

## ***Great Discoveries in Science: The Making of a Theory***

**[NARRATOR:]** After four arduous years of collecting animals in the Amazon jungle, Alfred Russel Wallace is finally heading back to England. Sailing with him are the rewards of a long journey: thousands of specimens he will sell to museums and collectors. Exhausted from his travels, Wallace is looking forward to the comforts of home.

**[CAPTAIN:]** I'm afraid the ship's on fire.

**[NARRATOR:]** Every one of Wallace's specimens is destroyed. His hard-earned records of which animals live where in South America are also lost. These notes contain clues to the question that Wallace risked so much to answer. It was the greatest scientific mystery of his time: where do species come from? But now Wallace's thoughts must turn to a more urgent concern. Survival. His hands are burned raw from sliding down a rope. His lifeboat is leaking badly. The castaways have little food or water and are 700 miles from the nearest shore. Wallace vows that if he survives, he will never sail again. This is the story of the search for the origin of species, and of the epic adventures of the two explorers who found the answer.

**[CARROLL:]** Alfred Wallace might have avoided his predicament had someone else not been keeping a secret. Another British naturalist had already answered the question of the origin of species years earlier. But he had dared to share his ideas with only a few trusted friends.

**[NARRATOR:]** Charles Darwin set sail on his own voyage twenty years before Wallace's shipwreck. He was an unlikely revolutionary. He lived in a time when most scientists believed that each species was specially created by God, in its present form and constant, and not somehow the product of natural laws and changeable. At the age of 22, Darwin also believed in Special Creation. He was even planning to become a clergyman. But then he got a surprising offer. Darwin jumped at the chance to sail around the world on a British naval vessel--the *Beagle*.

**[CARROLL:]** The offer was more about his pedigree than his resume. Darwin could be cheerful upper-class company for the captain--no small task, given that the *Beagle's* previous captain became despondent and shot himself. The lure for Darwin? He was a passionate amateur naturalist. And now he'd have the chance to see and collect animals, plants, and rocks around the globe. Early in the voyage, he examined plankton with his state-of-the-art microscope, an instrument that only the son of a wealthy family could have afforded. Darwin was perplexed. Why was there so much beauty in the middle of the ocean where no one was around to enjoy it? Why were these forms created for so little apparent purpose? But for every moment of joy or discovery, Darwin experienced a hundred of suffering. He was often seasick. Not merely queasy, but desperately, violently ill. His adventure came at a high price. Darwin's curiosity was not limited to science. On

the coast of Argentina, he sampled a local delicacy. Roast armadillo. He thought it tasted like duck. Not far from this barbecue, Darwin found an interesting fossil. It was a small piece of an extinct creature called Glyptodon. It was part of its protective covering. Darwin had seen a similar bony shell on the armadillo he had just eaten. But this fossil came from a giant. The animal he discovered would have been dinner for a thousand.

**[CARROLL:]** Darwin found several more fossils nearby, including ground sloths like this one. They were all enormous compared to living species. Darwin would ponder the geological relationship between the extinct and the living.

**[NARRATOR:]** Darwin didn't yet understand why fossils of extinct animals turn up where similar animals live today. After nearly four years at sea--twice as long as Darwin had signed up for—the *Beagle* arrived in a remote Spanish colony: the Galápagos. It would have been the dream of most any naturalist to explore these islands. But when Darwin arrived, he was more exhausted than excited. If Hell had a garden, he thought, this is what it would look like. The black volcanic rocks felt as if they'd been baked in an oven. The plants stank. He didn't see a single beautiful flower

**[CARROLL:]** The Darwin that arrived here was not the great theorist that we know today. He was a 26-year-old collector, collecting, really, almost at random. Any kind of plants, any kind of animals, any kind of rocks. He didn't even know the meaning of what he was collecting until much later.

**[NARRATOR:]** He thought the islands' sea-going iguanas looked "dim-witted" and "hideous." But he did like a different Galápagos reptile--the tortoises. He even took a ride on one.

**[CARROLL:]** You magnificent beast.

**[CARROLL:]** When Darwin was here on the Galápagos, he was given an important clue. The Spaniards told him that they could tell which island a tortoise came from, just from the shape of its shell.

**[NARRATOR:]** Why would tortoises on nearby islands look so different from one another? The islands' mockingbirds also caught Darwin's attention. He focused on their subtle differences. One kind of mockingbird had smudges on its breast. Another had a large dark patch under each eye. A third had a pure white breast. Darwin was astonished when he realized that, just like the tortoises, each kind of mockingbird lived on a different island.

**[CARROLL:]** So even though he stayed here just five weeks out of the whole five-year voyage, it's what he saw here, in these five weeks, that left the greatest impression on Darwin and would lead into his greatest ideas.

**[NARRATOR:]** After stops in Australia and Africa--and as the *Beagle* turned home to England--Darwin had the chance to reflect on what he had been seeing. In his cabin, Darwin puzzled over the Galápagos animals. It was remarkable that similar but distinct

creatures lived on such nearby islands. What would explain this fact? According to Special Creation, God made a different species for each island. But another possibility occurred to Darwin. Perhaps one species might have come from the mainland and then changed in different ways on different islands. The Galápagos animals were raising a radical idea: Species might change.

**[NARRATOR:]** After Darwin returned to England, he starts thinking about everything he saw on this five-year voyage.

**[CARROLL:]** And he's thinking back to the geology, the fossils, the animals that he'd seen. He's in this process he calls mental rioting, just letting every thought stream to him, until finally, he has his big idea.

**[NARRATOR:]** Rioting was the right word: his ideas were doing violence to the established order. The best explanation for what Darwin saw in the Galápagos was that species changed into new species. Over time, one kind of mockingbird somehow became three. Tortoises multiplied into different forms.

**[CARROLL:]** And what did it mean that armadillos and sloths live today were extinct giant versions once roamed?

**[NARRATOR:]** Maybe, Darwin thought, today's species are descended from older, extinct types. If so, then all species are connected to one another in a family tree. It is a simple, crude sketch, but Darwin's drawing is a radical new picture of life. Any species can give rise to new and slightly different species. As generations pass, grand-species arise, and then great-grand-species. Darwin's bold idea was that species come from other species just as naturally as children come from parents. There was a word for this kind of thinking... Heresy.

**[CARROLL:]** So the origin of species was natural, not divine. It was a revolutionary idea that overthrew Special Creation. It ran against church teachings and what most Europeans believed, including most scientists. Still a young man, Darwin couldn't reveal his great idea. He would be attacked and ruined.

**[NARRATOR:]** Many years later, Darwin's popular account of his voyage is a big success. He has published six books and has become England's most prominent naturalist. But he is still keeping his biggest idea secret. Darwin is gathering yet more evidence for his theory, when at a museum, he encounters an earnest young man.

**[WALLACE:]** I've read your book, *Voyage of the Beagle*. It is excellent, inspiring. Thank you very much.

**[NARRATOR:]** Wallace had survived his ordeal at sea. After 10 miserable days in a lifeboat, he had been rescued by a passing ship.

**[WALLACE:]** ...to my notes before I leave.

**[DARWIN:]** Ah, well, excellent!

**[NARRATOR:]** Wallace and Darwin are meeting for the first time. The two explorers share a great passion for nature, but they are in very different situations.

**[WALLACE:]** I'm headed to the Malay Archipelago to do some research.

**[DARWIN:]** Oh, excellent!

**[NARRATOR:]** Wallace is single. He has to collect for a living. And he has yet to make his mark.

**[DARWIN:]** I've never been there. Are you collecting? What...

**[NARRATOR:]** Darwin is married and has a family. He is financially well off and has a scientific reputation to protect. Wallace is as open as Darwin is secretive about his interest in the origin of species. Little does Darwin know that this young man will soon force his hand.

**[WALLACE:]** I could send you back some specimens if you'd like.

**[DARWIN:]** Oh, very much so, yes, thank you. But please, no barnacles. I've just finished a work on barnacles that...

**[NARRATOR:]** And Wallace doesn't have a clue that Darwin has already scooped him.

**[DARWIN:]** Have you written anything yourself?

**[NARRATOR:]** Believing that the question of the origin of species is still wide open, and despite having nearly lost his life at sea, Wallace sets out on a new voyage. He travels to the region between the Pacific and Indian Oceans-- the Malay Archipelago. For the next eight years, he will collect and study animals as he hops from island to island in a 14,000-mile journey. [animal sounds] Wallace is captivated by butterflies. His favorite group is called "birdwings," after their shape and large size. They command a high price for their striking colors. [music plays] He finds birdwing butterflies throughout the archipelago. He identifies new species--some that are slightly different from those on nearby islands. The Malay butterflies suggest to Wallace what the Galápagos animals revealed to Darwin: species change. But Wallace, too, seeks to understand the bigger picture. Having explored jungles on opposite sides of the globe, he can compare where different groups of animals live and ask why they are found where they are. Wallace the collector now becomes Wallace the theorist. Birdwings occur near other species of birdwings in the Malay

Archipelago. Across the globe, in the Amazon, live different families of butterflies. Bird families also cluster geographically. Cockatoos live only in the Malay Archipelago and Australia, whereas the Americas are home to macaws and hummingbirds. Around the globe, the more similar two species are, the closer they tend to live. Why is this so? Wallace formulates a new law of nature. It's about where new species arise. They don't appear in random places. They arise near similar species. He realizes the profound implication that species are connected to one another... like the branches of a tree. On his own, Wallace arrives at Darwin's still-secret tree of life. Wallace finds more evidence that all species are related by considering some intriguing creatures. Manatees are mammals that live entirely in the sea, but inside their flippers are finger bones. Similar apparently useless bones are inside whale flippers too. If God had created these animals from scratch, wouldn't He have skipped the fingers? Imperfections such as these vestigial structures make it clear that every species is a modified form of an older species. Zigzagging across the Malay Archipelago, Wallace gathers critical evidence for his law. On the island of Borneo, he sees monkeys and orangutans. But elsewhere in the archipelago--in New Guinea-- the mammals are strikingly different. No monkeys here. Instead, up in the branches are "tree kangaroos": marsupials whose young grow up in pouches. Island by island, Wallace notes which of the two groups of mammals lives there: those with pouches and those without. Animals on the eastern islands resemble those of Australia. Animals to the west, those of Asia. It's as if a line splits the archipelago. It will be dubbed "The Wallace Line."

**[CARROLL:]** Why would God draw a boundary through these islands, and put monkeys in the trees on one side, and put kangaroos in the trees on the other side? This made no sense. Special Creation couldn't explain the line, but Wallace's earlier law could: that species come from pre-existing, nearby species.

**[NARRATOR:]** The Eastern islands of the Malay Archipelago, Wallace surmised, were once connected by land to New Guinea and Australia. So animals like kangaroos could hop on over. The Western islands were never connected to the Eastern ones, but they were connected to Asia. So the West had different mammals-- ones with placentas instead of pouches.

**[CARROLL:]** It's the history of the planet-- not special creation-- that explains the distribution of species.

**[NARRATOR:]** In Wallace's time, geologists understood that natural processes, such as volcanism and erosion, could change the shape of islands and continents. But what about species? How do they change? That is Wallace's next question. As a collector, he has a great eye for detail as he chooses specimens to sell to his customers. He knows that among all living things, from butterflies to snails, individuals within a given species usually vary in small ways. But what does that variation have to do with how species change? [rain falls] The answer comes to Wallace during a high fever. He must have been thinking about the very real chance that he would die. He recalled the English economist Thomas Malthus, who noted that human populations are held in check by famine, disease, and

death. Wallace realized that was even more the case in nature. Without death, any species would quickly overrun Earth. But animal populations tend to hold steady. That's because huge numbers of young die every generation. Two facts now snap together: massive death plus variation. Wallace now sees how species could change. Those individuals with variations that give them even a slight edge will survive, reproduce, and in time outnumber those without the advantage. His is a fundamentally new picture of nature-- of intense, even violent competition. Wallace thinks he might have an important new idea, but he wants a second opinion before publishing. He knows just the right person to ask, thousands of miles away, in England.

**[MAID:]** Excuse me, sir, this just came for you.

**[DARWIN:]** Ah, yes, thank you.

**[NARRATOR:]** Darwin is shocked. He couldn't have written a better summary of his own theory of how species change--he called it "natural selection"-- than what had just arrived from Wallace. How could this happen?

**[CARROLL:]** Both men had observed slightly different species on nearby islands and concluded that species could change over time. Both had collected huge numbers of specimens and realized that individuals vary within species. And both had witnessed nature up close and realized it was a battlefield with massive casualties. Same fact patterns, same explanation. Great minds think alike.

**[NARRATOR:]** Darwin now worries that he will lose all the credit for his original idea.

**[CARROLL:]** Darwin turned Wallace's manuscript over to two close colleagues who had been privy to Darwin's ideas on natural selection. They decided that Wallace's manuscript and some excerpts from Darwin should be read aloud together on the same day in London. The idea was to share the credit, although everyone involved, including Wallace, agreed that Darwin got there first.

**[NARRATOR:]** Darwin published his own masterful full-length account in 1859. *On the Origin of Species* became one of the most influential books ever published. It was an instant sensation that signaled the birth of modern biology. Wallace eventually wrote a book on evolution. He gave it the title *Darwinism*. Darwin and Wallace, who framed a new view of life driven by competition, did not compete themselves. Instead they became lifelong friends, bound by their shared, hard-earned insight into how evolution shaped the living world.