

How to reproduce in a high-tech world



Humans are taking complete control over the reproduction of plants, animals, and their own species. If we do to ourselves what we do to plants and animals, sex will never be the same again.

OUR SEX LIFE

For most animals, including humans, finding a suitable sexual mate is basically a matter of getting close enough to a member of the opposite sex. Start by going for a walk, flight or swim and find out where members of the opposite sex are hanging out. Next, approach one of your species, and convince him or her that you are the one. Eventually sperm and eggs will mix, often on the spot.

There are some differences, however, between humans and other animals when it comes to sexual reproduction. For one, humans are one of the few mammals that are always in the mood for sex. Other animals generally experience periods of rest and heat. Once in a while, females are in heat and they make sure that males know. Often, these meetings happen at breeding grounds which may have been used for many years. Usually, males perform some kind of ritual - fighting with other males, singing or dancing - that should impress the females. These rituals, as well as certain sexual positions, have been the same for as long as the species has existed.

Not so with humans. Sex can happen anywhere, anytime, and there is no fixed ritual. This is what can make human sexuality so confusing, so clumsy, and so interesting at the same time. In *The Double Flame* (1994), Mexican poet Octavio Paz observes that human eroticism distinguishes itself from animal sexuality through its countless manifestations, in all times and places. Eroticism changes with the climate and the landscape, the society, the individual, and the temperament, as well as the occasion, the opportunity, and the inspiration of the moment.

THE SEX LIFE OF PLANTS

Last spring, I found myself on an uninhabited island in Helsinki, Finland. I was there to attend a workshop called "Understanding the Essence of Flowers - Exploring Pollen", which was hosted by Aalto University's Biofilia program, a platform for research and education on the relationship between the biosciences and art. The workshop was organised by Melliferopolis, an initiative on honeybees in urban environments, and "proposed to engage with the link between bees and flowers, a choreography that facilitates reproduction and nutrition of two very different species - insects and plants".

The sex life of plants and bees might seem unrelated to human sex life, but there are reasons to think that we are steadily

becoming more like them. First, let's talk about plant sex. Obviously, animal reproduction strategies won't work for plants. They can't fight, drive expensive cars, write poems, tell jokes, or dance to impress members of the opposite sex. Initially, plants relied solely on wind and water to combine their genes. These were the original gymnosperms, of which the largest surviving group are the conifers. More than 100 million years ago, the angiosperms had another idea. They entered into a symbiosis with animals to help them spread their genes, a strategy that was more successful than relying on the wind.



Flowering plants reproduce without ever meeting each other. Instead, they rely on the service of another species for pollination, which is the physical transfer of male reproductive material (pollen) to the female reproductive structure (pistil) of a compatible flowering plant. The "pollinators" are most often insects, but they can also be birds, reptiles and mammals.

Pollinators are like the matchmakers of flowering plants because they are rewarded for their effort by the plants. They usually seek nectar, which is found in the flowers, or sexual organs, of angiosperms. Pollen sticks to the bodies of the pollinators while they collect nectar. By visiting different flowers, these animals transfer pollen, and fuel pollination.

If you think about it, flowering plants have rather kinky sex lives. The sexual act is divided into stages, and involves at least three individuals from two different species. And while plants are rooted down, it doesn't mean they're not flirting. Angiosperms develop provocative flowers of which the shapes, colours, and odours attract specific animals. Many flowers have even developed seats for pollinators to comfortably lean on while they're feeding on nectar. Plants do not seduce each other, they seduce their matchmakers. They don't choose their sex partners either. This is left to the pollinators.

THE SEX LIFE OF BEES

Bees are not the only pollinators, but they are special. There is no other insect group that exploits flowers to such an extent. The main reason bees visit plants is to collect nectar. This is made into honey, their food for the winter. Honey is also needed to make wax, which is the main construction material for the combs the bees build in their hives. Bees also collect the pollen itself. For bees, it is an essential protein-rich food, as nectar contains very little protein. Unlike other insect groups such as butterflies, moths, flies, or beetles, who only consume nectar or pollen in their adult stage, adult bees collect these substances to feed their larvae. A beehive is almost entirely reliant on pollination.

So what about the sex life of these facilitators of plant sex? As with humans, there is physical contact between the male and female during reproduction. That, however, is where the similarities end. Bees and other social insects divide the labour of reproduction. The queen bee reproduces almost exclusively, while other members of the colony specialise in different tasks. Furthermore, bees tend to parent as a group rather than individually.

Another striking feature of the bee colony is the gender ratio. A bee colony is almost exclusively made up of females. Only in late spring is a small group of males (drones) produced, and they have only one purpose: sexual reproduction. The drones gather in congregation areas, high in the air, along with virgin queens and drones from neighbouring colonies.



While female bees are the result of combining sperm and an egg drones are created by parthenogenesis, a form of asexual reproduction in which an embryo can develop from an unfertilized egg cell. When a drone mates with a queen, the queen stores the sperm in her body. She later uses it to fertilise her own eggs. The queen usually lays fertilised eggs, which will all develop into female bees. Only when the queen decides to lay an unfertilised egg, a male bee appears. Queen bees thus have complete control over the reproduction process.

The amount of male bees in a colony is kept to an absolute minimum: there are no more than a couple of hundred drones among several tens of thousands of female bees. In autumn, the surviving drones are killed by the females. They have become useless (as they don't collect honey) and keeping them alive would deplete valuable food reserves in the winter. The drones that manage to mate with a queen have no better fate: during a successful mating, their penis is ripped off, and they die.

HAND POLLINATION

Scientists warn that plant reproduction is under threat. Indicators show a severe decrease in the populations of many pollinators such as honeybees, wild bees, butterflies, moths, and flies. The reason remains unclear, although pesticide use seems to be involved in one way or another. This decline is worrisome, because pollinators are at the beginning of the food chain. By maintaining the reproduction of many plants, they indirectly support the food supply for many animals, including people. Biologists estimate that three-quarters of the world's species of food crops require pollinators for reproduction.

If pollinators disappear, humans would have a difficult time taking over their job. The rise of monocultures in agriculture has made it common to truck in loads of beehives to pollinate agricultural fields, because there aren't enough pollinators naturally available. Pollinating fields has become a more important industry than producing honey. However, since bees are among the pollinators who are declining, shipping bees around might not be sustainable in the long term. In China, India, Pakistan and Nepal, there are farmers hand-pollinating their fruit crops because insect pollinators were wiped out.



Hand-pollination could make vegetables and fruit much more expensive. This is why scientists are developing robotic pollinators. The Harvard Microrobotics Laboratory has been working on "RoboBees" for several years, and the results seem encouraging.

Whether humans pollinate plants by hand, using brushes or cotton swabs, or delegate that task to robotic bees, the result is the same: humans become matchmakers for flowering plants. In a sense, this is nothing new. Humans are probably the most important pollinators on Earth. If you plant a potato in your garden, you are behaving like a bee: you facilitate the reproduction of a plant species. In *A Botany of Desire, A Plant's-eye View of the World*, journalist Michael Pollan describes how humans have largely expanded the habitat of many plants that they find useful, and suggests that it is not us but them who are in control of this process.

While humans spread plant species all over the world, our efforts are almost always aided by the work of smaller pollinators. If we take over their role, we would have complete control over the sexual selection process of plants. With this comes total control over their offspring. For example, robotic bees would further stimulate the use of monocultures and pesticides because, unlike natural pollinators, robotic bees are not harmed by a monotonous diet and toxic chemicals.

THIRD PARTY REPRODUCTION

There is an interesting parallel developing between plants, bees, and people. As with plants, infertility in humans is increasingly problematic. For instance, if the downward trend in human sperm quality continues, scientists say, the average British man would be classified as infertile by 2050. Increasingly, humans are becoming 'pollinators' of their own species, thereby substituting copulation between male and female with artificial acts.

Humans have designed many successful artificial reproduction strategies. Third party reproduction includes sperm banks, egg banks, embryo banks, and surrogate womb mothers. While they all treat infertility, they might serve a larger cause. Anybody who wants a child, but not a spouse, is able to procreate. From a strictly technological viewpoint, sexual intercourse is no longer a necessity for the survival of our species.

When human sexual evolution happens via third party reproduction, it becomes a mirror image of sexual reproduction in flowering plants. Take a sperm bank as an example. The sexual act is divided into phases. A male releases semen without knowing where it will end up. There is no contact between individuals. The courier that carries the sperm from the male to the female is the pollinator. With egg banks, embryo banks, and surrogate womb mothers, the process is similar.



ARTIFICIAL INSEMINATION

As with plants, our interference with human reproduction gives us increased power and control over our offspring. A potential outcome of third party reproduction technologies is that the 'matchmakers' may decide who should reproduce with whom, and which characteristics are desirable. We are already doing so with animals, using the same technology. In livestock breeding, we don't call it third party reproduction, but artificial insemination. Although artificial insemination is sometimes used to treat infertility in animals, it's mainly used to improve the production of meat or milk, or to develop other traits beneficial to us, but often harmful to the animals. For instance, turkeys have become so fat that they cannot have sex naturally anymore.

Apart from practical advantages, such as not having to transport animals, artificial insemination has made selective breeding of animals much more efficient, because a male with very desirable traits can inseminate a massive number of females. For example, although a bull cannot mate more than 100 times per year, frozen bull semen provides at least 200 doses of artificial insemination from one ejaculation, which is good for an estimated 40,000 inseminations a year. Artificial insemination brings additional advantages for livestock breeding: it prevents the transmission of sexual disease, makes it possible to synchronise births to facilitate herd management, and allows a choice of sex - some of our livestock herds are mostly male or female.

Does that ring a bell? Human strategies to boost the selective breeding of livestock are reminiscent of what happens inside a bee colony. With existent tools, we could increase the selective breeding of people and create a society that bears similarity to a bee colony. In theory, we could design castes of people (monocultures) for specific tasks and create a single-sex society, where very few males can sustain a mostly female population. There is a lot of talk about genetically manipulating life forms these days, but similar radical results are possible using existing technology.

THE ARTIFICIAL WOMB

One of the most complex designs in assisted reproductive technology is the artificial womb. We already perform fertilisation outside the female body through in vitro fertilisation (IVF), in which eggs are surgically removed from a female body, and then fertilized in a fluid medium in the laboratory. However, after fertilisation, the resulting embryo has to be transplanted back into the body. Human reproduction thus remains dependent on the number of females in a society.

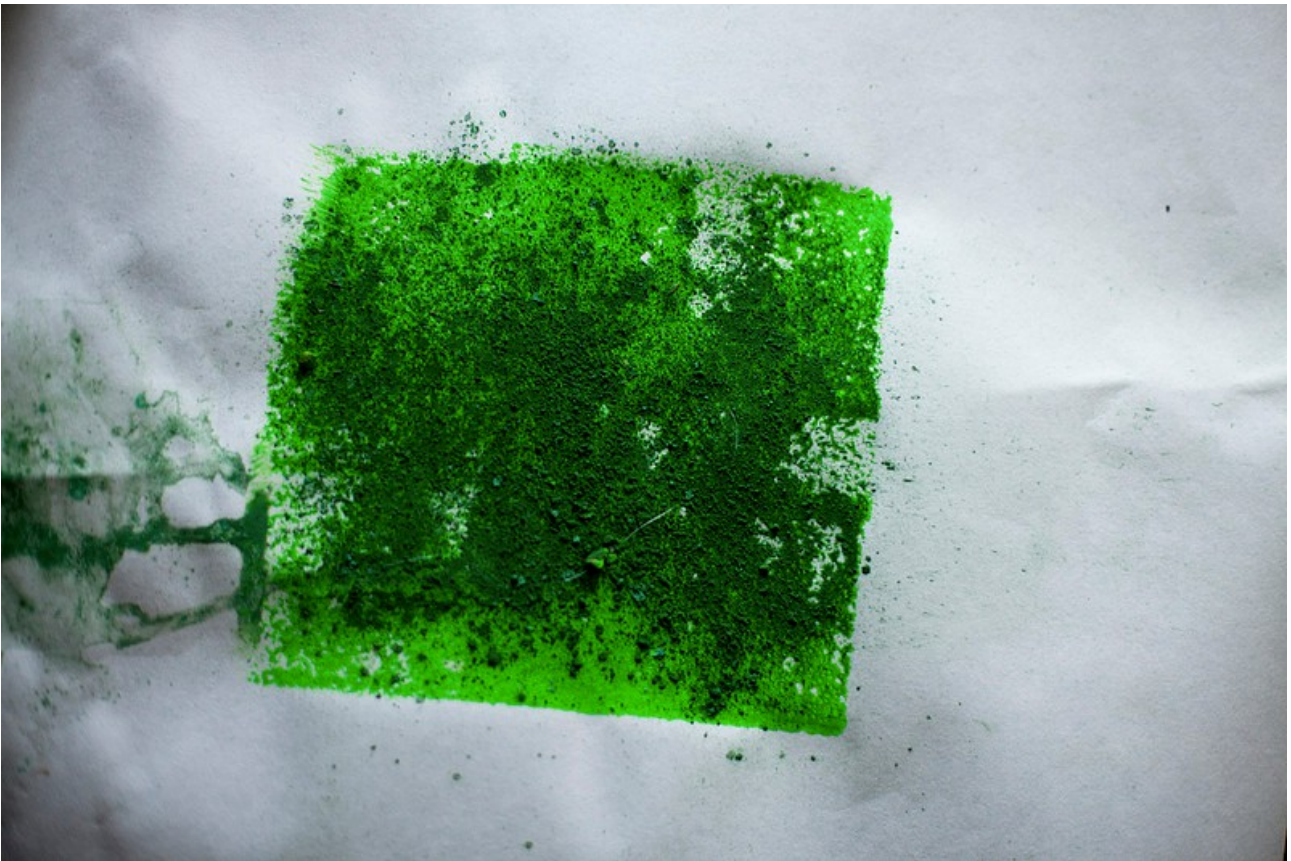


Scientists have already succeeded in growing human embryos in artificial wombs up to 14 days (the maximum period allowed by law for such experiments). Experiments with animals have kept embryos alive for longer, and have even accomplished live births - though the offspring were severely deformed. The research into artificial wombs is conducted within the context of treating infertility, but like third party reproduction, it offers additional possibilities. An artificial womb would allow males to do what a female can do today: get a donor egg and use it to procreate independently. The artificial womb would thus make it possible to maintain an all-male society, in which few women only serve to produce eggs.

On the other hand, an artificial womb would also bring potential advantages for females without fertility problems: it could provide a bloodless birth, no stretch marks or weight gain and the ability to do whatever she wants during pregnancy. While many women would not choose to avoid pregnancy, others may be seduced by the advantages of the artificial womb. There might come a day when an artificial womb is better for the child or the mother than a natural one, increasing the social pressure to use the technology even for women who are fertile. Artificial wombs would make it possible to transform human reproduction without some State or other central power steering it.

HUMAN REPRODUCTION IN THE FUTURE

Alternative ways to organise human reproduction have already been extensively explored in science fiction media. Interestingly, some of the most famous visions of the future are reminiscent of a bee colony. In *Consider her ways*, a 1956 novella by John Wyndham, scientific experiments have unintentionally created a virus that has wiped out all men in the world. A group of women embarks on an urgent research programme to enable them to reproduce without men. They achieve this by parthenogenesis, and create a caste-based society that resembles the social structure of a bee colony. One of these castes of women (the "Mothers") devotes their life to producing female babies. Like queen bees, these women are much larger than others. Parthenogenesis in mammals is impossible, but, as we have seen, we could achieve a similar result with existing technology.



In Aldous Huxley's *Brave New World* (1932), children are grown in artificial wombs. Only a small percentage of female embryos are allowed to develop reproductive organs, while the majority of females are born infertile. The ovaries of fertile women are removed and kept alive artificially. One ovary can produce up to 15000 eggs. Like a bee colony, the society in *Brave New World* is characterised by collective parenting. There are no family ties; all children belong to, and are educated by, the state. Furthermore, all individuals are bred (and conditioned) as part of a caste with specific duties, each having their own dress code. Monocultures thrive.

Importantly, *Brave New World* shows that sex is not incompatible with a mechanically reproducing human species. Although reproduction in Huxley's book has been taken out of the hands of individuals completely, sexual intercourse survives as one of the main social activities. From a very young age, people are conditioned to be promiscuous and the gender balance has not changed. Instead of serving as a means of reproduction and a fundament of human relationships, sex has become a way to dumb down and control people, a form of entertainment.

THE COMMON INTEREST

Looking at technological developments and science fiction literature it is clear that the freedom to choose our own mates, and with it the whole world of poetry and eroticism, should not be taken for granted. What is also at stake is the biodiversity of humankind. We have greatly reduced the biodiversity of plants and animals through our love for monocultures, and we could do the same with people. The technology to control human reproduction is available, it only takes the right ecological, political, social or religious conditions to be useful. Some important caveats should be made, however.

Firstly, technology is no prerequisite for changing reproduction in humans. In Margaret Atwood's dystopian novel *The Handmaid's Tale* (1985), society is faced with massive infertility, apparently due to a nuclear accident. This leads to an ultra-conservative theocratic military dictatorship. The new regime takes away all women's rights and turns females who are still fertile (the "handmaids") into breeding machines for the ruling class.

Sexual intercourse happens once a month during a disturbing fertility ritual: the male has sex with the handmaid who is lying between the legs of the wife. Today's reproductive medicine would describe this as a combination of natural insemination and surrogacy. No technology is involved. And yet, as in *Brave New World*, the society is divided into castes, parenting is in a way collective (family bonds between biological mother and child are destroyed), and sexual selection is not individual, but serves a higher goal. (The Chinese one child policy is a tamer contemporary example of interference in human reproduction using sheer political power and imposing rules.)



Secondly, it is tempting to conclude that interference in human reproduction is a bad thing - as it is presented in science fiction. This is true only when you consider individual freedom most important, as is the case in the western world today. For society as a whole, a centrally steered reproduction process could bring advantages. Here, again, is an interesting resemblance to bees. Some argue that a bee colony should be looked upon as one organism, the "Bien" (German pronunciation). In this organism, the queen is the female reproductive organ, the drones are the male reproductive organ, and the worker bees take the role of all other organs and functions of a body. All individuals in the hive, the nest made of wax and the larvae can be compared to a mammal in many respects.

Like bees, humans can be viewed in two ways: as individuals or as parts of a collective which is more than the sum of its parts. Similar to social insects, our greatest technical achievements are products of a collective effort - no individual could ever build a city, railway network, or nuclear reactor, for example. Likewise, no individual could cause grievous damage to the natural world, but together that's precisely what we're doing, largely as a consequence of our belief in individual freedom (i.e. the right to consume, to pollute, and to use any resources we like).

Therefore, it should not surprise that some people advocate an interference in human reproduction to avoid ecological collapse. For example, Finnish ecologist Pentti Linkola argues for a drastic reduction of the human population, and views individual autonomy as the main cause of environmental destruction. "Given the present condition of the world," he says, "under no circumstance can procreation be a family decision in the hands of parents or individuals."

Kris De Decker (edited by Deva Lee). All pictures were taken by Tommi Taipale at the [Melliferopolis workshop](#) in Helsinki, Finland.