Evolution's Dirty Dancing

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I observe life as a dance floor, and there you can see a dance of various partners- viruses and their hosts, flowers and insects, predators and their pray…But no list of life's dance partners would be complete without male and female and for the vast majority of animal species, the dance between the sexes is essential to their existence.

But as vital sex may be, it is still a glorious glistening puzzle. Why does the peacock drag around such grand tails when it makes him both visible in his surroundings and makes his escape from predators more difficult? Why is it that when Australian redback spiders mate, the male hurls himself onto the female's poisonous fangs, becoming a meal for her at the end of the act? Why do males always have small, mobile sperm, while females have giant, immobile eggs? Why are there males and females at all?

Many organisms can reproduce without sex. Bacteria and many protozoa can simply divide themselves in two without the help of a partner. Asexual animals are rare but they exist. Some species of whiptail lizards in the west of the United States, for instance, have no males. One female will mount another female, bite her neck, wrap around her, and otherwise mimic what a male lizard does while mating. That makes the other female ovulate. And she needs no sperm to fertilize her eggs. They simply start dividing and growing into embryos. When the lizards give birth, they produce only females, all of which are identical to their mothers.

When you think about it, sex is not only unnecessary, it ought to be a recipe for evolutionary disaster. For one thing it is an inefficient way to reproduce. In a population of asexual whiptail lizards every new lizard can bear baby lizards of her own, in a population that reproduces sexually only half of them can. So asexual should quickly swamp the sexual with their explosive birth-rate. And sex carries other costs as well. When males are competing for females by looking horns or by singing, they are using up a huge amount of energy, and sometimes put themselves at risk of being dangerously hurt or attacked by an enemy. The cost of sex is immense!

And yet sex reigns! In addition, only a fraction of a percent of all vertebrates reproduces asexually like whiptail lizards. Why is sex a success despite all disadvantages? Well, scientists have recently been gathering support for a surprising hypothesis: sex fights off parasites. And any adaptation that helps the host escape them may become hugely successful. Sex brings an advantage to sexual animals because it makes it harder for the parasites to adapt to them. It is because a sexual animal is not a clone of its mother and father; it carries a combination of genes from both parents. As cells divide into the eggs and sperm, each pair of chromosomes wraps around each other and swaps genes. Thanks to the sexual dance, the genes of male and female can be shuffled into billions of different combinations in their offspring.

The advantages of sex have allowed it to come into existence dozens of times, in many separate lineages of animals, plants, red algae, and other eukaryotes. Although sex has evolved independently numerous times, most gametes look pretty much the same: the egg is big and immobile, while the sperm is a small swimmer. Many mathematical models of gametes struggling to find each other have shown that this arrangement is the best possible. And the arrangement is popular because it works so well. The gametes are like two people lost in a giant forest at night. If both of them wandered around, they will be unlikely to find each other. It is better for one of them to remain motionless and send out signals to the other one. And not only that, because an entire search party through a forest will do a better job of finding someone than a single person. In the case of people the signals might be shouts; for gametes, there are powerful molecules

known as pheromones. The louder people shout, the easier they are to hear, and for the gametes shouting louder means producing more pheromones. That is exactly what the egg is doing. It is big, immobile and produces a lot of pheromones. It also stores more energy than it would need to fuel its cell division once it is fertilized. The more energy an egg could provide, the less the sperm would need to bring with them. They could become even smaller and more numerous. As the big-egg little-sperm arrangement evolved, it created a huge imbalance between sexes. A single man can produce enough sperm in his life to make every woman on the planet pregnant many times over. But each woman ovulates only once a month. And while a single male of a species may be able to fertilize every female, there are other males who wouldn't mind doing the same thing. And this conflict leads to battles among males.

Competition between males was well known to Darwin. And it fits into his theory of evolution without much trouble: if males competed with one another for females, the winners would mate more often. If having a slightly thicker skull means to win in battle, then more males of the next generation would have thick skulls. A pair of lumps might make the skull even more effective in fighting, and so those lumps might evolve into horns.

But Darwin wondered what the females were doing in these battles and he recognized there was a problem with it: what is happening with the species in which males do not go manor a manor?

Consider the peacock and his splendid tail. Why does a peacock drag around such grand trails, colourful feathers, when it makes him both visible in his surroundings and makes his escape from predators more difficult? And a male specially can't use its tail feathers to beat another male and make him surrender. Yet despite all disadvantages male peacocks grow a new set of tail feathers every year to replace the ones they shed at the end of the previous year. "The sight of feathers in a peacock's tail, whenever I gaze at it, makes me sick!" Darwin once said. Of course it made him sick! Darwin had a real problem with peacocks, because they seemed to go against his theory of evolution by natural selection. He thought about it a lot and it was several years before he produced his explanation for why peacocks tails might have evolved. And he had a special term for this process of emergence and existence of these sexual characteristics and behaviour that decrease survival. He called it Sexual Selection.

The concept of sexual selection explains differences in reproductive success between individuals in one population because: either there is a competition between individuals of the same sex (usually males) for the partner of opposite sex (usually females), or one sex (usually female) shows preference for the gametes of individual of opposite sex (usually males). For Darwin sexual selection was a mechanism of keeping trails that in any other case would have been eliminated by natural selection. So in the case of peacock's grand trail, deer's antlers, pheasants feathers, it explains emergence and existence of these sexual characteristics and behaviour that decrease survival precisely with female's preferences of these "handicapped" males. It is because females can be sure that these males had gone through numerous challenges and they won, survived even though they are handicapped. On the other hand, males with their imperfections actually advertise their excellent health, good genes and their superiority in the environment. Thus, a female can be sure that her young ones will also manage to survive in the given surroundings.

A female animal cannot send her suitor's genes to a lab for analysis, but she can detect clues of his fitness in the way he looks or acts. To sing loudly or grow brighter feathers, a male can't be too weakened by his fight with parasites. For example, the rooster's comb, like many other male displays, needs testosterone to trigger its growth. But testosterone also lowers the rooster's immune system. To grow a comb, a rooster must put himself at greater risk of getting sick. Only truly strong roosters can waste their immune system this way.

Here, I would just like to point out one thing. Following Darwin's concept of sexual selection, nowadays, scientists explain the differences in reproductive behaviour of male and female with the principle of parent investment. It is investment of energy and time that parents provide for

conception, bringing up, and taking care of their descendents. And in 90% of mammals the females are the ones who invest enormously. For example, orang-utans live a lonely life, males and females gather around only in the time of the mating season, and after that the male leaves the female partner. A pregnant female, with her weight of 40 kg, carries her embryo for 8 months, labours the baby, nurses it for three years, and takes care of it for the next 7 or 8 years. The investment of the 80 kg male orang-utan in his offspring is only a few hours looking for the female and a gram or two of his sperm! What an investment! So the sex that shows a larger parent investment becomes a limited factor, a "limited edition" for the opposite sex whose investment is much smaller. And these "stingy" sexes, whose parent investment is smaller, will be in mutual competition for this limited factor. In the majority of animal species females are "limited edition" for males. And this is actually Darwin's intersexual selection. Of course, females aren't always the limited factor. In 90% of fishes and birds, male investment in offspring is larger and they are the limited factor.

Once a male has earned a female's attention and has successfully mated, he doesn't automatically become a father. His sperm still have to struggle through her reproductive system to find an egg to fertilize. And quite often, his sperm won't be alone. They will be competing with sperm of other males that the female has mated with. This is the very best part of evolutions dirty dancing, Darwin's sexual selection, because it doesn't end even after copulation. We call this dance post-copulating selection and it is very practical to imagine the mix up of sperm inside a female is like a lottery. So what are the tactics of winning the lottery? Well, the first one is: the most tickets the male buys, the higher his chances of winning are. Some species of rats have multiple ejaculations. A sneakier way to win a lottery is to destroy the tickets of other contestants. Male fruit flies have poisonous semen that disables the sperm of previous suitors inside a female. Some insects like black-winged damselflies have penis-like organs covered in spines; before they deposit their sperm inside a female, they use spines like a scrub brush to clean out the sperm of other males. Another way for a male to win a lottery is to keep other males from buying tickets in the first place. Male fruit flies have chemicals in their semen that decrease a female's libido. Among some spiders, the females attract potential mates by scenting their webs with a male-attracting pheromone. Once a male locates a female, he destroys her web.

And at the end, for the males of one species, the best way to raise the odds that their sperm will succeed is to commit suicide. The male Australian redback spider sacrifices himself for sex. His dirty dancing begins as he crawls onto her belly and puts his palp, which is a tube with a miniature boxing glove at the end, into the female body and starts to pump sperm through the palp. At the same time she begins to chew on his abdomen and injects into his body, which begins to digest it. She dines slowly, as the male continues to inseminate her. The mating may take half an hour and at the end the female has reduced him to a mummified body (My grandfather told me pretty much the same thing on his 40th marriage anniversary). So does the suicide of the redback spider represent an evolutionary adaptation? Of course it does, because these spiders have a very short life span, a chance of finding more than one female in Australian deserts in his lifetime is very small. His sperm delivering palp snaps off during sex, living him sterile, so if he survives he can't have any more offspring. And in the lack of food, he can be sure that the female will have plenty energy to invest in their eggs. These sorts of benefits are apparently more valuable for male redback spiders than their own lives, so they make their one-time chance count!

Now, the focus of the modern scientific research in evolutionary biology is actually the question how much sexual selection has influenced the evolution of our sexual behaviour.

Would you consider the answer "So much!" knowing the fact that from 4.300 mammal species, only our sexual behaviour is beyond the bizarre.

Or much enough, since if you were to ask your dog: "Ok, what you think about my sexual behaviour", his answer would probably be:

“These disgusting people!!! They make love every day in a month!!! Mrs. Smith is in mood for sex even when she is not ovulating. Ok, Mr. Smith is always in mood and people don’t even care if their efforts will have results in an offspring or not. The silliest thing of all: Mr. and Mrs. Smith close the door of their bedroom and they hide when they make love! Every proud dog copulates in front of his mates, but people don’t!!! What a strange species!!!”

No, don’t be surprised by your dog’s puzzlement! In most animal species, during ovulation female advertise her sexual desire to male via visual signs, smells and specific behaviour. For example, in baboons, during oestrus the back of the female swell and becomes red; she also smell specifically; and if her partner is a little dumb and does not realize her state, she rolls in front of him and shows him her back. But in humans (and some other monkeys) neither female nor male are aware of female ovulation so the majority of their sexual contacts do not end with conception. So, from a biological point of view, sex in humans looks like monumental waist of energy, since the only thing that counts for one species is reproduction – passing your genes.

Following practice of evolutionary biology we have to find an explanation for that interesting sexual behaviour. The questions are: what is the benefit of that kind of sexual behaviour? Why we waist our energy on unproductive sex? Why women hide ovulation? What is the connection between these questions?

We began this life on the savannah as Australopithecus 4.2 million years ago. As a species we are not physically designed for large cities, high-level stress, fast food, we are designed for life in the threatening, hostile savannah surrounded with many predators and in a lack of food. Possibly we were as rare as the modern blue whale, so urge to reproduce must have been very strong for us to be here now. So if you’ve ever wondered why you have instinct for sex, it is because, personally, you are at one end of a very, very, very long line of sexual success stories. The other things that separate our species from other primates are our helpless children. It takes many years of parental care to prepare our offspring to live without our support. In other primates, after few years newborns are ready to take care of themselves. So, although that dependence from parents was really important for the evolution of our brain, we must pay the price for that in terms of enormous quantity and quality of parental care and limitation of offspring number. You cannot have a very high number of high quality children. Our strategy is to produce the small number but high quality. That job is very difficult for just one parent even nowadays and it was almost impossible in the savannah. Hidden ovulation evolved in ancient woman in order to keep the father of the child near her and their baby. In scenario where the man leaves the woman after copulation and goes out in search for another female to copulate, we can see the great risk for the survival of their helpless baby. If the female is always willing for sex, the man will have his sexual pleasure and there is no need to go around searching for other women. Additionally, since he doesn’t know when she is ovulating, if he goes away very far, there is a possibility that she will copulate with some other man, and so he cannot be sure that her future baby is also his. That is a great trick to keep the man at home. The outcome of this scenario is the benefit for both mothers and fathers – their babies have much more chance to survive, so their genes are transferred. This hypothesis is called “Daddy in the house.”

What about romance? Is love just another casualty? In 1976, a group of scientists in New York began investigating the genetics of mating, and they started by looking at laboratory mice. They concentrated on an important group of genes called MHC genes. They are expressed in all the cells of mammals and they play a major role in the immune system. They produce proteins that define us in immunological terms. By being able to recognize our cells, they can then recognize foreign bodies or pathogens, and send out the signals to mobilize the cells of immune defence. MHC genes vary from individual to individual. If two mice from an average colony mate, some of these genes will be similar while others won’t. But remarkably, the US researchers found that mice were more likely to mate with partners who had dissimilar MHCs. These mice appeared to have evolved a mechanism to “sniff out” a certain type of biological mate. What on earth could possibly be so sexy about an immunological mechanism? It turns out that there could be

something very attractive in evolutionary terms to choose a mate with different MHC. Inbreeding is dangerous, especially with genes that have a major role in the immune system. The more different combinations your offspring has, the better chances are that it will fight off parasites. But how do we detect if a potential mate has similar MHC genes to our own? One answer is provided by studies involving T-shirt sniffing. For example, researches at the University of Berne tested and typed the MHC genes of a number of female students. They asked a group of male students, whose MHC genes were also typed, to wear cotton T-shirts, so they would smell on their body odour. The T-shirts were taken to a laboratory and were sniffed by each of the girls in the sample. The women rated them according to how "pleasant" they found the smell. They preferred the smell of T-shirts worn by men with dissimilar MHC genes to their own. The results of these experiments do suggest we can literally sniff out suitable mates. But how is a complex piece of genetic coding translated into body odour? It is very likely to be due to bacteria each of us carries on his skin all the time. Bacteria produce and change the body odour, and the precise smell depends in part of the type of bacteria. It may well be that particular bacteria are favoured by one person's immune system rather than another, giving us each a slightly different olfactory signature. It is a very interesting research, and I think it was really important in the savannah for early hominids. It is quite interesting for the group of women (and man) who are using deodorant these days, or the group of women who use the contraceptive pill, who may smell different. What about their long relationships? Have they chosen a wrong mate? Jury is still out.

In his book "Descendence of man" Darwin, similarly to modern evolutionary biologist, said that differences that exist between modern man and woman, are a "window of our past." With this principle I agree, the all evolutionary biology is established on this principle, but in modern biology we have to concern many elements that enable us to perceive the evolution more widely, more broadly. Different disciplines in evolutionary biology, like socio-biology and evolutionary psychology, observe evolution like a simple change of frequency of genetic variation in a population. They simply link the specific trait with genes. There is no gene for aggression, gene for homosexuality or gene for mating. Today it is well known that phenotype depends of natural environment in which the individual lives and develops, and therefore evolutionary change cannot be observed without the context of environment influence. That specially refers to our behaviour. Social organisations, specific customs, prejudice, culture, education all have very big influence on the emergence of our specific behaviour. Those are not genes! For example, some studies of partner selection show that females prefer men with better social or financial status, tendency for family life and raise of children. On the other side, men are interested in younger and physically attractive women, were the ratio of hip and waist 0.7 is an indicator of high reproductive potential. But they ignore culture influence. The ideal of women beauty changed many times over few centuries. From chubby woman in baroque paintings of Rubens at the beginning of the seventeenth century, to modern days were the media are overcrowded with anorexic models. And what about African tribes in which body decoration reflected in exaggerated ear and lips punching, wearing of necklace that abnormally extend the woman's neck or even pulling out front teeth, are considered very attractive. So as much as cultural evolution could affect biological evolution, it must be considered independent from biological inheritance.

Nowadays the largest number of evolutionary biologists would agree that what contributed to the evolution of modern human kind, the development of speech, culture, arts, and the complex tool wielding is actually the evolution of upright posture, brain development and our bizarre sexual behavior formed under the influence of sexual selection. In what degree is very hard to say, because of the cultural evolution.

Mirco Djordjevic was awarded the FameLab prize 2009 as the Best Science Communicator.