Foundation Module

First Year MBBS(LGIS)

GAMETOGENESIS/SPERMATOGENESIS

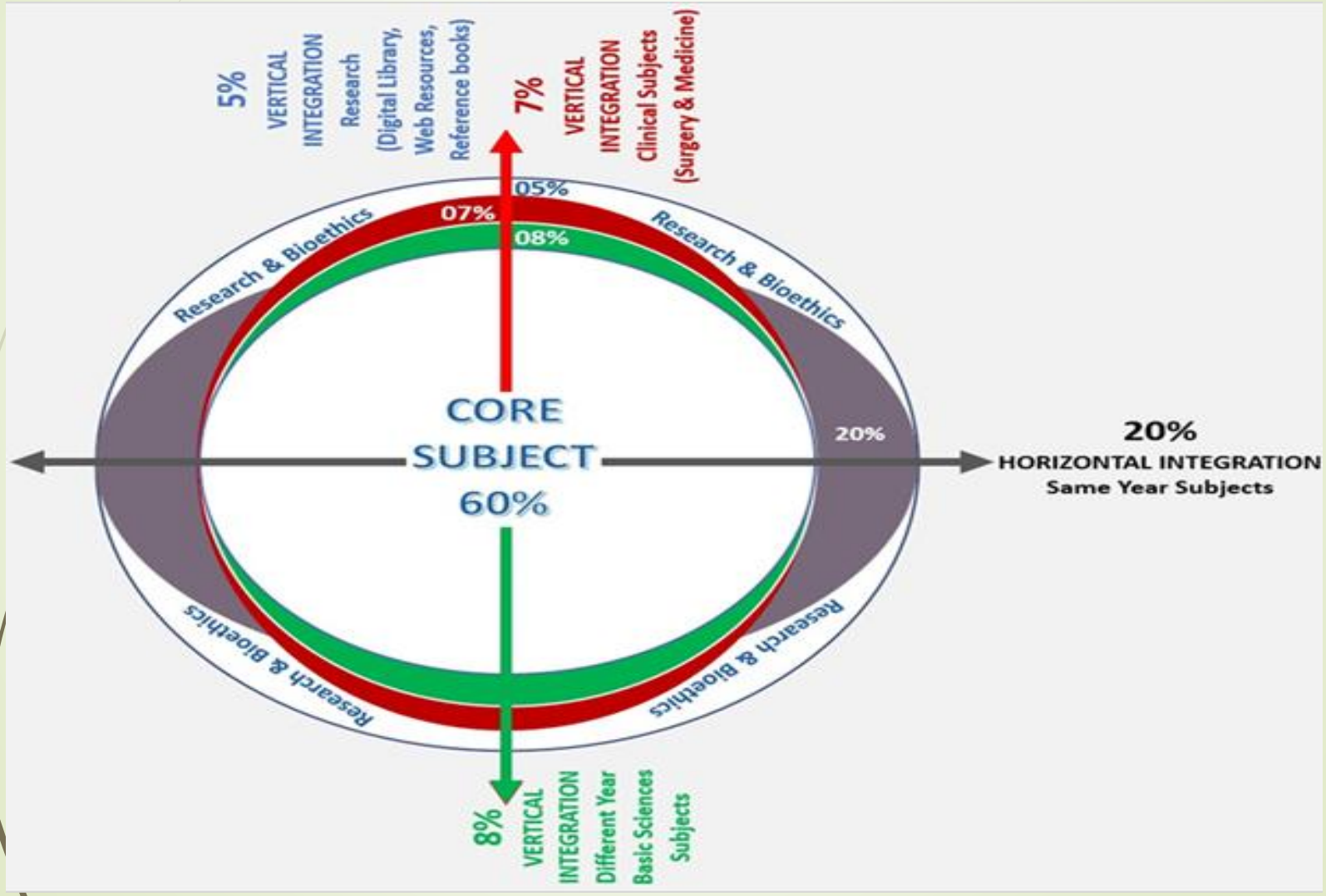
By Prof Dr Saima Naz

Dated: 5th March, 2025

Motto, Vision, Dream

- To impart evidence-based research oriented medical education
- To provide best possible patient care
- To inculcate the values of mutual respect and ethical practice of medicine

Professor Umar Model of Integrated Lecture



Learning Objectives

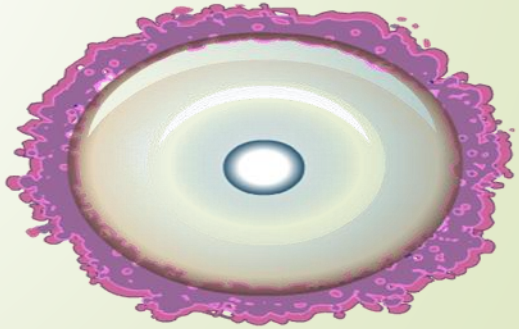
At the end of this session students should be able to

- Define Gametogenesis/Spermatogenesis
- Review concepts of Mitosis/Meiosis and will be able to apply this on Gametogenesis
- Describe different phases of spermatogenesis
- Discuss stages of spermiogenesis
- Elaborate functions of male hormones during spermatogenesis (Horizontal Integration)
- Correlate with the clinical conditions
- Practice the principles of bioethics
- Apply strategic use of A.I in relevant condition
- Read relevant research articles

Gametogenesis

- It is a specialized process which occur in a primordial germ cells by which early gem cells undergo meiosis & cytodifferentiation and convert into mature gametes

- During this process chromosome number is halved
- Diploid → Haploid
- And cell shape is altered



The Chromosome Theory Of Inheritance

- All nucleated cells in the human body, (with the exception of the final stages of gametogenesis) have 23 pairs of chromosomes in their nuclei.
- Two members of a pair are known as homologous chromosomes. In each pair, one chromosome is paternal, one maternal.
- A cell with 23 pairs of chromosomes is described as diploid ***(2n;46;2N)***; one with 23 single chromosomes is termed haploid.

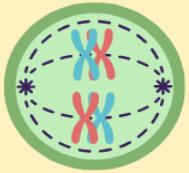
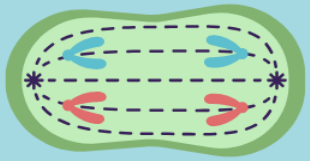
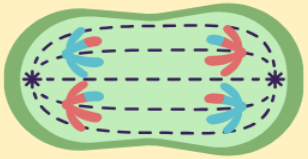
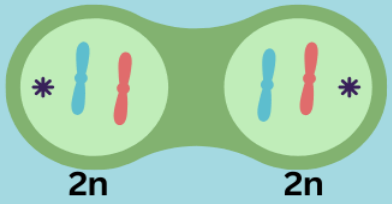
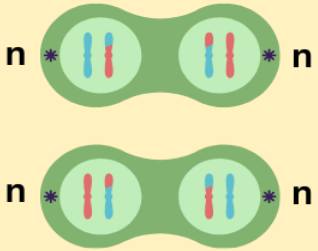
(23 maternal =1n=1N single structure, 23paternal =1n=1N=single structure)

- The genetic material in the nucleus of a cell undergoes 'replication' before cell division ***(4 N, Diploid,2n)***
-

Review

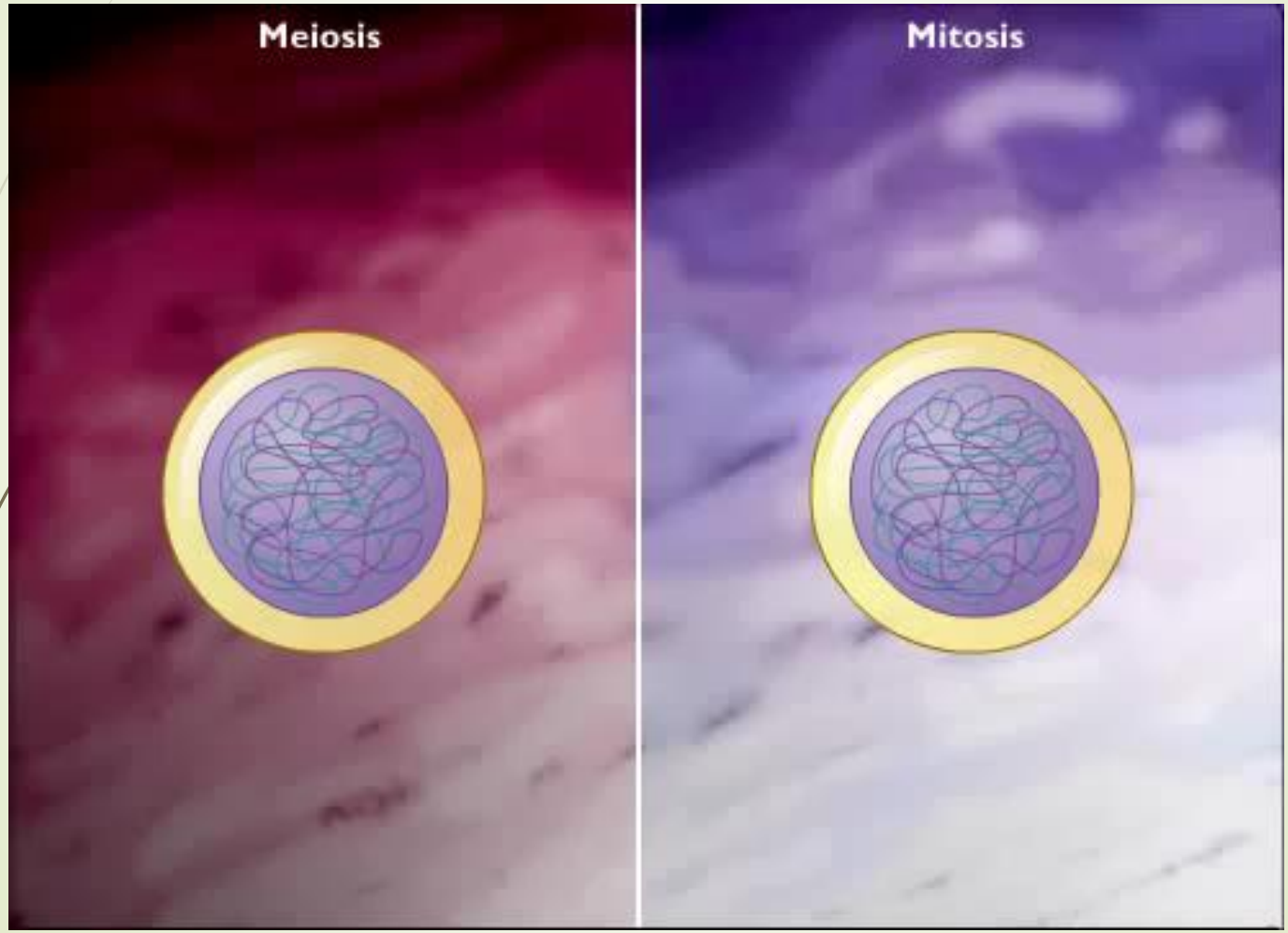
Mitosis vs Meiosis

sciencenotes.org

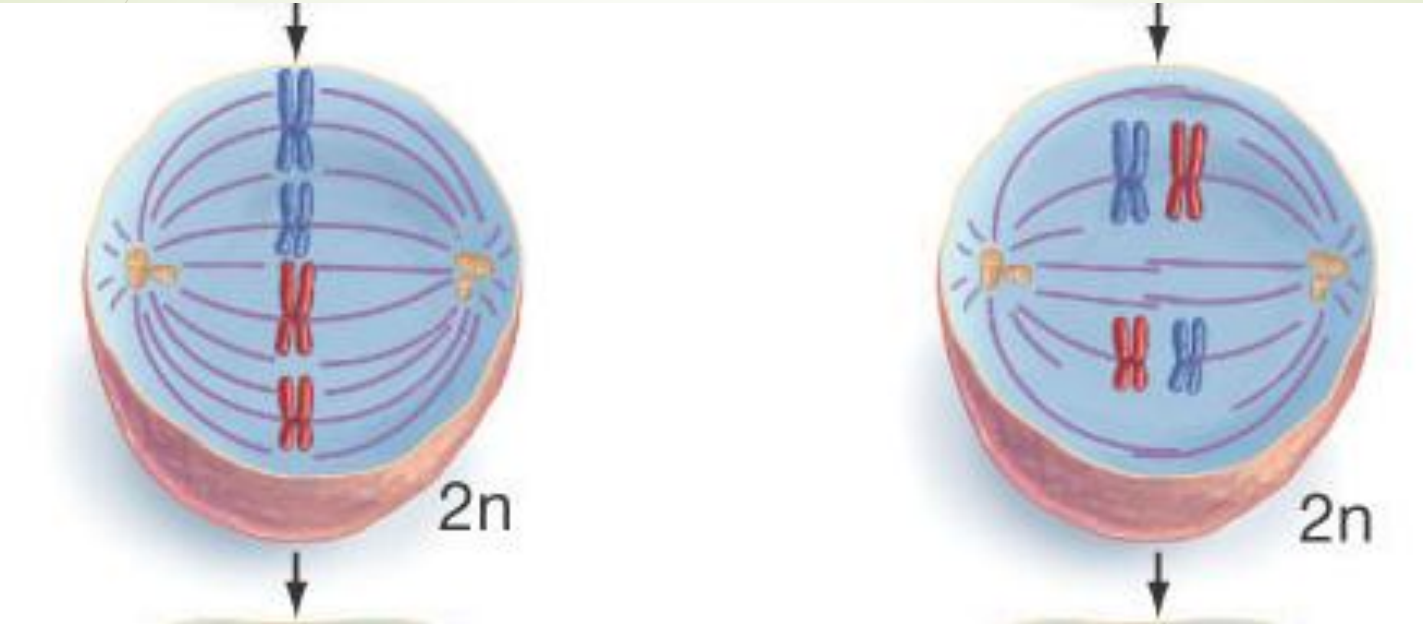
Prophase		Duplicated chromosomes are two sister chromatids	**Prophase I**		**Meiosis I** Tetrads are two pairs of sister chromatids
Metaphase		Duplicated chromosomes align	**Metaphase I**		Tetrads align Crossing-over
Anaphase **Telophase**		Sister chromatids separate	**Anaphase I** **Telophase I**		Homologous chromosomes separate
 2n 2n **2 diploid daughter cells**			Sister chromatids separate in anaphase II	 n n n n **4 haploid daughter cells**	**Meiosis 2**

Chromosome duplication 2n=4

Comparison of Mitosis & Meiosis



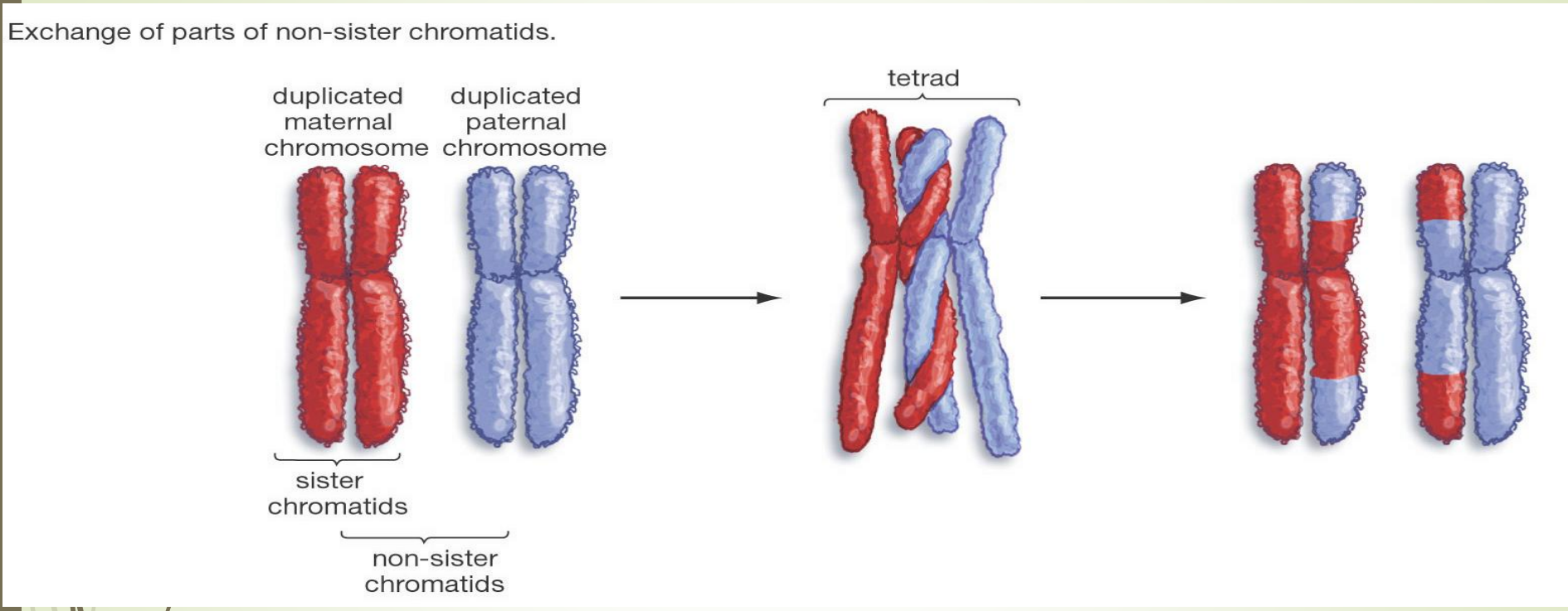
The **Key Difference** Between Mitosis and Meiosis is the Way Chromosomes Uniquely Pair and Align in Meiosis



Mitosis

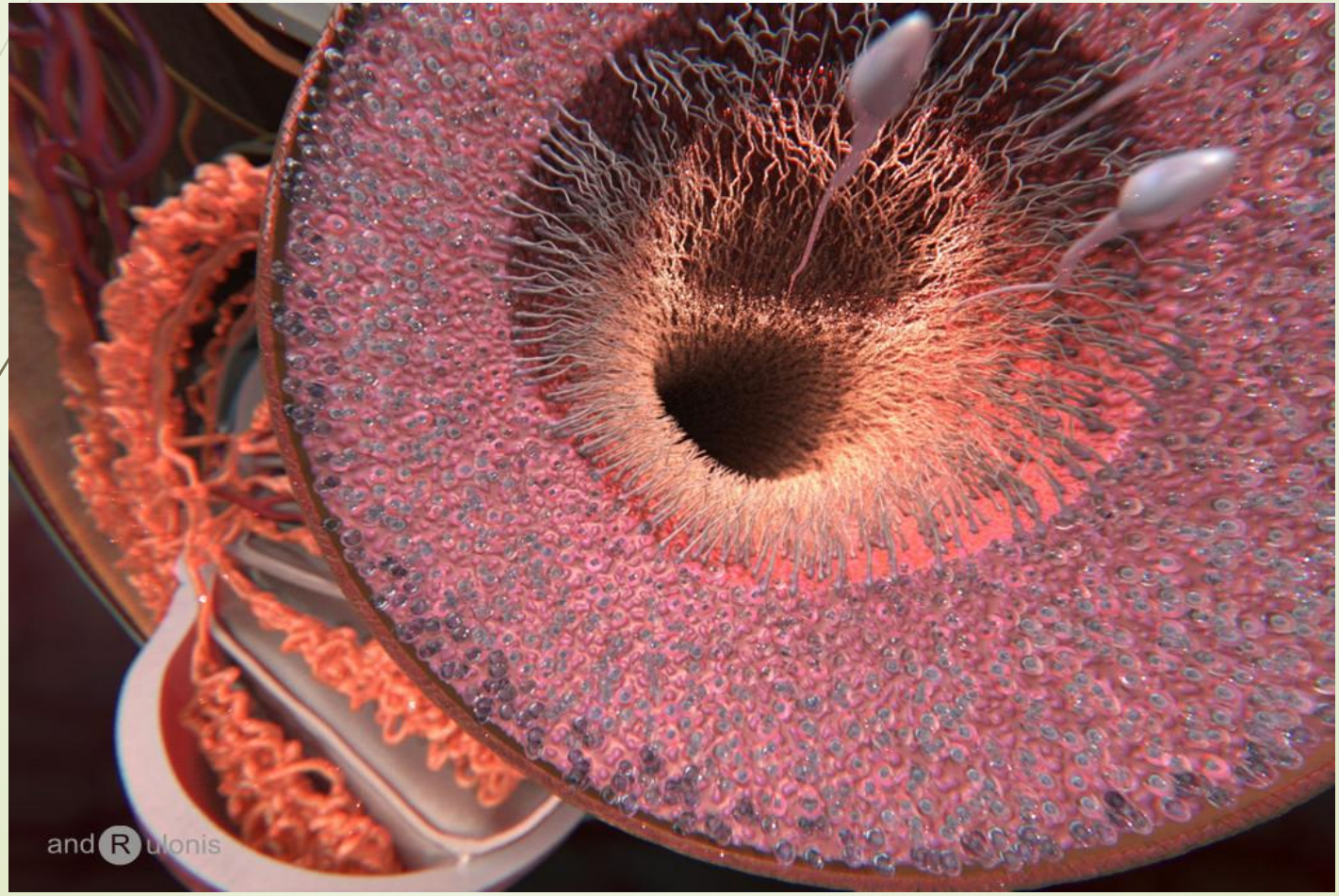
The first (and distinguishing) division of meiosis

Meiosis Makes Lots of Different Sex Cells – Crossing-Over



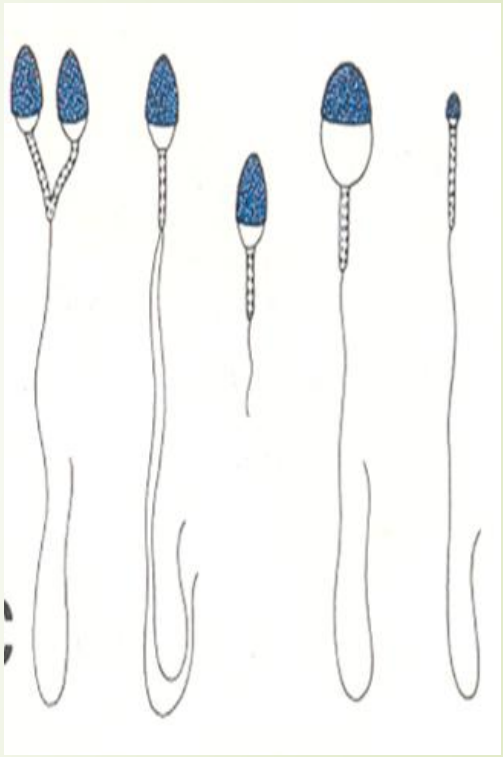
Crossing-over multiplies the already huge number of different gamete types produced by independent assortment.

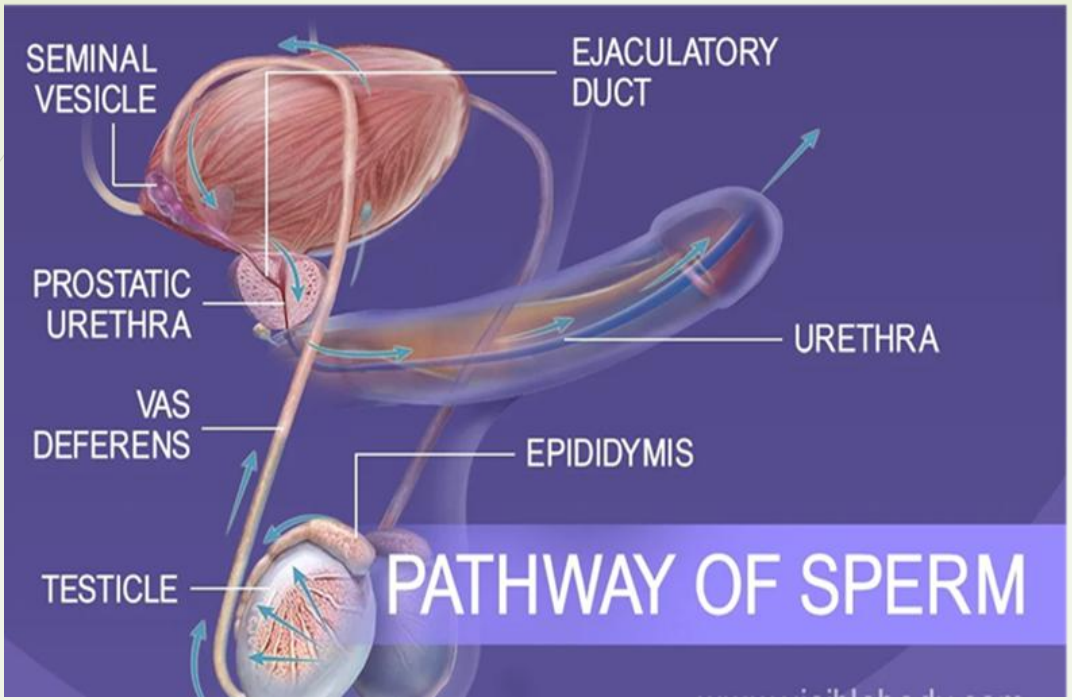
Any Guess ?



SCENARIO

- A 32-year-old male visited an infertility clinic with his wife after trying to conceive for two years without success.
- His medical history was unremarkable, and he denied any history of infections, trauma, or surgeries.
- His hormonal evaluation showed normal testosterone and FSH levels.





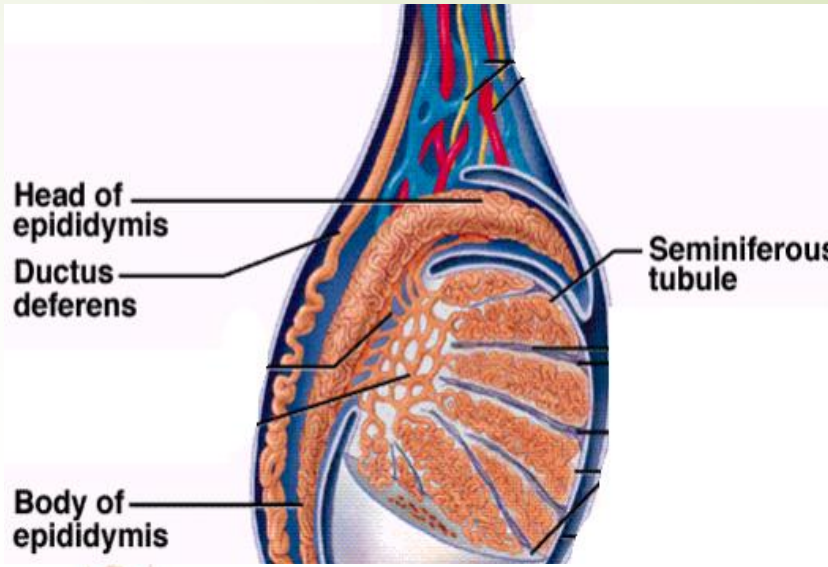
Sperm Transport - an overview

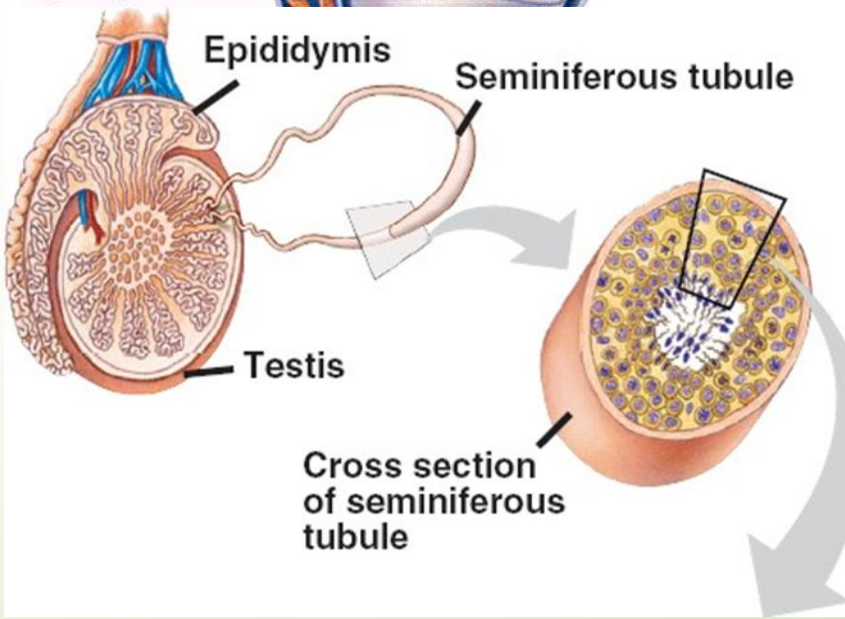
Testis Anatomy

- **Seminiferous tubules**

Convoluted coils which converge into the rete testis, which opens into the epididymis

•For production and transport of the sperm



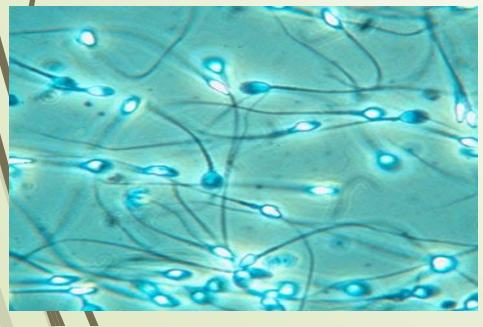


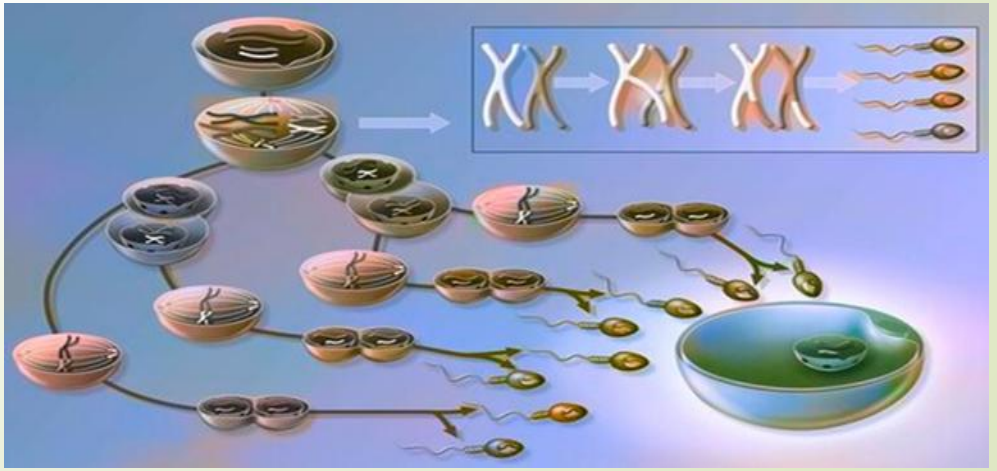
Epididymis

- Head , Body& Tail
- Connects to the vas deferens

Spermatogenesis

- It is the male gamete formation
- In the male, spermatogenic activity begins at puberty and continues throughout life
- The spermatogenic cells, called spermatogonia undergo mitotic division, whereby some cells remain as spermatogonia and some take the path of meiosis.





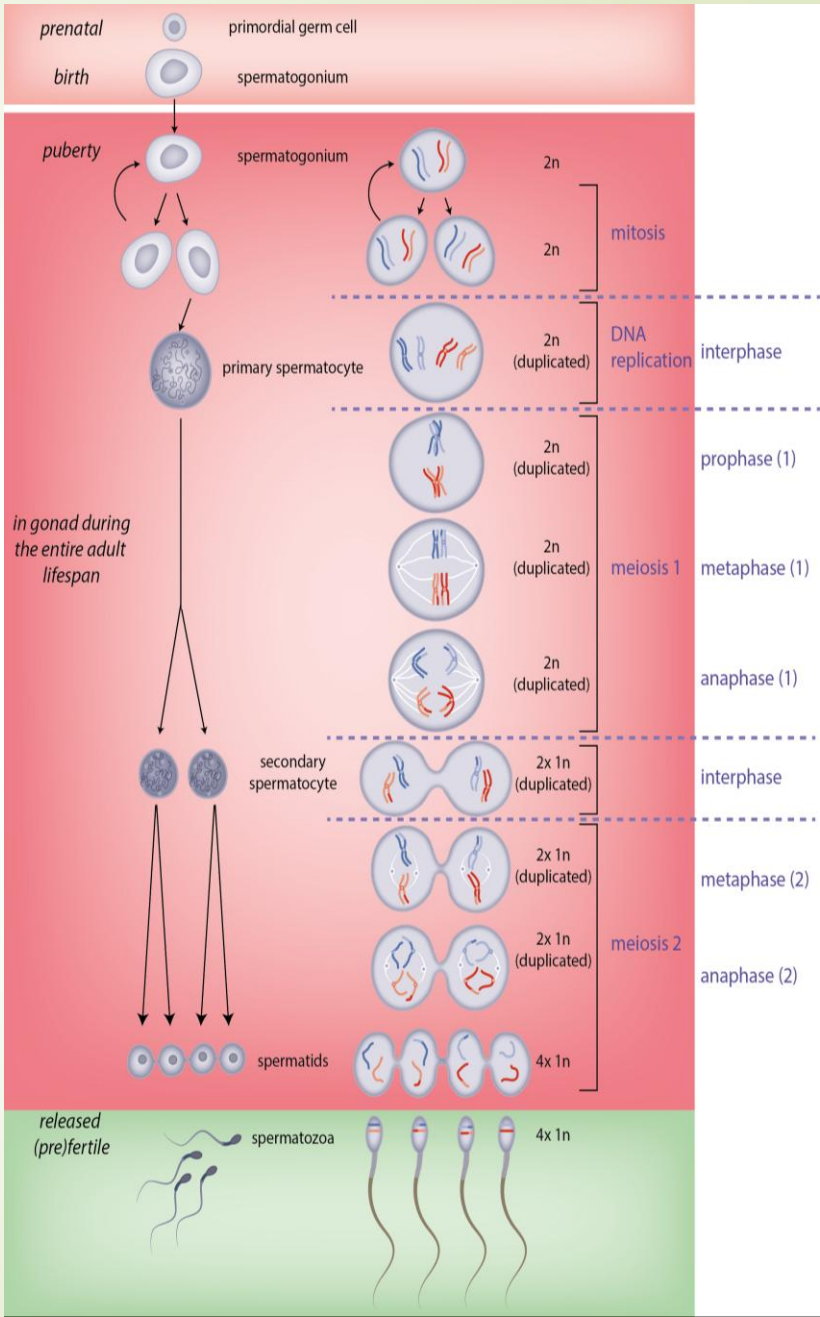
Spermatogenesis

Core Knowledge

Results in four haploid sperm from each diploid cell that undergoes meiosis.

a. Undifferentiated germ cells called **spermatogonia** (diploid) undergo mitosis to produce daughter cells called **primary spermatocytes**

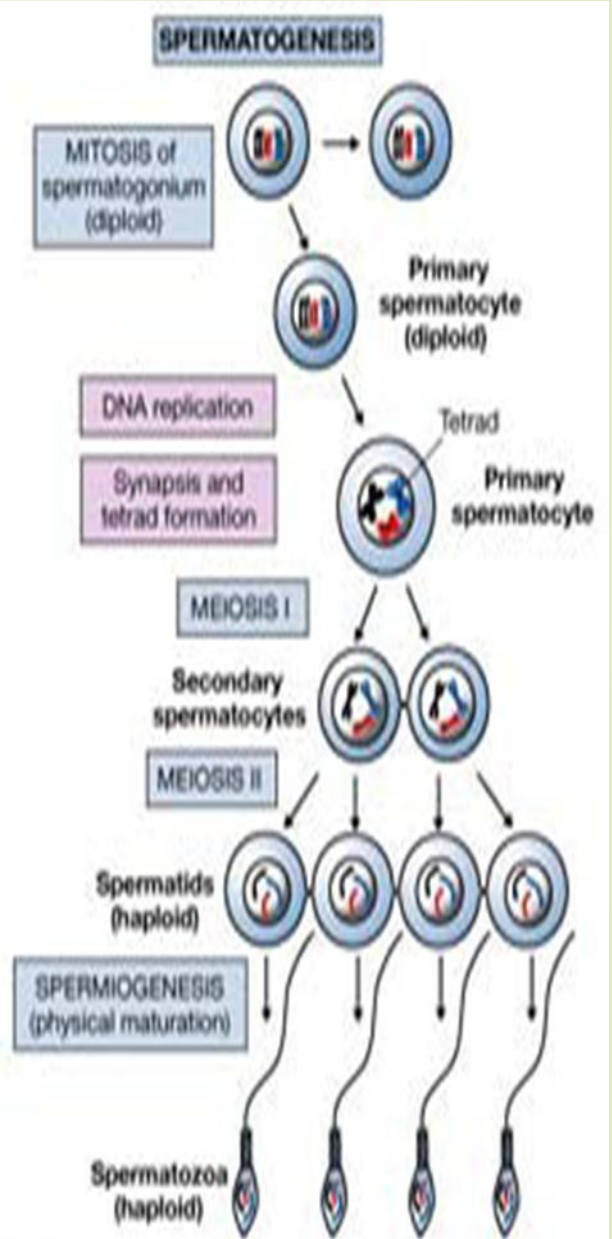
b.The primary spermatocytes undergo meiosis 1 to produce haploid **secondary spermatocytes** in a duplicated state.



Cont…

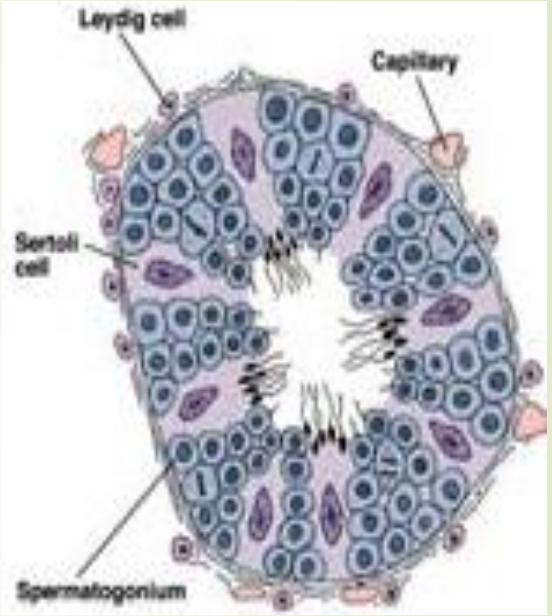
c. The sister chromatids of each chromosome separate from each other during meiosis II. The daughter cells are haploid **spermatids**.

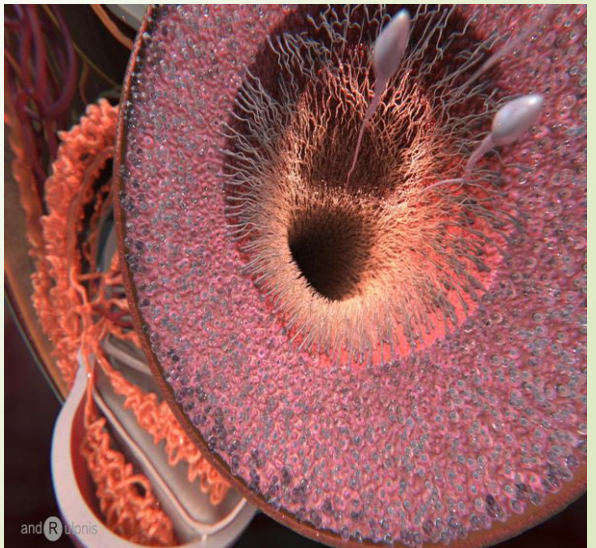
d. The spermatids will then eventually mature into functional **sperm** cells.



Seminiferous tubules at a Glance

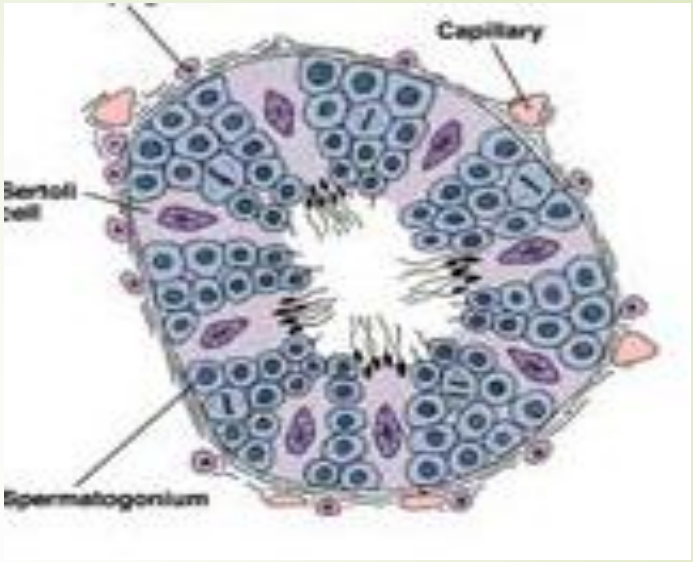
- Early spermatogonia are next to basal membrane
- As they divide and mature they move closer to the lumen
- Fully matured spermatids are released into the lumen of the seminiferous tubules

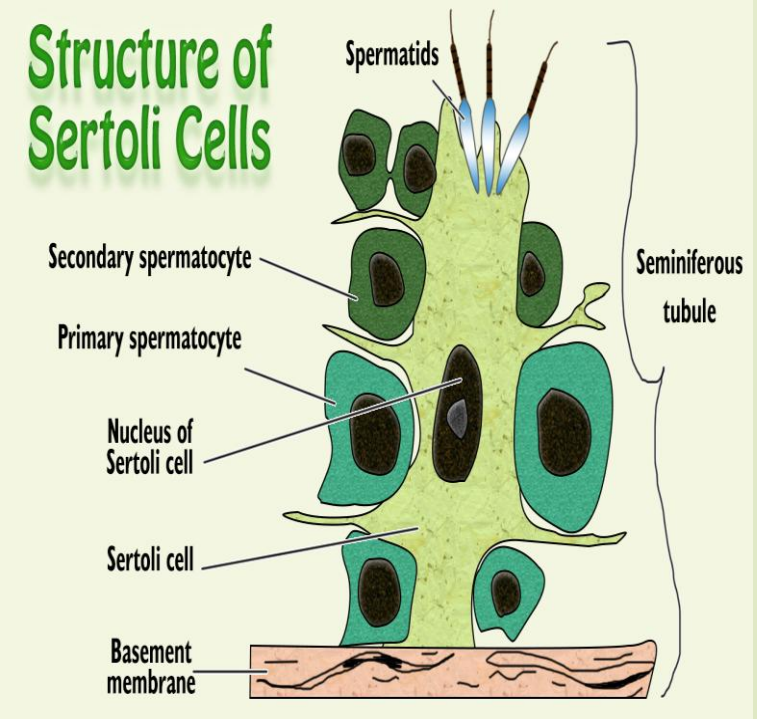




Sertoli cells

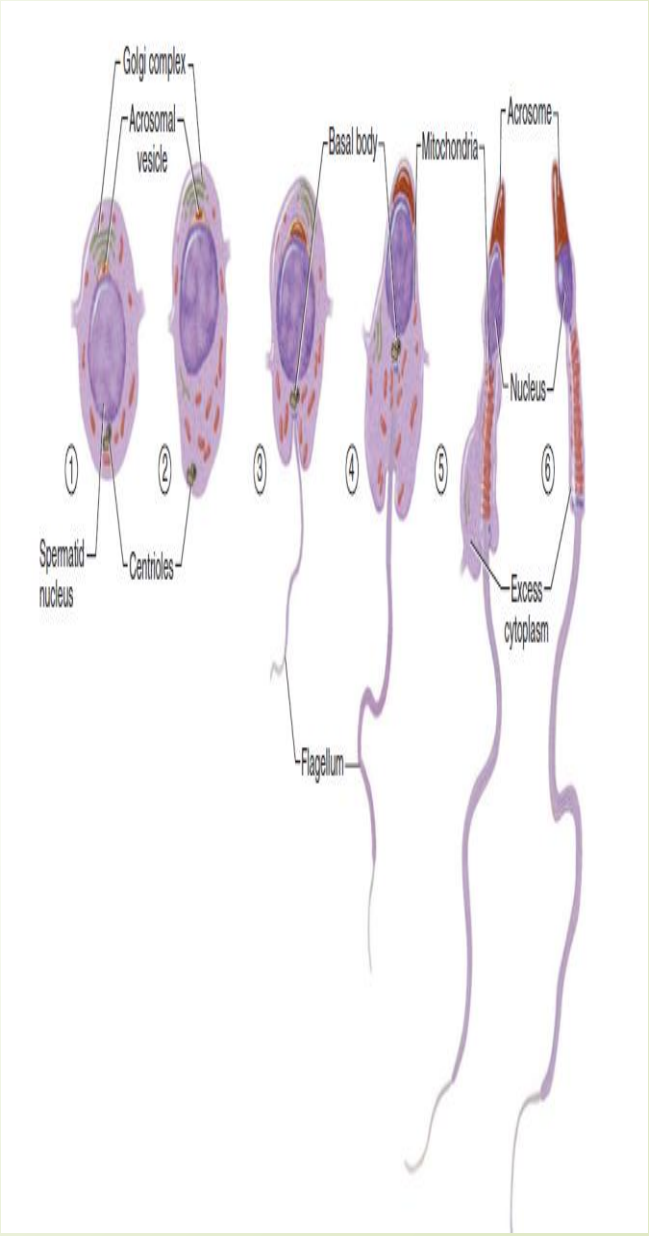
- Sertoli cells are "sitting" on the basal membrane
- With various stages of immature, as well as mature sperm cells embedded in them
- Tight junctions between Sertoli cells form blood testis barrier





Spermiogenesis

- The series of changes resulting in the transformation of spermatids into spermatozoa is **spermiogenesis.**
- Formation of acrosome
- Condensation of the nucleus;
- Formation of neck, middle piece, and tail;
- Shedding of most of the cytoplasm
- ***About 64 days are required to go from a spermatogonium to a sperm***



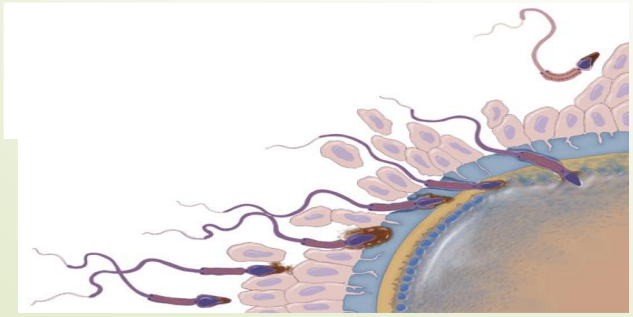
Fate of sperm cells

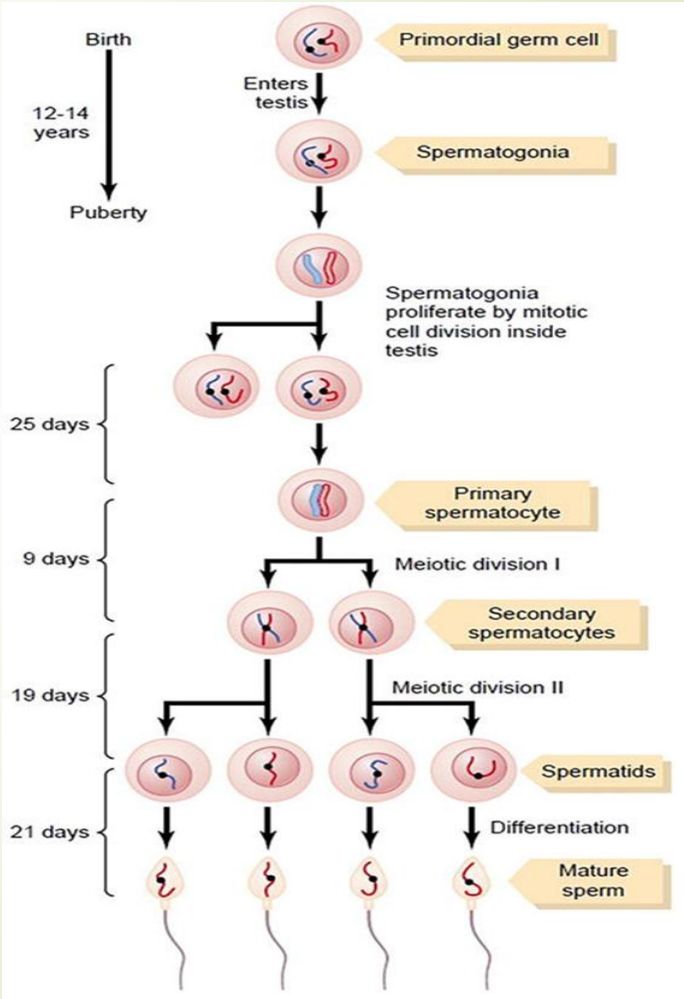
Men are busy – meiosis produces roughly 200-300 million sperm per day

viable for 2 days (egg: 12-24 hr)

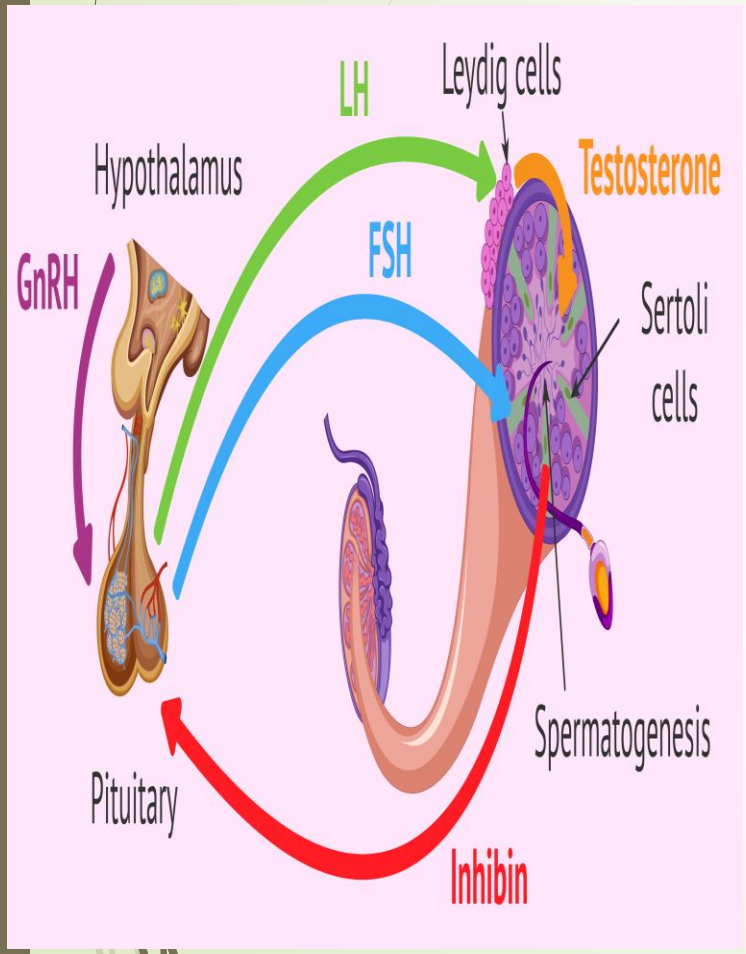
Only ~ 100 reach the destination.

Only one sperm fertilizes the egg.





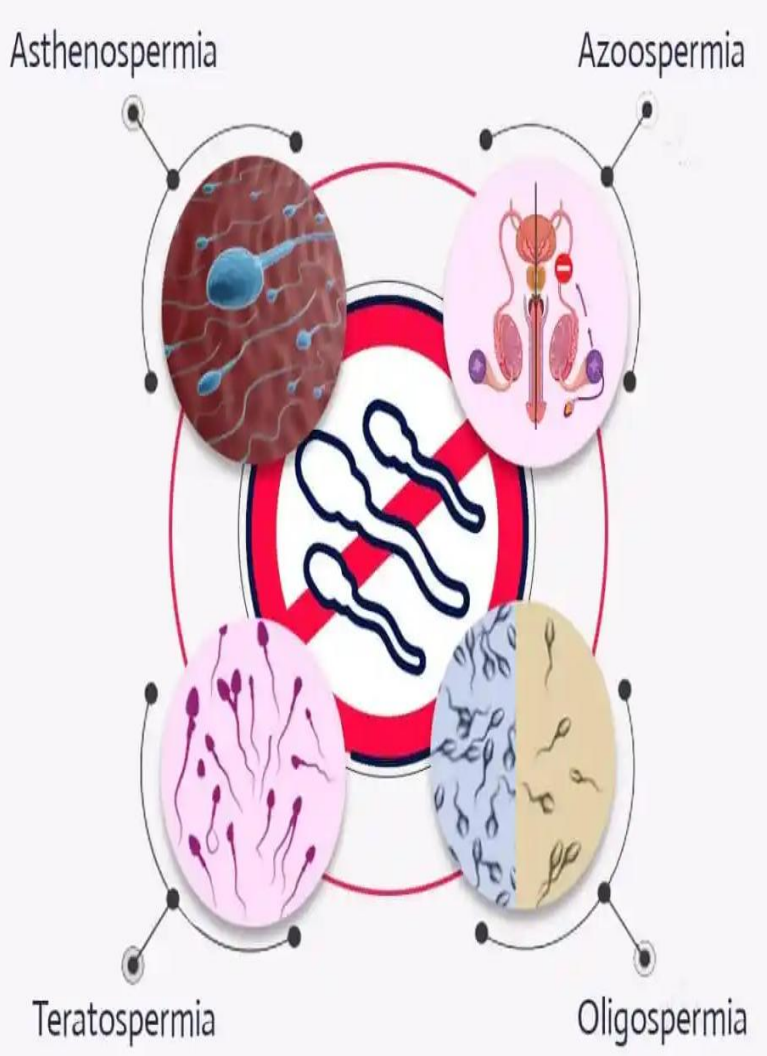
Role of Male Hormones



- LH released from the Ant. Pituitary in response to GnRH
- LH acts on leydig cells
- The Leydig cells are testosterone producing cells of the testis.
- Testosterone is required to initiate and subsequently support spermatogenesis .

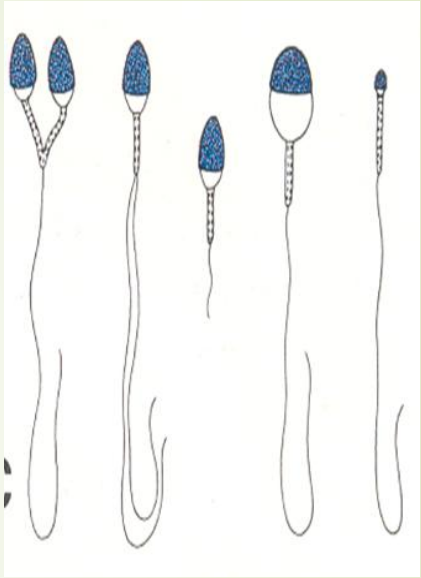
Male Infertility

- Normally, the ejaculate has a volume of 2 to 6 mL, with as many as 100 million sperm per milliliter.
- Men with less than 20 million sperm per milliliter are usually infertile.
- Male infertility may be a result of insufficient numbers of sperm and/or poor motility.



Male Infertility

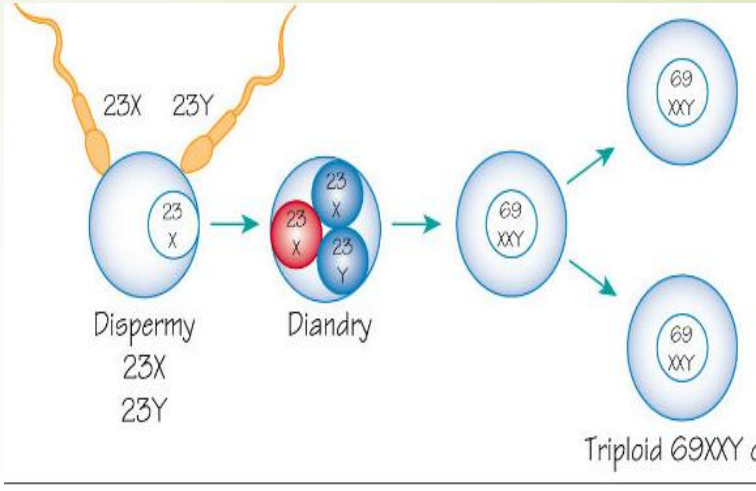
- As many as 10% of sperms ejaculated are grossly abnormal (e.g., with two heads), but it is believed that these abnormal sperms do not fertilize oocytes due to their lack of normal motility.



- Most morphologically abnormal sperms are unable to pass through the mucus in the cervical canal.
- Such sperms are not believed to affect fertility unless their number exceeds 20%.

Male Infertility

Vertical Integration



Too many sperm

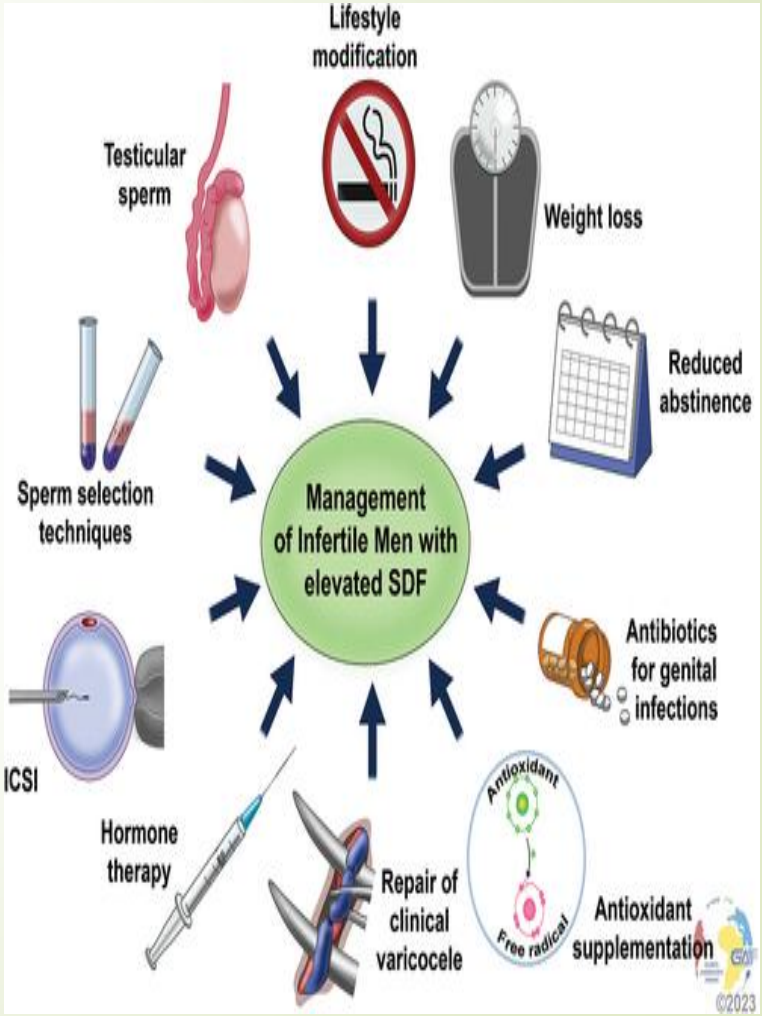
- Dispermy or triploidy
  - Leads to spontaneous abortion in most cases.

Bad timing:

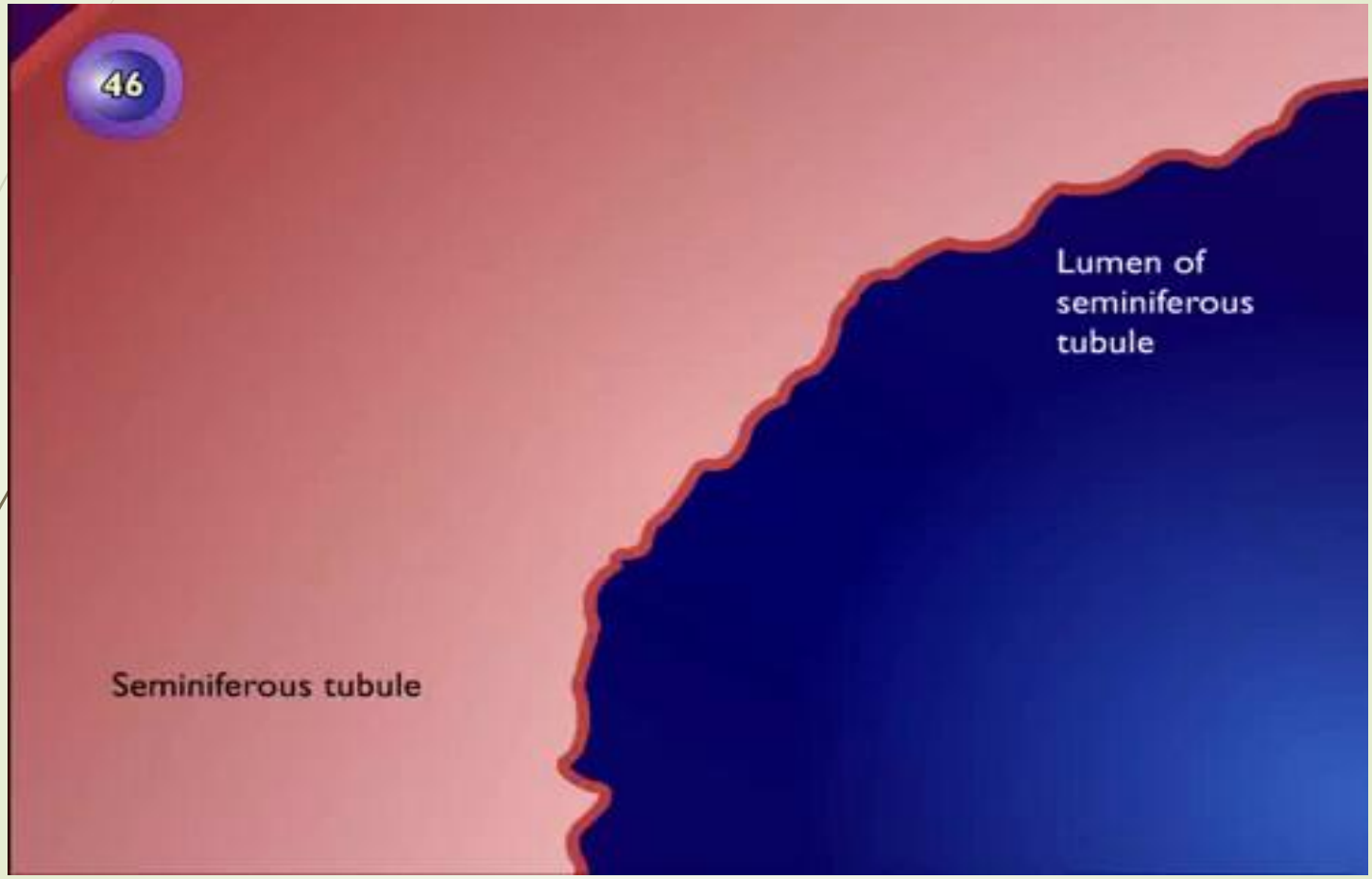
- The sperm can only survive 48 hours within the female genital tract.
- *In vitro* studies show the ovulated egg cannot be fertilized after 24 hours.

Treatment for male infertility

- Lifestyle modifications
- Surgery.
- Hormone therapy.
- Artificial insemination.
- In-vitro fertilisation (IVF)
- Intracytoplasmic sperm injection (ICSI)



SPERMATOGENESIS (Summary)



TAKE HOME MESSAGE

❑ Core Bioethical Principles:

The first 2 can be traced back to the time of Hippocrates “to help and do no harm,” while the latter 2 evolved later.

“Every human being has a right to determine what shall be done with his own body”

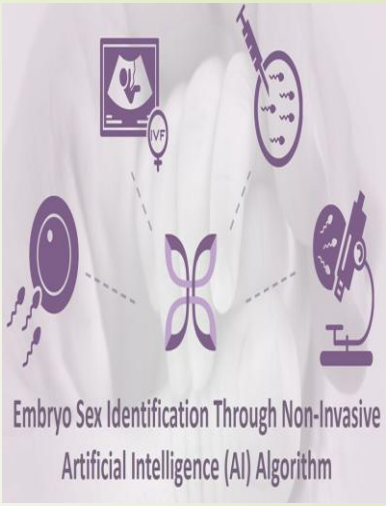
According to Aristotle “giving to each that which is his due”.

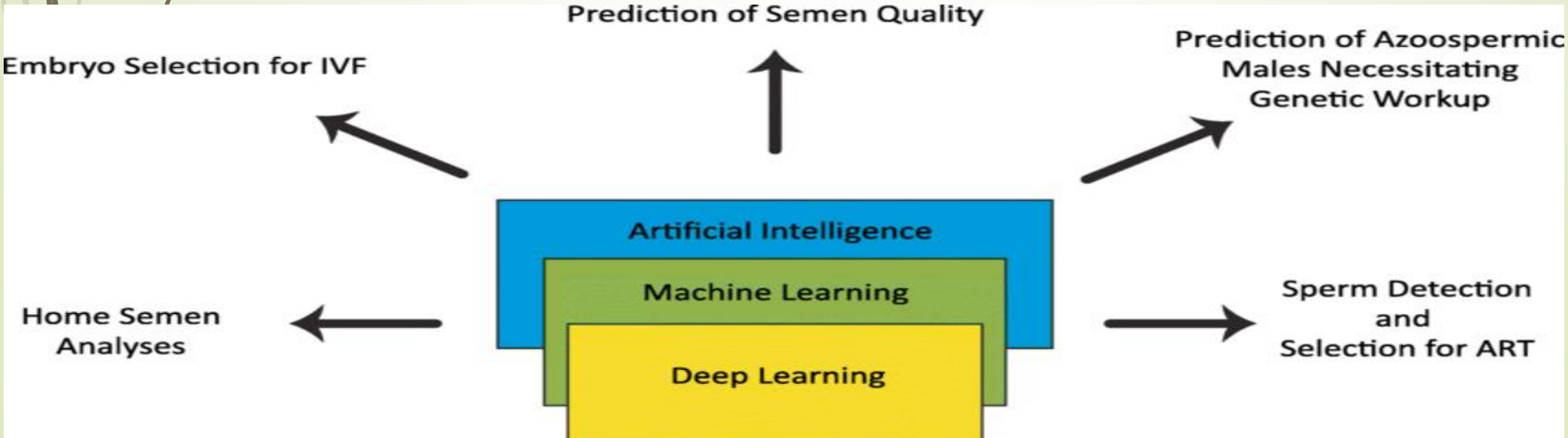
Everyone should qualify for equal treatment

Role Of Artificial Intelligence

Diagnostic Tools:

- AI can assist in the diagnosis of male infertility by analyzing various parameters related to sperm quality and function.
- For example, AI algorithms can analyze sperm morphology from microscopy images, assess sperm motility patterns, and predict fertilization potential based on various parameters.
- This can help clinicians diagnose specific causes of infertility and tailor treatment plans accordingly.

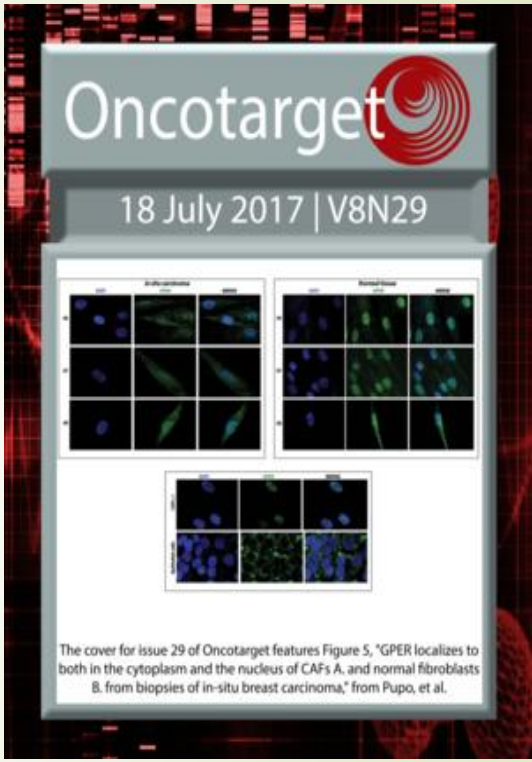




Title: Progress and future prospect of in vitro spermatogenesis

Abstract

Infertility has become a major health issue in the world. It affects the social life of couples and of all infertility cases; approximately **40–50% is due to "male factor" infertility**. Male infertility could be due to genetic factors, environment or due to gonadotoxic treatment. Developments in reproductive biotechnology have made it possible to rescue fertility and uphold biological fatherhood. **In vitro production of haploid male germ cell is a powerful tool,** not only for the treatment of infertility including oligozoospermic or azoospermic patient, but also for the fertility preservation in pre-pubertal boys whose gonadal function is threatened by gonadotoxic therapies. Genomic editing of in-vitro cultured germ cells could also potentially cure flaws in spermatogenesis due to genomic mutation. …



Reference: Ibtisham F, Wu J, Xiao M, An L, Banker Z, Nawab A, Zhao Y, Li G. Progress and future prospect of in vitro spermatogenesis. Oncotarget. 2017 Jul 27;8(39):66709-66727.

How to use the digital library

Steps to Access HEC Digital Library

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- On Home Page, click on the **INSTITUTES**.
- A page will appear showing the universities from Public and Private Sector and other Institutes which have access to HEC National Digital Library (HNDL).
- Select your desired Institute.
- A page will appear showing the resources of the institution
- Journals and Researches will appear
- You can find a Journal by clicking on **JOURNALS AND DATABASE** and enter a keyword to search for your desired journal.

Learning Resources

- KLM Embryology
- Langman's Embryology
- Google scholar
- Google images
- Youtube Animation