SRF Undergraduate Essay Competition: 1st Prize

The Greatest Race on Earth

Hannah Dhonye

Kings College London

There are many great challenges that life has to offer ranging from adrenaline pumping sailing over great oceans of the world, to running through swelteringly hot conditions over the deserted African planes. Though these challenges are only ever taken up by a minority of brave individuals, one race taken up by the male sex is hugely understated. Could swimming the length of the female reproductive tract be the greatest race on earth? Unbelievable as it sounds, this journey is as treacherous, dangerous and deadly as climbing up Everest, swimming through shark infested waters or biking through unkempt lands. The chaps strong enough to endure this journey are the sperm, where millions all line up ready for the race to begin- yet only one will ever be successful and reach the lonely oocyte. To ensure that at least one sperm from the male who has managed to copulate with a female wins this race, many different strategies are undertaken ranging from testis size to sperm size and number. This article will discuss various dangers sperm must encounter to achieving the ultimate goal - guaranteeing paternity.

So what hazards actually await the sperm on their epic long awaited adventure? Essentially, they need to be deposited into a female willing enough to allow copulation before the starting gun of the race can actually begin, and this can potentially be a huge hurdle requiring much time, energy and consideration depending on the species. Many species have the alpha male dominancy policy determined by rule of territory, where the title of dominant male can only be given to the strongest and most brave amongst the group. Human males adopt more complex strategies where much time is invested in courting and wooing of the female. Upon finding the desired female, males must employ enough sexual behaviours to allow copulation to ensue. This in itself can pose a large

survival gamble, as both must be aware of other males muscling in and brandishing their sexual desires potentially sparking into blazing conflict, being eaten or injured by predators and even of the passage of disease (Daly 1978). In many species, the idea of intercourse is neither attractive nor pleasant with males persistently revved leaving females to battle off unwanted attention themselves, ultimately consuming large quantities of energy (Daly 1978). During mating season, the risks involved can be translated into the wounds seen on both males and females of the Rhesus monkey (Vandenbergh & Vessey 1968).

More hurdles that the male has to postulate and burn down before it deploys its unique army to invade the female tract and rescue the oocyte, include how large this sperm army should be. Three huge factors dominate testicular production of sperm: energy resources, volume of sperm producing tissue and levels of sperm competition from other males all bidding for the same prize. For all the dangers the sperm will face in the female, it must be trained to such a degree where the male can rely on a handful reaching the oocyte, and eventually one capturing it. This training program is spermatogenesis. The time invested by the male in putting their immature spermatozoa through spermatogenesis is important such that the longer this cycle, a more elite group emerge (Peirce & Breed 2001). Therefore in a world with too few females for the testosterone driven males, the degree of sperm competition will be greatest (Hosken & Ward 2001). For males, it is a matter of quantity over quality in such male intense populations leaving them to develop larger testis packed full of spermatogenic tissue and fast tracking their spermatozoa through the enhanced training cycle. Thus much sperm does not fulfil supreme quality measures with regard to its morphology or motility. Gage & Morrow were the first to experimentally show that increased spermatozoa production or smaller spermatozoa from males had more successful sperm in the competition for the egg (Gage & Morrow 2003). On the opposite side of the spectrum, animals with low levels of inter male competition have very small testis (spinifex hopping mouse), with longer cycles of spermatogenesis (Peirce & Breed 2001).

After obtaining a female and depositing the load of swimmers accelerating towards the oocyte, the sperm themselves face several obstacles. There journey is littered with hostility initially starting with the first port of call, the vagina. Here sperm can expect an acidic environment and the arrival of the female immune defence force. However, sperm at this stage are coated in their escort medium from the penis- the seminal fluid which acts to protect it from such pH changes. With regard to dodging the immune system, sperm are laced in inhibitors provided by the seminal fluid (Suarez & Pacey 2006). Once past the vagina, into the cervix they pile and now face a huge physical barrier that will end a majority of their journey- the cervical mucus. Despite the daunting presence the cervical mucus provides, the cervix in itself can harbour sperm and allow a constant trickle up towards the uterus. The few surviving sperm that exit the cervix are those who have gone through a rigorous surveying process which is the females' only means of which genes will fertilise her longing oocyte (Suarez & Pacey 2006). Freundl *et al.* showed spermatozoa with intact outer shapes had a greater chance to surviving the blockade from cervical mucus and those left at the top of the female tract were defect free (Freundl *et al.* 1988).

As the remaining sperm have undergone a stringent selective criteria, leaving all undeserved behind, the female tract changes from a hostile, unkind area to one which promotes fertilisation. It does this by aiding sperm in their journey pushing them closer towards the ampulla of the fallopian tubes where the sleeping beauty oocyte waits her heroic prince sperm. This has been unravelled by high resolution ultrasound probes which enable us to see dynamic movements of the uterus which during the follicular phase of the menstrual cycle have been seen to be cranial in direction, resulting in the delivery of sperm to the distal fallopian tubes (de Zeigler *et al.* 2001).

The final frontier in a sperm's journey is transforming it from a regular swimmer and injecting a shot of energy enabling it to zoom over to the oocyte. This process is known as capacitation and can only occur via sperm travel through the female tract inducing morphological changes allowing these final contenders to become fertile and achieve a fully functional zygote (de Lamirande *et al.* 1997). From this, in the capacitation process,

the female can be seen to be a hugely important incubator causing the maturation of sperm via reorganisation of surface proteins, thus opening the window of sperm fertility (de Lamirande *et al.* 1997).

Gamete fusion requires an intimate interaction using the phenomenon of cell adhesion. The oocyte is dressed in two special coats, the zona pellucida and the cumulus layer, and ovulation leaves them for pick up by the ciliated infundibulum (Talbot *et al.* 2003). After the oocyte has been escorted to its waiting lounge, the first sperm which arrives must latch onto the zona pellucida (Talbot *et al.* 2003). The zona pellucida contains zona pellucida glycoprotein (ZP3) which is a potent drive for the acrosome reaction to occur, and it is this final catalyst which allows the clinging sperm to finally burrow through the outer coating of the oocyte (de Lamirande *et al.* 1997). Thus the journey is over, blood sweat and tears aside, the final goal of sperm and egg encounter has been achieved and fertilisation results.

As can be seen the sperm are such brave cells enduring the unfriendliness of the lower female reproductive tract, the gauntlet of the cervical mucus and timing pressures to allow it is in a fit enough state to fertilise the egg upon its meeting. Due to the many hazards these sperm must endure, it is not surprising that the many millions that excitedly start the race from the male ejaculate quickly fall by the wayside at such an intimidating adventure. However as has been discussed, the female tract alters from an unwelcoming, barren area to one which longs for a foetus, and thus helps sperm finish its journey aiding movement via contractions, and maturation. Thus the strategies undertaken by the successful sperm can be transmitted to latter generations. So there seems only one thing left to say, Ready, Steady, Go!

References:

Daly M. (1978) The cost of Mating. *The American Naturalist* 112 (986) 771-774

De Lamirande, Leclerc P & Gagnon C (1997) Capacitation as a regulatory event that primes spermatozoa for the acrosome reaction and fertilisation. *Molecular Human Reproduction* 3(3) 175-194

De Ziegler D, Bulletti C, Fanchin R, Epiney M & Brioschi PA. (2001) Contractility of the non pregnant uterus: The follicular phase. *Annals of the New York Academy of Sciences* 943:172-184.

Freundl G, Grimm HJ & Hofmann N. (1988) Selective filtration of abnormal spermatozoa by the cervical mucus. *Human Reproduction* 3(3)277-280

Gage M & Morrow EH. (2003) Experimental evidence for the evolution of numerous, tiny sperm via sperm competition. *Current Biology* 13:754-757

Hosken DJ & Ward PI. (2001) Experimental evidence for testis size evolution via sperm competition. *Ecology Letters* 4:10-13

Peirce EJ & Breed WG. (2001) A comparative study of sperm production in two species of Australian arid zone rodents (*Pseudomys australis, Notomys alexis)* with marked differences in testis size. *Reproduction* 121:239-247

Suarez SS & Pacey AA. (2006) Sperm transport in the female reproductive tract. *Human Reproductive Update* 12(1)23-37

Talbot P, Shur BD & Myles DG. (2003) Cell adhesion and fertilization: Steps in oocyte transport, sperm zona pellucida interactions, and sperm-egg fusion. *Biology of Reproduction* 68:1-9

Vandenbergh JG & Vessey S (1968). Seasonal breeding of free-ranging rhesus monkeys and related ecological factors. Journal of Reproductive Fertility. 15:71-79