

MALE REPRODUCTIVE SYSTEM 男性生殖系统

1. INTRODUCTION 前言

- **Testis:** production of **sperm** and **androgens** (predominantly **testosterone**)
睾丸: 产生精子和雄激素 (主要是睾酮)
- **Epididymis:** storehouse of **sperm**, further maturation of **sperm**
附睾: 精子仓库, 精子进一步成熟
- **Vas Deferens (Ductus Deferens)** 输精管
- **Accessory Reproductive Glands:** excretory organs of the **seminal plasma**
附属性腺: 精浆分泌器官
 - **Seminal vesicles** 精囊
 - **Prostate gland** 前列腺
 - **Bulbourethral glands (Cowper's glands)** 尿道球腺
- **Penis:** organ of seminal and urinary excretion 阴茎: 射精及排尿器官

2. TESTIS (*pl.* TESTES, *adj.* TESTICULAR) 睾丸

Descending before birth from the **abdominal cavity** (腹腔) through the **inguinal canal** (腹股沟管) into the **scrotum** (阴囊), with an extension of the **peritoneum** (腹膜) – the **tunica vaginalis** (鞘膜) – covering the anterolateral surface. Surrounded by **tunica albuginea** & containing convoluted (盘曲的) **seminiferous tubules** and the **interstitial tissue**.

2.1 Tunica Albuginea 白膜

- Thick and dense connective capsule 厚而密的结缔组织膜
- Posterior portion thickened to form the **mediastinum testis** 后缘增厚形成睾丸纵隔

2.2 Parenchyma: Seminiferous Tubules 实质: 生精小管

- Diameter ~200 μm in, total length ~400 m (per testis)
直径约 200 微米, 总长约 400 米 (每个睾丸)
- Wall: **seminiferous epithelium** (stratified), surrounded by **myoid cells**
壁: 生精上皮 (复层), 肌样细胞包绕
- 1–4 loop-shaped **tubules** in each of incomplete **lobules** (~250); each 30–70 cm in length, terminated as 2 short & thin **straight tubules (tubuli recti)** continuous with the **rete testis** (anastomosing channels within the **mediastinum**, simple columnar **epithelium**)
1–4 条祥祥小管在每个不全小叶 (约 250 个) 内; 每条 30–70 厘米长, 末端为短而薄的 2 条直精小管, 连接睾丸网 (睾丸纵隔内相互吻合的管道, 单层柱状上皮)

2.3 Interstitial Tissue 间质

- Intertubular **connective tissue** 小管间结缔组织
- Containing **Leydig cells** in groups 含成群的 **Leydig 细胞**
 - Secretion of **testosterone**, essential to **spermatogenesis** & development of **secondary sex characteristics** and important in **sexual function** (including **libido**)
分泌睾酮: 精子发生和**第二性征**发育所必需, 对**性功能** (包括**性欲**) 重要
 - Large, polygonal, with the **EM** morphological features of **steroid-secreting cells**
大, 多边形, 具**类固醇激素分泌细胞**的电镜形态特征

2.4 Cells In The Seminiferous Epithelium 生精上皮里的细胞

2.4.1 Spermatogenic cells / Germ cells 生精细胞 (Multilayer 多层)

- **Spermatogonia:** scattered along the **basement membrane**, spherical/oval, including **type A spermatogonia (stem cells, diffuse chromatin)** and **type B spermatogonia**

(relatively large granules of darkly stained **chromatin** along the nuclear membrane)
精原细胞: 沿基膜散在分布, 球形/卵圆形; 包括 **A型精原细胞** (干细胞, 染色质弥散) 和 **B型精原细胞** (核周边染色质颗粒粗大深染)

- **Spermatocytes**: spherical nucleus characterized by a mottled appearance (thread-like clumps of **chromatin**). Many **primary spermatocytes** (small to largest) and a few **secondary spermatocytes** (small) on sections

精母细胞: 核球形, 具斑点样 (染色质条块状) 特征。切片上见许多**初级精母细胞** (小到最大), 少量**次级精母细胞** (小)

- **Spermatids**: larger number, closer to the tubule lumen, smaller than **spermatocytes**, round to elongated in nuclear shape, pale to dark in nuclear staining

精子细胞: 较多, 近管腔, 比**精母细胞**小; 核圆形至细长, 染色由浅至深

- **Spermatozoa (Sperm, sing. Spermatozoon, adj. Spermatozoal) 精子**

◆ Mature **spermatids** released from the **seminiferous epithelium**

生精上皮释放出来的成熟**精子细胞**

◆ Nonmotile in the **seminiferous tubule** lumen; acquiring motility in the **epididymis** / 生精小管腔内不活动, 附睾内获得运动力

◆ **Tadpole-shaped**, ~60 μm in length 蝌蚪样, 约 60 微米长

➢ **Head**: mainly a flattened & pointed nucleus (4.5 \times 3 \times 1 μm), with an **acrosomal cap** (anterior 2/3) containing **acrosomal enzymes**. **头**: 主要是个扁而尖的胞核 (4.5 \times 3 \times 1 μm), 有个含**顶体酶**的**顶体帽** (前 2/3)

➢ **Tail**: a **flagellum** (elongated **cilium** with many **mitochondria**)
尾: **鞭毛** (长形纤毛, 线粒体多)

2.4.2 Sertoli cells / Sertoli细胞 (One full layer 完整一层)

- Irregular cell membrane (**processes**) surrounding all spermatogenic cells
不规则细胞膜 (**突起**) 包绕所有生精细胞
- **Tight junctions** between **Sertoli cells**, key component of the **blood-testis barrier**, dividing the **epithelium** into a **basal compartment** (**spermatogonia** & early **spermatocytes**) & an **adluminal compartment** / **Sertoli细胞**间的紧密连接 (血-睾屏障的关键结构), 把上皮分成**基底室** (精原细胞和早期精母细胞) 和**近腔室**
- Irregular nucleus with **euchromatin** and a single **nucleolus**
不规则细胞核, 含**常染色质**和单个**核仁**
- Nonreplicating in mature testes 成熟睾丸内不能复制
- **Function**: supporting **spermatogenesis**. Exocrine: **testicular fluid** & **ABP** (**androgen-binding protein**); endocrine: **inhibin** (inhibiting **FSH**) / **功能**: 支持精子发生。外分泌: **睾丸液**和**ABP** (**雄激素结合蛋白**); 内分泌: **抑制素** (抑制**FSH**)

2.4.3 Formation of spermatogenic cells 生精细胞的排列

- Neighboring spermatogenic cells connected by **intercellular (cytoplasmic) bridges**
相邻生精细胞有**细胞间 (胞质) 桥**相连
- **Stages of the seminiferous epithelium: cyclic associations** (formed together at certain area) of different **spermatogenic cells** at different steps / 生精上皮的分期: 不同阶段的不同生精细胞的周期性组合 (在一定区域形成排列在一起)

2.5 Spermatogenesis (adj. Spermatogenic) 精子发生

- The process of **spermatogonia** dividing & developing into **spermatozoa**, initiated postpuberty / **精原细胞**分裂、发育形成**精子**的过程, 青春期后启动

- **Divisions (mitoses, *sing.* mitosis) of spermatogonia (→ primary spermatocytes)**
精原细胞分裂 (有丝分裂) (→初级精母细胞)
- **Meiosis (*pl.* Meioses) of spermatocytes (1 primary spermatocyte → 2 secondary spermatocytes → 4 spermatids)**
精母细胞的减数分裂 (1个初级精母细胞 → 2个次级精母细胞 → 4个精子细胞)
- **Spermiogenesis (maturation of spermatids): shape changes; Golgi complexes → acrosome; excess cytoplasm pinched off**
精子形成 (精子细胞成熟): 形态改变, 高尔基复合体→顶体, 多余胞质脱落
- **Spermiation (sperm release) 精子释放**
- Regulation of spermatogenesis 精子发生的调节
 - **Primarily a hormonal regulation 主要是激素调节**
Testosterone & FSH (follicle stimulating hormone) maintain spermatogenesis via Sertoli cells / 睾酮和卵泡刺激素通过Sertoli细胞维持精子发生
 - Testosterone: secreted by Leydig cells via LH (luteinizing hormone) stimulation. / 睾酮: 黄体生成素刺激Leydig细胞分泌
 - Gonadotrophins (LH & FSH): secreted by the adenohypophysis
促性腺激素 (黄体生成素和卵泡刺激素): 腺垂体分泌
 - **Other factors (lower temperature...) 其他因素 (较低的温度……)**

3. EPIDIDYMIS (*pl.* EPIDIDYMIDES, *adj.* EPIDIDYMAL) 附睾

Consisting primarily of the **ductus epididymis (epididymal duct)**, a highly coiled (蟠曲) tube lined with a pseudostratified (假复层) columnar **epithelium**, which forms **stereocilia (静纤毛)**, and surrounded by **smooth muscle** and **connective tissue**.

- **Head (Caput) 头: 8–12 efferent ductules (efferent ducts, ductuli efferentes) + part of the ductus epididymis / 输出小管+部分附睾管**
- **Body (Corpus) 体: Ductus epididymis 附睾管**
- **Tail (Cauda) 尾: Ductus epididymis (regular luminal surface) 附睾管 (腔面整齐)**

4. VAS DEFERENS (*pl.* VASA DEFERENTIA, *adj.* VASAL) 输精管

- **Mucosa: pseudostratified columnar epithelium + lamina propria; muscularis (thick, three layers – inner longitudinal, middle circular, outer longitudinal); fibrosa**
粘膜: 假复层柱状上皮+固有层; 肌层 (厚, 三层——内纵、中环、外纵); 纤维膜

5. PROSTATE (PROSTATE GLAND, *adj.* PROSTATIC) 前列腺

- **30–50 tubuloalveolar glands, lined with simple columnar or pseudostratified epithelium. Fibromuscular stroma. Testosterone dependent**
复管泡状腺, 内衬单层柱状或假复层上皮。纤维肌性基质。睾酮依赖

6. SEMINAL VESICLE 精囊

- Tubular gland. **Mucosa: numerous branched folds, simple/pseudostratified columnar epithelium. Testosterone dependent. Eosinophilic secretion (fructose + prostaglandin...).**

7. SEMEN (SEMINAL FLUID) 精液

- **Spermatozoa (>40 million per ml, 200–600 million per ejaculate, >50% motile; undulatory motion at ~1–3 mm per min; 2–6 ml semen per ejaculate).**
- **Seminal plasma (~60% from the seminal vesicles, ~30% from the prostate gland), with some epithelial cells (the lining of the reproductive ducts & glands) and leucocytes.**

Phonetic symbols of anatomical & histological words / 解剖学与组织学单词音标

(**British pronunciation / 英式发音——Youdao/有道词典: <http://dict.youdao.com/>**)

Reproductive [ˌriːprəˈdʌktɪv] Testis [ˈtestɪs] Sperm [spɜːm] Androgen [ˈændrədʒ(ə)n]
Testosterone [teˈstɒstərəʊn] Epididymis [ˌepɪˈdɪdɪmɪs] Vas deferens [væsˈdefərənz]
Ductus [ˈdʌktəs] Accessory [əkˈses(ə)rɪ] Gland [glænd] Excretory [ɪkˈskriːtəri; ek-]
Seminal [ˈsemɪn(ə)l] Plasma [ˈplæzmə] Vesicle [ˈvesɪk(ə)l; ˈviː-] Prostate [ˈprɒsteɪt]
Cowper [ˈkuːpə] Penis [ˈpiːnɪs] Urinary [ˈjʊəri(ə)rɪ] Excretion [ɪkˈskriːʃ(ə)n; ek-]
Testes [ˈtestɪːz] Testicular [tɛsˈtɪkjʊlə] Abdominal [æbˈdɒmɪn(ə)l] Cavity [ˈkævɪtɪ]
Inguinal [ˈɪŋɡwɪn(ə)l] Canal [kəˈnæl] Scrotum [ˈskrɒtəm] Peritoneum [ˌperɪtəˈniːəm]
Tunica [ˈtjuːnɪkə] Anterolateral [ˌæntərəʊˈlætərəl] Albuginea [ˌælbjuːˈdʒɪniə]
Convolute[d] [ˌkɒnvəˈl(j)uːtɪd] Seminiferous [ˌsemɪˈnɪf(ə)rəs] Tubule [ˈtjuːbjʊːl]
Interstitial [ˌɪntəˈstɪʃ(ə)l] Tissue [ˈtɪʃuː; ˈtɪʃuː] Posterior [pɒˈstɪəriə]
Mediastinum [ˌmiːdɪəˈstaɪnəm] Parenchyma [pəˈrɛŋkɪmə] Epithelium [ˌepɪˈθiːliəm]
Stratified [ˈstrætɪfaɪd] Myoid [ˈmaɪɔɪd] Anastomose [əˈnæstəməʊz] Puberty [ˈpjʊːbətɪ]
Rete [ˈriːtɪ] Lobule [ˈlɒbjʊːl] Spermatogenesis [ˌspɜːmætə(ʊ)ˈdʒɛnɪsɪs; spəˌmætə(ʊ)-]
Libido [lɪˈbiːdəʊ; lɪˈbaɪdəʊ] Morphological [ˌmɔːfəˈlɒdʒɪkəl] Steroid [ˈstɪəriɔɪd; ˈsterɔɪd]
Secrete [sɪˈkriːt] Spermatogenic [spɜːˌmætəˈdʒɛnɪk] Germ [dʒɜːm] Membrane [ˈmembreɪn]
Spermatogonia [ˌspɜːmætəʊˈɡəʊnɪə] Chromatin [ˈkrɒmætɪn] Granule [ˈgrænjuːl]
Nuclear [ˈnjuːklɪə] Spermatoocyte [ˌspɜːmætə(ʊ)saɪt; spəˌmæt-] Nucleus [ˈnjuːklɪəs]
Spermatid [ˌspɜːmætɪd] Lumen [ˈluːmɪn] Spermatozoa [spɜːˌmætəˈzɔː] Process [ˈprɒsɪs]
Spermatozoon [ˌspɜːmætə(ʊ)ˈzəʊzɒn; spəˌmæt-] Spermatozoal [spɜːˌmætəˈzɔːl]
Motility [məʊˈtɪlətɪ] Acrosomal [ˌækroˈsəʊmə] Enzyme [ˈenzaɪm] Flagellum [fləˈdʒeləm]
Cilium [ˈsɪliəm] Junction [ˈdʒʌŋ(k)ʃ(ə)n] Barrier [ˈbæriə] Compartment [kəmˈpɑːtm(ə)nt]
Luminal [ˈljuːmɪnəl] Euchromatin [juːˈkrɒmætɪn] Nucleolus [ˌnjuːklɪˈɒləs]
Exocrine [ˌeksə(ʊ)kraɪn; -krɪn] Binding [ˈbaɪndɪŋ] Protein [ˈprəʊtiːn] Inhibin [ɪnˈhɪbɪn]
Endocrine [ˌendə(ʊ)kraɪn; -krɪn] Mitoses [maɪˈtəʊsɪːz] Mitosis [maɪˈtəʊsɪs] Meiosis [maɪˈəʊsɪs]
Meiocytes [maɪˈəʊsɪːz] Spermiogenesis [ˌspɜːmɪəʊˈdʒɛnɪsɪs] Maturation [mætjʊˈreɪʃ(ə)n]
Golgi [ˈɡɔːldʒi] Complex [ˈkɒmpleks] Acrosome [ˌækroˈsəʊm] Anterior [ænˈtɪəriə]
Cytoplasm [ˈsaɪtə(ʊ)plæz(ə)m] Spermiation [ˌspɜːmiˈeɪʃən] Hormonal [hɔːˈmɒn(ə)l]
Follicle [ˈfɒlɪk(ə)l] Stimulating [ˈstɪmjʊleɪtɪŋ] Hormone [ˈhɔːməʊn] Mitochondria [ˌmaɪtəʊˈkɒndrɪə]
Luteinize [ˈluːtɪnaɪz] Gonadotrophin [ˌɡəʊnədə(ʊ)ˈtrɒfɪn] Prepubertal [priːˈpjʊːbətəl]
Adenohypophysis [ˌædnəʊˈpʰɪzɪs] Epididymides [ˌepɪˈdɪdɪmɪdiːz] Stroma [ˈstrɒmə]
Epididymal [ˌepɪˈdɪdɪmə] Stereocilia [ˌsteriəˈsɪliə] Efferent [ˈef(ə)r(ə)nt] Ductule [ˈdʌktjuːl]
Caput [ˈkeɪpət] Corpus [ˈkɔːpəs] Cauda [ˈkaʊdə] Mucosa [mjuːˈkəʊsə] Lamina [ˈlæmɪnə]
Longitudinal [ˌlɒn(d)ʒɪˈtjuːdɪn(ə)l; ˌlɒŋɡɪ-] Semen [ˈsiːmən] Elongated [ˈiːlɒŋɡeɪtɪd]
Undulatory [ˌʌndjʊlətəri] Epithelial [ˌepɪˈθiːliəl] Leucocyte [ˈluːkə(ʊ)saɪt]

Hormonal Male Contraception

Family planning is a responsibility to be shared by both the male and the female partners. Globally, more than half the couples of reproductive age use some kind of contraceptive, and in about one third of these couples this is a male method. Approximately 40% of men choose device-free methods (periodic abstinence and coitus interruptus), 25% rely on condoms and 25% have had a vasectomy. The rhythm, withdrawal and barrier methods are acceptable and reversible but unreliable (associated with a high failure rate), whereas male sterilization is reliable but not readily reversible. Greater male participation requires the development of a safe, acceptable and reversible male contraceptive with similar reliability as modern female methods. Hormonal contraception, which involves suppression of gonadal functions by hormonal regulation using chemical agents, is well accepted by women and should be equally feasible in men.

Spermatogenesis is primarily regulated by follicle stimulating hormone (FSH), a gonadotropin secreted by the pituitary gland, and testosterone (T) produced by Leydig cells in the testis via stimulation of the other gonadotropin, luteinizing hormone (LH). Treatment with exogenous sex steroids, such as testosterone, estrogen and progestin, can activate a negative feedback mechanism that inhibits gonadotropin-releasing hormone (GnRH) secretion by the hypothalamus and (thereby) gonadotropin secretion. The withdrawal of FSH action and the marked suppression of the normally high intra-testicular testosterone level impair spermatogenesis. Specifically there is inhibition of the spermatogonial division, spermiogenesis and release of late spermatids, thus leading to azoospermia (absence of spermatozoa in the ejaculate), which can, however, be reversed when gonadotropin levels recover after the exogenous steroid treatment is ceased. .

Various regimens, e.g. testosterone alone or in combination with estrogens, progestins or GnRH antagonists, have been explored in developing an effective male contraceptive. In two WHO studies, over 670 men from 16 centers in 10 countries received weekly injections of 200mg testosterone enanthate (TE), and 60–90% of subjects became azoospermic with the remainder achieving oligospermia. In response to the same TE treatment in normal fertile men for 19–24 weeks, serum T levels increased twofold and serum FSH/LH levels fell to the limits of assay detection. Quantitative (stereological) studies on testicular biopsies revealed that the mean number of type A spermatogonia in the testis was unchanged, but type B spermatogonia decreased markedly by 90%, and later germ cell types (including elongated spermatids) decreased significantly to 11–18% of the control values.

Investigations over the past 30 years have established that hormonal regimens could induce azoospermia in the majority of men and contraceptive failures in the large WHO studies were rare when sperm counts fell < 3 million/ml. Azoospermia is a sufficient, but not absolutely necessary, requirement for effective contraception. Nevertheless, in order to ensure optimal contraceptive efficacy, azoospermia remains the desirable target for male hormonal contraceptive regimens. Although no regimen has yet achieved this goal, testosterone plus progestin combinations currently under extensive investigation appear promising and provide a likely opportunity to develop a practical and effective reversible male contraceptive in the near future.

(Zheng-Wei Yang & Robert I. McLachlan. 14 Feb. 2003.)

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