

# sexual Reproduction of Cacao

Eduardo Somarriba Chavez · Rolando Cerda Bustillos · Carlos Astorga Domian  
Francisco Quesada Chaverri · Nelly Vásquez Morera · Luis Orozco Aguilar

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Central  
American  
**CACAO Project** 

The Central American Cacao Project (PCC) at CATIE (Tropical Agricultural Research and Higher Education Center) aims to increase the productivity, diversity and financial and environmental value of the cacao plantations of at least 6,000 Central American families.

Working closely with cacao farming families, the Project creates alliances with other partners in the region in order to enhance the social interactions, competitiveness and business capacity of the producers' organizations and improve the living conditions of their members.

The Project promotes efforts to increase the knowledge and skills of farming families and students at agricultural schools, technical colleges and agronomy faculties, for the sustainable production of cacao.

The Project also offers equal opportunities as well as economic, social and cultural responsibilities for men and women in all its spheres of action.

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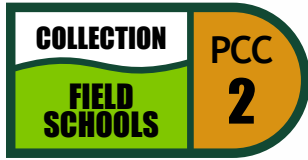
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Tropical Agricultural Research and Higher Education Center (CATIE)  
Turrialba, Costa Rica  
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Hello everyone, we're going to hold our meeting here in the cacao plantation, under the shade of this tree. We've put some chairs out for those who want to sit down.

Today's topic is very interesting isn't it Emilio?

Uh yes, it's an extremely interesting topic. Today we're going to talk about how sexual reproduction works in plants like cacao.



In plants? Excuse the question, but isn't sexual reproduction something that only happens in human beings and animals?

No Jose, many plants also reproduce sexually. This means that a male and a female join together to produce a seed which germinates and then produces a new plant.



To appreciate the similarities, let's review what happens with animals and human beings.



We all know that there are two sexes in human beings: men and women.

It's the same with animals like dogs and pigs, except that we call them males and females.

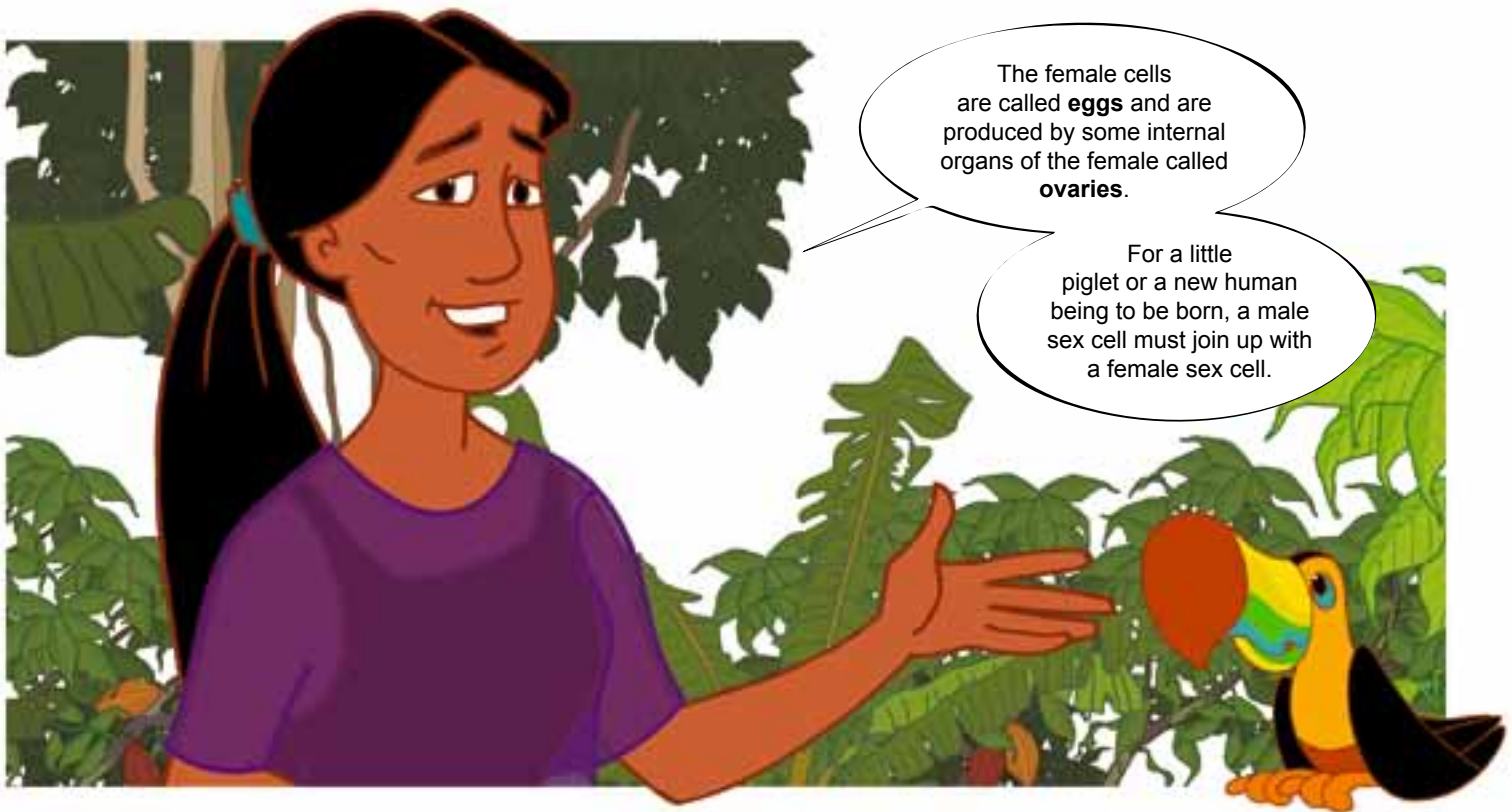
That's right Miriam. You need both sexes to make a new human being or to make a new piglet.

The important thing to know is that each sex has its own sex cells. Do you understand what I'm talking about?



Of course. **Sex cells** are tiny little things, impossible to see with the naked eye.

The male cells are found by millions in the semen of the male and are called **sperm**.



The female cells are called **eggs** and are produced by some internal organs of the female called **ovaries**.

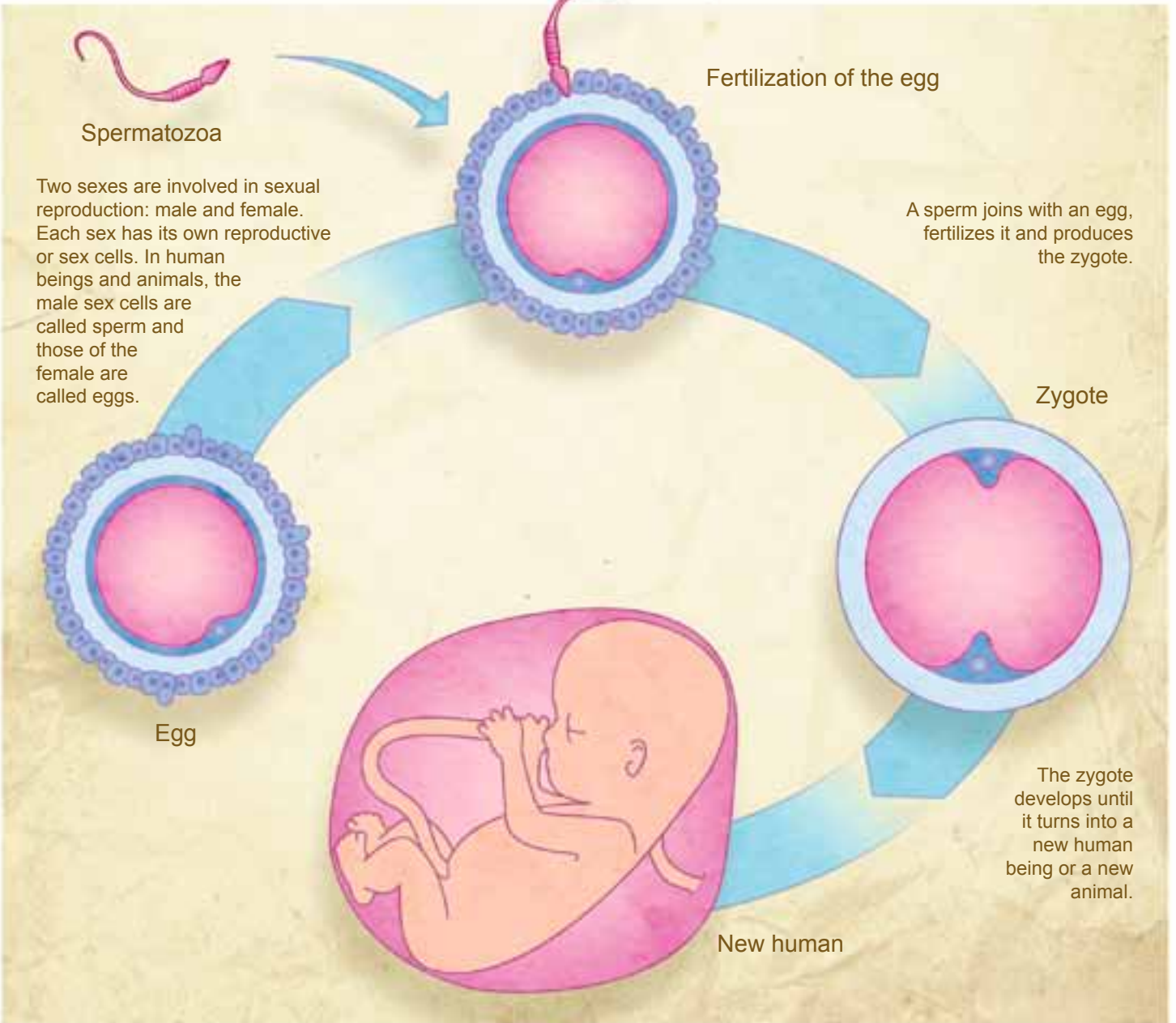
For a little piglet or a new human being to be born, a male sex cell must join up with a female sex cell.



When a sperm unites with an egg, we say that the egg has been fertilized.

The fertilized egg is called a zygote and from the moment of fertilization it begins to develop, eventually turning into a new human being or a new animal.

In a few words and put simply, this is how reproduction works in human beings and in pigs, dogs, cats, cows, horses and many other animals.



## Sexual Reproduction in Humans



Now let's consider the similarity between sexual reproduction in animals and sexual reproduction in cacao. In cacao, as in many other plants, there are male and female sex cells.

Yes, and both sex cells must unite to produce a seed from which a new cacao tree is born.

Did you know that?



I think it's important to mention that there are also plants that do not reproduce sexually, such as bananas and cassava, for example.

True. But for now, let us discuss the sexual reproduction of cacao in more detail.

Yes, let's look at the details of *Theobroma cacao*.



Good heavens! My friend the parrot has learned how to say the scientific name of cacao, that's very good.

And I also know other names too. You will see?



Hey, Parrot, don't confuse everyone. We don't want to hear more about your jokes!





Can anyone tell me where the sex cells of cacao are located? Are some cacao trees male and others female?



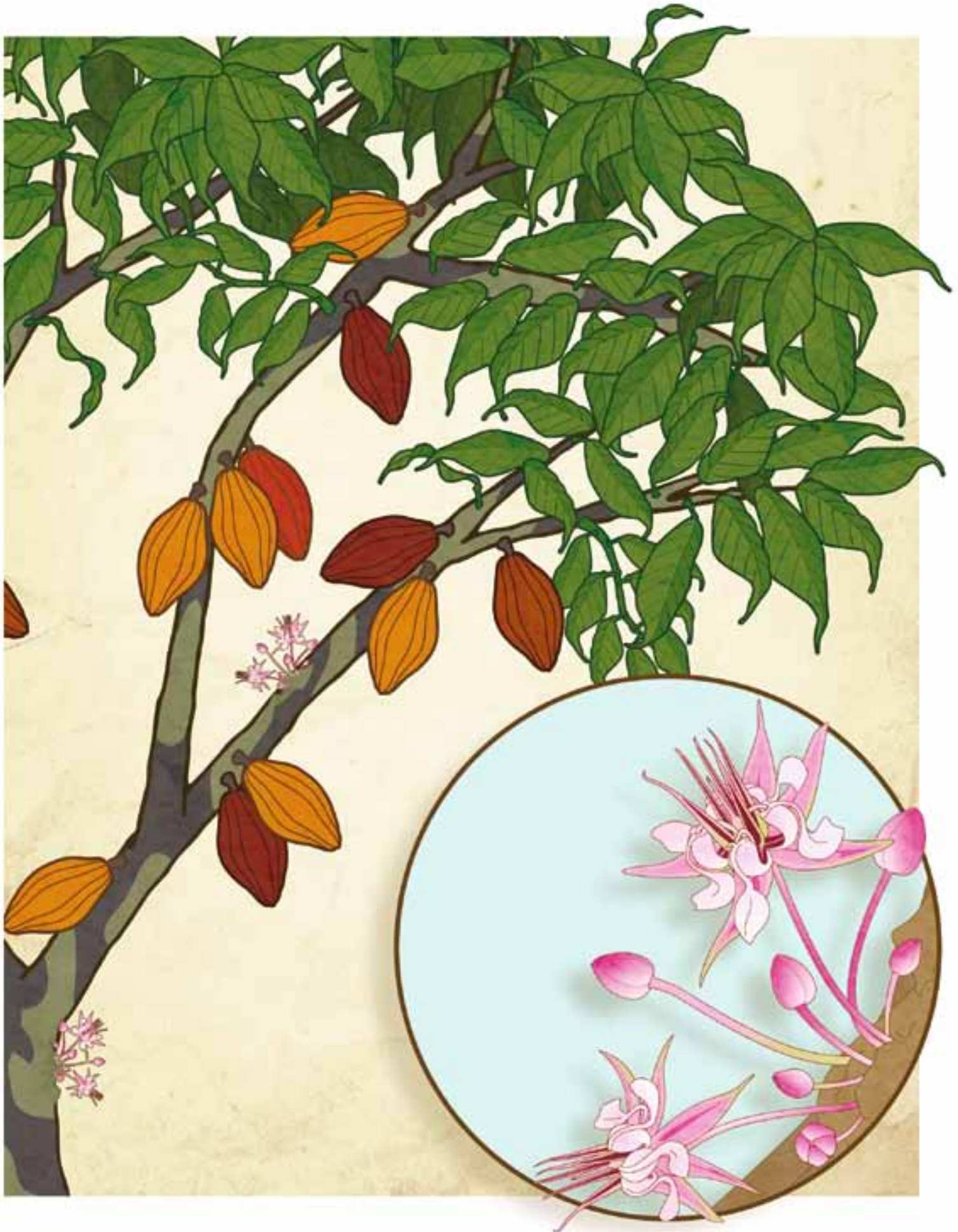
No, no, in cacao there are no male and female trees. Each cacao flower has male parts and female parts.

That's why we need to discuss the cacao flower in greater detail.



Let's begin by explaining where the flowers are located. Cacao flowers grow in large clusters that may have between 14 and 48 flowers, depending on the tree. These groups of flowers sprout from structures called **flower cushions**.

The flower cushions are mainly found on the trunk and on the main branches of the tree.

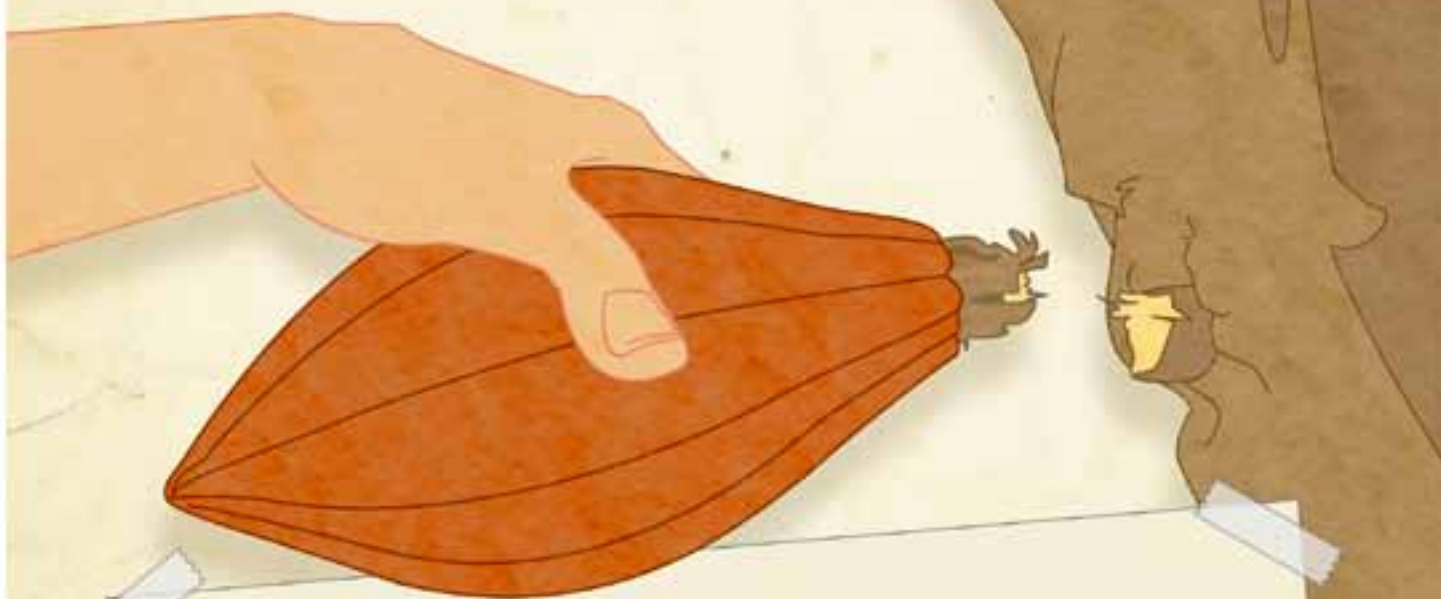


Flower cushions with cacao flowers

## Tips to encourage flowering and protect the flower cushions

### ✘ INCORRECT

Pulling or twisting the pods off the tree can damage the flower cushions permanently.



### Tips

- When cutting the cacao fruits or pods be careful not to damage the flower cushions, because if they are damaged, they will not produce flowers again.
- Harvest the fruits with a knife or pruning shears; do not remove them by pulling or twisting them off with your hand.
- When you prune the tree take care not to damage the flower cushions with the machete.
- Do not climb cacao trees, as climbing may damage the flower cushions.
- Prune shade trees and cacao plants after the main harvest and before the first rains to allow more light into the plantation and encourage flowering.

Incorrect way to harvest cacao fruits

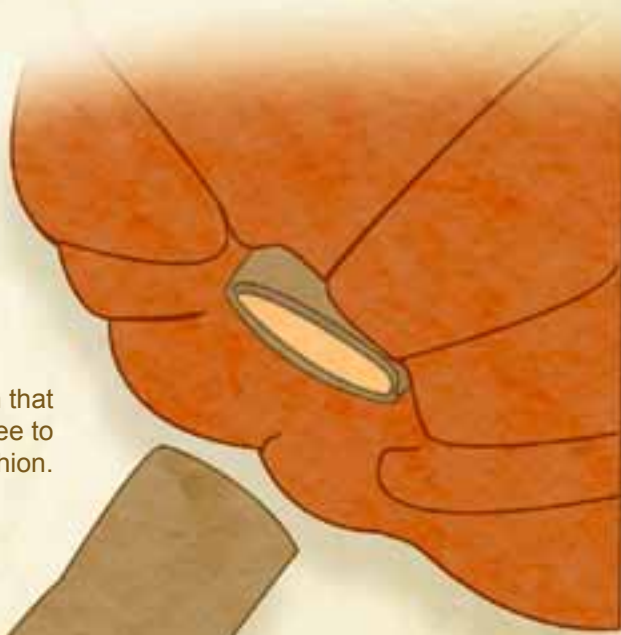


## CORRECT

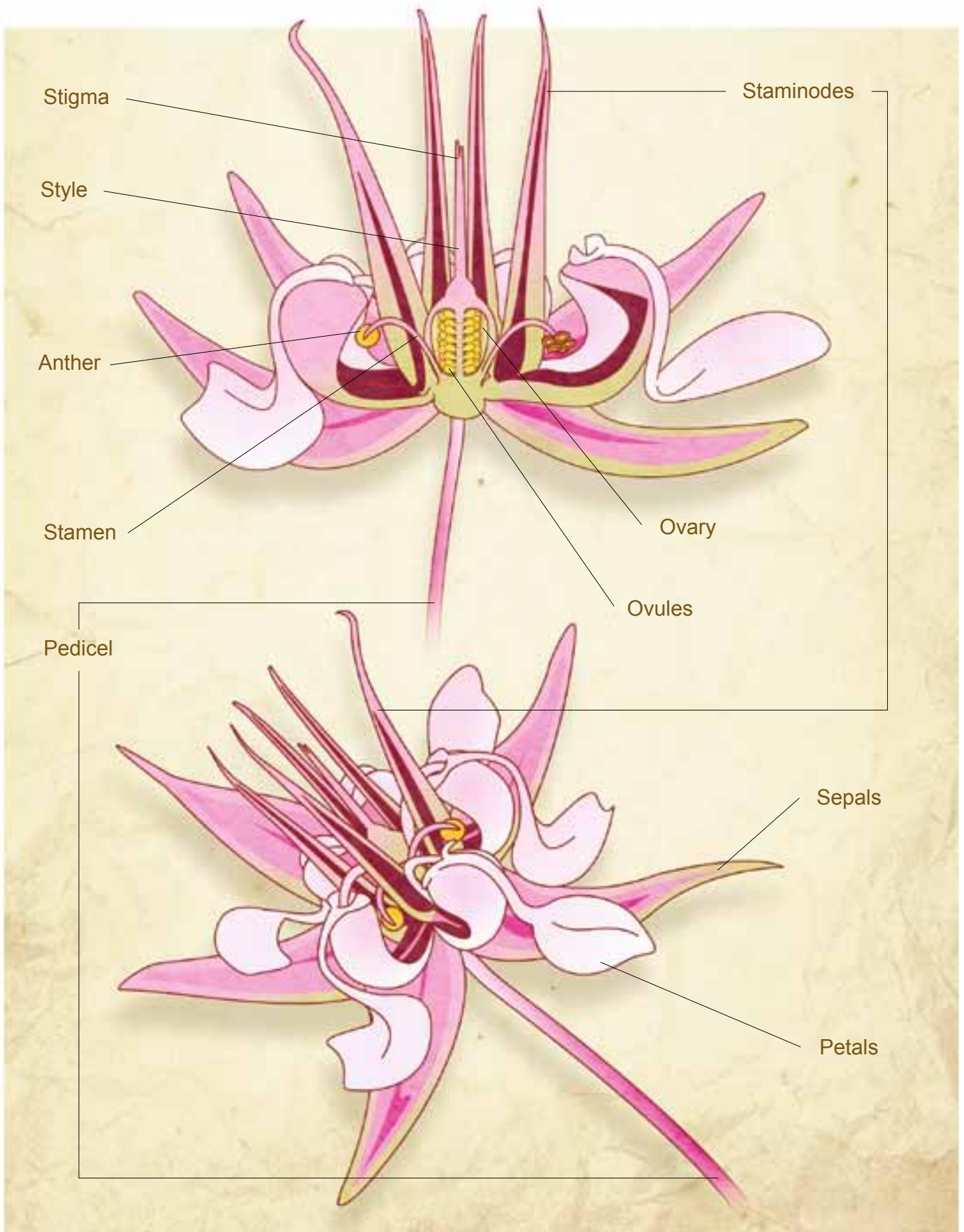
Use a knife or pruning shears to cut the pod from the tree.



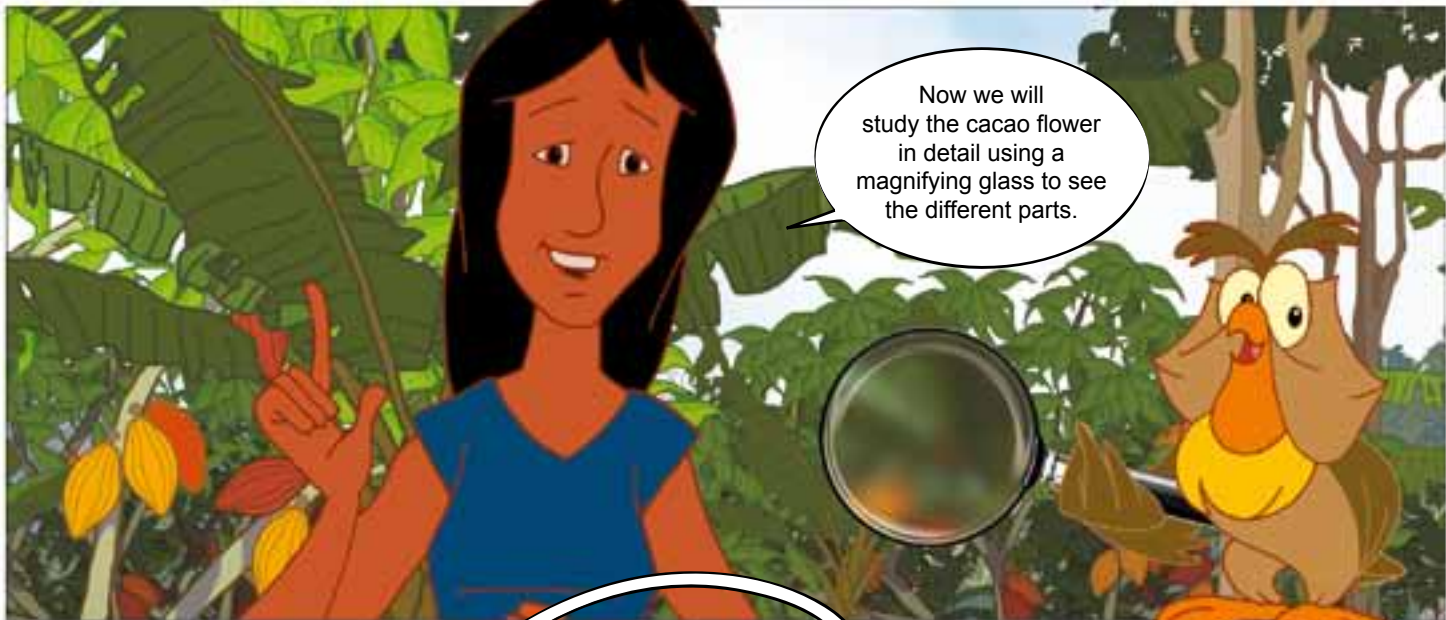
Leave a part of the stem that connects the pod to the tree to avoid touching the flower cushion.



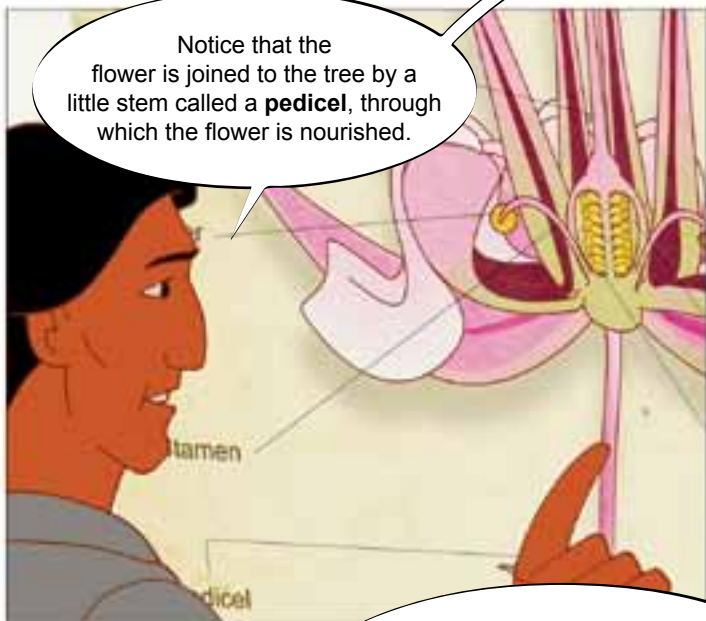
Correct way to harvest cacao fruits to prevent damage to the flower cushions



The cacao flower and its parts



Now we will study the cacao flower in detail using a magnifying glass to see the different parts.



Notice that the flower is joined to the tree by a little stem called a **pedicel**, through which the flower is nourished.



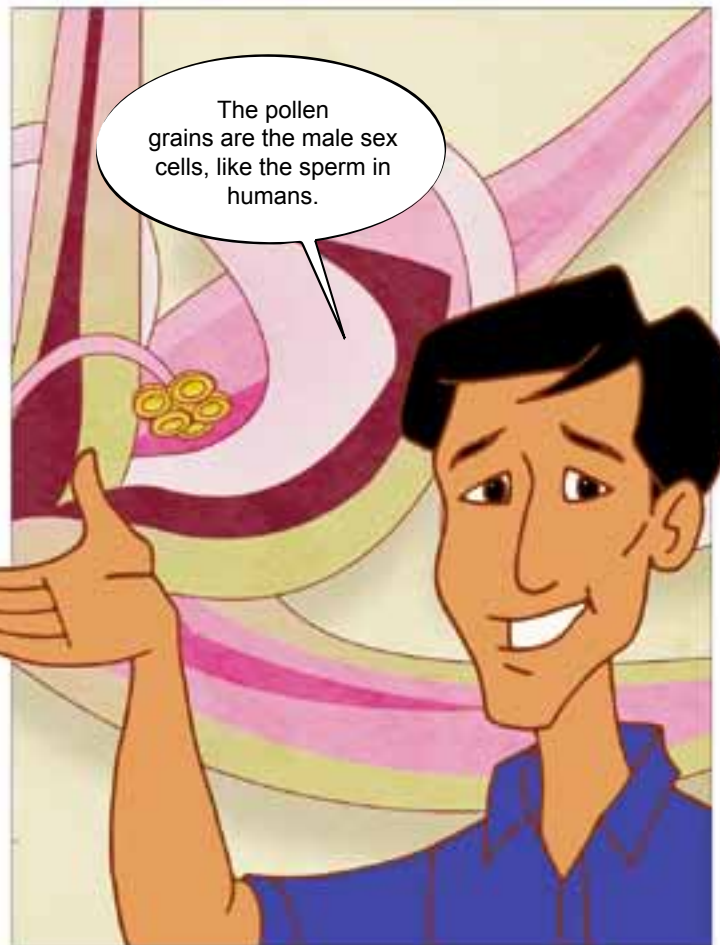
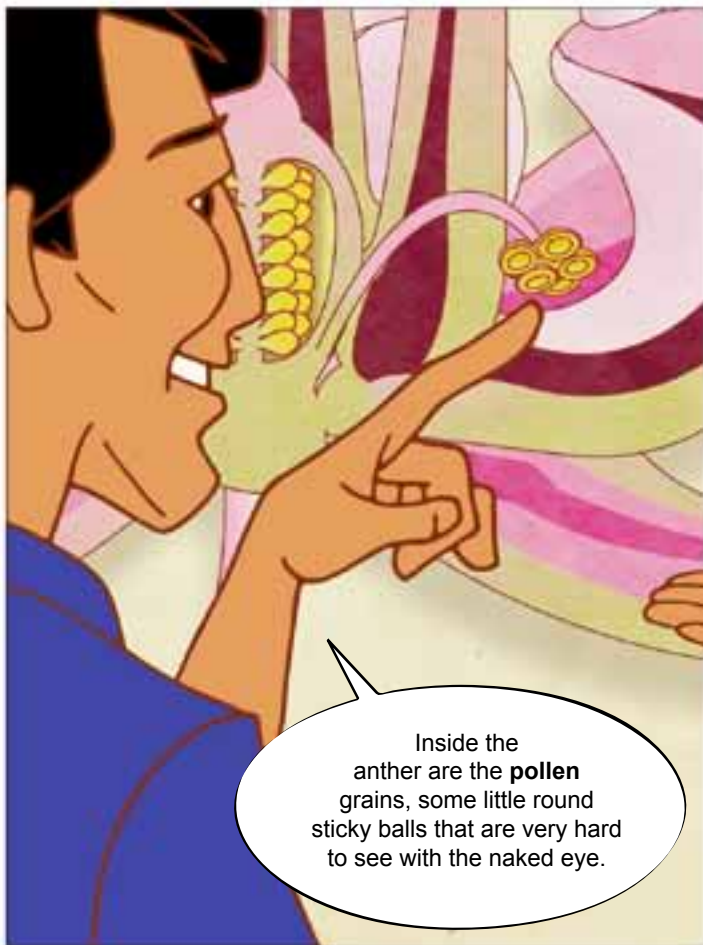
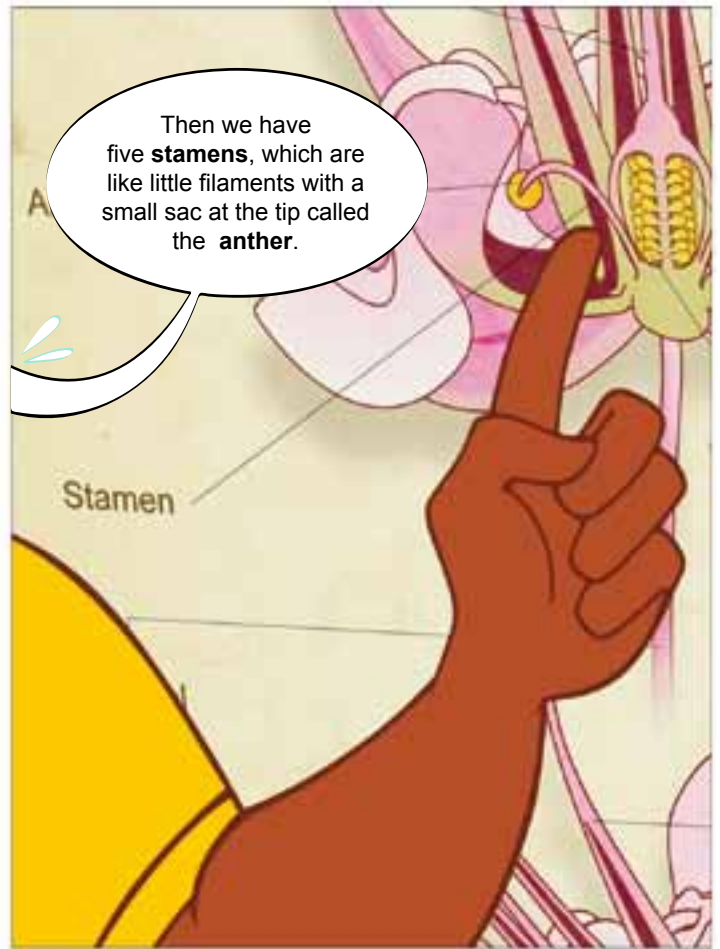
Before opening, the flower is enclosed **bud** in a **flower bud**.

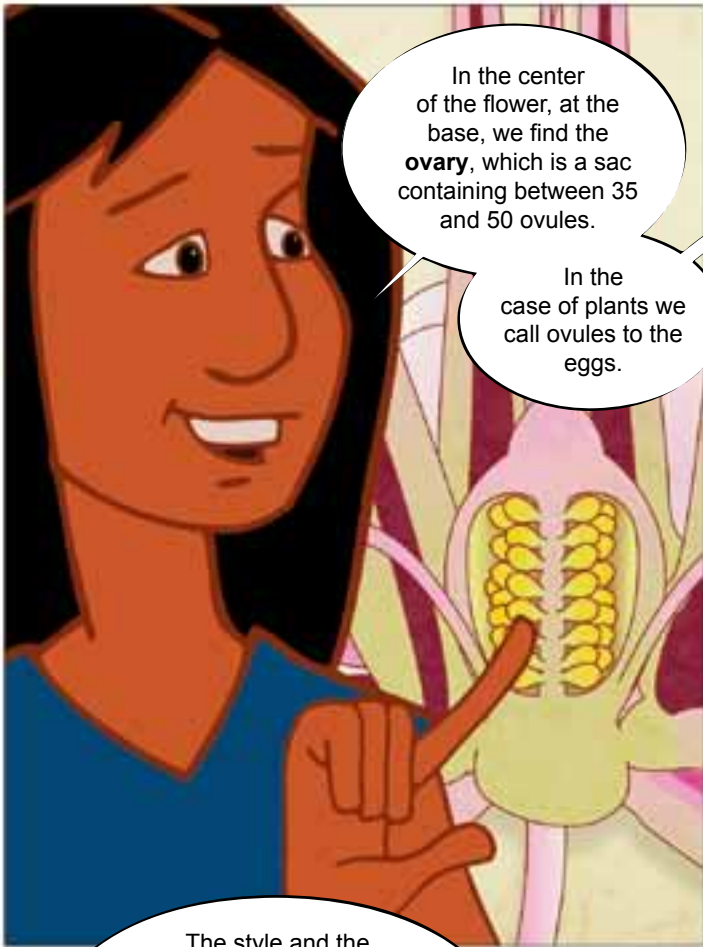


And look, when the flower is open we can see five little "leaflets" at the base, known as **sepals**. The sepals were wrapped around the flower and protected it before it opened.



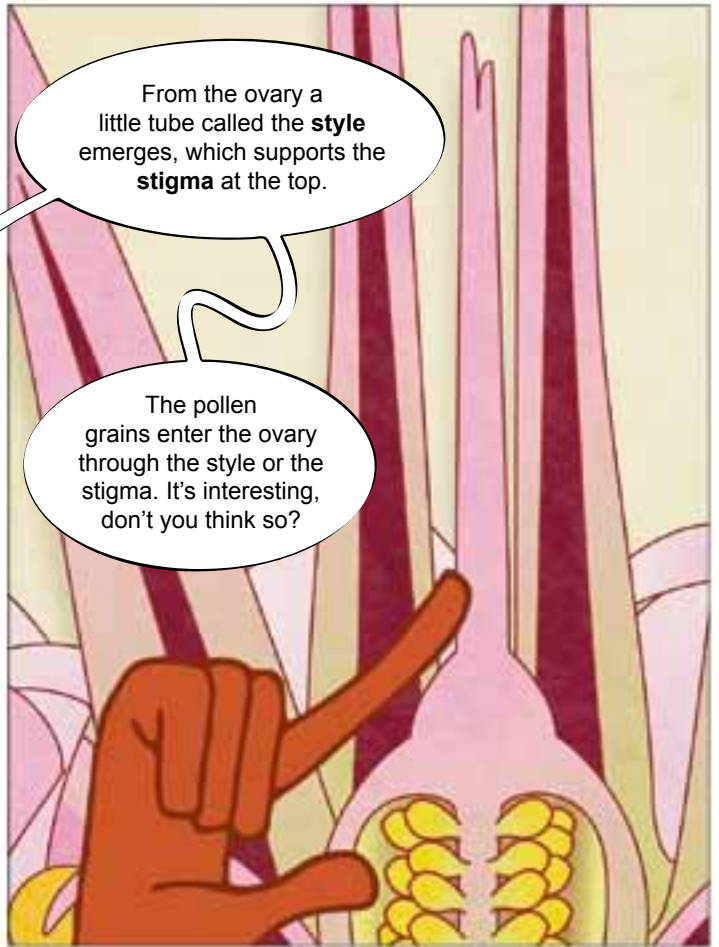
Moving toward the center of the flower, we see that after the sepals, the flower has five **petals**, which are responsible for attracting insects – we'll soon see why this is so important.





In the center of the flower, at the base, we find the **ovary**, which is a sac containing between 35 and 50 ovules.

In the case of plants we call ovules to the eggs.

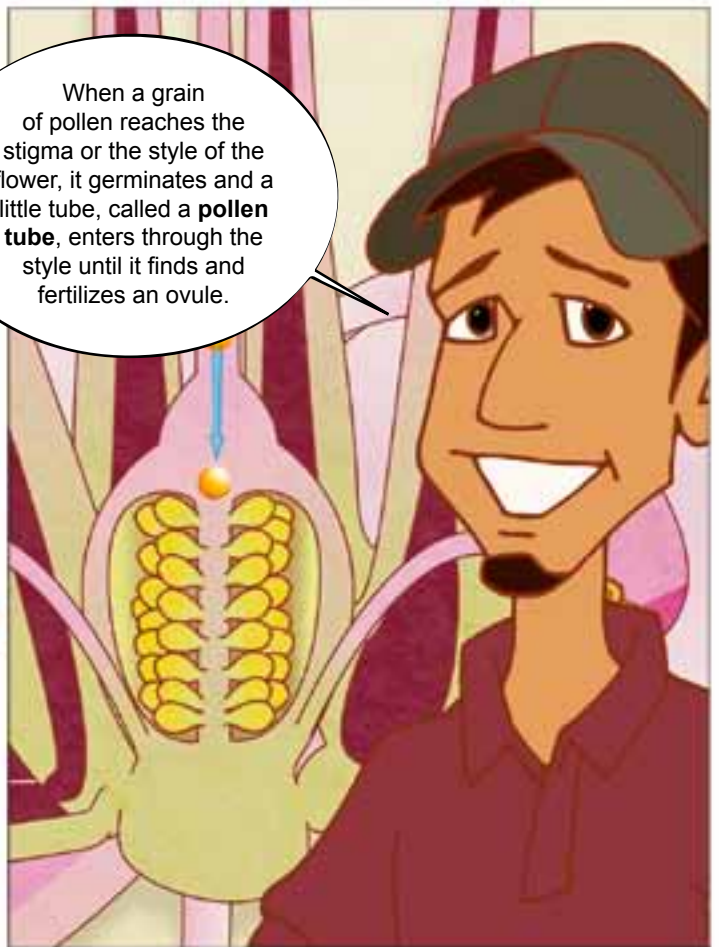


From the ovary a little tube called the **style** emerges, which supports the **stigma** at the top.

The pollen grains enter the ovary through the style or the stigma. It's interesting, don't you think so?

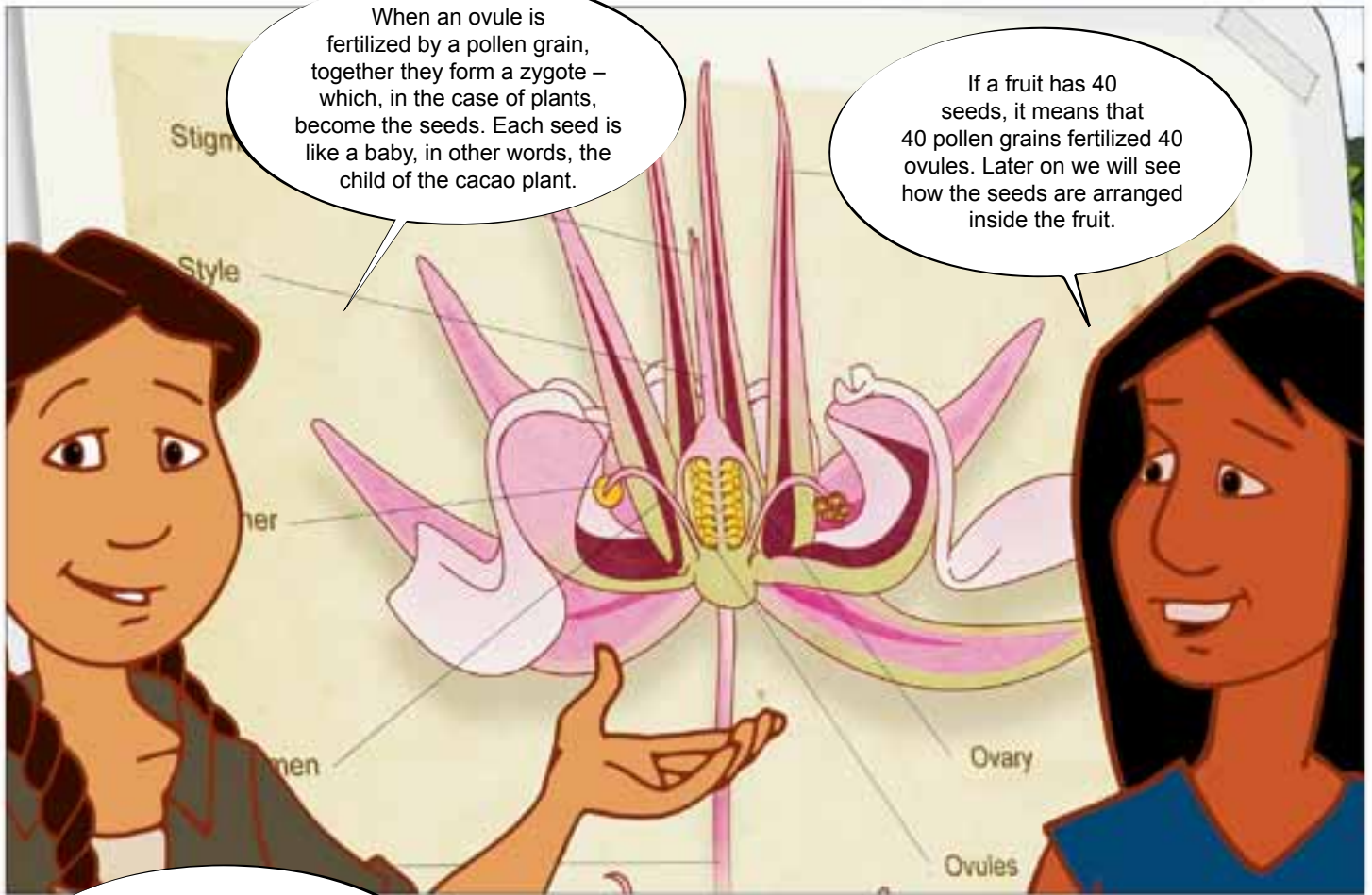


The style and the stigma are covered with a sticky substance that prevents the pollen grains that arrive there from falling off or being blown away by the wind.



When a grain of pollen reaches the stigma or the style of the flower, it germinates and a little tube, called a **pollen tube**, enters through the style until it finds and fertilizes an ovule.





When an ovule is fertilized by a pollen grain, together they form a zygote – which, in the case of plants, become the seeds. Each seed is like a baby, in other words, the child of the cacao plant.

If a fruit has 40 seeds, it means that 40 pollen grains fertilized 40 ovules. Later on we will see how the seeds are arranged inside the fruit.

When the pollen of a flower reaches the stigma or the style of the same flower or of another flower this is called **pollination**. But how does the pollen from one flower get to the style or stigma of another flower?

It would be very difficult for the pollen to be carried by the wind because the anthers - where the pollen is – are covered by petals and they are also farther down than the style or the stigma of the flower.

Nature has entrusted the pollination of cacao to a small insect, a midge with a complicated scientific name (*Forcipomya spp.*), but at this meeting we will call it the “pollinating midge”. Look, here’s a photograph of one.





The pollinating midge (*Forcipomya* spp.)  
Its body measures 2 - 3 millimeters long.

## The pollinating midge

These midges visit the cacao flowers because they are attracted by the colors of the petals and the staminodes and because they like the aroma and the taste of the sweet liquid produced by the flowers, called **nectar**.

When a midge walks on the flower in search of nectar, the pollen grains get stuck on its legs and on other parts of its body.

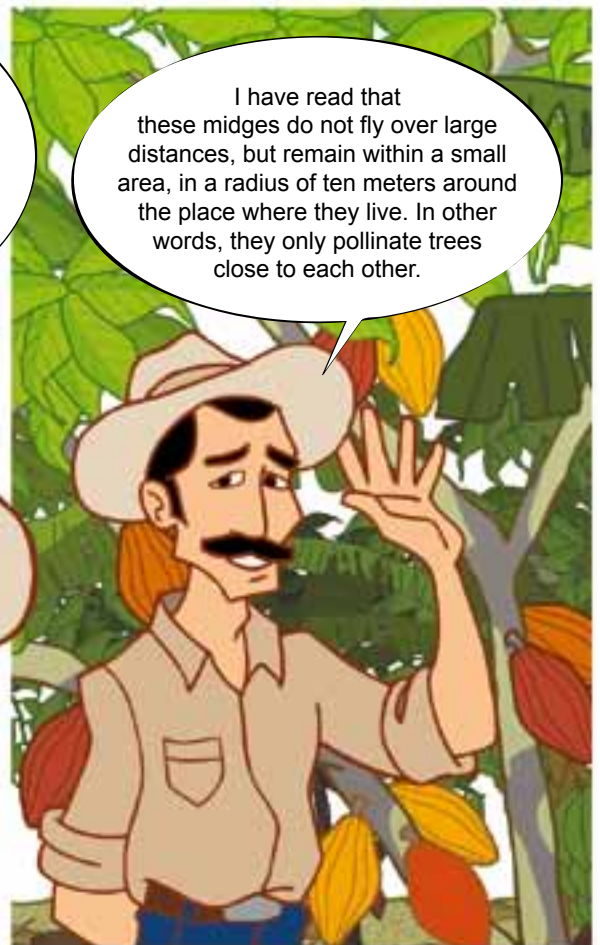
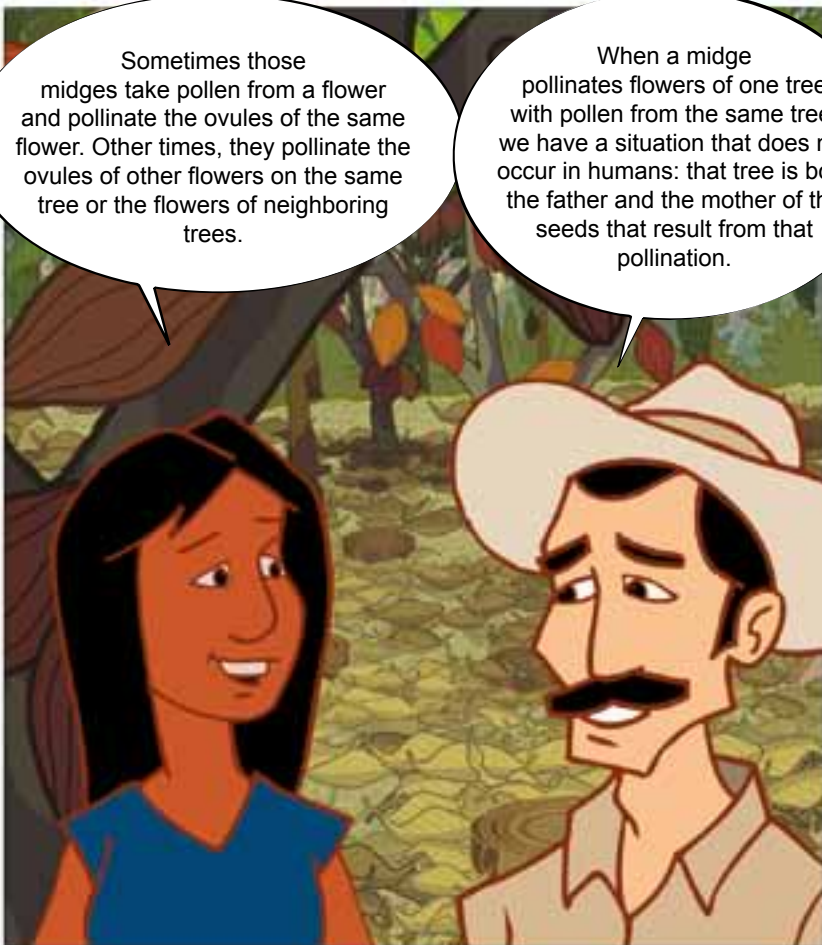
Then the midges spread the pollen grains over the same flower or carry it to other flowers that they visit afterwards. Some of those pollen grains get stuck on the style or the stigma and pollinate the flower.



Sometimes those midges take pollen from a flower and pollinate the ovules of the same flower. Other times, they pollinate the ovules of other flowers on the same tree or the flowers of neighboring trees.

When a midge pollinates flowers of one tree with pollen from the same tree, we have a situation that does not occur in humans: that tree is both the father and the mother of the seeds that result from that pollination.

I have read that these midges do not fly over large distances, but remain within a small area, in a radius of ten meters around the place where they live. In other words, they only pollinate trees close to each other.



Pollination  
within the same  
cacao flower.



Pollination  
between flowers  
of the same cacao tree.



Pollination  
of cacao flowers  
between trees.



## Pollination of the cacao flower



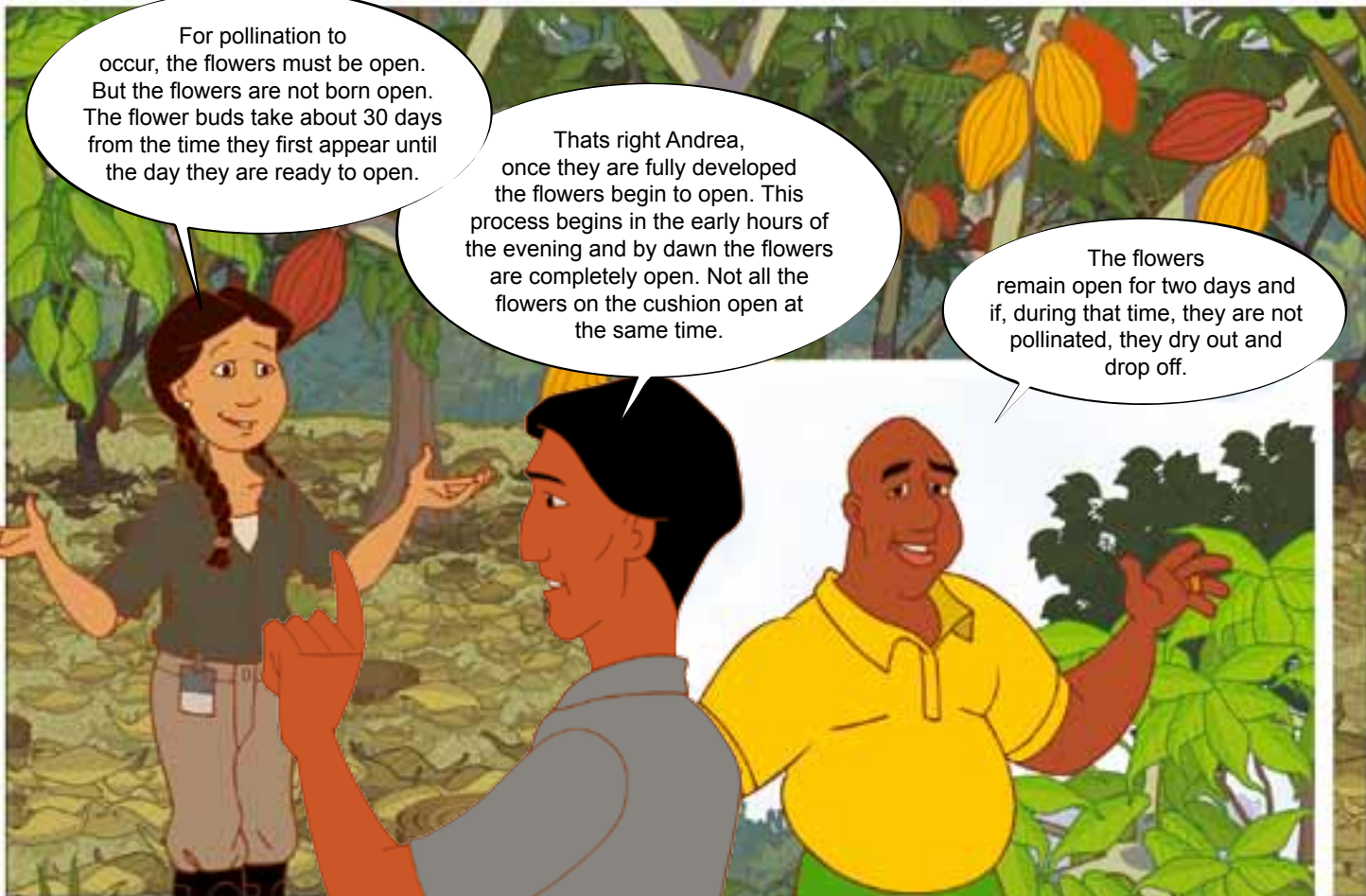
Why should we fly over long distances? In addition to being tiring, there's so much fumigation and so much danger nowadays that it's best not to venture too far from home.

I think that pollination in cacao is a kind of favor that the midges do for the cacao.



There are no favors here: it's a matter of everyone giving something. We give away that sugary nectar that the midges like so much.

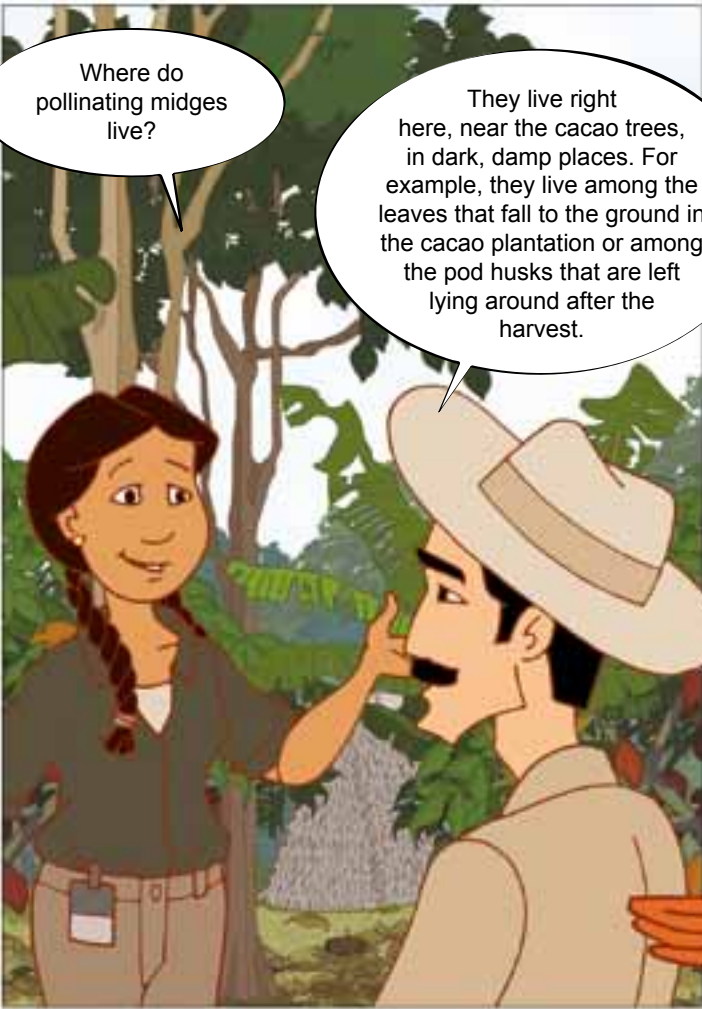
I wouldn't change that nectar for anything in the world - and although I'm a bit allergic to pollen, I put up with it and then take it off my body by rubbing myself against the flowers.



For pollination to occur, the flowers must be open. But the flowers are not born open. The flower buds take about 30 days from the time they first appear until the day they are ready to open.

That's right Andrea, once they are fully developed the flowers begin to open. This process begins in the early hours of the evening and by dawn the flowers are completely open. Not all the flowers on the cushion open at the same time.

The flowers remain open for two days and if, during that time, they are not pollinated, they dry out and drop off.

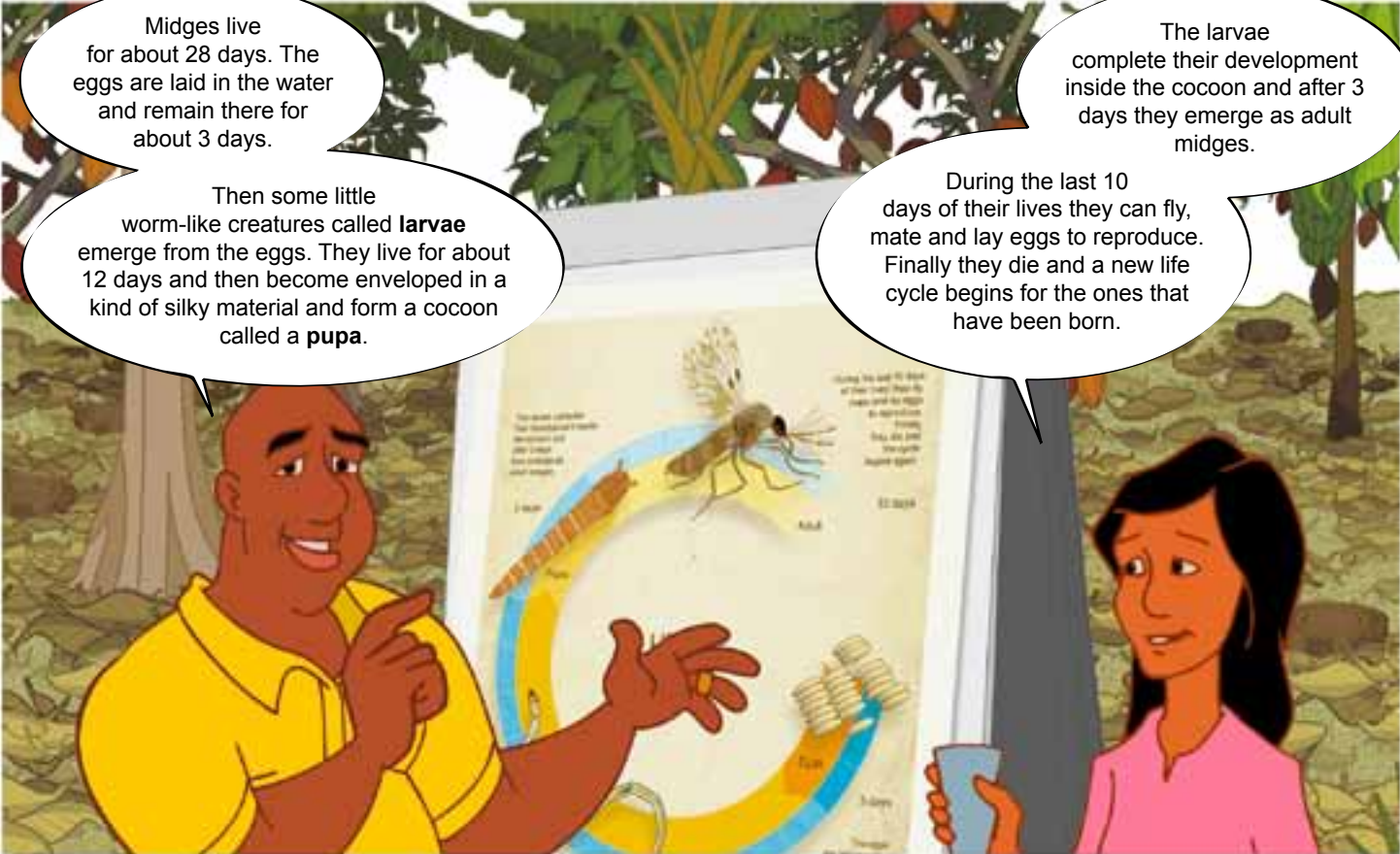


Where do pollinating midges live?

They live right here, near the cacao trees, in dark, damp places. For example, they live among the leaves that fall to the ground in the cacao plantation or among the pod husks that are left lying around after the harvest.



And they like to lay their eggs in places where there's water - for example, in old banana stems and in other plants that store water that grow near cacao trees or shade trees. In the rainy season there are more pollinating midges than during the dry season.

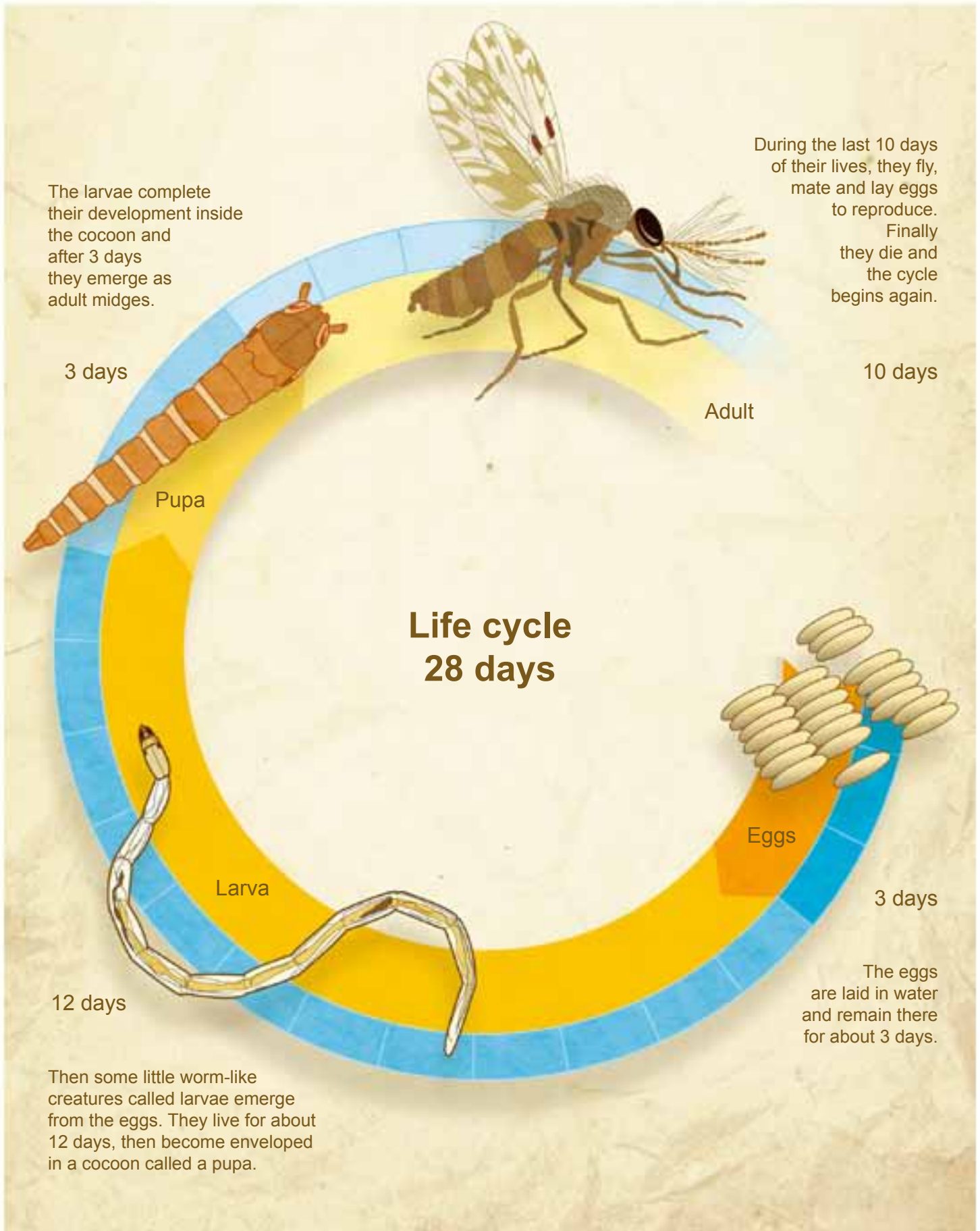


Midges live for about 28 days. The eggs are laid in the water and remain there for about 3 days.

Then some little worm-like creatures called **larvae** emerge from the eggs. They live for about 12 days and then become enveloped in a kind of silky material and form a cocoon called a **pupa**.

The larvae complete their development inside the cocoon and after 3 days they emerge as adult midges.

During the last 10 days of their lives they can fly, mate and lay eggs to reproduce. Finally they die and a new life cycle begins for the ones that have been born.



Life cycle of the pollinating midge





## Tips for maintaining a good population of pollinating midges

- Do not remove the leaves that fall to the ground from cacao and shade trees; leave a layer of leaves on the ground to provide a home for the pollinators.
- Insecticides or other toxic substances kill the pollinating midges. Try to avoid using chemicals in the cacao plantation.
- Grow shade trees, fruit trees and bananas throughout the cacao grove so that temperatures remain cool and the midges can reproduce, grow, fly and pollinate the cacao.
- Do not eliminate plants that grow on the branches of the cacao and shade trees and that retain rainwater, because this is another place where the pollinating midges lay their eggs.
- To provide more places for the midges to lay their eggs, cut the stems of banana or plantain trees into disk-shaped pieces or slices around 5 centimeters thick, and distribute these in different parts of the cacao plantation, near the trunks of the cacao trees. It is best to keep those banana or plantain stem slices around throughout the year, but especially during the months when the cacao trees are flowering.



If production on a cacao plantation is low, one of the things we would check is the population of pollinating midges in that plantation.



Well, we've said quite a lot about cacao pollination and the pollinating midge. But there is another way to pollinate the flowers.

True, there is also **manual pollination**.



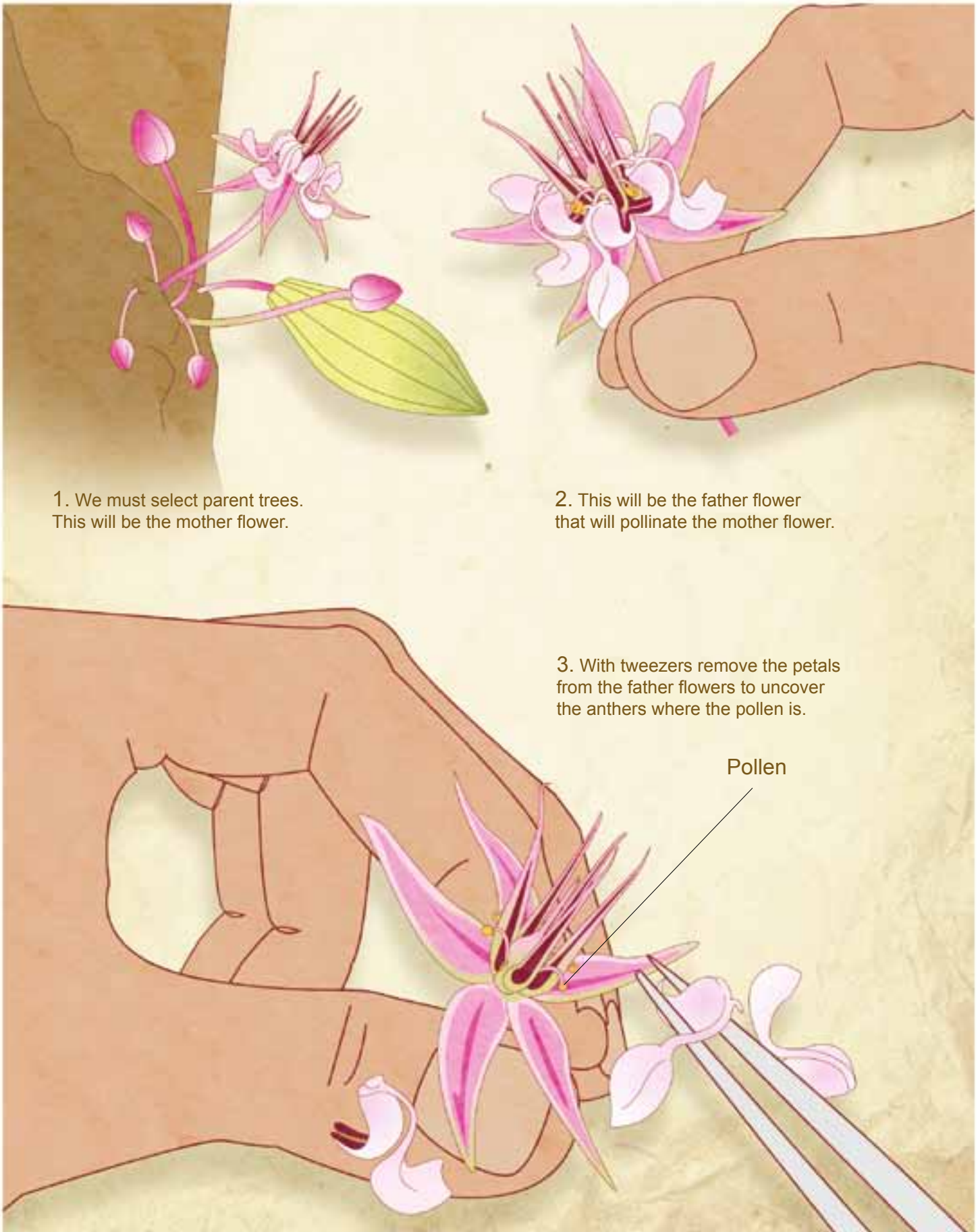
Of course! Human beings can serve as cacao pollinators and with an extra advantage: we can choose the trees that will be the fathers and mothers of the seeds.

And when we become really familiar with the cacao flower and know which are the male and female parts,

we can take pollen from a tree whose characteristics are well known to us and deposit it on the stigma of the flower that we wish to pollinate.



Manual pollination can be done like this: pick a flower from the father tree, remove the petals, revealing the anthers, and then rub it on the stigma or style of the flower of the mother tree.



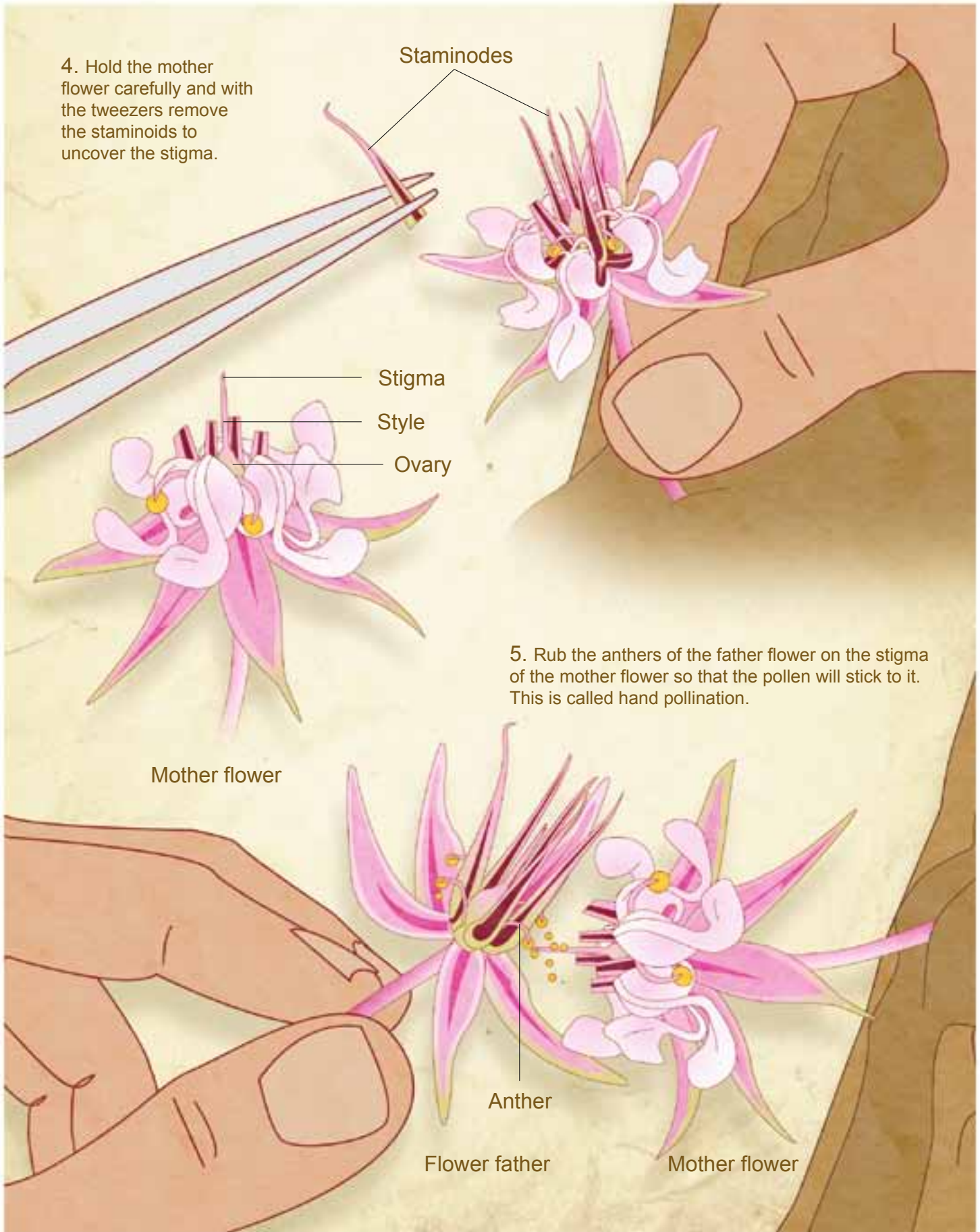
1. We must select parent trees.  
This will be the mother flower.

2. This will be the father flower  
that will pollinate the mother flower.

3. With tweezers remove the petals  
from the father flowers to uncover  
the anthers where the pollen is.

Pollen

Hand pollination of cacao flowers, part I

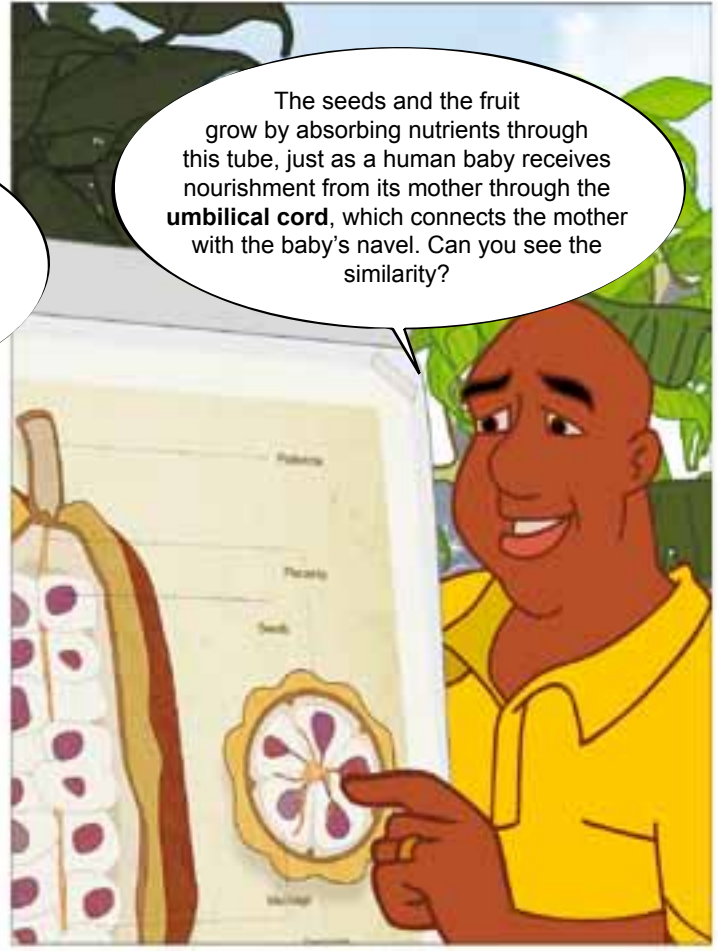
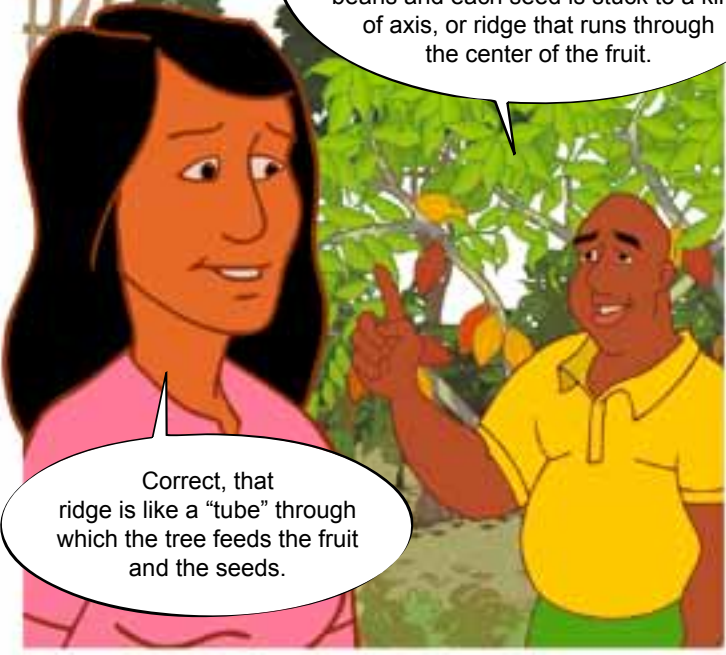


## Hand pollination of cacao flowers, part II

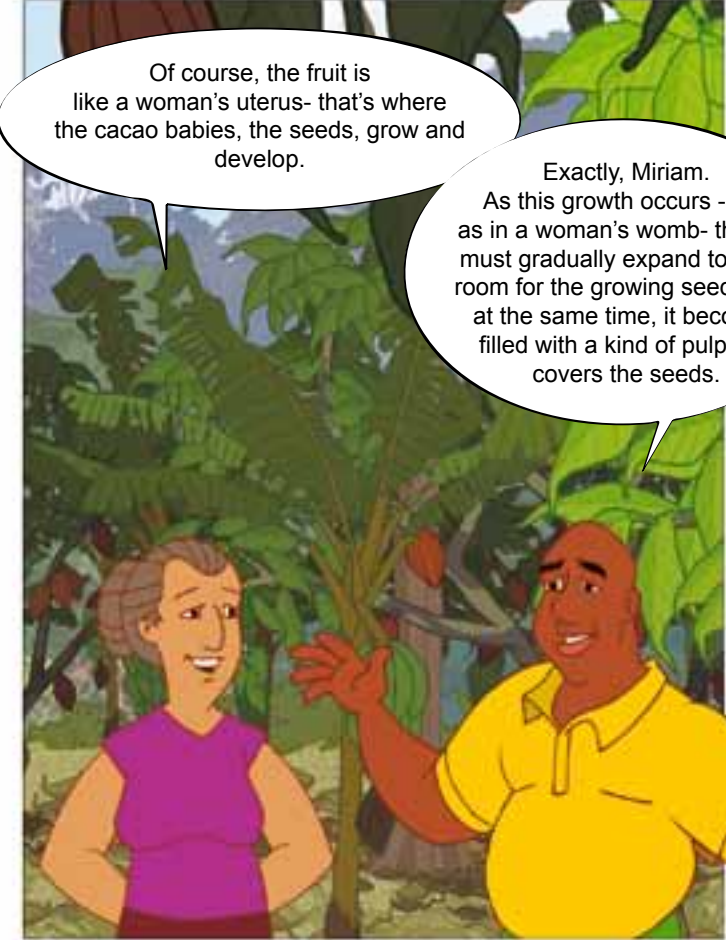
This is easy and fun, but you need a steady hand.

Let's talk about the fruit or pod. You know that when we open a cacao pod and remove the husk, we see five rows of seeds or beans and each seed is stuck to a kind of axis, or ridge that runs through the center of the fruit.

The seeds and the fruit grow by absorbing nutrients through this tube, just as a human baby receives nourishment from its mother through the **umbilical cord**, which connects the mother with the baby's navel. Can you see the similarity?



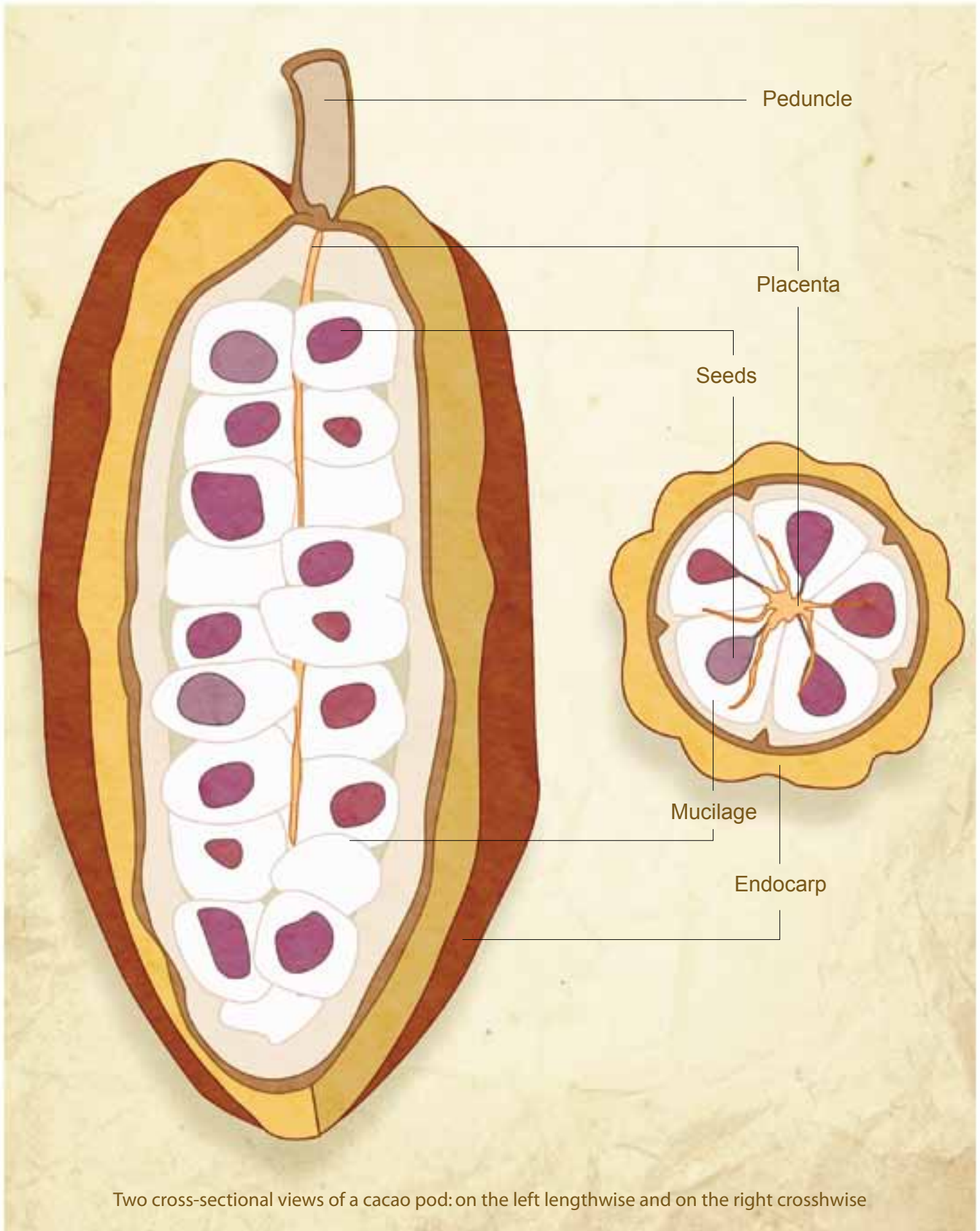
Correct, that ridge is like a "tube" through which the tree feeds the fruit and the seeds.



Of course, the fruit is like a woman's uterus- that's where the cacao babies, the seeds, grow and develop.

Exactly, Miriam. As this growth occurs - just as in a woman's womb- the fruit must gradually expand to make room for the growing seeds, and at the same time, it becomes filled with a kind of pulp that covers the seeds.

This pulp or mucilage attracts monkeys and other animals, they break open the pods to eat the pulp, but they throw the seeds away. So the animals help to spread the seeds around to places where they may grow into new trees.



Two cross-sectional views of a cacao pod: on the left lengthwise and on the right crosswise

## Cacao fruit or pod

Earlier we mentioned that the stem that joins the flower to the branch is called the pedicel, but once the flower has turned into a fruit, this stalk is called the **peduncle**.



Now I'm going to mention an important fact: it takes 5 to 7 months from the moment when fertilization takes place until the fruit is ripe and ready to be harvested, depending on the cacao tree and the temperature of the place where it grows.

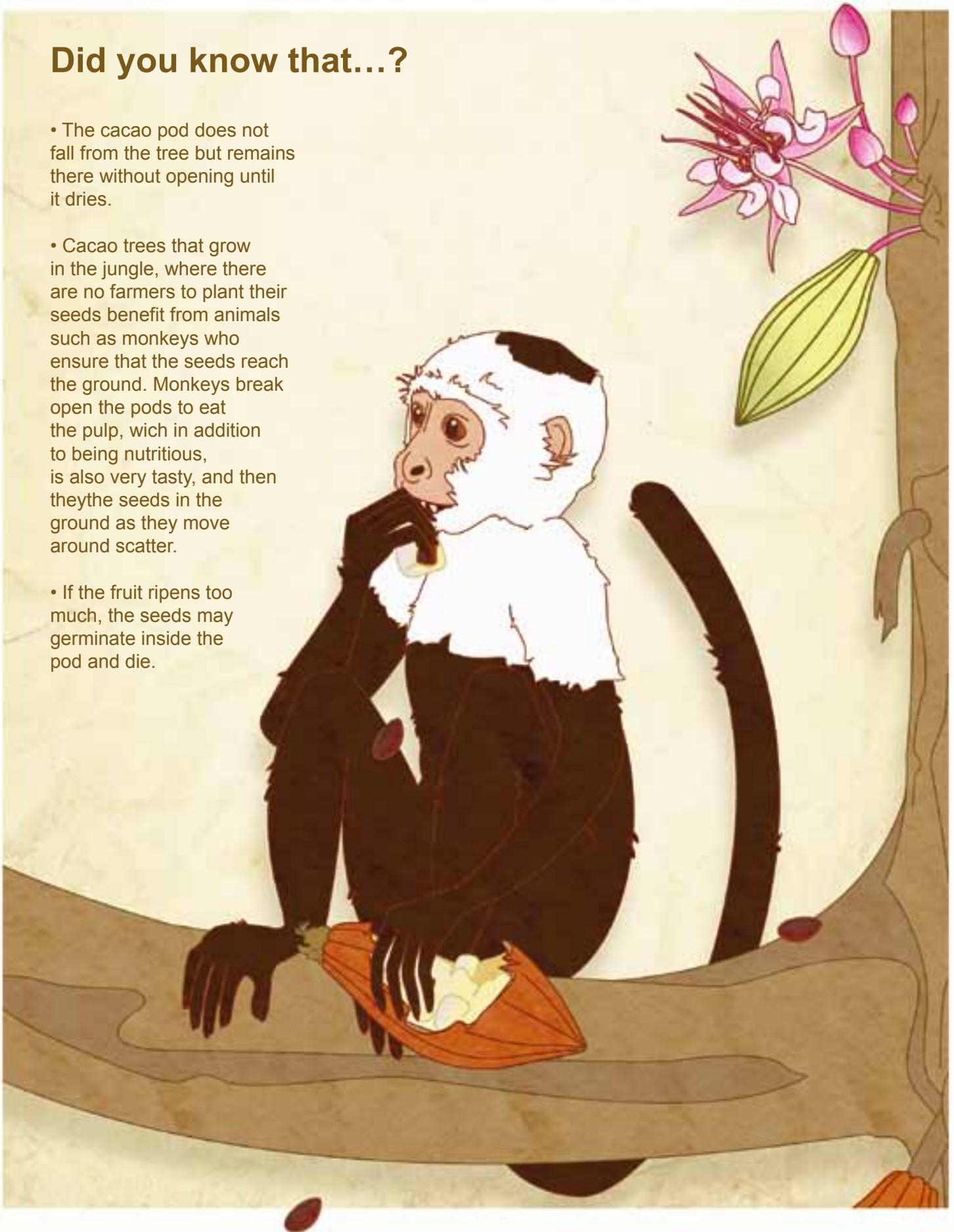


## Did you know that...?

- The cacao pod does not fall from the tree but remains there without opening until it dries.

- Cacao trees that grow in the jungle, where there are no farmers to plant their seeds benefit from animals such as monkeys who ensure that the seeds reach the ground. Monkeys break open the pods to eat the pulp, which in addition to being nutritious, is also very tasty, and then they scatter the seeds in the ground as they move around.

- If the fruit ripens too much, the seeds may germinate inside the pod and die.







Now we're going to discuss a topic that is closely related to sexual reproduction, and that is the topic of heredity.

Right. Heredity influences the characteristics or traits which parents pass on to their children.



Yes. For example, my daughter Cristina looks a lot like me.

True, she has the same shape of face, the same nose and the same eyes as her mother.

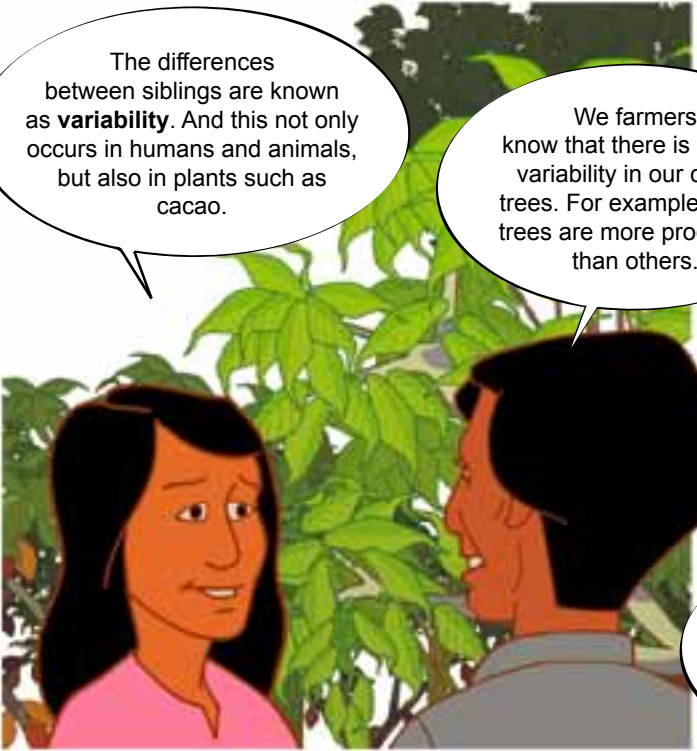
But her hair isn't anything like Miriam's, it's more like Carlos, her father.



You know, my other two children, Carlitos and Daniel, are very different from Cristina.

In our families, each child has his or her own characteristics that distinguish him or her from the rest of the brothers and sisters.

Although all the siblings may look like their parents, and may even look like each other, each one is different from the rest.



The differences between siblings are known as **variability**. And this not only occurs in humans and animals, but also in plants such as cacao.

We farmers know that there is a lot of variability in our cacao trees. For example, some trees are more productive than others.

The colors of the pods can also vary; some have larger seeds, others take less time to produce their first harvest; some are more resistant to certain diseases.

Even cacao trees that come from seeds from the same pod can be different from each other – like siblings from the same family.

I'll give you an example of what it means to inherit a defect. Pirate, my dog, began to lose his sense of smell when he was quite young and a friend told me that dogs of his breed suffer from this problem - that it's a hereditary disease.

Did you know that Pirate is a pure breed

And let's not forget that it's not just the good traits that can be inherited; bad ones can be too! For example, a parent cacao tree can pass its susceptibility to disease on to its offspring.

Pure skin and bones, you mean!



Okay, everyone, we've seen how sexual reproduction works in cacao; we've studied the flower, the fruit and pollination.

And we know these progresses are all important in cacao production. But why do that most of our cacao plantations produce so little?

That's a very important question. I think that there are least four possible reasons for this:

1. Too few pollinators in the cacao plantation.
2. A lot of variability between trees in the cacao plantation.
3. **Incompatibility** between the trees in the cacao plantation. I'll explain what that means in a minute.
4. Lack of maintenance in the cacao plantation.
5. Lots of pests and diseases.

Well, we've already discussed the problem of a lack of pollinators and we've learnt how to resolve it.


We also know how to remedy the problem of lack of maintenance: we have to "get ourselves moving", work hard and manage our cacao plantations properly.




Okay then, let's discuss the other two problems: variability and incompatibility between trees.

To understand how both problems arise it would be a good idea to review how we started our cacao plantations.






In most cases, our parents - or we ourselves - decided to plant a cacao grove. We either bought seed, or asked our neighbors for some, or else we took some seeds from cacao trees that were already growing on the farm.




Over the years we began to notice that we had a problem of variability: there were trees with green pods and red ones,

some produced a lot of pods and others only produced a few; some were severely affected by pests and diseases and others were not. In other words, we found we had a real jumble, a bit of everything.




We knew very little about the reproduction of cacao and most of us did not understand the reasons for these major differences between the trees.

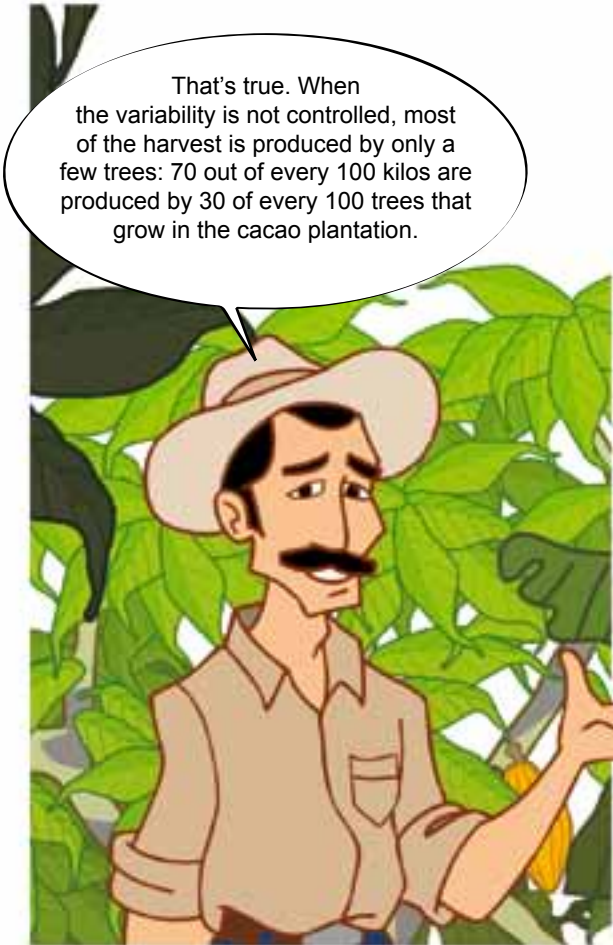


Yes Carmen, but now we know that variability in the cacao plantation is a direct result of sexual reproduction in cacao.

Midges carry pollen from one tree to another, but they don't consult us about which ones they visit.



The problem is that when variability is not controlled, the majority of the trees produce only a few fruits.



That's true. When the variability is not controlled, most of the harvest is produced by only a few trees: 70 out of every 100 kilos are produced by 30 of every 100 trees that grow in the cacao plantation.



Or to put it simply, 70 per cent of the harvest is produced by 30 per cent of the trees in the plantation.

My goodness! Imagine how much cacao our plantations could produce if 60 of every 100 trees were good producers!



And what if we managed to turn all our trees into good producers – after the harvest I'd take off on a two-week vacation with my family and stay at a luxury hotel.

If you invite me I'll carry your bags...



Very good. This is an important point. You can increase the number of trees that are good producers in the cacao plantation. There are techniques for doing that.

That's right Miguel, but that topic is so important that we will soon devote an entire meeting to discussing these techniques. Now we have to deal with the other problem – incompatibility between cacao trees.



Incompati... what?

Two things are **compatible** when they work well together, or produce good results when combined.



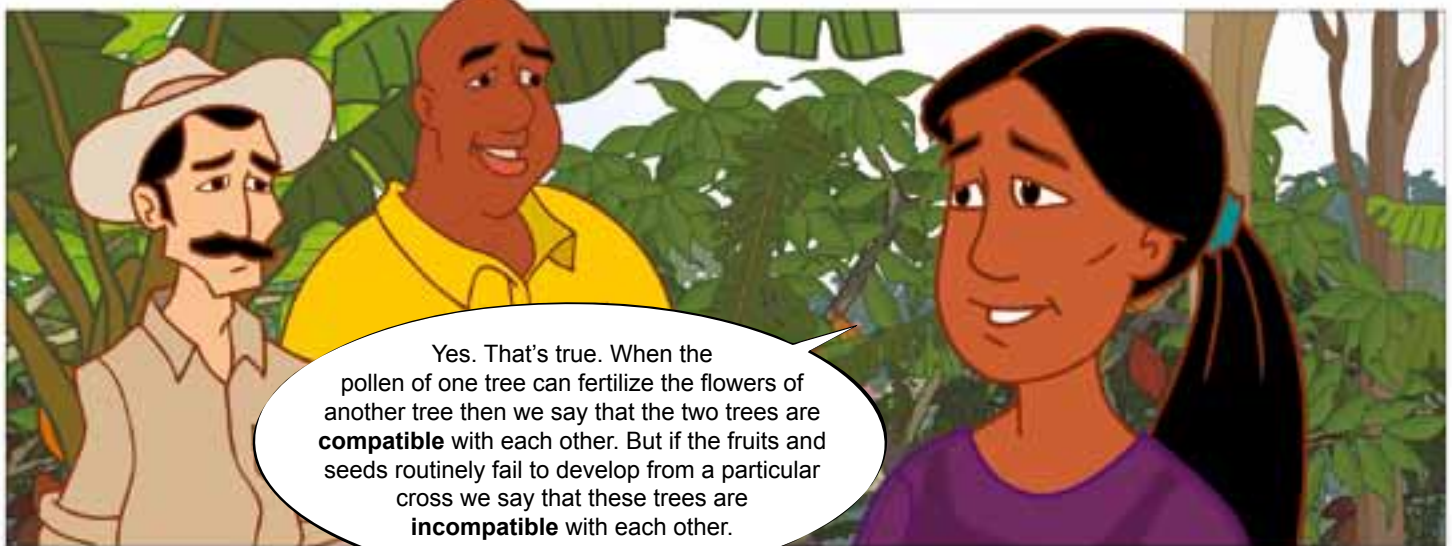
I'll give you some examples: with dogs, you can cross a German Shepherd with a Doberman and there's no problem. The puppies are born with the characteristics of both breeds.

That's because the German Shepherd and Doberman breeds are compatible.

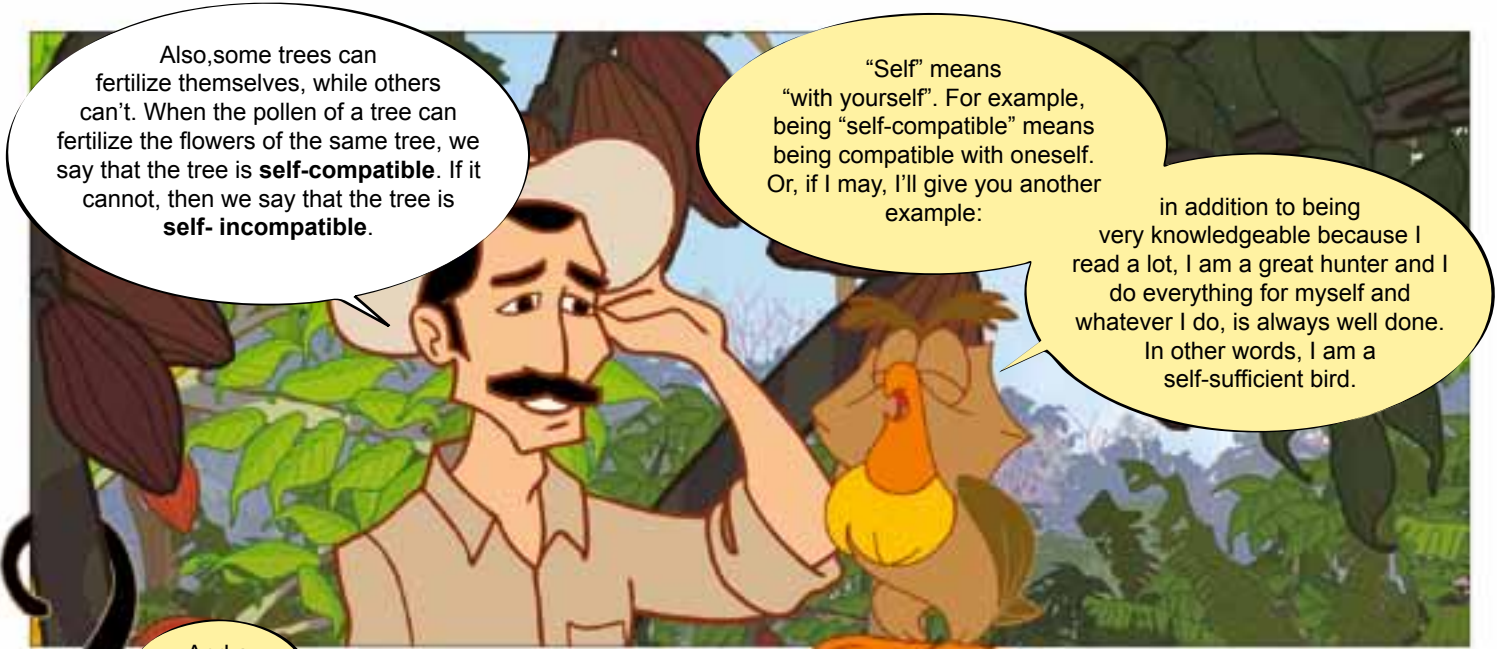


But when animals belong to different species, such as dogs and cats, usually they cannot be crossed – they're incompatible. So you can't cross a cacao tree with an orange tree because there's no compatibility between them.

Also, sometimes, you can find incompatibility. But between trees of a same species, such as with cacao. Isn't that right?



Yes. That's true. When the pollen of one tree can fertilize the flowers of another tree then we say that the two trees are **compatible** with each other. But if the fruits and seeds routinely fail to develop from a particular cross we say that these trees are **incompatible** with each other.



Also, some trees can fertilize themselves, while others can't. When the pollen of a tree can fertilize the flowers of the same tree, we say that the tree is **self-compatible**. If it cannot, then we say that the tree is **self-incompatible**.

"Self" means "with yourself". For example, being "self-compatible" means being compatible with oneself. Or, if I may, I'll give you another example:

In addition to being very knowledgeable because I read a lot, I am a great hunter and I do everything for myself and whatever I do, is always well done. In other words, I am a self-sufficient bird.

And a very humble one!



We must pay a lot of attention to this business of compatibility and incompatibility, because it can really affect production of a cacao plantation.



Of course. For example, some trees produce flowers but do not produce fruit. Often this is caused by incompatibility.

If the trees in a cacao plantation are not compatible with each other or with themselves, then fewer fertilizations are successful. The plantation would produce many flowers but few pods. Does anyone know how to correct this problem?



By opening a flower shop to take advantage of the flowers.

Monkey, please keep your silly ideas to yourself! We're being serious here. When we have this type of problem, the solution is to introduce trees that are compatible with the other trees on the plantation and with themselves. In other words, they should be self-compatible as well as compatible with nearby trees.



You must think about compatibility when you're buying seed. Many farmers, when they want to establish new cacao plantations, don't pay enough attention to where they obtain the seed.

For example, they go and ask their neighbor for seed from a tree that is very productive and that produces many pods, with large seeds and other good traits. Or, they may look for seeds from a good tree in their own cacao plantation.



They expect those seeds to produce trees that are the same as the mother tree from which they took the fruits and seeds.

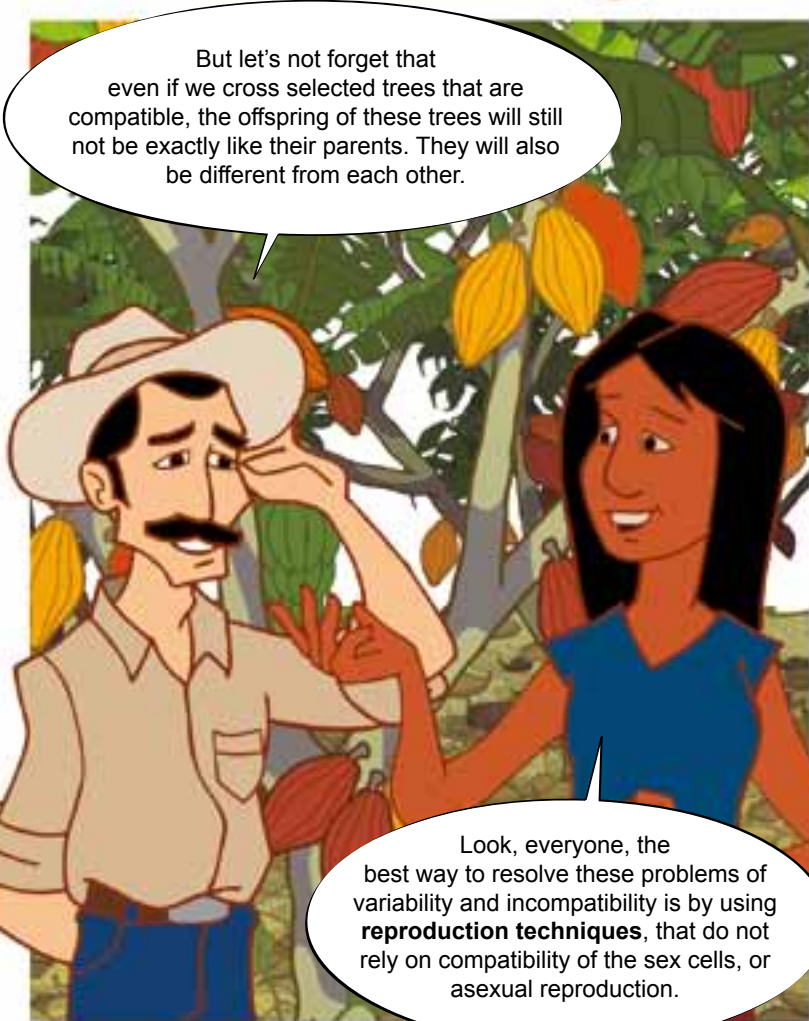
But, it's also possible that those seeds could produce trees that are not compatible with other trees in the cacao plantation.





Another solution is for us farmers to identify our best trees and then cross them with each other using manual pollination, to see which ones are compatible. That way we could produce better seeds for our cacao farms.

In that case, it's advisable to find out where to obtain certified seed. In those places they select trees with good traits and without problems of incompatibility.



But let's not forget that even if we cross selected trees that are compatible, the offspring of these trees will still not be exactly like their parents. They will also be different from each other.

Look, everyone, the best way to resolve these problems of variability and incompatibility is by using **reproduction techniques**, that do not rely on compatibility of the sex cells, or asexual reproduction.



That's right. The word "asexual" means "without the sexual aspect". In asexual reproduction there's no union of sex cells, no union between a grain of pollen and an ovule. There is no union between the males and females.

## Did you know?

Many plants and well-known crops reproduce asexually. Some examples are:



Bananas  
(*Musa spp*)



Sugar cane  
(*Saccharum- officinarum*)



Bamboo  
(*Bambusa -vulgaris*)



The stakes in live fences

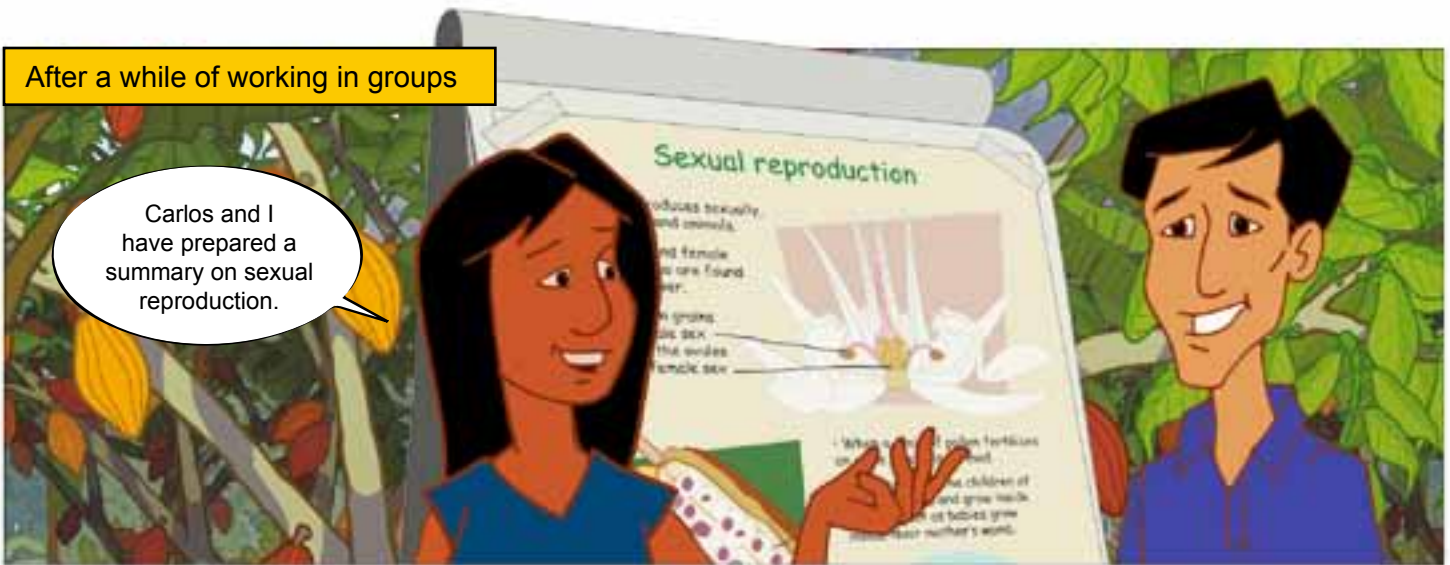


Cassava (*Manihot esculenta*)



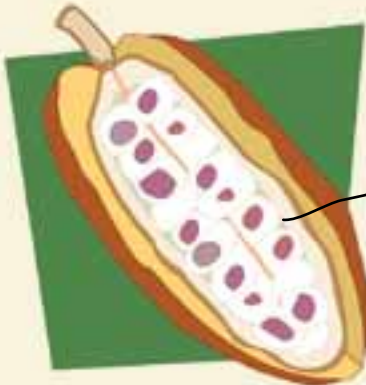
After a while of working in groups

Carlos and I have prepared a summary on sexual reproduction.



## Sexual reproduction

- Cacao reproduces sexually, like humans and animals.
- The male and female cells of cacao are found on each flower.
- The pollen grains carry the male sex cells and the ovules are the female sex cells.



- When a grain of pollen fertilizes an ovule a seed is formed.
- The seeds are the children of the cacao tree and grow inside the pod, just as babies grow inside their mother's womb.

- For the pollen grains to reach the ovules and fertilize them, a pollinating midge must carry the pollen from the father flower to the mother flower.





## Heredity

- In the sexual reproduction of humans, animals or plants, the parents transmit some of their characteristics to their children.
- This is called heredity and that's why it's common to hear phrases such as this boy inherited his mother's eyes.
- But the children are not exact copies of their parents. There are differences between siblings with the same father and mother. The characteristics of the father and the mother combine to produce different looking sons and daughters.



A cacao tree can inherit some of the good characteristics of its parents, such as producing good quality chocolate, but it could also inherit some bad ones, such as not being very resistant to diseases or producing few pods.



This poster was done by Filadelio, Maria, Miriam, and me. It's about the flower.



## The flower



- Cacao flowers grow in clusters of between 14 and 48 flowers, which sprout from flower cushions.

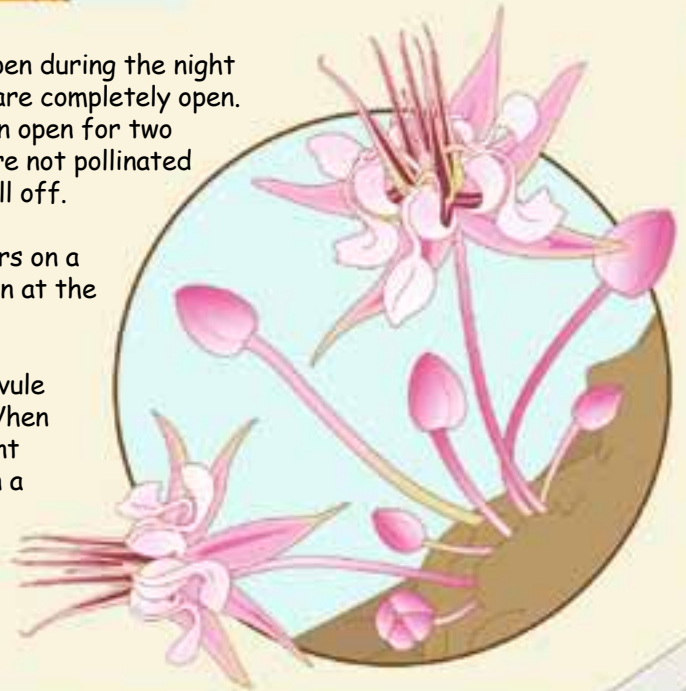
- The flower cushions are found on the trunk and on the main branches of the tree.

- It is important to take care of the flower cushions because if they are damaged they will not produce flowers again. For example, do not pick the fruits by pulling or twisting them off. They must be cut off without damaging the flower cushion.

- Cacao flowers open during the night and by dawn they are completely open. The flowers remain open for two days and if they are not pollinated they dry up and fall off.

- Not all the flowers on a flower cushion open at the same time.

- Each fertilized ovule becomes a seed. When there are sufficient fertilized ovules in a flower, the ovary of the flower turns into a fruit or pod.



We made a poster about ourselves.



## Pollinating midge

• We midges are the main pollinators of cacao; we take the pollen from one flower to another.



• Midges live in places where there is water - in damp, shady and cool environments, such as piles of leaves on the ground or among the discarded cacao husks that are left lying around the plantation.



• We live for 28 days but we only fly around pollinating during the last 10 days.

• If there are not enough midges in the cacao grove, we cannot pollinate sufficient flowers and that is one of the reasons why the harvest of a cacao plantation may be low.





Look at the poster that we made - the toucan, the owl and me. It's about the problems of variability and incompatibility. We chose the most difficult topic.

## Incompatibility and variability

- There are some cacao trees whose pollen cannot fertilize the ovules of other trees. When this happens we say that the two trees are incompatible.
- There are trees whose pollen cannot fertilize the flowers of the same tree. These trees are self-incompatible.

If there is a lot of incompatibility between trees in a cacao plantation then the harvest will be poor.

- Many cacao plantations that do not have problems of incompatibility still produce very little because there is a lot of variability.
- In cacao plantations where the variability is not controlled, 70 per cent of the harvest is produced by only 30 per cent of the trees. In other words, many trees produce little cacao and only a few are good producers.

Variability in cacao trees can be managed using asexual or vegetative propagation techniques.

Now I think we can all go back to our cacao plantations and take a close look at the flowers, the pods and the characteristics of the trees there.





## GLOSSARY

**Anther** Part of the flower similar to a small sac containing the pollen.

**Bud** Growth organ of the cacao plant. A type of button found on the trunk and branches, normally in the base of the leaves and the tips of the branches, which is capable of developing and producing new leaves, branches or flowers.

**Cocoon** A silk-like covering that envelops the pupa of the pollinating midge.

**Compatibility** When two things work well together and can be successfully combined we say that they are compatible. For example, when the pollen of a cacao tree can pollinate the flower of another cacao tree, we say that the trees are compatible with each other.

**Egg** In animals and humans an egg is a structure that contains the female sex cell before it has been fertilized by a sperm.

**Feminine** A word that refers to the female or to everything related to the female of a plant or animal species, or to a woman in the case of human beings.

**Fertilization** The union of the male sex cell with the female sex cell. The fertilized ovule develops to form a new animal or a seed in the case of plants.

**Flower bud** A bud that will eventually develop into a flower, an “unopened” flower.

**Flower cushions** The places from which the cacao flowers grow on the trunk and branches of the cacao tree.

**Forcipomya** The name of the pollinating midge of cacao.

**Graft** Asexual propagation technique that involves tying a shoot or bud of a tree to trunk or branch of another tree so that it will grow there nourished by the roots of the other tree.

**Heredity** The transmission of characteristics or traits from parents to their children.

**Incompatibility** When the pollen of a cacao tree cannot fertilize the flower of another cacao tree we say that the trees are incompatible with each other.

**Larvae** Worm-like creatures that emerge from the eggs laid by pollinating midges.

**Layering** An asexual reproduction technique used in cacao.

**Manual pollination** A technique that involves a human taking pollen from a flower and placing it on the style or stigma of another flower to fertilize its ovules.

**Masculine** Refers to the male sex or to everything related to the male parts of a plant or animal species, or to a man in the case of humans.

**Nectar** Sweet liquid produced by cacao flowers to attract pollinating midges.

**Ovary** The part of the female flower where the ovules are located.

**Ovule** The female sex cell of animals and plants.

**Pedicle** Small stalk or stem that supports the flower and connects it to a trunk or branch.

**Petal** Part of the flower, usually brightly colored, which attracts pollinating midges.

**Pod** In many countries the cacao fruit is called the pod.

**Pollen** In plants that reproduce sexually the pollen contains the male sex cells.

**Pollen tube** A small tube created by the pollen grain when it reaches the style or stigma of the flower. This little tube is used by a pollen grain to fertilize one of the ovules that is found in the ovary.

**Pollination** The process through which pollen grains are transferred the female organ of the flower to fertilize its ovules and form seeds.

**Pupa** A stage of development in pollinating midges in which the larvae turn into adult midges.

**Semen** In animals or human beings it is the liquid that produced in the male glands (the testicles), containing millions of sperms.

**Sepal** Part of a flower that looks like small green leaflets enveloping the flower before it opens.

**Sex cells** Very small organs, impossible to see with the naked eye. These must join with sex cells of the opposite sex to create a new person, animal, or plant.

**Somatic embryogenesis** Asexual reproduction technique used in cacao, which is studied in another episode.

**Sperm** The male sex cell in animals and humans.

**Stamen** Filament that supports the anthers.

**Staminode** Small filaments of a purplish color that attract pollinating midges.

**Stigma** Female part of the plant where the pollen grains are deposited in order to fertilize the flower.

**Style** A slender stalk on the flower that bears the stigma at its tip. The pollen grains that become stuck to the style can also fertilize the ovules of the flower.

**Umbilical cord** The cord connecting the mother with the fetus (or developing baby) through the baby’s navel, while it remains in its mother’s womb.

**Variability** From the word “vary”, which means to change. Variability is the group of differences evident in cacao plants.