



**THE INCREDIBLE**  
⚡ **POP-UP** ⚡  
**BUG**

**WITH 20 FLAPS  
TO LIFT AND  
GIANT POP-UPS!**

**BEN HOARE**

**JASMINE FLOYD**



# INVERTEBRATES RULE THE WORLD

Most animals don't have a backbone, or spine, like we do. They are called invertebrates. There is not a single bone anywhere in their body! This book looks at two kinds of these brilliant creatures: insects and arachnids (which include spiders and scorpions). One of their secret weapons is a tough outer covering, the exoskeleton, which gives them support and protection. They come in a mind-blowing variety of shapes and sizes, grow incredibly fast and eat just about anything. No wonder they are so successful.

**10**

**QUINTILLION**

10,000,000,000,000,000,000

This is the number of individual insects thought to be alive today. Insects outnumber us by 200 million to one!

"An insect is more complex than a star... and is a far greater challenge to understand."  
Martin Rees  
Astronomer Royal



## HABITATS

Insects and spiders live in almost every habitat - even in the ocean.

### AIR

Lots of insects fly, and some spiders are able to parachute.

### CITY

Urban areas can be great habitats for insects and spiders.

### FOREST

Forests have more different species than anywhere else!

### DESERT

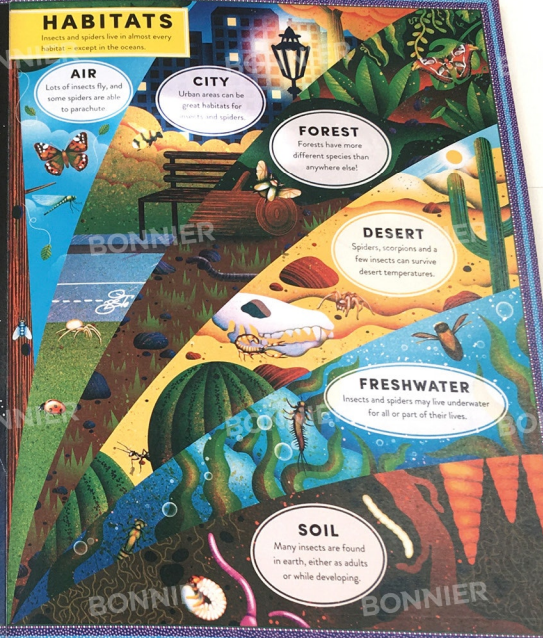
Spiders, scorpions and a few insects can survive desert temperatures.

### FRESHWATER

Insects and spiders may live underwater for all or part of their lives.

### SOIL

Many insects are found in earth, either as adults or while developing.



# INVERTEBRATES RULE THE WORLD

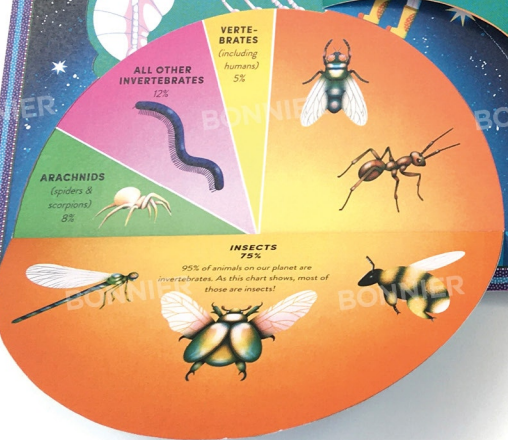
Most animals don't have a backbone, or spine, like we do. They're called invertebrates. There is not a single bone anywhere in their body. This book looks at two kinds of invertebrates: insects and arachnids (which include spiders and scorpions). One of their secret weapons is a tough, chitinous exoskeleton, which gives them support and protection. They also have a mind-blowing variety of shapes and sizes, grow incredibly fast and eat just about anything. No wonder they are so successful!

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"An insect is more complex than a human, and is a far greater intelligence than we understand."  
— Thomas Huxley, *Lessons in Evolution*, 1863



95% of animals on our planet are invertebrates. As this chart shows, most of those are insects!

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# INSECT ANATOMY

Every insect, whatever shape or size it is, has three main body sections. These are the head, followed by the thorax, and finally the abdomen. The thorax is the part with the legs and wings of the insect (if any). The abdomen usually the largest section, contains the organs for digesting and breathing.

## HEAD

Most insects' head is the largest part of their body. It is the part where the insect's brain, eyes and a pair of feelers, or antennae, which the insect uses to touch, smell and taste things. Some insects have up to three pairs of eyes on top of their head, though they are far smaller.



**ORCHID BEE**  
*Euglossa*

Eyes and jaws take up much of the bee's head.

## THORAX



**COMMON WASP**  
*Vespa vulgaris*

Wings have a defined thorax, where the legs and wings attach.

The middle part of an insect can often seem quite small, but it's incredibly important. It is the insect's powerhouse, packed with powerful muscles to move the legs and wings.

The thorax also has a feeding tube, blood vessels and nerves that connect the head and abdomen.

## FIVE-HORNED INOCEROS BEETLE

*Eupacris brachycornis*

## ABDOMEN

The abdomen is where an insect digests and stores its food, and produces waste products. Also here is the insect's main heart - unlike us, it has several smaller ones too, in other parts of the body! The reproductive organs are normally near the tail end of the abdomen.



**FOOTROLLER HOVERFLY**  
*Tringulobus parvulus*

Each kind of hoverfly has a different pattern on its abdomen.

## LEGS

Insects always have six legs, and this is one of the smartest ways to tell if you are looking at an insect or something else. They come in stiff sections, which are linked by flexible joints, with sharp claws at the tip. Tiny hairs covering the legs help detect movement.

## FIRE BUG

*Pyrrhocoris apterus*

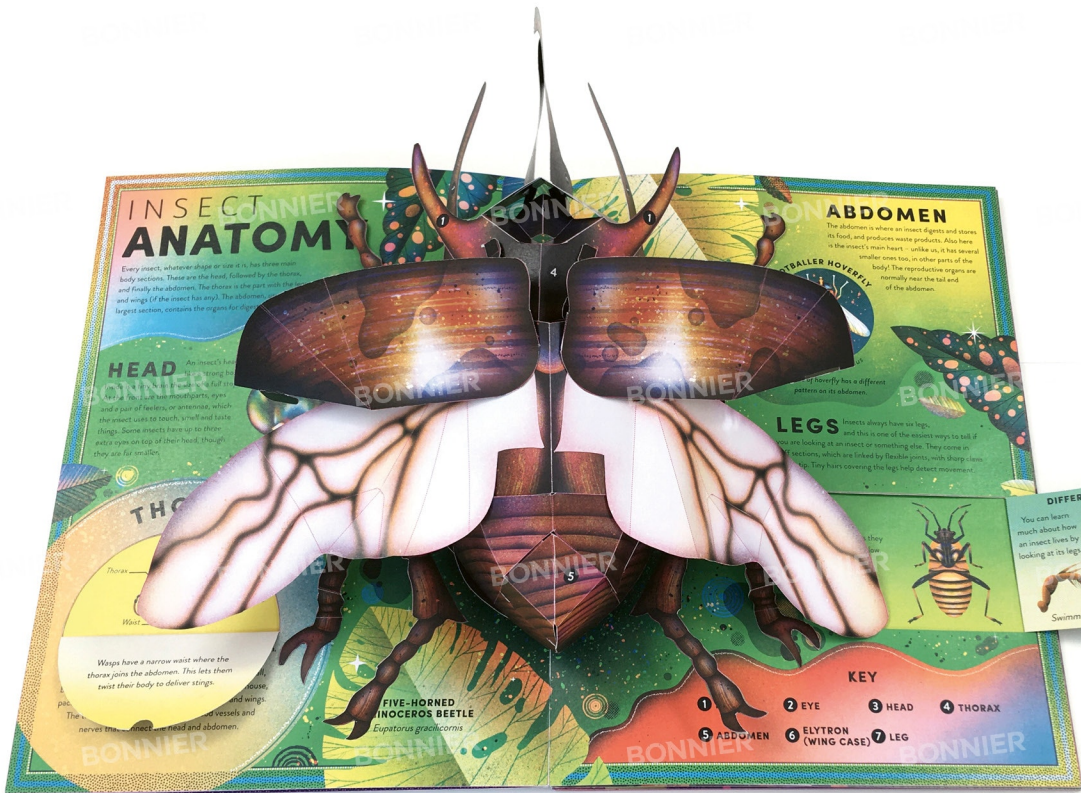


Here we see the firebug's legs from above.

## KEY

- 1 HEAD
- 2 EYE
- 3 HEAD
- 4 THORAX
- 5 ABDOMEN
- 6 ELYTRON (WING CASE)
- 7 LEG





# INSECT ANATOMY

Every insect, whatever shape or size it is, has three main body sections. These are the head, followed by the thorax, and finally the abdomen. The thorax is the part with the legs and wings (if the insect has any). The abdomen, the largest section, contains the organs for digestion.

## HEAD

An insect's head is the strongest part of its body. It has a pair of large compound eyes, a pair of antennae, and a pair of feelers, or antennae, which the insect uses to touch, smell and taste things. Some insects have up to three pairs of eyes on top of their head, though they are far smaller.

## THORAX

The thorax is the middle section of the insect's body. It is where the legs and wings are attached. It also contains the heart and the trachea, which are the insect's respiratory system.

Wasp have a narrow waist where the thorax joins the abdomen. The ants have a similar waist. The bees have a wider waist. The flies have a very narrow waist. The beetles have a very thick waist.

**FIVE-HORNED INOCEROS BEETLE**  
*Eupatorus gracicornis*

## ABDOMEN

The abdomen is where an insect digests and stores its food, and produces waste products. Also here is the insect's main 'sex' - unlike us, it has several smaller ones too, in other parts of the body. The reproductive organs are normally near the tail end of the abdomen.

## LEGS

Insects always have six legs, and this is one of the easiest ways to tell if you are looking at an insect or something else. They come in different shapes and sizes, and are used for different purposes. Some legs are used for walking, some for jumping, some for digging, and some for swimming.

### DIFFERENT TYPES OF LEGS

You can learn much about how an insect lives by looking at its legs.



### KEY

- 1 ANTENNAE
- 2 EYE
- 3 HEAD
- 4 THORAX
- 5 ABDOMEN
- 6 ELYTRON (WING CASE)
- 7 LEG



# HOW INSECTS WORK

The life-support systems in insects are fascinating. Their bodies are tiny, yet they breathe and circulate the insect equivalent of blood in 1/100th of a second. They have 360° vision and can detect the slightest movement in a split-second. Their antennae send vast amounts of information to their brain. And their mouthparts are perfectly adapted to their food.

## CIRCULATION

Instead of blood, insects have hemolymph. It's green or yellow and flows throughout the body, rather than in veins and arteries.

## WESTERN HONEYBEE

*Apis mellifera*

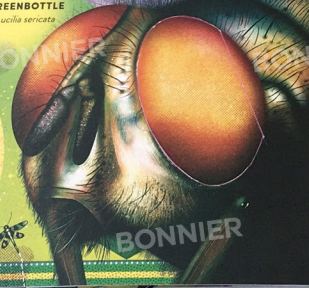


## BREATHING

Insects don't breathe in and out using lungs. Air enters microscopic holes, called spiracles, all over their bodies. It passes straight into tubes known as trachea, which deliver it to organs that need it.

## GREENBOTTLE

*Lucilia sericata*



## HOW INSECTS SEE

Insects have a pair of eyes made from many tiny units called ommatidia, which detect light and movement. We call these compound eyes. Some insects also have simple eyes, which are single, not in pairs.



## ANTENNA

Antennae come in lots of shapes. Insects use them to find food and partners, and to pick up chemical messages from each other.



## BEETLE MOUTH

### MOUTHPARTS

Not every insect has a working mouth (some never feed!). Those that do have an amazing variety of mouth structures, according to what they eat. They taste and smell with their mouths, too.



Beetle - chewing

A mosquito stabs skin and sucks blood with its mouthparts, but those of other insects may work like bolt cutters, grinders, saws, spades, straws or sponges!



## HOW INSECTS WORK

A huge network of tubes takes the essential oxygen. The same system gets rid of the insect's waste carbon dioxide.



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#### COMMON KATYDID

*Paranepytus ornaticollis*



#### RED WOOD ANT

*Formica ruginopilis*



#### SILK MOTH

*Bombyx mori*



#### BLUE LONGHORN BEETLE

*Rosalia katesi*



#### RED WOOD ANT

*Formica ruginopilis*



#### SILK MOTH

*Bombyx mori*



### MOSQUITO MOUTH

#### MOUHPARTS

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Mosquito -  
stabbing and  
sucking





# HOW INSECTS FLY

Insects can zip through the air at speed, perform stunning aerial moves, climb higher than mountains and cross oceans. They were the first animals to take to the skies, around 350-400 million years ago, and are the only invertebrates with wings. Most have two pairs, but flies use a single pair and some insects in the oceans have to also use their wings to make towards a friend to display to each other.

## FLIGHT MUSCLES

In most insects, special muscles stretch and squeeze the thorax to move the wings up and down. They work fast, which enables rapid wing beats – midges can do over 1,000 beats a second!



**WHITE-TAILED BUMBLEBEE**  
*Bombus lucorum*

**GLOBE SKIMMER DRAGONFLY**  
*Pantala flavescens*

## DRAGONFLY

Unlike other insects, dragonflies have separate muscles fixed to each wing. This allows all four wings to move on their own, giving great acceleration and agility.

## IN FLIGHT

To take off, a beetle flips open its shield-like elytra, then unfurls its two working wings.

## TAKE OFF

To take off, a beetle flips open its shield-like elytra, then unfurls its two working wings.

## BUTTERFLY

Butterflies and moths have large, flat wings. Minute scales on the wings produce colours and patterns, which are used to show off and attract mates as well as camouflage.

**MONARCH BUTTERFLY**  
*Danaus plexippus*

## SWARMING

Some butterflies fly long journeys, or migrations, usually to avoid cold winters. Millions of monarch butterflies swarm south from Canada and northern USA to California and Mexico each year, gathering in huge swarms.

## FLYING FAMILIES

The main groups of flying insects are dragonflies and damselflies, butterflies and moths, flies, grasshoppers and crickets, beetles, bugs, and ants, bees and wasps.





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WHITE-TAILED BUMBLEBEE  
*Bombus lucorum*

GLOBE SKIMMER DRAGONFLY  
*Pantodon jacksoni*

7-SPOT LADYBIRD  
*Coccinella septempunctata*

### DRAGONFLY

Unlike other insects, dragonflies have separate muscles fixed to each wing. This allows all four wings to move on their own, giving great acceleration and agility.

### BEETLES

In beetles, the front pair of wings has turned into hard cases called elytra. They protect the beetle and hide the rear wings, folded beneath.

MONARCH BUTTERFLY  
*Danais plexippus*

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Some butterflies fly long journeys, or migrations, usually to avoid cold winters. Millions of monarch butterflies swarm north from Canada and northern USA to California and Mexico each year, gathering in huge swarms.



## HOW INSECTS LIVE

Insects hatch from eggs, then develop in one of two ways. They may live as a larva, a kind of juvenile stage, and go through a spectacular transformation into an adult. Or they have several juvenile stages and change into adults gradually. Many species live alone, but ants, termites and some bees and wasps form large societies called colonies.



**AFRICAN TERMITE MOUND**



### COLONIES

Termites work together as a team to build, look after and defend a huge nest mound. Up to 5 million of them live inside! A queen lays all of the colony's eggs. Her workers are all non-breeding females.

### CAMOUFLAGE

Lots of insects are masters of disguise. Their body shape and colour helps them blend into their background to escape predators. The morpheo butterfly has startling blue upper wings, but the undersides are camouflaged to look like dead leaves.

**MORPHO BUTTERFLY**

*Morpho peacock*



### INSECT LOOKALIKES



**HORNET MOTH**

*Sesia apiformis*

One way to deal with enemies is to look like something more dangerous. Many insects use this strategy, called mimicry. The lookalike insects are harmless, but mimic the appearance of species that are poisonous or have stings.



**PAINTED LADY**

*Vanessa cardui*

### CHANGING SHAPE

Most insects, including butterflies, become adults by complete metamorphosis.



**GREEN STINK BUG**

*Chinavia hilaris*

### GROWING UP

Some insects, like bugs, grow into adults in a step-by-step process called incomplete metamorphosis.



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**EUROPEAN HORNET**  
*Vespa crabro*

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*Elanica carminostemata*, *Ichneumonidae*, *wasps*  
*Velocipes monostictus*, *honey bees*, *Hymenoptera*  
*Lasius niger*, *Ichneumonidae*, *wasps*, *Hymenoptera*  
*Sphecus*, *Ichneumonidae*, *wasps*, *Hymenoptera*  
*Stenobothrus*, *Ichneumonidae*, *wasps*, *Hymenoptera*



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# SPIDER & SCORPION ANATOMY

Spiders and scorpions are arachnids: arthropods with eight legs and two body sections. At the front, the head and thorax are joined to form the cephalothorax, behind which is the abdomen. They are all predators, with venom to overpower prey. Spiders deliver it through sharp fangs, while scorpions use the curved stinger at the end of their body called the pincers. They often fear spiders and scorpions, but they are beautiful animals that only attack if provoked.

## VENOM

Spider and scorpion venom is toxic and causes paralysis. It is produced by venom glands and stored until needed, when it flows along tubes, called venom ducts, and out through the fangs or stinger and at us.

**REDBACK SPIDER**  
*Latrodectus mactans*



**EMPEROR SCORPION**  
*Pandinus imperator*



- KEY**
- 1 PINCER
  - 2 LAW
  - 3 STING
  - 4 CEPHALOTHORAX

## HOW SPIDERS SEE

Most spiders have eight eyes, arranged in two rows, yet can't see well. They rely on sensitive hairs to feel things move. But the front and jumping spiders can see better.



**REGAL JUMPING SPIDER**  
*Phidippus regalis*

## MALE OR FEMALE

**GIANT HOUSE SPIDER**  
*Tigraeus duellax*



MALE

FEMALE

Female spiders are much bigger than males – in fact, they sometimes eat them! Another way to tell the sexes apart is by their palps, which are leg-like structures each side of the jaws. In males, they are much smaller.



- KEY**
- 1 PALP
  - 2 FANG
  - 3 EYE
  - 4 CEPHALOTHORAX
  - 5 LEG
  - 6 ABDOMEN

**SPINNERET** (to spin a web)



## HOW SPIDERS & SCORPIONS LIVE

Insects hatch from eggs, then develop in one of two ways. They may live as a larva, a kind of juvenile stage, and go through a spectacular transformation into an adult. Or they have several juvenile stages and change into adults gradually. Many species live alone, but ants, termites and some bees and wasps form large societies called colonies.



### MATING DANCE

Spiders and scorpions often do a courtship dance before mating. Scorpions may lock pincers during their dance, and the male warns stings his partner with a mild dose of venom. Weirdly, it seems to calm her.



**DEATHSTALKER**  
*Leiurus quinquestriatus*

### DEVOTED MOTHERS

Like insects, spiders hatch from eggs, and the female spider may carry her spiderlings on her back. Scorpion mothers do this too, except they give birth to live young. The scorpions have a soft exoskeleton, so need her protection.

### SUNNY FUNNEL-WEB SPIDER

*Atrax robustus*

### DEADLY TRAP

Many spiders hide under rocks or in burrows and wait for unwary prey to pass by. Species like the Sydney funnelweb set tripwires made of silk. When these are triggered, they rush from their hiding place to seize their meal.

### SUPER SILK

Every spider produces silk. This wonder material is astonishingly stretchy, and, weight for weight, stronger than steel! Silk consists of proteins. It's made by sil glands, the T-shaped organs of a spider's abdomen by six spinnerets, which look like little moving fingers. Many spiders use silk to spin webs, including wheel, sheets and funnels, to catch prey.

### USES OF SILK

Spiders make several varieties of silk for different jobs. Apart from spinning webs, they use it to line burrows, wrap up prey, form parachutes and abseil through the air. The bolas spider swings a line of silk with a gooey blob at the end to catch its prey.

### GARDEN ORB WEAVER

*Araneus diadematus*



**BOLAS SPIDER**  
*Cladomela debilis*





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Spiders often wrap prey in silk to stop it moving before they inject it with venom. Wrapped prey can also be stored like that to eat later!



**BOLAS SPIDER**  
*Cidometes detrita*





# BONNIER HUMANS & INSECTS

Insects shape our world. They are food for many other animals. They pollinate flowers. They feed on rotting plants, dead bodies and dung, to act as a natural recycling service, returning nutrients to the soil. They provide us with many useful products. And they inspire new technology. But insect numbers are falling. Today, over 40% of insect species are at risk of extinction. We must do everything we can to save these amazing, beautiful and vital creatures.

## POLLINATION



Flowering plants need to transfer pollen (tiny grains they use to reproduce) from male to female flowers. This is pollination – and insects are brilliant at it! Pollen sticks to hairs on their legs and body and they carry it from flower to flower. In return, they drink plants' sugary nectar. Bees, wasps, butterflies, moths, flies, beetles and bugs are all important pollinators.



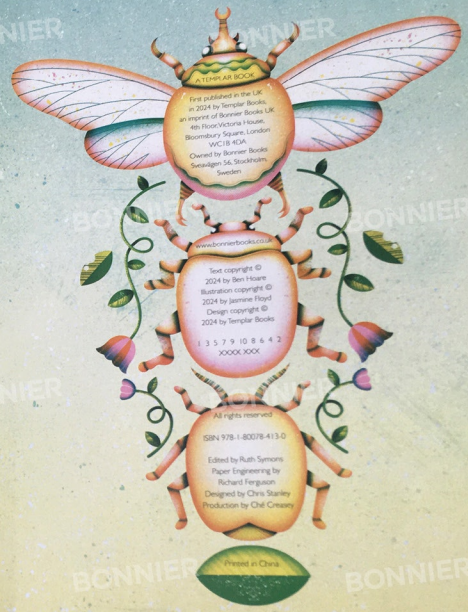
## PRODUCTS FROM INSECTS

Insects have always been a source of food and materials for humans. Five thousand years ago, the Chinese discovered that silk from certain moth caterpillars can be turned into thread. Honeybees give us honey and beeswax. Tiny scale insects are the main ingredient in cochineal, a red dye. People even eat insects, and mealworms (larvae larvae) and crickets can be ground into flour for baking.



## INSECTS AND THE FUTURE

Insects are giving scientists and engineers lots of ideas. The super-mobile wings of dragonflies inspire the design of micro-drones. And researchers have discovered that waxworms (moth caterpillars) have saliva that can break down plastic. One day, we may be able to extract or copy the chemicals that do this to recycle plastic waste. Who knows what insects might help us do next?



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