- Little Questions
- Plant

Nobody can really tell you what a flower is

We can all recognise a flower when we see one, but it is surprisingly tricky to define what they are

- By Claire Asher

17 September 2016

Flower is one of the earliest words we learn, and a fundamental part of our every day lives. Flowers may be the most common form of nature we encounter on a day-to-day basis, and yet when we try, they are surprisingly hard to define.

We posted the question on the BBC Earth Facebook page to see if any of our readers had the answer.

Passionflowers (Passiflora caerulea) do not look like typical flowers (Credit: Gabriel Rojo/naturepl.com)

A flower, says Kevin Drucas, is an adaptation that "was so successful that over the last 200+ million years they radiated, speciated, climbed up into trees, cliffs, hid beneath snow ... even battled pathogenic fungi and insects", adding, "one could say flowers have conquered every habitat on Earth".

A flower is "a very conspicuous sexual organ"

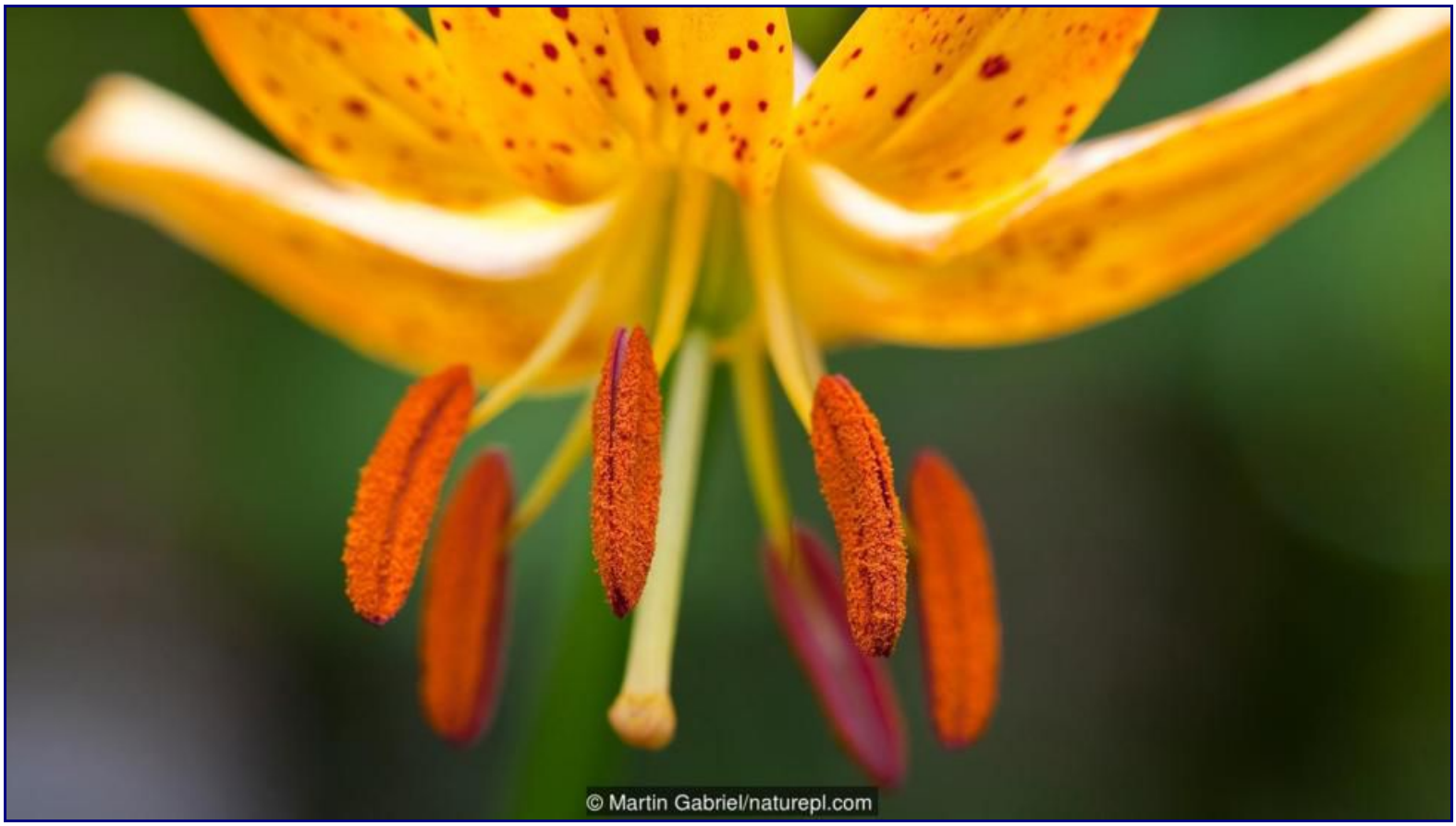
Other people felt a more spiritual relationship to the flower. "A flower is to a plant as eyes are to a person...expressive, beautiful, delicate yet strong," says Kristy Hardage Launius, while Valerie Wakefield describes flowers as "magic, beauty, abundance".

Many expressed the feeling that there is something indefinable about the flower.

"Describing how I feel about blooming flowers is like baring my soul...how do I put it into words?" says Naomi Sunczyk.

"What are flowers? We just don't know," says Jeff Schultz.

The flower is so hard to define that even scientists are still discussing it.



Hanson's lily (Lilium hansonii) showing the male and female sex organs (Credit: Martin Gabriel/naturepl.com)

Over the past year, the journal *Botany Letters* has published a series of articles discussing how best to define a flower.

There are over 350,000 known species of flowering plant

Most simply, a flower is "a very conspicuous sexual

organ", says Marc-André Selosse, Professor of plant evolution at the National Museum of Natural History in Paris. Flowers are responsible for the producing the next generation of plants. "The exchange of sexual cells, which are embedded in the pollen, is carried out by wind or, most often, animals," Selosse says.

Each flower is made up of the female reproductive parts, known as carpels, and a male part called the stamen. These are surrounded by petals, which are in turn enclosed by sepals.

But not all plants have flowers: only flowering plants, or "angiosperms", do. What's more, there are over 350,000 known species of flowering plant, and their flowers make every imaginable shape, colour and scent. So we need to dig a little deeper.

Carl Linnaeus classified flowering plants (Credit: Paul D. Stewart/naturepl.com)

The naturalist Carl Linnaeus was among the first to try to classify this diversity. "[Linnaeus] had lots of plants to study, including many from biodiverse regions," says Mark Chase, Senior Research Professor at the Royal Botanic Gardens, Kew in the UK.

Many plants that have similar flowers turn out to be distant relatives

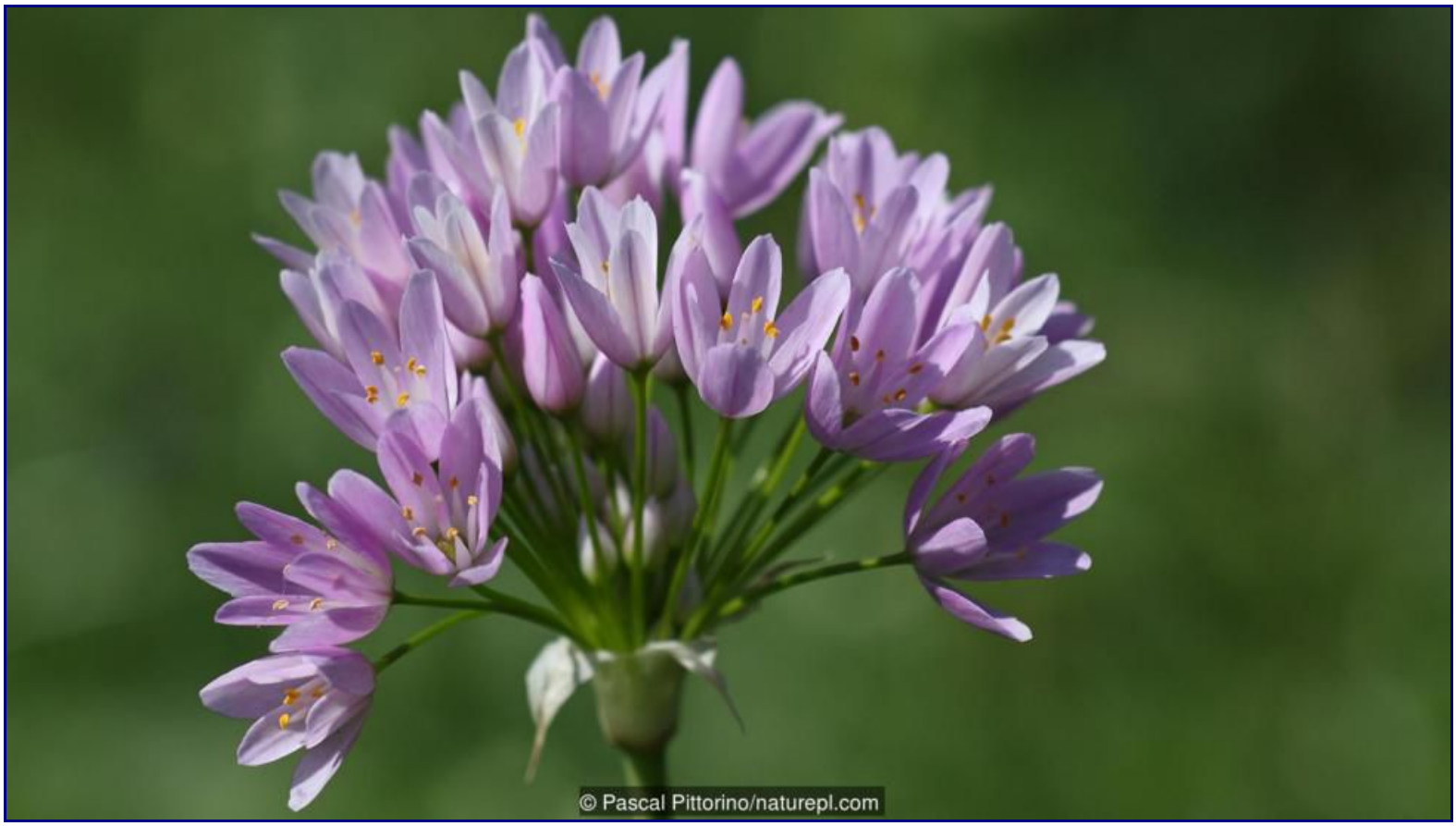
In his 1753 book *Systema Naturae*, Linnaeus classed angiosperms based on the characteristics of their flowers. This was useful, but it only went so far.

Modern botanists are interested in the family tree of flowering plants, known as a phylogeny. This tells us who is related to whom, the first step in understanding how flowers evolved. But when constructing a family tree, appearances can be deceiving.

Chase is part of the Angiosperm Phylogeny Group (APG), which he describes as "a consortium of botanists who summarise the literature and frame phylogenetic results in a

system of classification." They mostly use genetic data, which is more reliable for understanding how species are related than their physical appearance.

The APG's classification was first published in 1998, and was most recently updated in March 2016. It differs from Linnaeus's quite dramatically.



This is not a rose: it is a rose garlic (Allium roseum), illustrating how different flowers converge on the same design (Credit: Pascal Pittorino/naturepl.com)

Many plants that have similar flowers turn out to be distant relatives. The plants had independently stumbled upon the same floral design.

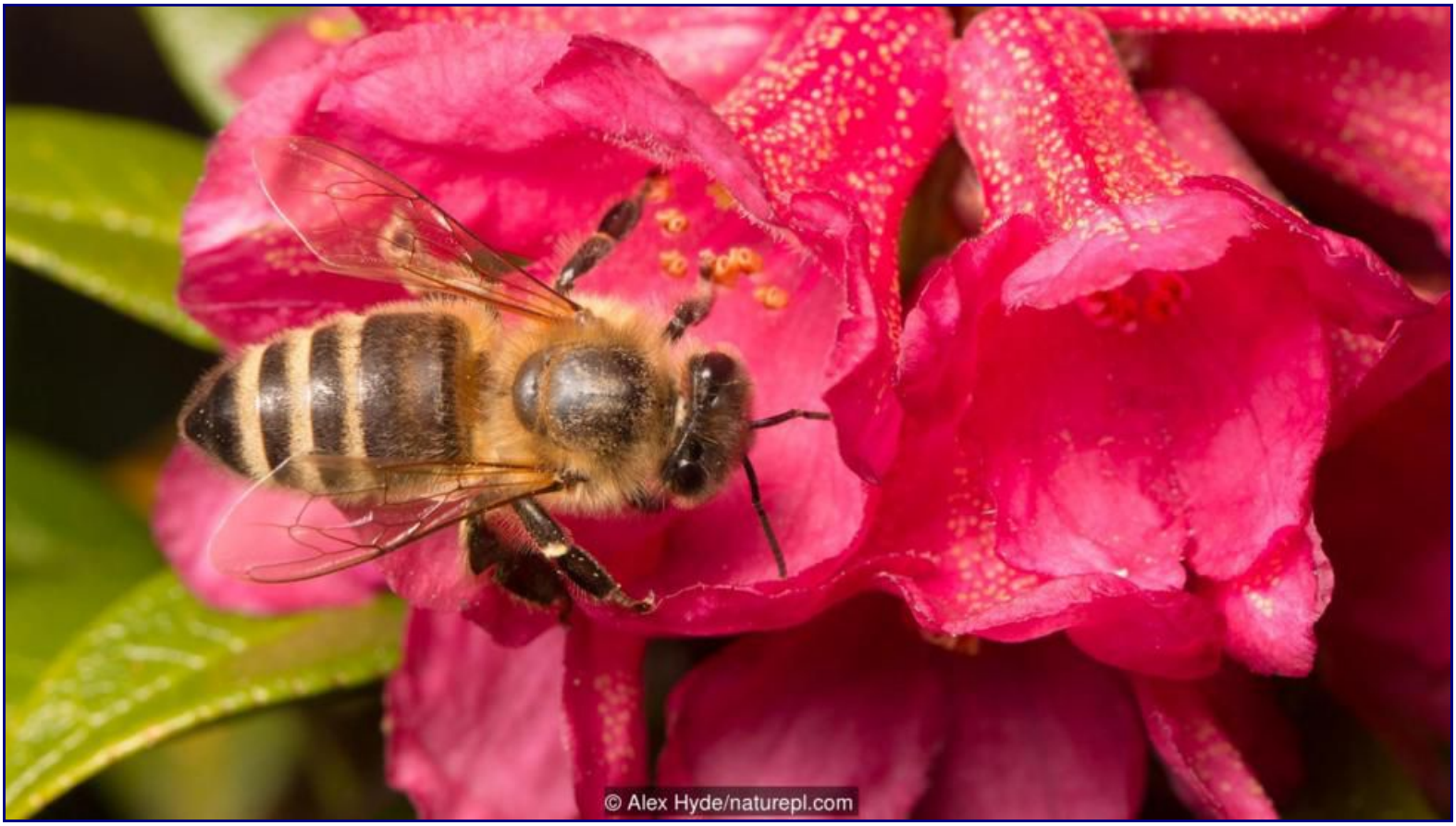
All flowers ultimately have the same purpose - pollination

Plants that attract the same kind of pollinator often converge on similar flower designs. For instance, flowers that attract beetles often have multiple stamens, which increase the chances that the beetle will carry pollen away on its body.

In fact, flower characteristics may be the least helpful characteristic for classifying angiosperms.

When flowering plants first evolved, around 130 million years ago, they underwent a period of very rapid evolution, during which many new forms of flower appeared. Charles Darwin described the sudden appearance of flowering plants as an "abominable mystery", because he could not imagine how natural selection could have acted so fast.

But this rapid evolution makes more sense if we understand the flower, not simply as a reproductive organ, but as a place where plants and animals must meet.



A honeybee worker on an alpine rose (Rhododendron ferrugineum) (Credit: Alex Hyde/naturepl.com)

All flowers ultimately have the same purpose – pollination. Although bees are the most famous pollinator, flowers can also be pollinated by beetles, flies, butterflies, and even birds and bats.

"Flowers," as Warren McDonald puts it, "are the short skirts of the plant kingdom. They advertise that something inside needs to be pollinated."

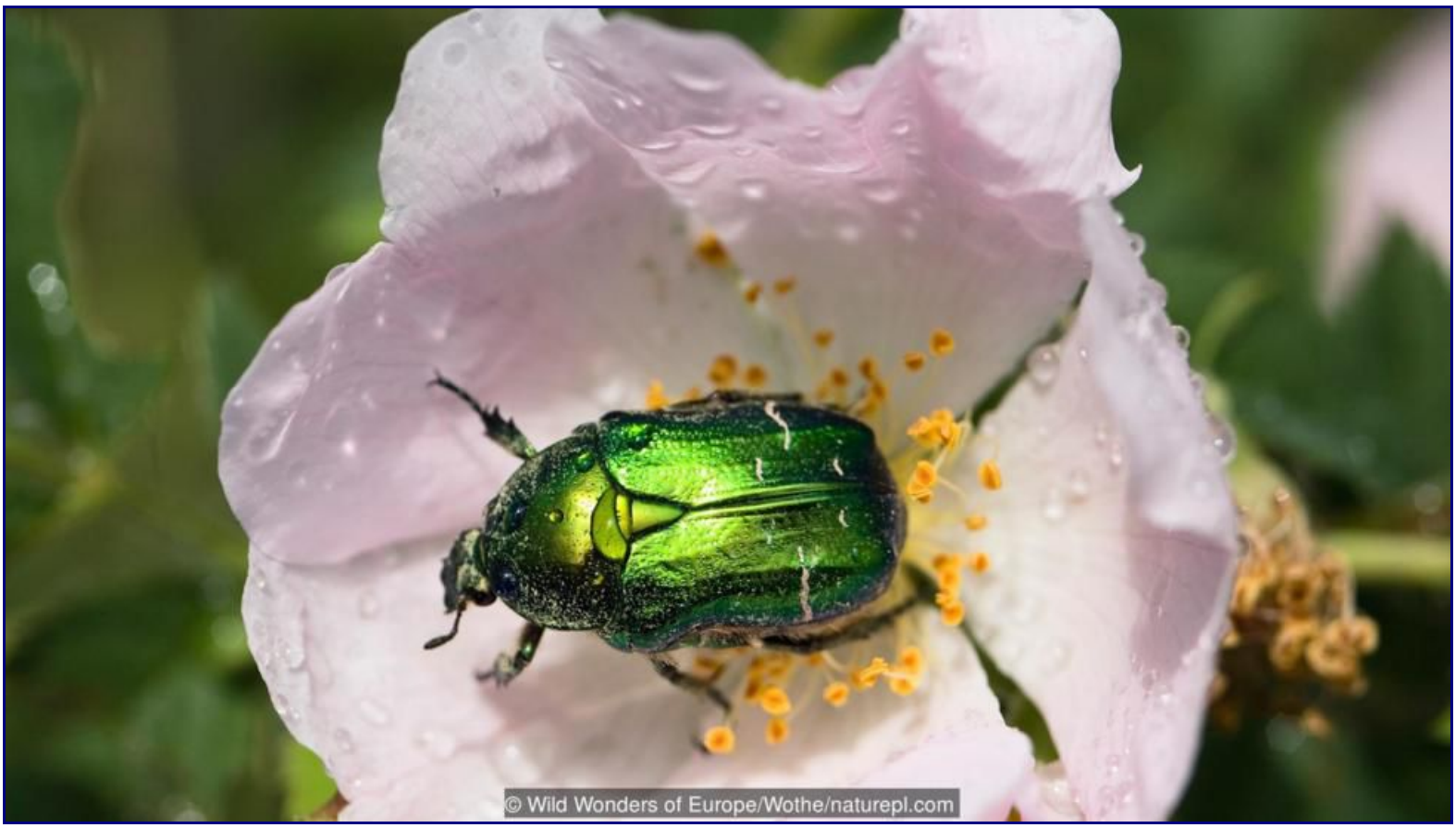
Red flowers are more likely to appeal to butterflies and birds

A flower is "the delicate link between the plant and animal kingdoms," says Adisha Kariyawasam. Similarly, Felomena Chart says that flowers are a "very important part of [an] ecosystem. Without flowers, there will be no bees or vice versa. No pollinator, no food."

To be successful, a flower needs to produce pollen, as well as a reward such as nectar, and it must be attractive to the right animals. The diversity of size, shape, colour and smell across flowering plants reflects the many ways to attract an animal pollinator.

Angiosperms have tailored their flowers to the specifics of their chosen pollinator, variously making sure the flower appeals to their visual system, that the scent is picked up by their sense of smell, and that the flower is the right shape, size and design to fit their body.

These wild flowers may be appealing to human eyes, but this is little more than a coincidence.



A rosechafer (Cetonia aurata) pollinates a dog rose (Rosa canina) (Credit: Wild Wonders of Europe/Wothe/naturepl.com)

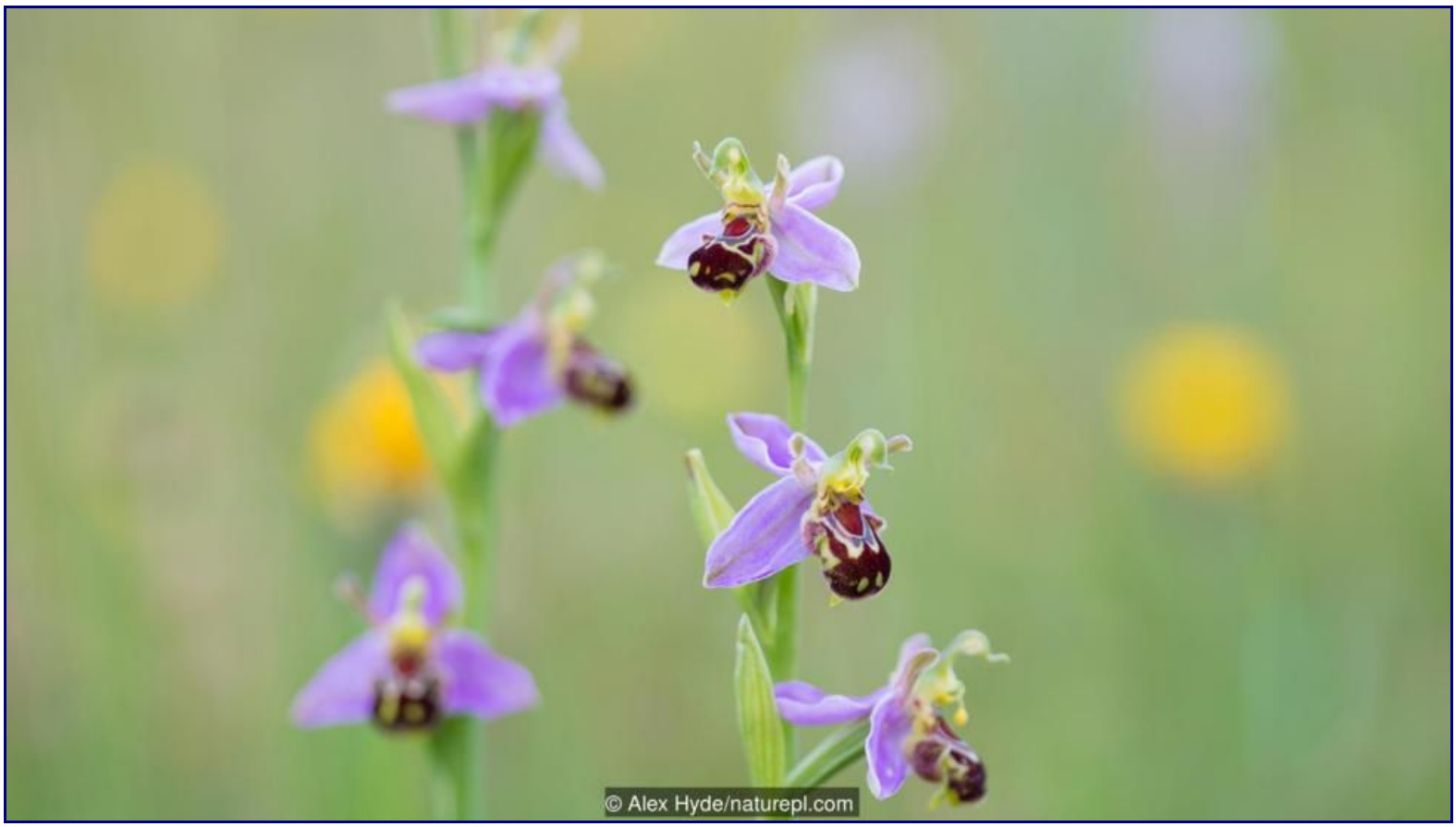
Bees can see blue and green light, but they lack our ability to distinguish red. However, unlike us they can also see ultraviolet light, and many flowers have evolved to exploit this.

Around one third of all orchid species offer no reward to their pollinator

One study of 180 different species of flower found that they tend to fall into one of three colours – UV or violet, blue-green or red. Two of these categories, UV and green, correspond to the wavelengths perceived by bees. Red flowers are more likely to appeal to butterflies and birds, which can see a wider spectrum of red colours.

Flowers that attract other types of pollinator have to employ different approaches. For example, many bat-pollinated plants flower at night, and focus on scent rather than looks to attract pollinators in the dark.

But the three features of flowers – pollen, reward and attraction – are not necessarily linked. It is possible to evolve some but not all of these traits, and this leaves opportunities for cheating and conflict.



Bee orchids (Ophyris apifera) (Credit: Alex Hyde/naturepl.com)

Around one third of all orchid species offer no reward to their pollinator. Instead, they focus on the attraction part of the equation – mimicking the appearance and scent of a female of their pollinator's species.

Flowers are evolving and counter-evolving in response to another living, evolving species

For example, the bee orchid has evolved petals and sepals that resemble a female bee feeding on a flower. Confused male bees pollinate the flower while trying to mate with it. Bee orchids have also been found to mimic pheromones produced by female bees.

Similarly, many hummingbird species have been found to steal nectar from flowers without pollinating the flower.

But the angiosperms do not take this kind of behavior lightly: they have evolved mechanisms to enforce cooperation. For instance, sage flowers have a lever-like stamen that forces any insect entering the flower to pick up pollen before they can get to the nectar.

This leads us to another view of the flower: it is a battleground.

Sage (Salvia pratensis) flowers force insects to pick up pollen before taking nectar (Credit: Fabrice Cahez/naturepl.com)

Selosse argues that rapid evolution in flowers should be expected because they are the sites of inter-species interactions.

Pollinating animals like bees visit flowers, and the flower needs to ensure that when they do they pick up pollen. This means flowers are evolving and counter-evolving in response to another living, evolving species.

Each species must evolve as fast as it can, just to keep up with the other

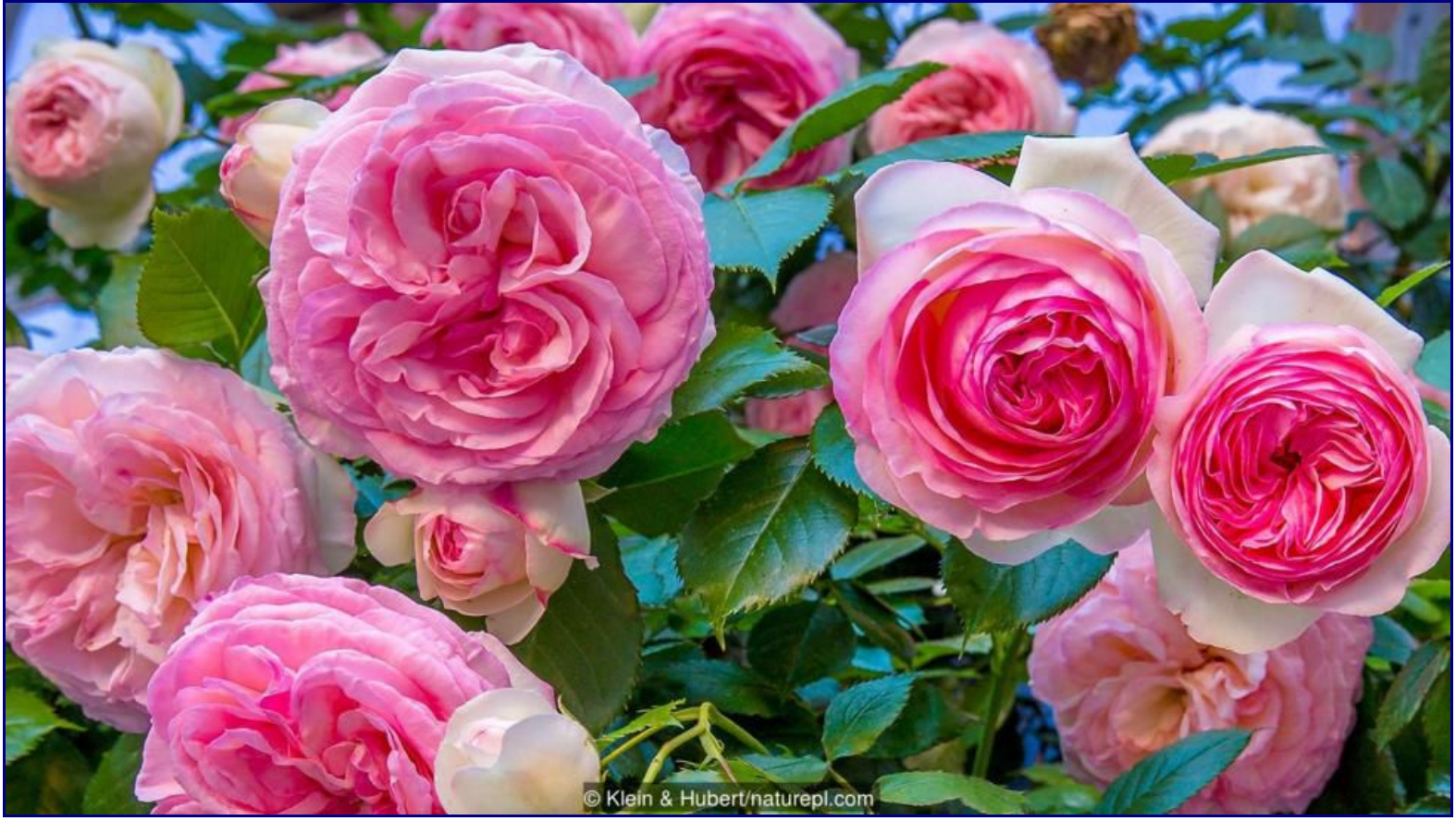
That is something that many scientists believe tends to result in more rapid evolution. And rapid evolution, Selosse says, increases the chances that the same evolutionary innovations will appear again and again.

This idea is known as the Red Queen hypothesis, after Lewis Carroll's classic book *Alice's Adventures in Wonderland*. In the story, the Red Queen runs a never-ending race because "it takes all the running you can do, to keep in the same place".

When two species evolve and counter-evolve in an "arms race", as happens with flowers and cheating pollinators, each species must evolve as fast as it can, just to keep up with the other.

"The interaction is evolutionarily dynamic," says Selosse. "This cruel view of ecosystems and evolution may be useful when we think about the dynamics of life."

However, there is yet another way to think of flowers.



A climbing rose (Credit: Klein & Hubert/naturepl.com)

Although flowers show incredible diversity, when you strip away the details they all have the same basic structure. This is the abstract, physical definition of a flower.

With only a handful of exceptions, all flowers conform to the basic ABC model of development, which was first described in 1988.

As a flower forms, each cell must be assigned a role. During development, the concentration of different proteins in each cell determines whether they will become a petal cell, part of the stamen, or something else.

An entire flower can be produced from just three genes. "A" proteins alone produce a sepal cell, while A and "B" together make petal cells. "C" proteins control the carpels and the stamen: C alone produces carpel cells, while C and B together form stamen cells.

There is one flower that does not follow the classic ABC layout. It bewildered botanists for decades, but it turns out to be the exception that proves the rule.

Lacandonia schismatica is the vampire of the plant world

Lacandonia schismatica has inverted sex organs (Credit: Claudio Contreras/naturepl.com)

Lacandonia schismatica is the vampire of the plant world. It is completely white because its cells contain no chlorophyll – the green component of plant cells that performs photosynthesis. Instead of feeding on sunlight, this parasitic plant feeds on fungi.

Before flowers appeared, most plants reproduced like modern pine trees

Its flowers are peculiar, in that the male and female parts are inverted: the stamen is in the centre with the carpels around it.

This was a puzzle until quite recently. A study in 2010 found that the inverted flower was caused by a mutation, which causes B genes to be expressed in the centre of the flower; ACB rather than ABC.

Because the ABC model is shared by almost all flowering plants, we can assume that the first flower had this basic structure. But we will probably never know what the first flower looked like.

Avocados (Persea americana) are flowering plants (Credit: Visuals Unlimited/naturepl.com)

Before flowers appeared, most plants reproduced like modern pine trees.

These plants produce either male or female pinecones. Male pinecones contain pollen, which is carried away on the wind and hopefully lands on a female pinecone, which then produces seeds.

This method of reproduction dominated for nearly 200 million years.

I can't imagine a world without flowers. It would be ugly, dim, and sad

What the first flower looked like is "still a very much open question" says Chase. Nobody is sure which ancient plants gave rise to the flowering plants.

The first flower may have been a modified cone. A study in 2009 found that avocados – a relatively early branch on the family tree of flowering plants – still harbour the genes that would have produced cones. The genes have simply been modified to instead produce a flower.

So we can define a flower in evolutionary terms, as a particular structure, and as a way for plants and animals to interact. But there is one final element: the human angle.

We have bred flowers to look how we want them (Credit: Aflo/naturepl.com)

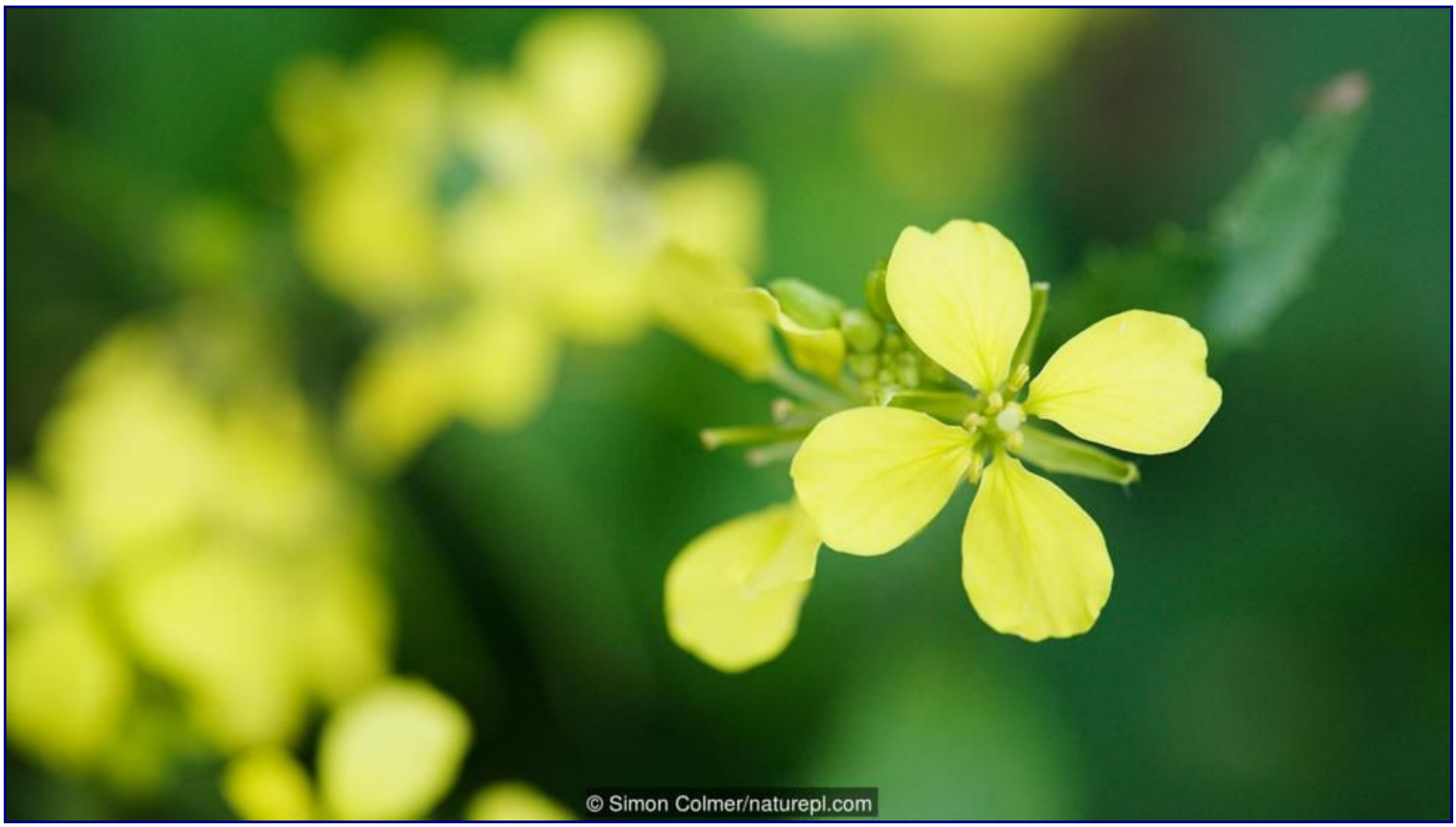
Felomena Chart says: "I can't imagine a world without flowers. It would be ugly, dim, and sad."

Flowers are "a symbol of nature and 'wilderness'," says archaeologist Elisabeth Dodinet of the University of Toulouse II in France. They "are also part of our wellbeing now on a more aesthetic, sensitive level, as a remedy to mitigate our urbanised way of life."

Several cultivated roses have twice as many petals as wild roses

Flowers first gained cultural significance when our civilisations became more developed and urbanised, says Dodinet. In the West, our love of flowers blossomed in the 18th Century, but earlier sophisticated societies in China and Japan saw them as symbols of beauty, leisure and rarity.

But it is not a one-way street: our love of flowers has also had a huge impact on flowers themselves. Over the centuries we have artificially selected for flowers that we like to look at, to smell, or in some cases to eat.



Wild mustard, also known as charlock (Sinapis arvensis) (Credit: Simon Colmer/naturepl.com)

For instance, the wild mustard plant is a delicate, inconspicuous yellow-flowered plant from the Mediterranean. Over many generations, it has been shaped by humans to make what we now know as cabbage, broccoli, kale and cauliflower. These modern vegetables, which all belong to the Brassicaceae family, look nothing like their wild ancestors, demonstrating the incredible evolutionary flexibility of flowers.

Flowers first gained cultural significance when our civilisations became more developed and urbanised

Roses have also been changed by artificial selection. Several cultivated roses have twice as many petals as wild roses, and a 2010 study identified the mutation responsible. Plant breeders in Europe and China had independently selected for mutations in the same gene, resulting in more petals and prettier roses.

Our relationship with the flower has fundamentally changed plants at the genomic level. It has even made some species sterile, breaking the pollination link that some many of us think of when we picture a flower.

The flower is our closest link to nature. As our societies became more urban and we grew increasingly separated from the natural world, it became an important symbol of life, vitality and wildness. But the beauty of the flower disguises the evolutionary conflicts it harbours.