Human Reproduction

Humans are sexually reproducing, viviparous animals. Reproductive events :

1. Gametogenesis - formation of gametes
2. Insemination - sperm transfer to female
3. Fertilisation - fusion of M & F gametes
4. Implantation - blastocyst embedded in uterus
5. Gestation - embryonic development (9 months)
6. Parturition - delivery of baby
7. Lactation - milk secretion (mammary glands)

Onset of Reproductive Life

Begins at PUBERTY - triggered by hypothalamic GnRH.
Males 13-14 yrs ; Females 10-12 yrs (Menarche).
Ends at - Menopause (45-50 yrs in females);
Males - ~~andropause~~ no abrupt stop; gradual decline.

Secondary Sex Characters

Male : facial hair, deep voice, broad shoulders, developed muscles, body hair.
Female : enlarged breasts, broad pelvis, menarche, menstrual cycle, soft skin.

Driven by Testosterone (M) and Estrogen (F).

Male Reproductive System

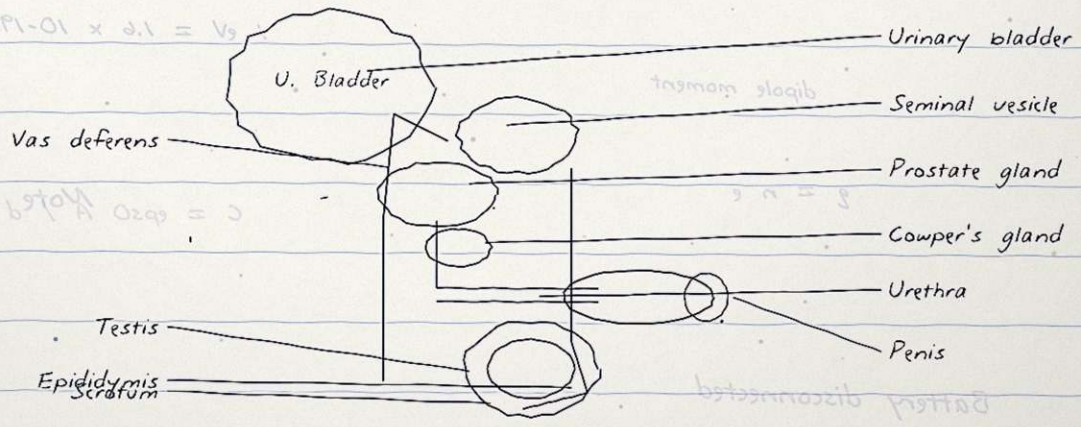
Located mainly in pelvis. Consists of:

Pair of testes (inside scrotum)

Accessory ducts (rete testis -> vasa efferentia -> Epididymis -> Vas deferens -> Ejaculatory duct)

Glands (seminal vesicle + prostate + Cowper's)

External genitalia (penis).



Testis - Detailed Anatomy

Pair of male gonads in SCROTUM (a sac outside body).
Why scrotum - testes need 2-2.5 deg C LOWER than body temp for spermatogenesis (37 -> 34.5 deg C).
If testes remain in abdomen (cryptorchidism) -> ~~hyperactive~~ s

Compartments

Each testis enclosed in tunica albuginea (capsule);
internally: divided into 250 testicular lobules.
Each lobule has 1-3 highly coiled seminiferous tubules.

Cells of the Tubule

Inside tubule (germinal epithelium):

1. Male germ cells - spermatogonia / spermatocytes / spermatids -> sperms
2. Sertoli cells - tall nurse cells -> nourish germ cells, form blood-testis barrier

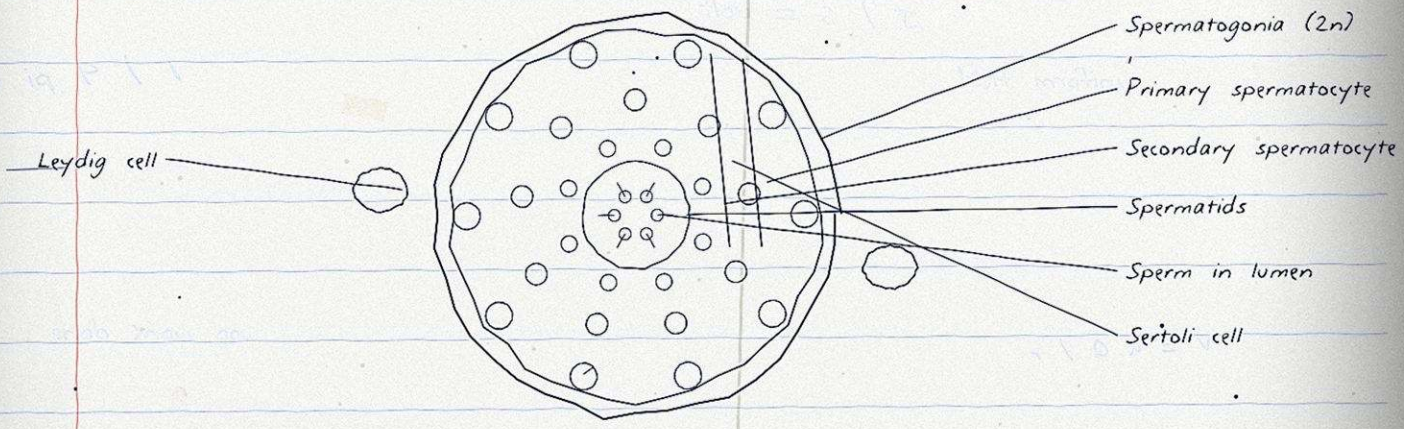
Between tubules (interstitial space):

3. Leydig (interstitial) cells - secrete testosterone
4. Blood vessels + immune cells

Functions of Testis

Spermatogenesis (sperm production) + ENDOCRINE (testosterone, inhibin from Sertoli, ABP).

T.S. of Seminiferous Tubule



Cell Function Recap

Sertoli - nourishes; secretes INHIBIN -> -ve feedback

Leydig - secretes ~~FSH~~ androgens (testosterone)

FSH - acts on Sertoli ; LH - acts on Leydig

Testosterone - spermatogenesis + 2dy chars + libido.

Spermatogenesis - Sequence

Production of mature spermatozoa from spermatogonia, starting at puberty. Process takes 64-72 days in man.

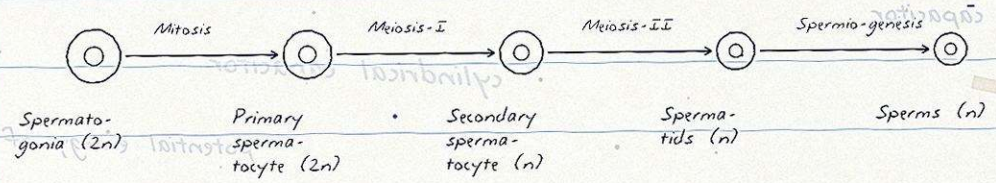


Fig. Stages of spermatogenesis

Hormonal Control

Hypothalamus GnRH -> Anterior pituitary :

FSH -> Sertoli -> spermatogenesis + ABP

LH (ICSH) -> Leydig -> Testosterone

Testosterone + Inhibin -ve feedback to ant. pit.

Spermiogenesis vs Spermiation

Spermiogenesis - spermatid -> spermatozoon (morphological change + tail development)

Spermiation - release of mature sperm from Sertoli cells into the tubule lumen.

Structure of a Sperm

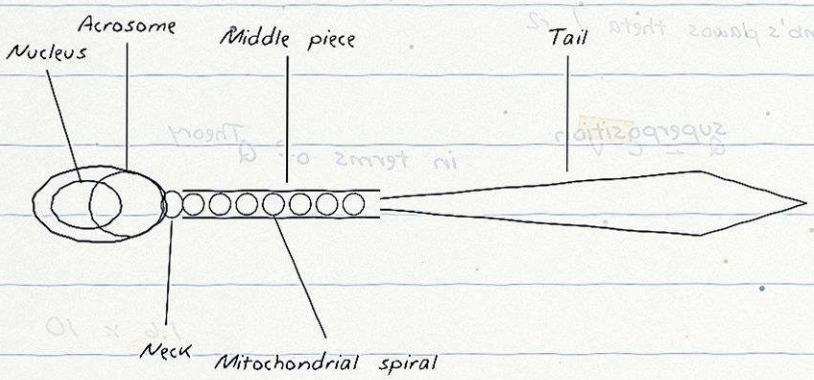


Fig. Mature human sperm

Parts & Their Roles

Acrosome - Hyaluronidase (drills through zona)

Nucleus - Haploid (n) - carries genetic info

Neck - Centrioles -> form sperm aster

Middle piece - Many mitochondria -> ATP

Tail - Flagellum (9 + 2 axoneme)

Sperm Numbers

A normal ejaculation = ~~20 ml~~ 2-3 ml of semen.

Sperm count 200-300 million; fertility >=60% normal.

Semen & Accessory Glands

Composition of Semen

Seminal plasma + sperms.

Plasma contributed by :

(1) Seminal vesicles - 60 % of volume
Rich in fructose (sperm energy), Vit C, prostaglandins, coagulating proteins.

(2) Prostate gland - 20-30 % volume
Slightly alkaline -> neutralises vaginal acidity.
Contains citric acid, enzymes (PSA).

(3) Cowper's (bulbourethral) - pre-ejaculatory lubricant
Clears urethra of acidic urine traces.

Sperm Maturation Trail

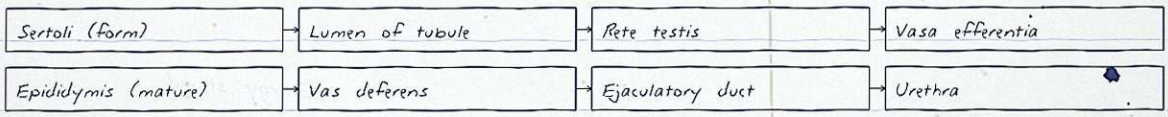


Fig. Path of sperm in male tract

Female Reproductive System

Located in pelvic region. Parts :

1. Ovaries (2) = primary reproductive organs
2. Fallopian tubes (oviducts)
3. Uterus = site of foetal development
4. Cervix + Vagina = birth canal

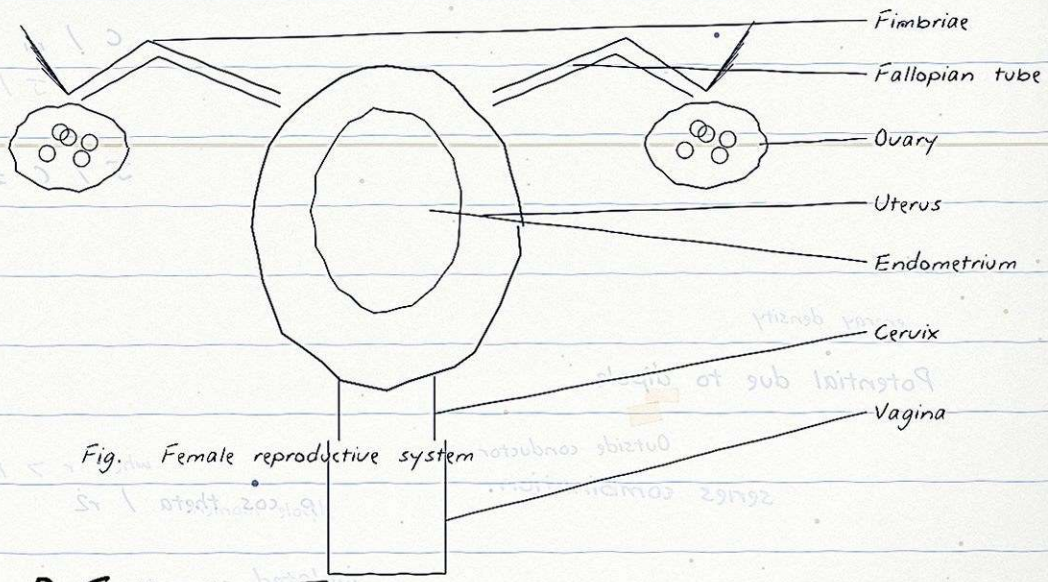


Fig. Female reproductive system

Parts of Fallopian Tube

Fimbriae -> Infundibulum -> Ampulla -> Isthmus -> uterus

Fertilisation site = ~~isthmus~~ AMPULLA-isthmus junction.

Mammary Glands

Uterus & Mammary Glands

Uterus

Hollow muscular organ, inverted pear-shape.

Parts - fundus (top), body, cervix (lower).

Three layers of wall (outer -> inner) :

(1) Perimetrium - external serous covering

(2) Myometrium - thick smooth muscle (contractile)

(3) Endometrium - innermost glandular (undergoes cyclic changes in menses).

Vagina

Highly elastic, fibromuscular tube; receives penis, serves as birth canal + outlet for menses.

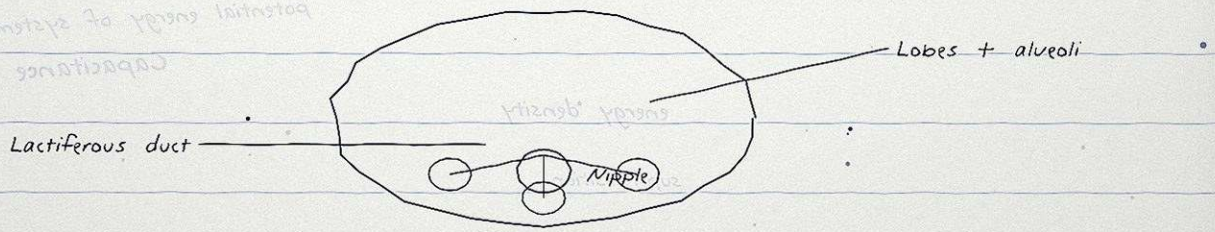
HYMEN (thin membrane) often partially covers opening.

Mammary Glands (functional in F)

Paired modified sweat glands. Each breast has :

15-20 mammary lobes - contain alveoli (cells secreting milk).

Mammary tubules -> ducts -> ampullae -> lactiferous ducts -> nipple.



Oogenesis

Formation of ovum in the ovary.
INITIATED during foetal life (unlike spermatogenesis).

Timeline

Foetal stage :
Oogonia (2n) divide by mitosis (only in foetus)
-> Primary oocytes (2n) - enter prophase-I
Arrest at ~~metaphase~~ DIPLOTENE of prophase-I (DICTYATE

Birth : 1-2 million primary oocytes
Puberty : 60-80 thousand remain
Each cycle : 1 primary oocyte resumes meiosis I
-> secondary oocyte (n) + 1st polar body
Secondary oocyte arrests at METAPHASE-II.
Fertilisation -> meiosis-II completes ->
ovum + 2nd polar body.

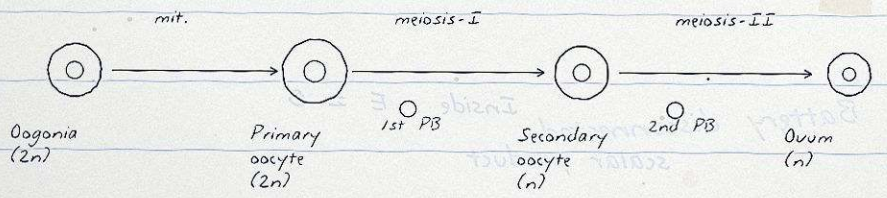


Fig. Oogenesis stages

Graafian Follicle Development

Primary oocyte develops within a follicle.

Follicle stages : primordial -> primary -> secondary -> tertiary -> GRAAFIAN (mature).

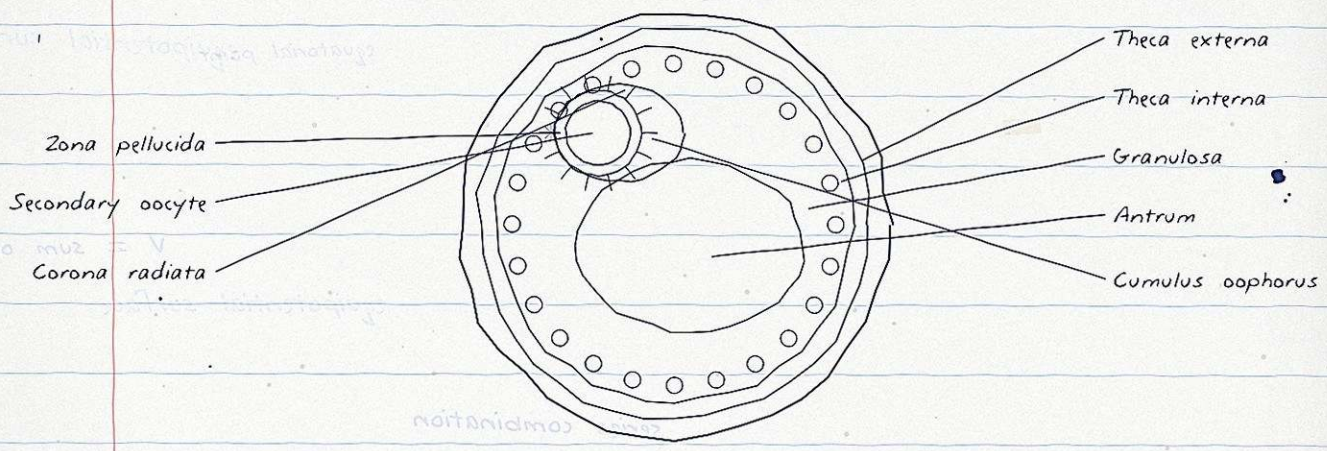


Fig. Graafian (mature) follicle

Atresia

Most follicles degenerate without maturing.

Only 400 follicles ovulate over lifetime.

Corpus Luteum

Menstrual Cycle (4 phases)

Reproductive cycle of female primates (28 days).
Begins at menarche, ends at menopause.

Phases

1. Menstrual (1-5 d) - endometrium sheds; bleeding
2. Follicular (6-13 d) - follicle grows; estrogen
3. Ovulation (14 d) - LH SURGE -> egg released
4. Luteal (15-28 d) - corpus luteum -> progesterone

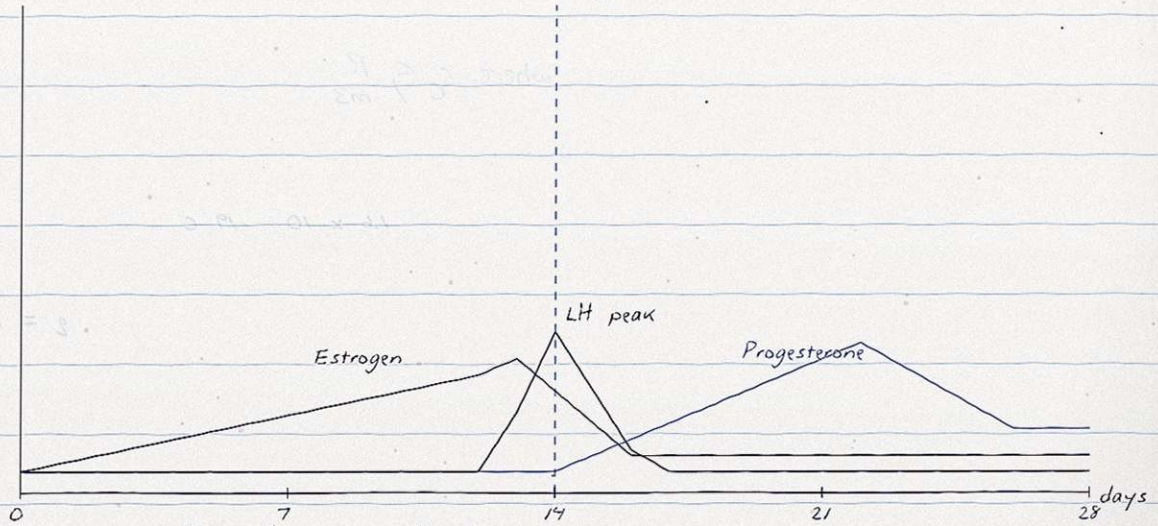


Fig. Hormone profile during cycle

If Fertilisation Doesn't Occur

Corpus luteum ~~becomes embryo~~ degenerates (corpus albicans); progesterone drops -> endometrium sheds -> Menses.

If Fertilisation Occurs

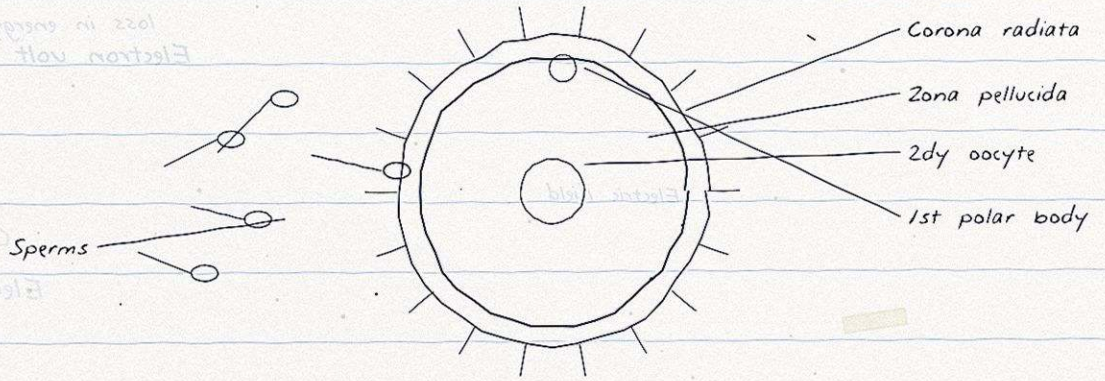
CL maintained by hCG (from chorion) -> no menses.

Fertilisation

Fusion of sperm + secondary oocyte.

Site : AMPULLARY-ISTHMIC junction of fallopian tube.

Only ONE sperm enters egg; others repelled.



Mechanism of Fertilisation

1. Sperm reaches corona radiata.
2. Acrosomal reaction - releases hyaluronidase + acrosin to digest zona pellucida.
3. Sperm membrane fuses with egg membrane.
4. Cortical reaction - prevents POLYSPERMY.
5. Sperm nucleus enters; egg completes meiosis-II.
6. Nuclei (n + n) fuse = ~~triploid~~ ZYGOTE (2n).

Sex Determination at Conception

Cleavage & Blastocyst

Mitotic divisions of zygote (NO growth between divisions) as it moves down the fallopian tube to uterus.

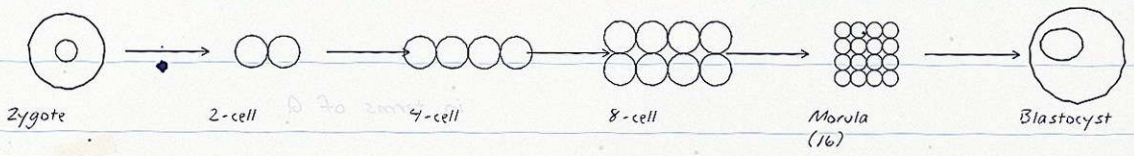


Fig. Cleavage to blastocyst

Parts of Blastocyst

TROPHOBLAST - outer layer of cells (attaches to uterine wall, becomes placenta)

INNER CELL MASS - becomes the embryo proper

BLASTOCOEL - fluid-filled cavity inside

Implantation

Trophoblast attaches to endometrium day 7-8;

Blastocyst gets embedded -> implantation.

Stem Cells

Inner Cell Mass - pluripotent (can form any cell).

Placenta - Structure

Temp organ; finger-like CHORIONIC VILLI of trophoblast intermesh with uterine endometrium.

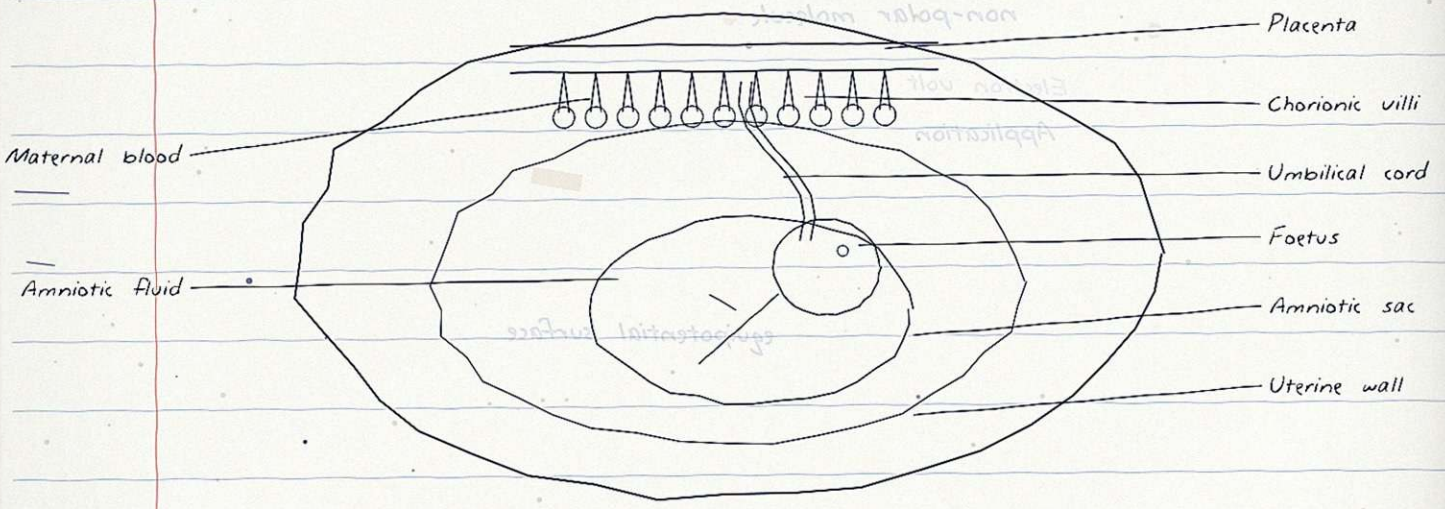


Fig. Foetus + placenta

Functions

(i) Nutrient supply - glucose, aa, fats

(ii) Gas exchange - O2 in, CO2 out

(iii) Excretion of waste from foetal blood

(iv) Endocrine - hCG, hPL, estrogen, progesterone

(v) Immune barrier - protects foetus

(vi) Passive immunity (IgG crosses placenta).

Foetal Development Timeline

Trimester-wise

M-1 limb buds + facial features ; heart beats
M-2 limbs, digits formed; ear, eye visible
M-3 major organ systems formed; sex identifiable
M-4 rapid growth ; fine hair (lanugo)
M-5 foetal movements felt by mother ; hair on head
M-6 eye-lids separate ; respiratory system develops
M-7 viable if born ; CNS development
M-8 fat layer deposits ; movements vigorous
M-9 fully developed ; head engages in pelvis ; delivery.

Three Germ Layers (Gastrulation)

Inner cell mass differentiates into :

ECTODERM - skin, nervous system, sense organs
MESODERM - muscle, bone, blood, kidney, gonads
ENDODERM - gut, lungs, liver, pancreas, glands

Embryonic Period

1st 2 months = EMBRYO ; thereafter FOETUS.
Heart beats from 24 days ; visible on USG 6 wks.
Most ~~organogenesis~~ teratogen sensitivity in 1st trimester.

Parturition (Childbirth)

Average gestation 266-280 days (40 weeks).
Initiated by neuroendocrine FOETAL EJECTION REFLEX.

Three Stages of Labour

1. Dilation - cervix opens (longest)
2. Expulsion - baby is delivered
3. Placental - placenta is expelled (30 min)

Lactation

Production + secretion of milk by mammary glands.
Begins in last trimester (preparation) and increases rapidly after parturition.

Hormones Involved

PROLACTIN (anterior pit) - milk synthesis in alveoli
OXYTOCIN (post pit) - milk ejection (let-down reflex on baby's suckling).
Estrogen + progesterone ~~promote~~ inhibit prolactin during pregna

Colostrum

First milk for 3-4 days after delivery.
YELLOWISH, thicker than regular milk.
Rich in IgA antibodies, leukocytes, growth factors, and vitamins -> passive immunity to neonate.

Breast Feeding

WHO recommends exclusive breast feeding for first 6 months of infant's life.
Benefits:

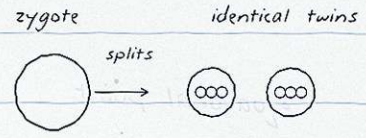
1. Complete nutrition
2. Passive immunity (from antibodies)
3. Bonding (oxytocin)
4. Natural contraception (LAM, 6 mo)

Twins & Multiple Births

(1) Monozygotic / Identical

Single zygote splits into TWO embryos.

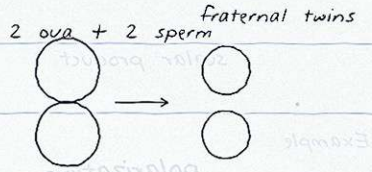
Same DNA; same sex, look identical.



(2) Dizygotic / Fraternal

Two ova fertilised by two different sperms.

Different DNA, may be different sex.



Conjoined (Siamese) Twins

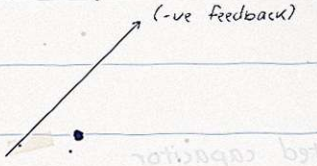
Incomplete separation of monozygotic embryos.

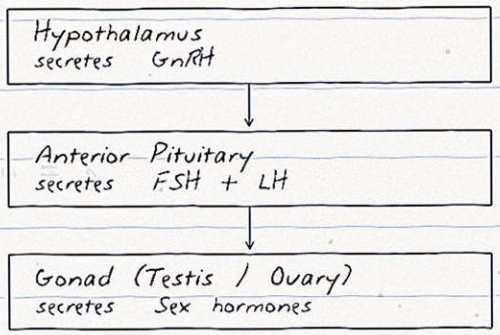
Higher Multiples

Triplets, quadruplets etc. more common with ART (fertility drugs / IVF).

Hormonal Control Loops

HPG Axis (Hypothalamus - Pituitary - Gonad)





Notes - Male

FSH -> Sertoli (-> ABP, inhibin)

LH (ICSH) -> Leydig -> Testosterone

Testosterone + Inhibin -> -ve feedback

Notes - Female

FSH -> follicle growth ; estrogen rises

LH surge -> ovulation ; CL -> progesterone

Important Terms & Recap

Menarche	- first menstruation (puberty in F)
Menopause	- permanent cessation of cycle
Oligospermia	- low sperm count
Azoospermia	- no sperm in semen
Cryptorchidism	- undescended testes
Anovulatory	- cycle without ovulation
Vasectomy	- cut vas deferens (M sterilisation)
Tubectomy	- cut fallopian tubes (F sterilisation)
Embryo (1-8 wk)	- vs Foetus (after 8 weeks)
Cleavage	- mitosis WITHOUT growth
Implantation	- blastocyst embeds in endometrium
Gastrulation	- 3 germ layers form
Organogenesis	- organs differentiate
Parturition	- delivery of baby
Lactation	- milk secretion
Colostrum	- first milk - IgA, immunity
Polyspermy	- multiple sperms enter -> prevented
hCG	- secreted by chorion ; maintains CL
Atresia	- follicle degeneration
Corpus albicans	- scarred CL after degeneration

Key Points for Exams

Numbers to Remember

Testis temperature - 2-2.5 deg C below body

Each testis - 250 lobules

Sperm count / ejaculation - 200-300 million

Spermatogenesis duration - 64-72 days

Primary oocytes at birth - 1-2 million

Primary oocytes at puberty - 60-80 thousand

Menstrual cycle - 28 days, ovulation day 14

Gestation - 266-280 days (40 weeks)

Implantation - day 7-8 after fertilisation

Site Mapping

Spermatogenesis - seminiferous tubule (testis)

Sperm maturation - Epididymis

Fertilisation - Ampulla of fallopian tube

Implantation - Endometrium of uterus

Oogenesis - Ovary cortex

Hormone Map

Testosterone - Leydig cells -> 2dy chars + sperm

Estrogen - Granulosa, theca, placenta

Progesterone - CL, placenta

hCG - Chorion -> pregnancy test

Oxytocin - Posterior pit -> uterus + breasts