Sperm Transport

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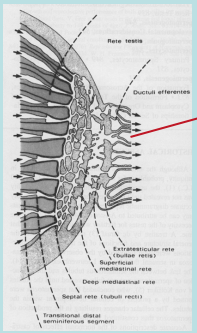
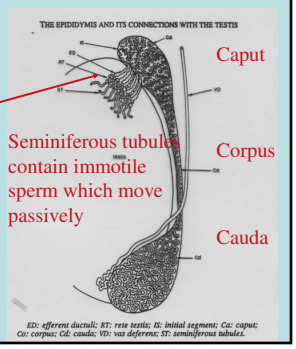
Objectives

To understand the post-testicular developments in sperm.

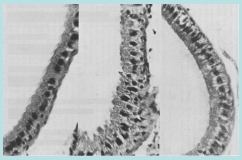
To understand the interaction between sperm and the female reproductive tract.

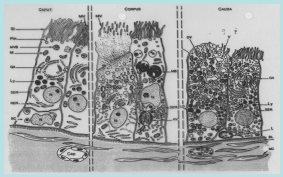
The epididymis & connections with the Testis.



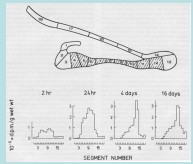


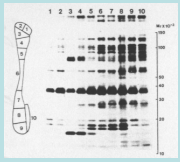
The epithelial cells of the epididymis change along the length

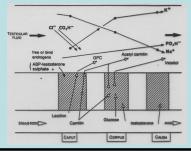


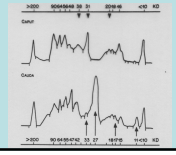


Uptake of radioactive methionine, proteins & immunostaining, elecrolyte changes in the epididymis of rodents; & Proteins in Chimps









Epididymis

A convoluted tube dorsolaterally on the testis

- Allows concentration of sperm numbers (10-100x)
- Post-testicular maturation
- Storage (70% of sperm)
- Sperm passage by peristaltic muscle contraction in duct wall - ~ 12 days.
- Passage time is influenced by ejaculatory frequency.
- Non ejaculated sperm degenerate and are reabsorbed or expelled by retrograde leakage into bladder.

Development of fertilising ability

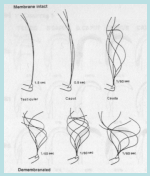
based upon homologous % IVF or HOPT

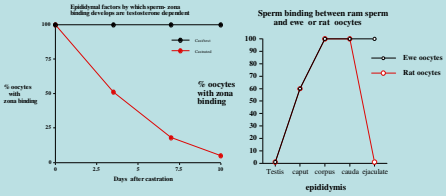
Species	Caput	Corpus	Cauda
Mouse	0	7	100
Rabbit	0	4 - 30	85 - 100
Pig	4	20 - 77	100
Human	0	0 - 50	100

•Sperm in cauda are more fertile than those from caput.
•Sperm acquire motility (in aerobic conditions) with different patterns (amplitude) as they pass.
•Sperm are exposed to sequential changes in electrolyte and proteins - precise role(s) have not been fully elucidated.

Post testicular maturation

- Loss of cytoplasmic droplet
- Potential for motility
- Potential for fertilisation





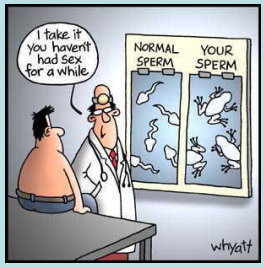
Proteins secreted by rat epididymal epithelium and possible roles

Size (kDa)	Homology	Possible function
18-28	Retinoic BP	-
27-37	Lipid BP	motility, zona binding, vitellus interaction
66-70	Lipid BP	Immunosuppression
23.2	2D6 antigen	Sperm-vitellus interaction
>400	Immobilin	Restriction of flagella movement

Duration of Transit times through epididymis in mammals

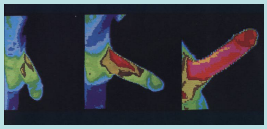
Species	Caput	Corpus	Cauda	Total
Human	1-2.5	0.5	5	1-12
R.Monkey	3		5	8-10
Stallion	1	1.5	6	7.5-10
Ram	1	3	8	13
Bull	2	2	10	14
Pig	3	2	4-9	9-14
Hamster	3	2	8	13
Guinea-pig	3	2	6-8	10-15
Rabbit	3	1	5-6	9-10
Rat	3	3	5	11
Mouse	-	-	-	3-5

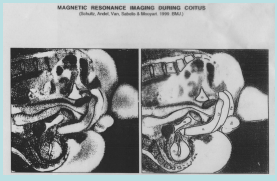
Sperm Transit.



- Sperm transit times can be effected by sexual activity and impact on the quality of sperm found in the ejaculate.

Penile erection, leading to coitus and ejaculation





•Orgasm requires ' build-up of excitation in specific centres in the central nervous system.
•May be divided into :-
Seminal emission - oozing of semen associated with alpha adrenergic neurons.
Ejaculation proper - Emission in pulsatile spurts usually in tandem with orgasm.

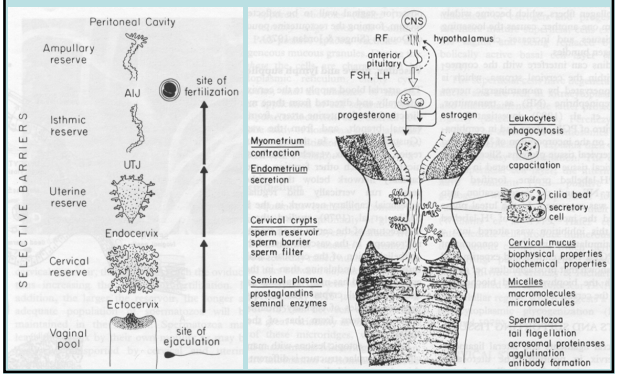
The ejaculatory sequence

Gland	Ejaculatory Sequence	Vol. (ml)	Characteristics
Cowper's Gl.Littre	1	0.2	
Prostate 3.5x4 cm 20g	2 Serous / acidic	0.5 15-30%	Citric acid, zinc Acid phosphatase Fibrinolytic enzymes
Epididymis Spermatocrit	2	- 1-5%	Spermatozoa - Glycerylphos-phorycholine
Seminal Vesicles Pair~5cm	3	2-2.5 50-80%	Fructose, proteins Prostaglandins Depleted in single ejaculate

No. of sperm and site of semen deposition

Species	Sperm No./ej.	Site	No.in ampulla
Mouse	50	Uterus	<100
Rat	58	Vagina	500
Rabbit	280	Vagina	250-500
Ferret	-	Uterus	18-1600
Guinea Pig	80	Vagina/ Uterus	25-50
Bull	3000	Vagina	Occasional
Ram	1000	Vagina	600-700
Boar	8000	Uterus	1000
Man	280	Vagina	200

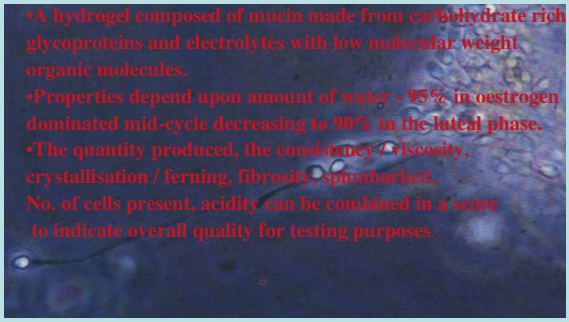
Barriers for sperm within the female tract



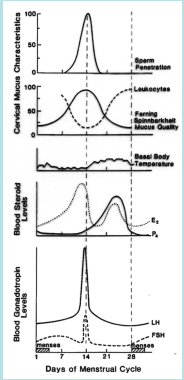
Semen deposition into vagina

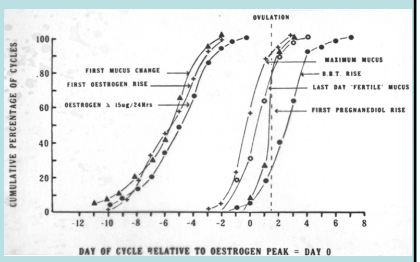
- Semen is deposited close to external os in human.
- Vaginal pH <5, hostile to sperm and alkaline semen provides a better milleu.
- Seminal plasma coagulates and then is broken down over 20-30 min.by which time most sperm that are able are thought to have penetrated cervical mucus.
- In some species a negative vaginal pressure may occur during intromission sucking sperm into the vaginal canal.
- Some species develop a vaginal plug.

Sperm penetration of cervical mucus.



Cervical mucus changes through the menstrual cycle

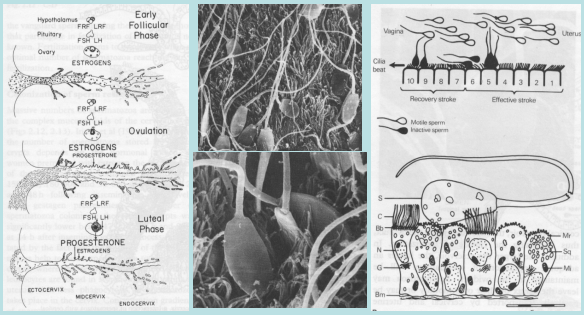




Sperm transport through the cervix.

- Coitus on the day of max. mucus hydration is correlated with pregnancy and micro-architecture may provide channels.
- Generally considered semen does not usually enter uterus in human.
- Carbon particles placed in vagina may be found in oviduct within minutes - too fast for sperm motility alone.
- Only motile sperm penetrate mucus.
- Sperm colonise extensive crypts in cervix and some species deep channels may provide route to uterus.
- Whether sperm are able to leave crypts where considerable leukocytosis occurs in unclear.
- The central cervical column may the limit of the cervical reservoir.

Sperm interactions within the cervix



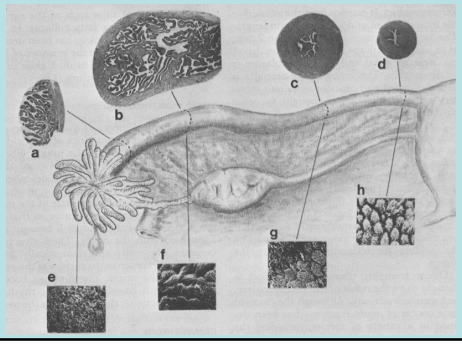
Time from coitus or AI to arrival of spermatozoa in oviduct

Species	Time(min)	Reg.of tube
Mouse	15	Ampulla
Rat	15-20	Ampulla
Hamster	2-60	Ampulla
Rabbit	A few	Ampulla
Guinea pig	15	Ampulla
Bitch	2->60	Oviducts
Sow	15	Ampulla
Cow	1-13	Ampulla
Ewe	6 -300	Ampulla
Women	5-68	Oviducts

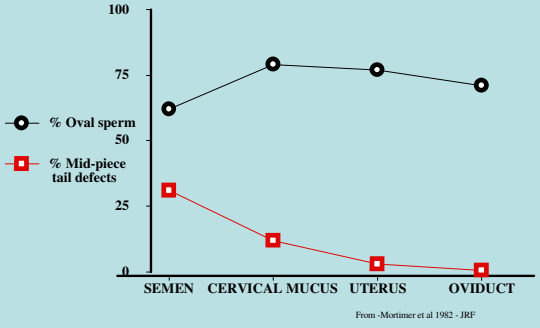
Sperm transport through uterus & uterotubule junction.

- Since sperm reach oviducts so rapidly smooth muscle contraction must have some role.
- Only small numbers of sperm are found in oviduct even in species that deposit semen directly in the uterus.
- The uterotubule junction appears to act as some sort of barrier but anatomically a mechanism is unclear since inanimate particles can pass though perhaps cell-cell interactions, a vascular plexus & viscous mucus may have roles.

The fallopian tube



Changes in sperm morphology during passage through the female reproductive tract - sperm selection.



Sperm transport through oviduct

- Sperm may passage through oviduct since they may be recovered in peritoneal fluid.
- There is evidence of sperm selection in tract.
- Sperm may survive for 4 -7 day but often only only as little as a day.
- It has been suggested that the first sperm to arrive at the site of fertilisation act as ‘pathfinders’.
- The initial failure of IVF was overcome by sperm exposure to oviductal fluid leading to the concept of ‘ capacitation’.

Storage reservior(s)

- Various compartments have been postulated, perhaps the most compelling is physiological interactions with female tract.
- The ability of sperm to interact with cells of the female tract may be influenced by acquired molecules from seminal plasma, removal of such molecules could effect hyperactive motion.

Capacitation

- A species and time dependent preparation for fertilisation - *in the cat fresh epidiymal sperm appear ready for fertilisation and guinea pig sperm can acrosome react without in vitro incubation.*
- Not all sperm undergo a 'physiological' capacitation despite the population of sperm gaining functional competence.
- Early signs of sperm senescence may be similar to capacitation
- Whether some changes associated with capacitation are essential or facilitate fertilisation remains unclear.

Sperm competition

- Male competition and female promiscuity are common features of sexual selection.
- Reproductive traits evolve rapidly when females are promiscuous producing exaggerated phenotypes.
- In some species females exhibit discrimination between the sperm of different males.
- In some species sperm quality is influenced by female novelty.

John Calvin and Grace 'The Coolidge Effect'

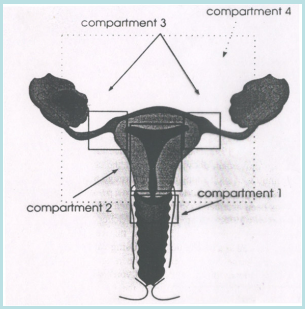
The impact of novelty on the male sexual response.

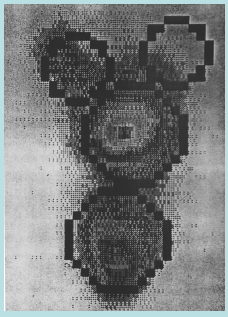
The kamikaze sperm hypothesis- sperm wars !

- **A theory of post-copulatory reproductive competition in mammals sometimes applied to humans**
- **The human connection is based on survey from 'life-style' magazines indicating significant extra-pair copulation through female choice and selected volunteer study groups.**
- **Includes both intra-pair and extra-pair post-copulatory semen collection for comparison, results have been interpreted as the production of '*killer sperm*' in response to a reproductive competition.**
- **But there is no *in vitro* evidence of '*killer sperm*' or other selective interactions between sperm from different males.**
- **Comparison of testis/body weight ratios are inconsistent with sexual selection pressures based on promiscuity in human females.**

Distribution of labelled albumin spheres assessed by hystersalpingoscintgraphy.

Pattern depends on direction of muscular flow and time of cycle.





Taxis towards ooctye

- Thermo-taxis; 2C differences have been seen between the cooler isthmus and warmer ampulla in the rabbit.
- Chemo-taxis; perhaps by switching between symmetrical flagella beats and asymmetrical hyperactivity controlled via odorant receptors. Likely in species that fertilise in vitro, identification of factors remains elusive and is compounded by general stimulants.

Some useful references

and acknowledgements

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