An Introduction to Evolutionary Biology

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Evolutionary Conflicts

Hi. So, in our last discussion, we looked at the phenomenon of cooperation and we saw how relatedness among individuals can explain cooperation to a great degree. But, as I said, cooperation is just one part of the story. The other thing that happens a lot between organisms is conflicts, you know. Due to various evolutionary reasons and selection operating in certain ways. So, this particular discussion today is going to be entirely about evolutionary conflicts.

One of the most interesting and eye-catching conflicts that we encounter is what is known as infanticide. So, what is infanticide? I am sure people in India are aware of this animal. This is the so-called Hanuman Langur or Semnopithecus entellus; it is found pretty much all over India. And in this particular organism, groups are made up of a single dominant male, and multiple females surround that male.

Now, the dominant male has total reproductive monopoly over the females. That means it does not allow any of the other males to mate with the females. So, obviously, that means that the reproductive success of the subordinate males in the group is much, much lower. I mean, the best that they can do is sneak a mating when the dominant male is not looking, and even that is, you know It is very fraught with danger because if the dominant male discovers such a sneaky mating, it is going to react rather violently. So, the subordinate males obviously do not like it, and very often they will fight to take over the you know the dominant male role in the group, and when that happens, typically either they will kill. Or you know they will banish the dominant male away, and he will now become the group leader. Interestingly, when a new male takes over, the first thing he does is that he kills all the infants that were not sired by him you know and produced by the other females. Now, this behavior, although I am talking about it in the context of the Hanuman Langur, It is by no means only you know restricted to this animal; it is present in many other animals. You know, for example, this happens in many lions and many other mammals, etc.

But why? Why exactly is this happening? So, it turns out that female mammals are not typically going to ovulate while they are lactating, while they are producing milk. Therefore, and at the same time if you take a lactating female and you kill its infant, so there is no more infant to feed, Now the female will stop lactating, and that is the point when the male can have access to the female. and mate with it to produce a new baby. In other words the dominant male if it does not kill off the female's kids then it is going to have to wait to reproduce whereas if it kills them off then it can start its reproduction very soon. Now, this is very important for the dominant male because, remember, Once a subordinate has become dominant, there are other subordinates in the group that are waiting to challenge.

Therefore, the dominant does not have too long a time before it can reproduce, and if it spends all that time waiting, then that is not really going to work. Therefore, the dominant male needs to start reproducing as soon as possible, and the best way for that is to you know kill off all the existing babies such that the females become receptive to mating. In other words, all these males who show this infanticidal behavior. They are the ones who are going to have a larger reproductive success. Now, as I said, this is something that has been seen in many other groups.

Mostly it is the males, but does that mean that it is a male-specific behavior? And it turns out that although it is mostly males, there are cases. Where there is a role reversal, the female can also become infanticidal. So a very famous case is that of this bird; it is a wattled jacana, Jacana jacana. And in this particular case, the males are the ones who are responsible for brooding and, you know, taking care of the young. So what happens is that the female ends up defending a territory inside which there are male jacanas standing and guarding the brood and the eggs. Now if you end up killing a female or otherwise removing it from the territory, the other females who are around that area, They will quickly come over, attack the chicks, and either kill them. or they will evict them from the nest, which obviously typically leads to their death. The moment that happens, the male becomes receptive to mating. And then it mates with the attacking female and now starts taking care of her offspring.

So, this is just to show that no matter which sex is doing the parental care, the other sex is committing infanticide. Typically, it is the females who provide parental care, which is why the males commit infanticide. But if you have the whole role reversed, then you can have infanticide by females as well. But the important point to note here is that this does not really lead to a situation like this. This does not imply a situation like this where the father or the mother is, you know, sitting with a calculator and trying to calculate you know what is my relatedness and what is my reproductive success and then it says ha, therefore, I need to kill the baby. No, it is not necessarily a conscious decision. All that is needed in this case is some kind of a genetic predisposition to kill off other you know males or females babies. And if you have such a predisposition, then that predisposition or tendency is going to be evolutionarily favored. Now, of course, in a situation like this where you have, you know, babies sired by other males or produced by other females, then You know it is very easy to explain evolutionarily why it is going to be favored, my offspring versus other people's offspring.

But there are several situations in which some organisms actually kill their own offspring. Or, in many cases, they even end up killing their relatives. Now we have already discussed inclusive fitness. So we know that killing your relatives is not a very good idea. It reduces your inclusive fitness.

Therefore, under what kind of scenario will a parent decide to kill its babies? Or will a you know brother decide to kill his brothers or half-brothers or so on? In order to understand this, we have to do some kind of evolutionary cost-benefit analysis factoring in how much. Is the cost-benefit of producing babies versus how much is the inclusive fitness of killing your babies? or killing your relatives and so on. So, I will show you a very famous graphical model. This is a very important point to note. This is not a mathematical model.

There are no equations underlying this. It is a logical thing, and the logic is presented in the form of a graph; I will show you the logic behind the graph. So, let us assume that we have parental investment on the x-axis and the cost or the benefit on the y-axis. Now, in order for any offspring to survive, they require some resources. Either the resources have to be provided in the form of The proteins, etcetera, surrounding the nucleus, or it has to be some amount of parental care.

If there is zero resource investment by the parents, then the chances of an offspring surviving are close to 0. That is why when the offspring, or rather when the parent, starts investing, Then, in the initial phase, the benefit to the offspring goes up very sharply. So, that is what is being shown here in this cyan line. So, as the parental investment starts increasing, the benefit to the offspring increases very sharply. However, we are talking about the survivorship of the offspring or the fecundity of the offspring.

There is a point after which, if the parents end up giving further nourishment, Further resources, further parental care, then the survivorship has to taper off at 1; right, it has to plateau at 1. Therefore, after the initial sharp increase, After some point, the rate at which the benefit increases slows down, and at some point, it kind of levels off, right? So, that is what is leading to the shape of this graph. So, it does not really matter what functional form or what parameter values are used to create this. All that matters is the appreciation that it is initially going to rise sharply. And then after some point, it is going to taper off, and then at some point, it will level off.

So, this is the benefit for the offspring. Now, obviously, when a parent is making an investment, that is coming at a cost to the parent. Now, what is the cost in terms of? So in this particular case, we talk about the cost in terms of missed reproductive opportunities. So in other words, if I were to give, let us say, this much extra care to the offspring, Then I am missing out on making so many babies. So the cost is to be considered in terms of a missed opportunity.

Now, obviously, as the parental investment increases, this cost keeps increasing. Now, here you have to appreciate one thing: a parent in a diploid case is always related to its offspring by half, r = 1/2. So it is related to all its offspring by the same degree. Therefore, genetically speaking, in terms of relatedness, all offspring are the same for the parent. And hence, the cost of the parent actually keeps increasing monotonically, right? As it keeps on increasing more and more in the offspring, the total amount of existing offspring also increases.

The total amount of loss that it incurs in terms of obtaining future offspring keeps increasing monotonically. So, where exactly is the parents' reproductive success maximized? The parent's reproductive success is, of course, maximized where the gap between these two graphs The cyan graph and this orange graph show that the gap is maximum, right? The profit is the maximum difference between benefit and cost. So that maximum, in this particular case, let us say it happens over here; exactly where it happens is not the point. The point is that given the nature of these graphs, there is going to be a point. Where the difference is going to be maximum, this is where the parent achieves the maximum net reproductive success.

So that is what is shown by this difference here. Great. So this is the parents' side of the story. Now what is happening to the offspring? Remember the parent is related equally to all the offspring. But when it comes to the offspring, the offspring's relatedness to itself is 1. But its relatedness to its siblings, assuming that we are talking about full siblings, is 1/2, or 50%, right? So the offspring would obviously want more and more resources for itself, even if it comes at a cost to its siblings. to its brothers or sisters. However here the inclusive fitness also becomes a thing. If it ends up taking everything for itself, let us assume you know that there is one offspring. Who ends up taking the entire resources for himself or herself, because of which no further offspring are produced by the parent.

In that case, the offspring is actually going to have direct fitness, but it is also going to lose out on inclusive fitness. The indirect fitness that comes through its relatives. Therefore, the offspring also feel this cost, but the cost is felt by the offspring in a very different way. As I said, the offspring is related to itself by one; the offspring is related to its full sibling by 1/2. Therefore, all the extra investment that the parent is making in the offspring discounts it by 50%.

Because of its 50% relatedness to its sibling. And that 50% reduction is what I am showing you in this particular graph, this, you know, violet or purple, whatever you call it. So, this graph is 50% of this orange graph, and because it is 50%, It is going to be at a lower level; it is going to have a shallower slope. And because it is going to have a shallower slope, the maximum difference between the benefit to the offspring and You know, in terms of the cost discounted by 50 percent, that this graph is going to move towards the right. In other words, the offspring would want the parent to keep on giving investment, you know, Keep on increasing the parental investment so that the maximum inclusive fitness in the context of full siblings occurs here.

This is at a higher value of parental investment compared to what is optimal for the parent, right? And this is when we talk about full sibs. Suppose you have, let us say, one mother but multiple fathers, or the other way around. So, the offspring are all related to each other by 1/4, and that is this graph, this one, this pink one. So, obviously in this case, the maximum inclusive fitness is going to be even more toward the right-hand side. So, this graphical model that I told you about, This is what is known as parent-offspring conflict, and this was proposed by Robert Trivers in the year 1974.

It is a very famous, highly cited paper in which he essentially proposes this graphical model. So, now what I will do is essentially repeat this entire thing, but now instead of referring to the graph, I will just, you know, use it, using simple words to say the same thing. So, this is just to reinforce the concept that we just discussed. So, parent-offspring conflict: what is the parent's view? The parent has equal relatedness with all its children and therefore values all its children equally. And therefore, for the parent, all it wants to do is maximize the number of offspring that survive.

The offspring on the other side has 100% relatedness to itself. but only 50% relatedness with their full siblings and 25% relatedness with their half siblings. In other words, its relatedness to itself is greater than its relatedness to its sibs. And therefore, the offspring, if it has to maximize its inclusive fitness, It actually wants the parent to invest a lot more than what the parent wants to invest based on equal distribution, right? The offspring wants to pull it, pulling the resources more. And because of this, the cost to the parent is in terms of the missed opportunity to produce future offspring.

But the offspring is going to discount this cost by 50% because of the offspring. is, after all, related to its potential future siblings by only 50%. Therefore, because it discounts the cost that the parent is paying, the offspring wants the parent to invest more and more. So, this is at the crux; this is like the, you know, basis. because of which the evolutionary interests of the parent are very different from the evolutionary interests of the offspring.

So, obviously you can see that there is a parental side of the story here and there is an offspring side of the story here. So, what we are going to do is first look at what the parent does in three or four scenarios. And then we are going to look at what the offspring does. So, in the context of the parents, the most interesting and apparently confusing thing that people often see is is what is known as filicide or filial cannibalism. So, this is the situation in which parents kill their own offspring.

And this is extremely widely found in insects, fish, birds, and mammals; you know, a huge number of examples. So, as I said, on the face of it, it makes no sense because it apparently reduces the parents' fitness. However, if you look at it closely, there seem to be hidden benefits that the parents can get. by killing and in some cases eating and in some cases not eating their own offspring. So, we are going to talk about three or four of those.

So, the first case that we are talking about is in the context of this beetle known as a burying beetle, Nicrophorus orbicollis. So, this beetle is a fascinating organism. The way it works is something like this. So, whenever there is a mammal, let us say a mouse or a squirrel, small mammals, whenever they die, These beetles will go and find these insects. They have these, you know, small mammals; they have very, you know, nice sensory systems to locate these dead mammals.

So, once they find these dead mammals, they will quickly bury them in the ground, and once buried, they will keep rolling that animal. Remember, the animal has started to decay slightly, so it has begun to become soft. So, then they end up making it into some kind of ball like this, right? Then, can you see these white dots over here? These are the eggs. So, they do not lay the eggs on the animal; they lay the eggs slightly away from the animal. And the eggs hatch, larvae are formed, and these larvae slowly crawl to that animal and start eating it.

And then they get all the nourishment from the animals, and after some time, You know, here are the larvae, and after some time, they form the adults and so on. So, once the larvae have started going out, the two parent beetles just disperse. Now, it sounds a bit gruesome if you want to see live photographs of this. You can check out this particular paper, but the main point that I want to show you is this cycle. Now, it turns out that in this case, not all mammals are of the same size, right? You can have a large squirrel of about this size, or you can have a small mouse of about this size.

So, the larger the food source, the greater the number of surviving offspring. But very interestingly, the size of the surviving offspring, which is a very good measure of how much food they are getting per capita, is noteworthy. The size of the surviving offspring remains exactly the same irrespective of the size of the food source. In other words, even if you have a small, you know, mouse like this, or you have a large squirrel like this, The surviving babies of this particular beetle will always be of the same size. So, how is that happening? One possibility is that if they have a large food source, they may lay more eggs.

If they have a small food source, they may lay fewer eggs, right? But it turns out that is not what happens. The number of eggs that these beetles lay is statistically similar, irrespective of the size of the food source. So, if that is the case, there is some kind of regulation happening at some point. So, one possibility is that you know there may be a lot of competition between the larvae. Only a fixed number or only a fixed fraction is able to survive.

But if you directly observe the beetles, which is what was done by Wilson and Fudge, You realize that that is not what is really happening. What is really happening is that they lay as many eggs as they want. But later they actually kill and eat some of the larvae, and the control they exert is proportional to how much food they have. They have more food; they kill fewer larvae.

They have less food; they kill more larvae. But what they ensure is that the amount of food available per larva is more or less constant. And because of this, the remaining larvae have a sufficient amount of food to grow. Therefore, this infanticide is a way that is being used by the parents to control the family size. such that all larvae end up getting a similar amount of food. Now, of course, one can ask the question here: doesn't it seem a little bit wasteful? Would it not have been better if they had evolved a way of laying? more eggs or fewer eggs depending on whether they had more food or less food? Correct, it would have been, but not all solutions that make sense to a human being or an engineer are what the organism will be able to you know execute.

Maybe it does not have the genes to do that kind of sensing. But anyway, that aside, the main point I am trying to make here is that Organisms can use infanticide to reduce competition for food among their offspring. So, that is one. Another way in which organisms sometimes use infanticide is to recover resources. And this is found, for example, in a big way in these polar beers. So, you know polar bears are probably the largest among all the bears; they are certainly the most carnivorous among all the bears.

So, in these cases, it is well known that the male bears kill the cubs of other males to bring the females back to estrus. So that they can mate. That part is not what we are dealing with here; that part is not surprising. The surprising bit is that female polar bears sometimes end up killing their own babies, and this typically happens during two stages. Either when there is extreme starvation, there is no food, and the female is on the cusp of death, or if the baby is extremely weak and the baby is highly unlikely to survive, even in that case the female can kill the baby and eat it.

So, this is thought of more in terms of, you know, recovering the resource so that they are able to survive longer. The third interesting way, I mean, obviously, recovering the resource in this way works if you are a carnivore. There are situations where organisms weed out the weak without necessarily eating them. So, this is the golden takin; this is a kind of goat that is found only in China; it is native to China. And in this particular case, what happens is that once the baby is born, The mother actively tries to help the baby get up on its legs.

Now, most of the babies are able to do so within a very short amount of time, but sometimes there are weaklings. Very weak babies are produced who, even after several tries and a lot of help from the mother, are unable to get up. When that happens, it has been seen that typically about 50 minutes or so is the level to which the mom tries. After that, suddenly the mom changes her behavior; she no longer helps the baby. she actually actively goes and attacks the baby with her horns, you can see the sharp horns and then tosses the baby up into the air several, several times till you know it punctures vital organs and basically till the baby dies.

Now, in this particular case, obviously this is not a carnivore, so it is not really trying to eat the baby. It is essentially trying to relieve itself of the burden of taking care of a weak baby, which would have died on its own anyway. So, that is the third one, and the final one is very interesting. This is, in some sense, restarting reproduction. So, we have been talking about the males' killing of unrelated babies so that the females start reproducing again.

But here you have a situation where the male is killing its own babies. So how does it work? So, this is the barred-chin blenny. It is found in the coral reefs of the western Pacific Ocean. So, typically what happens is that the male goes and creates, you know, this is coral living in the coral reefs, right? It goes and gets hold of a nesting site, typically a hole in the coral or some other site, and then the male stands guard over there. And the females, you know, they start to guard and they start coating the females.

The females come, mate with the male, deposit their eggs, and then leave. And the males will stand guard over there, and they are going to, you know, take care of the babies. So, taking care of the babies or other eggs in this particular case is fanning behavior. So, if you remember, we discussed that in some fish, the male fish typically stands guard over the eggs and keeps on. You know, having a flow of water over the eggs. Why? Because that flow of eggs ensures that the eggs are aerated, It ensures that there is no algal or any other kind of growth on the eggs, and that is essential for the eggs to hatch.

So, the same fanning behavior is shown by this particular fish. Now, obviously, not all females are equally fecund, right? So, it is not the case that the number of eggs laid by the females is large in all cases. Turns out, if the number of eggs is low and people have figured out that if the number of eggs is about 1000 or so, then Rather than quoting more females, the males they kill, or, you know, eating the eggs. This is the very interesting part. Sometimes they eat, but many a times they simply kill them without eating them. So, it is not really a case of, you know, recovering resources; they are killing them for some other reason.

What is the reason? It's very interesting. Turns out that when the eggs are present, the male's androgens. The male hormones, testosterone and some of its analogues, have lower levels in the presence of the eggs. And when that level is low, the male is not able to coat the females properly. So, they have to expend a certain amount of energy to coat the females, and if they are not coating vigorously, The females will not come. And therefore, in the presence of the eggs, the males are not able to coat the females sufficiently to obtain matings.

Therefore, when the males end up killing the eggs, that leads to a sudden boost in their androgen levels and now the male can coat the females very, very vigorously. And that is why, if they have a small brood, remember that in the context of fish, 1000 is nothing, right? So, they have a type 3 survivorship curve, which means that the death rate in the early phase of life is very, very high. So, if you have only 1,000 eggs, the chances that you are going to get any surviving offspring out of that are relatively low. Therefore, instead of wasting time with a small brood, The male gets a benefit because it can now start immediate courtship with other females. who hopefully will be able to lay many more eggs, some of which you know are going to survive.

So, this is what we know about the parents' side of the story. And as you can see, the parents do all kinds of things to increase their own fitness, right? And in many cases, actually killing the organisms does end up increasing the parents' fitness, which is why they do it. Now, obviously, you are going to think that you know poor offspring; it is either a one-celled egg or it is not even born in some cases. Or it is, you know, very weak and unformed in the early stage; the poor offspring has no real defense. But see, in the context of evolution, which is happening over a long, long time. Any trait that the offspring is able to develop which enhances the offspring's fitness, That ultimately is going to benefit, or it is going to have an evolutionary effect in terms of the species' success, right? Therefore, it turns out that the offspring do not really sit idle; They have ended up evolving a large number of characters that can enhance their success rate and evolutionary success rate.

Even if you know the parents are not necessarily trying to help them, or even if it conflicts with what the parent is trying to do. And perhaps the biggest example of exploiting parents happens in mammals, particularly primates like us, humans. So, this is a picture of a fetus inside a mother's womb, and as all of you know, the fetus is connected in primates. Particularly in humans, the fetus is connected to the mother's uterine wall, the wall of the uterus, with this structure called the placenta. Now, the placenta is perhaps one of the biggest and hottest battlegrounds that you can find between mothers and offspring.

Particularly in primates. So, for example, in humans, these placental cells. They will actually go and sit on the mother's artery, right, and they will invade the mother's artery. Now, normally, the mother should be able to control how much resource she shares with the fetus by constricting those arteries. However, once the placental cells go there, the first thing they do is kill off the smooth muscle cells of the arteries. Because of this, the mother's arteries are no longer under her control. She cannot contract them anymore because there are no muscle cells, right? And then they synthesize all kinds of growth factors, as a result of which the mother's artery grows larger.

What is the result? Two results: number one, the mother's blood is directly coming into contact with the placenta. There is no barrier in between, and the mother is not even able to control the flow of blood. As a result, the mother has no control over how much nutrition the offspring are getting. The offspring can do all kinds of things, and it actually does, as I will show you in a second.

It does all kinds of things to extract as much nutrition as it can from the mother. And this invasiveness of the placenta is actually a huge thing in the context of, you know, primates, and particularly humans. So, you know that when a baby is being carried by a human mother, then abortion is possible only up to a certain point. If the age of the mother or the age of the fetus is beyond a certain point, abortion is no longer advised. Why? That is because the placenta, as I told you, actually goes and invades the mother's uterine wall and its arteries in such a way that essentially the mother has no control now. At that point, if you are having an abortion and tearing off the placenta, Then the mother's tissues over there are paralyzed, right? And it is pumping blood at a huge rate.

So, because of that, there is typically a very, very large amount of bleeding that happens, which is why. Miscarriage at slightly advanced stages is extremely dangerous for the human mother. But this invasion of the uterine wall is probably one of the simpler things that you know the fetus is doing. There is also a massive amount of chemical warfare going on.

So, in humans, the placenta releases a hormone that is known as human placental lactogen (hPL). Now, what this hPL does is very interesting. So you know that in our body, the amount of sugar or glucose in the blood is controlled by this hormone called insulin, right? Which is coming out of the pancreas. Now, what this hPL does is it reduces maternal insulin sensitivity, okay? Because it does that, this is essentially saying that it reduces the ability of insulin to control the amount of glucose in the blood. To reduce the amount of glucose in the blood. What will happen? As a result, the maternal blood glucose level is going to go up, and not only that what hPL does is reduce the mother's ability to use the same glucose. Because if glucose is not being absorbed into the cells, The mother is not even getting the glucose that she is producing, right, or is she having it? So, the maternal blood glucose level goes up, and the mother's ability to use the glucose goes down. And because the mother is not using the glucose, obviously there is more glucose in the blood. Now remember, this blood is going to the placenta, and from the placenta, this glucose is being absorbed by the fetus. Therefore, this essentially ends up increasing the amount of nutrition that the fetus is receiving. Now, in the context of primates and humans in particular, this is huge because Much of the energy that the baby is getting is being used for the development of its brain.

And remember, much of the development of the brain actually ends up, you know, happening during the fetal stage. And that is because this is the only stage where it has access to so much nutrition that it can essentially pull from its host. Which in this case is the mother. Now normally the mother has ways by which she can take care of this thing that the baby is doing, you know, increasing its glucose level. But sometimes that control by the mother ends up failing, and when that happens, Then the mothers get what is known as gestational diabetes.

Essentially, their sugar levels become abnormally high. Now, what I gave you is a very small description of the entire war that is happening between the mother and the offspring. So, in the context of humans, this tussle between the mother and the offspring. If you want a fabulous non-technical, you know, account of that, I will strongly recommend this particular, you know, essay to you. This is a 2014 article. So obviously, there are many molecular discoveries that happened after that which you will not find in this article.

Today, we know even more than what is presented in this particular piece, but what it discusses here is fascinating to begin with. So this is the first thing that the offspring does. It is absolutely trying to exploit its parents. The other thing that the offspring can do, and they often do, is try to exploit their siblings.

Again, remember 100% relatedness with itself and 50% relatedness with its full siblings. Therefore, if there are other claimants to the resource that the parent is giving, if you can bump off those claimants, it is good for you. So, one of the ways in which it happens is known as adelphophagy. So, this is the rather, you know, dangerous-looking sand tiger shark. Although it looks this dangerous, apparently it is not very harmful to humans; it does not really attack humans at all. Now, in this particular species, the females end up mating with multiple males; therefore, Inside their belly, they have many embryos in the uterus; that is, they have many, many embryos.

Now, these embryos start growing, and at some stage, one of the embryos—the one that is known as a hatchling—ends up. Killing and eating all its siblings inside the uterus. So, even if they are starting with 30 to 40 embryos, at the end of the day, only one baby is going to come out of this mother. And this is what is known as intrauterine cannibalism. Cannibalism is when members of a species eat their own kind; intrauterine, inside the uterus, it is also known as adelphophagy.

Now, this is a very special case of a generic phenomenon, what is known as siblicide. And siblicide is simply when one offspring ends up killing another. So, again, it's pretty well known. I am showing you one example you know; I will show you one more in the next slide. So, this is a bird known as the Nazca booby, and it lays eggs, but the eggs are not laid at the same time.

One egg is laid earlier; the second egg is laid later. And in this particular case, you have what is known as obligate siblicide, which means that this chick. Which has come out of one egg, this is the firstborn; this is going to kill the second one when it emerges. So, this is obligate siblicide. There are other cases where you have fatal data siblicide, which means.

Siblicide happens when brothers or sisters are killed, but only when there is a resource constraint. And that kind of thing happens, for example, in spotted hyenas. So, these are animals you find, as you know, in Africa: spotted hyenas, and these guys, the mother normally gives birth to two cubs. Sometimes, three cubs are also produced, but typically, two cubs are produced. Now, when two cups are produced, if the mother gives a lot of care, Either because she is capable of giving a lot of care, or you know the environment is such that she is able to give a lot of care.

In that case, the chances of siblicide are lower. It is not 0, but it is less. But when the mom is unable to provide adequate care to both, Then there is a very high chance that one of the cubs is going to kill the other. And this is the interesting part: when siblicide is going to happen. The killer cub is typically the one that ends up getting more resources from the mother before it has killed the siblings. So, probably this is the one that ends up getting more resources.

Therefore, getting a little stronger, this is the one that ends up killing its siblings. Now, very interestingly, in this species, the mother does not modulate the amount of food that she is bringing. The amount of care that she is giving. Now, because of this, the entire amount of care that was earlier getting divided into two, That entire amount of care now goes to that killer cub. And because of this, the growth rate of the cub, which has, you know, killed its sibling, increases significantly.

So, there is a very visible benefit to killing your sibling in spotted hyenas. Now, with this, we will come to an end of, you know, killings or conflicts. that are somehow among related individuals, relatives. There is one more kind of conflict that happens between males and females; it is a sexual conflict. And I mean I probably should have included it in the previous week's discussion, but that discussion was anyway pretty long.

So, that is why I have brought it over here in this context when I deal with other kinds of conflicts. So, these are known as inter- and intra-locus sexual conflicts. What really happens here? So, in the context of inter-locus sexual conflict, these occur through the interaction of two or more different loci. In males and females, resulting in the deviation of either or both sexes from the fitness optimum for the traits. which in simple words means that let us say you have the male, and the male has certain traits that are improving its fitness at the cost of the female's fitness and the female has some other traits which is allowing it to resist that. Now, in the context of behaviors, you know a lot of conflict is behavioral, right? So, in the context of behavior, we now know that many of these are actually related to the genes.

But for a long time, people thought that many behaviors were simply environmentally stimulated. So, this intralocus and interlocus are explicitly coming in the context of those behaviors. where we have reasons to believe that the behaviors have a genetic basis. That is why you know they are talking about locus. So, in the context of interlocus conflicts, the conflict is between some genetically modulated traits. which are localized in males due to some loci that are only expressed or present in males and another set of traits that are related to loci that are only present in the females.

So, basically, genetic traits are expressed either in the males or in the females. Now, to give you one example, this is a mating drosophila, or fruit flies. We know that when the Drosophila male mates with the female, along with the sperm, It actually ends up giving a host of other proteins. You know, introducing a host of other proteins into the reproductive tract of the female. And these are taken together, known as seminal fluid proteins or SFPs.

Now it turns out that these SFPs play a major role in modulating the behavior of the female. in a way that is not necessarily good for the female. So these proteins actually end up speeding up the egg production rate of the females. Now how does this help the male? So remember, the Drosophila female mates with multiple males, right? So the more number of males the Drosophila female is going to mate with and the longer she stores the sperm inside her, The chances that she will end up, you know, with some other male's sperm fertilizing the egg increase. On the other hand, you know that there is something known as last male preference in Drosophila females, which means that The male that has ended up mating last in a sequence typically fertilizes a greater number of eggs. So, if you speed up egg production, Then the chances of the male who has, you know, just now mated, that male's sperm fertilizing a lot of eggs go up.

Similarly, you know Drosophila females mate multiple times. So, there is remating. Obviously, the faster the Drosophila female remates, the worse it is for the males. Why? Because I told you last male preference was right. So, the longer the female takes to remate, The greater the chance that the male which has mated will fertilize the eggs with its sperm. So, if there is something that can cause a delay in terms of remating, then, That is excellent for the male, but obviously, for the same reason, it is not good for the female.

Because she is not getting, you know, more sperm, more choices in terms of fertilization. And of course, some of these are also known to reduce the lifespan of the female. So, you can see this is good for the male but bad for the female. And people have figured out in many of these cases which specific proteins are which are responsible for causing all these harmful effects. Now, of course, the female is also not taking this lying down. The female has also evolved certain traits to, you know, resist all these harmful effects. And, for example, the female has actually evolved genes that promote remating. which is against the effect of the delay in remating caused by some of these SFPs. So, here is the reference that interested people can look up.

So, this is about inter-locus sexual conflict, where the conflict is happening. But what the male is doing and what the female is doing are being controlled by different traits. And because they are controlled by different traits, The assumption is that they are controlled by different loci in the individuals. Contrast this with what is known as intra-locus sexual conflict. So, this is the canonical example of intralocus sexual conflict: you know, the tail of the peacock.

So, on the left side, I am showing you a pea hen, the female, and on the right side, I am showing you a peacock. Now, think about it. The peacock, as we have already discussed, has evolved a long tail because of sexual selection. Awesome. But when a peacock is reproducing, it produces males and females; I mean offspring of both sexes. Now, this gene, or set of genes, is leading to a large, longish tail. When that is expressed in a pea hen, the female, what is it going to do? If it ends up creating a long tail in the pea hen, what benefit does the pea hen have? As far as we know, peacocks, that is, the males, do not have an extra preference for females with long tails.

On the other hand, if it has a long tail, it is going to have the, you know, Whatever, it is going to be more vulnerable to the predators, right? So, its fitness is going to go down simply because its chances of getting caught increase. So, the same long tail, which benefits the male by getting him more matings, It is actually harmful to the female of the same species. So, intralocus sexual conflict is a form of sexual antagonism that arises when. The same genes control the same phenotype in both sexes, but the optimal trait values for males and females are very different. So, this is what you have to understand: when the same trait is going to have different fitness in males and females, That is when you have a case of intralocus sexual conflict.

And you know, just to say the same thing in slightly different language, It appears in all those cases where the direction of selection at a given allele depends on. Whether the allele is being expressed in males or whether the allele is being expressed in females. Now, what intralocus sexual conflict does is that it can, you know, Because of this, selection that benefits things in one sex will end up hampering adaptive evolution in the other. And the thing that intralocus sexual conflict can often lead to is the evolution of sexual dimorphism.

Now, how exactly will that happen? So, again we are presenting, you know, a graphical representation of the whole thing. But people have actually modeled this in a nice way and have figured out all the various conditions. genetic conditions under which this kind of thing can happen. We are not going into those genetic details. But I am just showing you the stages through which sexual dimorphism can evolve because of intra-local sexual conflict. So, let us assume that we have a trait and that this is the distribution of the trait in the population, right? And what we also have is the fitness surface.

What is the fitness surface? So, the fitness surface is simply telling me that for a given value of the trait, what the fitness value is. And right now, there is no conflict over here. So, the same fitness surface operates for both males and females. So, what you see over here is the trait distribution optima. Sorry, maximize here, and this is where the fitness is also maximized.

Makes sense? Now, assume that there has been some change in the population, whatever that change might be. Some mutation or something, some change in the environment, something, and Because of that, the trait distribution still remains the same, but the fitness surface. The fitness distribution for the male and female has now changed. So, now the male—sorry, the female—has a fitness optimum over here, fitness maxima over here. whereas the male has a fitness maxima over here, right.

Now, the trait distribution is still the same, but the females are facing one kind of fitness surface. The males are facing a different kind of fitness surface. And when that happens, that is where the conflict begins. The something that is good for the female is bad for the male, and vice versa. Now, when this happens, typically the females will start evolving toward this maxima.

This fitness maximum, the males will start evolving towards this fitness maximum. such that the trait distribution between the female and the male will start separating itself out.

So, you can see that here the trait distribution has started, you know, separating; it has started becoming bimodal. And the female trait maxima is going in this direction; the male trait maxima is going in this direction.

This is kind of like disruptive selection, except that it is happening within the same species. And this is why it is called a partially resolved conflict. And when this keeps happening, the two trait distributions will move further apart from each other. And at some point, the male and female trait distributions will completely separate from each other. And this is, you know, where you will get sexual dimorphism. When the male and the female have totally different trait distributions, Maybe in terms of, you know, size, body size, or maybe in terms of plumage color or maybe in terms of some kind of, you know, gene expression, we do not know what it is. But the male and the female will end up having two different distributions that are not overlapping, and the males' trait distribution, Sorry, the female's trait distribution maxima will again coincide with the females' selection fitness maxima, and the same for the males. As I said, people have worked out what the underlying genetic conditions are needed for this kind of event to happen. But we are not going into that; we are just showing you what the process is going to look like. Now, do we have reasons to believe that intra-local sexual conflict occurs? We have a few examples.

So, this is one example from a species that we have already met: this is the red deer. What people have shown is that male red deer, which have relatively high fitness, If you look at their daughter's fitness, it is negatively correlated with their fitness, and vice versa, obviously. So, this tells you that what is turning out to be good for the males is turning out to be bad for the females. A similar example in the context of this bird is that we have met this bird before; it is a colored flycatcher. And in this particular case, they looked at fitness in terms of survivorship from fledging to breeding. Fledging is when the birds leave the nest, and breeding is when they reproduce, and it turns out that Selection acts very differently on the body size of males and females during this period.

So, it turns out that males, if they are smaller in size, end up achieving higher fitness.

Females get higher fitness only if they are larger in size. So, you can see it is the same trait, but it acts in different ways in males and females. Females are, you know, getting a benefit if they are larger; males are getting a benefit if they are smaller. So, we are going to stop our discussion on conflicts here. But you can already see that this kind of situation can lead to dimorphism, right? And as you know, dimorphism, or the production of very different amorphs, that of course, We are talking about sexual dimorphism, but if that dimorphism is not happening at the level of across sexes, but, If it is happening at the level of populations, then that can lead to the formation of new species, right? And if you remember correctly, at the introduction level, I had said this is one of the big questions in biology. How exactly are new species formed, and what are the conditions required for that? And we have looked at many of the, you know, evolutionary forces that are operating on various organisms and populations.

With all that information, we are now in a position to tackle this big question. However, that is what is going to happen in the next discussion. See you then. Goodbye.