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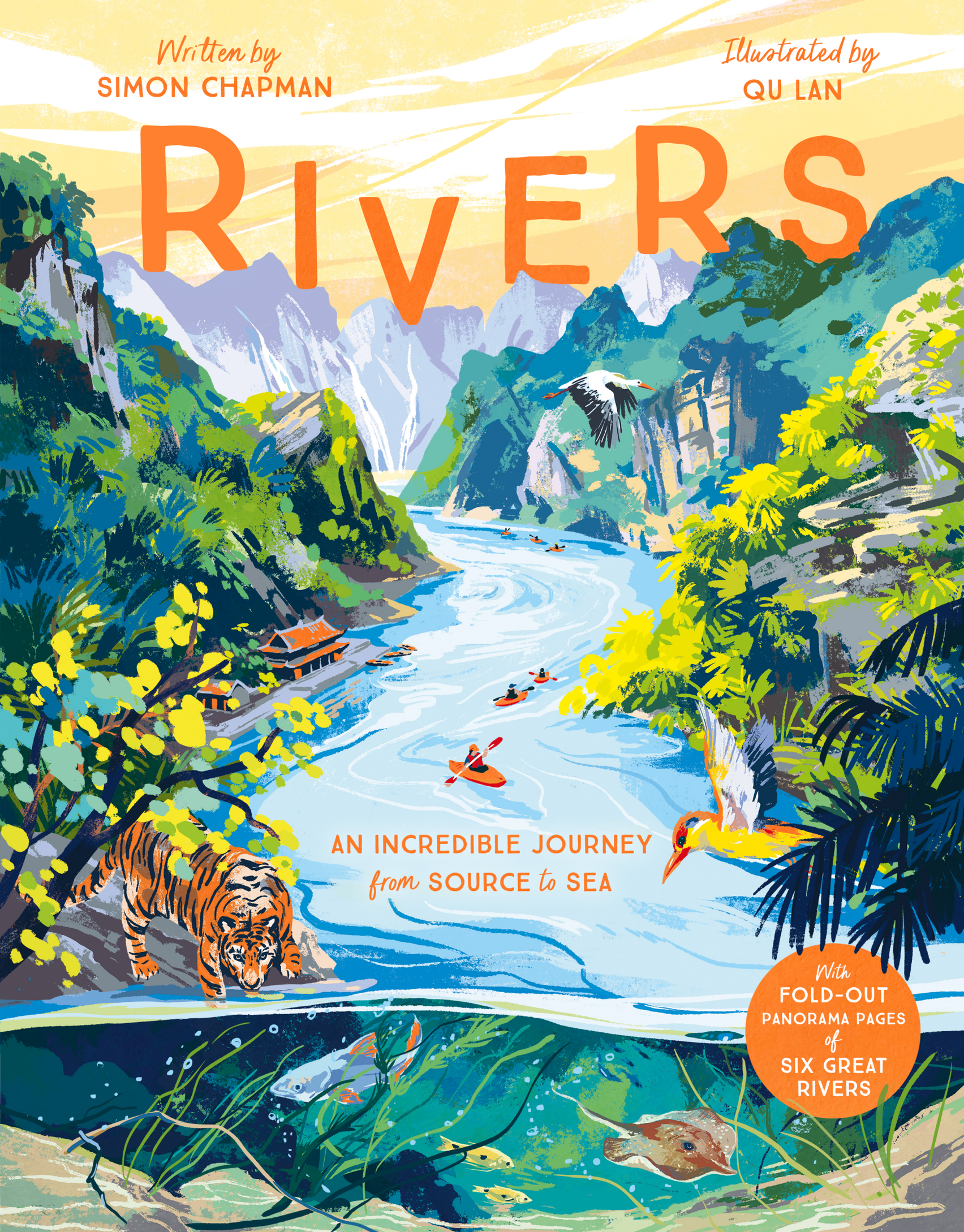
RIVERS



AN INCREDIBLE JOURNEY
from SOURCE *to* SEA

With
FOLD-OUT
PANORAMA PAGES
of
SIX GREAT
RIVERS

Water

EVEN THOUGH RIVERS BEGIN IN HILLS AND MOUNTAINS, their water comes from the sea. The sun's energy evaporates sea water into the air, which cools to form clouds. When the clouds drop rain or snow onto the land, rivers take this water downhill to the sea. The whole journey from sea to clouds to river and back to the sea to complete the loop is called the water cycle. Here's how that happens.

1. The sun's energy evaporates water from the sea and other water sources as water vapour (a gas). Plants give out water vapour too.

2. As the water vapour rises it cools and condenses (turns back in to water) to form clouds of tiny water droplets.

3. Winds blow the clouds inland.

4. When winds blow clouds high up mountainsides they cool. This makes more water vapour condense and the water droplets grow bigger and heavier.

5. The water falls to earth as precipitation – rain, hail or snow.

The area of land where all the water flows into one river system is called the river's **catchment**.

6. The force of gravity pulls this liquid water down streams and rivers, back to the sea.

7. The river meets the sea.

This white dashed line shows the **watershed** – the divide between two river systems. Any rain or snow falling on the far side of this mountain ridge will flow into a different river system.

WHAT IS WATER?

Each molecule of water (H_2O) contains two hydrogen atoms and one oxygen atom bonded together. These molecules can flow around each other and stay close together, and, because of this, water can change its shape.

Water is HEAVY!
One cubic metre weighs one tonne – about the same as a small car. The largest river in the world, the Amazon, moves over 200,000 tons of water every second. The much smaller River Thames in London, UK, shifts just 66 tons of water every second.

Water is FAST!
Most rivers flow at a speed of around 3 metres per second – that's about how fast you run. Rivers in flood after heavy rain flow even faster.

Water is POWERFUL!
Because it is heavy and can flow easily, moving water can push with a lot of force. It can break rocks into tiny particles and carry objects along with it. Over millions of years, it can wear down mountains.

GORGES: *The Grand Canyon*

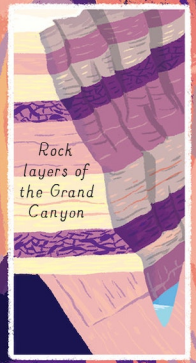
THE MOST FAMOUS GORGE IN THE WORLD, the Grand Canyon winds its way through the semi-desert of the Southwestern United States. It is 1,600 metres deep and over 400 kilometres long, carved by the Colorado River. The Paiute people of the Great Basin Desert area call it the Kaibab, which means the 'mountain turned upside down'. But the Colorado is no great Mississippi or Amazon. It is only 100 metres wide on average as it passes between the canyon's rock walls. So how did it cut so deeply into the earth?

The River Colorado is only 23 metres wide at its narrowest point in the Grand Canyon. That's about the length of a town swimming pool. But at this point, the river is also at its deepest – 25 metres.

Gorges are formed by waterfalls eroding backwards, caverns collapsing or by the sheer force of the water eroding through rock, and this takes time. Six million years in the case of the Grand Canyon!

The sedimentary rock that the Colorado River flows over is made of compacted sand and mud that was once at the bottom of the sea. This seabed was raised higher by the same earth movements that raised the land to form the nearby Rocky Mountains.

For most of the year the Colorado hardly erodes the rock beneath it. Virtually all of its downwards cutting happens when snow in the Rockies melts each spring, swelling the river to many times its usual size.



Rock layers of the Grand Canyon

Carrying 500,000 tons of tiny broken rock pieces, the floodwaters of the Colorado act like sandpaper, eroding the riverbed deeper and washing away the valley sides.

Water erodes hard and soft rock away at different rates, which has created the Grand Canyon's distinctive steps.

In the past, before people built dams across the Colorado, nearly 40 times as much water flowed through the canyon during its spring floods. Sometimes these floods washed fossils from the canyon walls all the way to the where the river meets the sea over 300 kilometres away.

Swirling currents can cause rocks, pebbles and sediment to erode circular hollows called potholes in the riverbed.

"A PERFECT HELL OF WAVES"

The Colorado River was first explored in 1869 by a 10-man expedition led by geologist Colonel John Wesley Powell. They set off in four wooden rowing boats, not knowing what they would discover. Over three months and 1,500 kilometres they encounted hundreds of rapids, one of which they described as "a perfect hell of waves". After one of the boats was smashed to pieces, three of the team deserted to take their chances in the desert. They were never seen again. The three remaining boats made it through the canyon and Colonel Powell became famous for his achievement. Powell took another expedition through the Canyon in 1871, this time with cameras and equipment to map the river's course.

Mangroves

NEAR THE COAST ON THE VAST MAHAKAM RIVER DELTA IN BORNEO, ASIA, one of the most resilient and adaptable plants on earth lines the riverbanks. Mangroves thrive along tropical and subtropical coasts where few other plants can grow. They survive daily flooding with saltwater and, on the outside edge of the delta, being battered by ocean waves. How? Because of their extraordinary roots.

It is the mangroves' cage-like 'stilt' roots that hold the river mud together. They anchor the plants and in doing this they bind the sediments washed down from the river, stopping land being washed away. The submerged root tangles also provide a protective 'nursery' for shoals of young fish and is a home to crustaceans like prawns and crabs. As the mangroves grow out towards the sea, they increase the length of the river whose banks they hold together, sometimes by as much as 50 metres every year.

Mangroves are designed to survive against the odds. Most plants cannot survive in even slightly salty water, but mangroves are adapted to get rid of the salt that would otherwise poison them. Many species excrete salt through their leaves but the mangroves closest to the sea do this through their roots, which grow outwards under the mud then stick up into the air to do this. Unusually, mangrove seeds sprout while they're still on the tree/branches, ready to start growing as soon as they drop into the mud.

Mudskipper fish climb up the stilt roots with their stiff front fins.

Proboscis monkeys will leap across the channel to avoid salt-water crocodiles.

Like mangroves, nipa palms grow along some of the delta's brackish channels but they cannot survive in the sea's salt water.

Sucker Barb

Amongst the roots the current is slower and, there, young fish are out of reach of most predators.

Salt-water crocodile

Tiger Prawn

Catfish

Kissing Gourami

Fiddler crabs pick off dead plant and animal matter from the mud.

Stilt roots bind the mud together.

[Since XXXX] Thirty eight percent of the world's mangrove forests have been cut down to clear space for shrimp farms. The Mahakam delta has been badly affected. Mangroves are also damaged by water pollution and global warming, which has a knock-on effect to the ecosystem they support. Without nursery areas for marine wildlife, there are fewer fish in the sea. Without mangrove roots holding the mud together and creating a barrier from the ocean, tropical river mouths and coastlines suffer more damage from storms, putting over a billion people's lives at risk.

HEADING UPSTREAM: *The Salmon Run*

IN OCTOBER AT THE ADAM'S RIVER IN BRITISH COLOMBIA, CANADA, Sockeye salmon are fighting their way upriver against the current to get to the watercourse where they were born. Three years ago, they migrated downstream to the Pacific Ocean, where they have lived as ocean fish until their bodies were ready for this strenuous return journey. Now the race is on.

Thirty-four million sockeye salmon in the Adam's River and hundreds of millions more in rivers around the North Pacific, from Hokkaido in Japan to Eastern Siberia around to Alaska and Oregon in the USA, are all travelling back home to breed.

Geese fly in V-shape skeins as they flee southwards where the conditions are more favourable.

If there aren't human-built dams in the way, the salmon easily make it through the weak current of the river's lower and middle courses. But near its headwaters, there are rapids to fight through and waterfalls to jump up. Salmon can leap higher than 3.5 metres but, at some falls, predators are waiting for them. Grizzly bears wait to swipe them out of the air with their claws.

By the time they reach the stream of their birth, the salmons' bodies have changed. Both sexes have turned bright pinkish red. The males have developed humped backs and the top half of their mouths have hooked over so that their teeth are on show. This is not for eating. They have not eaten for the full four weeks of their journey. They have changed so that they can fight other males for females to mate with. Once they have mated and the females have laid the eggs, both the males and females die.

The salmon know the river where they were born from its taste. They can detect tiny amounts of minerals dissolved from the sediments the water carries. As the salmon continue upstream and the river splits into smaller and smaller tributaries, they will almost always pick the right stream to follow.

But the eggs survive and there are thousands of them. In one to three years' time, the young fish that hatch will work their way downriver to the Pacific Ocean and the cycle will start again.