

# Sperm Transport

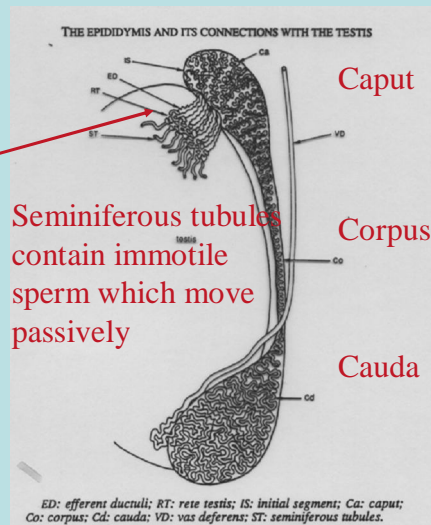
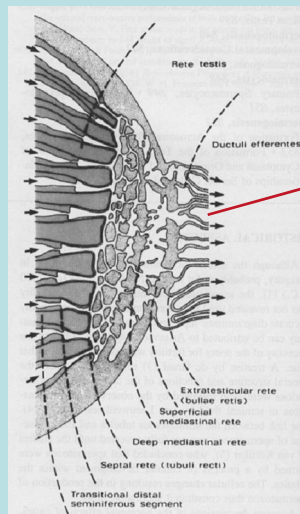
Dr K Lindsay

## Objectives

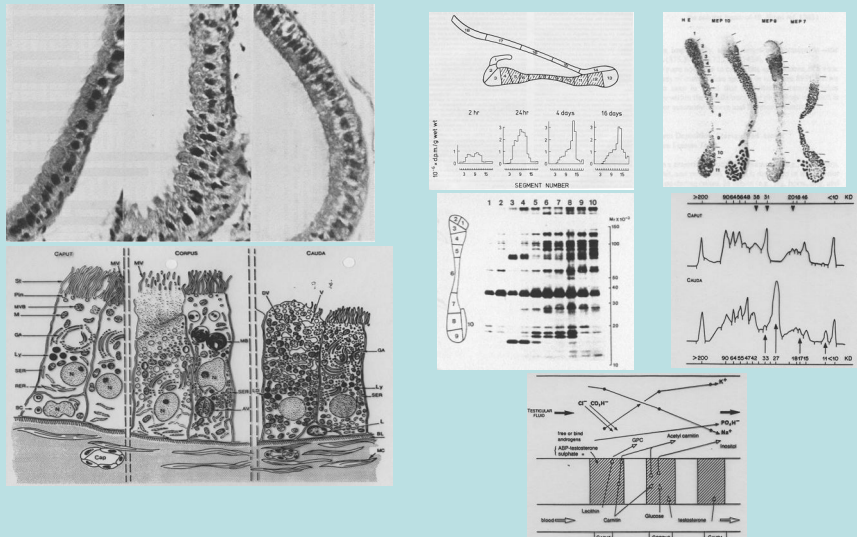
To understand the post-testicular developments in sperm.

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 demonstrated by uptake of radioactive methionine, proteins & immunostaining, electrolyte 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.
- Sperm may be ejaculated by spontaneous night emissions.

### 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 motility patterns in amplitude as they pass.
- Sperm are exposed to sequential changes in electrolyte and proteins - precise role(s) have not been fully elucidated but impact on sperm behaviour.

### 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

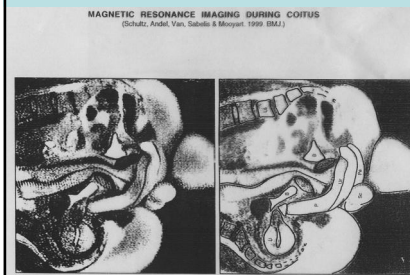
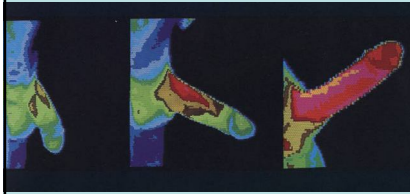
Species	Caput	Corpus	Cauda	Total
Human	1-2.5	0.5	5	1-12
R.Monkey	3		5	8-10
Stallion	1	1.5	6	7.5-10
Ram	1	3	8	13
Bull	2	2	10	14
Pig	3	2	4-9	9-14
Hamster	3	2	8	13
Guinea-pig	3	2	6-8	10-15
Rabbit	3	1	5-6	9-10
Rat	3	3	5	11
Mouse	-	-	-	3-5

## 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 a build-up of excitation in specific neural centres

•May be divided into :-

**Seminal emission** - oozing of fluid; associated with alpha adrenergic neurons.

**Ejaculation** proper characterised by emission in pulsatile spurts usually in tandem with orgasm.

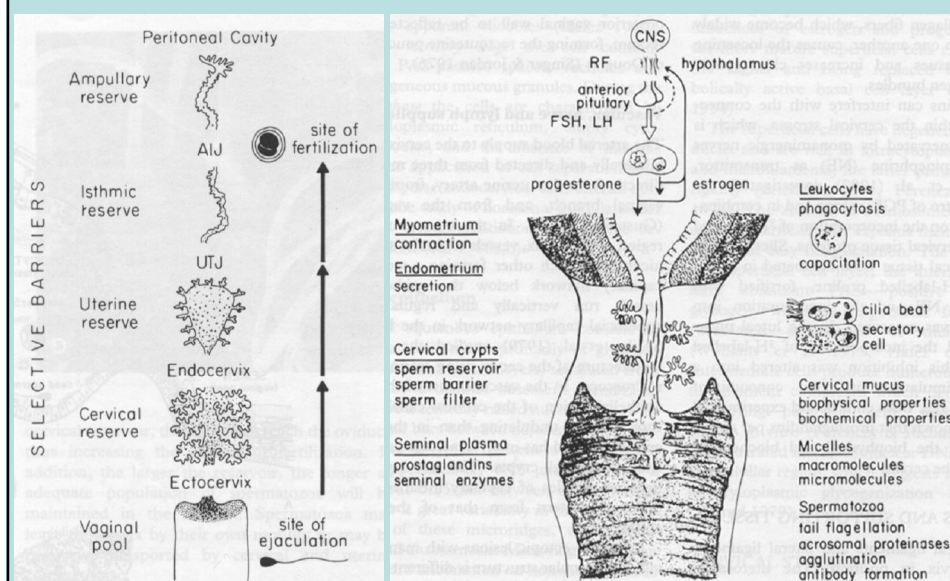
## The ejaculatory sequence

Gland	Ejaculatory Sequence	Vol.(ml)	Characteristics
Cowper's Gland 3.5x4 cm~20g	1	0.2	<i>(so called pre-cum which may or may not have sperm present)</i>
Prostate	2	0.5	Citric acid, zinc
	Serous / acidic	15-30%	Acid phosphatase Fibrinolytic enzymes
Epididymis Spermatocrit	2	< 0.1 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

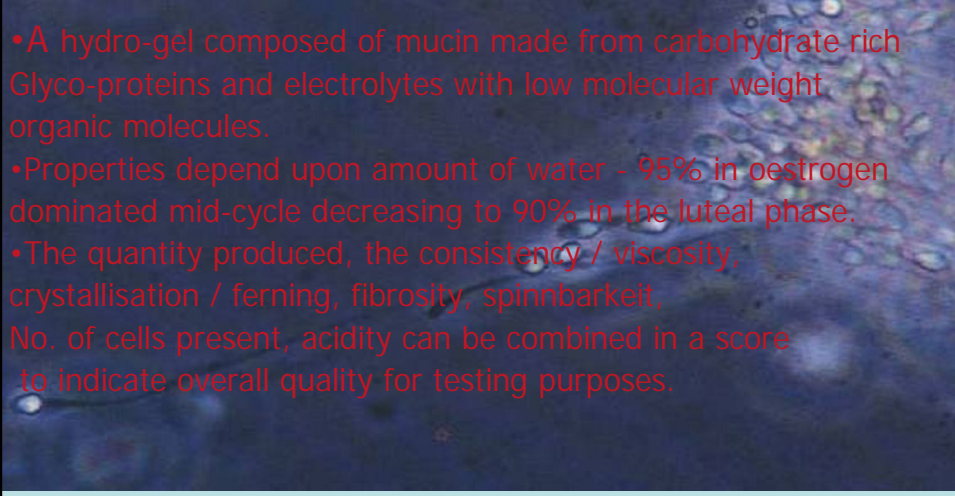
## Barriers for sperm within the female tract



## Semen deposition into vagina

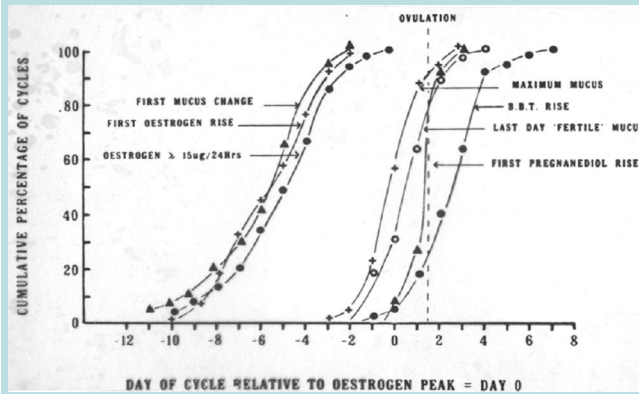
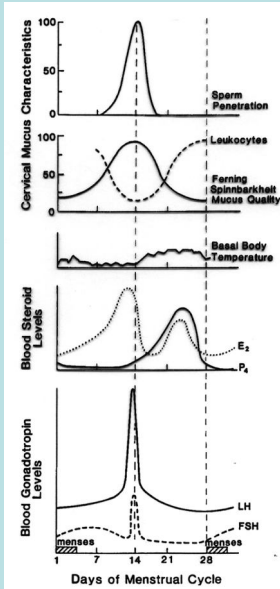
- Semen is deposited close to external os in human.
- Vaginal pH <5, hostile to sperm and alkaline semen provides a better milieu.
- Seminal plasma coagulates and then is broken down over 20-30 min. by which time most sperm that are able are thought to have penetrated cervical mucus.
- In some species 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.

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- A hydro-gel composed of mucin made from carbohydrate rich Glyco-proteins and electrolytes with low molecular weight organic molecules.
  - Properties depend upon amount of water - 95% in oestrogen dominated mid-cycle decreasing to 90% in the luteal phase.
  - The quantity produced, the consistency / viscosity, crystallisation / ferning, fibrosity, spinnbarkeit, No. of cells present, acidity can be combined in a score to indicate overall quality for testing purposes.



## Cervical mucus changes through the menstrual cycle

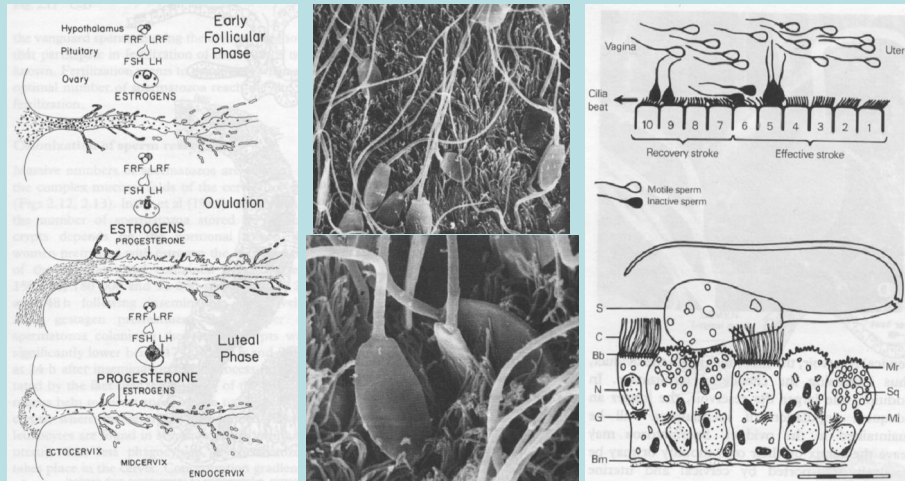


## Sperm transport through the cervix.

- 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 is unclear.
- The central cervical column may be the limit of the cervical reservoir.



## Sperm interactions within the cervix



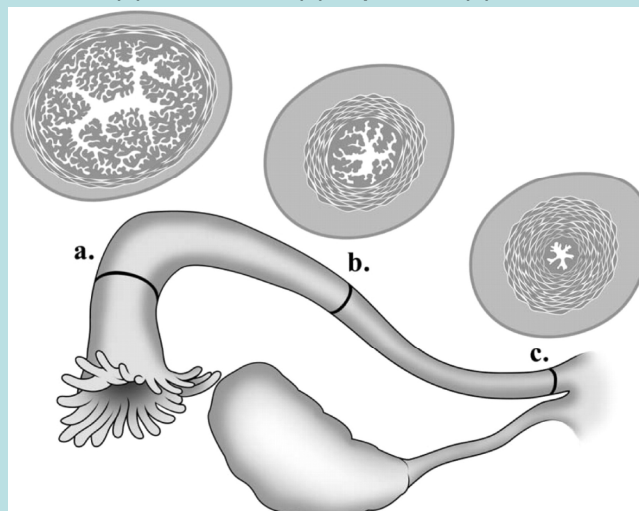
## Time from coitus or AI to arrival of spermatozoa in oviduct

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.

Illustration of the human Fallopian tube, showing the longitudinal folds in cross-section at the (A) infundibulum, (B) ampulla and (C) isthmus.

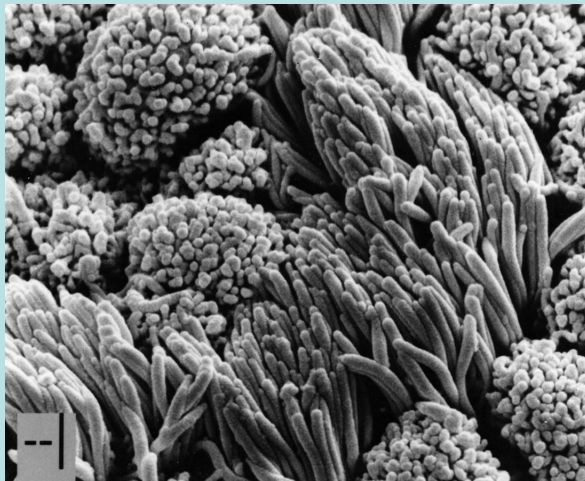


Lyons R et al. *Hum. Reprod. Update* 2006;12:363-372

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human  
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Scanning electron microscopic photograph of ciliated and secretory cells within the human Fallopian tube epithelium.

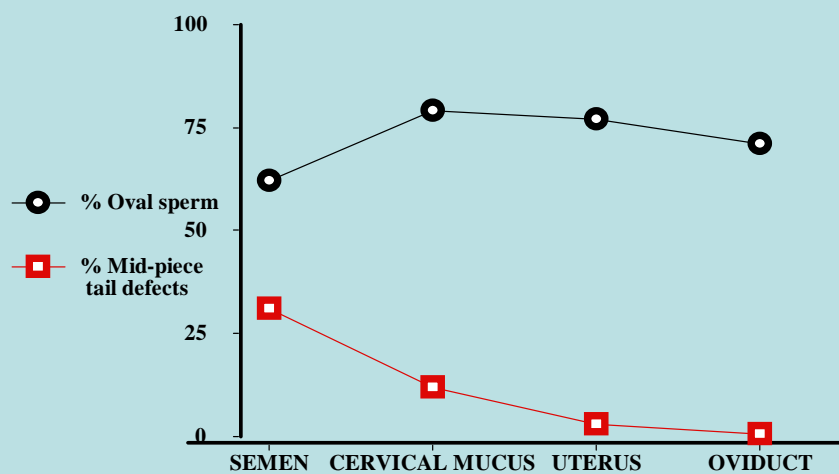


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Changes in sperm morphology during passage through the female reproductive tract - sperm selection.



From -Mortimer et al 1982 - JRF

## 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 reservoir

- 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 epididymal 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.

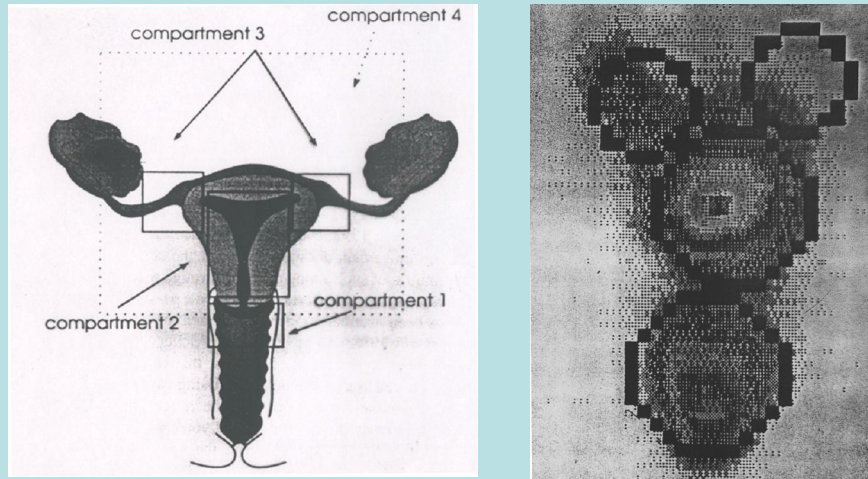
## The kamikaze sperm hypothesis- sperm wars !



- A theory of post-copulatory reproductive competition in mammals 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 hysterosalpingoscintigraphy.

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



## Taxis towards oocyte

- 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.
- Taxis is found in species that fertilise in vitro but identification of factors in species that fertilise in vivo remains elusive and is compounded by general stimulants.



## Some useful references

and acknowledgements

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