

# Grafting and other methods for the asexual Propagation of Cacao

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Luis Orozco Aguilar · Francisco Quesada Chaverri · Marilyn Villalobos Rodriguez · Shirley Orozco Estrada  
Eduardo Say · Olivier Deheuvelds · Lauren Fins

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3



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.

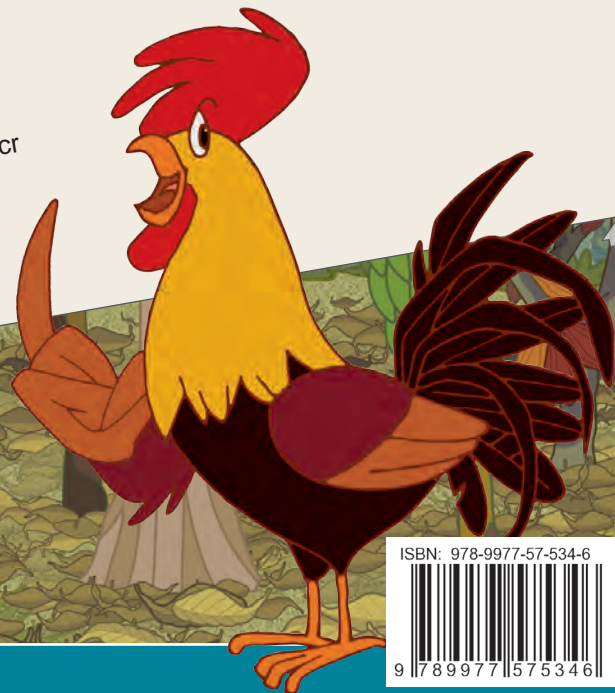
Working closely with cacao farming families, the Project creates alliances with other partners in the region in order to enhance the social interactions, competitiveness and business capacity of the producers' organizations and improve the living conditions of their members.

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 of all ages and from different ethnic groups in all its spheres of action.

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The Tropical Agricultural Research and Higher Education Center (CATIE) is a regional center dedicated to research and graduate education in agriculture and the management, conservation and sustainable use of natural resources. CATIE's members include: the Inter-American Institute for Cooperation on Agriculture (IICA), Belize, Bolivia, Colombia, Costa Rica, the Dominican Republic, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Venezuela and Spain.

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Good morning. How is everyone? Thank you for coming to visit with us this morning. I would like to introduce Gerardo, who owns this special demonstration farm where he has planted grafted cacao trees.

Good morning. It is a real pleasure for me to have you here on our farm.



Thank you, Gerardo. Friends, you remember in the last meeting we learned that sexual reproduction involves the union of male (pollen) and female (ovules) parts of cacao flowers to produce new seeds, which then grow into new plants.

However, during today's meeting, we are going to learn about other ways to produce new cacao plants. These methods are collectively known as asexual reproduction or asexual propagation.

### Propagation

means making more of something. For example, to propagate plants is to make more plants. Today we will learn how to propagate cacao trees by using their branches or other small pieces of the plant instead of planting their seeds.


Asexual means that new plants are generated from parts, such as leaves or branches, of already existing plants. By using asexual propagation, we can make many exact copies of the best cacao trees in our farm.

Let's get to work. Here are the topics for today's meeting. Please pass around these sheets that Filadelio and I prepared yesterday, which list the topics.

### LIST OF TOPICS FOR THE MEETING

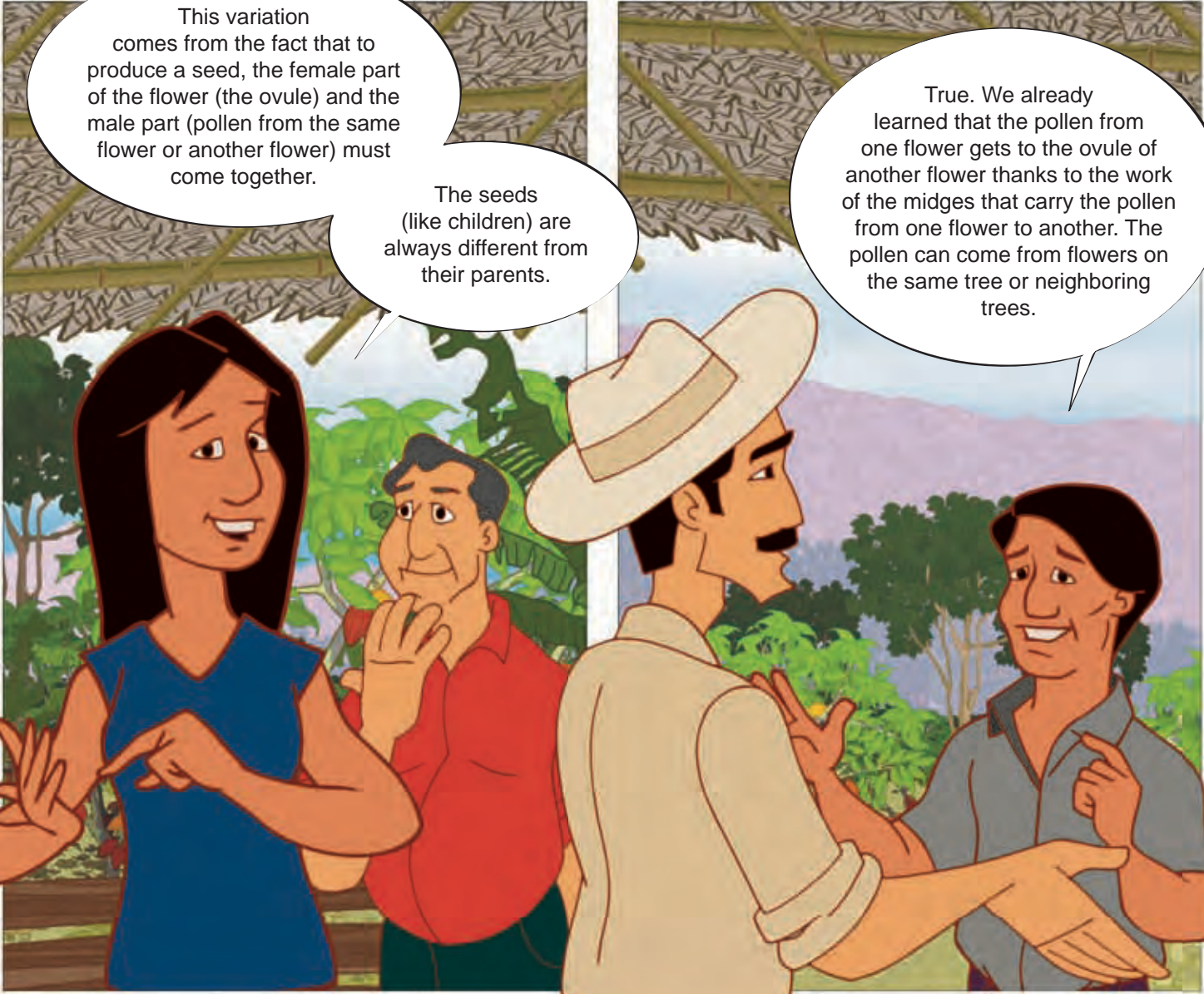
1. How does asexual propagation of cacao help us improve the farm?
2. Most common asexual propagation techniques.
  - A. Grafting
    - Grafting with buds
    - Grafting with scions
  - B. Rooting cuttings
  - C. Air layering
  - D. Somatic embryogenesis

# How does asexual propagation of cacao help us improve the farm?



As we all know, most of the cacao trees on the farm produce small crops. For every 100 cacao trees, only 30 are good producers.


That's right...There's a lot of variability between cacao trees in production and other characteristics.



This variation comes from the fact that to produce a seed, the female part of the flower (the ovule) and the male part (pollen from the same flower or another flower) must come together.

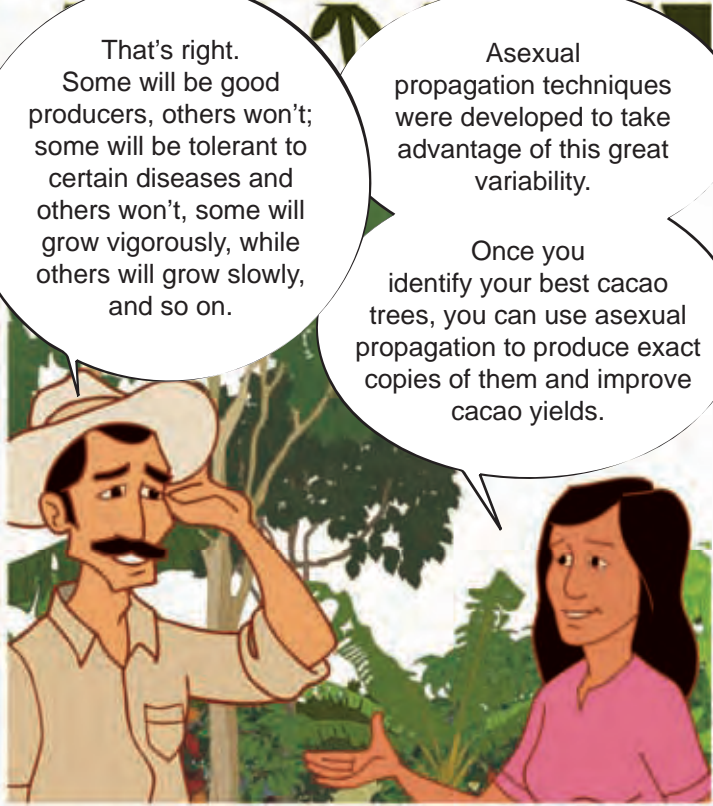
The seeds (like children) are always different from their parents.

True. We already learned that the pollen from one flower gets to the ovule of another flower thanks to the work of the midges that carry the pollen from one flower to another. The pollen can come from flowers on the same tree or neighboring trees.



The 40 to 50 seeds found in a cacao fruit all have the same mother, but they can have the same or different fathers.


No wonder cacao plants from the same fruit may be very different from each other.




That's right. Some will be good producers, others won't; some will be tolerant to certain diseases and others won't, some will grow vigorously, while others will grow slowly, and so on.

Asexual propagation techniques were developed to take advantage of this great variability.


Once you identify your best cacao trees, you can use asexual propagation to produce exact copies of them and improve cacao yields.




These exact copies of a plant are called clones. Animals can be cloned too.



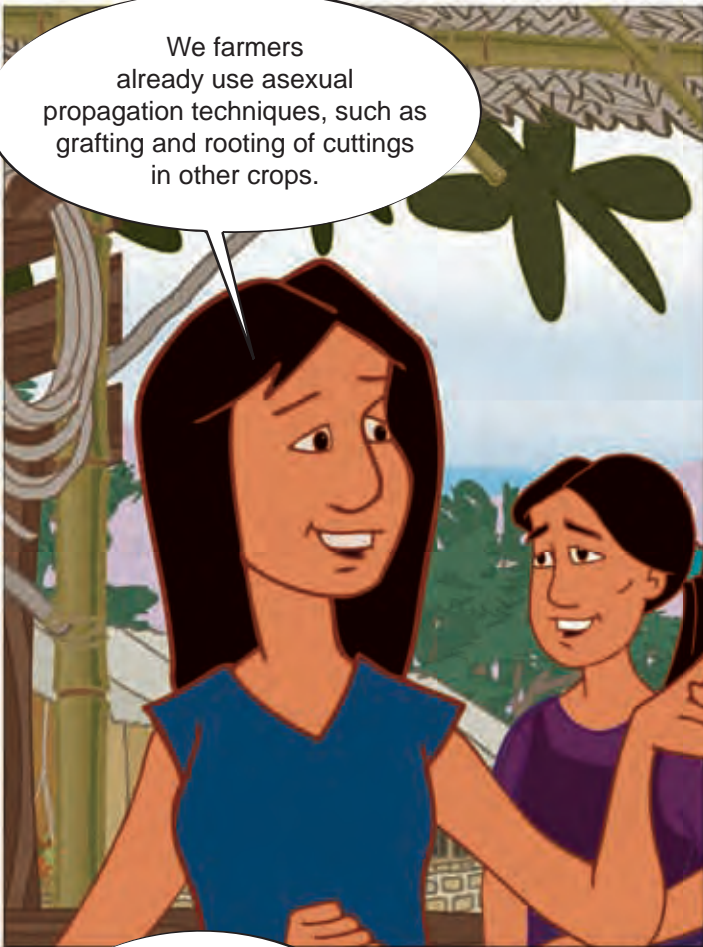
Are we going to lose our job? Aren't we going to pollinate anymore?



No, you still have a job to do! The cloned trees will also have flowers and you will need to pollinate them too. Otherwise there will be no fruits to harvest.



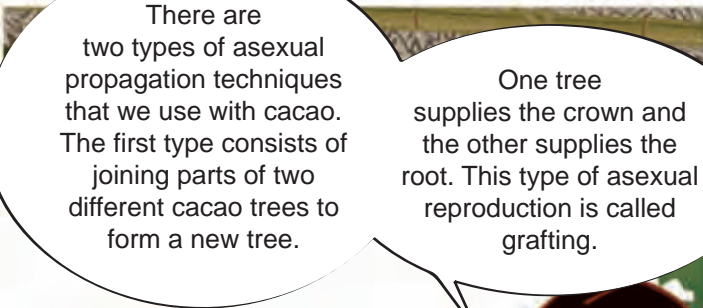
Happy is what I am going to be, with the feast I am going to have on the fruits from the cloned cacao trees. Yeeha.



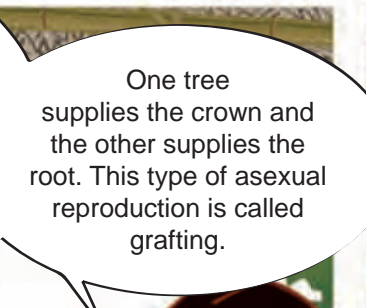
We farmers already use asexual propagation techniques, such as grafting and rooting of cuttings in other crops.



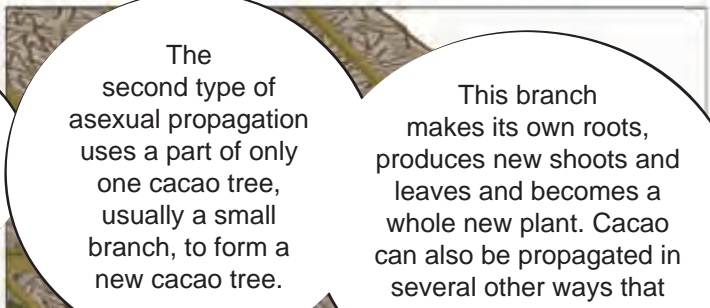
Yes, when we plant a cassava cutting or plant a banana sucker to create a new plant, we are using asexual propagation.



There are two types of asexual propagation techniques that we use with cacao. The first type consists of joining parts of two different cacao trees to form a new tree.



One tree supplies the crown and the other supplies the root. This type of asexual reproduction is called grafting.



The second type of asexual propagation uses a part of only one cacao tree, usually a small branch, to form a new cacao tree.

This branch makes its own roots, produces new shoots and leaves and becomes a whole new plant. Cacao can also be propagated in several other ways that we are going to see today.





# Most common asexual propagation techniques

Let's look at this poster, which shows several ways of propagating cacao asexually.

**Type 1:** Techniques that produce a new tree by joining parts of two trees: one supplies the crown and the other supplies the root.



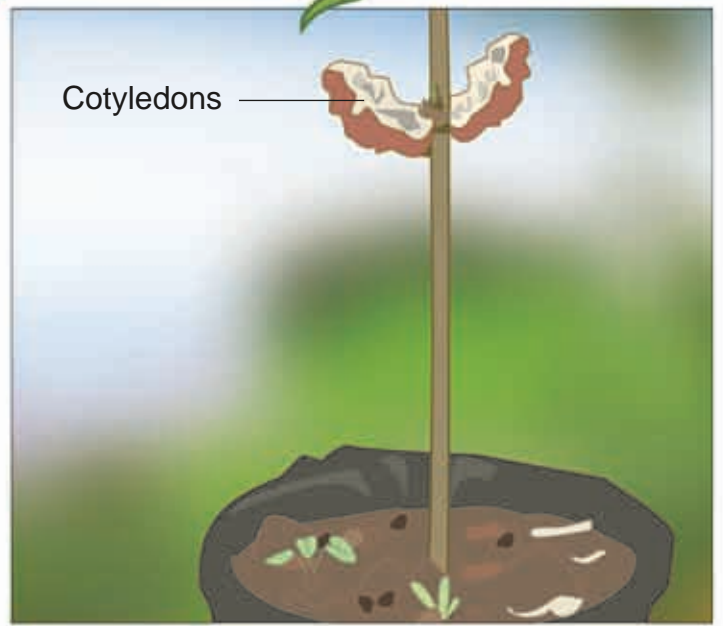
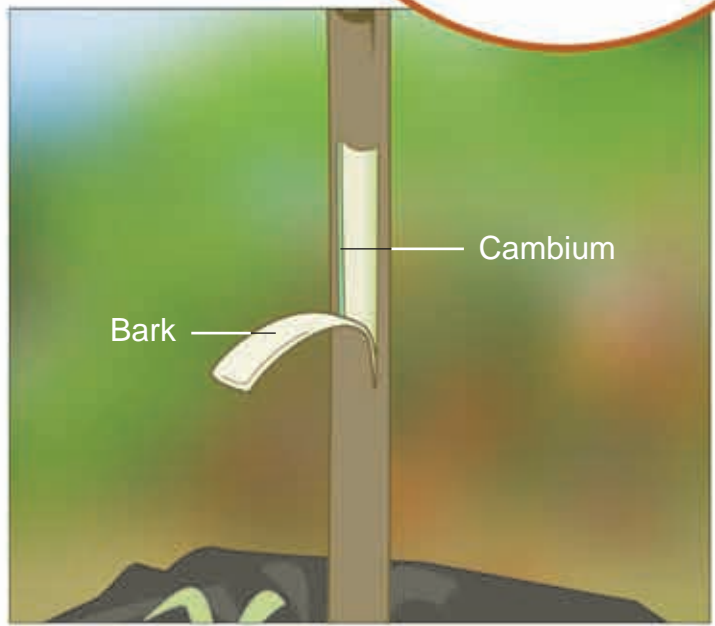
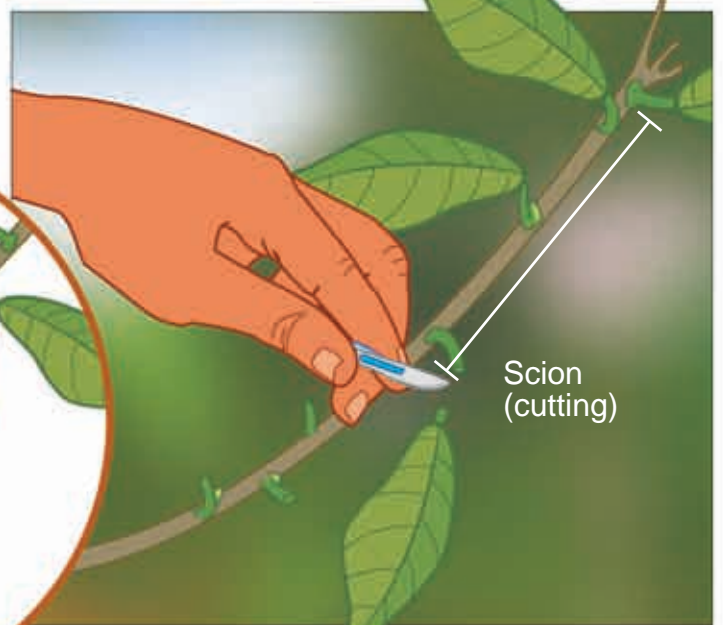
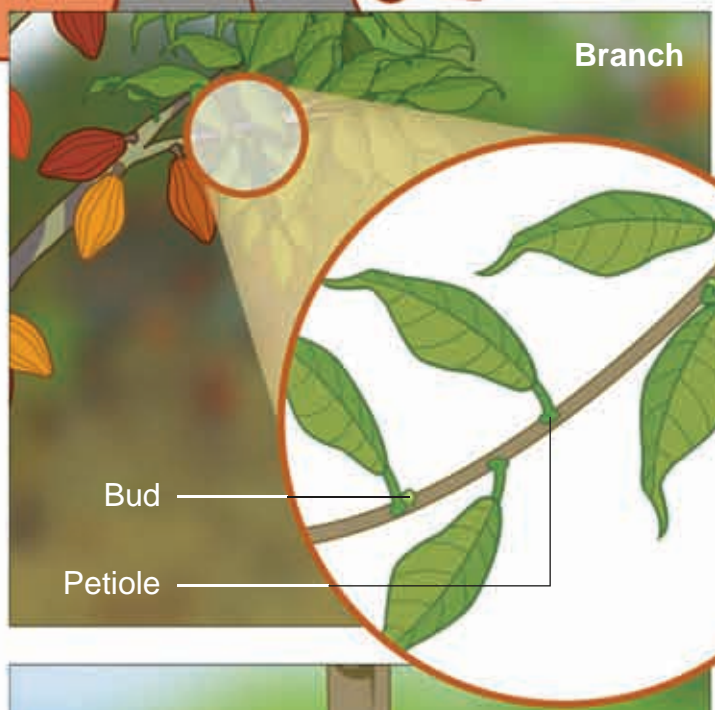
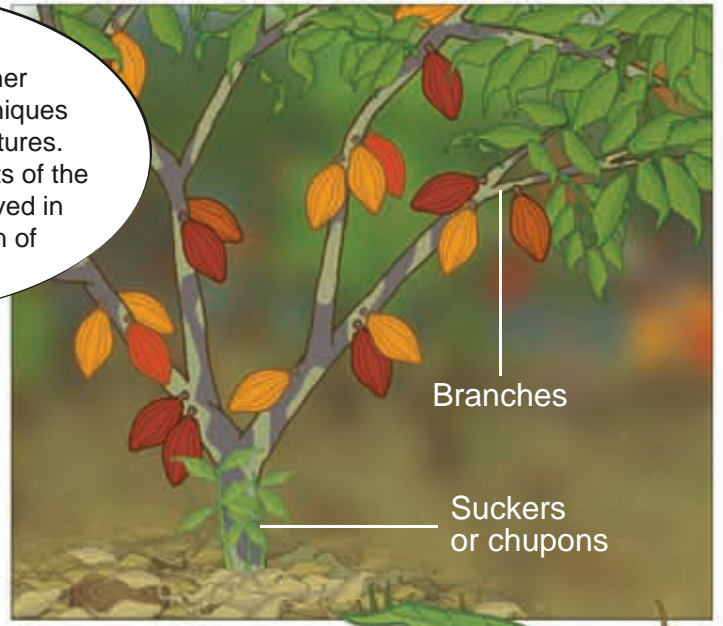
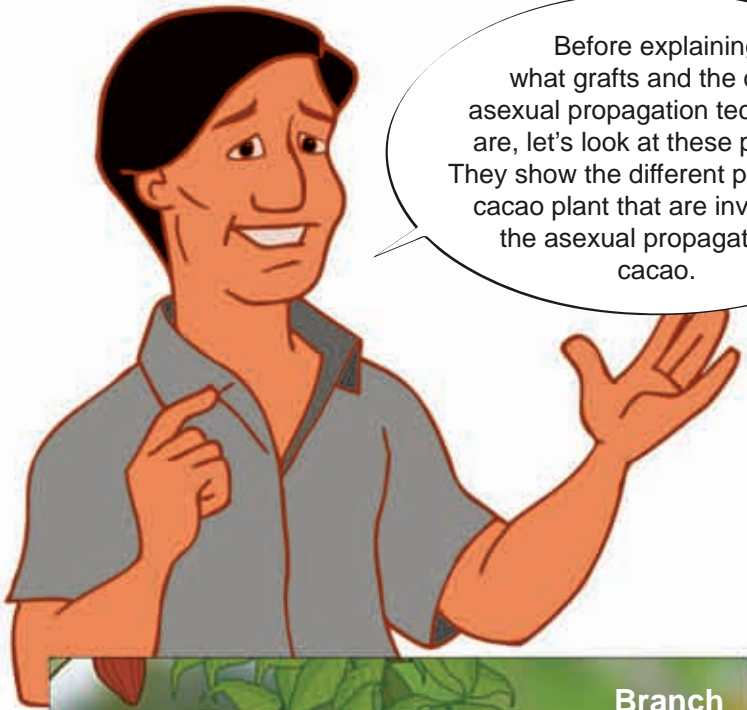
- Bud grafting (Bud patch)
  - Green budding
  - Early grafting
  - Traditional grafting
- Scion grafting
  - Side-veneer grafting
  - Cleft grafting
  - Cleft micrografting
  - Grafting on chupons
  - Side grafting on adult trees (Malay graft)

**Type 2:** Techniques that produce a new tree using parts of only a single tree: the same tree supplies both the crown and the root.

- Rooting of cuttings
- Air layering
- Somatic embryogenesis



Before explaining what grafts and the other asexual propagation techniques are, let's look at these pictures. They show the different parts of the cacao plant that are involved in the asexual propagation of cacao.



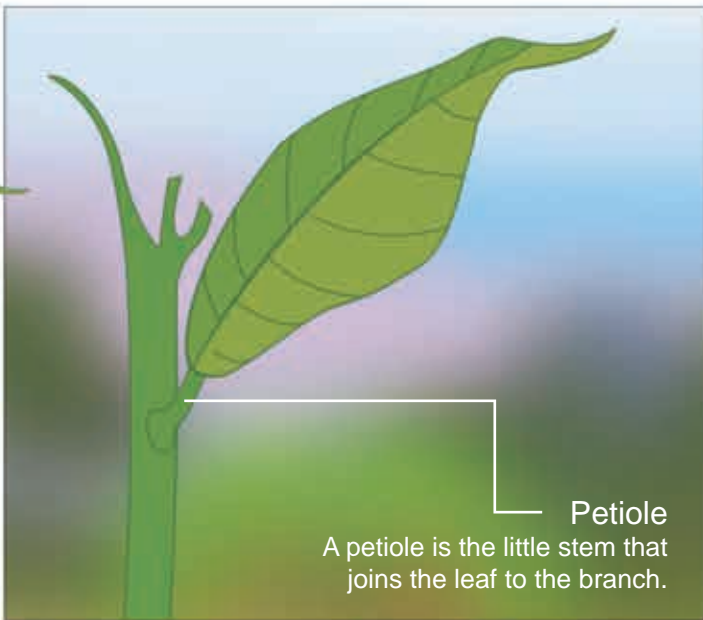
### Chupons or Suckers

Chupons are shoots that grow upward from the trunk of the tree, and which originate at points between the base and the main fork. The name for the main fork is "the horquette".



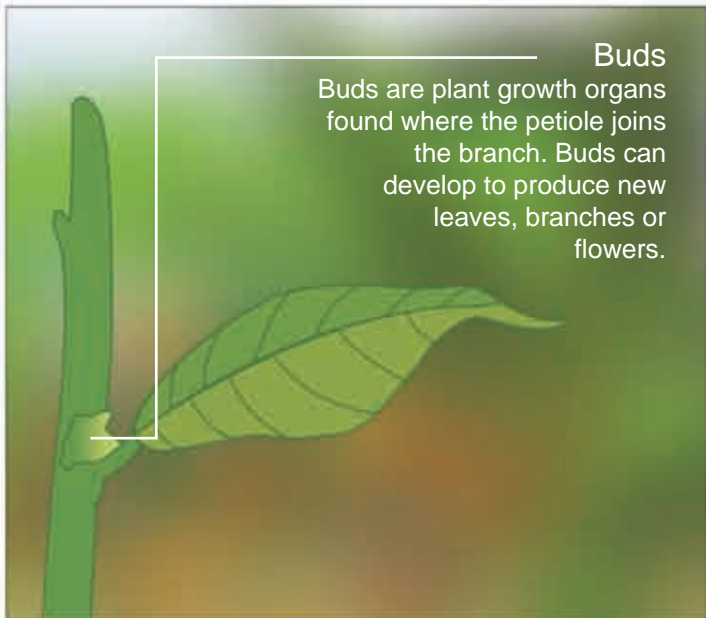
### Petiole

A petiole is the little stem that joins the leaf to the branch.



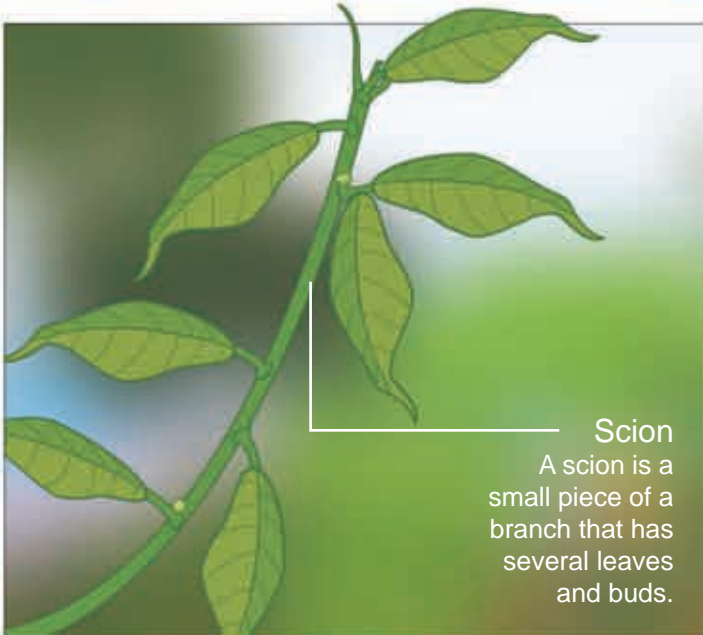
### Buds

Buds are plant growth organs found where the petiole joins the branch. Buds can develop to produce new leaves, branches or flowers.



### Scion

A scion is a small piece of a branch that has several leaves and buds.



### Cotyledons

Cotyledons are the food reserve for the small cacao plant during its first weeks of life. Each seed has two cotyledons. As the cacao plant grows and produces new leaves, it draws out all of the nutrients stored in the cotyledons, which then dry and fall off. Chocolate is made from the cotyledons of seeds that have been fermented, dried and roasted, but not germinated.

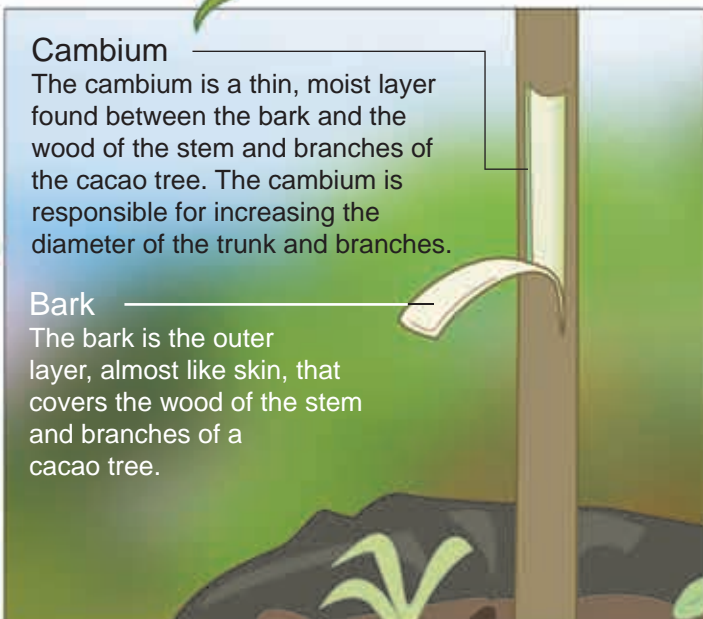


### Cambium

The cambium is a thin, moist layer found between the bark and the wood of the stem and branches of the cacao tree. The cambium is responsible for increasing the diameter of the trunk and branches.

### Bark

The bark is the outer layer, almost like skin, that covers the wood of the stem and branches of a cacao tree.



# Grafting

let's discuss the various methods that are used to achieve our goal of making more of the best individuals. We can begin with grafting.

Now that we understand the concept of asexual propagation,

## What does grafting entail?

Grafting consists of joining a bud or a scion of one plant to another plant, so that the union produces a new, single plant.

The plant that receives the bud or scion— and which contributes the root of the new plant—is called the rootstock, and the upper part—which will be the crown of the new plant—is called the graft.



It is possible to graft onto plants in the field or on potted seedlings in a nursery. But grafting in a nursery is recommended. Do you know why?

Yes, because that way we can use very young plants that use only a small space. This lowers the cost of labor.

Yes, that's true. And besides, in the nursery there is less of a chance for animals or bad weather to harm the plants.

Also the quantity of shade and water that they receive can be controlled.



Gerardo, now that we are on your farm,

please tell us how you have benefited from using grafted trees on your cacao plantation.

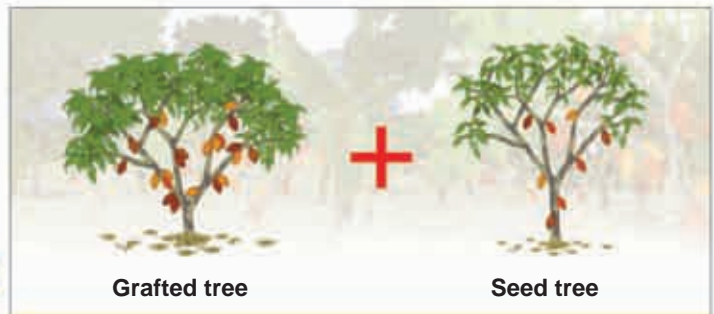


I was sure you were going to ask me that so I prepared this poster summarizing my experiences.



Grafted trees flower early and produce fruits at only two years of age. Trees from seed start flowering when they are three years old and start producing fruits at four years of age.

## Advantages of grafted cacao plantations



Grafted tree

Seed tree

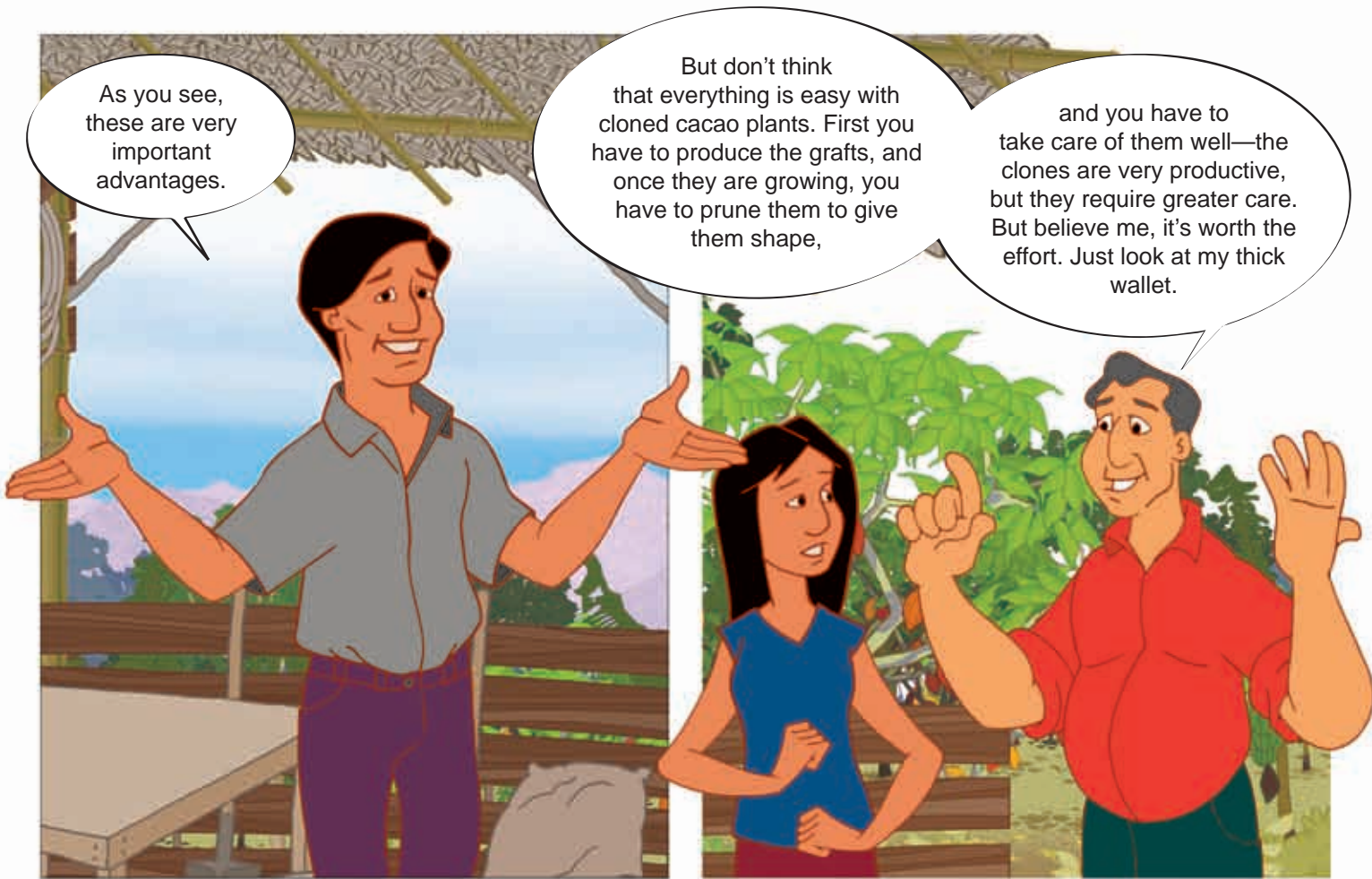
I have found that my grafted cacao plot produces more fruits than the cacao plot planted from seed. This is because these grafted clones were selected for high production, disease resistance and good chocolate quality. All of my cloned trees produce quite well.



Grafted tree

Seed tree

Grafted trees are smaller than trees from seed because they produce only branches and no chupons. Unlike chupons, branches grow outward rather than upward. This keeps the trees small. The small size and rounded form of the grafted trees make pruning, harvest and control of pests and diseases all much easier.



As you see, these are very important advantages.

But don't think that everything is easy with cloned cacao plants. First you have to produce the grafts, and once they are growing, you have to prune them to give them shape,

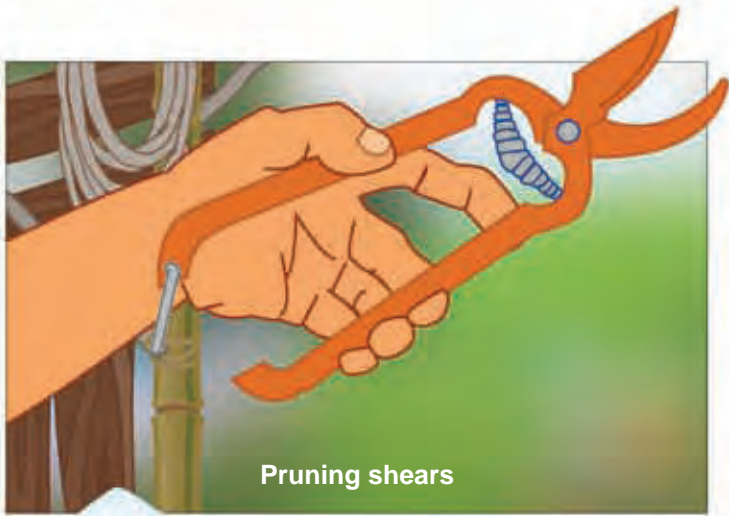
and you have to take care of them well—the clones are very productive, but they require greater care. But believe me, it's worth the effort. Just look at my thick wallet.



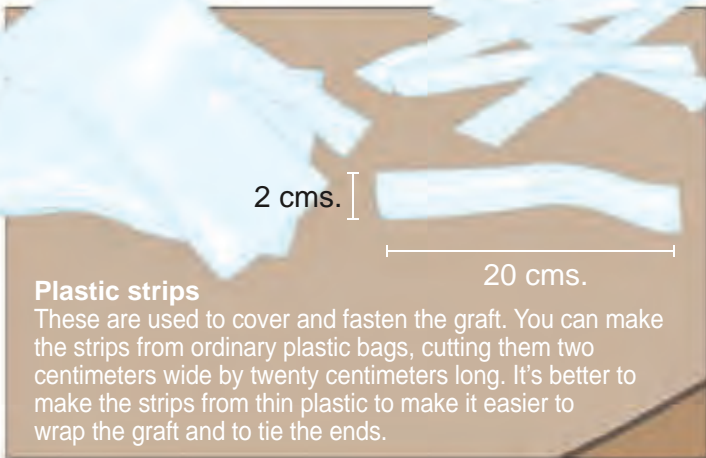
So what things do you need to make a grafted cacao plant?

Well, in addition to the buds or scions, and the rootstock, we also need tools and some materials—I brought them.

Let's have a look.



**Pruning shears**



**Plastic strips**

These are used to cover and fasten the graft. You can make the strips from ordinary plastic bags, cutting them two centimeters wide by twenty centimeters long. It's better to make the strips from thin plastic to make it easier to wrap the graft and to tie the ends.



**Grafting knife**

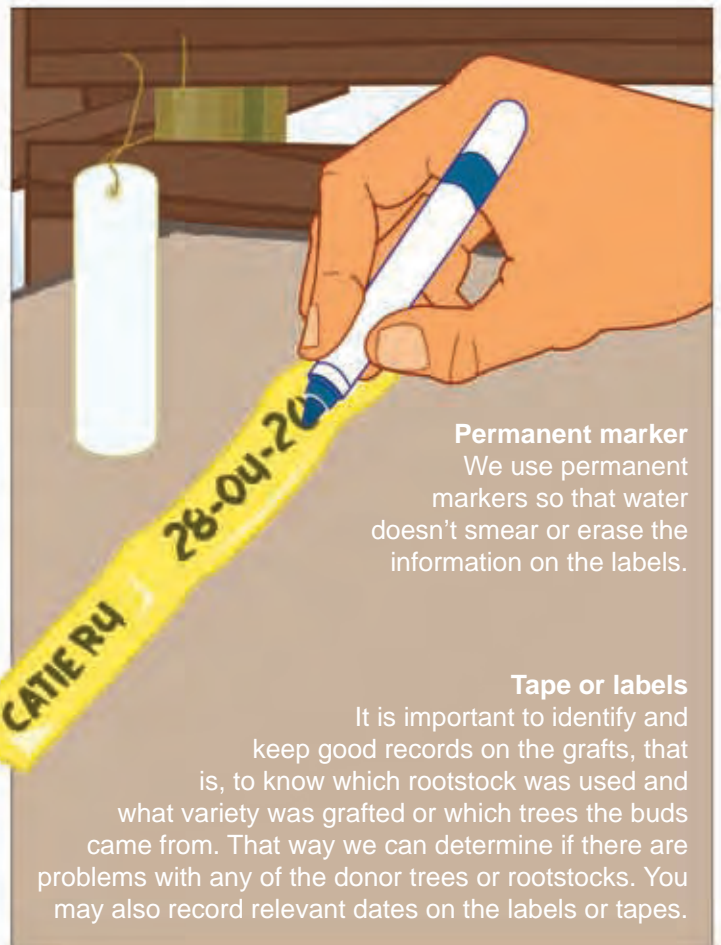
You can also use any scalpel, cutter or homemade knife to make the cuts; what's most important is that the knife is sharp.



**Sharpening stone**



**Newspaper or plantain leaves.** These are used to protect the scions and keep them moist.



**Permanent marker**

We use permanent markers so that water doesn't smear or erase the information on the labels.

**Tape or labels**


It is important to identify and keep good records on the grafts, that is, to know which rootstock was used and what variety was grafted or which trees the buds came from. That way we can determine if there are problems with any of the donor trees or rootstocks. You may also record relevant dates on the labels or tapes.

# Bud grafting

First let's look at bud grafting, also known as patch grafting.

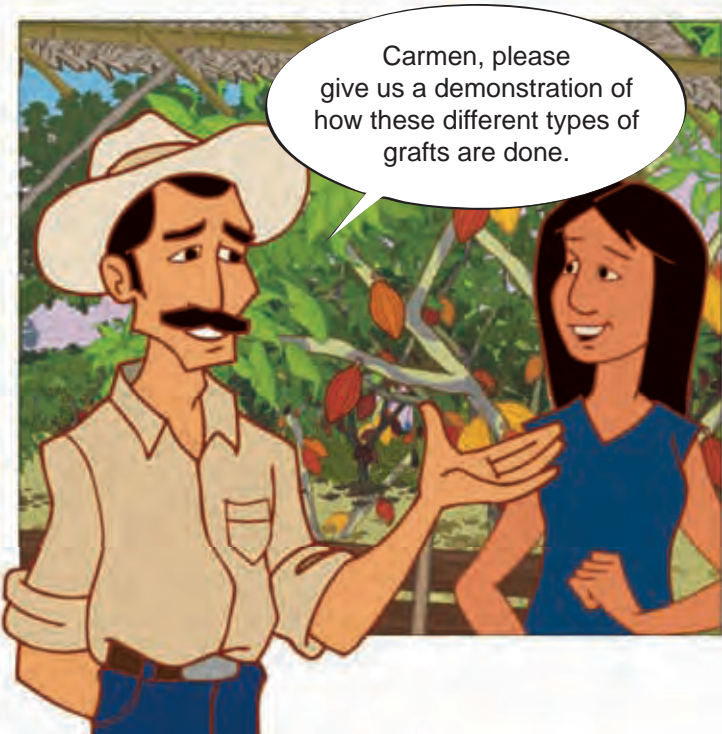
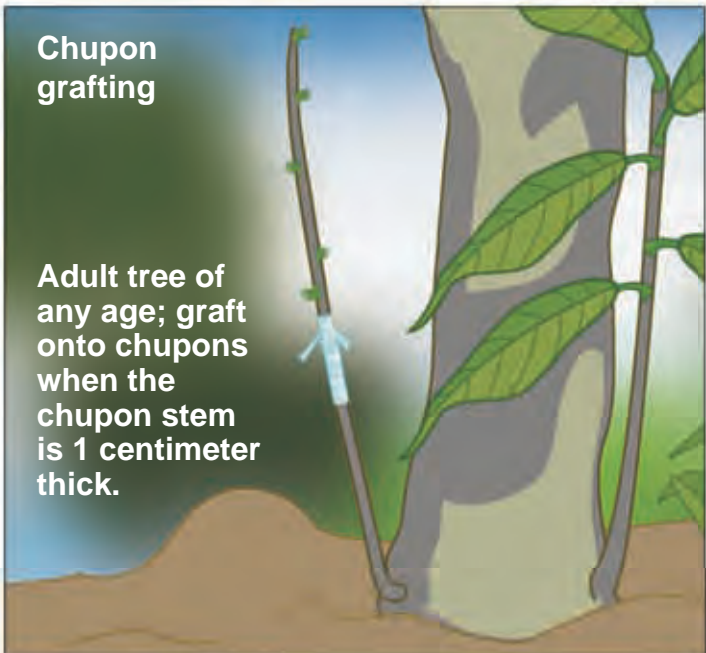
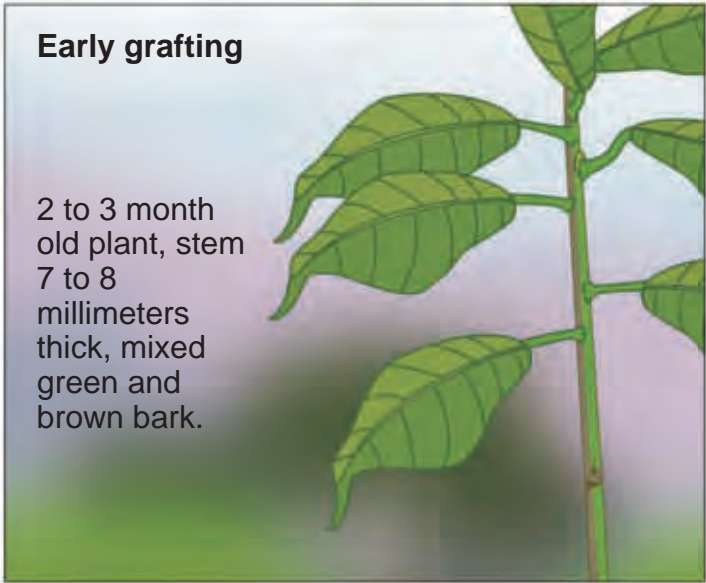


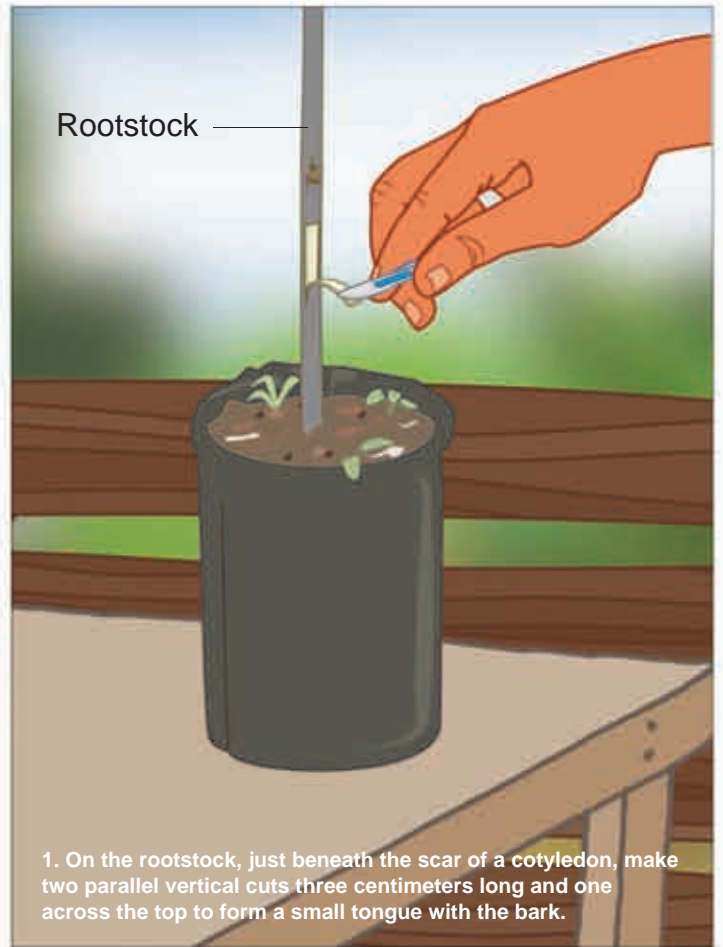
Regardless of the age and size of the rootstock, the bud or scion and the rootstock must match in bark color, stem thickness and maturation state. This will increase the chances that the graft will take and heal quickly.

TYPE OF GRAFT	ROOTSTOCK AND BUD OR SCION
Green budding	4- to 5-week-old plant, stem a half-centimeter thick and green in color. Buds are grafted onto rootstock to generate the crown. 
Early grafting	2- to 3-month-old plant, stem 7 to 8 millimeters thick, with stem color a mixture of green and brown. Either buds or scions may be used to generate the new crown. 
Traditional grafting	5- to 6-month-old plant, stem 1 centimeter thick and light brown. Either scions or buds may be used to generate the new crown. 
Grafting on chupons	Adult tree of any age; scion or buds are grafted when the stem is 1 centimeter thick. 

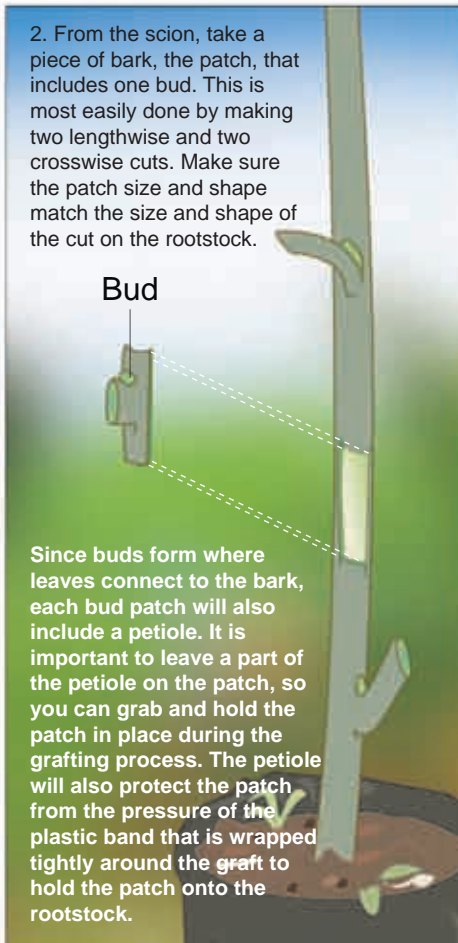








1. On the rootstock, just beneath the scar of a cotyledon, make two parallel vertical cuts three centimeters long and one across the top to form a small tongue with the bark.



2. From the scion, take a piece of bark, the patch, that includes one bud. This is most easily done by making two lengthwise and two crosswise cuts. Make sure the patch size and shape match the size and shape of the cut on the rootstock.

Since buds form where leaves connect to the bark, each bud patch will also include a petiole. It is important to leave a part of the petiole on the patch, so you can grab and hold the patch in place during the grafting process. The petiole will also protect the patch from the pressure of the plastic band that is wrapped tightly around the graft to hold the patch onto the rootstock.

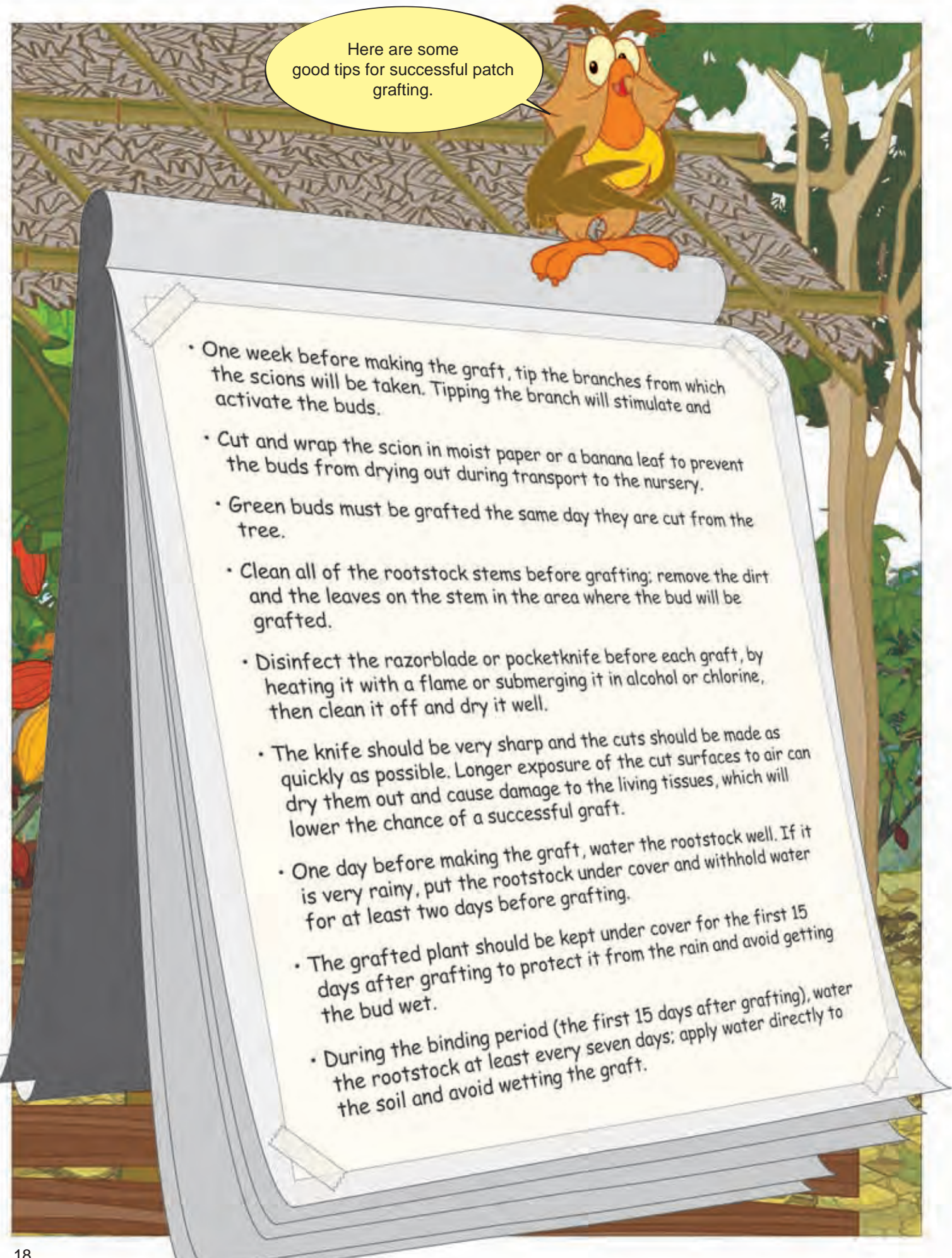


3. Carefully peel the tongue down without tearing the bark. Place the patch on the open face of the wood of the rootstock.



4. Cover the patch with the tongue and bind them together with a plastic strip. Begin at the top of the union and wrap the graft first in a downward direction, then upward, and then down again,

Always keep the plastic snug around the graft to ensure good contact between the patch and the rootstock. Make the knot at the bottom of the graft union to secure it and to prevent water from getting in.



Here are some good tips for successful patch grafting.

- One week before making the graft, tip the branches from which the scions will be taken. Tipping the branch will stimulate and activate the buds.
- Cut and wrap the scion in moist paper or a banana leaf to prevent the buds from drying out during transport to the nursery.
- Green buds must be grafted the same day they are cut from the tree.
- Clean all of the rootstock stems before grafting; remove the dirt and the leaves on the stem in the area where the bud will be grafted.
- Disinfect the razorblade or pocketknife before each graft, by heating it with a flame or submerging it in alcohol or chlorine, then clean it off and dry it well.
- The knife should be very sharp and the cuts should be made as quickly as possible. Longer exposure of the cut surfaces to air can dry them out and cause damage to the living tissues, which will lower the chance of a successful graft.
- One day before making the graft, water the rootstock well. If it is very rainy, put the rootstock under cover and withhold water for at least two days before grafting.
- The grafted plant should be kept under cover for the first 15 days after grafting to protect it from the rain and avoid getting the bud wet.
- During the binding period (the first 15 days after grafting), water the rootstock at least every seven days; apply water directly to the soil and avoid wetting the graft.

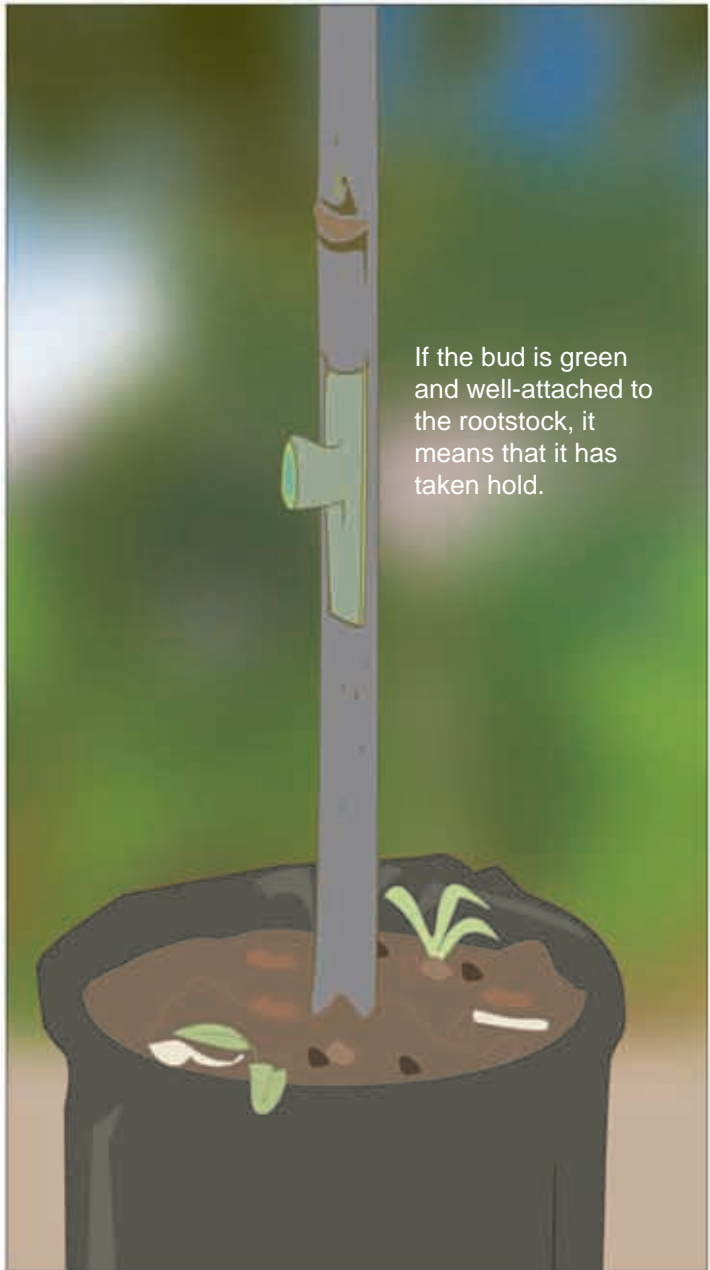


To find out whether the graft has taken, remove the binding on the 15th day after grafting and examine the bud.

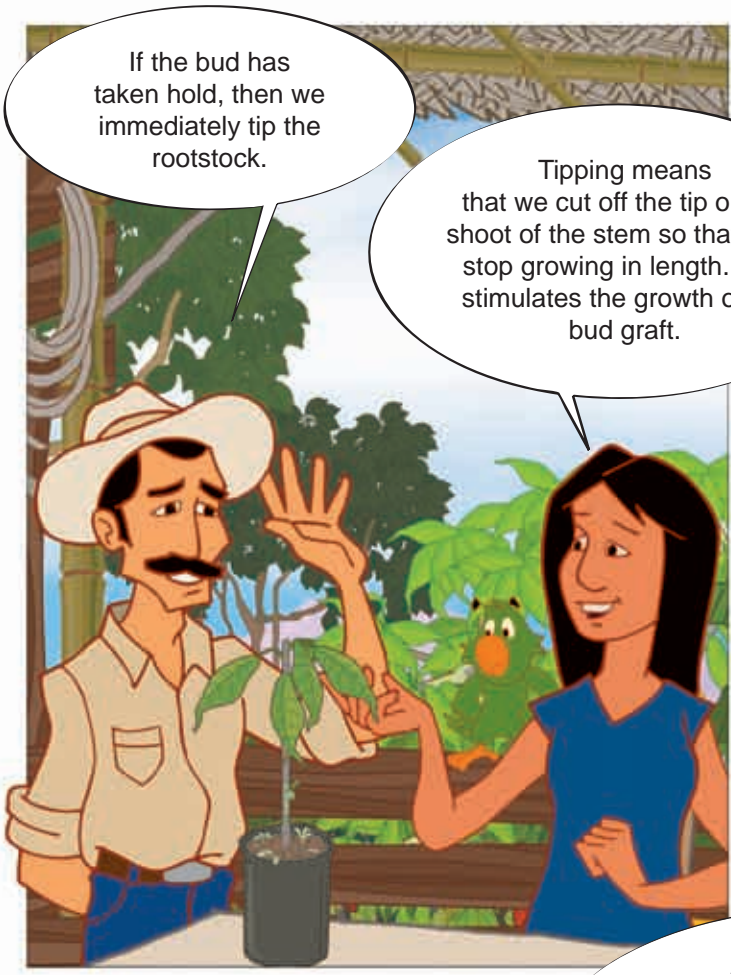
If it is green and well-attached to the rootstock, it means that it has taken hold. If the bud is dry or dark brown in color, it means that the graft did not attach and has died.



Do not remove the binding before the 15th day after grafting.



If the bud is green and well-attached to the rootstock, it means that it has taken hold.



If the bud has taken hold, then we immediately tip the rootstock.

Tipping means that we cut off the tip or last shoot of the stem so that it will stop growing in length. This stimulates the growth of the bud graft.

When tipping, be sure to keep several leaves on the rootstock to support both the rootstock and the graft.



Also making sure to regularly remove all chupons from the rootstock because they will weaken the grafted bud. Be careful not to cut the graft by mistaking it for a chupon.



Once the bud has developed into a branch with at least four leaves, remove the top of the rootstock.

Making the cut at 10 centimeters above the graft so the scar will not damage the bud.



Tipping and decapitation of the rootstock

Here is a chart that summarizes the necessary conditions for tipping and decapitation.

Numbers of leaves needed on rootstock and scion before tipping or decapitating three types of grafts on cacao.

	Green budding	Early grafting	Traditional grafting
Leaves remaining after tipping the rootstock	2 to 4	4 to 6	6 or more
Leaves needed on graft before decapitating the rootstock	4	5	5

José, how do you decide what type of grafts to use?

I think that depends on one's ability to graft

and on the availability of scions and the rootstock we have.

Right. If, for example, we have very young rootstock, then we will have to use green budding and choose green buds;

we have to adjust the size of the scion to the size of the rootstock.

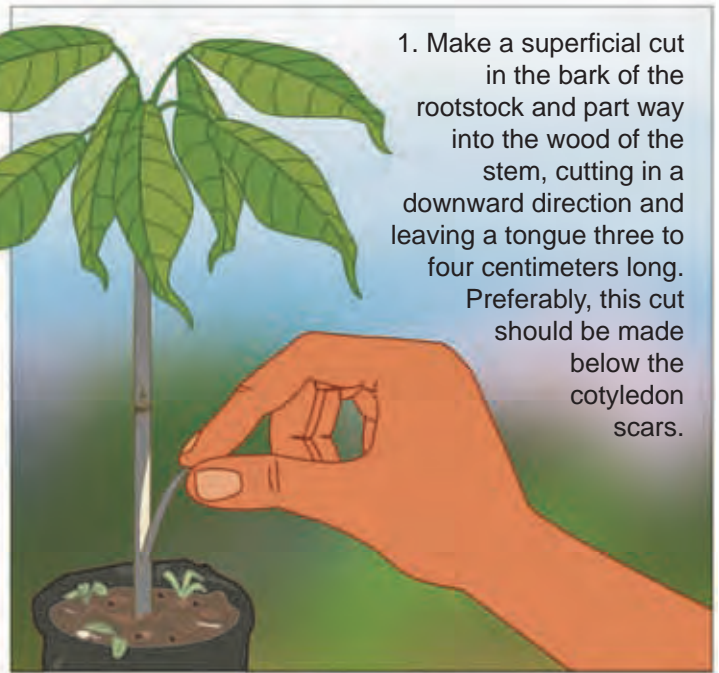
## Scion grafting



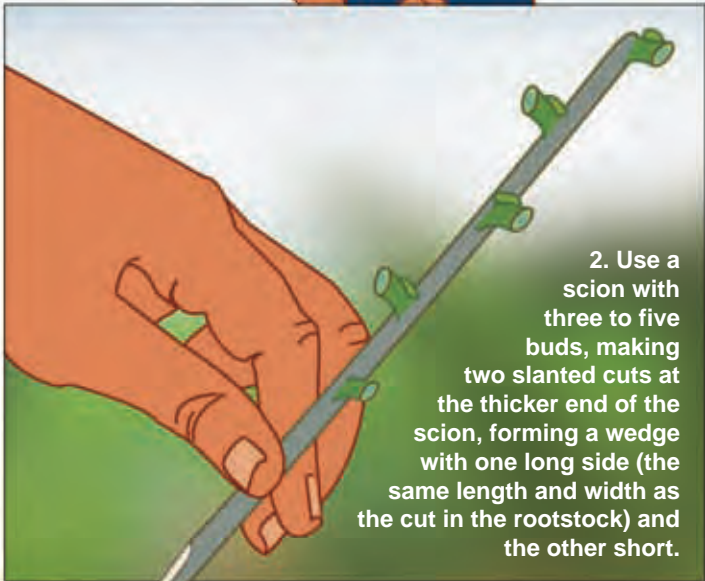


## The side graft

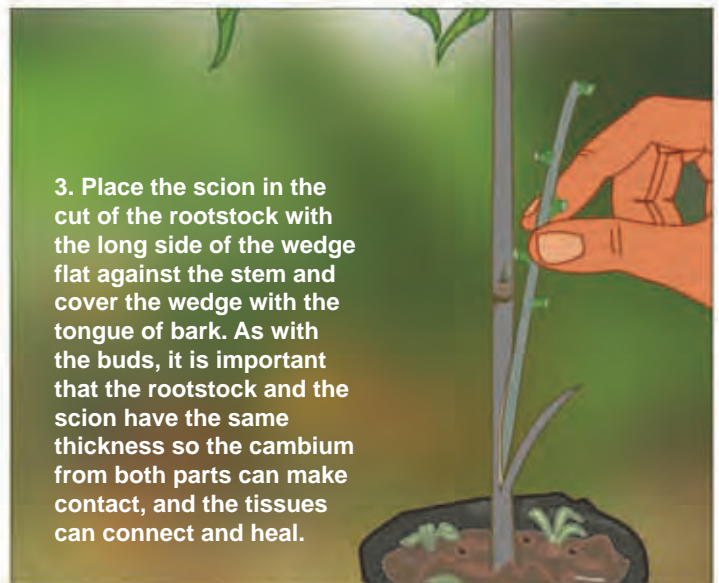
I am going to explain the technique while I make a side graft with scion.



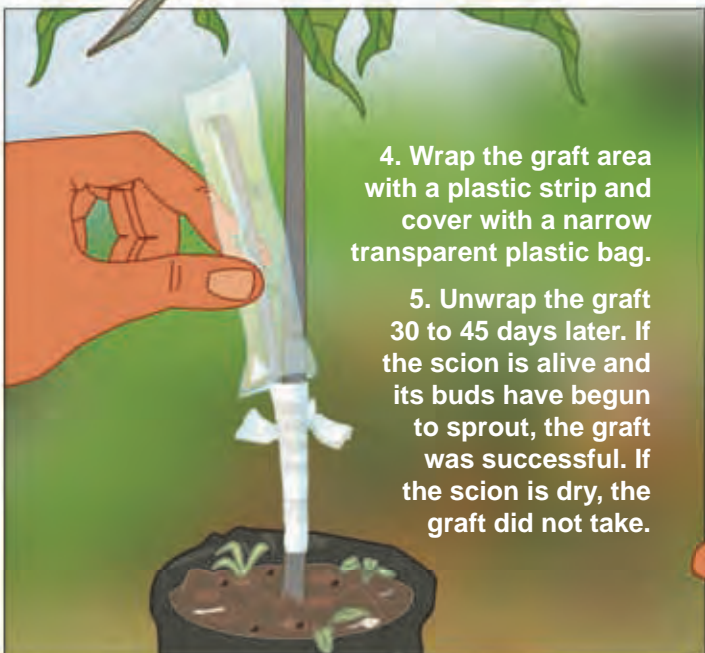
1. Make a superficial cut in the bark of the rootstock and part way into the wood of the stem, cutting in a downward direction and leaving a tongue three to four centimeters long. Preferably, this cut should be made below the cotyledon scars.



2. Use a scion with three to five buds, making two slanted cuts at the thicker end of the scion, forming a wedge with one long side (the same length and width as the cut in the rootstock) and the other short.



3. Place the scion in the cut of the rootstock with the long side of the wedge flat against the stem and cover the wedge with the tongue of bark. As with the buds, it is important that the rootstock and the scion have the same thickness so the cambium from both parts can make contact, and the tissues can connect and heal.



4. Wrap the graft area with a plastic strip and cover with a narrow transparent plastic bag.

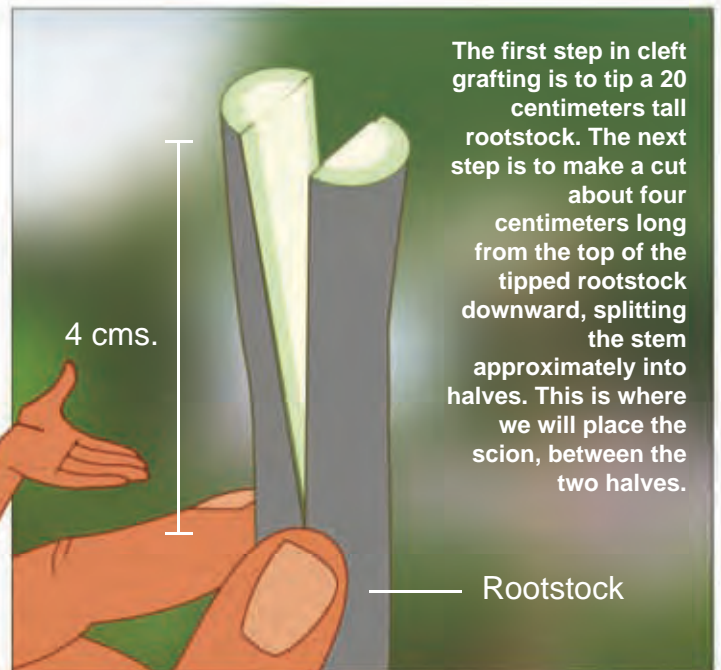
5. Unwrap the graft 30 to 45 days later. If the scion is alive and its buds have begun to sprout, the graft was successful. If the scion is dry, the graft did not take.



Now let's look at cleft grafting. Instead of grafting on a side of the rootstock, a cleft graft is made on the top of the rootstock after the rootstock has been tipped.

## Cleft graft

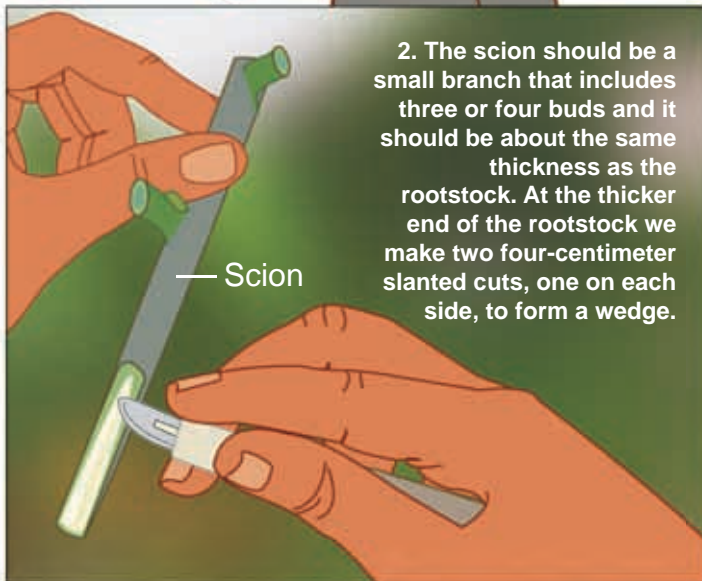
Let me show you how to do this graft.



The first step in cleft grafting is to tip a 20 centimeters tall rootstock. The next step is to make a cut about four centimeters long from the top of the tipped rootstock downward, splitting the stem approximately into halves. This is where we will place the scion, between the two halves.

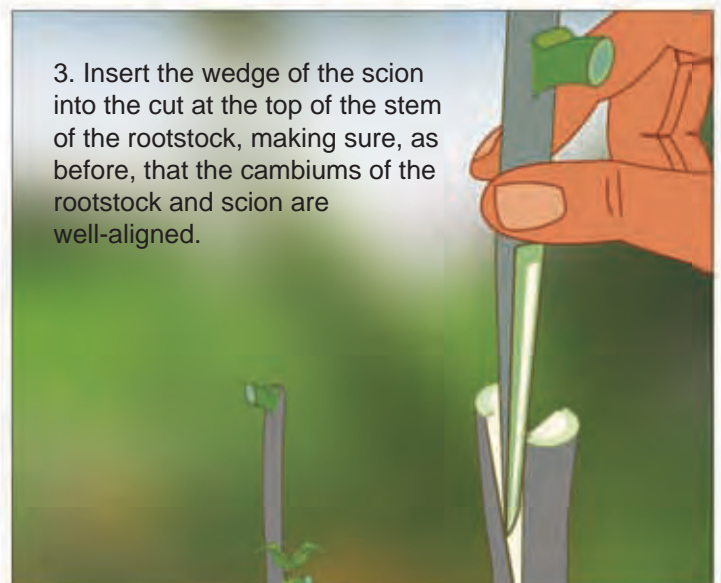
4 cms.

Rootstock



2. The scion should be a small branch that includes three or four buds and it should be about the same thickness as the rootstock. At the thicker end of the rootstock we make two four-centimeter slanted cuts, one on each side, to form a wedge.

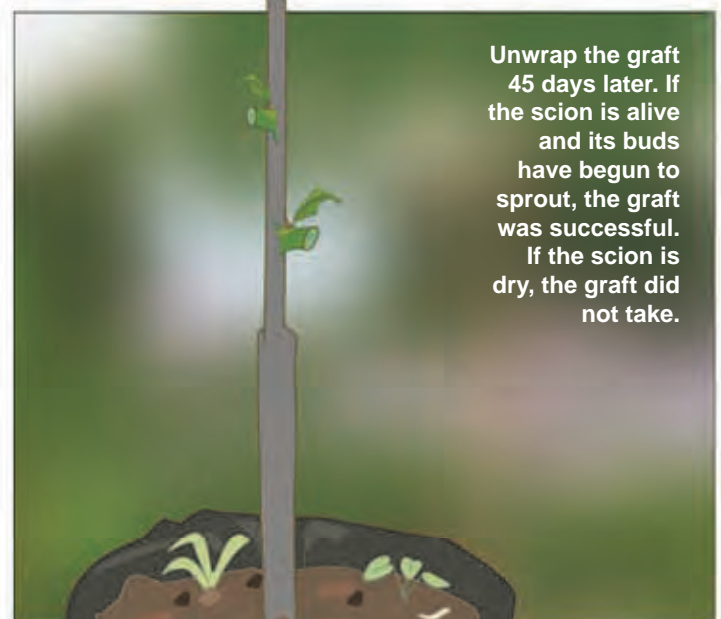
Scion



3. Insert the wedge of the scion into the cut at the top of the stem of the rootstock, making sure, as before, that the cambiums of the rootstock and scion are well-aligned.



4. Bind the graft with plastic strips, tightening it well. Once it is wrapped, place a transparent plastic bag over the graft to keep it dry and warm.



Unwrap the graft 45 days later. If the scion is alive and its buds have begun to sprout, the graft was successful. If the scion is dry, the graft did not take.

## Cleft micrografting

With the next method, known as cleft micrografting, young scions are grafted onto rootstock that is barely three weeks old. Let's see how this is done.

First germinate the seed in a plastic bag filled with substrate, which is the soil-like material that nurseries use to grow their plants. When they are watered and kept warm, most of the seeds will germinate in three to seven days.

When the seedling is three weeks old, it will still have its cotyledons and its first pair of true leaves.

My grandmother sold chicken manure from the henhouse to make organic fertilizer. I can still hear her singing:

### What is a substrate?

Substrate is the material that is used to fill the bags for plants in the nursery. Plants use the substrate to absorb nutrients and water, and also to hold themselves upright.

Prepare the substrate by mixing fertile soil (top soil from the forest, for example) with some material that provides aeration, such as sand, rice hulls or sawdust (don't use redwoods because their wood and bark are harmful to cacao).


Organic producers can disinfect the substrate by covering it with black plastic and placing it in the sun. The fertility of the substrate can be improved by adding organic material or chicken manure before sterilizing.

Buy eggs from my hens.  
They're the best,

For my chickens  
eat well and get rest.


I'll sell some to you  
with a bag of their poo

At a price that's the best  
in the West.




With a thin, sharp knife blade, decapitate the rootstock one centimeter above the cotyledons and then cut the stem downward,


four centimeters, splitting it into halves, with one cotyledon on each half of the stem.



Prepare a scion of the same color and thickness as the rootstock. Each scion should have three leaves. Cut the leaves with scissors, leaving only one third of each leaf.

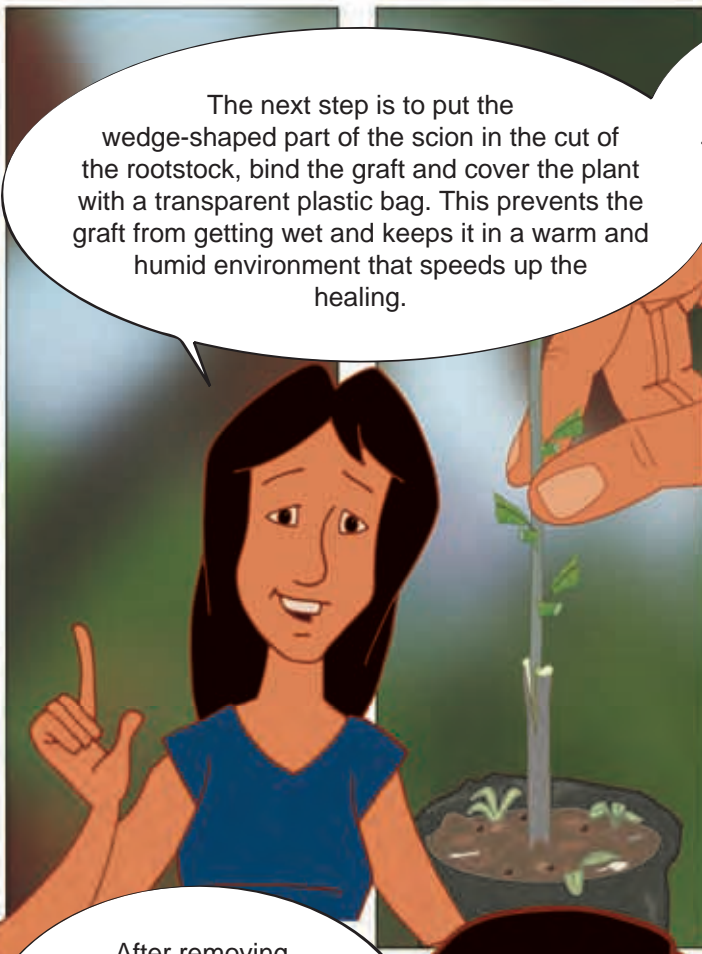


Cut two strips from the base of the scion, one on each side, to form a thin wedge. The two cuts should be the same length as the cut on the rootstock.




The trimmed leaves of the scion are very important


because they, together with the cotyledons, are the only ones left to feed the newly grafted plant after the leaves of the rootstock are lost through decapitation.



The next step is to put the wedge-shaped part of the scion in the cut of the rootstock, bind the graft and cover the plant with a transparent plastic bag. This prevents the graft from getting wet and keeps it in a warm and humid environment that speeds up the healing.




The bag must remain over the grafted plant for two weeks, without watering. This is why the rootstock must be watered well one day before grafting.




After removing both the bag and the binding, the grafted plant remains in the nursery for three to four months and then it is transplanted to the field.

## Grafting on chupons



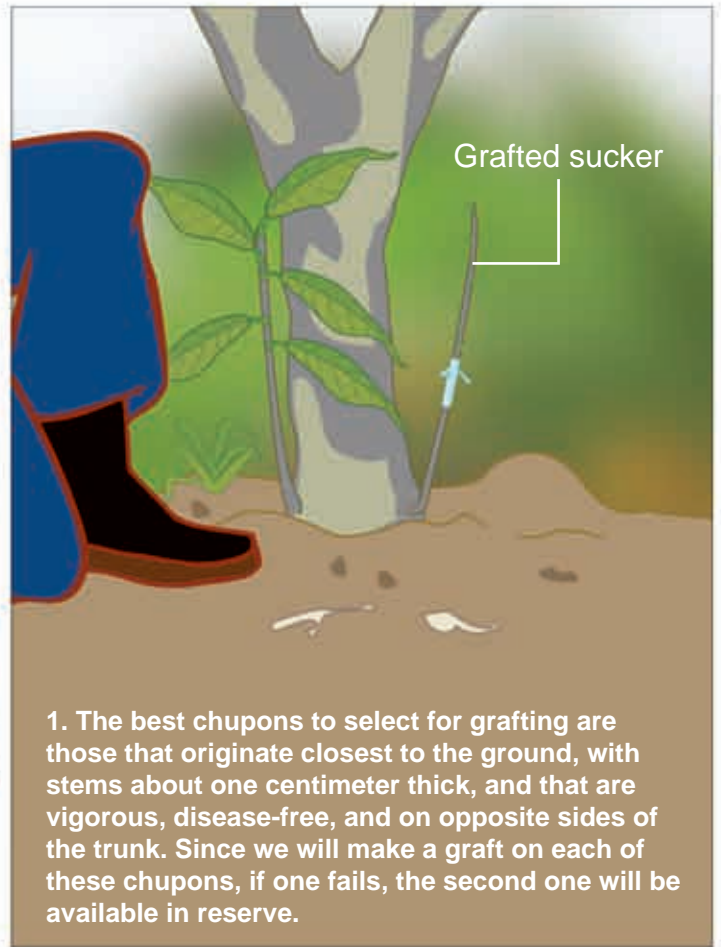
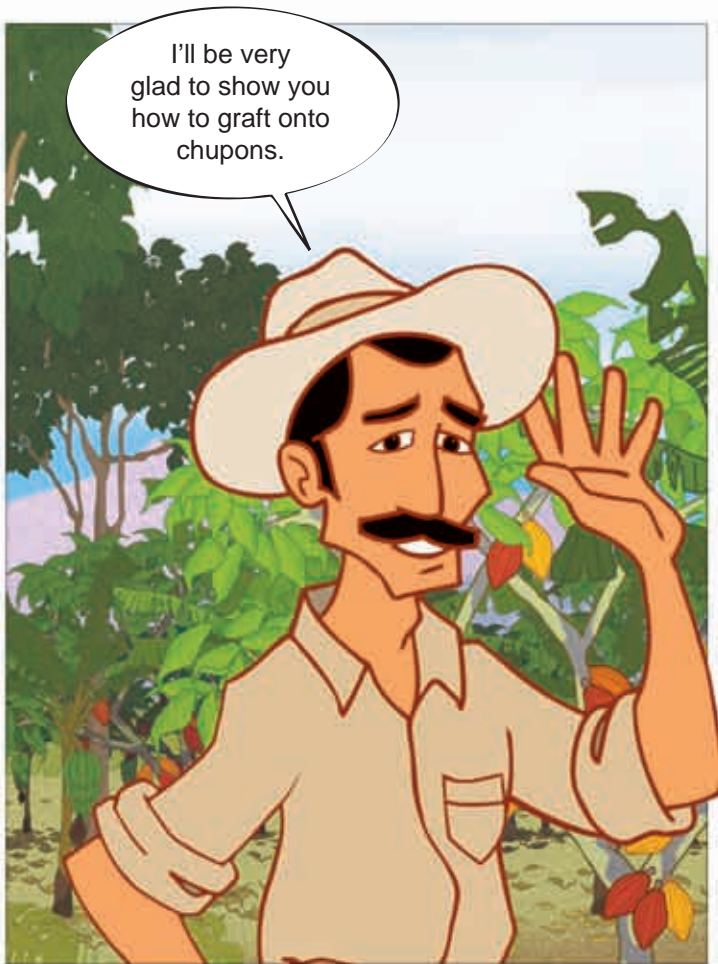
When non-productive or old trees need to be replaced, a good solution is to graft productive clones onto chupons of the old trees. For this situation we use the cleft graft method.

The technique is the same as cleft grafting in the nursery, except that in this case, the chupon is the rootstock.

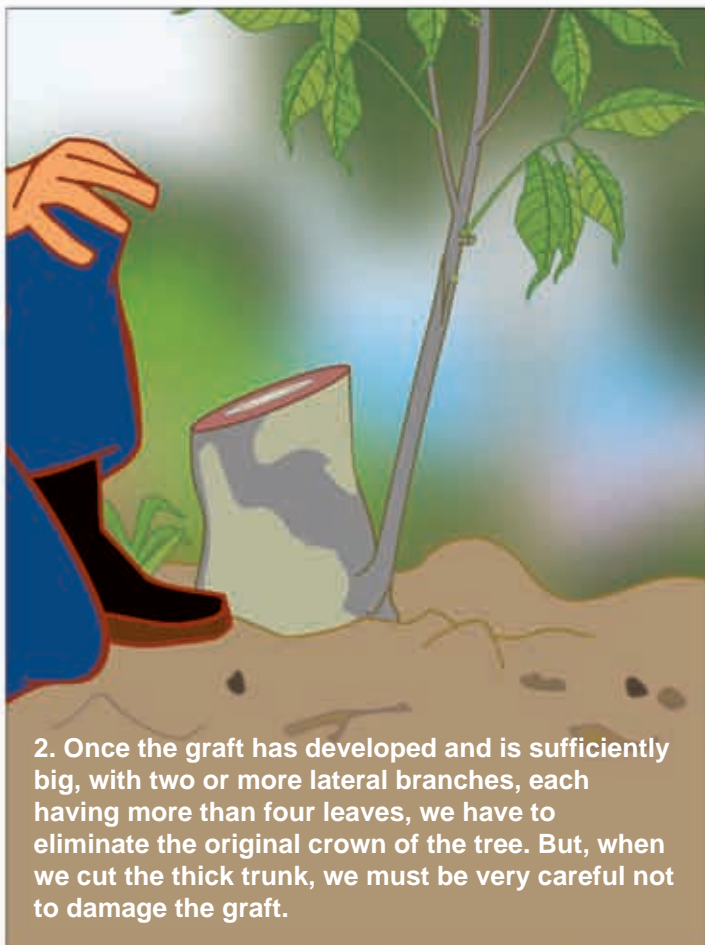


To prepare the trees that are going to be grafted, their crowns must be severely pruned or completely removed so more light comes through to the trunks of the trees and stimulates the formation of new chupons.

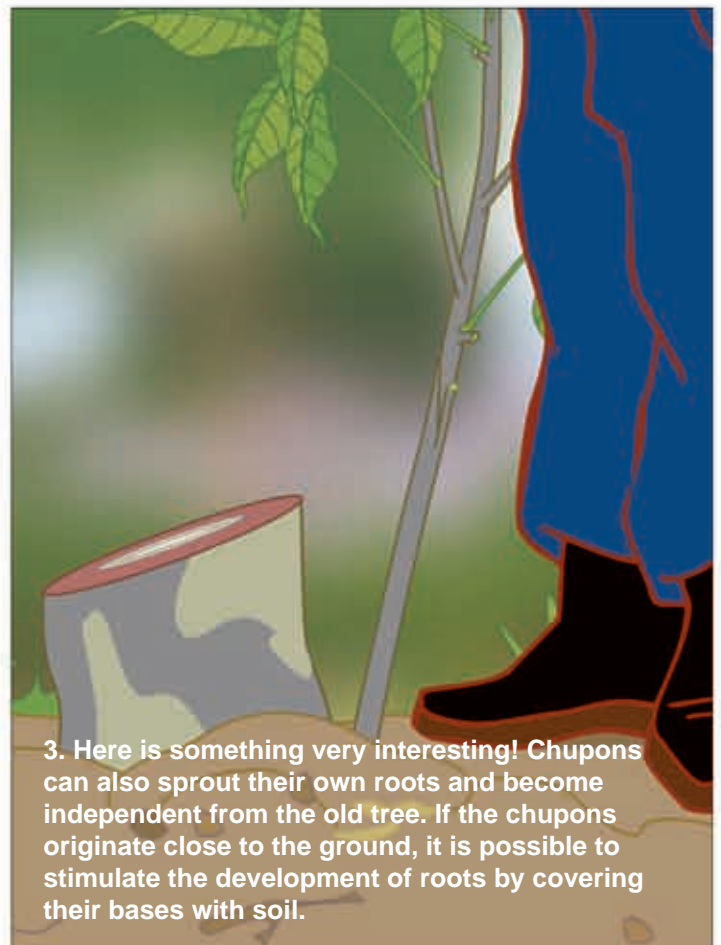
José, please, show us how to do this type of graft.



1. The best chupons to select for grafting are those that originate closest to the ground, with stems about one centimeter thick, and that are vigorous, disease-free, and on opposite sides of the trunk. Since we will make a graft on each of these chupons, if one fails, the second one will be available in reserve.



2. Once the graft has developed and is sufficiently big, with two or more lateral branches, each having more than four leaves, we have to eliminate the original crown of the tree. But, when we cut the thick trunk, we must be very careful not to damage the graft.



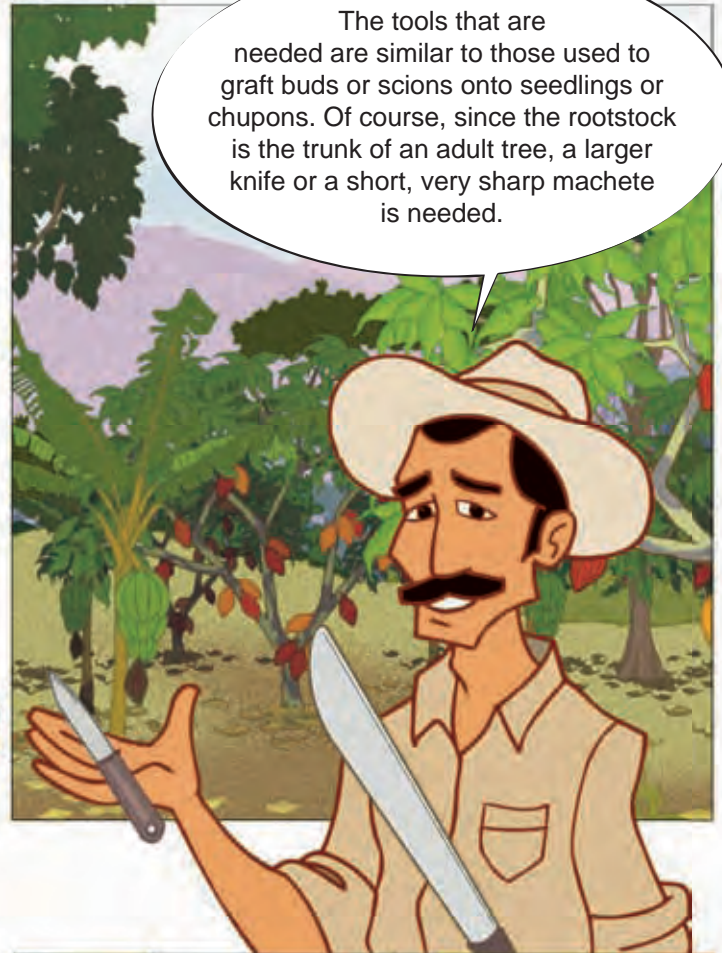
3. Here is something very interesting! Chupons can also sprout their own roots and become independent from the old tree. If the chupons originate close to the ground, it is possible to stimulate the development of roots by covering their bases with soil.

## Side grafting on adult trees

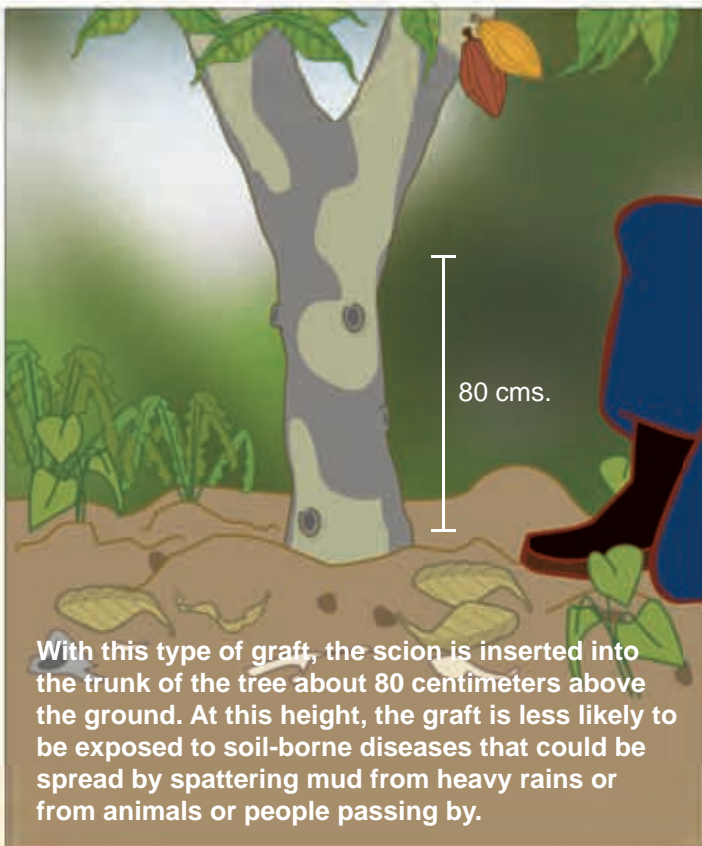
Side grafting can also be done on old trees, not just on potted nursery seedlings or chupons in the field.



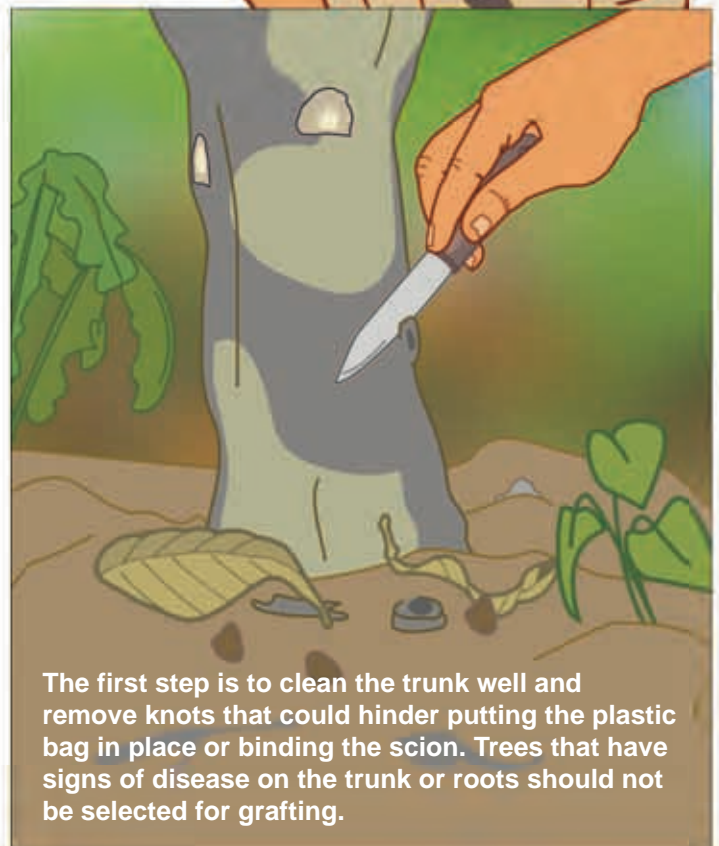
The tools that are needed are similar to those used to graft buds or scions onto seedlings or chupons. Of course, since the rootstock is the trunk of an adult tree, a larger knife or a short, very sharp machete is needed.



## Preparation for the graft



With this type of graft, the scion is inserted into the trunk of the tree about 80 centimeters above the ground. At this height, the graft is less likely to be exposed to soil-borne diseases that could be spread by splattering mud from heavy rains or from animals or people passing by.

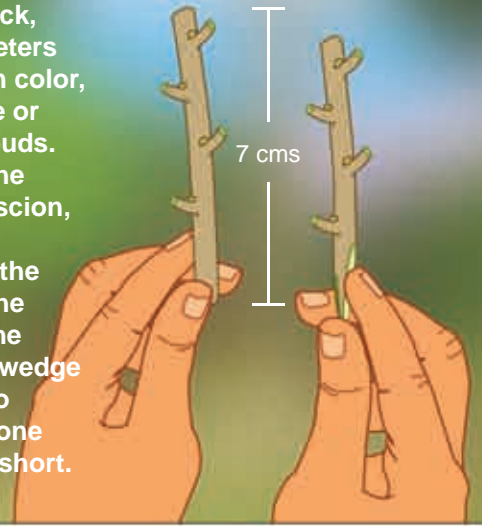


The first step is to clean the trunk well and remove knots that could hinder putting the plastic bag in place or binding the scion. Trees that have signs of disease on the trunk or roots should not be selected for grafting.

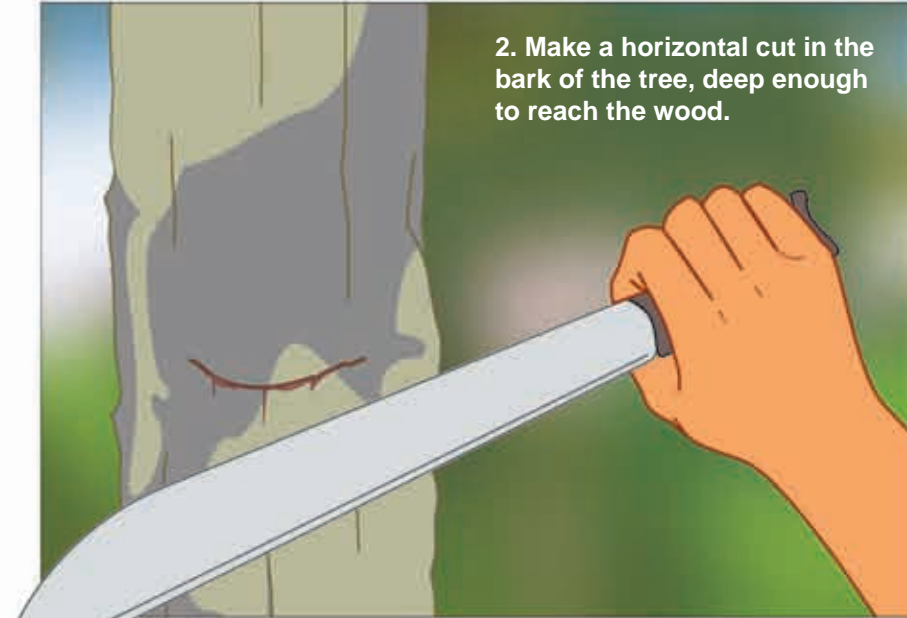




1. Select scions that are about one centimeter thick, seven centimeters long, brown in color, and with three or four healthy buds. Then cut off the leaves of the scion, leaving half a centimeter of the petioles. On the thick end of the scion, form a wedge by making two slanted cuts, one long and one short.



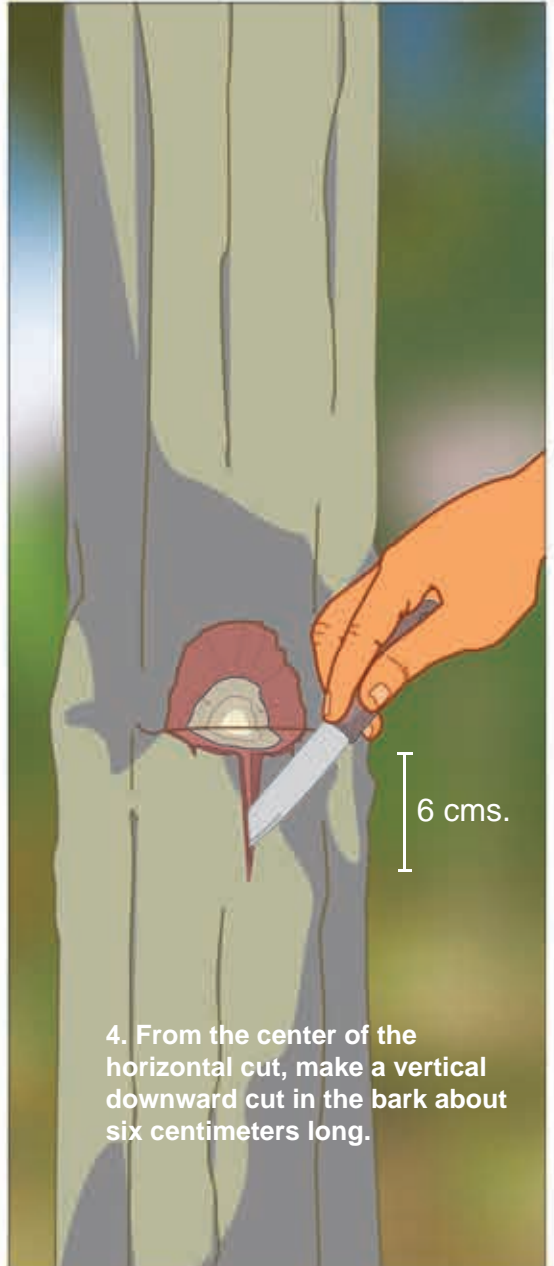
2. Make a horizontal cut in the bark of the tree, deep enough to reach the wood.

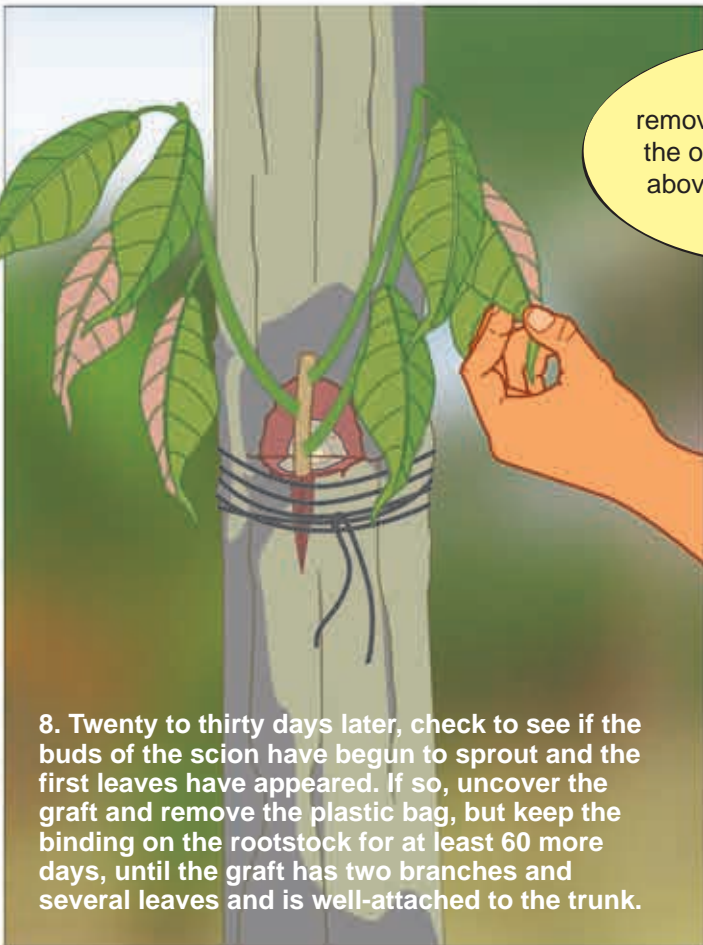
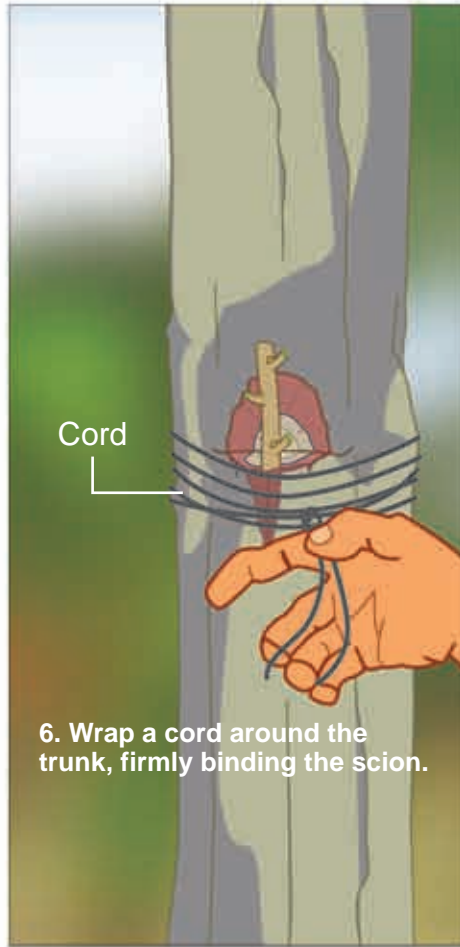
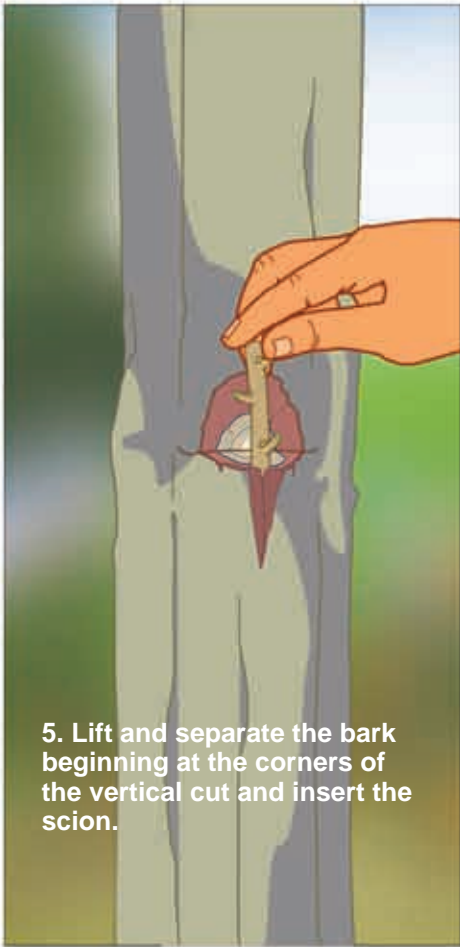


3. Starting about ten centimeters above the horizontal cut, cut out a wedge by making another shallow cut in downward direction, angling toward the center of the tree, and ending where the horizontal cut meets the wood. The base of the wedge should be about the same width as the horizontal cut. Remove the wedge to form a window, like the one shown in the figure.

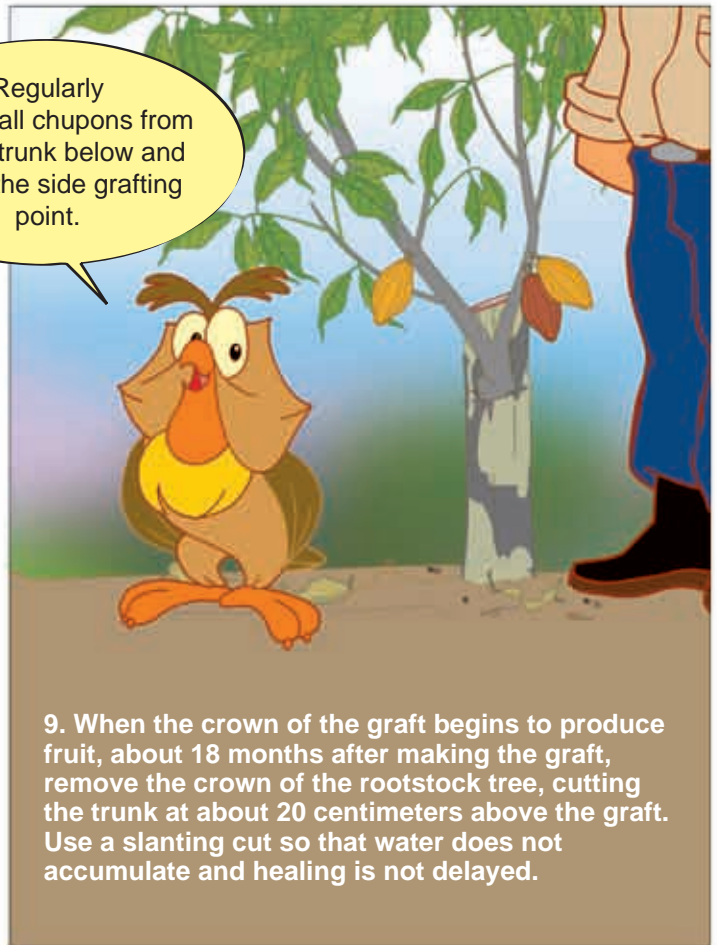


4. From the center of the horizontal cut, make a vertical downward cut in the bark about six centimeters long.





Regularly remove all chupons from the old trunk below and above the side grafting point.



If the trunk is thick enough, two grafts can be made, one on each side of the trunk. With two grafts, the new crown can develop faster than with only one graft.

Now that we have covered all of the types of grafts, let's look at the poster to learn how the grafts take hold.

### How does the graft take hold?

Inside the cacao, as in many other plants, a system of tubes carries the substances the plant needs to survive and grow, much like the veins and arteries that transport blood in animals. There are two types of tubes: the xylem and the phloem.

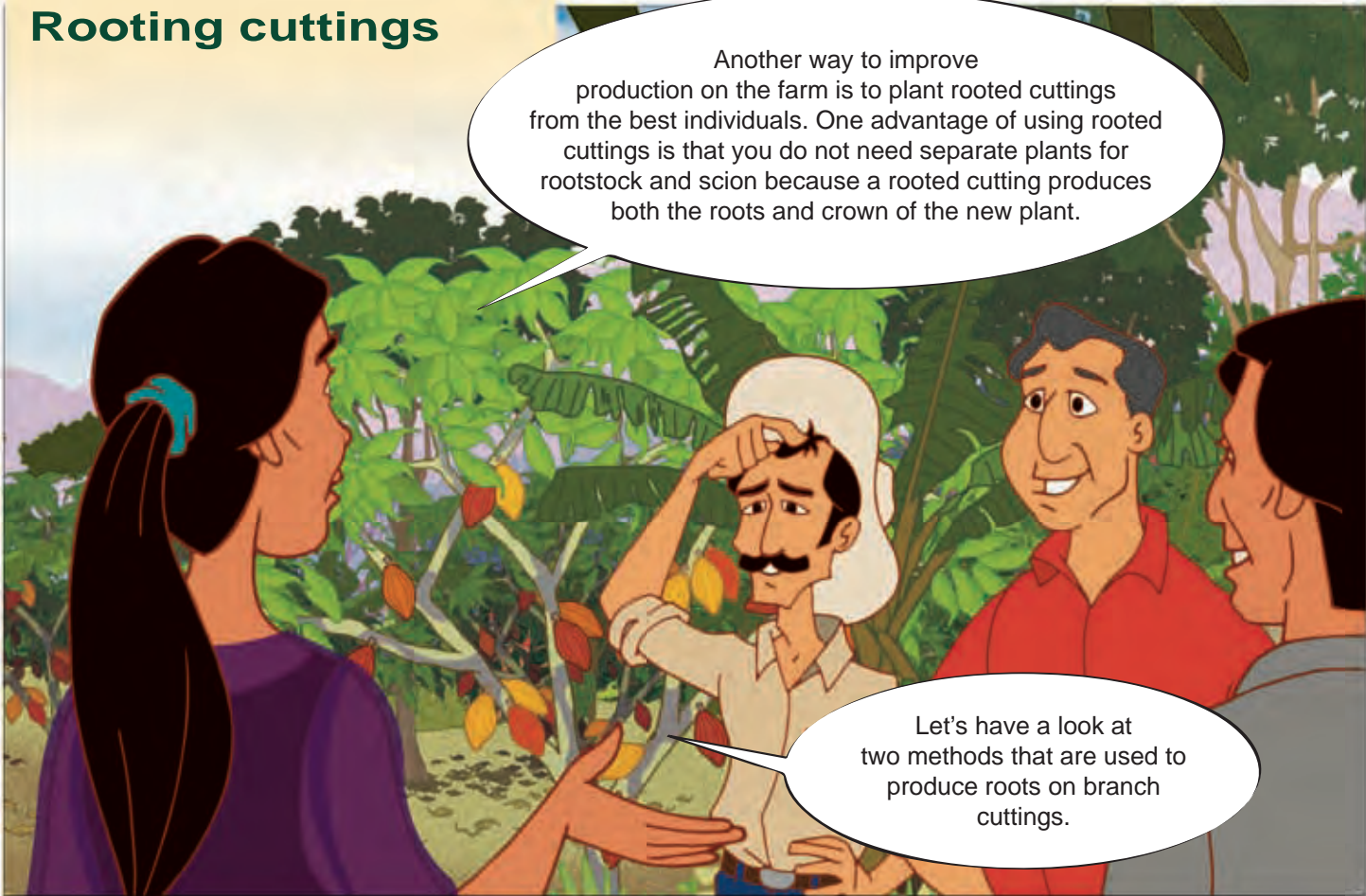
Between xylem and phloem there is a moist layer called cambium.



When the roots extract water and minerals from the soil, the xylem transports these substances to the leaves and other parts of the plant. The leaves, which are like the "kitchen" of the plant, use energy from the sun to combine the water and minerals with carbon dioxide (a gas in the air), transforming them into food. The phloem then takes this food to other parts of the plant, like the roots, flowers, and branches. That's why the xylem, phloem and the cambium of the graft all have to line up well with those of the rootstock.

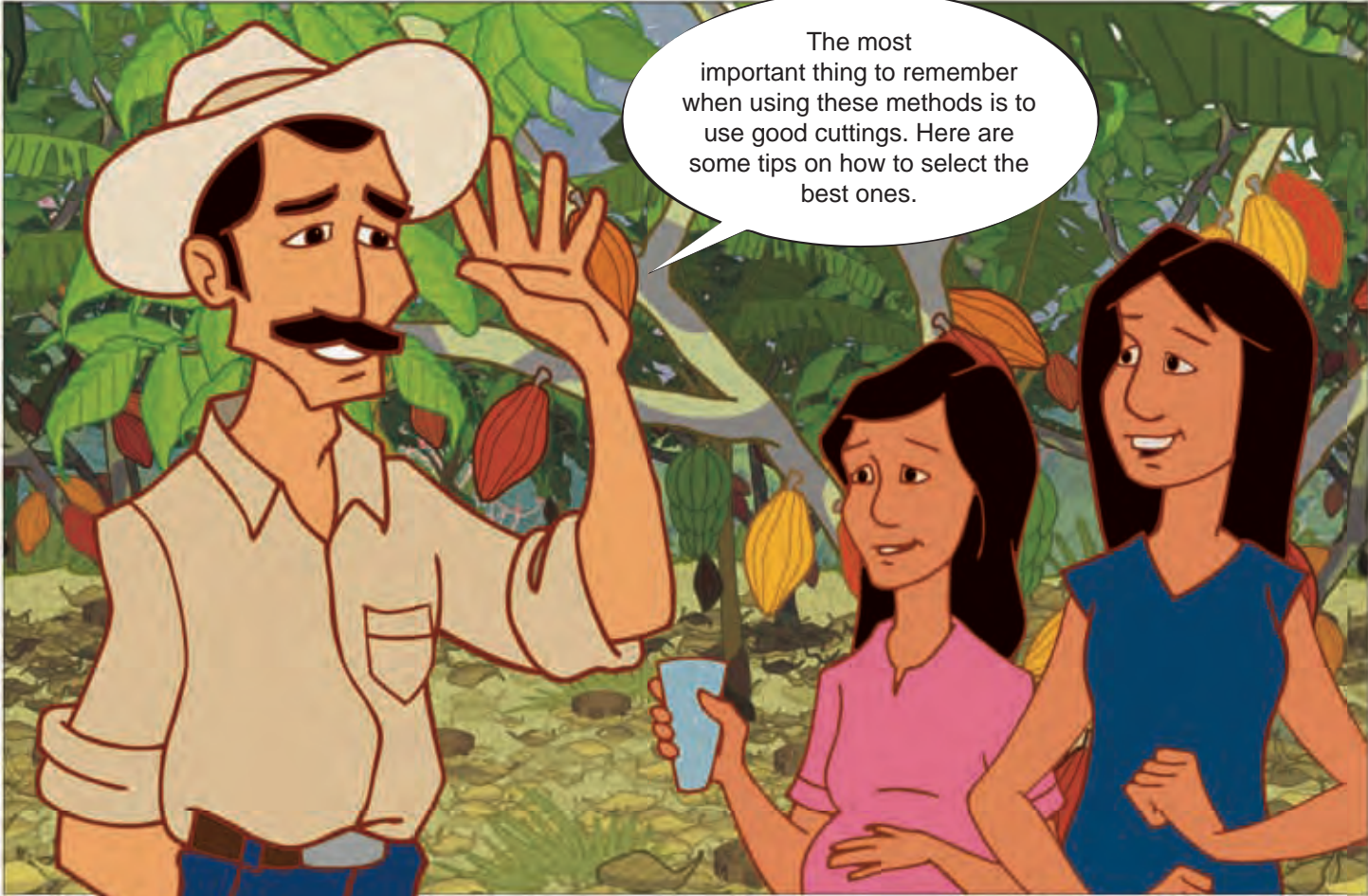
Only when they are properly aligned can the graft take hold, heal and function properly to provide nutrients and water to the new plant.

## Rooting cuttings



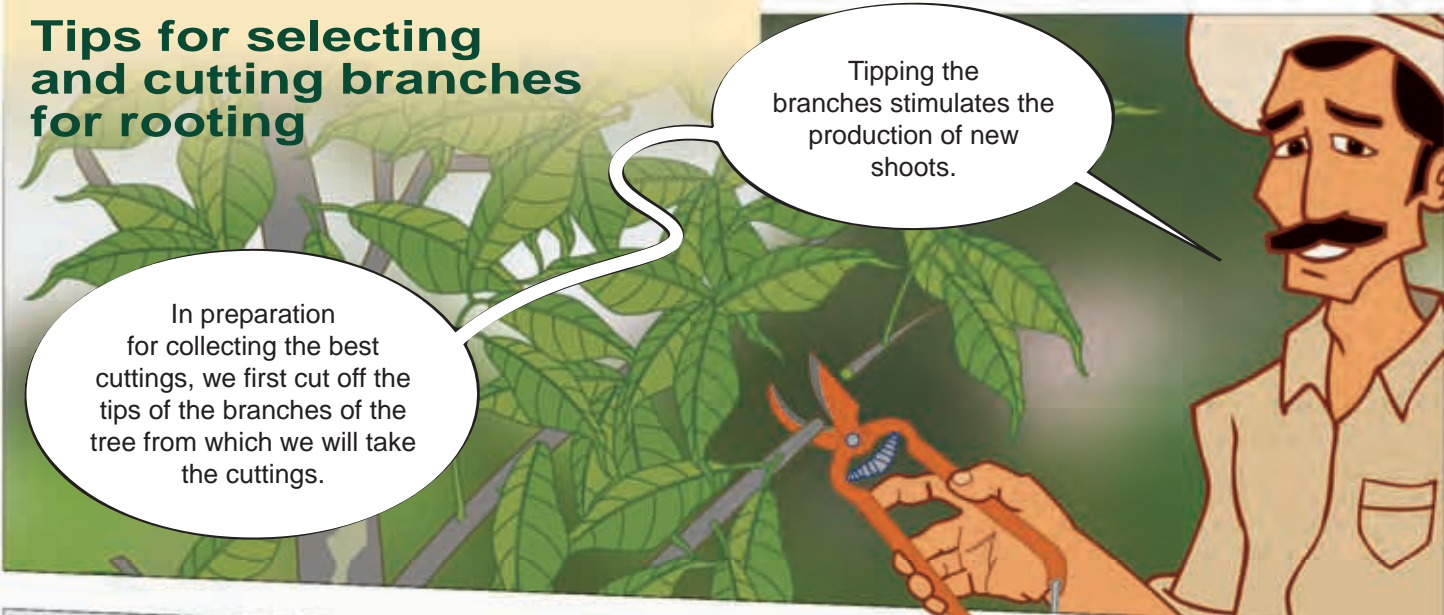
Another way to improve production on the farm is to plant rooted cuttings from the best individuals. One advantage of using rooted cuttings is that you do not need separate plants for rootstock and scion because a rooted cutting produces both the roots and crown of the new plant.

Let's have a look at two methods that are used to produce roots on branch cuttings.

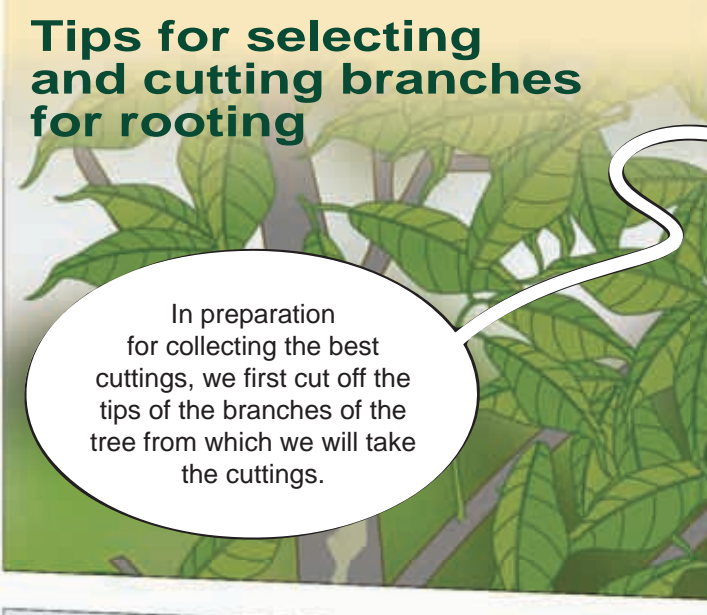


The most important thing to remember when using these methods is to use good cuttings. Here are some tips on how to select the best ones.

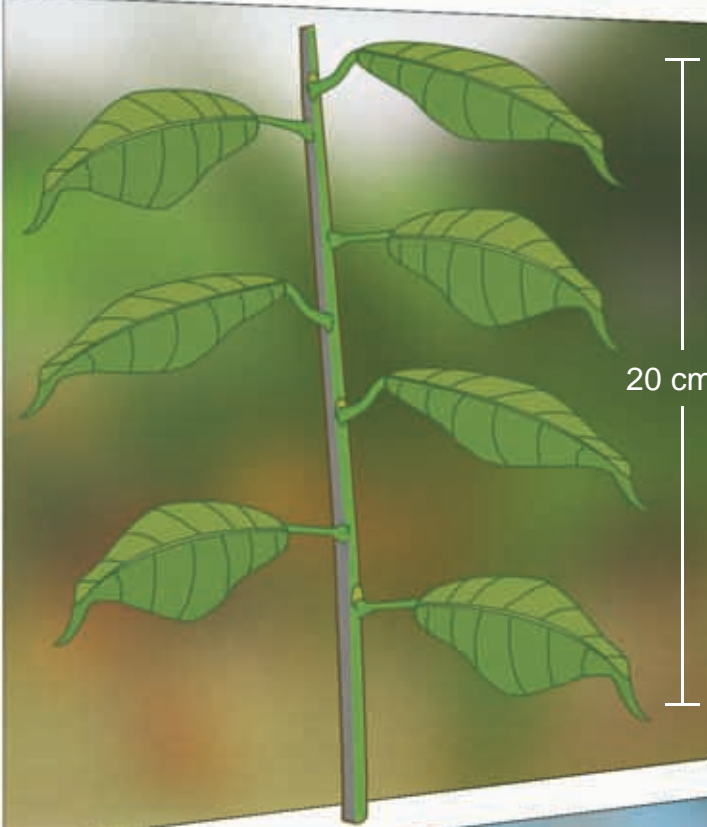
## Tips for selecting and cutting branches for rooting



Tipping the branches stimulates the production of new shoots.




In preparation for collecting the best cuttings, we first cut off the tips of the branches of the tree from which we will take the cuttings.



20 cms.

Choose shoots that are about a half-centimeter in diameter, that are located near the end of the branch and are cinnamon colored on one side and green on the other. Scion should be approximately 20 centimeters long and have four to six leaves.



Be sure to cut the shoots early in the morning and wrap them immediately in wet paper, a damp cloth or banana leaves to keep them moist.

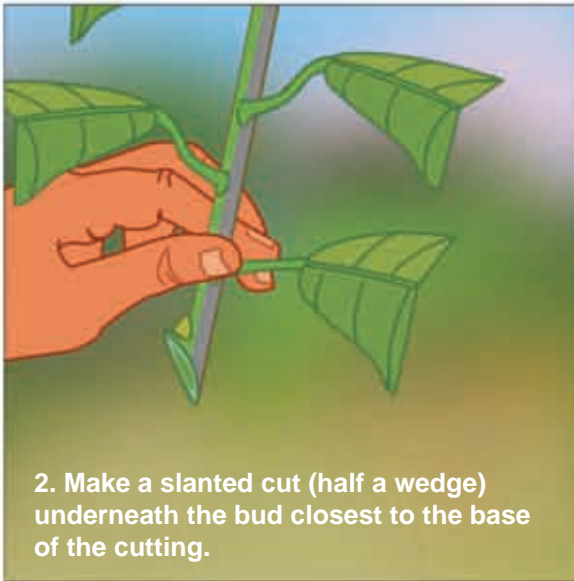


In the nursery, you will dip the thick end of the shoot into a rooting hormone, a substance that stimulates roots to sprout. Place the shoot in a bag with substrate,

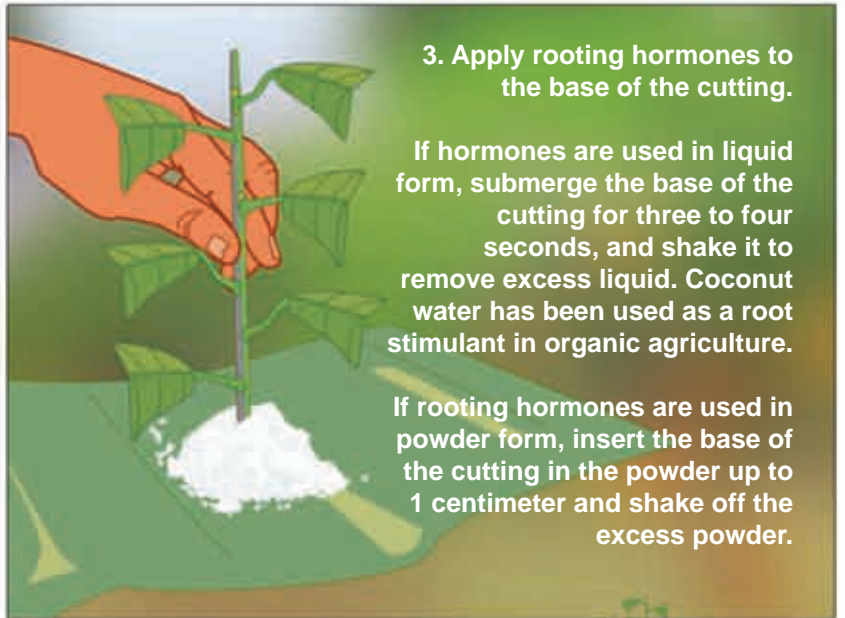
with the thick end stuck into the substrate, and put the bags with the cuttings inside a warm moist chamber, called a rooting chamber. Let's see the details required for success:



1. After harvesting the shoots and bringing them back to the nursery, tip each one and, with scissors, cut the leaves, leaving only a third of each leaf blade.



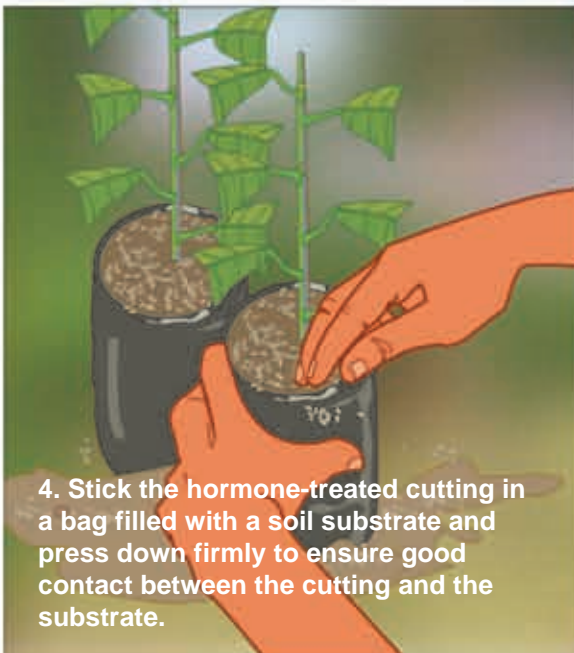
2. Make a slanted cut (half a wedge) underneath the bud closest to the base of the cutting.



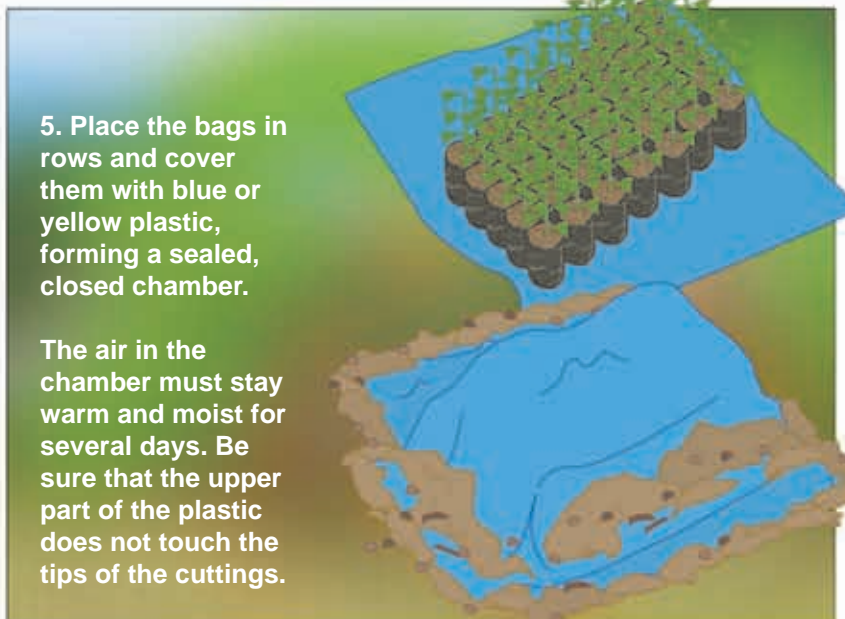
3. Apply rooting hormones to the base of the cutting.

If hormones are used in liquid form, submerge the base of the cutting for three to four seconds, and shake it to remove excess liquid. Coconut water has been used as a root stimulant in organic agriculture.

If rooting hormones are used in powder form, insert the base of the cutting in the powder up to 1 centimeter and shake off the excess powder.

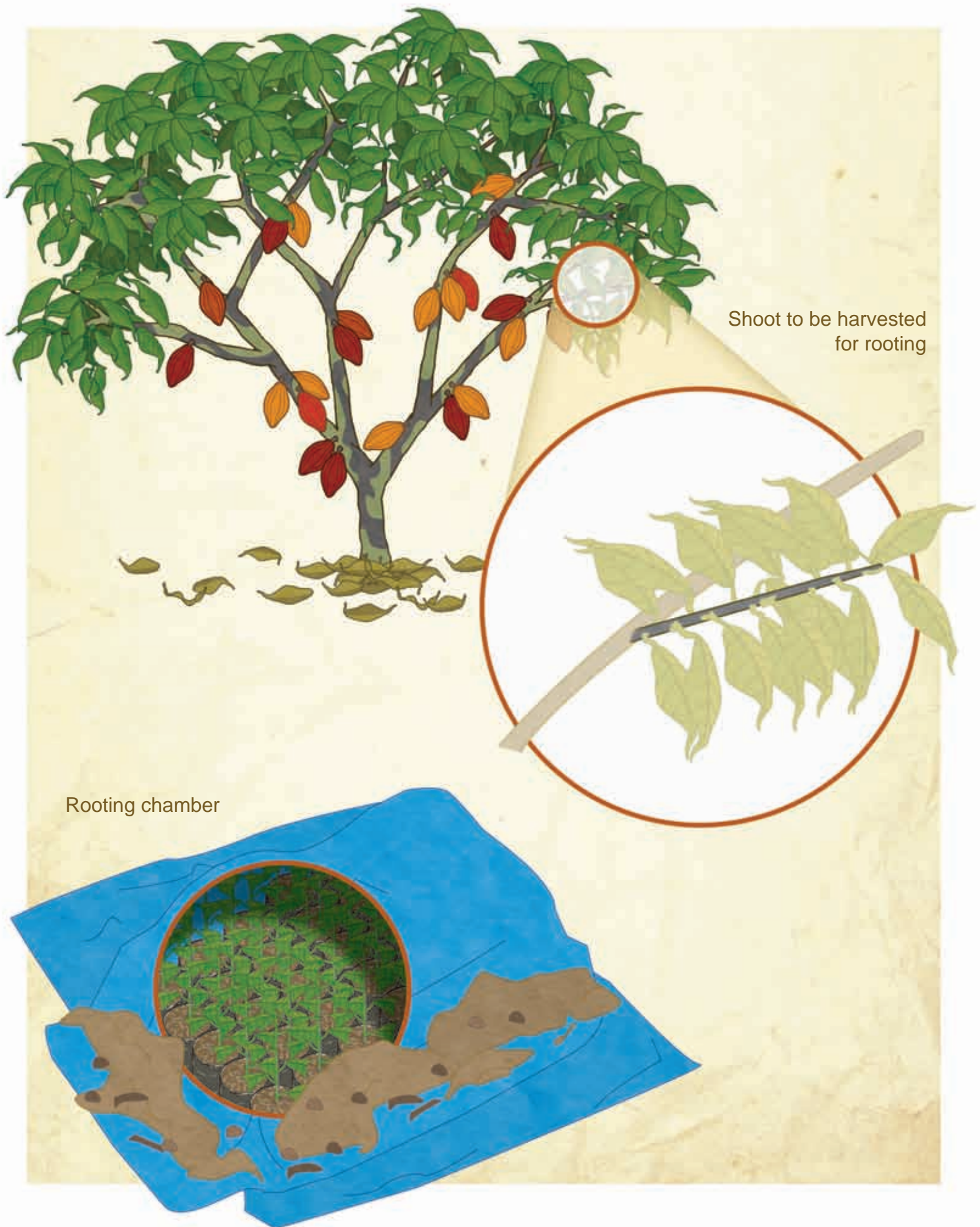


4. Stick the hormone-treated cutting in a bag filled with a soil substrate and press down firmly to ensure good contact between the cutting and the substrate.



5. Place the bags in rows and cover them with blue or yellow plastic, forming a sealed, closed chamber.

The air in the chamber must stay warm and moist for several days. Be sure that the upper part of the plastic does not touch the tips of the cuttings.



Shoot to be harvested  
for rooting

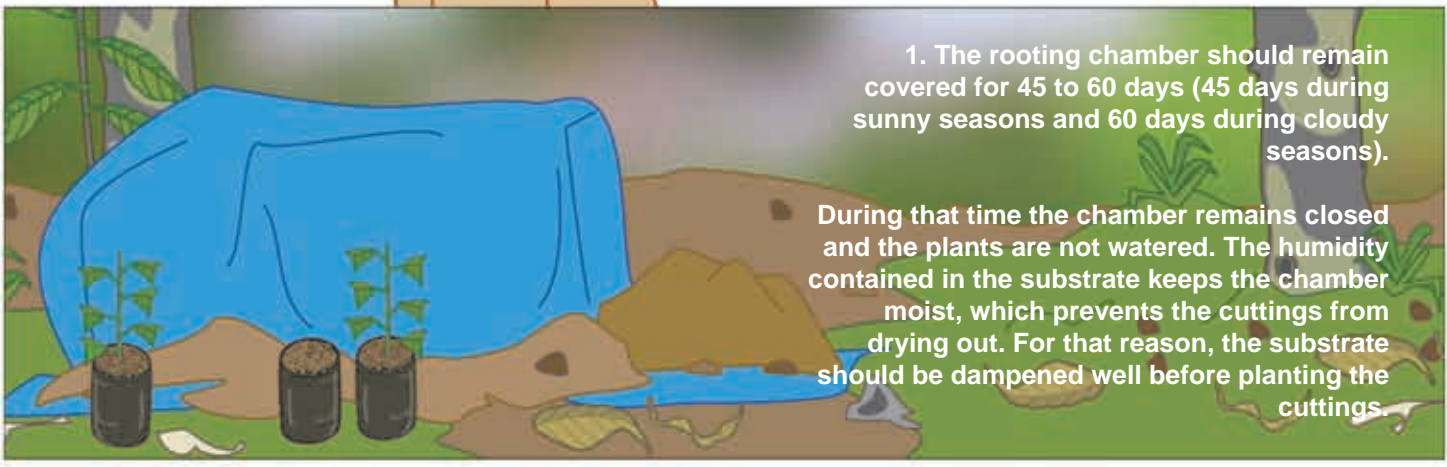
Rooting chamber

Cuttings stuck in substrate in a rooting chamber



After one and a half or two months in the rooting chamber, the cuttings will develop roots.

This is when they can be moved to the nursery where they will be taken care of until they are ready for transplanting to the field. Here are our recommendations for how to care for the cuttings:



1. The rooting chamber should remain covered for 45 to 60 days (45 days during sunny seasons and 60 days during cloudy seasons).

During that time the chamber remains closed and the plants are not watered. The humidity contained in the substrate keeps the chamber moist, which prevents the cuttings from drying out. For that reason, the substrate should be dampened well before planting the cuttings.



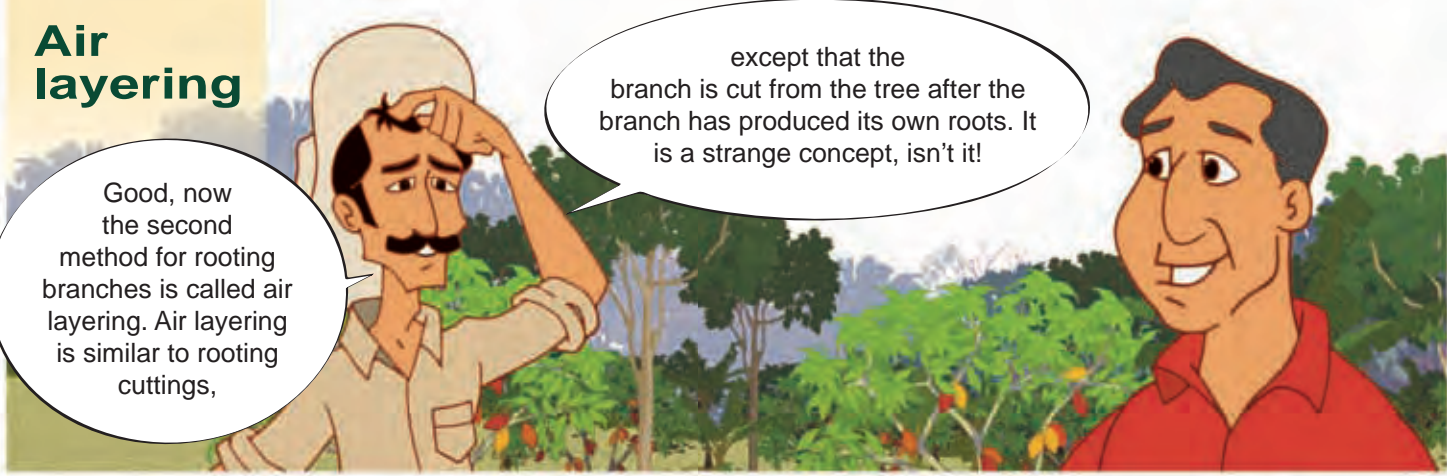
2. After 45 or 60 days, begin to gradually expose the newly rooted cuttings to light. On the first day, remove the plastic and leave it off for only one hour. During the following days, increase exposure by one hour each day until the plants are exposed to light for eight hours.



From then on the cuttings must remain exposed and should be watered until they are transplanted to the field.




## Air layering




Good, now the second method for rooting branches is called air layering. Air layering is similar to rooting cuttings,

except that the branch is cut from the tree after the branch has produced its own roots. It is a strange concept, isn't it!



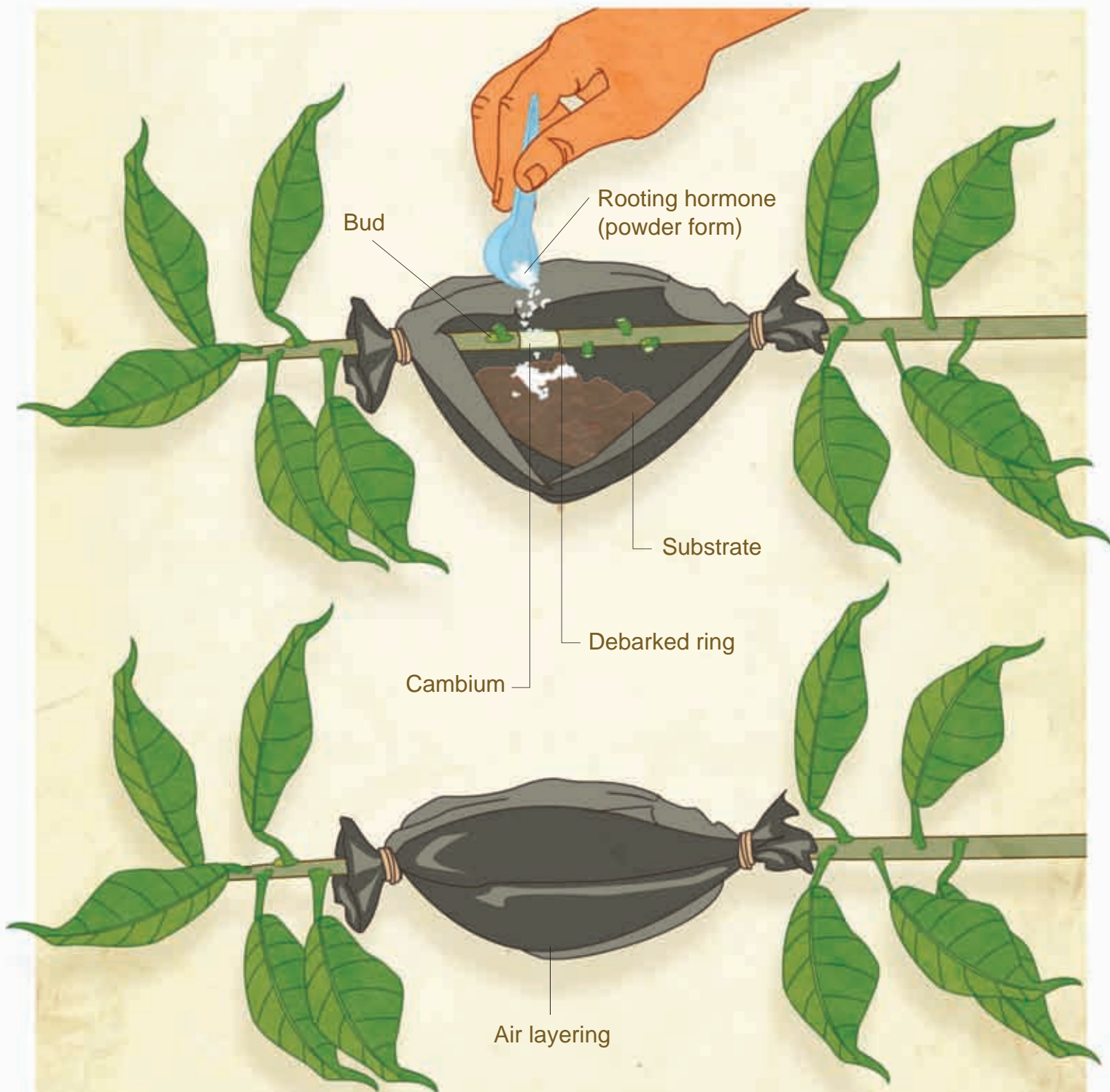
With the air layering method, we remove a small ring of bark from a branch and we apply rooting hormones

to stimulate the production of roots on the branch while it is still attached to the cacao tree.




What? Please explain. How can a branch produce roots while it is still attached to the tree?

It is very simple. All you have to do is follow these steps:




1. First choose a healthy branch, one to two centimeters thick, with all its leaves.
2. Ring the branch, which means cut and remove a ring of bark, about one and a half centimeters wide, exposing the wood of the branch.
3. Apply rooting hormones to the ringed area, wrap the ring with moist substrate and cover it with black plastic tied on both ends.
4. Leave the cover in place for 30 to 40 days, until roots sprout.
5. Once it has produced roots, cut the branch 15 centimeters below the ring and plant the cutting in a bag with substrate, being careful not to damage the delicate roots.
6. Care for the plant in the nursery until it produces new leaves.
7. Transplant to the field.

## Air Layering



Here is another tip. The plastic that covers the debarked ring must be black so light won't penetrate to the area where the new roots are going to form. Roots don't like light.

As you can see, with air layering, there is no need for a rooting chamber.



OK, friends. Can you explain the advantages and the disadvantages of using either rooted cuttings or rooted branches from air layering?

Well, one advantage of both methods is that you don't need separate rootstocks. In order to have rootstocks, you have to get the seeds,

plant them and take care of the plants until they are ready to graft. And all of that must be done in a nursery, which costs money.

That's true, but on the other hand, since air layering is done in the field, it's not a practical method for rooting a lot of branches because you would spend so much time going from one tree to the next.

But isn't that what life is about, spending time going from one tree to another, eating, without getting tired, and having fun?

Besides that, in the field you can't control rain or drought and they affect the rooting efficiency and development of roots from the branches.

## When should plants be taken to the field?

Keeping plants in the nursery costs money. So the new plants should be transplanted as soon as they can survive under field conditions.


Before taking the cacao plants to the field, be sure they will have some shade there, that the soil is not too dry, and that you are well into the rainy season.

Plants going to the field should be about 20 centimeters tall, with 12 or more mature leaves. They should look vigorous and healthy.

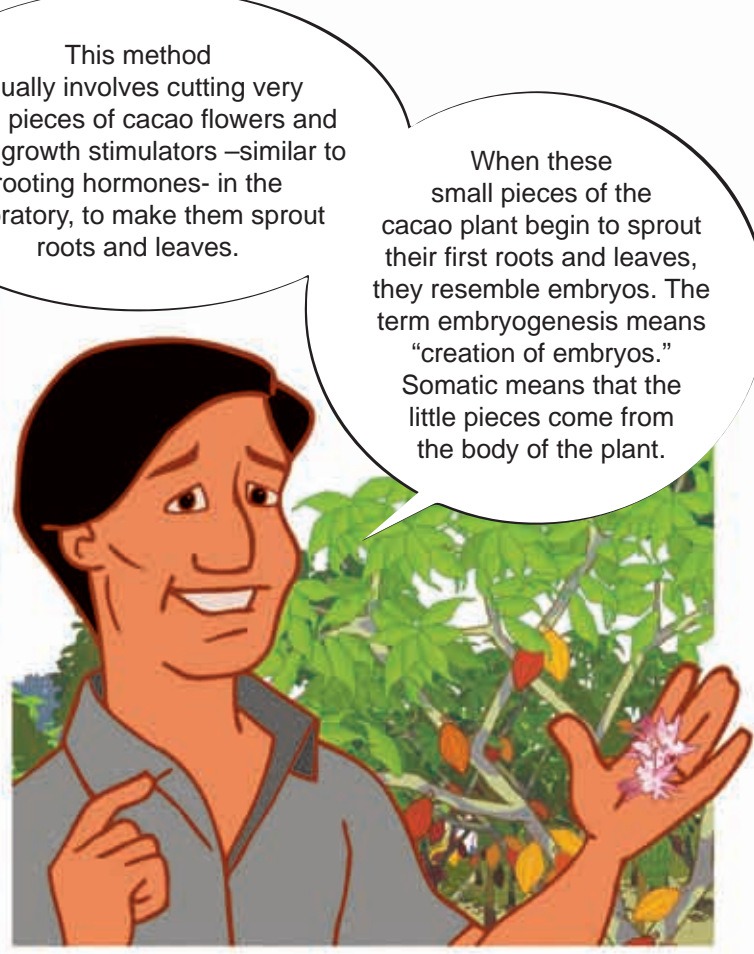
Here is a chart that has information about when to take asexual propagation plants to the field. It is worth our time to look at it:

The amount of time that plants spend in the nursery depends on the method used for propagation - grafting, cutting or air layering

Type of propagation	Time needed to grow the rootstock (months)	Time in nursery after grafting or rooting (months)	Total time before planting in field (months)
Green budding	1	3	4
Early bud grafting	3 weeks	3	almost 4 months
Traditional bud grafting	6	3	9
Cleft micro-grafting	3 weeks	4	almost 5 months
Rooting cuttings	Doesn't use rootstock	4 to 6	4 to 6
Air layering	Doesn't use rootstock	3	3




Before our meeting ends, and to be well-informed, we want to mention a modern, asexual propagation method called somatic embryogenesis.



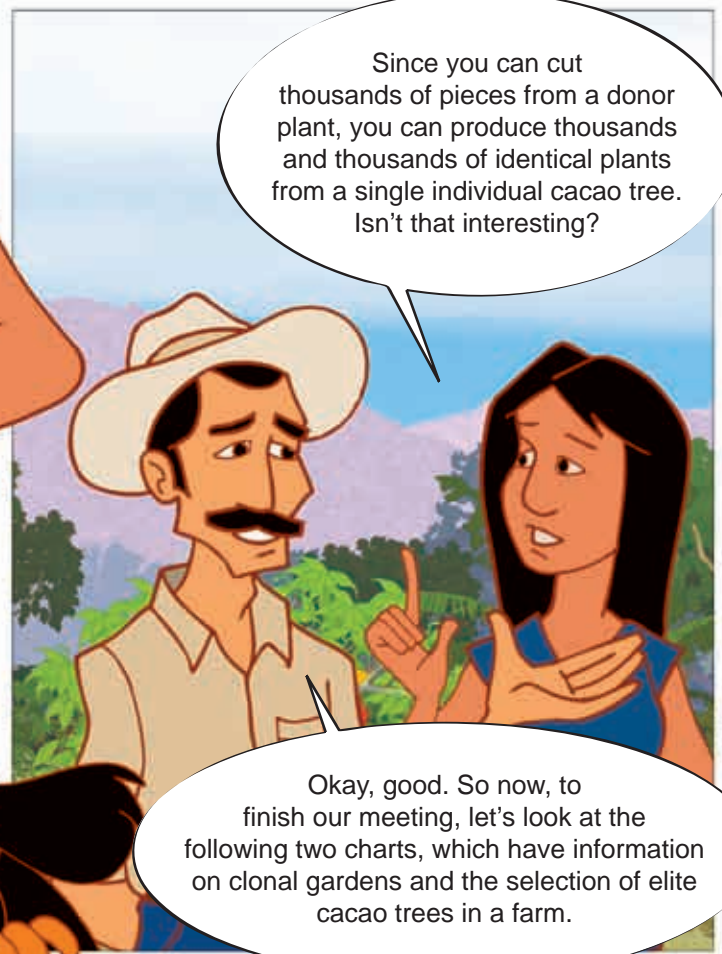
This method usually involves cutting very small pieces of cacao flowers and using growth stimulators –similar to rooting hormones- in the laboratory, to make them sprout roots and leaves.

When these small pieces of the cacao plant begin to sprout their first roots and leaves, they resemble embryos. The term embryogenesis means “creation of embryos.” Somatic means that the little pieces come from the body of the plant.



I am really interested in this topic of romantic embeddedness.

Don't mix things up, and pay attention!



Since you can cut thousands of pieces from a donor plant, you can produce thousands and thousands of identical plants from a single individual cacao tree. Isn't that interesting?

Okay, good. So now, to finish our meeting, let's look at the following two charts, which have information on clonal gardens and the selection of elite cacao trees in a farm.

## What is a clonal garden of cacao?



A clonal garden of cacao is a parcel of land planted with different clones of cacao trees, all selected for their desirable traits, for example, high yield, good quality chocolate or tolerance to diseases.

The main purpose of a clonal garden is to produce scions with buds for grafting or cuttings for rooting. Clones intended for seed production for rootstock are also planted in clonal gardens.

Good rootstock should be resistant to soil-borne diseases that attack roots and their roots should grow vigorously.

## What are superior cacao trees?



Farmers and cacao agronomists select individual cacao trees that regularly produce superior yields, are resistant to diseases, produce large seeds and good-quality chocolate, or which have other desirable traits, such as tolerance to drought.

Once the farmer spots a likely superior cacao tree, he or she should mark it and monitor its yield, growth, and other traits for at least two years.

Some cacao trees that appear to be superior at first are not truly superior, because their high production is due to their privileged location near sources of water or they happen to have been planted in a location with high fertility soils, at the edge of the plantation without competition with neighbor trees, or with unusually favorable light regimes.



Well, we are at the end of today's meeting. Now all we have to do is put these asexual propagation methods into practice in our farms.

The recipe is simple: practice, practice, and practice.

All members of the family should do this. In each cacao family there is at least one expert in asexual propagation of cacao just waiting to be discovered!



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