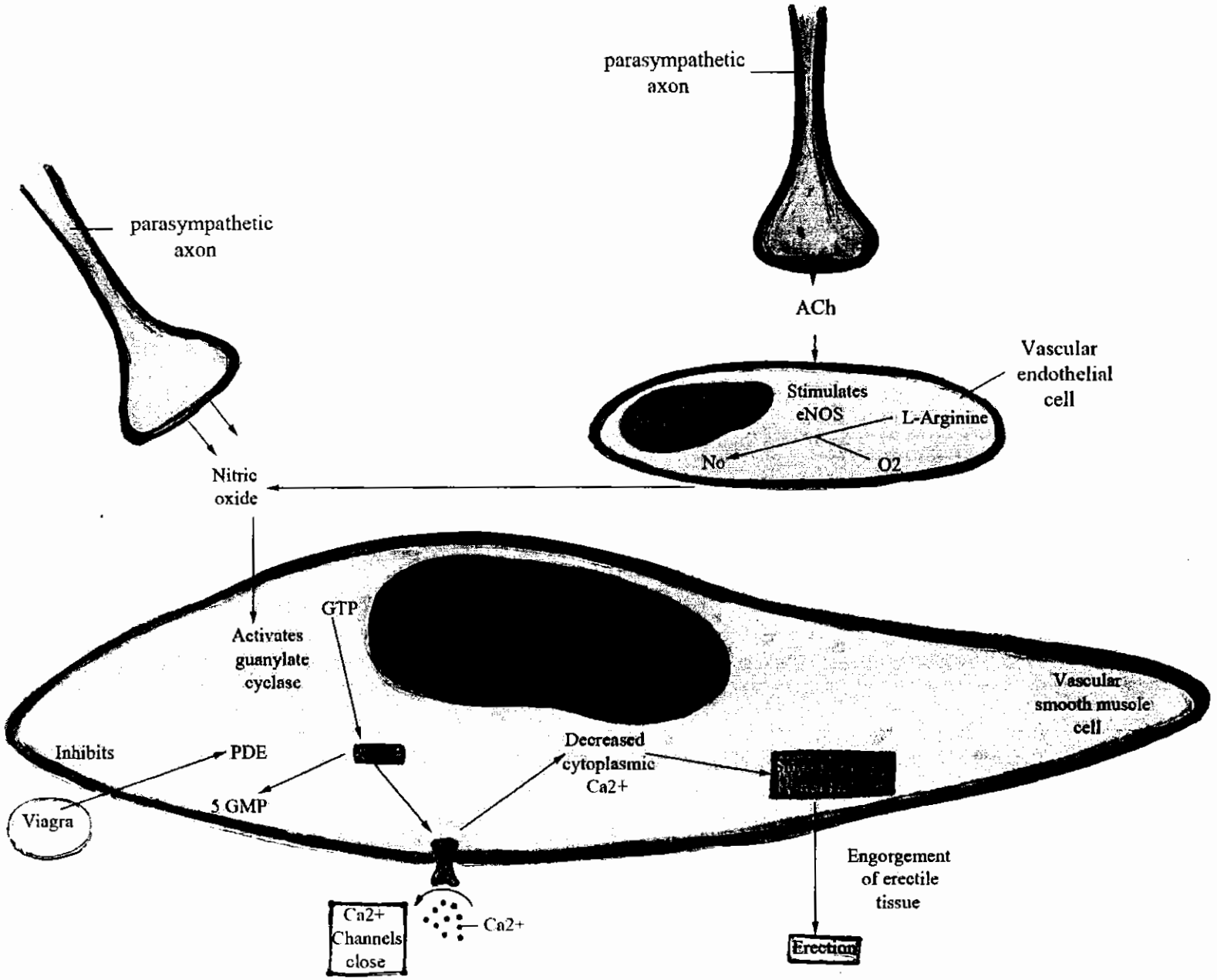
Figure 23–16. Human spermatozoon. (Redrawn and reproduced, with permission, from Schultz-Larsen J: The morphology of the human sperm. *Acta Pathol Microbiol Scand* [*Suppl*] 1958;No. 128.)

Table 8.10 Causes of delayed puberty

Normal variant
familial
racial
Coincidental serious illness
Psychological stress
Hypogonadism from any cause
Hyperprolactinaemia

Table 8.6 Causes of impotence

Psychological disturbance (the most common)
Drugs
Methyldopa
Guanethidine and related substances
Spironolactone
Autonomic neuropathy (including diabetes)
Hyperprolactinaemia
Hypogonadism
Vascular disease (the Leriche syndrome)
Hypogonad men seldom complain of impotence because of the associated loss of libido


parasympathetic axon
parasympathetic axon
ACh
Vascular endothelial cell
Stimulates eNOS
L-Arginine
No
O2
Nitric oxide
GTP
Activates guanylate cyclase
Vascular smooth musole cell
Inhibits
PDE
5 GMP
Viagra
Decreased cytoplasmic Ca2+
Engorgement of erectile tissue
Ca2+ Channels close
Ca2+
Erection

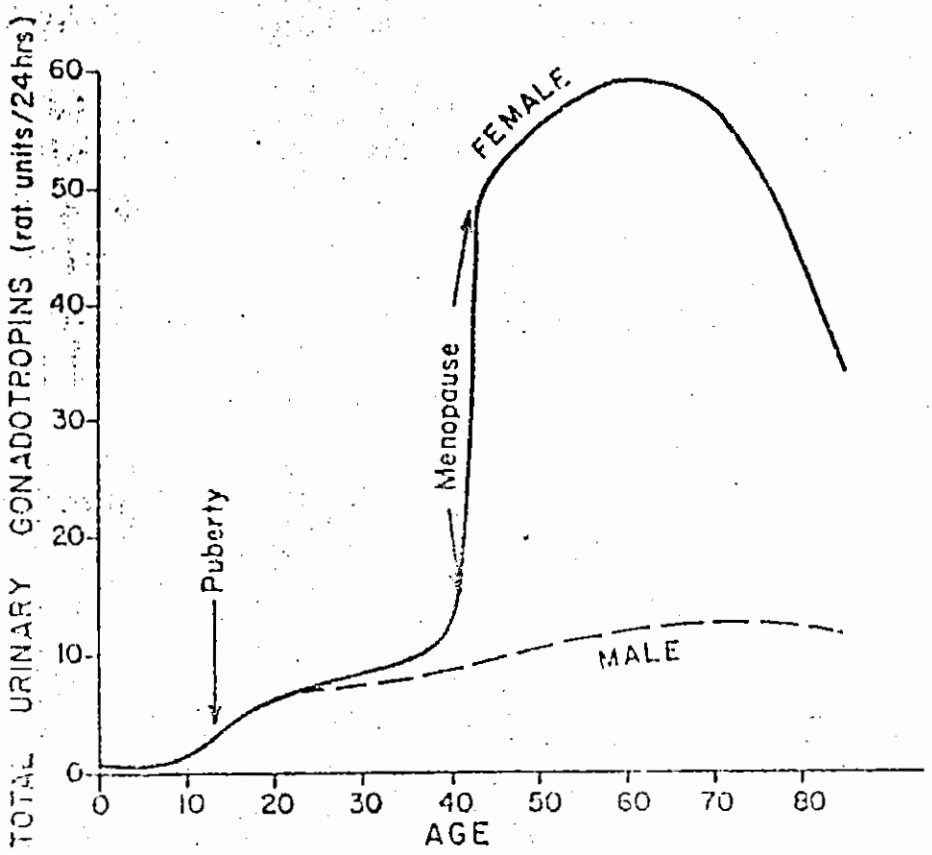


Figure 81–7. Total rates of secretion of gonadotropic hormones throughout the sexual lives of females and males, showing an especially abrupt increase in gonadotropic hormones at the menopause in the female.

Location	Time of appearance (min after ejaculation)	Percent of ejaculated sperm*
Fertilization site (upper third of oviduct)	30–60	.001
Uterus	10–20	0.1
Cervical canal	1–3	3
Vagina	0	100

*Based on data from animals. Sperm and ovum enlarged.

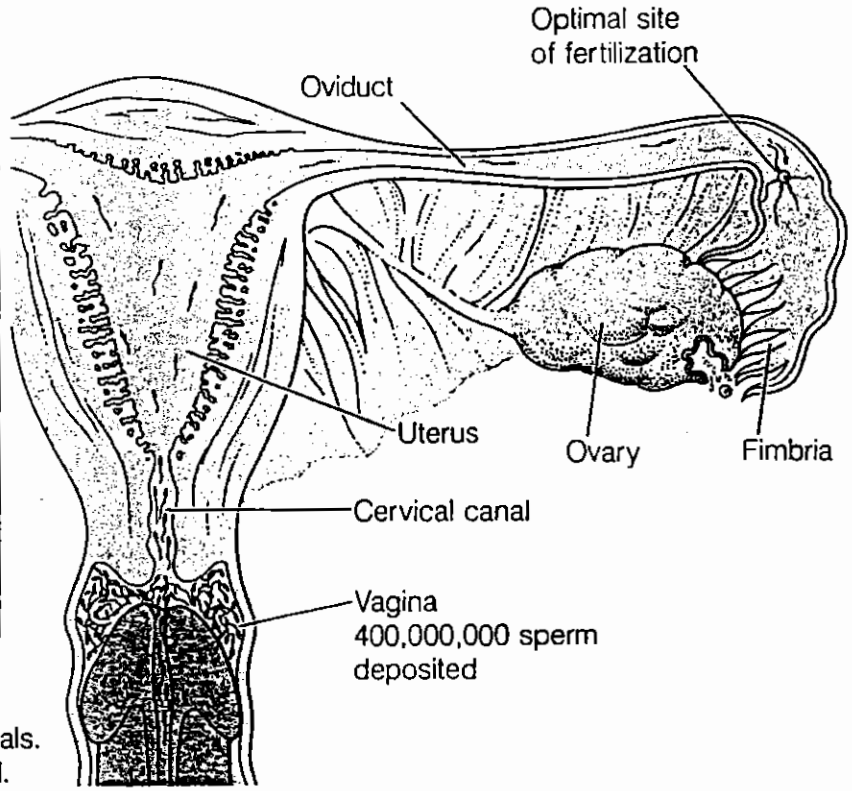


FIGURE 16–16 Sperm and Ovum Transport to Site of Fertilization

TABLE 25–4 Composition of human semen.

Color: White, opalescent	
Specific gravity: 1.028	
pH: 7.35–7.50	
Sperm count: Average about 100 million/mL, with fewer than 20% abnormal forms	
Other components:	
Fructose (1.5-6.5 mg/mL)	From seminal vesicles (contributes 60% of total volume)
Phosphorylcholine	
Ergothioneine	
Ascorbic acid	
Flavins	
Prostaglandins	
Spermine	From prostate (contributes 20% of total volume)
Citric acid	
Cholesterol, phospholipids	
Fibrinolysin, fibrinogenase	
Zinc	
Acid phosphatase	
Phosphate	Buffers
Bicarbonate	
Hyaluronidase → is not a product of the accessory glands, rather ~~It is contained within the sperms~~	

* The secretions of the accessory glands promote sperm survival and fertility.

* The coagulum forms of sperm, minimizing the expulsion of semen from the vagina.

Table 8.2 Seminal fluid — mean values for a fertile semen

Volume	3.5 ml (Range 1–7 ml)
Sperm count	100 million/ml (minimum 20 million/ml)
Motility	Normal in more than 60 per cent of total
Morphology	Normal in more than 60 per cent of total
Secondary liquefaction	Complete within fifteen minutes
Fructose content	2.2 g/l

Inflammatory cells and blood elements should be absent; spermatozoal precursor cells should not exceed 10 per cent of sperm count

* Oligospermia: Low sperm count (below 20 millions/ml.
* Azospermia: No sperms at all.

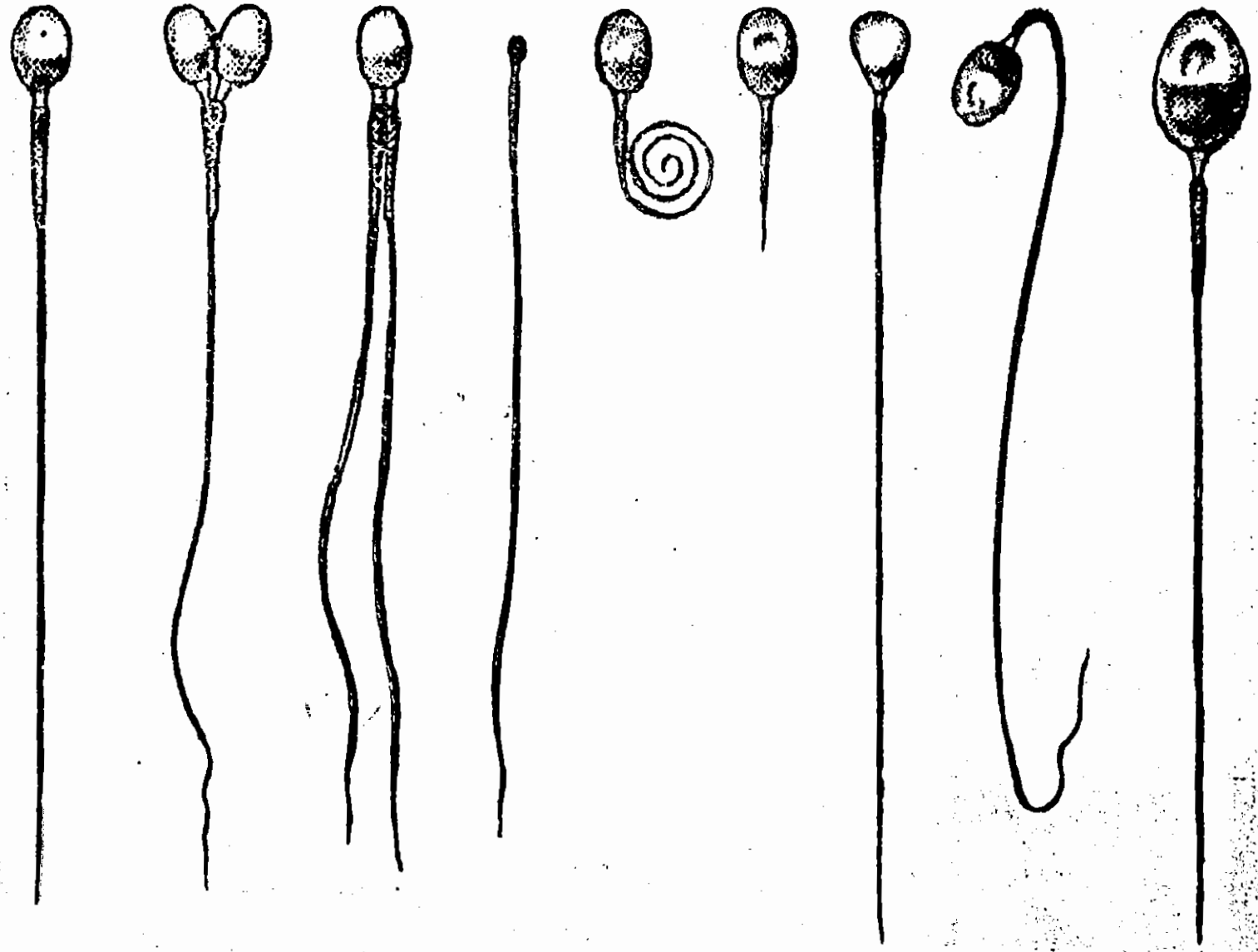


Figure 80–4. Abnormal sperm, compared with a normal sperm on the right.