

ALL THE WAY DOWN DINOSAURS

AND OTHER PREHISTORIC CREATURES



ALEX WOOLF & ISOBEL LUNDIE



THE TRIASSIC PERIOD



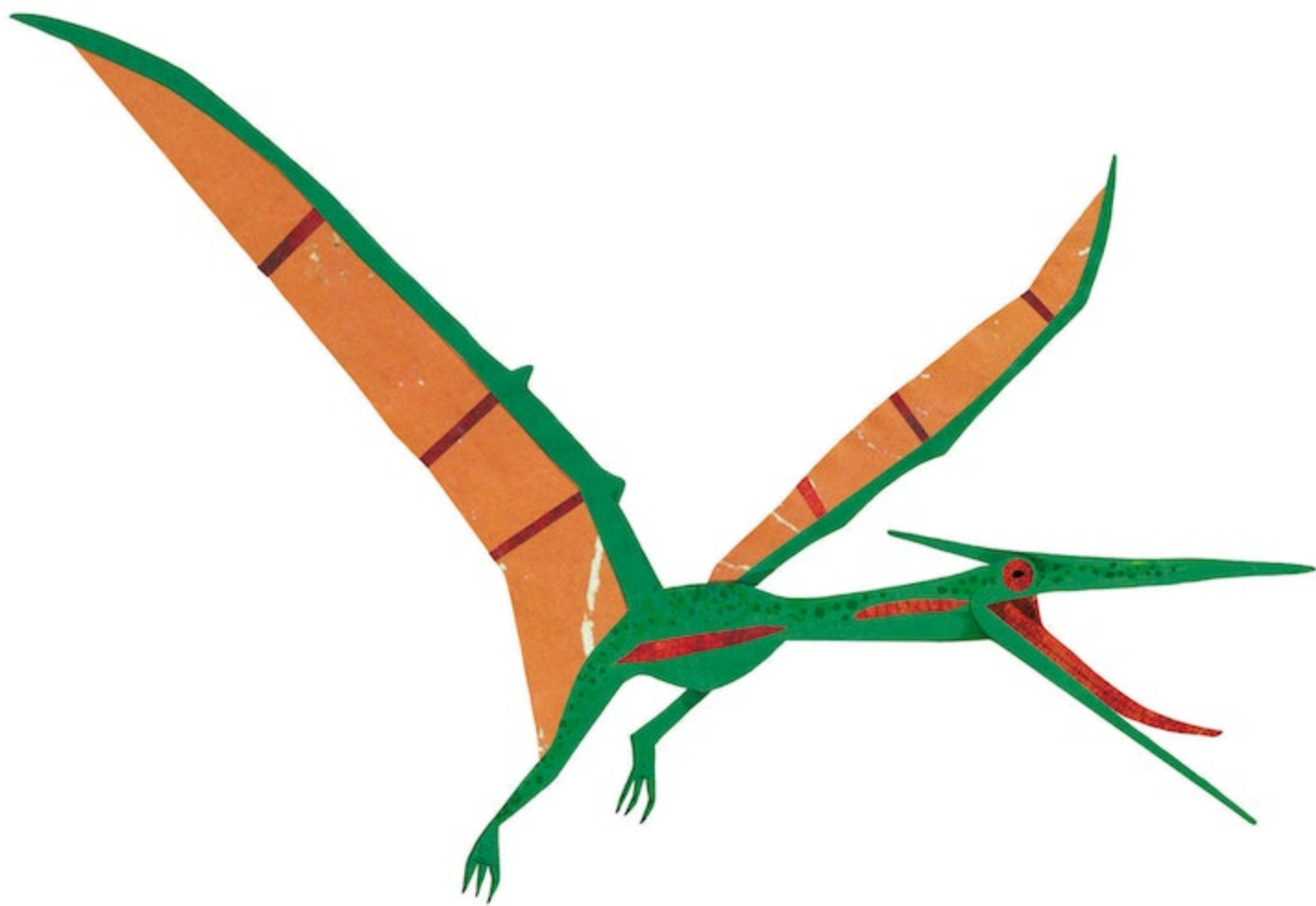
THE JURASSIC PERIOD



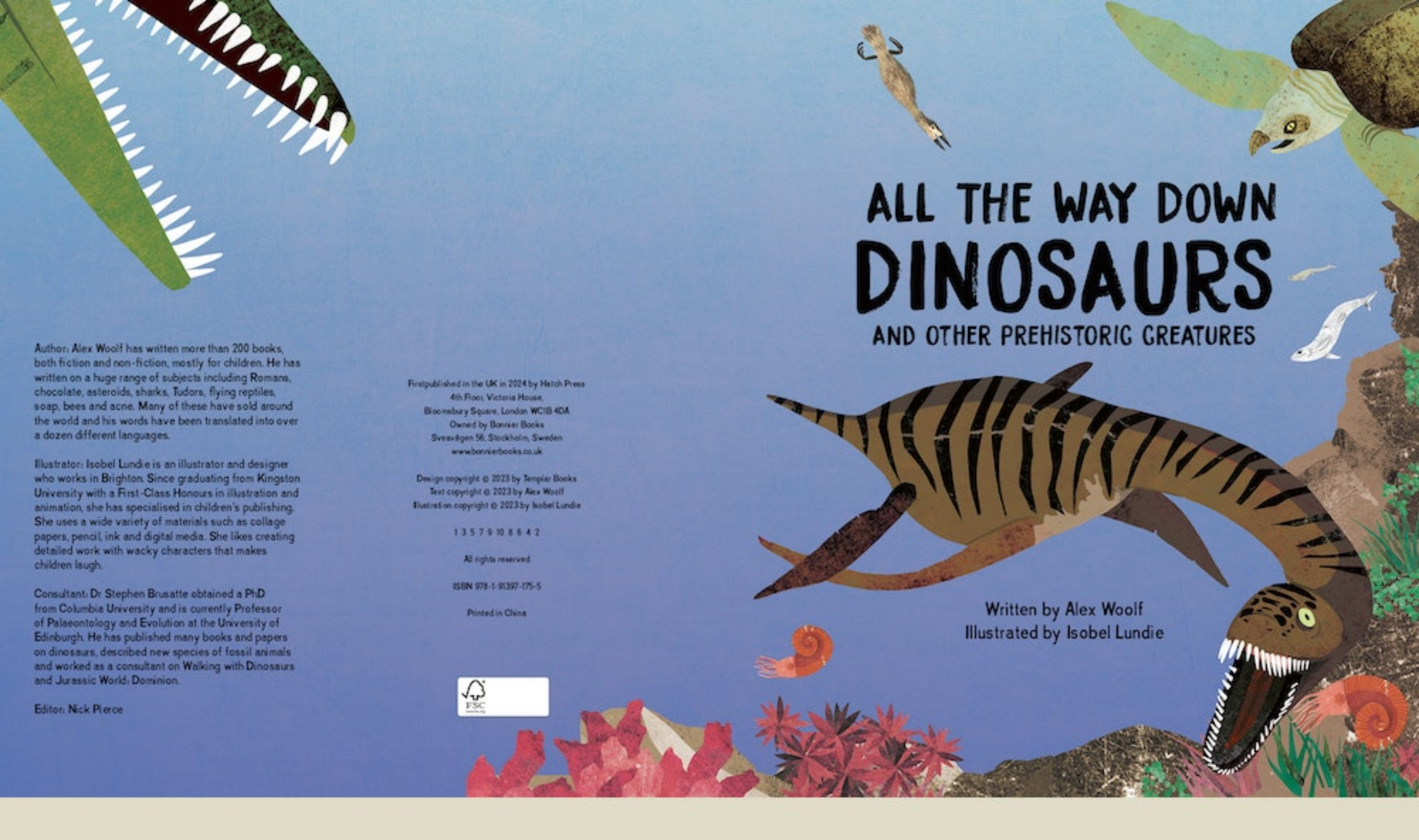
THE CRETACEOUS PERIOD



ALL THE WAY DOWN
DINOSAURS
AND OTHER PREHISTORIC CREATURES



Hatch



ALL THE WAY DOWN DINOSAURS

AND OTHER PREHISTORIC CREATURES

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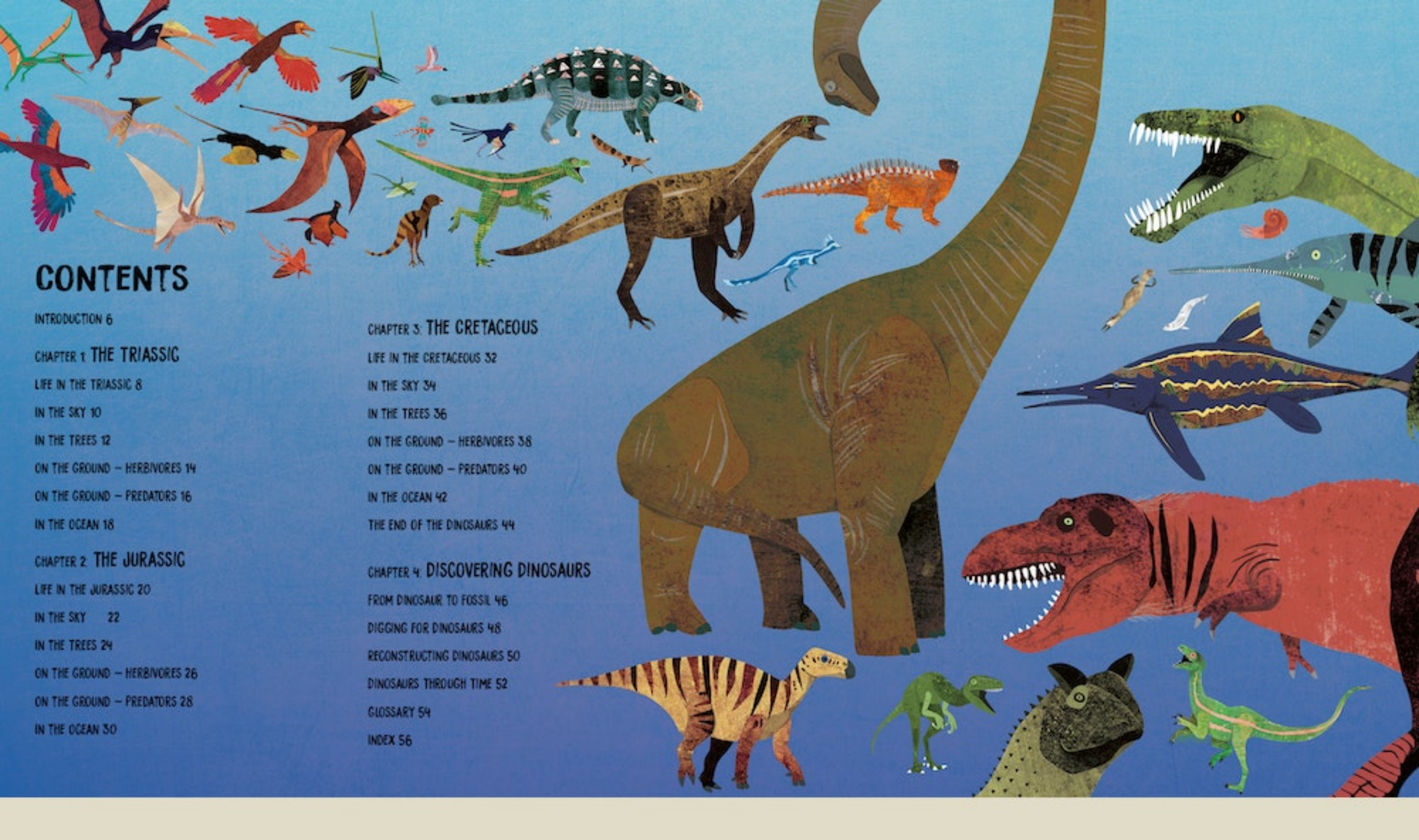
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Illustrated by Isobel Lundie



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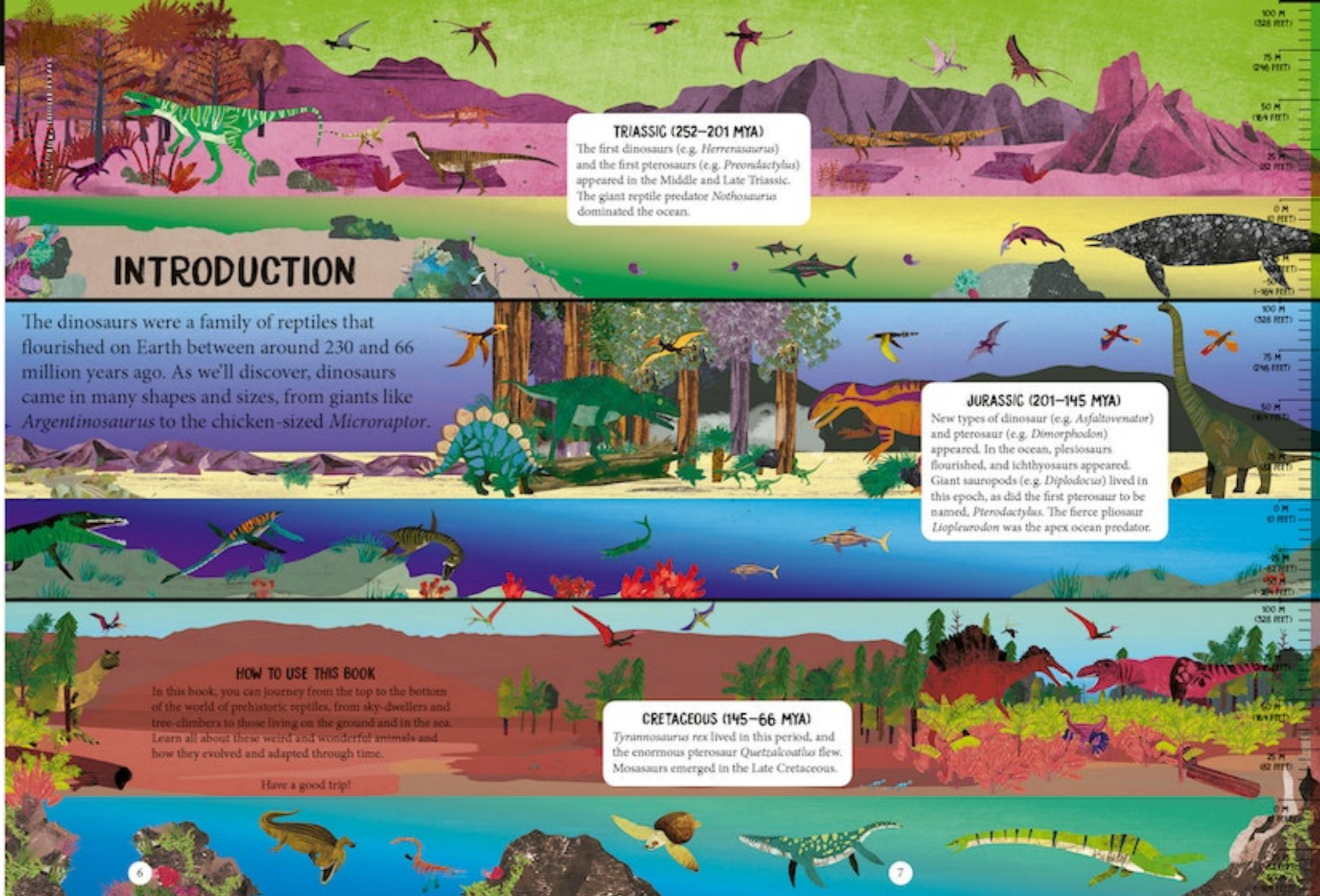
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1 THE WORD 'DINOSAUR' MEANS 'TERRIBLE LIZARD' IN GREEK. HOWEVER, DINOSAURS WEREN'T LIZARDS, BUT A SEPARATE FAMILY OF REPTILES. HUNDREDS OF SPECIES OF DINOSAURS LIVED THEIR LIVES ON EARTH OVER MILLIONS OF YEARS, YET THEY ALL HAD PARTICULAR CHARACTERISTICS IN COMMON.

2 DINOSAURS HAD LEGS POSITIONED BENEATH THEIR BODIES, UNLIKE TODAY'S LIZARDS AND CROCODILES, WHICH HAVE THEIR LEGS STICKING OUT TO THE SIDES. THIS GAVE DINOSAURS AN UPRIGHT STANCE. IT ALSO MEANT THEIR WEIGHT WAS BETTER SUPPORTED AND THEY NEEDED LESS ENERGY TO MOVE AROUND.

3 WHILE DINOSAURS DOMINATED THE LAND, PTEROSAURS RULED THE AIR. THESE FLYING REPTILES SHARED A COMMON ANCESTOR WITH THE DINOSAURS AND COULD BE EVERY BIT AS FEROCIOUS. REPTILES ALSO ROAMED THE OCEAN, INCLUDING LONG-NECKED PLESIOSAURS AND FIERCE, FAST-SWIMMING MOSASAURS. WE'LL BE MEETING ALL THESE AND MORE.



INTRODUCTION

The dinosaurs were a family of reptiles that flourished on Earth between around 230 and 66 million years ago. As we'll discover, dinosaurs came in many shapes and sizes, from giants like *Argentinosaurus* to the chicken-sized *Microraptor*.

TRIASSIC (252–201 MYA)

The first dinosaurs (e.g. *Herrenasaurus*) and the first pterosaurs (e.g. *Preondactylus*) appeared in the Middle and Late Triassic. The giant reptile predator *Nothosaurus* dominated the ocean.

JURASSIC (201–145 MYA)

New types of dinosaur (e.g. *Asfaltovenator*) and pterosaur (e.g. *Dimorphodon*) appeared. In the ocean, plesiosaurs flourished, and ichthyosaurs appeared. Giant sauropods (e.g. *Diplodocus*) lived in this epoch, as did the first pterosaur to be named, *Pterodactylus*. The fierce plesiosaur *Liopleurodon* was the apex ocean predator.

HOW TO USE THIS BOOK

In this book, you can journey from the top to the bottom of the world of prehistoric reptiles, from sky-dwellers and tree-climbers to those living on the ground and in the sea. Learn all about these weird and wonderful animals and how they evolved and adapted through time.

Have a good trip!

CRETACEOUS (145–66 MYA)

Tyrannosaurus rex lived in this period, and the enormous pterosaur *Quetzalcoatlus* flew. Mosasaurs emerged in the Late Cretaceous.

LIFE IN THE TRIASSIC

The Triassic Period (252–201 million years ago) began after a series of massive volcanic eruptions devastated life on this planet, wiping out up to 90% of all species. It took the planet millions of years to recover from 'the Great Dying', and for new species, including dinosaurs and pterosaurs, to emerge.

PANGAEA

During this period, all of Earth's land area was concentrated in one vast supercontinent called Pangaea, surrounded by a world-ocean known as Panthalassa. Towards the end of the Triassic, Pangaea began to break up: Gondwana (today's Africa, South America, Antarctica, India and Australia) split from Laurasia (modern Eurasia and North America).

THE WORLD AT THE START AND END OF THE TRIASSIC



252 MILLION YEARS AGO



201 MILLION YEARS AGO

CLIMATE

This was a hot, dry period in Earth's history, and much of Pangaea's interior was desert. Yet there were tropical conditions near the equator, and the poles were moist and temperate, providing a suitable climate for forests and animal life, including reptiles.

END OF THE TRIASSIC

Another great extinction event ended the Triassic. It was probably caused by an increase in volcanic eruptions. These sent vast amounts of carbon dioxide and methane into the atmosphere, leading to massive global warming and the destruction of around 75% of all life on Earth.



EARLY TRIASSIC

SYNAPSIDS

During the Early Triassic, synapsids dominated. Some of them looked like reptiles, but they were actually ancestors and cousins of mammals.

PLANT LIFE

The fertile regions of the Triassic were dominated by vast forests of conifer trees, ferns and other seed plants. Grass and flowering plants had yet to evolve.

MIDDLE TRIASSIC

ARCHOSAURS

By the Middle Triassic, synapsids were in decline, replaced by archosaurs (ancestors of dinosaurs) and the first dinosaurs.

MANDASUCHUS
(an archosaur)



LATE TRIASSIC

PTEROSAURS

In the Late Triassic, the first pterosaurs appeared.



IN THE SKY

PTEROSAURS APPEARED AROUND 228 MILLION YEARS AGO IN THE LATE TRIASSIC. THE WORD PTEROSAUR MEANS 'WINGED LIZARD'. THEY WERE THE FIRST ANIMALS TO FLY APART FROM INSECTS, USING WINGS MADE OF SKIN, SUPPORTED BY A SINGLE, LONG FINGER. PTEROSAURS WERE NOT DINOSAURS, BUT CLOSE COUSINS OF THEM.

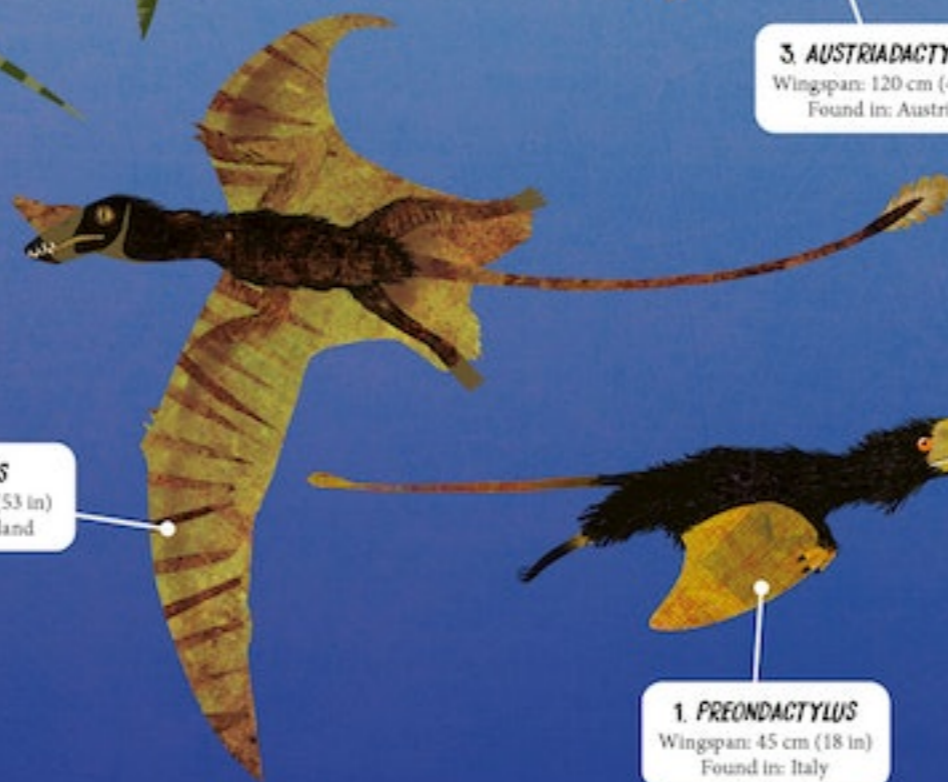
- 1. PREONDACTYLUS** (Lived: from around 228 mya)
Preondactylus had perhaps the shortest wingspan of any pterosaur. It had a long beak and tail, and small, pointed teeth, and ate fish and maybe insects, but was sometimes preyed on by fish, too. It lived around 228 million years ago, making it one of the first known pterosaurs.
- 2. PETEIOSAURUS** (Lived: 221–210 mya)
One of the smallest and earliest known pterosaurs, *Peteiosaurus* had a short wingspan – about the size of a magpie's – and a long, bony tail. With its small, conical, needle-sharp teeth, it probably preyed on species of insects.
- 3. AUSTRIADACTYLUS** (Lived: 215 mya)
Austriadactylus had a lengthy skull with a bony crest that rose 2 cm (0.79 in) from its snout and may have been used for display. Its strong upper arms suggest it was a good flyer. In the front of its upper jaw were five large, curving teeth for grabbing prey.
- 4. EUDIMORPHODON** (Lived: 210–203 mya)
This small pterosaur had a long, bony tail, a large head and a short neck. Its jaws contained 110 teeth. The front teeth were long and sharp, suggesting the pterosaur would swoop low over lakes and rivers to catch fish.
- 5. CAVIRAMUS** (Lived: 205 mya) This long-winged pterosaur had a bony crest on top of its head. Its sharp, fang-like teeth at the front of its jaws indicated it hunted for fish in similar style to its close cousin, *Eudimorphodon*. However, its long limbs suggest it may also have spent time foraging for food on the ground.



2. PETEIOSAURUS
Wingspan: 60 cm (24 in)
Found in: Italy



3. AUSTRIADACTYLUS
Wingspan: 120 cm (47 in)
Found in: Austria



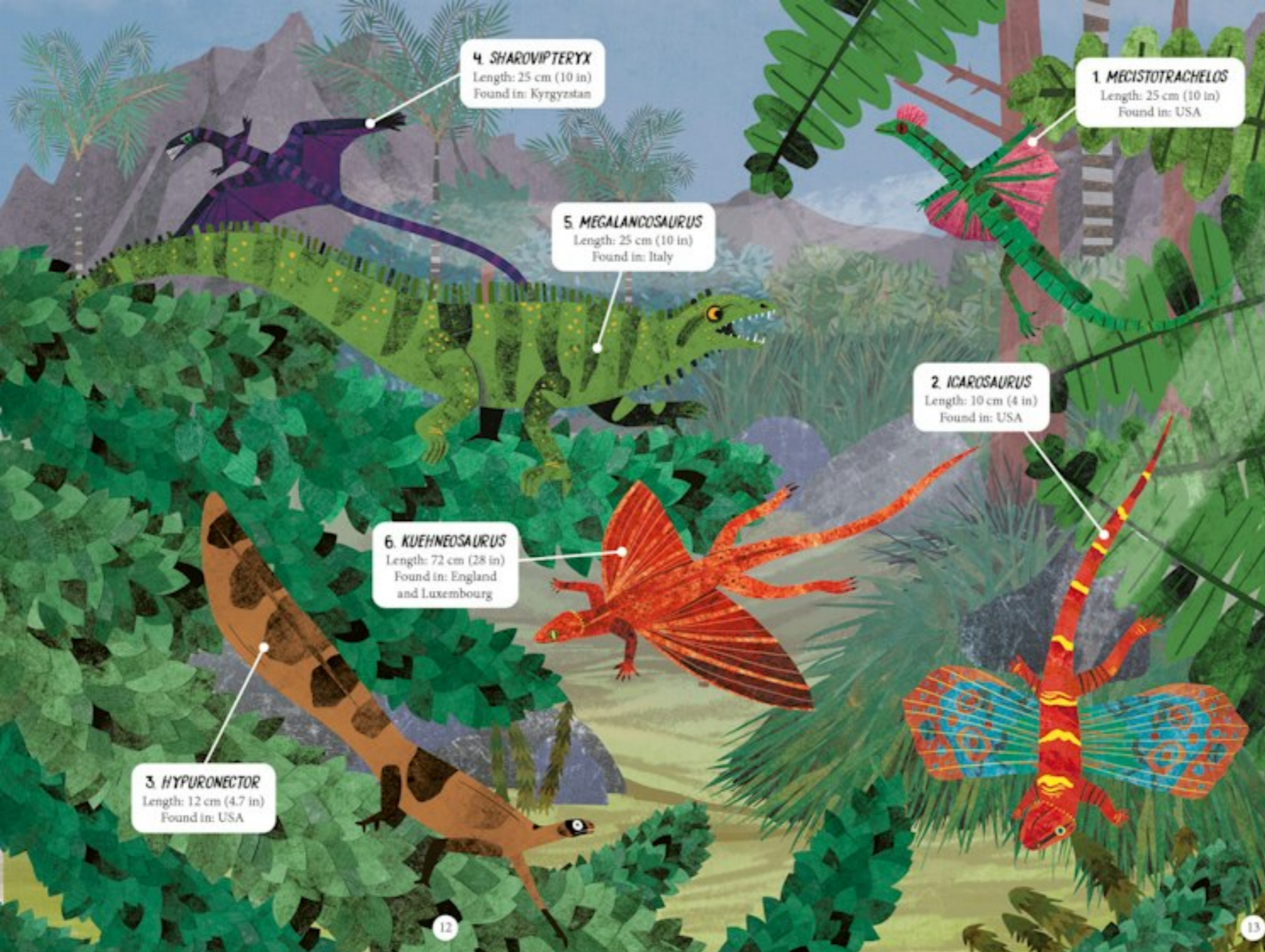
4. EUDIMORPHODON
Wingspan: 100 cm (39 in)
Found in: Italy



5. CAVIRAMUS
Wingspan: 135 cm (53 in)
Found in: Switzerland

1. PREONDACTYLUS
Wingspan: 45 cm (18 in)
Found in: Italy





4. SHAROVIPTERYX
Length: 25 cm (10 in)
Found in: Kyrgyzstan

5. MEGALANCOSAURUS
Length: 25 cm (10 in)
Found in: Italy

2. ICAROSAURUS
Length: 10 cm (4 in)
Found in: USA

6. KUEHNEOSAURUS
Length: 72 cm (28 in)
Found in: England
and Luxembourg

3. HYPURONECTOR
Length: 12 cm (4.7 in)
Found in: USA

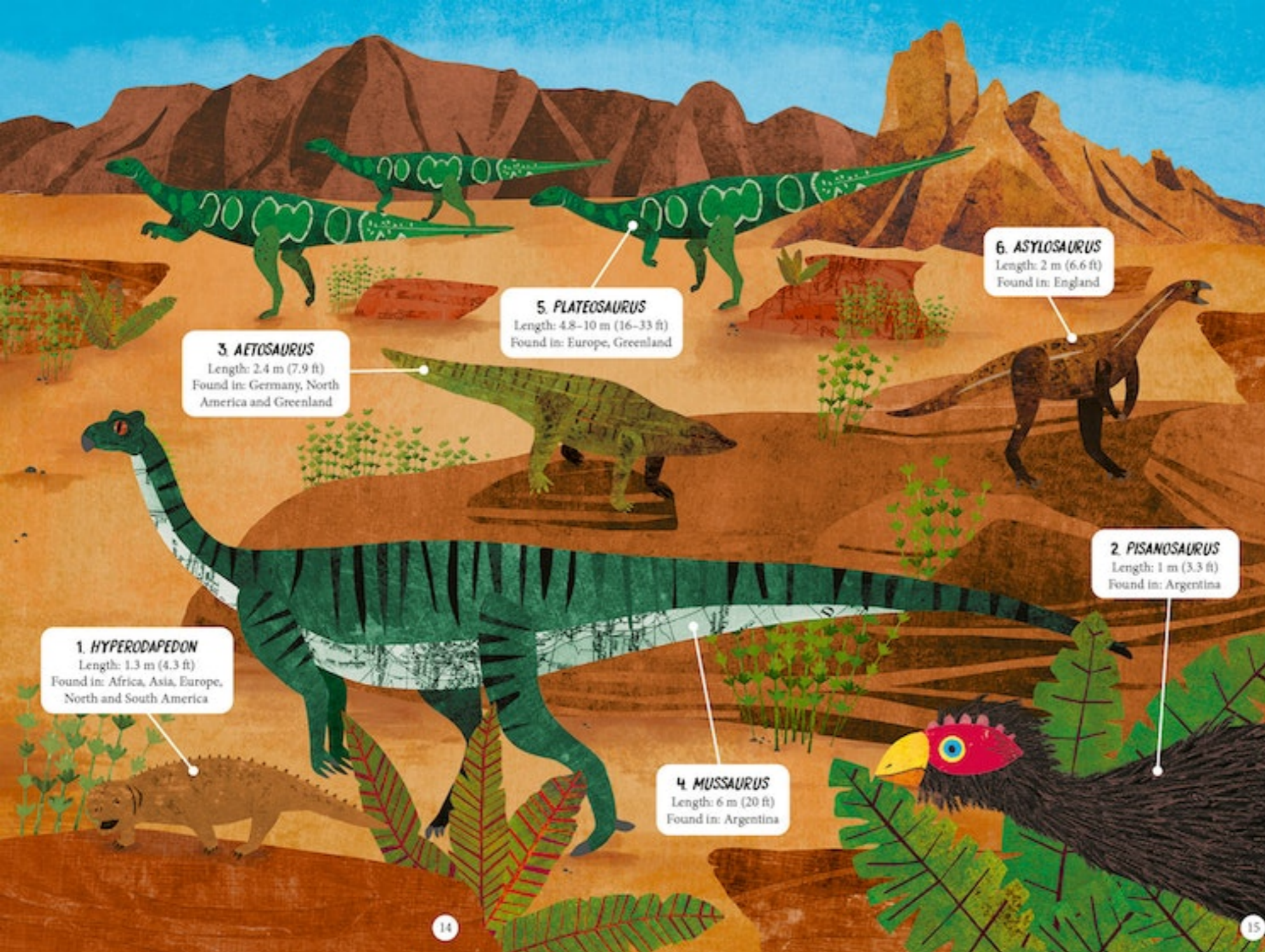
1. MECISTOTRACHELOS
Length: 25 cm (10 in)
Found in: USA

IN THE TREES

DURING THE TRIASSIC, MANY REPTILES MADE THEIR HOMES IN THE DENSE FORESTS OF PANGAEA, HUNTING FOR INSECTS AND OTHER SMALL PREY AMONG THE TREES. THEY HAD THE AGILE BODIES AND HOOKED CLAWS OF EXPERT CLIMBERS AND SOME EVEN EVOLVED THE ABILITY TO GLIDE BETWEEN THE BRANCHES.

- 1 MECISTOTRACHELOS (LIVED: C. 226 MYA)**
was able to spread its long ribs to glide on skin-wings. This lizard-like animal had a much longer neck than other Triassic gliding reptiles. It probably lived in the trees and ate insects.
- 2 ICAROSAURUS LIVED: (228–209 MYA)**
Like *Mecistotrachelos*, this tiny reptile could glide short distances between trees using its long, skin-covered ribs. The wings had a convex upper surface and concave lower surface, giving it good lift.
- 3 HYPURONECTOR (LIVED: 228–209 MYA)**
This small reptile from the drepanosaur family was originally assumed to live in the water, due to its paddle-like tail (its name means 'deep-tailed swimmer'). However, further studies of its limbs and tail suggest it lived in the trees.
- 4 SHAROVIPTERYX (LIVED: 225 MYA)** This slender animal is the only known gliding reptile with a skin-wing surrounding its hind legs instead of its forelegs. The delta-shaped wing would have allowed it to glide short distances, but controlling the glide would have been difficult.
- 5 MEGALANCOSAURUS (LIVED: 215–212 MYA)**
was a small reptile of the drepanosaur family. It had a tail with a claw that could grasp onto a branch, as well as clawed hind feet, giving it stability while it hunted for insects with its forelimbs and jaws.
- 6 KUEHNEOSAURUS (LIVED: 215–201 MYA)** had skin-wings formed from its ribs, which jutted from its body up to 14.3 cm (5.6 in). It probably couldn't glide, but used these wings to slow its fall from trees, like a parachute. It used flaps of skin to keep itself horizontal while descending.





1. HYPERODAPEDON
Length: 1.3 m (4.3 ft)
Found in: Africa, Asia, Europe, North and South America

3. AETOSAURUS
Length: 2.4 m (7.9 ft)
Found in: Germany, North America and Greenland

5. PLATEOSAURUS
Length: 4.8–10 m (16–33 ft)
Found in: Europe, Greenland

4. MUSSAURUS
Length: 6 m (20 ft)
Found in: Argentina

2. PISANOSAURUS
Length: 1 m (3.3 ft)
Found in: Argentina

6. ASYLOSAURUS
Length: 2 m (6.6 ft)
Found in: England

ON THE GROUND — HERBIVORES

THE FIRST DINOSAURS APPEARED AROUND 231 MILLION YEARS AGO. THEY WERE SMALL CREATURES DARTING AROUND ON THEIR HIND LEGS. THE DINOSAURS FORMED TWO MAIN GROUPS: THE SAURISCHIA (LIZARD-HIPPED) AND THE ORNITHISCHIA (BIRD-HIPPED). BIRD-HIPPED DINOSAURS WERE MOSTLY PLANT-EATERS. LIZARD-HIPPED DINOSAURS INCLUDED BOTH MEAT-EATERS AND PLANT-EATERS.

- 1 HYPERODAPEDON (LIVED: 231–227 MYA)**
This weird-looking animal is a kind of rhynchosaur – a beaked reptile related to the dinosaurs. It had a scaly body and moved slowly, using its beak to cut through tough plants.
- 2 PISANOSAURUS (LIVED: 228–216 MYA)**
This small, lightly built plant-eater weighed less than 10 kg (22 lb). It had strong hind legs and could run away quickly if a predator came near. We don't know if it was a true dinosaur or a close cousin.
- 3 AETOSAURUS (LIVED: 228–209 MYA)** This small, slow-moving, plant-eating archosaur had a long, slender body and short arms. Four rows of thick, bony plates covered its body, providing good protection against predators.
- 4 MUSSAURUS (LIVED: 215 MYA)** or 'Mouse Lizard', got its name because the first fossils discovered were tiny. We now know these were infants. It was a sauropodomorph dinosaur – a bipedal ancestor of the giant sauropods that walked on all fours.
- 5 PLATEOSAURUS (LIVED: 214–204 MYA)**
Plateosaurus was one of the bigger dinosaurs of the Triassic and another sauropodomorph. It had a small head on a long, flexible neck, short but muscular arms with large claws on its three fingers, and powerful hind legs.
- 6 ASYLOSAURUS (LIVED: 208–201 MYA)** was one of the last sauropodomorph dinosaurs to walk on its hind legs. Its close cousins, the sauropods, all walked on four legs.

100 M (328 FEET)

75 M (246 FEET)

50 M (164 FEET)

25 M (82 FEET)

0 M (0 FEET)

-25 M (-82 FEET)

-50 M (-164 FEET)

-100 M (-328 FEET)

75 M (246 FEET)

50 M (164 FEET)

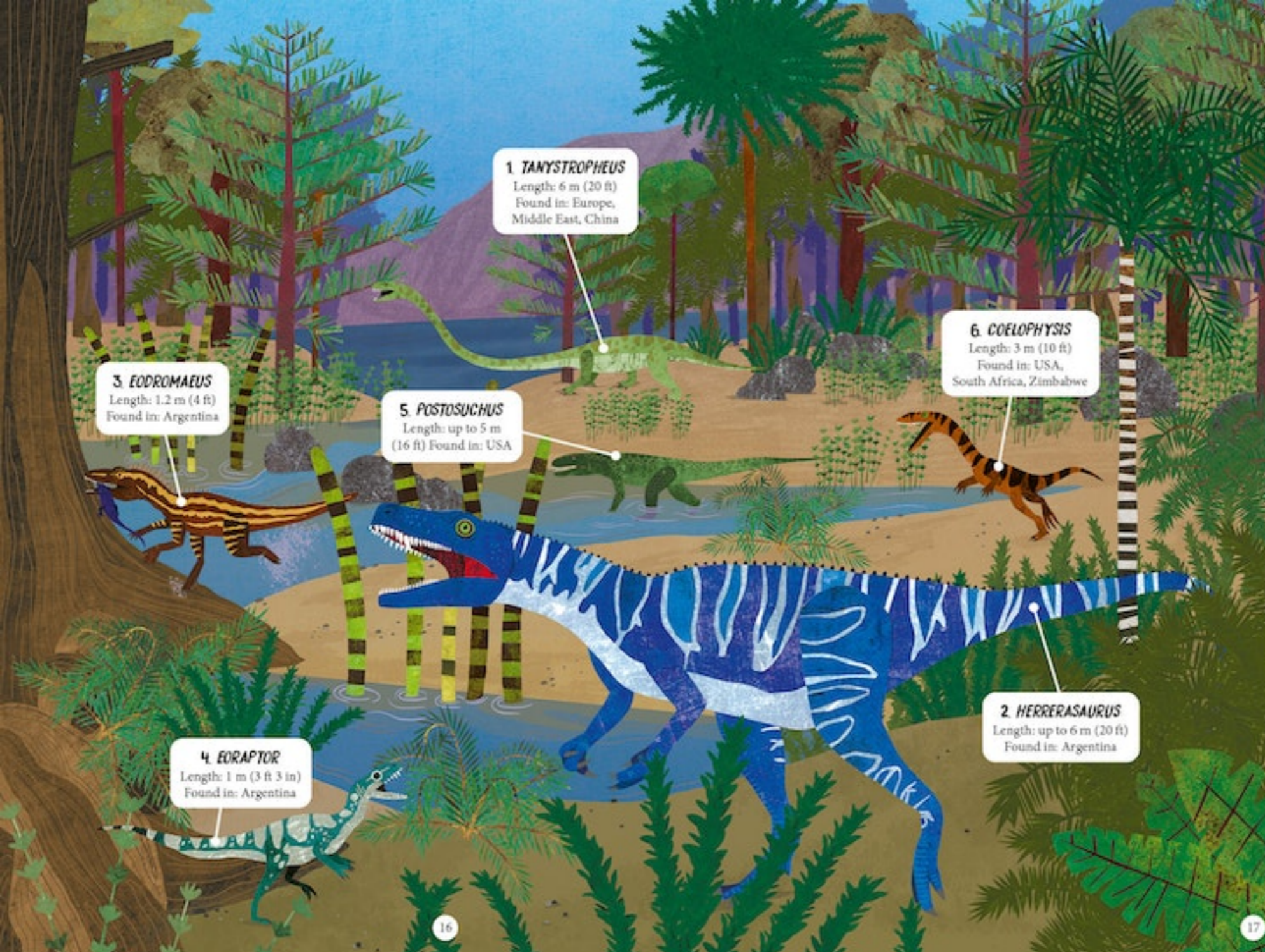
25 M (82 FEET)

0 M (0 FEET)

-25 M (-82 FEET)

-50 M (-164 FEET)

-100 M (-328 FEET)



1. TANYSTROPHEUS

Length: 6 m (20 ft)
Found in: Europe, Middle East, China

3. EODROMAEUS

Length: 1.2 m (4 ft)
Found in: Argentina

5. POSTOSUCHUS

Length: up to 5 m (16 ft)
Found in: USA

4. EORAPTOR

Length: 1 m (3 ft 3 in)
Found in: Argentina

6. COELOPHYSIS

Length: 3 m (10 ft)
Found in: USA, South Africa, Zimbabwe

2. HERRERASAURUS

Length: up to 6 m (20 ft)
Found in: Argentina

ON THE GROUND — PREDATORS

AROUND 231 MILLION YEARS AGO, A GROUP OF LIZARD-HIPPED DINOSAURS CALLED THEROPODS EMERGED IN WESTERN GONDWANA (MODERN SOUTH AMERICA) BEFORE SPREADING AROUND THE GLOBE. THEY MOVED ON TWO LEGS, HUNTED FOR MEAT, AND WERE THE ANCESTORS OF HUGE CARNIVORES SUCH AS *TYRANNOSAURUS REX*. EVERY BIRD YOU SEE TODAY EVOLVED FROM THE THEROPODS.

- 1. TANYSTROPHEUS (LIVED: 247–237 MYA)** This reptile is unusual for its extremely long neck, which was longer than its body and tail combined. It was probably a fish-eater, spending its time in shallow water, using its long neck to reach for its prey.
- 2. HERRERASAURUS (LIVED: 231–229 MYA)** One of the earliest known dinosaurs, this fierce predator had strong hind limbs giving it speed in the chase, combined with sharp teeth and claws for grasping and tearing up its prey.
- 3. EODROMAEUS (LIVED: 231–229 MYA)** may be one of the earliest theropods. It was about the size of a dog, yet it was an effective hunter. It could run fast on its hind legs and had sharp teeth and claws to catch prey.
- 4. EORAPTOR (LIVED: 231–228 MYA)** This small, lightly built dinosaur was possibly an early theropod or sauropodomorph. It ate both meat and plants, moved fast on its hind legs and possessed claws and teeth for effective hunting.
- 5. POSTOSUCHUS (LIVED: 221–203 MYA)** With its sharp, serrated teeth and powerful jaws, this archosaur was an apex predator of its time. It is a precursor of modern crocodiles and had a similar-looking armoured hide, but unlike crocs *Postosuchus* was probably bipedal.
- 6. COELOPHYSIS (LIVED: 221–196 MYA)** had a slender build and, like all theropods, many of its bones were hollow. This made it light, giving it speed when chasing prey and when escaping larger predators. It ate small animals and probably hunted in packs to bring down bigger prey.



IN THE OCEAN

DURING THE TRIASSIC, PANTHALASSA, THE VAST WORLD-OCEAN, TEEMED WITH LIFE. AMMONITES, MOLLUSCS, FISH, SHARKS AND SEA URCHINS SURVIVED THE EXTINCTION EVENT THAT ENDED THE PREVIOUS PERIOD AND BEGAN TO DIVERSIFY. THE FIRST MODERN REEF-BUILDING CORALS APPEARED. AT THE TOP OF THE FOOD CHAIN WERE THE GIANT REPTILES. SOME, LIKE TURTLES, WE WOULD RECOGNISE TODAY, BUT MANY WOULD SEEM COMPLETELY ALIEN TO OUR EYES.

- 1 CARTORHYNCHUS (LIVED: 248 MYA)** This small, rather cute marine reptile looked similar to a seal and swam like an eel, but had flexible flippers that allowed it to move around on land. It most likely preyed on shellfish using suction feeding.
- 2 THALATTOARCHON (LIVED: 247–242 MYA)** was one of the first marine predators able to eat prey similar in size to itself. We know this because its teeth are large and well adapted to slicing through flesh and muscle, rather than the needle-like teeth of fish-eaters.
- 3 PLACODUS (LIVED: 245–235 MYA)** may have looked like a land reptile, but it was a good swimmer with a strong tail and webbed feet. It ate shellfish, plucking them off the sea floor with the pointed teeth at the front of its jaws before crushing the shells with its strong, flat teeth.
- 4 NOTHOSAURUS (LIVED: 240–210 MYA)** This sleek reptile had paddle-like limbs, a long snout and a powerful tail. Like today's seals it basked on land and hunted in the water. Its long jaws were lined with needle-like teeth for trapping fish or squid.
- 5 SHASTASAURUS (LIVED: 235–205 MYA)** was a member of the ichthyosaur family and one of the largest marine predators of the Triassic. Its size meant it could take in lots of air and dive deep. It had no teeth and probably fed by suction.
- 6 ICHTHYOSAURUS (LIVED: 205 MYA–182 MYA)** had a streamlined body, a crescent-shaped tail that propelled it fast through the water, and dolphin-like jaws filled with razor-sharp teeth. Its excellent eyesight enabled it to see prey from great distances.



5. SHASTASAURUS
Length: up to 21 m (69 ft)
Found in: USA, Canada, China

2. THALATTOARCHON
Length: 8.6 m (28 ft)
Found in: USA

4. NOTHOSAURUS
Length: 4 m (13 ft)
Found in: North Africa, Europe, China

3. PLACODUS
Length: up to 2 m (6.6 ft)
Found in: Germany, France, Poland, China

6. ICHTHYOSAURUS
Length: 3.3 m (11 ft)
Found in: Belgium, England, Germany, Switzerland, Indonesia

1. CARTORHYNCHUS
Length: 40 cm (16 in)
Found in: China

LIFE IN THE JURASSIC

During the Jurassic (201–145 million years ago), dinosaurs became the dominant animals on land. With pterosaurs supreme in the skies and huge reptiles patrolling the oceans, this was an age when reptiles truly ruled the Earth.

CONTINENTAL DRIFT

In this period, the two giant landmasses of Gondwana and Laurasia began to break up and start to form the continents we know today. Despite this, fossil records show there were still land connections between the continents during the Early Jurassic.

THE WORLD AT THE START AND END OF THE JURASSIC



201 MILLION YEARS AGO



145 MILLION YEARS AGO

20

EARLY JURASSIC

MIDDLE JURASSIC

LATE JURASSIC



IN THE AIR

Pterosaurs still ruled the skies, but the first bird-like dinosaurs with some flying ability, such as *Archaeopteryx*, appeared during the Jurassic.

PLANT-EATERS

The abundance of plants allowed the rise of huge plant-eating sauropods. These were some of the largest animals ever to walk the Earth.

MEAT-EATERS

By the Middle to Late Jurassic, enormous theropods, such as *Allosaurus*, began to appear.

PLANT LIFE

Changes in the climate caused a spread of plant life, such as ferns and horsetails, across vast areas of former desert. Conifers were the dominant plant species in the Jurassic, but ginkgo trees and seed plants also flourished. Flowering plants had yet to evolve.

CLIMATE

Temperatures cooled slightly during the period, although it was still warmer than today. The seas forming between the landmasses led to an increase in rainfall. Forests grew near the poles, which experienced warm summers and cold winters.



21



6. ALCONAVIS
Length: 55 cm (22 in)
Found in: Germany

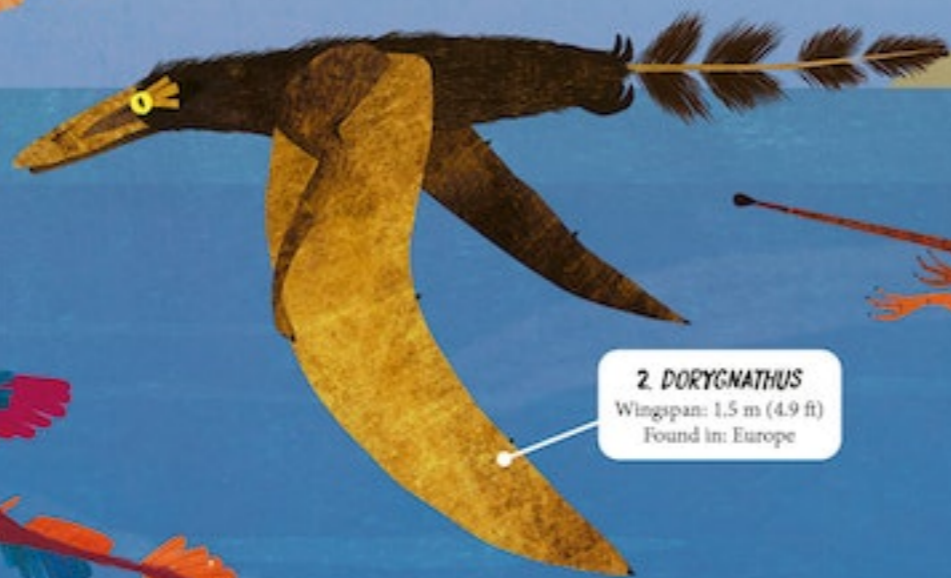


5. PTERODACTYLUS
Wingspan: 104 cm (3.4 ft)
Found in: Germany

4. ARCHAEOPTERYX
Wingspan: 60 cm (24 in)
Found in: Germany



2. DORYGNATHUS
Wingspan: 1.5 m (4.9 ft)
Found in: Europe



3. JEHOLOPTERUS
Wingspan: 91 cm (36 in)
Found in: China



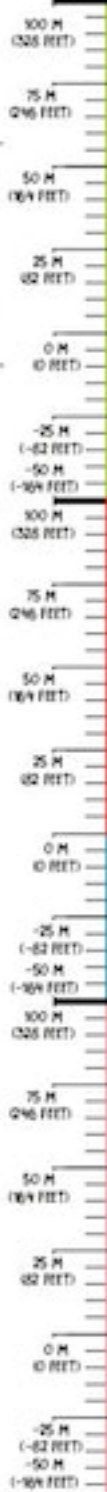
1. DIMORPHODON
Wingspan: 1.45 m (4.8 ft)
Found in: England

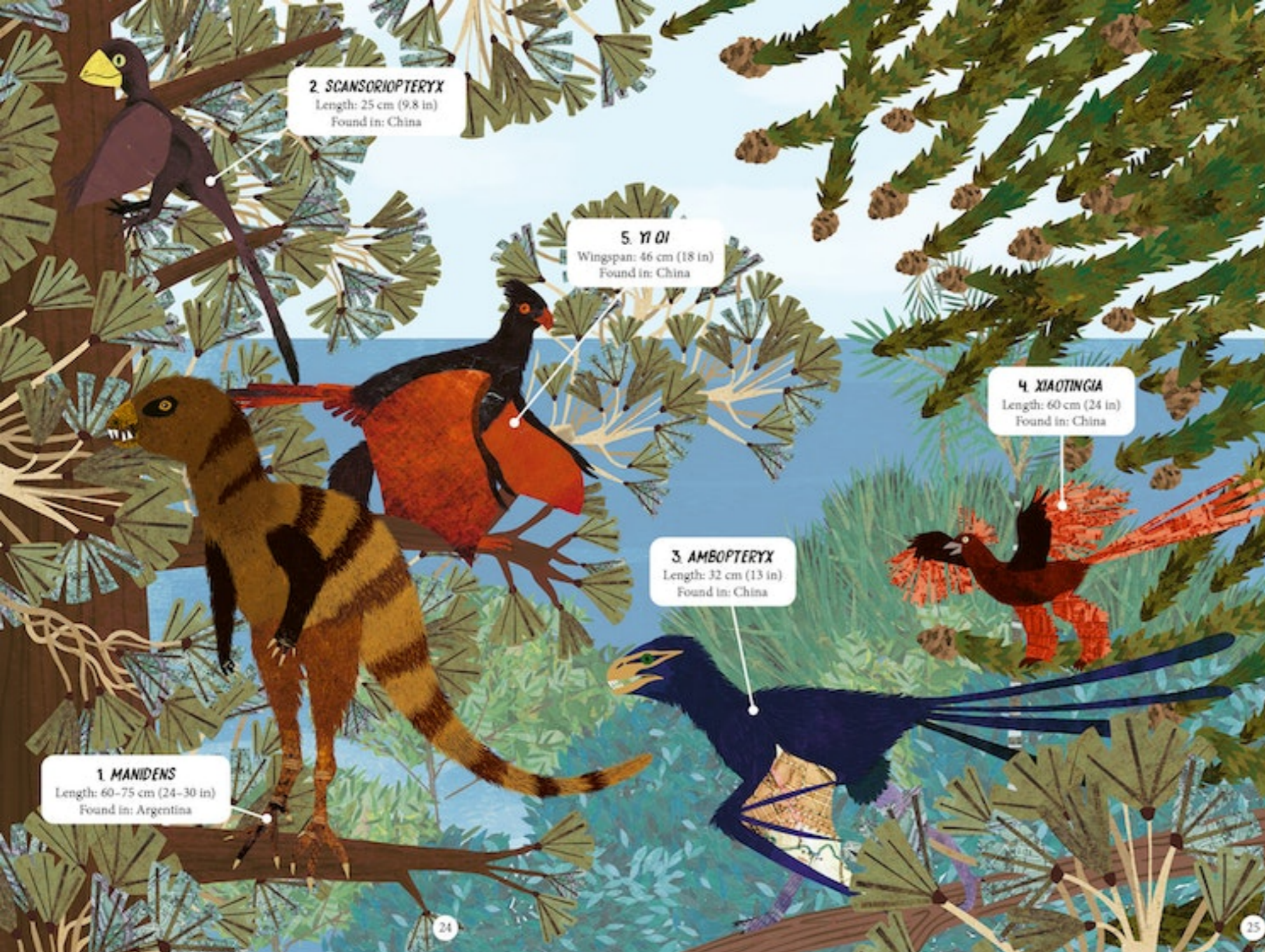


IN THE SKY

PTEROSAURS CONTINUED TO FLOURISH DURING THE JURASSIC PERIOD AS NEW, DIVERSE SPECIES EMERGED. DURING THE MIDDLE JURASSIC, THE FIRST BIRDS APPEARED. SCIENTISTS ARGUE ABOUT HOW WELL THESE EARLY BIRDS FLEW. TWO THAT PROBABLY COULD FLY — AFTER A FASHION — WERE ARCHAEOPTERYX AND ALCONAVIS.

- 1. DIMORPHODON (LIVED: 195–190 MYA)** This Early Jurassic pterosaur had forty small, sharp teeth lining the sides of its deep jaws, and two larger, piercing teeth at the front — its name means 'two-form teeth'. Studies of its jaw and teeth suggest it hunted small lizards and mammals.
- 2. DORYGNATHUS (LIVED: 180 MYA)** During the Early Jurassic, shallow seas covered much of modern Europe, and this became a hunting-ground for the fish-eating *Dorygnathus*. Its long front teeth meshed together when the jaws closed, trapping its fish prey.
- 3. JEHOLOPTERUS (LIVED: 164 MYA)** was an owl-sized pterosaur with long, sharp claws and short wings. Its small jaws were filled with tiny, sharp teeth that it used to catch insects in flight. Its head and body were covered in hair-like strands called pycnofibres.
- 4. ARCHAEOPTERYX (LIVED: 151–149 MYA)** had both theropod and bird features and is regarded as an important link between dinosaurs and birds. The size of a raven, it had broad wings and long tail feathers. Studies show it could probably fly, though its flapping ability was limited.
- 5. PTERODACTYLUS (LIVED: 151–140 MYA)** (meaning 'winged finger') is fairly unremarkable except for the fact that it was the first pterosaur ever to be identified. At first, scientists assumed it was a sea creature and its wings were flippers!
- 6. ALCONAVIS (LIVED: 151–149 MYA)** A single wing of a new Jurassic bird species was discovered in 2017. *Alconavis* lived at the same time and place as *Archaeopteryx* but was larger and may have been a better flyer. Studies show it was probably better at flapping its wings.





1. MANIDENS
Length: 60-75 cm (24-30 in)
Found in: Argentina

2. SCANSORIOPTERYX
Length: 25 cm (9.8 in)
Found in: China

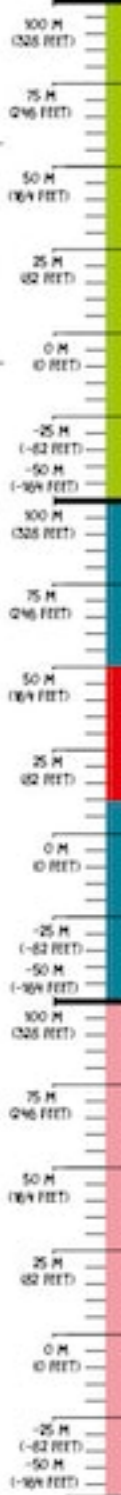
5. YI DI
Wingspan: 46 cm (18 in)
Found in: China

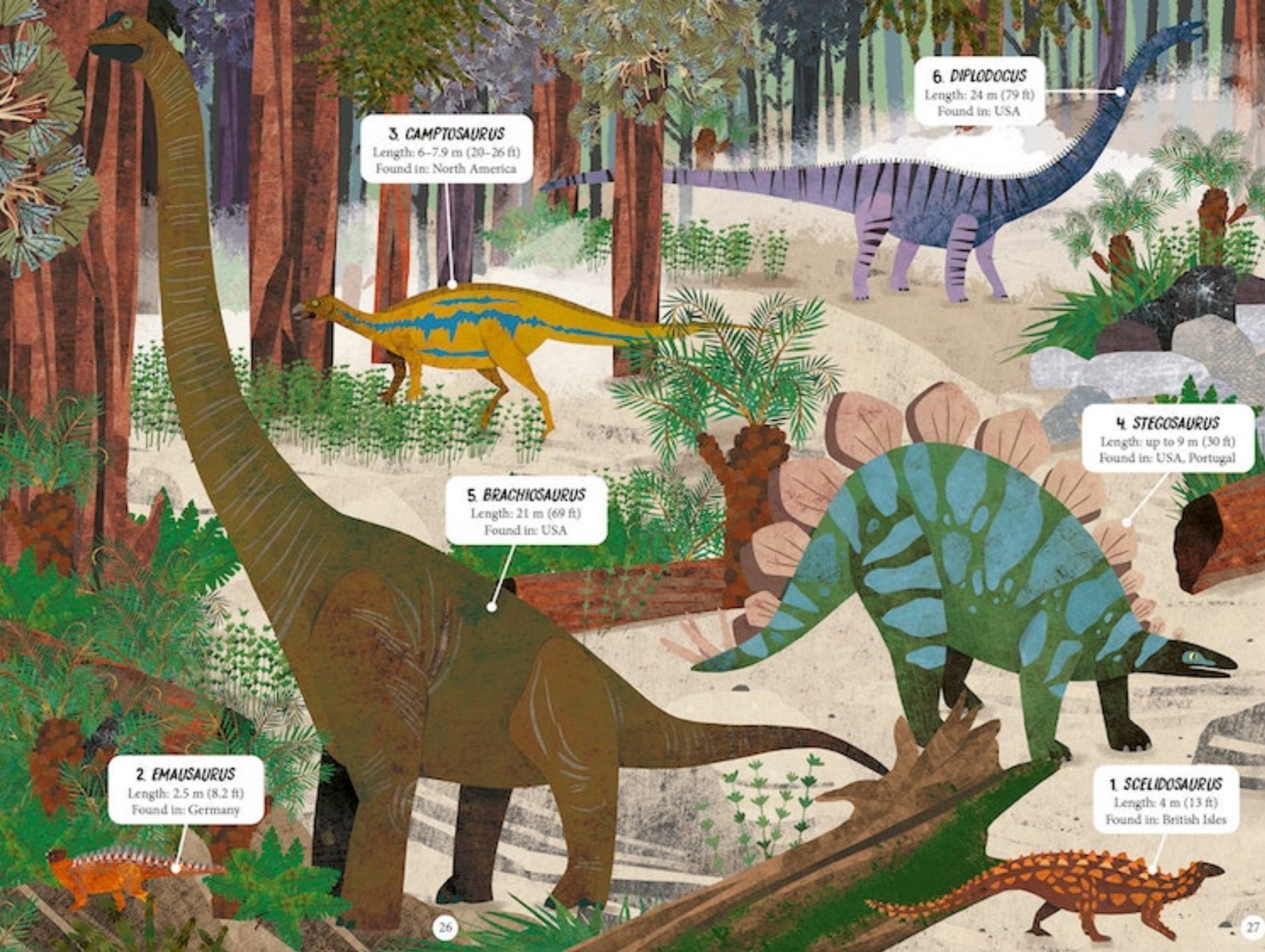
3. AMBOPTERYX
Length: 32 cm (13 in)
Found in: China

4. XIAOTINGIA
Length: 60 cm (24 in)
Found in: China

MANY EARLY BIRDS OR BIRD-LIKE DINOSAURS PROBABLY LIVED IN THE TREES, CLIMBING AND GLIDING RATHER THAN FLYING. THIS WAS A GROUP OF THEROPODS KNOWN AS THE PARAVIANS AND ALL MODERN BIRDS ARE DESCENDED FROM THEM. THEY HAD THE FEATHERED WINGS OF BIRDS, BUT ALSO THE CLAWED TOES AND TEETH OF DINOSAURS.

- 1. MANIDENS (LIVED: 171-167 MYA)** This small, bird-hipped dinosaur had very long toes and curved claws capable of grasping onto branches, similar to birds. Some scientists see this as evidence that *Manidens* spent some of its time climbing through trees and bushes. Studies of its teeth suggest it ate both plants and insects.
- 2. SCANSORIOPTERYX (LIVED: 165-156 MYA)** This pigeon-sized paravian was well adapted for tree-climbing. It could use its long, clawed fingers to grab onto branches and its feet were suited to perching. Its short, stiff tail could have been used as a support, much like the tails of modern woodpeckers. It couldn't flap its wings but may have been able to glide short distances.
- 3. AMBOPTERYX (LIVED: 163 MYA)** Ambopteryx had a short, blunt head, a feather-covered body and long tail feathers, as well as an extra-long third finger that supported a bat-like skin-wing. Studies of its teeth and stomach contents suggests it ate both meat and plants.
- 4. XIAOTINGIA (LIVED: 160 MYA)** This chicken-sized paravian had feathers all over its body, including on its head, with long feathers on both sets of limbs. If it flew, it may even have used its hind limbs as wings. It lived in trees and ate insects and small animals.
- 5. YI DI (LIVED: 159 MYA)** This small, tree-dwelling paravian had an unusually long third finger supporting a skin-wing, similar to modern bats. It had bird-like feathers on its body and tail but wasn't capable of sustained flapping and probably used its wings for gliding between trees, hunting for insects.



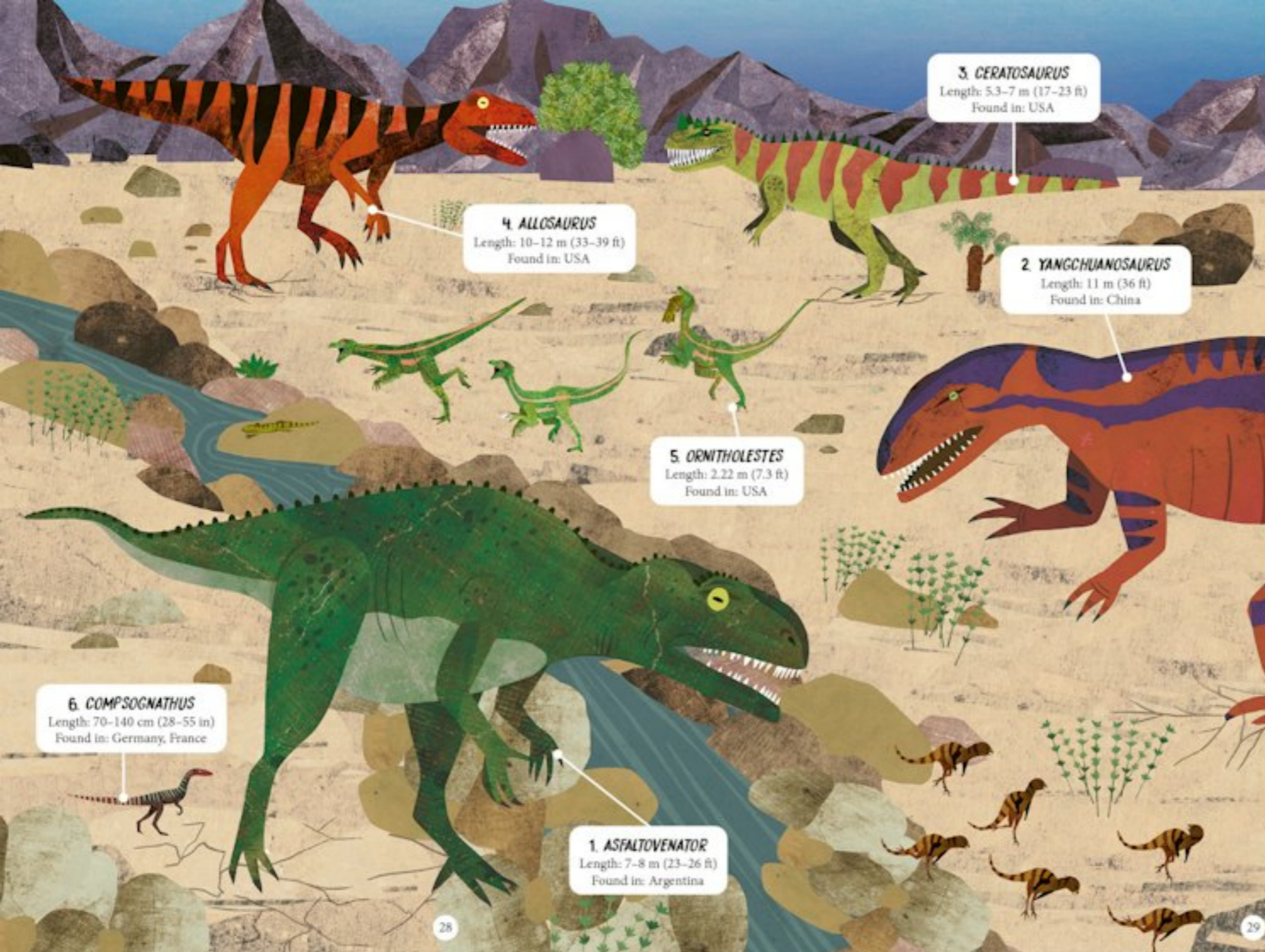


ON THE GROUND — HERBIVORES

WITH MOST OTHER KINDS OF ARCHOSAUR NOW EXTINCT, THE GROUND-DWELLING DINOSAURS TOOK CENTRE STAGE IN THE JURASSIC. PLANT-EATERS THRIVED ON THE LUSH VEGETATION. LIZARD-HIPPED SAUROPODS LIKE *DIPLODOCUS* GREW ENORMOUS, WHILE BIRD-HIPPED ORNITHISCIANS LIKE *STEGOSAURUS* DEVELOPED IMPRESSIVE ARMOUR.

- 1 SCOLIDOSAURUS (LIVED: 197–183 MYA)** was a bird-hipped dinosaur that fed on low, scrubby plants, which it tore up with its beak-like jaws. It protected itself with parallel rows of bony plates or spikes that ran along its neck, back and tail.
- 2 EMAUSAURUS (LIVED: 181 MYA)** This bird-hipped, armoured dinosaur from the Early Jurassic probably spent time on both two legs and four. It mainly ate ground vegetation, but could reach for higher-growing plants if it desired.
- 3 CAMPTOSAURUS (LIVED: 156–147 MYA)** was a bird-hipped dinosaur with the powerful hind legs and broad feet of a bipedal animal. The heavy wear on its teeth indicate a diet of tough plants. Its defence may have been speed; scientists estimate it could run at up to 25 km/h (over 15 mph).
- 4 STEGOSAURUS (LIVED: 155–150 MYA)** With its huge size and spike-tipped tail, *Stegosaurus* was very capable of defending itself against predators and rivals. The double row of plates along its back were probably too weak to be armour and may have been used to regulate its temperature.
- 5 BRACHIOSAURUS (LIVED: 154–153 MYA)** had a long neck and small skull, typical of the giant sauropods of the Late Jurassic. Unusually, it had longer forelimbs than hind limbs, giving it an upward-tilted trunk and a relatively short tail.
- 6 DIPLODOCUS (LIVED: 154–152 MYA)** This famous sauropod of the Late Jurassic is one of the longest dinosaurs known from nearly complete skeletons. Many experts believe it had a horizontal posture, keeping its neck low. Its long tail may have been cracked like a whip as a form of defence.





4. ALLOSAURUS
Length: 10–12 m (33–39 ft)
Found in: USA

3. CERATOSAURUS
Length: 5.3–7 m (17–23 ft)
Found in: USA

2. YANGCHUANOSAURUS
Length: 11 m (36 ft)
Found in: China

5. ORNITHOLESTES
Length: 2.22 m (7.3 ft)
Found in: USA

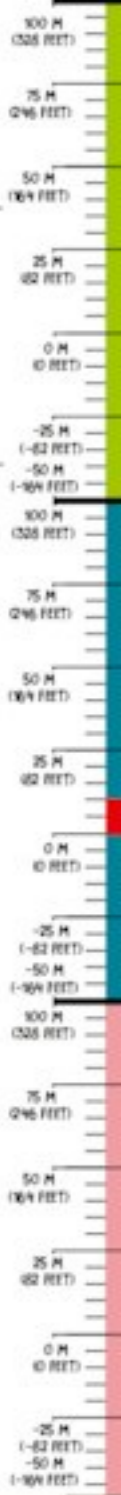
6. COMPSOGNATHUS
Length: 70–140 cm (28–55 in)
Found in: Germany, France

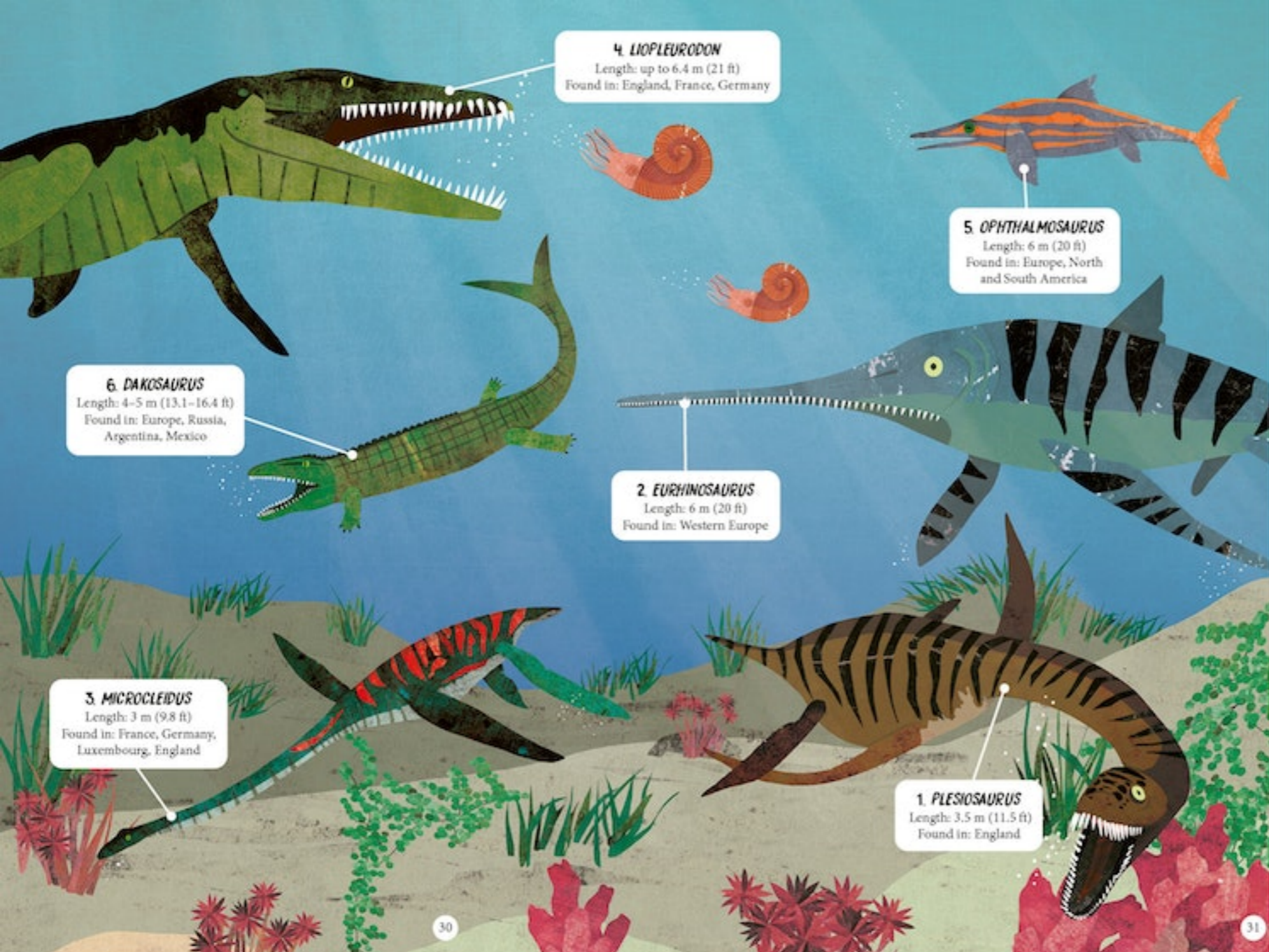
1. ASFALTOVENATOR
Length: 7–8 m (23–26 ft)
Found in: Argentina

ON THE GROUND — PREDATORS

THE THEROPODS — THE ONLY MEAT-EATING DINOSAURS — GREW BIGGER AND MORE NUMEROUS DURING THE JURASSIC PERIOD. MANY HUNTED IN GROUPS TO BRING DOWN THEIR GIANT OR ARMoured PREY. THE LARGE PREDATORS OF THE TRIASSIC, LIKE *HERREROSAURUS*, WOULD HAVE BEEN DWARFED BY THE GIANTS OF THE LATE JURASSIC SUCH AS *ALLOSAURUS*.

- ASFALTOVENATOR (LIVED: 174–168 MYA)** Although it lived millions of years before famous Jurassic carnivores like *Allosaurus*, *Asfaltovenator* looked very similar to them and was only slightly smaller. It may represent the start of the transition from big to gigantic predatory dinosaurs.
- YANGCHUANOSAURUS (LIVED: 168–157 MYA)** was the apex predator in the area where China is now located, hunting sauropods such as *Omeisaurus* and armoured dinosaurs like *Chialingosaurus*. Its skull alone was 1.11 m (3.6 ft) in length and its massive tail was over half the length of its body.
- CERATOSAURUS (LIVED: 157–145 MYA)** was a medium-sized theropod of the Late Jurassic, with long, blade-like teeth and a horn on its snout, probably used for display. Smaller than *Allosaurus*, it may have been a scavenger, or hunted different prey.
- ALLOSAURUS (LIVED: 155–145 MYA)** This apex predator of the Late Jurassic was big enough to hunt the biggest sauropods and armoured dinosaurs. Its skull was filled with sharp, serrated teeth and each of its six fingers ended in an 11-cm (4.3-in) claw.
- ORNITHOLESTES (LIVED: 154 MYA)** What this bipedal carnivore lacked in size and strength it made up for in speed and agility. Its relatively long arms and small head suggest it used its hands rather than its mouth to capture and hold onto prey.
- COMPSOGNATHUS (LIVED: 151 MYA)** This dinosaur may only have been the size of a turkey, but it was fast and ferocious with small, pointed teeth and large claws on its forelimbs, well suited for its diet of small vertebrates.





4. LIOPLEURODON
 Length: up to 6.4 m (21 ft)
 Found in: England, France, Germany

5. OPHTHALMOSAURUS
 Length: 6 m (20 ft)
 Found in: Europe, North and South America

2. EURHINOSAURUS
 Length: 6 m (20 ft)
 Found in: Western Europe

6. DAKOSAURUS
 Length: 4–5 m (13.1–16.4 ft)
 Found in: Europe, Russia, Argentina, Mexico

3. MICROCLEIDUS
 Length: 3 m (9.8 ft)
 Found in: France, Germany, Luxembourg, England

1. PLESIOSAURUS
 Length: 3.5 m (11.5 ft)
 Found in: England

IN THE OCEAN

AS THE LANDMASSES PARTED, NEW OCEANS AND SEAS FLOODED THE SPACES IN BETWEEN. THESE WATERY REALMS TEEMED WITH LIFE. CORAL REEFS GREW IN THE WARM, SHALLOW SEAS, ATTRACTING SPONGES, MOLLUSCS AND FISH. AT THE TOP OF THE FOOD CHAIN WERE THE LARGE REPTILES – PLESIOSAURS, PLIOSAURS, ICHTHYOSAURS AND CROCODILES.

- 1 PLESIOSAURUS (LIVED: 200–176 MYA)** belonged to a family of marine reptiles called plesiosaurs, which flourished in the Jurassic. They had small heads, long and slender necks, short tails and paddle-like fins, and they fed on fish, clams, snails and other small prey.
- 2 EURHINOSAURUS (LIVED: 183–175 MYA)** This ichthyosaur had a long upper jaw, similar to a modern-day swordfish. Its powerful front fins made it among the fastest swimmers of its time. It may have swiped at its fish prey with its sword to injure them, making them easier to capture.
- 3 MICROCLEIDUS (LIVED: 182–175 MYA)** This dolphin-size plesiosaur had forty neck vertebrae, giving it a longer neck compared to its body than most others of its kind. This would have enabled it to surprise groups of fish, with its jaws arriving long before its body.
- 4 LIOPLEURODON (LIVED: 166–155 MYA)** was a pliosaur – a short-necked cousin of the plesiosaurs. With its enormous jaws and 20-cm (8-in) teeth, it was the dominant predator of its time, and there is fossil evidence that it dined on ichthyosaurs, plesiosaurs and squid.
- 5 OPHTHALMOSAURUS (LIVED: 165–150 MYA)** This ichthyosaur had extremely large eyes (bigger than a human head), suggesting it hunted at depths where there was little light, or at night when prey species were more active.
- 6 DAKOSAURUS (LIVED: 157–137 MYA)** This cousin of modern crocodiles was well adapted to life at sea, with a streamlined body, flippers and a finned tail for quick propulsion. Its large jaws and serrated teeth suggest it ate big fish and other marine reptiles.



LIFE IN THE CRETACEOUS

In the Cretaceous period (145–66 million years ago), the landmasses separated further, forming some of the continents we recognise today. With oceans now separating them, dinosaurs began evolving independently in different parts of the world.

THE WORLD AT THE START AND END OF THE CRETACEOUS



145 MILLION YEARS AGO



66 MILLION YEARS AGO

CLIMATE

The climate was cool during the Early Cretaceous, but then global temperatures began to increase again, possibly due to volcanic activity, before decreasing slightly towards the end. Sea levels rose and fell. In the Late Cretaceous, the poles started to grow cooler and the equatorial regions became warmer.

IN THE AIR

Pterosaurs increasingly shared the skies with birds during the Cretaceous, yet they retained their impressiveness, growing ever larger.

PLANT EATERS

New types of herbivorous dinosaur appeared, such as *Iguanodon*, *Gastonia* and *Triceratops*.

NEW ANIMALS

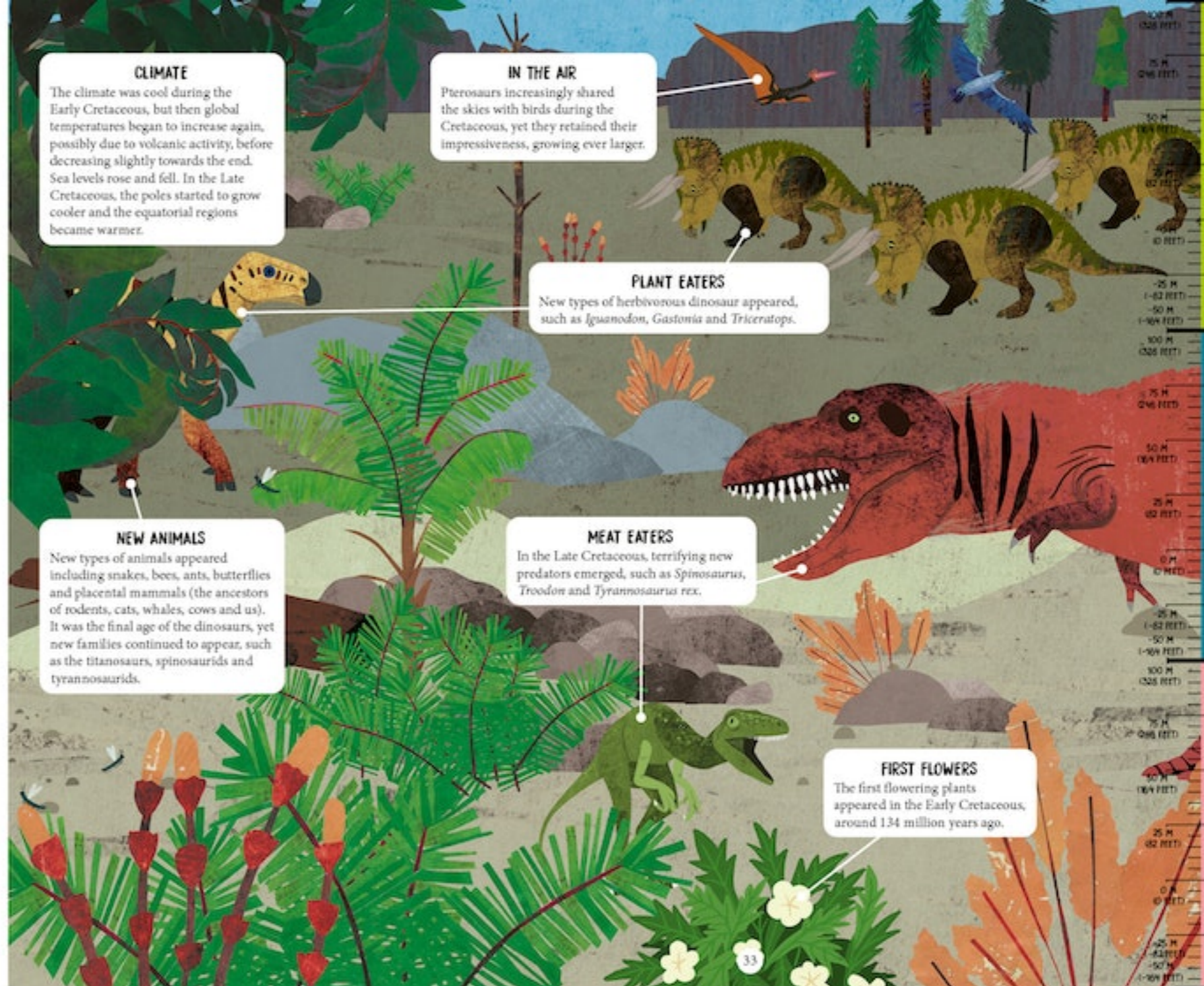
New types of animals appeared including snakes, bees, ants, butterflies and placental mammals (the ancestors of rodents, cats, whales, cows and us). It was the final age of the dinosaurs, yet new families continued to appear, such as the titanosaurs, spinosaurids and tyrannosaurids.

MEAT EATERS

In the Late Cretaceous, terrifying new predators emerged, such as *Spinosaurus*, *Troodon* and *Tyrannosaurus rex*.

FIRST FLOWERS

The first flowering plants appeared in the Early Cretaceous, around 134 million years ago.



5. ARAMBOURGIANA

Wingspan: 7–10 m (23–33 ft)
Found in: Jordan

3. PTERANODON

Wingspan: over 6 m (20 ft)
Found in: USA

1. DSUNGARIPTERUS

Wingspan: 3–3.5 m (9.8–11.5 ft)
Found in: China

4. NYCTOSAURUS

Wingspan: 2 m (6.6 ft)
Found in: USA

6. QUETZALCOATLUS

Wingspan: 10–11 m (33–36 ft)
Found in: USA

2. MOGANOPTERUS

Wingspan: 7 m (23 ft)
Found in: China

IN THE SKY

PTEROSAURS GREW STEADILY BIGGER DURING THE CRETACEOUS. THEIR ENORMOUS WINGS COULD TAKE ADVANTAGE OF UPDRAUGHTS OF WARM AIR TO STAY ALOFT FOR LONG PERIODS WITHOUT HAVING TO FLAP THEIR WINGS. THEY FLEW OVER THE VAST INLAND SEAS OF NORTH AMERICA AND EUROPE, SWOOPING TO SNATCH FISH.

- 1 DSUNGARIPTERUS (LIVED: 145–100 MYA)** lived in muddy coastal environments. Its long, narrow jaws tapered to a sharp, up-turned point like a pair of tweezers – ideal for grabbing prey such as shellfish and crustaceans from between rocks.
- 2 MOGANOPTERUS (LIVED: 125 MYA)** This giant had one of the largest skulls of any toothed pterosaur. Its long jaws were lined with at least 62 comb-like teeth, which it used for filter-feeding – scooping up water, then gulping down any creatures it found in there.
- 3 PTERANODON (LIVED: 86–84 MYA)** had a huge head and wings, yet its body was little bigger than a cat's. The spectacular backward-pointing crest may have acted as a rudder or a balance for its beak. It could dive almost a metre (3.3 ft) to snatch its fish prey from the water.
- 4 NYCTOSAURUS (LIVED: 85–84 MYA)** Few pterosaurs sported head crests as spectacular as that of *Nyctosaurus*. It was at least 55 cm (1.8 ft) tall – three times longer than its skull – and may have been used like a deer's antlers, to attract mates.
- 5 ARAMBOURGIANA (LIVED: 72–66 MYA)** This huge pterosaur was once estimated to have a wingspan of up to 13 m (43 ft), based on the discovery of an incomplete neck vertebra. This would have made it the largest flying creature ever known, but it has since been revised downwards.
- 6 QUETZALCOATLUS (LIVED: 68–66 MYA)** Perhaps the largest flying animal of all time, *Quetzalcoatlus* was the size of a light aircraft. Scientists have pondered how such a vast creature got off the ground. Some suggest it was flightless, while others argue it was capable of long-distance journeys through the air.





2. CONFUCIUSORNIS
Wingspan: 70 cm (2.3 ft)
Found in: China

5. SINORNIS
Wingspan: 20 cm (7.9 in)
Found in: China

3. IBEROMESORNIS
Wingspan: 20 cm (7.9 in)
Found in: Spain

6. NEMICOLOPTERUS
Wingspan: 25 cm (10 in)
Found in: China

1. XIANGLONG
Length: 15.5 cm (6.1 in)
Found in: China

4. MICRORAPTOR
Length: 77-120 cm (2.5-3.9 ft)
Found in: China

IN THE TREES

THE FORESTS OF THE CRETACEOUS PLAYED HOST TO FROGS, INSECTS AND SMALL, SHREW-LIKE MAMMALS. BEES BUZZED AROUND THE FLOWERING PLANTS, WHILE REPTILES AND BIRDS CLIMBED, GLIDED AND FLEW BETWEEN THE BRANCHES, HUNTING FOR PREY

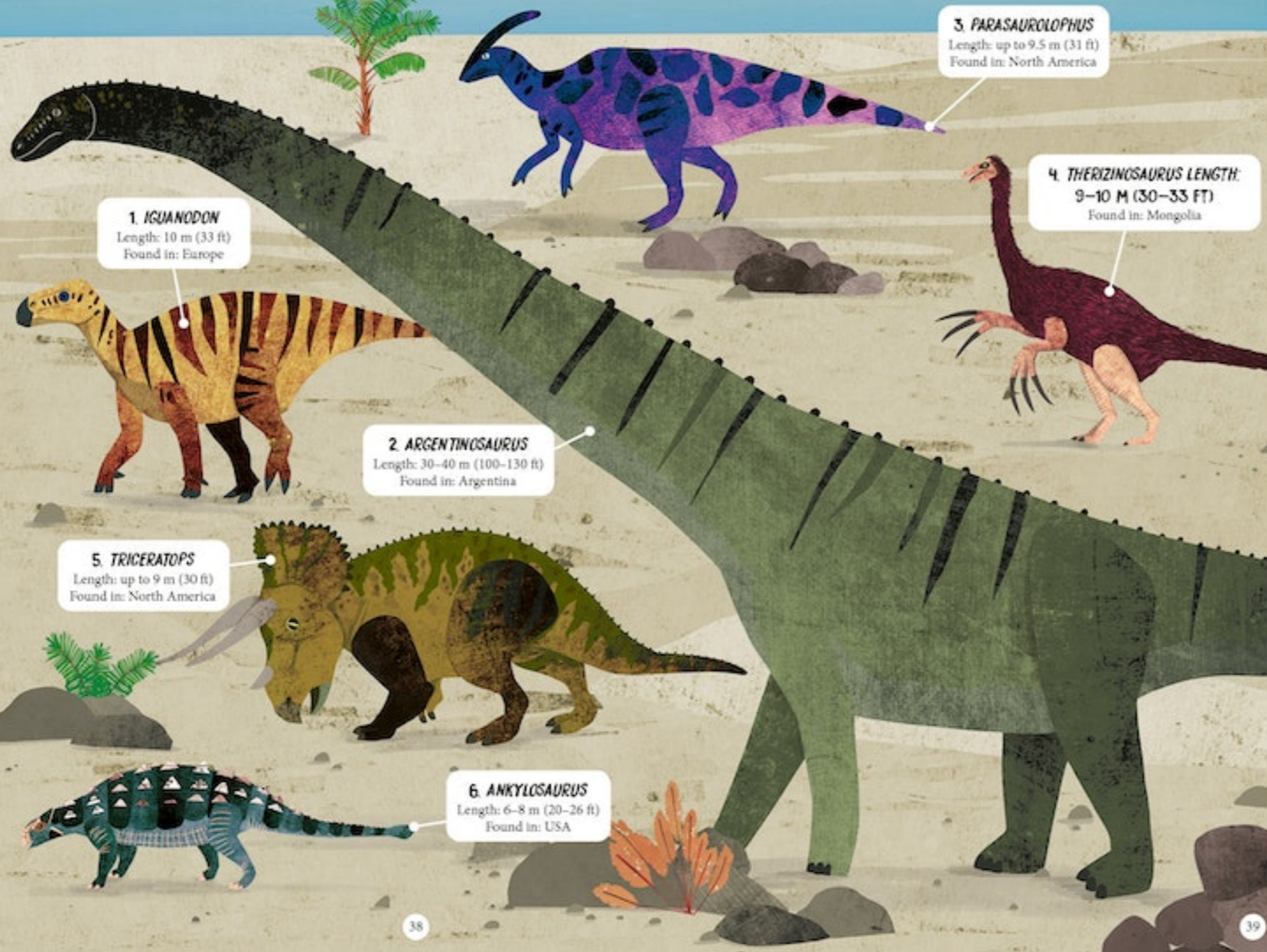
- 1 XIANGLONG (LIVED: 129-125 MYA)** (meaning 'flying dragon') was a lizard with projecting ribs - eight on each side - attached to a membrane of skin, allowing it to glide between trees in the Cretaceous forest. With its 11-cm (4.3-in) wingspan, it could have been quite agile in the air.
- 2 CONFUCIUSORNIS (LIVED: 125-120 MYA)** Unlike previous birds, like *Archaeopteryx*, *Confuciusornis* had a toothless beak and feathers at the rear that resembled a tail. The long flight feathers on its wings suggest an agile glider over short distances, and its curved foot claws indicate it may have lived and perched in trees.
- 3 IBEROMESORNIS (LIVED: 125 MYA)** was a sparrow-sized bird with long toes and curved claws that helped it perch on branches. Its fossil was found in an area that was once a forest next to a lake. It may have swooped from the trees to catch insects from the lake surface.
- 4 MICRORAPTOR (LIVED: 120 MYA)** was a small, paravian dinosaur, with long feathers on its arms, legs and tail. It probably lived in forests and used its wings to parachute from trees, arms and legs spread, to ambush prey on the ground.
- 5 SINORNIS (LIVED: 120 MYA)** This bird had a toothed beak, but could fly like modern birds thanks to its powerful flight muscles and long, stiff feathers on its wings and tail, giving it thrust and lift. Its claw shape suggests it was capable of perching and climbing and probably lived in forests.
- 6 NEMICOLOPTERUS (LIVED: 120 MYA)** (meaning 'forest-dweller') is the smallest pterosaur yet discovered. It probably used its curved claws to climb trees and perch on branches. Living in the canopy, it could avoid most predators while using its toothless beak to catch insects.



ON THE GROUND — HERBIVORES

THE CRETACEOUS WAS THE AGE OF THE TITANOSAURS — THE LARGEST LAND ANIMALS EVER TO WALK THE EARTH. THESE GIGANTIC SAUROPODS RANGED ACROSS CONTINENTS AND WERE THE DOMINANT PLANT-EATERS OF THEIR TIME. THE PERIOD ALSO SAW THE RISE OF NEW BIRD-HIPPED DINOSAUR FAMILIES LIKE THE DUCK-BILLED HADROSAURS AND THE HORNED CERATOPSAINS.

- 1 IGUANODON (LIVED: 126–122 MYA)** These large herbivores had long hind limbs and shorter forelimbs, and could walk on either two legs or four. They had toothless beaks and their thumbs were conical spikes, possibly used for defence or foraging.
- 2 ARGENTINOSAURUS (LIVED: 96–92 MYA)** This titanosaur was possibly the largest of all the sauropods, but incomplete remains make this hard to verify. Its colossal size would have given it protection against predators, with only the very biggest daring to attack it.
- 3 PARASAUROLOPHUS (LIVED: 77–73 MYA)** This hadrosaur was notable for the long, tube-like crest that curved backwards from its skull. This may have been for display, to regulate its body temperature, or even for making trumpeting sounds.
- 4 THERIZINOSAURUS (LIVED: 70 MYA)** The most spectacular feature of this herbivore were its huge, curved claws, each over 50 cm (20 in) long, which it used like scythes to collect vegetation. Its long neck allowed it to reach for foliage on high branches.
- 5 TRICERATOPS (LIVED: 68–66 MYA)** (or 'three-horned face') was an awesome, 14-tonne beast that moved in herds across the plains. Its neck frill was too thin for armour and was probably for attracting mates, but its horns were useful weapons against its main predator, *Tyrannosaurus rex*!
- 6 ANKYLOSAURUS (LIVED: 68–66 MYA)** This heavily armoured beast was covered in protective knobs and plates of bone. It had two horns pointing backwards from its wide, low skull and a large club on the end of its tail to swing at attackers.



1. IGUANODON

Length: 10 m (33 ft)
Found in: Europe

2. ARGENTINOSAURUS

Length: 30–40 m (100–130 ft)
Found in: Argentina

5. TRICERATOPS

Length: up to 9 m (30 ft)
Found in: North America

6. ANKYLOSAURUS

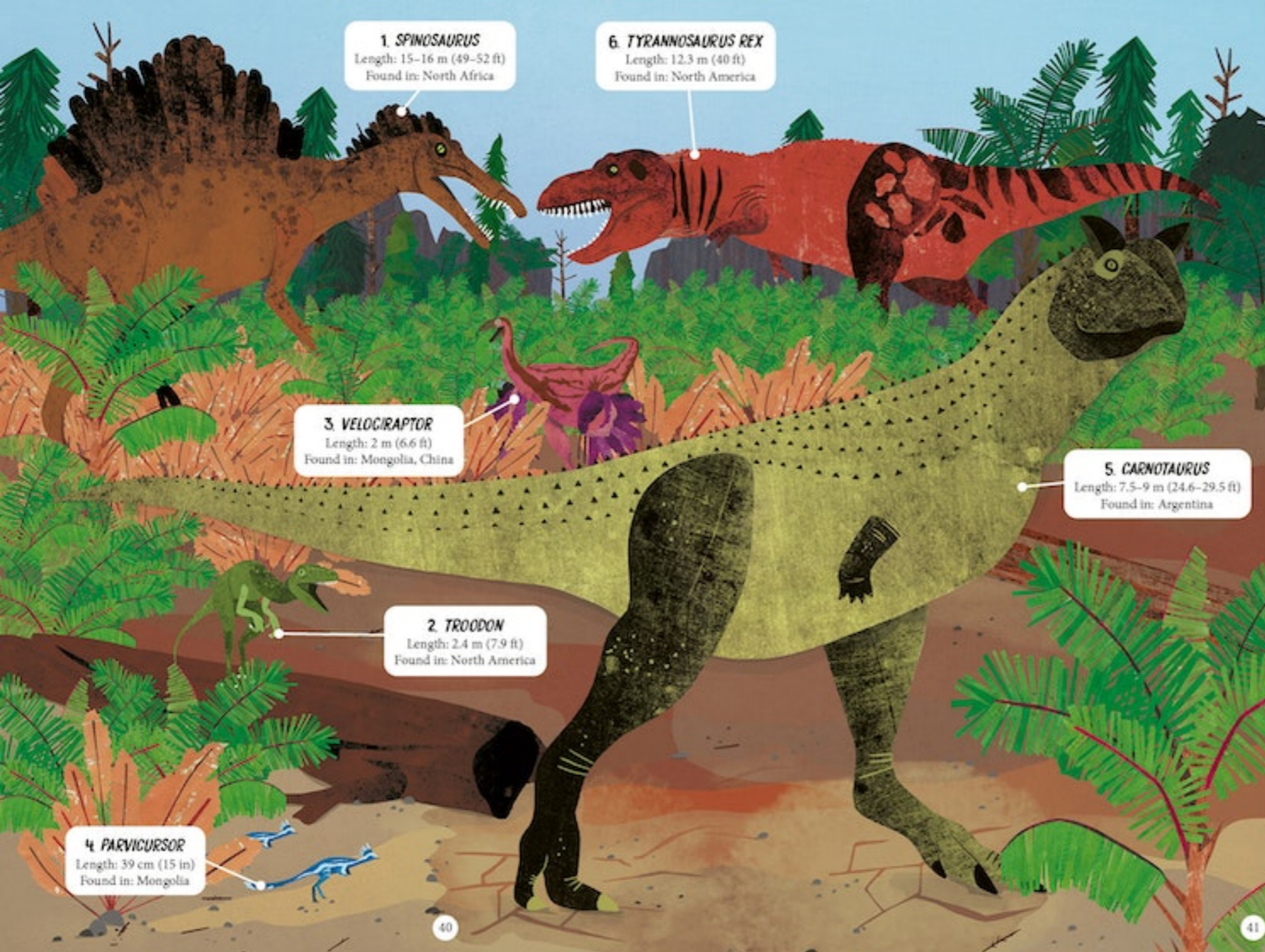
Length: 6–8 m (20–26 ft)
Found in: USA

3. PARASAUROLOPHUS

Length: up to 9.5 m (31 ft)
Found in: North America

4. THERIZINOSAURUS LENGTH:

9–10 M (30–33 FT)
Found in: Mongolia



1. SPINOSAURUS
Length: 15–16 m (49–52 ft)
Found in: North Africa

6. TYRANNOSAURUS REX
Length: 12.3 m (40 ft)
Found in: North America

3. VELOCIRAPTOR
Length: 2 m (6.6 ft)
Found in: Mongolia, China

5. CARNOTAURUS
Length: 7.5–9 m (24.6–29.5 ft)
Found in: Argentina

2. TROODON
Length: 2.4 m (7.9 ft)
Found in: North America

4. PARVICURSUS
Length: 39 cm (15 in)
Found in: Mongolia

ON THE GROUND — PREDATORS

THREE MAJOR GROUPS OF THEROPOD DINOSAURS SURVIVED TO THE END OF THE CRETACEOUS: THE CERATOSAURS, ALLOSAURS AND COELUROSAURS. THE COELUROSAURS WERE THE MOST DIVERSE OF THESE, PRODUCING AMONG MANY OTHERS, *T. rex*, *Troodon*, *Velociraptor* AND THE AVIANS — THE FAMILY THAT INCLUDES TODAY'S BIRDS.

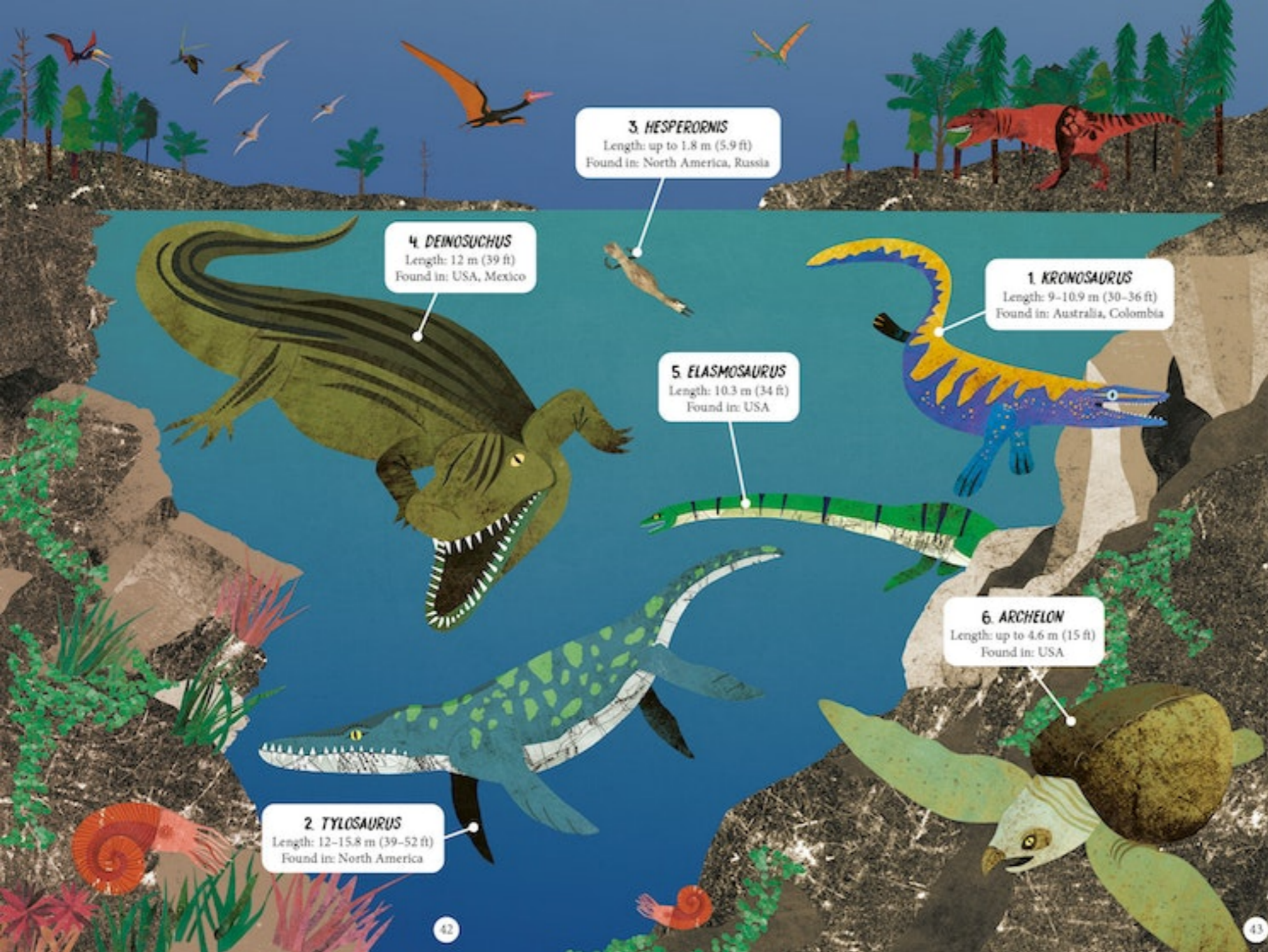
- 1 SPINOSAURUS (LIVED: 99–93.5 MYA)** was a huge carnivore — even bigger than *T. rex*. The sail on its back may have been to regulate body temperature or for display. It lived mainly in and near shallow water, preying on fish, lizards, turtles and other dinosaurs.
- 2 TROODON (LIVED: 77.5–76.5 MYA)** was a small, bipedal dinosaur with long, curved claws, sharp teeth and large eyes. It may have been the cleverest of all the dinosaurs, since it had one of the biggest known dinosaur brains relative to its body mass.
- 3 VELOCIRAPTOR (LIVED: 75–71 MYA)** This small, feathered, yet terrifying dinosaur could run really fast and had an extra large, curved claw on each hind foot, probably used to tear at or restrain prey, or to latch onto the sides of prey like a climbing crampon.
- 4 PARVICURSUS (LIVED: 72 MYA)** was one of the tiniest predatory dinosaurs of the Cretaceous. Its long, slender legs gave it speed when escaping predators. Instead of hands it had a single large claw that it probably used to pierce termite mounds to get at the insects within.
- 5 CARNOTAURUS (LIVED: 72–70 MYA)** The horns above its eyes gave this dinosaur its name, which means 'meat-eating bull'. It had pebbly skin, a row of bumps down its spine, and tiny forelimbs. With its long, muscular legs, it was probably one of the fastest of the large theropods.
- 6 TYRANNOSAURUS REX (LIVED: 68–66 MYA)** The most famous of all dinosaurs remains one of the largest ever land predators, and its huge jaws, filled with over sixty razor-sharp teeth, probably exerted the strongest bite force of any terrestrial animal, enough to break the thickest bones.



IN THE OCEAN

SHARKS AND CARNIVOROUS, RAY-FINNED FISH WERE COMMON IN THE OCEANS AND INLAND SEAS OF THE CRETACEOUS, COMPETING FOR PREY WITH REPTILES SUCH AS PLESIOSAURS AND PULSOSAURS. ICHTHYOSAURS WERE EXTINCT BY THE LATE CRETACEOUS, THEIR PLACE TAKEN BY A NEW, FAST-SWIMMING REPTILE PREDATOR: THE MOSASAUR.

- 1. KRONOSAURUS (LIVED: 120–100 MYA)** This huge and terrifying pliosaur had a head as long as a horse, and jaws full of sharp teeth the size of bananas. It preyed on turtles, plesiosaurs and possibly giant squid. Its streamlined body was propelled by four powerful flippers.
- 2. TYLOSAURUS (LIVED: 90–66 MYA)** The mosasaurs were the top predators of the Late Cretaceous, and one of the biggest was *Tylosaurus*. It moved like a shark, its broad tail sweeping from side to side, as it chased after fish, turtles, plesiosaurs and even other mosasaurs.
- 3. HESPERORNIS (LIVED: 835–78 MYA)** was a large, flightless seabird that resembled a modern grebe. It had virtually no wings and swam with powerful strokes of its hind legs. It could dive deep, using its long neck and tooth-lined beak to pluck fish from between rocks.
- 4. DEINOSUCHUS (LIVED: 82–73 MYA)** This giant cousin of the modern crocodile would have terrorised coastal areas, dining on fish, turtles and land animals. *Deinosuchus*'s bite force has been estimated as even stronger than *T-rex*'s – enough to crush a turtle's shell.
- 5. ELASMOSAURUS (LIVED: 805 MYA)** had one of the longest necks of any plesiosaur, with 72 vertebrae and extending up to 7.1 m (23 ft). Its long, sharp teeth could not chew, but were used for trapping fish before it swallowed them whole.
- 6. ARCHELON (LIVED: 80–74 MYA)** Not only was this the largest turtle ever to exist, it was also a fierce predator, using its hooked beak and jaws to crush the shells of crustaceans and molluscs as it swam slowly above the sea floor.



3. HESPERORNIS
Length: up to 1.8 m (5.9 ft)
Found in: North America, Russia

4. DEINOSUCHUS
Length: 12 m (39 ft)
Found in: USA, Mexico

1. KRONOSAURUS
Length: 9–10.9 m (30–36 ft)
Found in: Australia, Colombia

5. ELASMOSAURUS
Length: 10.3 m (34 ft)
Found in: USA

6. ARCHELON
Length: up to 4.6 m (15 ft)
Found in: USA

2. TYLOSAURUS
Length: 12–15.8 m (39–52 ft)
Found in: North America

THE END OF THE DINOSAURS

The Cretaceous period ended 66 million years ago when a terrible catastrophe struck, wiping out three-quarters of all the plant and animal species on Earth, including all the dinosaurs (except for birds) and the pterosaurs. Most large marine reptiles died out, too, with a few exceptions, such as sea turtles and crocodiles.

WHAT HAPPENED?

Around 66 million years ago, the Earth was hit by a massive asteroid, some 10 to 15 km (6–9 miles) wide. It struck the Gulf of Mexico's Yucatán Peninsula, leaving a 180-km (112-mile) wide crater. Scientists have calculated it struck with a force of over 100 million megatons, sending giant tsunamis across the oceans and igniting devastating wildfires.



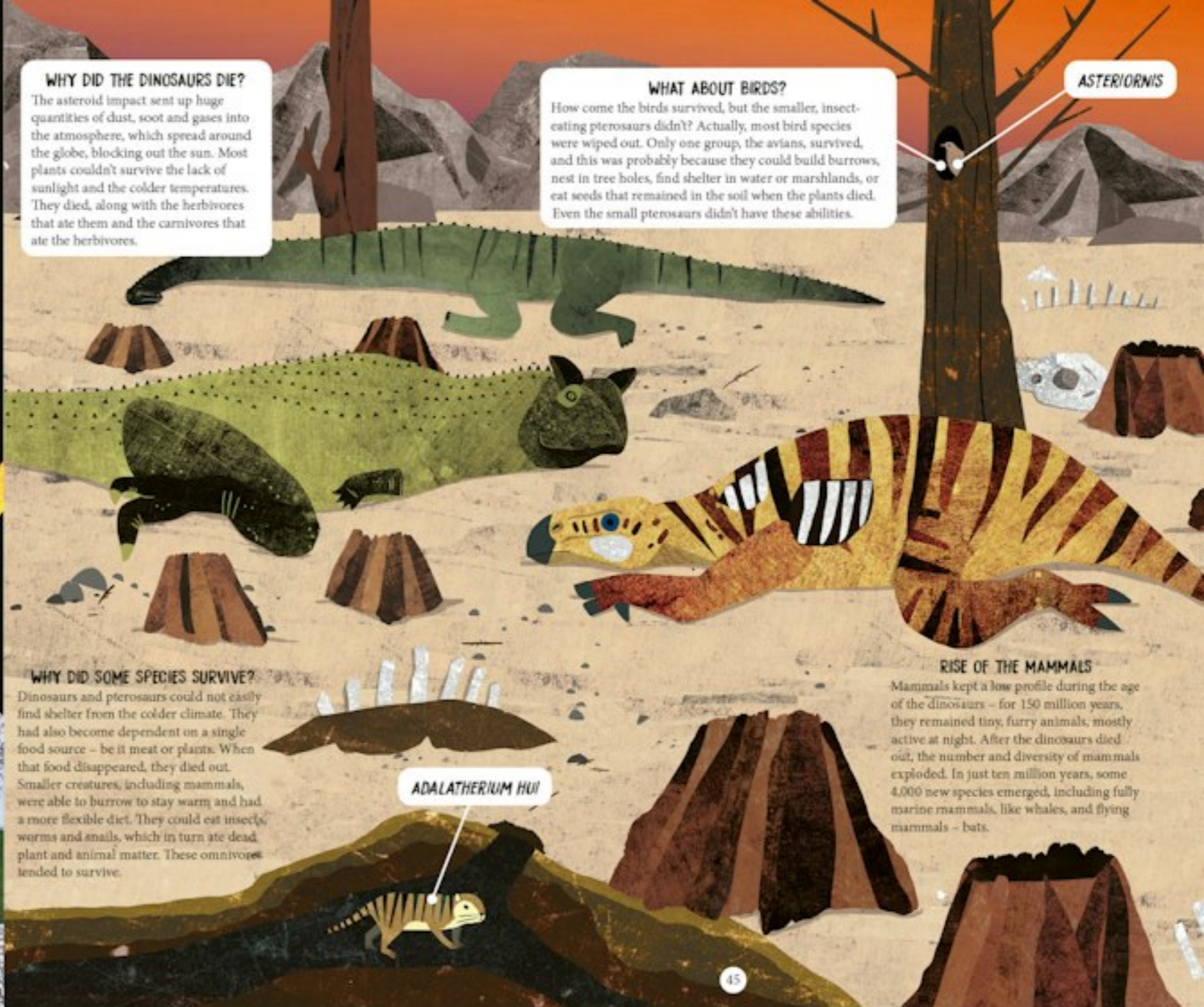
WHY DID THE DINOSAURS DIE?

The asteroid impact sent up huge quantities of dust, soot and gases into the atmosphere, which spread around the globe, blocking out the sun. Most plants couldn't survive the lack of sunlight and the colder temperatures. They died, along with the herbivores that ate them and the carnivores that ate the herbivores.

WHAT ABOUT BIRDS?

How come the birds survived, but the smaller, insect-eating pterosaurs didn't? Actually, most bird species were wiped out. Only one group, the avians, survived, and this was probably because they could build burrows, nest in tree holes, find shelter in water or marshlands, or eat seeds that remained in the soil when the plants died. Even the small pterosaurs didn't have these abilities.

ASTERIORNIS



WHY DID SOME SPECIES SURVIVE?

Dinosaurs and pterosaurs could not easily find shelter from the colder climate. They had also become dependent on a single food source – be it meat or plants. When that food disappeared, they died out. Smaller creatures, including mammals, were able to burrow to stay warm and had a more flexible diet. They could eat insects, worms and snails, which in turn ate dead plant and animal matter. These omnivores tended to survive.

ADALATHERIUM HUI

RISE OF THE MAMMALS

Mammals kept a low profile during the age of the dinosaurs – for 150 million years, they remained tiny, furry animals, mostly active at night. After the dinosaurs died out, the number and diversity of mammals exploded. In just ten million years, some 4,000 new species emerged, including fully marine mammals, like whales, and flying mammals – bats.

FROM DINOSAUR TO FOSSIL

How do we know so much about the dinosaurs if they died out millions of years ago? The reason is that they left evidence behind in the form of fossils. These are preserved remains, such as footprints or bones embedded in rock. We're not talking about the original bones – over so much time they have fossilised, or turned into stone.



HOW DO FOSSILS RISE?

How do fossils reach the surface? The giant plates that form the Earth's crust sometimes collide, forcing rocks together and pushing them upwards, creating mountain ranges. Some of these rocks contain fossils. That's why fossils have been found at the top of Mount Everest. In other cases, fossils may be pushed to the surface because new igneous rocks (made from solidified magma or lava) have formed beneath them.



HOW DO FOSSILS FORM?



1. SCAVENGED

After it dies, the dinosaur's soft parts – the flesh, skin and muscles – rot away or are eaten by scavengers, leaving only its bones and teeth.



2. BURIED

Sediment – mud, sand or silt – covers the remains. This prevents oxygen from getting to the skeleton, slowing down decomposition.



3. SEDIMENT

Over millions of years, layers of sediment build up, putting enormous pressure on the layers below and turning them into sedimentary rock.



4. WATER

At the same time, water seeps into the bones and teeth, dissolving them. Minerals in the water replace the bones and teeth, producing stone replicas called fossils.



5. EROSION

Over millions more years, the rock containing the fossil rises to the surface and is worn away by erosion, to be discovered by fossil hunters!

WHY ARE DINOSAUR FOSSILS RARE?

Very few living things turn into fossils. Most just rot away completely, leaving nothing behind. To turn into a fossil, an animal must be covered by sediment soon after death. That's why 99% of fossils are from marine animals, whose remains are quickly buried by sand or mud. For a dinosaur to fossilise, its body might have got washed into a lake or river, or perhaps it died before an area flooded, covering its remains in mud. Or it might have been buried in a sand storm or landslide.

DIGGING FOR DINOSAURS

Experts in fossils are known as palaeontologists. These are the people who hunt for dinosaur fossils, dig them out of the ground and study them. Everything we know about dinosaurs today is thanks to their painstaking efforts. Palaeontologists searching for dinosaurs don't just dig for them at random. They look for rocks dating from the Mesozoic era – that is, from the Triassic, Jurassic and Cretaceous periods – where there will be a good chance of finding dinosaur remains.

EXCAVATING

Once a palaeontologist has located a dinosaur, the next task is getting it out of the ground. Large digging machines might be needed to remove the material on top. Once the fossil is fully exposed, palaeontologists use smaller tools such as trowels, knives and brushes to work around the ancient bones. It can take days or even weeks of patient work to extract the fossil without damaging it.

WHAT TO LOOK FOR

There are often signs on the surface that a fossil is hidden below. Perhaps part of the fossil is sticking out of the surface, or there may be fossil fragments lying on the ground. Sometimes the fossils are a different colour than the surrounding stone, but it's not always easy to spot them. One important difference is that fossils have the fine webbed structure of the bones they once were, whereas ordinary stone is smooth inside. If you try licking a fossil, the tiny tubes inside it will suck moisture from your tongue. So if it sticks to your tongue, it's probably a fossil.

TRANSPORTING

The next challenge is getting the fossil to a laboratory for study. Fossils are extremely fragile and liable to break during transport, so they are first covered in a 'field jacket' – plaster of Paris and canvas material is used to create a protective cast around the bone.

RECONSTRUCTING DINOSAURS

The fossilised bones, claws, horns and teeth found in the ground are not always easy to reconstruct into the original dinosaur. Palaeontologists draw on their knowledge of animal and dinosaur anatomy to work out what bones go where. Sometimes they make mistakes. *Iguanodon*'s thumb spike was once thought to be a horn on its nose, and *Elasmosaurus*'s long neck was originally believed to be its tail!

WHAT KIND OF DINOSAUR?

One of the first jobs of a palaeontologist after discovering a dinosaur fossil is to work out what species it is. They do this by comparing the remains to other previously excavated dinosaurs to see if they can find a match. If they can find one, it will help them reconstruct the new find. If they can't, then it's possible they've discovered a new species.



WHAT DID THEY LOOK LIKE?

Once the bones are reassembled correctly, palaeontologists can use digital technology to add in muscles, tendons, flesh and skin. It's very rare for impressions of dinosaur skin or feathers to be preserved as fossils, so palaeontologists use what they know about similar living animals, such as birds and reptiles, to make educated guesses about the skin patterns, colours and plumage of dinosaurs.

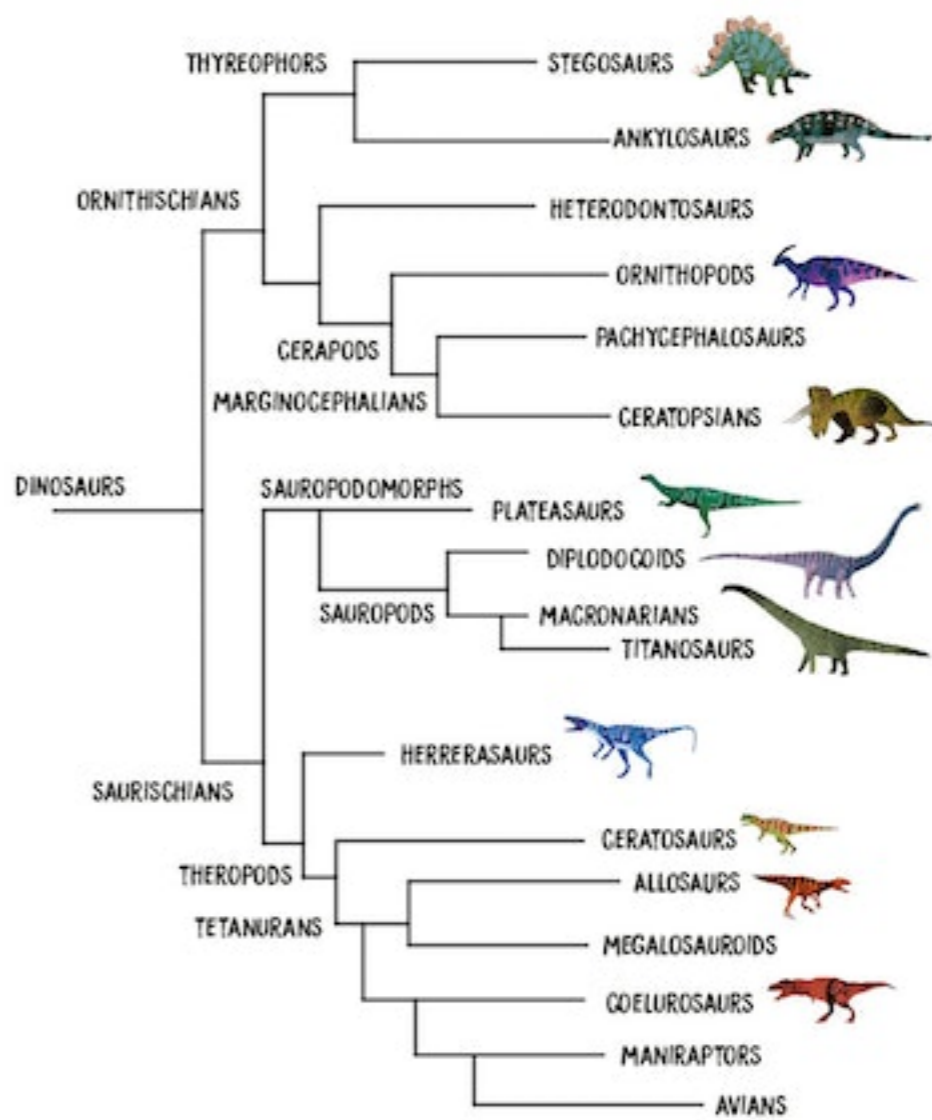


HOW DID THEY LIVE?

As well as the dinosaur fossil itself, palaeontologists also extract lots of other material from the site, including the fossilised remains of plants and other animals, so they can reconstruct how the animal lived in its environment. Computers are used to model how dinosaurs moved. We can only speculate on how dinosaurs actually behaved, although occasionally we get a clue: in 1971, palaeontologists in Mongolia discovered fossils of a Protoceratops and a Velociraptor caught in mid-fight.

CLASSIFYING DINOSAURS

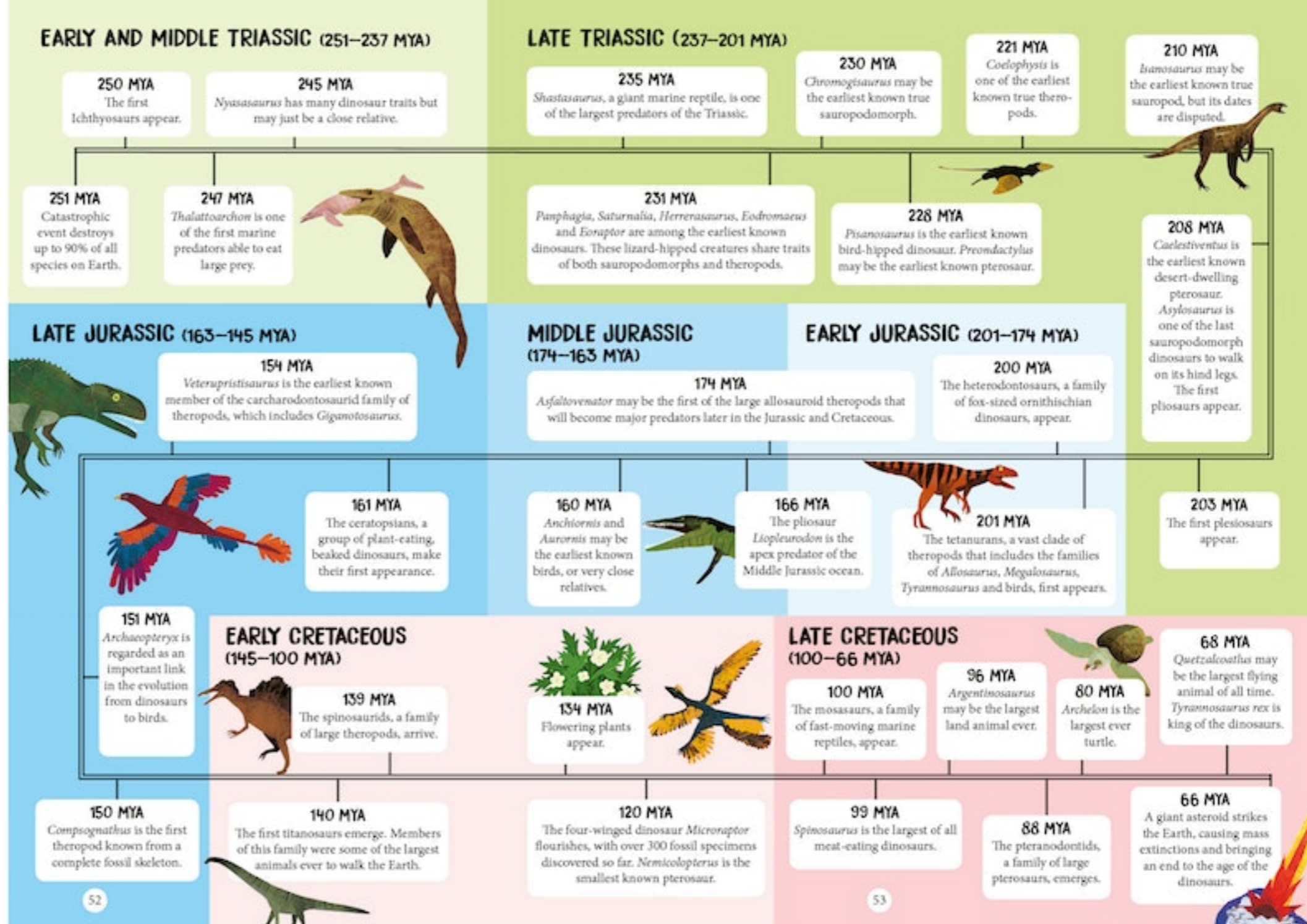
As dinosaurs evolved, they split into different families and sub-families like a giant, many-branched family tree. Palaeontologists try to place each new dinosaur discovery on this tree. They work out where they belong based on their physical characteristics.



DINOSAURS THROUGH TIME

The age of the dinosaurs lasted around 165 million years, from 231 to 66 million years ago. Scientists call this time the Mesozoic era and they divide it into three periods: the Triassic, Jurassic and Cretaceous. The Mesozoic was preceded by the Palaeozoic, which began 541 million years ago, during which animals such as molluscs, fish, arthropods and amphibians first appeared. The Mesozoic was followed by the Cenozoic, the age of mammals, an era we are still living in today.

In this timeline, we look at some of the key developments in the age of dinosaurs. However, we should bear in mind that palaeontology is a constantly evolving science, and our understanding of this era and exactly when developments took place will inevitably change as new discoveries are made.



GLOSSARY



AMMONITE An extinct mollusc of the Jurassic and Cretaceous, with a spiral shell.

ANATOMY The bodily structure of an organism.

APEX PREDATOR The dominant predator (animal that preys on others) in a particular time and habitat.

ARCHOSAUR A large group of animals that includes dinosaurs and pterosaurs, as well as modern birds and crocodilians.



ASTEROID A small, rocky body orbiting the Sun. Occasionally in its history, Earth has been struck by asteroids.

BIPEDAL Using only two legs for walking.



BIRD-HIPPED Describing a kind of dinosaur whose hip bones pointed backwards, like those of birds.

CARNIVORE An animal that feeds on other animals.



CRUSTACEAN A member of a large family of mainly aquatic animals that includes crabs, lobsters, shrimps and barnacles.

EROSION The process by which land gets worn away through the action of wind, water and other natural forces.

EXTINCTION The dying out of a species.



FILTER-FEEDING Feeding by straining particles of food from water using a filtering process such as the teeth or gills.

FOSSIL The remains or impression of a prehistoric animal or plant embedded in rock and preserved in stony form.



GLOBAL WARMING An increase in the overall temperature of the Earth caused by increased levels of carbon dioxide and other gases, which trap heat in the atmosphere.

GONDWANA A vast southern landmass of the Mesozoic era, made up of modern Africa, South America, Antarctica, India and Australia.

HERBIVORE An animal that feeds on plants.

IGNEOUS ROCK Rock that has formed out of solidified lava or magma.

LAURASIA A vast northern landmass of the Mesozoic era, consisting of North America and Eurasia.

LIZARD-HIPPED Describing a kind of dinosaur whose hip bones pointed forward and down, like those of lizards.



MESOZOIC ERA The era in Earth's history that lasted from 252 to 66 million years ago.

MOLLUSC A member of a large family of soft-bodied animals that includes snails, slugs, mussels, squid and octopuses.

OMNIVORE An animal that feeds on both plants and on the meat of other animals.

PALAEONTOLOGY The study of fossil animals and plants.



PANGAEA A supercontinent comprising all the land area of Earth that existed in the late Palaeozoic and early Mesozoic eras.

PANTHALASSA A vast ocean that surrounded the supercontinent of Pangaea.

PARAVIAN A group of theropod dinosaurs that emerged in the late Jurassic, some of which would evolve into birds.

PLUMAGE The feathers of a bird or dinosaur.



PTEROSAUR (meaning 'wing lizard') An order of flying reptiles that existed for most of the Mesozoic era.

REPTILE A member of a large class of animals with dry, scaly skin that typically lay soft-shelled eggs on land.



SAUROPOD A very large, herbivorous dinosaur with a small head, a long neck and tail and massive limbs.

SAUROPODOMORPH A large, bipedal herbivorous dinosaur that was the ancestor of the sauropods.

SCAVENGER An animal that feeds on dead animals or plant matter.



SEDIMENTARY ROCK Rock formed from sediment deposited by water or air.



SERRATED Having a jagged edge.

SUCTION FEEDING A kind of feeding used by some marine animals in which they use water pressure to suck prey into the mouth.

SYNAPSID A group of animals related to mammals that emerged around 323 million years ago and dominated much of the Permian and early Triassic periods.

THEROPOD A carnivorous, bipedal, lizard-hipped dinosaur whose members ranged from small and lightly built to very large.

VERTEBRA (plural: vertebrae) One of a series of small bones that make up an animal's backbone.



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