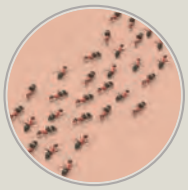


3.2 Nest architecture

The different stages of brood development (eggs, larvae, and pupae) require different temperatures and humidity levels. The workers are constantly transporting the brood to rooms where the conditions are the most favorable.

The interior of the dome is made of coarse materials and surrounds a central tree stump. A dense network of rooms serves as chambers, incubators, and storage areas.

The central stump gives stability to the dome. The rooms allow the queen to be sheltered when the dome is destroyed by animals in search of food, for example, wild boars. The precious eggs are well sheltered under the stump.

The pupae in their cocoons require a dry and warm environment. They are brought up to the outer areas of the anthill, at a temperature of 29°C–31.5°C. If prolonged rains moisten and cool these areas, the cocoons are briefly brought to the surface to dry in the sun.

workers hatching

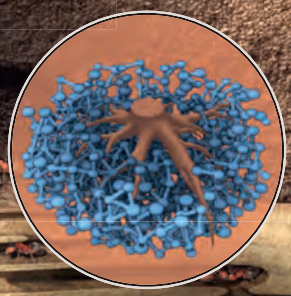
Recently hatched ants have a soft, clear cuticle. This hardens after a few days and takes on its characteristic color.

Young pupae have a pale cocoon.

Older pupae have a dark cocoon.

Due to the dome's constant movement, coarse materials such as pebbles and large twigs end up piling up at the bottom of the nest.

second instar larvae



The subterranean part of the nest extends far into the ground, up to two meters deep and wide in large nests. Underground, the temperature is quite low and relatively constant. If it's too hot or too cold on the surface, the workers retreat to these subterranean areas.

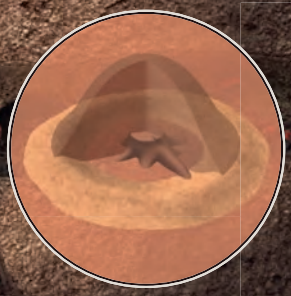
second instar larvae

humid part of the nest

The workers constantly maintain the dome. They repair damage and transport damp materials from the interior to the surface so the materials can dry, thus preventing a mold infestation.

foragers leaving the nest in search of food

Workers carry the empty pupae outside and deposit them on a waste heap, along with food scraps and dead congeners.



Fine earth and sand produced by the digging of chambers and tunnels are spread around the dome. This deposit forms a circular wall that supports the sides of the dome and prevents the materials that constitute it from slipping.

captured spider

captured caterpillar

workers digging

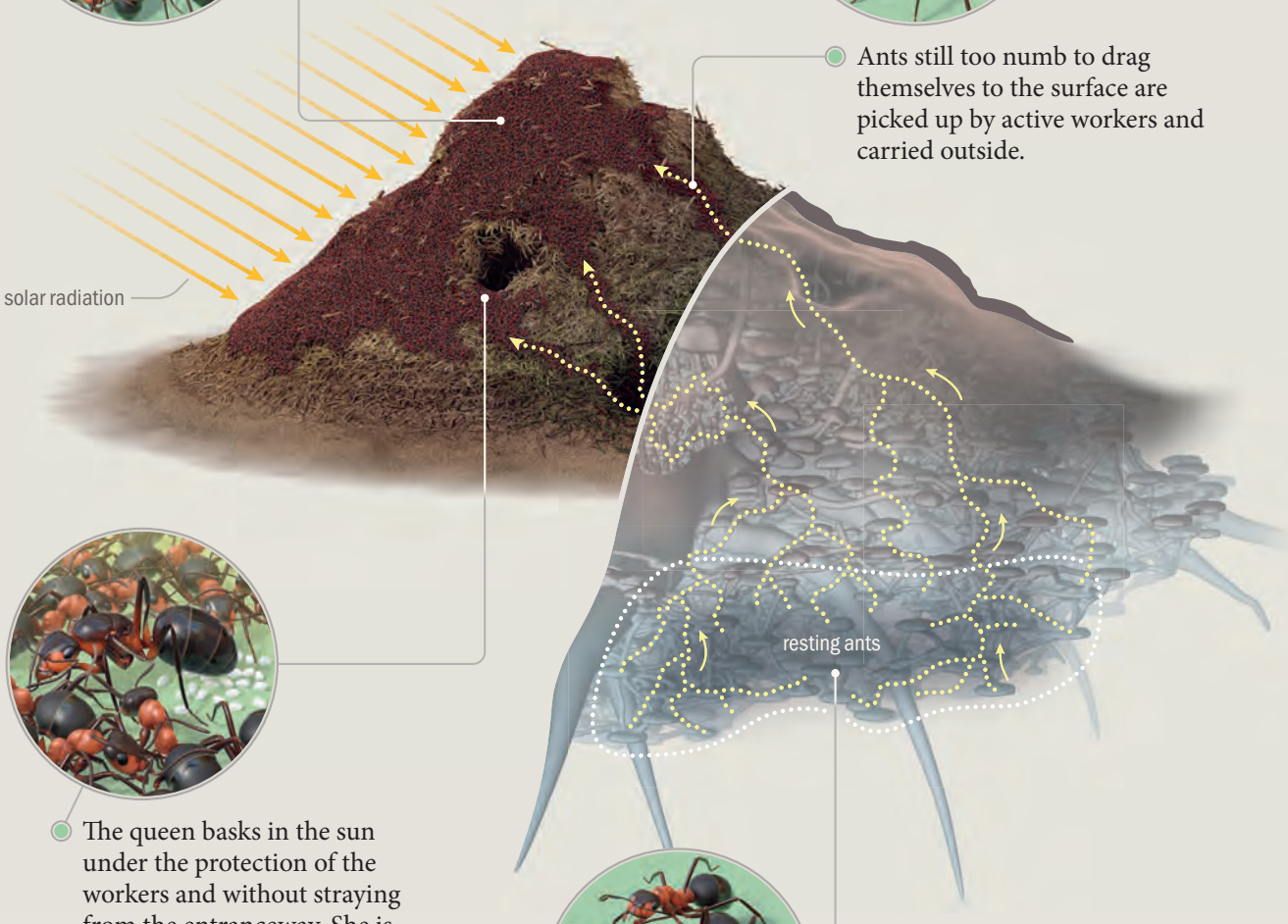
prey cut up and stored in underground granaries

3.3 Annual cycle | Spring

A red wood ant nest is a dynamic structure that the workers are constantly adapting to temperature and weather fluctuations. In the spring, the colony awakens from its winter rest. It begins by restoring the nest to working order and warming it up.

At the end of the winter rest, the ants gather on the surface of the dome to warm themselves in the sun. Ants being heterothermic, they need external heat to accelerate their metabolism and become active again.

Ants still too numb to drag themselves to the surface are picked up by active workers and carried outside.



The queen basks in the sun under the protection of the workers and without straying from the entranceway. She is already beginning to lay the winter eggs, which will produce reproductive individuals.

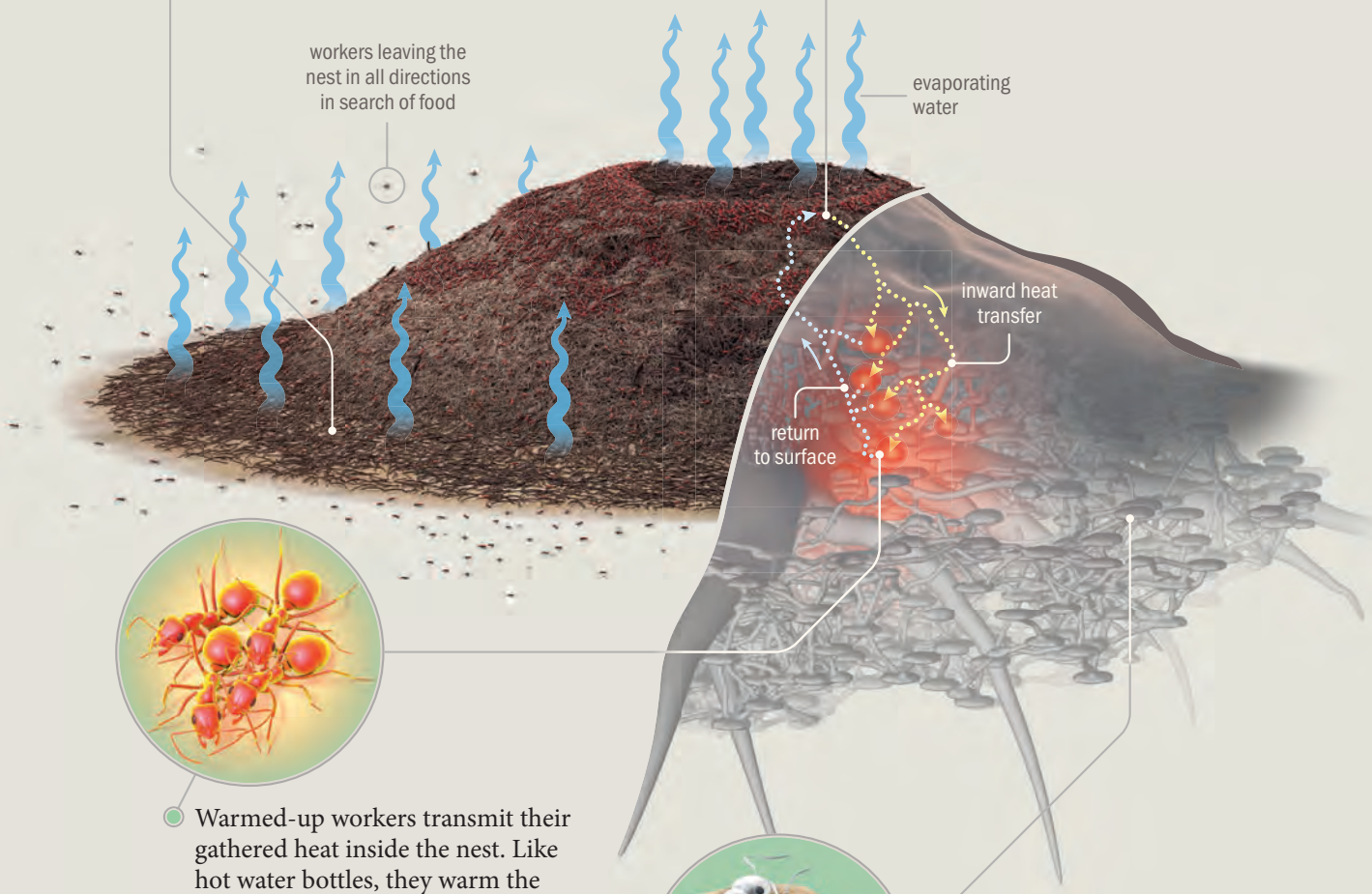
The active workers, already warmed up, return to the interior of the nest and try to wake up the still numb workers by tapping their antennae and tugging on them.

winter rest

January | February | March

After this first sunbathing, some of the workers begin to rebuild the dome, clearing away the dirty layer covering it. Thus uncovered, the inside of the nest can dry out in the sun. The interior materials are spread around to dry too.

The workers who are not busy rebuilding the nest gather in small clusters on the surface to warm themselves in the sun. Once their body temperature reaches 30°C–34°C, they immediately rush inside the nest.



Warmed-up workers transmit their gathered heat inside the nest. Like hot water bottles, they warm the anthill. They then return to the surface to warm up, and the heat transfer begins again.

The first laid eggs hatch in the spring and generally give rise to reproductive individuals, who are cared for by the workers. In late spring and early summer, they leave the nest to mate.

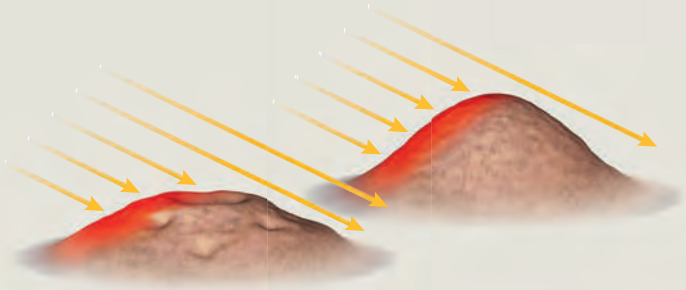
spring sun bath | raising reproductive individuals

April | May

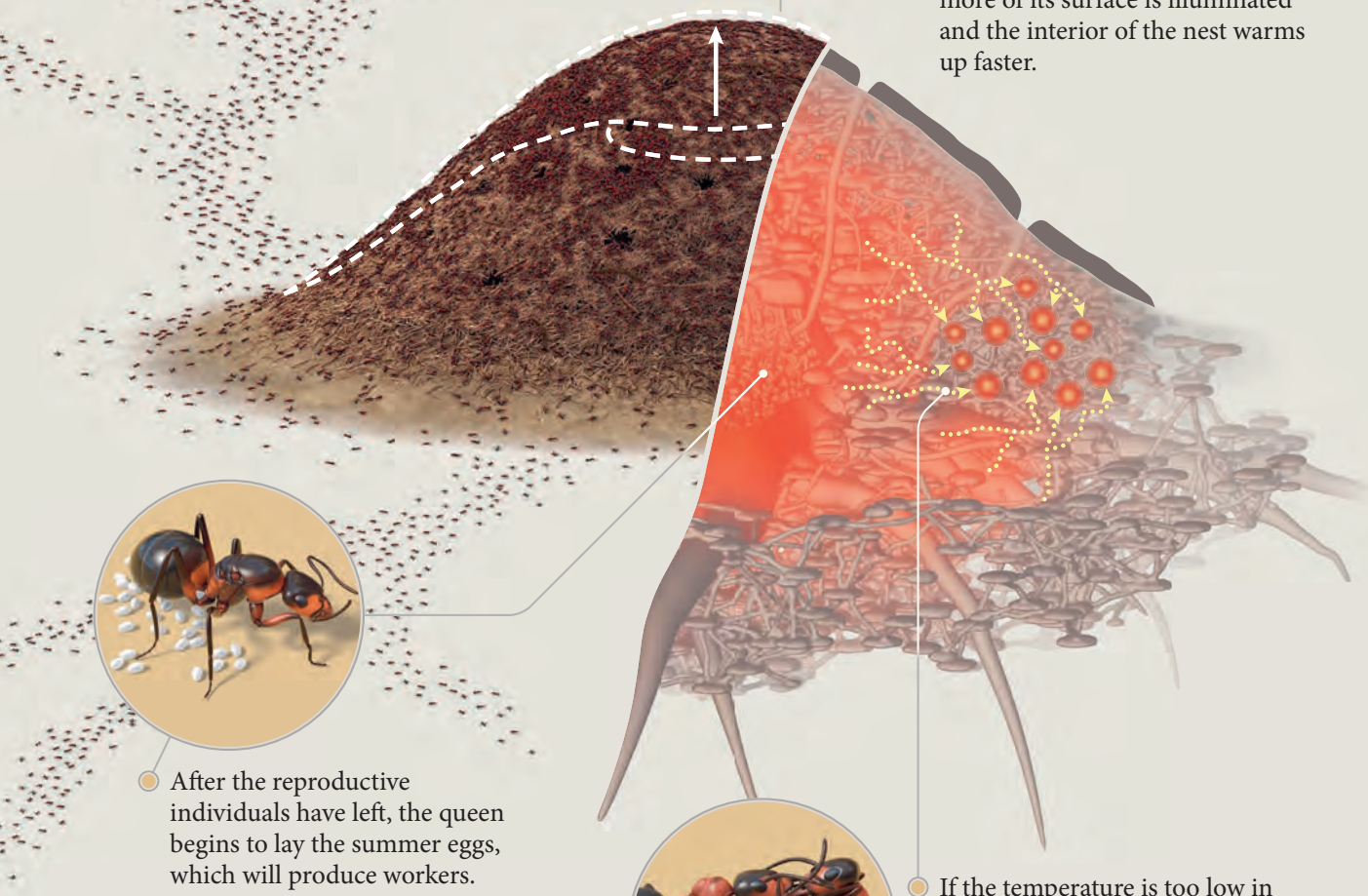
3.4 Summer

The anthill reaches a stage of intense activity and growth. Workers adapt the nest to the summer heat.

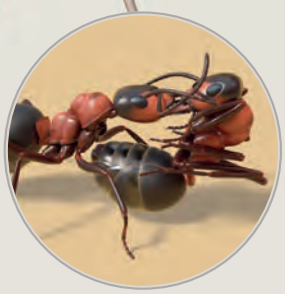
In spring, there is still little food in the forest. Outings from the nest rapidly increase and reach their maximum intensity. At first diffused, exploration outings are eventually concentrated in specific directions. The workers move farther and farther away from the nest and trails are created.



Due to its flattened shape, a damaged dome captures little sunlight. Once restored, it is higher: more of its surface is illuminated and the interior of the nest warms up faster.



After the reproductive individuals have left, the queen begins to lay the summer eggs, which will produce workers.



If the temperature is too low in certain areas of the nest, workers are transported there to increase the ant density. Since more ants transmit more body heat, the temperature of these areas increases and approaches that of the rest of the nest.

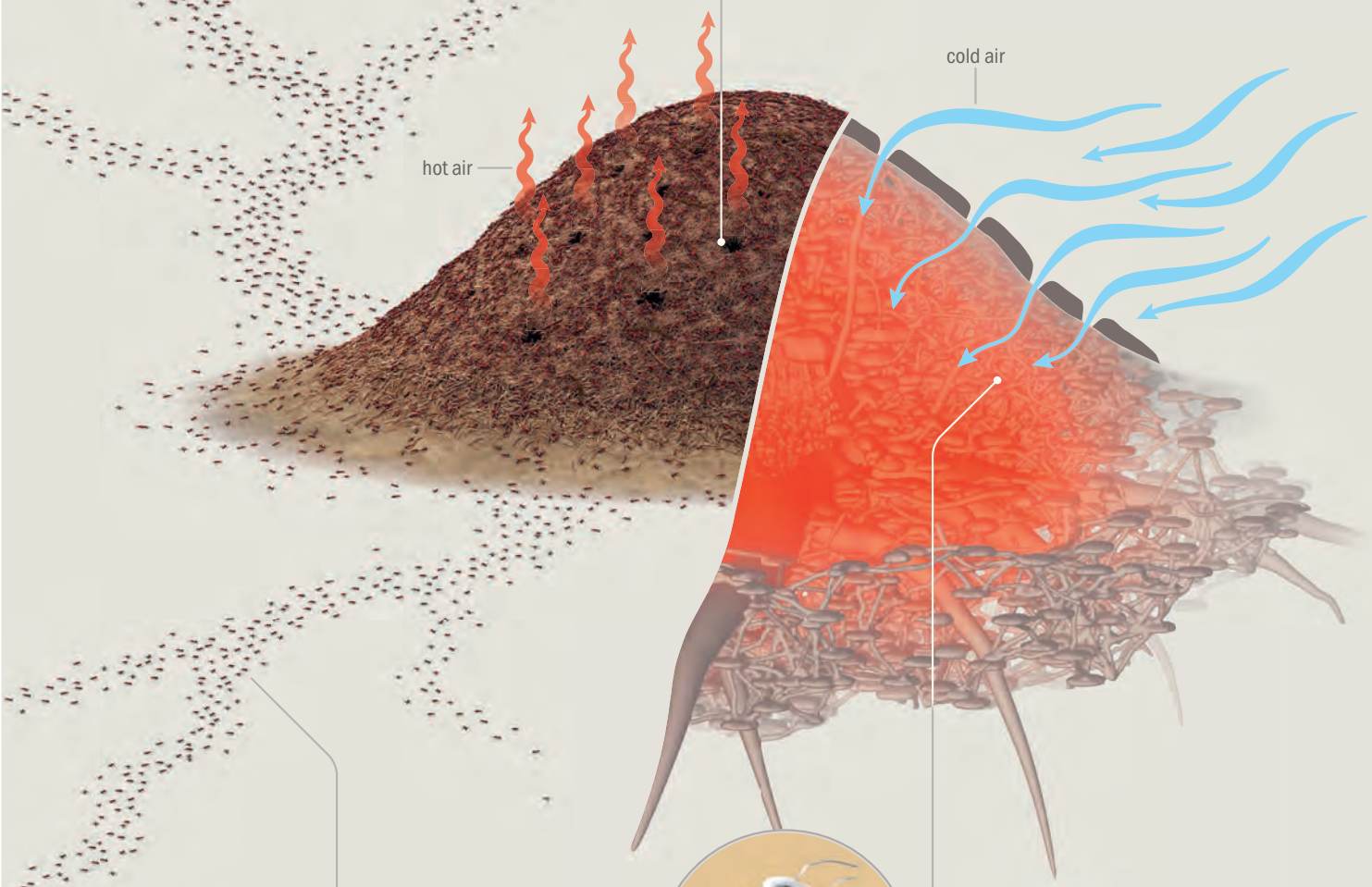
nuptial flight

May June

When the nest is in danger of overheating, the workers remove materials from the dome, creating new openings that allow the warm interior air to escape. In addition, this allows the wind to push fresh air inside.

cold air

hot air



With the revival of wildlife, there is enough food around the nest. Exploration outings are a little less intense, but remain numerous until the end of August. The workers follow the network of trails to bring back the sweet secretion of aphids, known as honeydew, as well as the many animals captured.

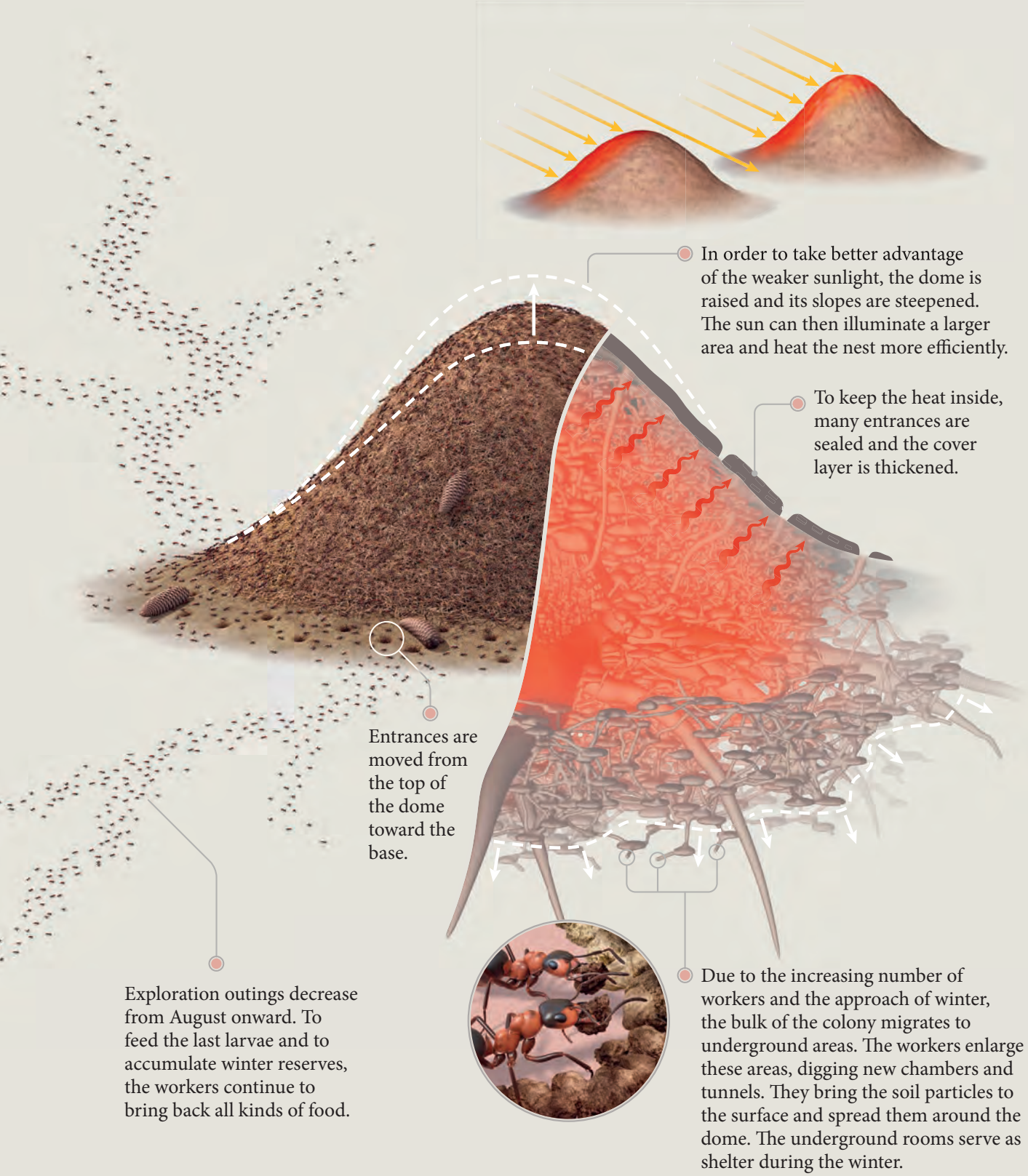
In summer and spring, only workers are born. To provide enough food for all these larvae, hunting intensifies.

raising workers

July August

3.5 Autumn

Toward the end of the season, the colony gets ready for winter rest and the nest is prepared for the cold.



In order to take better advantage of the weaker sunlight, the dome is raised and its slopes are steepened. The sun can then illuminate a larger area and heat the nest more efficiently.

To keep the heat inside, many entrances are sealed and the cover layer is thickened.

Entrances are moved from the top of the dome toward the base.

Exploration outings decrease from August onward. To feed the last larvae and to accumulate winter reserves, the workers continue to bring back all kinds of food.

Due to the increasing number of workers and the approach of winter, the bulk of the colony migrates to underground areas. The workers enlarge these areas, digging new chambers and tunnels. They bring the soil particles to the surface and spread them around the dome. The underground rooms serve as shelter during the winter.

raising workers

August — September

Shortly before winter, the dome is still passively heated. Food reserves are stored in the form of fatty bodies in the workers' abdomens, which expand greatly. The ants feed on these reserves during the resting period and in spring, when there is still little food in the forest.

When it rains, the entrances are closed to prevent water from flooding the interior.

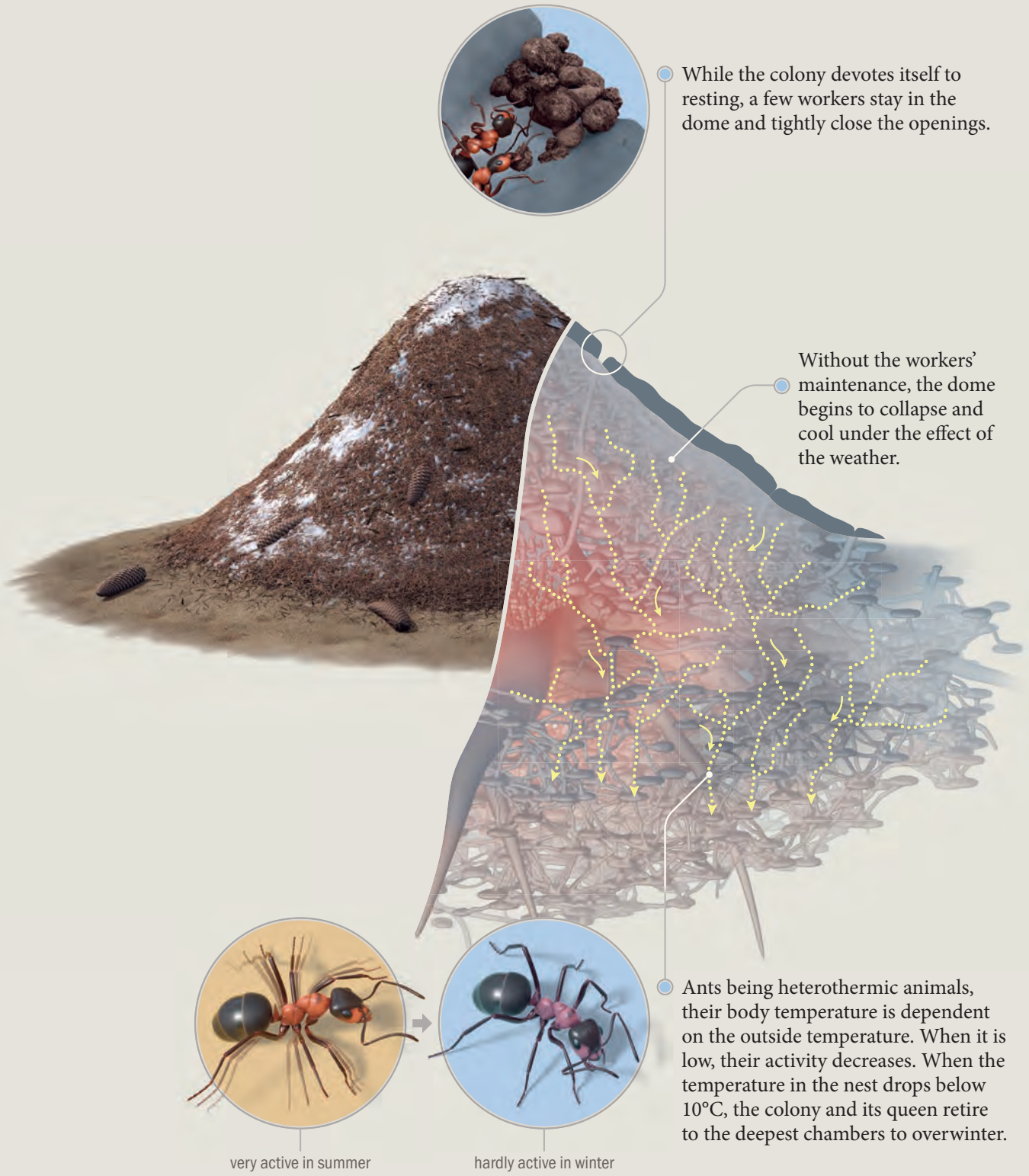
The digging of new rooms enlarges the pile of rubble.

In autumn, the outings continue to decrease and, in the absence of brood, the foragers no longer capture prey. They only bring back the aphids' sweet honeydew to build up their reserves.

Once the last workers have hatched, the queen stops laying. Without brood, the workers cease to regulate the temperature in the nest, which gradually begins to cool.

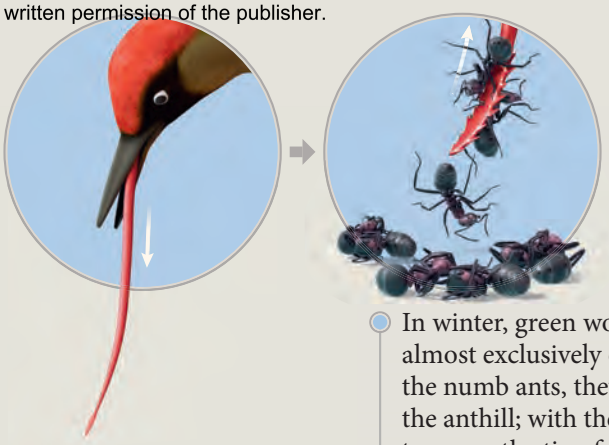
3.6 Winter

In winter, the ants cease all their activities. To protect themselves from the cold and frost, they retreat underground, to the bottom of the nest.



October — November

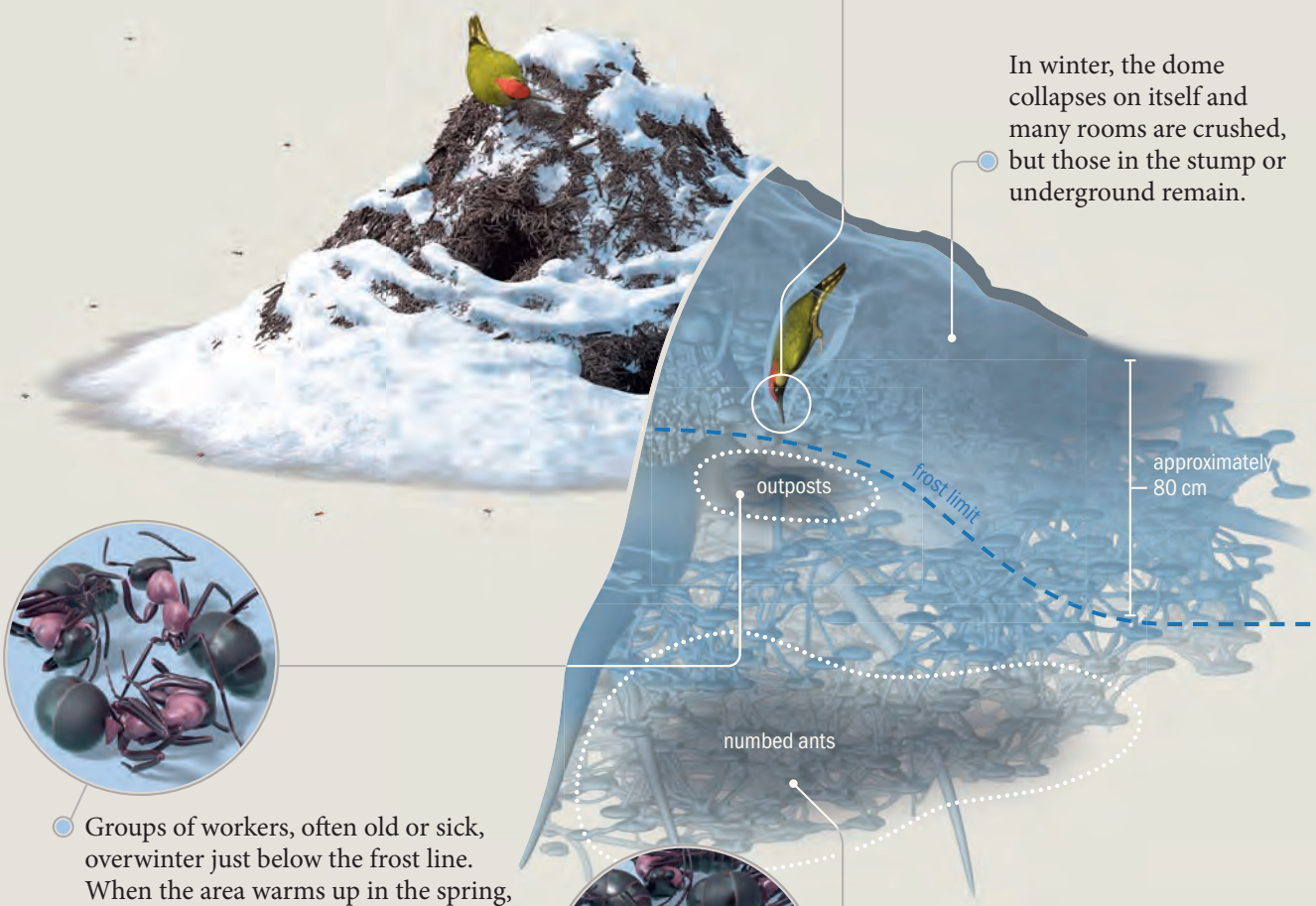
stockpiling of food



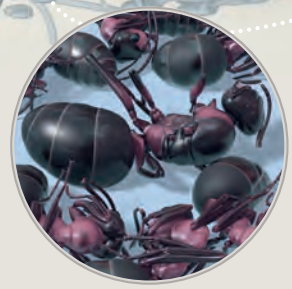
In mild weather, a few foragers emerge from the anthill.

In winter, green woodpeckers feed almost exclusively on ants. To capture the numb ants, they dig deep holes in the anthill; with the help of their sticky tongues, the tip of which has curved hooks, they penetrate the convoluted galleries to the wintering rooms.

In winter, the dome collapses on itself and many rooms are crushed, but those in the stump or underground remain.



Groups of workers, often old or sick, overwinter just below the frost line. When the area warms up in the spring, these outposts sense the warming and awaken their fellow congeners. Without these outposts, the bulk of the colony would miss the start of spring because the rise in temperature on the surface cannot be perceived from the depths of the nest.



During the winter rest, the workers gather around the queen. When the temperature approaches 0°C, the metabolism of ants slows down so much that they do not need to feed.

winter rest

December

4.1 Forest exploration

Foragers are constantly looking for food in the vicinity of the anthill.

1 Most foragers leave the nest in the morning. If there is a shortage of food in the anthill, workers emit pheromones that incite scouts to come out.

2 Outside the nest, the scouts orient themselves by taking in the position of the sun and some noteworthy trees in the surrounding forest.

3 Along the way, they take advantage of natural trails, like fallen branches, to progress faster.

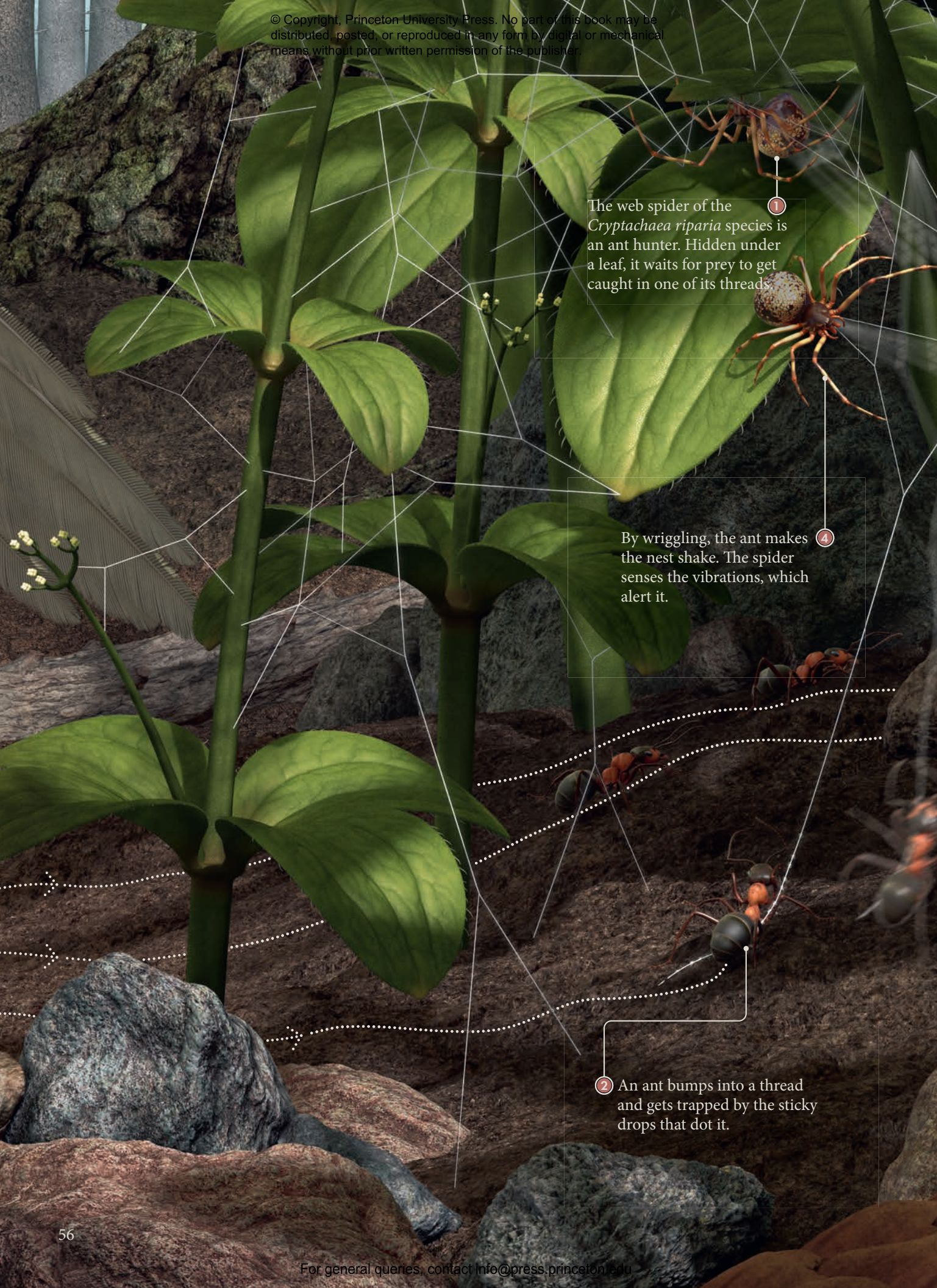
4.2 Ants' enemies

Outside the anthill, the workers are exposed to numerous predators specialized in capturing ants.

3 Because of their full poison reservoir, red wood ants are inedible to woodpeckers. To make them consumable, it rubs them on its plumage. When it does this, the ants project their defensive secretion, completely emptying their glands, and then the woodpecker can swallow them. In addition, the formic acid kills or drives away parasites from its feathers. Other birds, such as blackbirds and thrushes, take care of their plumage in the same way.

4 Red wood ants are the woodpecker's primary food, and it spends most of its time on the ground looking for them.

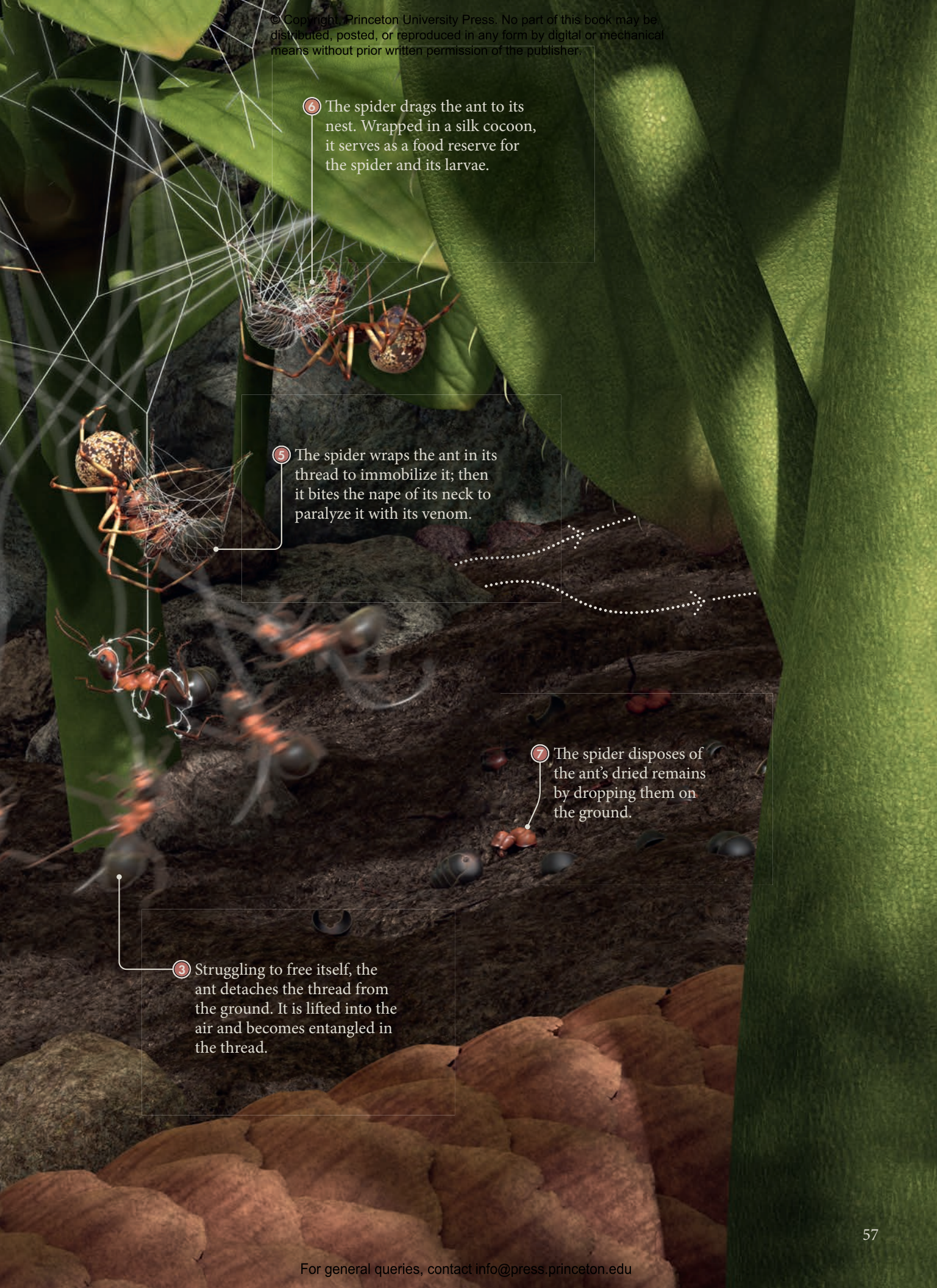
2 The woodpecker quickly grabs several ants and keeps them in its beak.



1 The web spider of the *Cryptachaea riparia* species is an ant hunter. Hidden under a leaf, it waits for prey to get caught in one of its threads.

2 An ant bumps into a thread and gets trapped by the sticky drops that dot it.

4 By wriggling, the ant makes the nest shake. The spider senses the vibrations, which alert it.



6 The spider drags the ant to its nest. Wrapped in a silk cocoon, it serves as a food reserve for the spider and its larvae.

5 The spider wraps the ant in its thread to immobilize it; then it bites the nape of its neck to paralyze it with its venom.

7 The spider disposes of the ant's dried remains by dropping them on the ground.

3 Struggling to free itself, the ant detaches the thread from the ground. It is lifted into the air and becomes entangled in the thread.

An ant approaches the funnel of an ant lion, which is the larva of a dragonfly-like insect. The larva digs a funnel in the sand to capture small arthropods. The sand at the edge of the funnel crumbles, and the ant slides inside. (1)

The loose sand prevents the ant from finding a hold, and its slide continues. Its movements produce vibrations that alert the ant lion. (2)

To prevent the ant from escaping, the ant lion, which occupies the center of the funnel, throws grains of sand on it with rapid body movements. (3)

6 The ant lion throws the ant's dried remains out of the funnel.

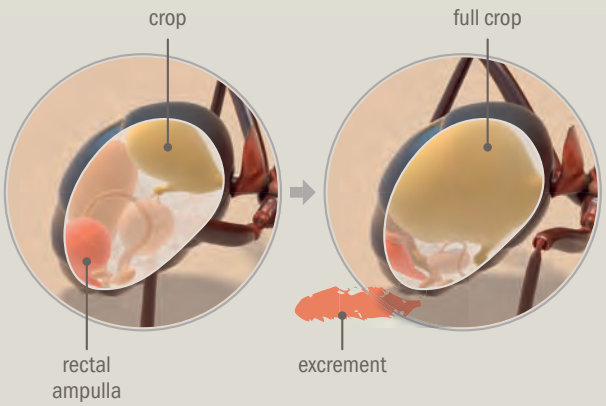
4 As soon as the ant is within reach, the ant lion grabs it with its mandibles and paralyzes it with its venom.

5 The ant lion pulls its prey under the sand. It sucks the liquid from its body and completely empties it. When an ant lion funnel is near an anthill, ants are its primary food.

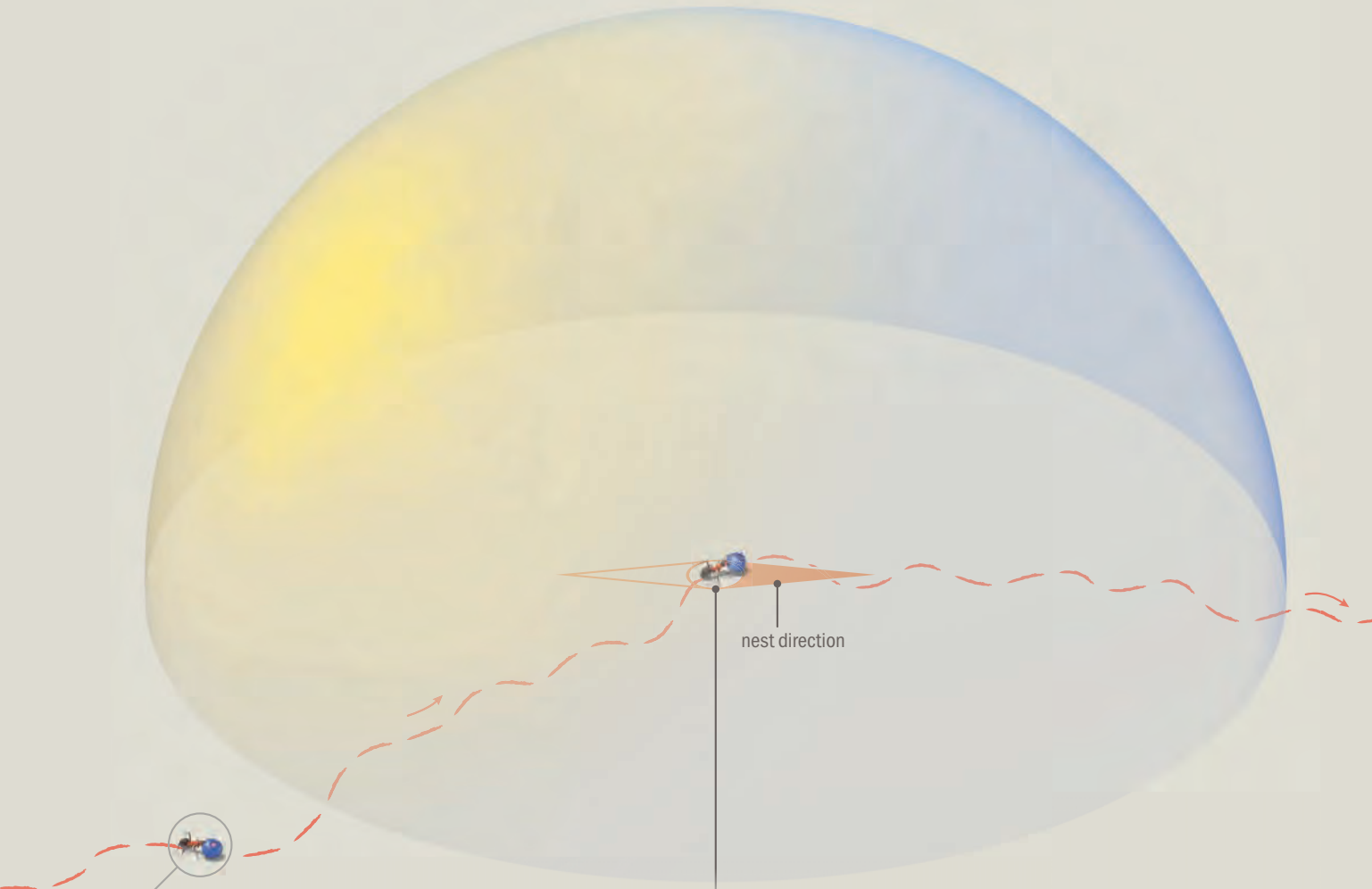
4.3 Foraging

The scout has found food. She must now find her way back to the nest and lead other foragers to the food source.

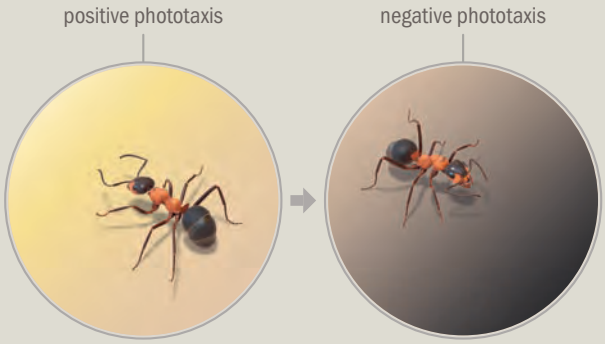
1 The scout tastes the food. If it suits her, she fills her crop with it. The more she likes the food, the more she ingests.



2 The ant's crop expands until it fills much of the abdomen, compressing other organs. The rectal ampulla is also compressed and releases excrement. The amount defecated depends on the amount of food ingested.



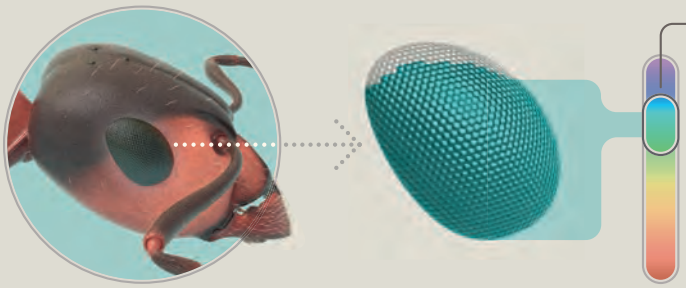
3 To mark the path to the food, the scout brushes the ground with her abdomen at regular intervals and deposits excrement there. The excrement contains pheromones produced by the intestine and creates a scent trail. The amount of excrement deposited determines the intensity of the smell. The scout proceeds in this way to the nest.



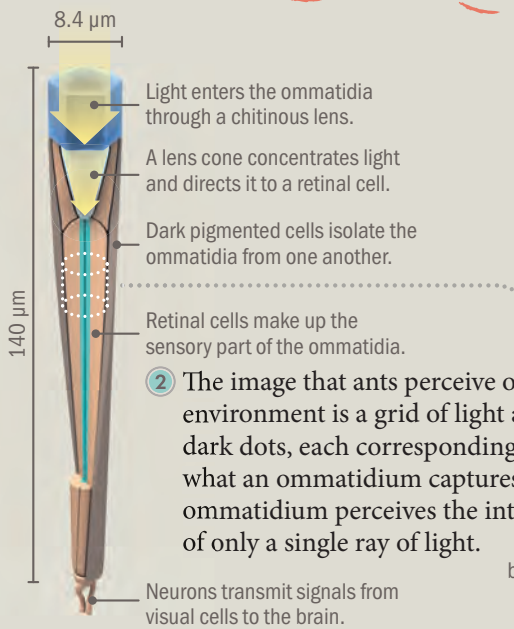
4 After finding food, the scout's body reacts differently to sunlight (phototaxis). It's no longer light that attracts her but darkness. She now heads in the opposite direction of the sun, more or less toward the nest. During the trip, she deviates regularly to the right and left of the chosen direction. If she deviates too much, she corrects her course and goes back in the other direction, drawing a winding path.

4.4 Visual orientation

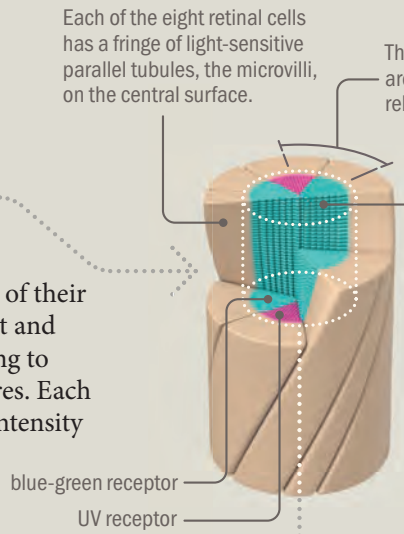
On the return journey, the worker's two complex eyes give her a rough picture of her surroundings.



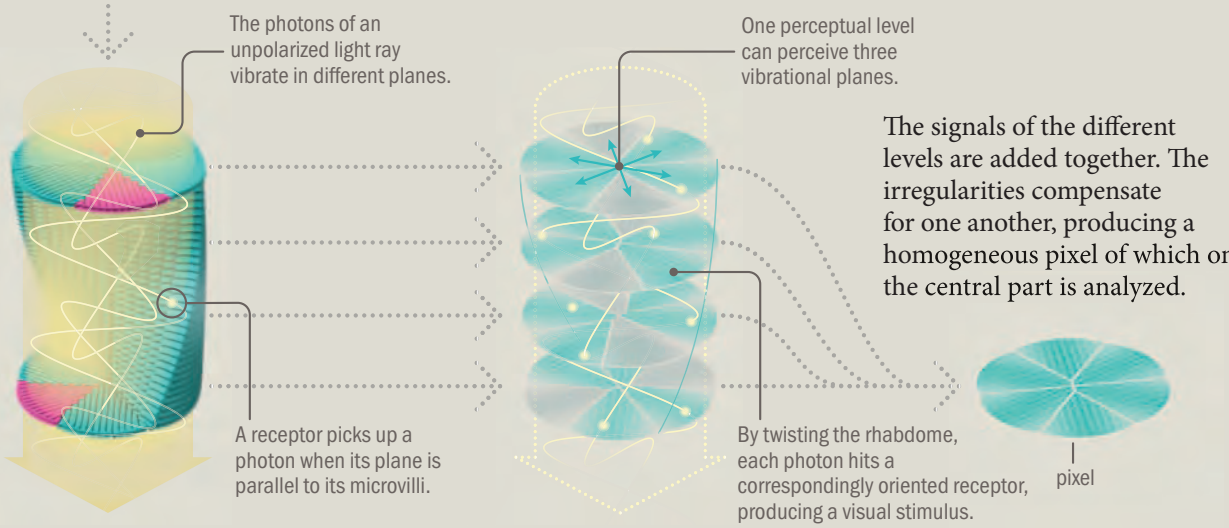
(1) The ants' compound eyes are composed of a large number of isolated individual eyes in apposition, known as ommatidia, which each produce a visual signal. A red wood worker ant's compound eye has between 580 and 700 ommatidia, most of which capture polarized light in the green-blue region of the visible light spectrum.



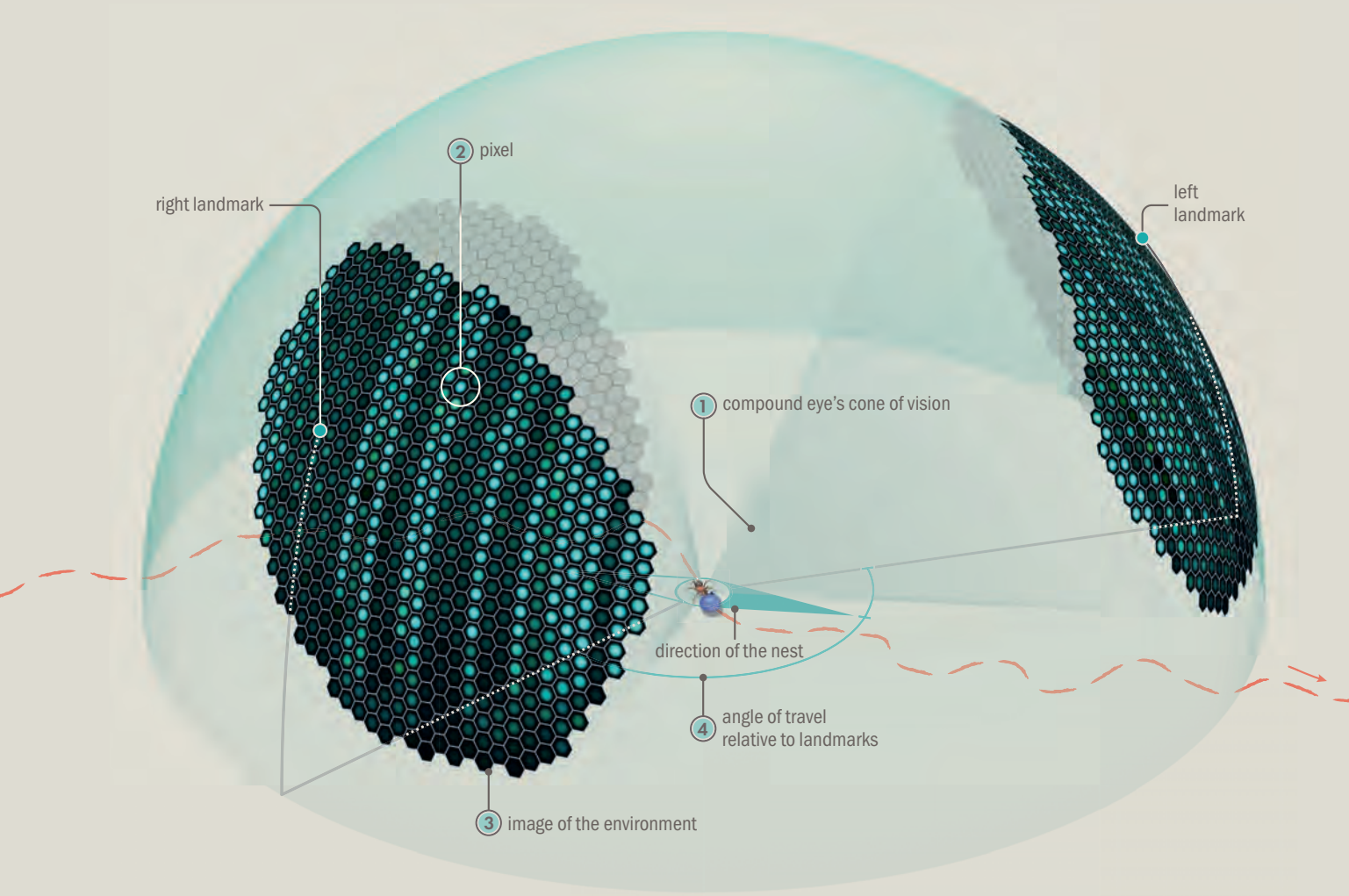
(2) The image that ants perceive of their environment is a grid of light and dark dots, each corresponding to what an ommatidium captures. Each ommatidium perceives the intensity of only a single ray of light.

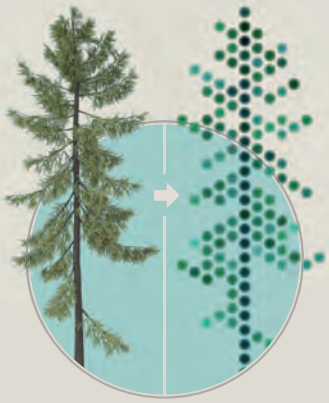


A large number of tubules stacked on top of each other constitute the ommatidia's light receptors. Each perceptual level is made up of six blue-green receptors and two UV receptors. Due to the twisting of the retinal cells, the receptors all have different orientations.

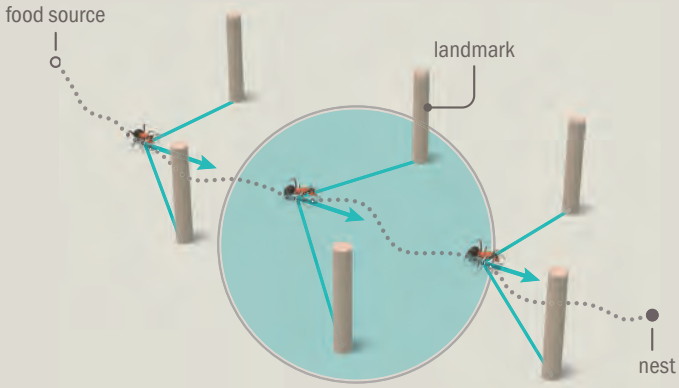


The signals of the different levels are added together. The irregularities compensate for one another, producing a homogeneous pixel of which only the central part is analyzed.





3 In the brain, the ommatidia's pixels are assembled to form a rough vertical image. The image of the forest is thus reduced to vertical silhouettes of the trunks and foliage patterns. The trunks' silhouettes serve as the scout's orientation landmarks.



4 The scout has recognized the nest's surroundings from previous outings. She memorized the trees and light sources, as well as the angle of her route. On the way back, she recognizes these landmarks and remembers the corresponding angle, and she takes the correct direction to return to the anthill.

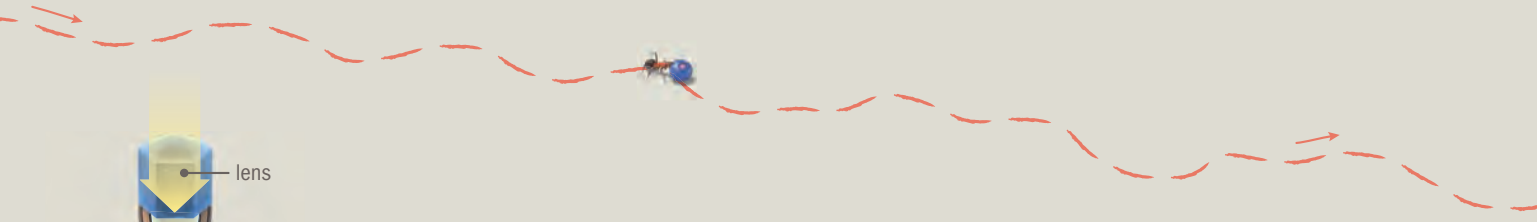
4.5 Celestial orientation

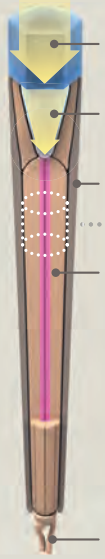
The position of the sun and its light polarization are landmarks that complete the visual orientation.

ultraviolet light perceived by the POL region

light spectrum perceived by the human eye

(1) With its compound eyes, the ant also perceives polarized light. This is the function of the ommatidia of the POL region on the upper edge of the eye, which specializes in the perception of UV light. Using polarized light, the ant determines the sun's position even when it is hidden.





lens

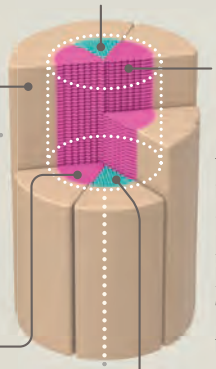
crystalline

pigment cells

retinal cells

neurons

(2) The image provided by ommatidia of the POL region is a pattern indicating the direction of the sky's polarization. These ommatidia are similar in structure to the others, but are specialized in the perception of polarized light.



microvilli fringe

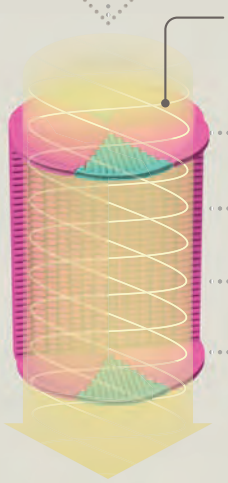
rhabdome

retinal cells

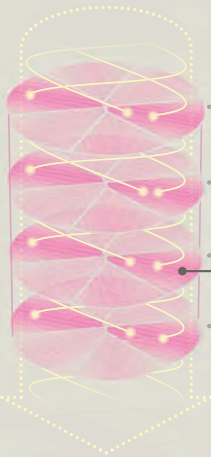
UV receptor

blue-green receptor

A large number of tubules stacked on top of each other constitute the ommatidia's light receptors. Each receiving level has two blue-green receptors and six UV receptors. The receptors are not inclined and therefore are all oriented in the same direction.

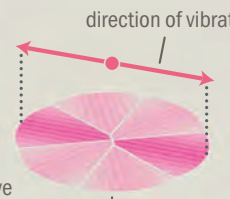


Almost all photons in a polarized light ray vibrate in the same plane.



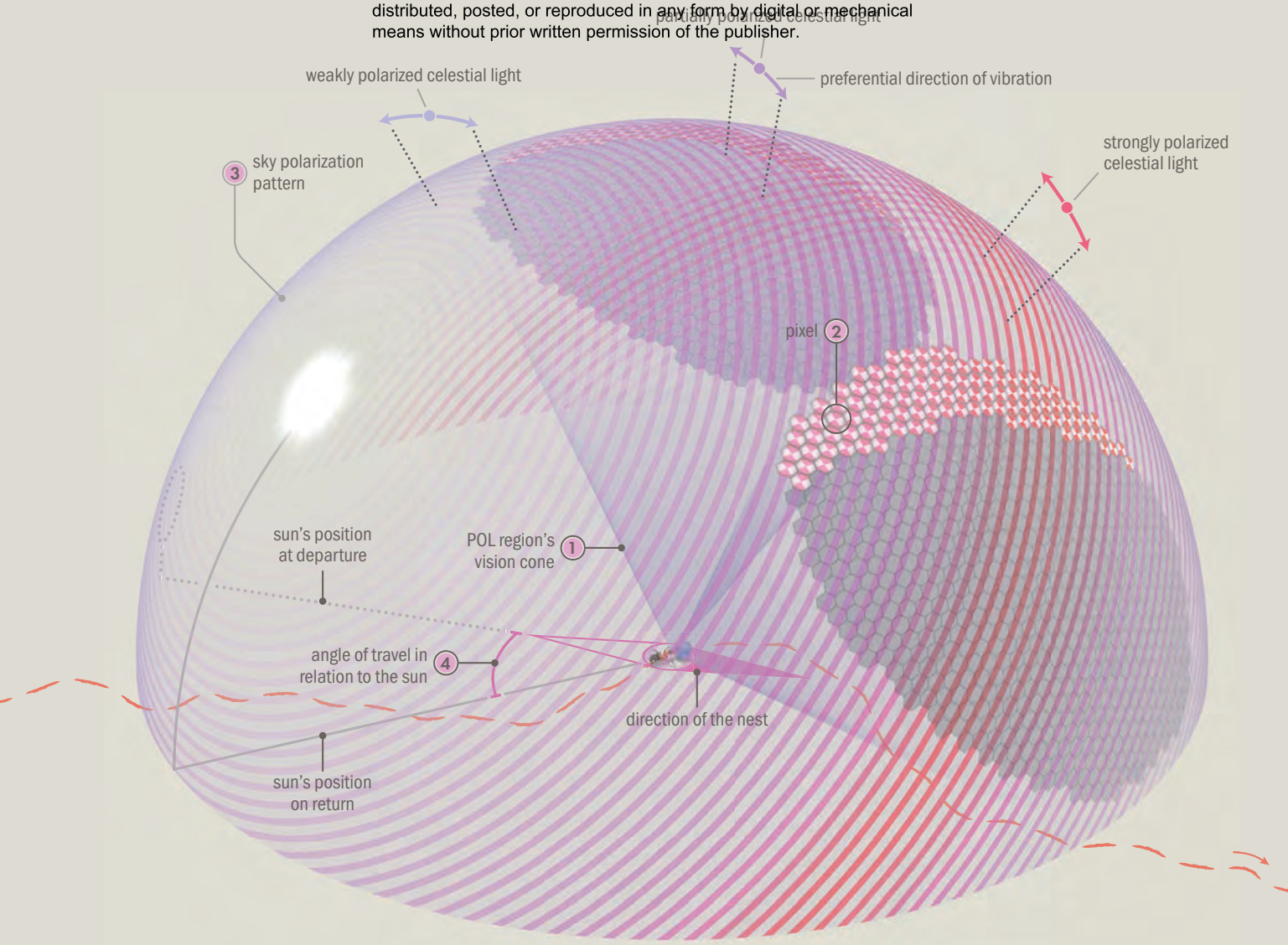
Since the receptors all have the same orientation, the polarized light produces the same stimulus on all reception levels.

At each level of reception, the polarized light stimulates only two receptors located in opposition. The signals of the different levels are added together to give a pattern, which makes visible the direction of the light ray's vibration.

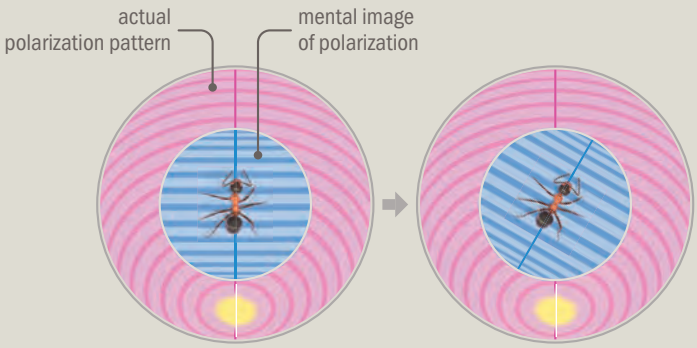


direction of vibration

pixel



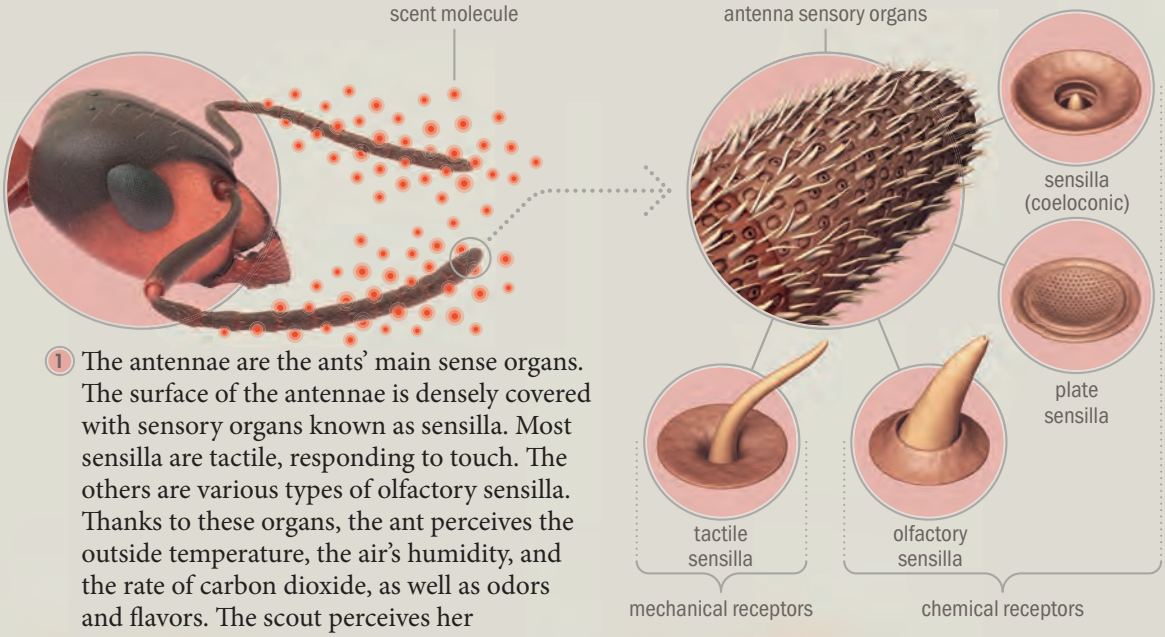
3 The sky polarization pattern is produced by the refraction and reflection of sunlight in the earth's atmosphere. Regardless of their angle of incidence, light rays are more or less polarized. The preferential direction of polarized light vibration is always perpendicular to the direction of the sun. The directions of the different light rays' polarization thus create a pattern of concentric circles around the sun, allowing the ant to orient itself.



4 The scout compares the sky polarization pattern with a simplified image stored in her brain. The degree of correspondence between the two images allows her to know the angle of her course in relation to the sun. This faculty serves as a compass to determine the direction of the nest: when leaving the nest, she goes toward the sun; on her return, she turns her back on it. But since the sun has changed its position in the meantime, she follows a certain angle with respect to it in order to take the right path.

4.6 Return to the nest

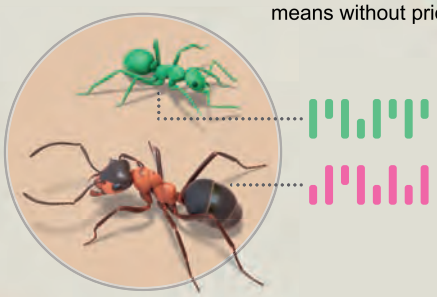
Arriving near the nest, the scout meets members of her colony. Their scent helps her find her way back.



1 The antennae are the ants' main sense organs. The surface of the antennae is densely covered with sensory organs known as sensilla. Most sensilla are tactile, responding to touch. The others are various types of olfactory sensilla. Thanks to these organs, the ant perceives the outside temperature, the air's humidity, and the rate of carbon dioxide, as well as odors and flavors. The scout perceives her congeners' scent and follows it.

2 The scent leads to a nearby trail, where she encounters another worker. The two ants feel each other and check each other's collective scent. If the two ants belong to the same nest, they separate and the scout follows the trail toward the nest.

3 When two workers from the same colony meet, they often exchange food, a behavior called trophallaxis. Encounters, checking each other's scent, and trophallaxis are repeated several times until the scout reaches the nest.



1 When the workers encounter a greater number of ants from a colony or a foreign species in unfamiliar territory, they adopt a defensive attitude and avoid them.

1 meeting a foreign ant

2 On familiar ground and in the presence of other members of their colony, the workers are more aggressive toward foreign ants, assuming a threatening posture and striving to drive them away.

3 In close proximity to the nest, the ants are very aggressive. Intruders are collectively attacked and killed before being transported to the nest, where they are used as food.

Once the scout arrives, she recruits other workers to lead them to the food source.

5.1 Recruiting help

In order to exploit the food source, the scout needs help. Back at the nest, she informs her congeners of her discovery and recruits foragers.

The blueberry she brought back arouses the attention of the colony. The neighboring workers rush in and start tearing up the blueberry.

The scout strives to transmit to her fellow congeners the excitement of her discovery. She regurgitates a drop of blueberry pulp and offers it to another worker, whose head she taps.

Along with these taps, the scout emits pheromones through the Dufour's gland in her abdomen. The odor molecules disperse in the air, causing a food alert.

(continued...)