SPERMATOGENESIS

Spermiogenesis

Process in which spermatozoa are produced from male primordial germ cells in testicles by way of mitosis and meiosis.

About Spermatogenesis

Spermatogenesis produces mature male gametes, commonly called sperm but specifically known as spermatozoa, which are able to fertilize the counterpart female gamete, the oocyte, during conception to produce a single-celled individual known as a zygote. This is the cornerstone of sexual reproduction and involves the two gametes both contributing half the normal set of chromosomes (haploid) to result in a chromosomally normal (diploid) zygote.

The production cycle

The spermatogenesis occurs in the seminiferous tubules that form the bulk of each testis (Pic.1). The process begins at puberty, after which time sperm are produced constantly throughout a man’s life. One production cycle, from spermatogonia through formed sperm, takes approximately 64 days. A new cycle starts approximately every 16 days, although this timing is not synchronous across the seminiferous tubules. Sperm counts the total number of sperm a man produces slowly decline after age 35, and some studies suggest that smoking can lower sperm counts irrespective of age.

Cell types in the spermatogenesis cycle consecutively:

- spermatogonium
- primary spermatocyte
- secondary spermatocyte
- spermatid
- sperm (spermatozoa)

**The process of spermatogenesis**

Spermatogenesis begins with mitosis of the diploid spermatogonia (Pic.2). Because these cells are diploid (2n), they each have a complete copy of the father’s genetic material, or 46 chromosomes. However, mature gametes are haploid (1n), containing 23 chromosomes meaning that daughter cells of spermatogonia must undergo a second cellular division through the process of meiosis.

**Meiosis I**

As in mitosis, DNA is replicated in a primary spermatocyte, and the cell under goes cell division to produce two cells with identical chromosomes. Each of these is a secondary spermatocyte. Now a second round of cell division occurs in both of the secondary spermatocytes, separating the chromosome pairs.

**Meiosis II**

This second meiotic division results in a total of four cells with only half of the number of chromosomes. Each of these new cells is aspermatid. Although haploid, early spermatids look very similar to cells in the earlier stages of spermatogenesis, with a round shape, central nucleus, and large amount of cytoplasm.

**Spermiogenesis**

A process called spermiogenesis transforms these early spermatids, reducing the cytoplasm, and beginning the formation of the parts of a true sperm. The fifth stage of germ cell formation spermatozoa, or formed sperm is the end result of this process, which occurs in the portion of the tubule nearest the lumen. Eventually, the sperm are released into the lumen and are moved along a series of ducts in the testis toward a structure called the epididymis for the next step of sperm maturation.

**Sertoli cells**

At all stages of differentiation, the spermatogenic cells are in close contact with Sertoli cells (Pic.3) which are thought to provide structural and metabolic support to the developing sperm cells in the following ways:

- Secrete substances initiating meiosis.
- Secrete supporting testicular fluid.
- Secrete androgen-binding protein (ABP), which concentrates testosterone in close proximity to the developing gametes.
- Testosterone is needed in very high quantities for maintenance of the reproductive tract, and ABP allows a much higher level of fertility.
- Secrete hormones affecting pituitary gland control of spermatogenesis, particularly the polypeptide hormone, inhibin, estradiol.
- Protect spermatids from the immune system of the male, via the blood-testis barrier.

**Hormonal control of spermatogenesis**

In humans the mechanism is not completely understood; however it is known that initiation of spermatogenesis occurs at puberty due to the interaction of the hypothalamus, pituitary gland and Leydig cells. If the pituitary gland is removed, spermatogenesis can still be initiated by follicle stimulating hormone (FSH) and testosterone. In contrast to FSH, LH is thought to have little role in spermatogenesis outside of inducing gonadal testosterone production.

FSH stimulates both the production of androgen binding protein (ABP) by Sertoli cells, and the formation of the blood-testis barrier. ABP is essential to concentrating testosterone in levels high enough to initiate and maintain spermatogenesis, which can be 20–100 times higher than the concentration found in blood. FSH may initiate the sequestering of testosterone in the testes, but once developed only testosterone is required to maintain spermatogenesis.

**External influences**

The process of spermatogenesis is highly sensitive to fluctuations in the environment, particularly hormones and temperature. Seminiferous epithelium is sensitive to elevated temperature in humans and will be adversely affected by temperatures as high as normal body temperature. Consequently, the testes are located outside the body in a sack of skin called the scrotum. The optimal temperature is maintained at 2 °C below body temperature in human males. This is achieved by regulation of blood flow and positioning towards and away from the heat of the body by the cremasteric muscle and the dartos smooth muscle in the scrotum. Dietary deficiencies (such as vitamins B, E, and A), anabolic steroids, metals (cadmium and lead), x-ray exposure, dioxin, alcohol, and infectious diseases will also adversely affect the rate of spermatogenesis.
Diagnoses

Aspermia
Male diagnosis connected with male infertility characterised by the complete absence of semen.
Learn more at: www.fertilitypedia.org/therapy/diag/aspermia

Azoospermia
Complete absence of sperm in the ejaculate of a man.
Learn more at: www.fertilitypedia.org/therapy/diag/azoospermia

Ejaculatory disorders
A class of sexual disorders defined as the subjective lack of normal ejaculation.
Learn more at: www.fertilitypedia.org/therapy/diag/ejaculatory-disorders

Hypogonadism
A medical term which describes a diminished functional activity of the gonads – the testes and ovaries.
Learn more at: www.fertilitypedia.org/therapy/diag/hypogonadism

Hypospermia
A condition in which a man has an unusually low ejaculate (or semen) volume.
Learn more at: www.fertilitypedia.org/therapy/diag/hypospermia

Idiopathic male infertility
A condition in which fertility impairment occurs spontaneously or due to an unknown cause.
Learn more at: www.fertilitypedia.org/therapy/diag/idiopathic-male-infertility

Non-obstructive azoospermia
Complete absence of sperm in the ejaculate due to testicular failure.
Learn more at: www.fertilitypedia.org/therapy/diag/non-obstructive-azoospermia

Obesity
A disease of excess body fat that can have a negative effect on health, leading to reduced life expectancy and other health problems.
Learn more at: www.fertilitypedia.org/therapy/diag/obesity
Obstructive azoospermia
Medical condition where sperm are produced but not ejaculated due to physical obstruction.
Learn more at: www.fertilitypedia.org/therapy/diag/obstructive-azoospermia

Oligozoospermia
Semen with a low concentration of sperm and is a common finding in male infertility.
Learn more at: www.fertilitypedia.org/therapy/diag/oligozoospermia

Orchitis
An inflammation of the testes, involving swelling and heavy pains.
Learn more at: www.fertilitypedia.org/therapy/diag/orchitis

Prostatitis
An inflammation of the prostate gland.
Learn more at: www.fertilitypedia.org/therapy/diag/prostatitis

Retrograde ejaculation
The semen, which would normally be ejaculated via the urethra, is redirected to the urinary bladder.
Learn more at: www.fertilitypedia.org/therapy/diag/retrograde-ejaculation

Sertoli cell-only syndrome
The absence of any developmental stage of sperm cell in the testes.
Learn more at: www.fertilitypedia.org/therapy/diag/sertoli-cell-only-syndrome

Sperm autoantibodies
Antibodies that bind to sperm, inhibiting their movement, stopping recognition and entry into the egg.
Learn more at: www.fertilitypedia.org/therapy/diag/sperm-autoantibodies

Testicular cancer
Cancer that develops in the testicles.
Learn more at: www.fertilitypedia.org/therapy/diag/testicular-cancer

Testicular torsion
Emergency medical condition occurring when the spermatic cord twists and cuts off the testicle's blood supply.
Learn more at: www.fertilitypedia.org/therapy/diag/testicular-torsion
Thyroid disorders
A medical condition impairing the function of the thyroid.
Learn more at: www.fertilitypedia.org/therapy/diag/thyroid-disorders

Undescended testes
In the case of cryptorchidism one or both testes are absent from the scrotum. It is the most common etiologic factor of azoospermy in the adult.
Learn more at: www.fertilitypedia.org/therapy/diag/undescended-testes

Varicocele
An abnormal enlargement of the pampiniform venous plexus in the scrotum.
Learn more at: www.fertilitypedia.org/therapy/diag/varicocele

XX male syndrome
The male sex chromosomal disorder characterized by a spectrum of clinical presentations, ranging from ambiguous to normal male genitalia.
Learn more at: www.fertilitypedia.org/therapy/diag/xx-male-syndrome

Y-chromosome deletions
A family of genetic disorders caused by missing gene(s) in the Y chromosome.
Learn more at: www.fertilitypedia.org/therapy/diag/y-chromosome-deletions

Reproductive cells

Leydig cell
The cell found in interstitial tissue of testicles responsible for production of androgens - male hormones.
Learn more at: www.fertilitypedia.org/edu/reproductive-cells/leydig-cell

Sertoli cells
The cell in seminiferous epithelium responsible for nutrition and development of germ (sperm) cells.
Learn more at: www.fertilitypedia.org/edu/reproductive-cells/sertoli-cells

Spermatogonium
An undifferentiated male germ cell with self-renewing capacity representing the first stage of spermatogenesis.
Learn more at: www.fertilitypedia.org/edu/reproductive-cells/spermatogonium

Biological control
**Testosterone**
Steroid hormone produced primarily in the testes of the male; responsible for the development of secondary sex characteristics in the male.
Learn more at: [www.fertilitypedia.org/edu/biological-control/testosterone](http://www.fertilitypedia.org/edu/biological-control/testosterone)

**Gallery**

**Pic**
*This sagittal view shows the seminiferous tubules, the site of sperm production.*

**Pic**
*Cross section of seminiferous tubule*

**Pic**
*Labelled diagram of the organisation of Sertoli cells (red) and spermatocytes (blue) in the testis. Spermatids which have not yet undergone spermination are attached to the lumenal apex of the cell.*

**Sources**
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