Evolution
in Action

BOMBUS MEDLEY

1. *Cool climates call for warm coats: the evolution of bumblebees*

To help you better understand how bumblebees evolved, this recording will first take you 135 million years back in time. Look around you here on pre-historic earth: you'll find yourself in a world dominated by ferns, horsetails and different kinds of coniferous trees. You are surrounded by plenty of plants, but there is no buzzing of bumblebees to be heard or colourful flowers to be seen. In this era, plants were a greenish brown, as their attractive colours hadn't evolved yet.

Observe the surrounding plants and their different colours. Close your eyes and imagine: what would it look like in this spot, if you were to travel back in time to the Cretaceous period, where the many colours of the plants and flowers are missing? If its winter and there are no flowers, you can try to think what might grow here in the spring or summer.

You can stop the tape to take a moment to imagine.

The bees that pollinate plants had not yet evolved on earth and the pollen of the plants in the pre-historic landscape was carried by the wind. Parasitoid wasps and wasps that fed on haemolymph, the blood of other insects, reigned the order of sawflies. When flying insects began to feed on pollen, they accidently also carried it from flower to flower, which made pollination more

effective, and the plants produced more seeds. Plants that were favoured by insects began to reproduce more and pollination by insects became common on earth. To be pollinated, plants began to attract insects with ever more colourful flowers and sweet nectar. This co-operation between plants and insects changed the colours of the planet and the entire landscape.

The oldest fossil of a nectar eating wasp found in amber dates back 80 million years. Using DNA, however, researchers have determined that Apoidea, the family of bees and wasps, is about 130 million years old. We assume that the first bumblebees evolved 25-40 million years ago. This took place when the continental plates of Eurasia and India collided and created the Himalayas. This forced the wasps in the area to adapt to the cold climate of the mountains.

Nectar eating wasps became more round and grew a furry coat. Bumblebees prefer cool climates, and they are in fact most common in the mountains of Central Asia. The northernmost social insect is the polar bumblebee, which lives north of the polar circle. Give your fur a brush and buzz off to the next checkpoint to hear about how bumblebees and plants co-operate.

2. Fussy about flowers: Co-operation between bumblebees and plants

How do you think bumblebees sense the world around them? The way bumblebees see is in fact very different from our eyesight.

You see, a bumblebee's eyes can also detect the patterns of the flower in the range of ultraviolet, that is wavelengths of light that are invisible to humans. Shining in the centres of many flowers, dark nectar signals visible only to ultraviolet sensing insects guide bumblebees like signposts. It took a long time for people to understand that bumblebees have their own way of seeing the world.

These days, however, researchers can, using gadgets to help them, look at the world as it might appear to a bumblebee. This has increased our ability to appreciate how different creatures, such as pollinating insects, sense the surrounding world and how human activities alter it for them.

Flowers are important for the sensory experiences of bumblebees. What kinds of flowers do you like most? Think about all of the flowers in the summer and of your favourite ones. What colour are they and what do they smell like? What shape are the petals? And do you remember: where did you last see your favourite flowers?

Why do flowers come in so many colours, scents and shapes? Like people, also insects have their own preferences for flowers. Bumblebees have been found to like especially blue and purple flowers. For the plants, these preferences for colours, scent and shape are important, because this way the pollinators they attract are more likely to transfer the pollen to a flower of the same species. If they next flew to the wrong address, the plant would fail to pollinate.

In addition to having different preferences, bumblebees also quickly learn how favourable it is to visit a certain flower and they begin to correlate the colour with the nectar supply. Also, the structure and scent of the flowers influence where the pollinating bumblebees pay a visit. For example, heavy bumblebees stop at big flowers, which can take their weight.

In their mouth bumblebees have a tongue, which they use to suck nectar out of flowers. The tongue works like a suction tube and its length dictates what kind of flowers the bumblebees visit. A short tongue is suited for sucking nectar from small and shallow flowers, whereas a long tongue can suck nectar from clovers and other such flowers where the nectar is deep inside them. This specialisation reduces the amount of competition for food between bumblebees. The length of the tongue of bumblebees found in Finland varies from just over seven millimetres to twentyone millimetres. So the tongue is quite large compared to the body of the bumblebee.

Bumblebees, which feed on the nectar and pollen of flowers, suffer from the changes humans cause to the environment. Bumblebees consume a tremendous amount of energy, they have a fast metabolism and therefore they need to eat and lot and often to stay alive. So there needs to be many kinds of flowers available close to the bumblebees' nest from early spring to late autumn. When you last saw a bumblebee, was it buzzing on a flower and what did the flower look like?

Monoculture, or the cultivation of just one plant species, has turned fields into green deserts, at least from the point of view of pollinators. The ditches surrounding fields have been replaced by underground drains, which in turn has reduced the amount of nesting places, useful willow bushes and flowering meadows. The use of pesticides in farming has increased. These agents increase crop production, but have been shown to be harmful to pollinators. They affect the pollinators' ability to navigate and make finding food harder.

In cities, the habitats of bumblebees have become fragmented and bumblebees are in fact larger in cities, because large bumblebees can fly for longer distances. At the same time, however, a large body causes problems as the climate becomes warmer, as it is more difficult to keep cool and the bumblebee's body overheats easily.

Can you think of a way to make life easier for bumblebees?

3. What does an excited run look like? Communicating bumblebees

Life on earth is a network of interactions. Bumblebees co-operate with the other bumblebees they share a nest with. When they go out collecting food, bumblebees encounter other bumblebees as well as predators, such as birds. But how do bumblebees communicate with each other? Can they send messages to other species? Do they engage in conversations with each other? Do you know: how do bumblebees convey messages?

Now move a bit closer to the plants surrounding you. Pause for a moment, close your eyes and sniff the air. What do the flowers close by smell like? You can pause the recording and spend a moment exploring the environment with your nose.

Scents are important for bumblebees and they use them to convey messages to each other in many situations. Bumblebees then use their antennas to detect the scents.

When a bumblebee collects nectar from a flower it leaves a scent print on the petals. The next bumblebee approaching the flower knows, by sensing the scent, that someone has already been there. Bumblebees learn to recognise the scents left on flowers and they know when to stop and when to instead carry on looking for flowers with more nectar. Did you know that flowers have electric fields! Bumblebees learn to recognise them, which also helps them find flowers to feed on.

With the help of scents bumblebees also help each other navigate. They mark the entrance to their nest with their own scent, which helps young bumblebees find their way back to the nest.

On returning home from a successful food-hunting trip, the bumblebee runs around its nest in excitement. By running around, the bumblebee tells the other bees in the nest that it has found a good flower, with plenty of nectar. The excited bumblebee runs around the nest and bats its wings. Its behaviour serves as a hint to the other bumblebees: now is a good time to go out looking for food. What could this running look like? What makes you run around in excitement? If you dare, you too can try the excited run: use your arms as small wings against your body and start shaking your upper body, only very slightly at first. Gradually let the shaking grow, and grow and move to your wings and finally your entire body. Excited by the shaking you can run around a little.

In addition to the excited run, bumblebees can move in other ways to communicate too. A distressed bumblebee will lift its middle foot. This way it can cling on to and sting its enemy. Lifting a leg can also act as a message to other bumblebees.

4. Stripes never go out of fashion: the warning signals of bumblebees

Bumblebees use colours to convey messages to other animals. Bumblebees have a black furry coat, with yellow, orange, red or white stripes. The purpose of these colours is to warn off predators. The predator learns to connect the bright colour pattern with an unpleasant feature of the prey and will in future avoid attacking prey with the same pattern. The unpleasant feature of bumblebees is the sting, which makes the victim itch and burn.

Female bumblebees have a poisonous stinger at the tip of their backside, which they can use to sting an approaching predator or to defend their nest against intruders. Honeybees have protrusions on their stingers, which make the stinger cling to the skin of the victim and pull off a piece of the bee. This is why honeybees can only sting once, as a result of this violent encounter they die after the sting. Female bumblebees instead don't have protrusions on their stinger, so they can sting several times in a row. Predators that have been stung will avoid the nasty stinging female bumblebees as well as males, which look the same, but don't have a poisonous stinger. Sometimes a bumblebee might sting a human. They do so by accident or when trying to defend themselves, if they feel threatened by the human.

Can you think of other black and yellow insects that sting?

The stripy colours of bumblebees resemble the colours of wasps and bees. This makes the work of predators easy, as they only need to remember to avoid all insects with black and yellow stripes instead of having to learn to avoid many different patterns. On the other hand, this allows insects to cheat. For example, hoverflies, and bee beetles, which don't have a stinger, mimic the colours of bees and wasps. These copycats rely on the birds thinking that they are wasps or bumblebees and will then leave them alone.

What kind of a warning outfit would you like to wear? What would it protect you, or your friends against and what colours would the outfit have? Would it be striped too, or would you design something completely different?

5. *Always a team player: the sociable and smart bumblebee*

Without the evolution of teamwork, all of earth would look very different than it does today. Crouch down to observe the life around you. When you look around for a moment, which organism do you first see? Is it an insect, a bird, a plant or some other creature? Also the animal or plant you see is the result of teamwork. With the palm of your hand, touch a nearby plant or tree trunk or even the person next to you. Under your palm there is a multicellular being, whose cells have developed through collaboration. Trees, plants, birds and for instance, bumblebees, are all like this. Can you see ants on the ground? Or is the air buzzing with pollinators? Take a moment to observe, where they are going or what they might be doing. Multicellular organisms, such as the insects you are watching, form groups, which can work as a team to hunt or to defend themselves against predators. Animals can also form colonies, where different individuals specialise in different tasks, depending on their skills, experience or, say, their size or the shape of their body.

What kind of teamwork did you take part in today? Did you get help from someone with something today? And did you help somebody?

For teamwork to evolve, it has to be of advantage to the animal. These advantages can, for example, mean a more efficient way of defending against predators, easier ways of hunting for food or providing better opportunities for offspring. At the same time, however, taking part in teamwork means personal sacrifices. This can be as little as the time invested in keeping an eye on predators, during which you can't look for food. The evolution of team work sometimes also results in an animal giving up the ability to reproduce. This is common among insects that live in colonies, such as termites, ants, bees, wasps and some spiders. In these colonies only one or a few individuals reproduce, while the rest help them raise and nurture the offspring.

Also the inhabitants of a bumblebee nest form a colony. A nest will have young and old bumblebees living there at the same time doing their different jobs. The queen is a female bumblebee, who

has spent the winter in hibernation. In the spring, she finds a place to nest and lays her eggs in the nest. The bumblebees that hatch from the first eggs are called workers. Bumblebee workers are always female and they don't reproduce. Some workers collect pollen and nectar for the new bumblebee larva developing in the nest, while others keep the nest clean and feed the larva. One reason for why the workers are so keen to help their queen mother is that they are related to her. Although the workers can't produce offspring of their own, by helping their siblings they help their genes replicate in later generations. In addition to collecting food and taking care of the offspring bumblebees work as a team to defend their colony against predators and other threats. For example, tree bumblebees are known for fiercely defending their nest.

Bumblebees, bees and wasps are in fact very intelligent, which is something we have only begun to appreciate in the past few decades. These insects can for example solve mathematical puzzles, navigate in complicated environments remarkably well, contemplate decisions and even show empathy on some level. They also learn from each other, including completely new skills, and can use the new information to make decisions.

For example, the buff-tailed bumblebee learns by watching other bumblebees to play, for example, football. It can improve its performance in the game based on what it sees, if it means it can better reach the sweet liquid offered to it by the researcher.

This ability to make informed decisions and consider uncertainties was earlier though to be characteristic for only humans and some apes, such as chimpanzees.

One bumblebee colony in Finland will last one summer. At the end of the summer the eggs laid by the queen begin to develop into males and new queens. The males often live for less than a month. They mate with the new queens and die, as the weather becomes colder in the autumn. The old queen and the workers die too after the summer. Only the new queens survive the winter. They dig or find a hole for themselves and hibernate there until the warm spring days come along. So please be careful that you don't accidently tread on a big buzzing bumblebee in the spring, because she holds the beginning of a whole colony of hundreds of new bumblebees.