Horizons

A Global History of Science

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Introduction: The Origins of Modern Science

Where did modern science come from? Until very recently, most historians would tell you the following story. Sometime between 1500 and 1700, modern science was invented in Europe. This is a history which usually begins with the Polish astronomer Nicolaus Copernicus. In *On the Revolutions of the Heavenly Spheres* (1543), Copernicus argued that the Earth goes around the Sun. This was a radical idea. Since the time of the ancient Greeks, astronomers had believed that the Earth was at the centre of the universe. For the first time, scientific thinkers in sixteenth-century Europe started to challenge ancient wisdom. Copernicus was followed by other pioneers of what is often called the 'scientific revolution' – the Italian astronomer Galileo Galilei, who first observed the moons of Jupiter in 1609, and the English mathematician Isaac Newton, who set out the laws of motion in 1687. Most historians would then tell you that this pattern continued for the next 400 years. The history of modern science, as traditionally told, is a story focused almost exclusively on men like Charles Darwin, the nineteenth-century British naturalist who advanced the theory of evolution by natural selection, and Albert Einstein, the twentieth-century German physicist who proposed the theory of special relativity. From evolutionary thought in the nineteenth century to cosmic physics in the twentieth century, modern science – we are told – is a product of Europe alone.[1]

This story is a myth. In this book, I want to tell a very different story about the origins of modern science. Science was not a product of a unique European culture. Rather, modern science has always depended upon bringing together people and ideas from different cultures around the world. Copernicus is a good example of this. He was writing at a time when Europe was forging new connections with Asia, with caravans travelling along the Silk Road as well as galleons sailing across the Indian Ocean. In his scientific work, Copernicus relied upon mathematical techniques borrowed from Arabic and Persian texts, many of which had only recently been imported into Europe. Similar kinds of scientific exchange were taking place throughout Asia and Africa. This was the same period in which Ottoman astronomers journeyed across the Mediterranean, combining their knowledge of Islamic science with new ideas borrowed from Christian and Jewish thinkers. In West Africa, at the courts of Timbuktu and Kano, mathematicians studied Arabic manuscripts imported from across the Sahara. To the east, astronomers in Beijing read Chinese classics alongside Latin scientific texts. And in India, a wealthy maharaja employed Hindu, Muslim, and Christian mathematicians to compile some of the most accurate astronomical tables ever made.[2]

All this suggests a very different way of understanding the history of modern science. In this book, I argue that we need to think of the history of modern science in terms of key moments in global history. We begin with the colonization of the Americas in the fifteenth century and move all the way through to the present. Along the way we explore major developments in the history of science, from the new astronomy of the sixteenth century through to genetics in the twenty-first. In each case, I show how the development of modern science depended upon global cultural exchange. It is worth emphasizing, however, that this is not simply a story of the triumph of globalization. After all, cultural exchange came in lots of different forms, many of which were deeply exploitative. For much of the early modern period, science was shaped by the growth of slavery and empire. In the nineteenth century, science was transformed by the development of industrial capitalism. Whilst in the twentieth century, the history of science is best explained in terms of the Cold War and decolonization. Yet despite these deep imbalances of power, people from across the world made significant contributions to the development of modern science. Whatever period we look at, the history of science cannot be told as a story which focuses solely on Europe.[3]

The need for such a history has never been so great. The balance of the scientific world is shifting. China has already overtaken the United States in terms of science funding, and for the last few years researchers based in China have produced more scientific articles than anywhere else in the world. The United Arab Emirates launched an unmanned mission to Mars in the summer of 2020, whilst computer scientists in

Kenya and Ghana play an increasingly important role in the development of artificial intelligence. At the same time, European scientists face the fallout from Brexit, whilst Russian and American security services continue to wage cyberwarfare.[4]

Science itself is plagued by controversy. In November 2018, the Chinese biologist He Jiankui shocked the world by announcing that he had successfully edited the genes of two human babies. Many scientists believed that such a procedure was too risky to justify trying on human subjects. However, as the world quickly learned, it is very hard to enforce an international code of scientific ethics. Officially, the Chinese government distanced itself from He's research, serving him with a three-year prison sentence. But in 2021, researchers in Russia are already threatening to replicate his controversial experiment. Alongside issues surrounding ethics, science today, as in the past, suffers from deep inequalities. Scientists from minority ethnic backgrounds are underrepresented at the top of the profession, Jewish scientists and students continue to suffer antisemitic abuse, whilst researchers working outside of Europe and the United States are often denied visas for travel to international conferences. If we are to tackle such problems, we need a new history of science, one that better reflects the world in which we live.[5]

Scientists today are quick to acknowledge the international nature of their work. But they tend to think of this as a relatively recent phenomenon, a product of the 'big science' of the twentieth century, rather than something with a history stretching back more than 500 years. When contributions to science from outside of Europe are acknowledged, they are typically relegated to the distant past, not part of the story of the scientific revolution and the rise of modern science. We hear a lot about the 'golden age' of medieval Islamic science, the period around the ninth and tenth centuries, when scientific thinkers in Baghdad first developed algebra and many other new mathematical techniques. There is a similar emphasis on the scientific accomplishments of ancient China, such as the invention of the compass and gunpowder, both well over 1,000 years ago. But these stories only serve to reinforce the narrative that places like China and the Middle East have little to do with the history of modern science. Indeed, we often forget that the notion of a 'golden age' had originally been invented during the nineteenth century in order to justify the expansion of European empires. British and French imperialists promoted the false idea that the civilizations of Asia and the Middle East had been in decline since the medieval period, and so needed to modernize.[6]

Perhaps surprisingly, these stories are still just as popular in Asia as they are in Europe. Cast your mind back to the 2008 Beijing Olympics. The opening ceremony began with an enormous scroll unfolding, signifying the invention of paper in ancient China. Throughout the ceremony, a television audience of over one billion watched as China showcased its other ancient scientific achievements, including the compass. Fittingly, the ceremony closed with a spectacular display of another Chinese discovery. Fireworks lit up the sky above the Bird's Nest Stadium, a nod towards the invention of gunpowder during the Song dynasty. Yet throughout the ceremony, there was very little reference to the many scientific breakthroughs that China has contributed to since then, such as the development of natural history in the eighteenth century or quantum mechanics in the twentieth century. The same is true of the Middle East. In 2016, the Turkish President, Recep Tayyip Erdoğan, gave a lecture at the Turkish–Arab Congress on Higher Education in Istanbul. In his talk, Erdoğan described the 'golden age of Islamic civilization', the medieval period in which 'Islamic cities . . . acted as a science center'. Yet Erdoğan was seemingly unaware of the fact that many Muslims, including those living in what is today modern Turkey, had also contributed just as much to the development of modern science. From astronomy in sixteenth-century Istanbul to human genetics in twentieth-century Cairo, the Islamic world of scientific advance continued well beyond the medieval 'golden age'.[7]

Why are these stories so common? Like many myths, the idea that modern science was invented in Europe did not come about by accident. During the middle of the twentieth century, a group of historians in Britain and the United States started to publish books with titles like *The Origins of Modern Science*. Almost all were convinced that modern science – and with it modern civilization – originated in Europe, sometime around the sixteenth century. 'The scientific revolution we must regard . . . as a creative product of the West,' wrote the influential Cambridge historian Herbert Butterfield in 1949. Similar views were expressed on the other side of the Atlantic. Students at Yale University in the 1950s were taught that 'the West generated the natural sciences . . . the East did not', whilst readers of *Science* – one of the most prestigious scientific magazines in the world – were informed that 'a small circle of Western European nations provided the original home for modern science'.[8]

The politics of all this couldn't be clearer. These historians lived through the early decades of the Cold War, a period in which the struggle between capitalism and communism dominated world politics. They thought about the contemporary world in terms of a strict divide between East and West, and then – whether intentionally or not – projected this back onto the past. During this period, science and technology were widely seen as markers of political success, particularly after the Soviet Union launched Sputnik, the first artificial satellite, in October 1957. The idea that modern science was invented in Europe therefore served as a convenient fiction. For leaders in Western Europe and the United States, it was essential that their citizens saw themselves on the right side of history, as bearers of scientific and technological progress. This was also a history of science designed to convince post-colonial states around the world to follow the path of capitalism, and to steer clear of communism. Throughout the Cold War, the United States spent billions of dollars on foreign aid, promoting a combination of free market economics and scientific development in countries across Asia, Africa, and Latin America. This was intended to counter the foreign assistance programme run by the Soviet Union. 'Western science', when combined with 'market economies', promised nothing less than an economic 'miracle', at least according to American policymakers.[9]

Somewhat ironically, Soviet historians ended up reinforcing a very similar narrative concerning the origins of modern science. They tended to ignore the earlier achievements of Russian scientists working under the Tsars, instead promoting the spectacular rise of science under communism. 'Up to the twentieth century, there was really no physics in Russia,' wrote the President of the Soviet Academy of Sciences in 1933. As we'll see, this was not true. Peter the Great supported some of the most important astronomical observations made during the early eighteenth century, whilst Russian physicists played a key role in the development of the radio in the nineteenth century. Some later Soviet historians did try and highlight earlier Russian scientific achievements.

But at least in the early decades of the twentieth century, it was much more important to emphasize the revolutionary advances made under communism rather than anything achieved under the old regime.[10]

Things played out slightly differently in Asia and the Middle East, although ultimately with similar consequences. The Cold War was a period of decolonization, in which many countries finally gained independence from European colonial powers. Political leaders in places like India and Egypt desperately wanted to forge a new sense of national identity. Many looked to the ancient past. They celebrated the achievements of medieval and ancient scientific thinkers, ignoring much of what had happened during the period of colonialism. It was in fact in the 1950s that the very idea of an Islamic or Hindu 'golden age' started to become popular – not just in Europe, as it had been in the nineteenth century, but also in the Middle East and Asia. Indian and Egyptian historians seized on the idea of a glorious scientific past, one waiting to be rediscovered. In doing so, they unwittingly reinforced the very myth being peddled by European and American historians. Modern science was Western, ancient science was Eastern, or so people were told.[11]

The Cold War is over, but the history of science is still stuck in the past. From popular history to academic textbooks, the idea that modern science was invented in Europe remains one of the most widespread myths in modern history. Yet there is very little evidence to support it. In this book, I provide a new history of modern science, one that is both better supported by the available evidence and more suited to the times in which we live. I show how the development of modern science fundamentally relied on the exchange of ideas between different cultures across the world. That was true in the fifteenth century, just as it is true today.

From Aztec palaces and Ottoman astronomical observatories to Indian laboratories and Chinese universities, this book follows the history of modern science across the globe. However, it is important to remember that this is not an encyclopaedia. I have not tried to cover every country in the world, nor every scientific discovery. Such an approach would be foolhardy, and not particularly enjoyable to read. Rather, the aim of this book is to show how global history shaped modern science. For that reason, I have picked four key periods of world historical change, linking each of these to some of the most important developments in the history of science. By placing the history of science at the heart of world history, this book also uncovers a new perspective on the making of the modern world – from the history of empire to the history of capitalism, if we want to understand modern history, we need to pay attention to the global history of science.

Finally, I want to emphasize that I see science as very much a human activity. Modern science was undoubtedly shaped by wider world events, but it was nonetheless made through the efforts of real people. These were individuals who, whilst living in a very different time and place, were not fundamentally different from you or me. They had families and relationships. They struggled with their emotions and health. And each of them wanted more than anything else to better understand the universe in which we live. Throughout this book, I have tried to give a sense of that more human side of science: an Ottoman astronomer captured by pirates in the Mediterranean; an enslaved African collecting medicinal herbs on a plantation in South America; a Chinese physicist fleeing the Japanese assault on Beijing; and a Mexican geneticist collecting blood samples from Olympic athletes. Each of these individuals, although largely forgotten today, made important contributions to the development of modern science. This is their story – the scientists who have been written out of history.

4. Economy of Nature

Foraging at the edge of the plantation, Graman Kwasi came across a plant he had never seen before. The bright pink flowers caught his eye. Cutting a sample of the small shrub, Kwasi took it back to his hut and stowed it away. He didn't know it at the time, but this plant would ultimately change the course of his life. Graman Kwasi was born around 1690 in West Africa, a member of an Akan-speaking tribe in what is part of modern-day Ghana. Aged just ten, he was captured during a raid by African slave traders from a rival tribe. Kwasi was then marched in chains to the coast. Once there, he was purchased by a Dutch captain, and shipped across the Atlantic Ocean – just one of the six million enslaved Africans transported to the Americas during the eighteenth century. On arriving in South America, Kwasi was put to work on a sugar plantation in the Dutch colony of Surinam. As a child, he was forced to spend all day in the baking heat, picking weeds from the ground. As he grew into a young man, Kwasi then took part in the backbreaking work of the harvest, cutting sugar cane by hand using a machete.[1]

Kwasi, however, was much more talented than his Dutch masters initially gave him credit for. Amidst the diverse flora and fauna of South America, he began to develop an intimate knowledge of the natural world. Fusing healing traditions from both Africa and the Americas, Kwasi collected plants and prepared medicines. He treated both Africans and Europeans on the plantation, earning small sums of money. However, one plant in particular brought Kwasi great fame. The small shrub with pink flowers that he collected on the plantation in Surinam turned out to have incredible healing properties. The bark, when boiled in water to make a bitter tea, acted as an effective treatment against malarial fever. It also seemed to strengthen the stomach and restore appetite. Kwasi most likely learned about the medicinal properties of the plant from an Amerindian slave on the same plantation, as the shrub was used in existing South American herbal traditions – exactly the kind of medical knowledge we learned about in chapter 1. Before long, word of Kwasi's discovery spread across Surinam, and then on to Europe. At the time, the only effective treatment for malaria was derived from the bark of the cinchona tree, known as 'Peruvian bark'. However, the Spanish had a monopoly on this valuable product, which could only be found in the Viceroyalty of Peru, hence the name by which it was known. In fact, at the beginning of the eighteenth century, cinchona bark was the most expensive commodity in the world. It was literally worth more than its weight in gold. An alternative treatment for malaria was therefore an extremely lucrative prospect.[2]

In 1761, a sample of the shrub discovered by Kwasi reached Carl Linnaeus, one of the most influential scientific thinkers in Europe at the time. Linnaeus, who was Professor of Medicine and Botany at the University of Uppsala in Sweden, had transformed the study of the natural world through his new taxonomic system. This was first set out in his *System of Nature* (1735). In this book, Linnaeus divided the natural world into three major kingdoms: the animal, mineral, and vegetable. Below this, there were four more levels of classification, each one more precisely identifying a particular animal or plant. These went from the class, through the order, genus, and finally, species. In this system, everything in the natural world had its place. Following this, Linnaeus proposed that animals and plants each be given an official 'binomial' or 'two-part' name consisting of the genus and species. For example, the scientific name for the lion is *Panthera leo*, indicating the lion is a member of the genus *Panthera* (which includes tigers, leopards, and jaguars) and the species *leo* (which includes the different sub-species of lion in Africa and Asia). The advantage of this system was that it provided a straightforward and uniform way to classify the natural world. It also allowed naturalists to express the similarities between different species of animals or plants, as in the example of the lion being part of the same genus as the tiger. Linnaeus's binomial system still forms the basis of all modern biological classification systems today.[3]

Linnaeus was sent a sample of the plant by a Swedish plantation owner in Surinam. On confirming the medicinal properties of the plant, Linnaeus was impressed. He duly recorded the discovery in the new edition of his *System of Nature*, not only as a previously unknown species, but an entirely new genus. In honour of Kwasi, Linnaeus named the plant *Quassia amara*. ('Quassi' was the Latinized version of Kwasi's Akan name.

'Amara' means bitter in Latin, referring to the taste of the medicine.) With the backing of Linnaeus, and having discovered this revolutionary treatment, Kwasi found his life transformed. As knowledge of the plant spread, *Quassia amara* became a major export crop for planters in Surinam, cultivated for sale as an alternative to the more expensive cinchona bark. Kwasi was soon granted his freedom. He was then invited to Holland to meet William V, Prince of Orange, who, in recognition of Kwasi's achievements, presented him with an ornate coat and a gold medal. On returning to Surinam, Kwasi was given his own small plantation, complete with enslaved people to work the land. He also began receiving letters from European naturalists, eager to learn more about the plants of South America. Some of these letters were even addressed to Kwasi as 'Professor of Herbology in Surinam'. Somehow, against all the odds, Graman Kwasi had escaped slavery and found himself as a respected authority on the medicinal properties of South American plants.[4]

Graman Kwasi's story is exceptional in many ways. During the eighteenth century, it was extremely rare for an enslaved African to be publicly recognized in Europe as a source of scientific knowledge. When it came to natural history, plants were typically named after the European men credited with discovering them. For the most part, Europeans saw Africans as little more than commodities, to be bought and sold in order to work on plantations. Kwasi was unusual in that, through his knowledge of the healing properties of plants, he managed to escape this world, or at least end up on the other side of it. However, in another sense, Graman Kwasi is an example of something much more widespread.

The traditional story of natural history in the Enlightenment focuses almost exclusively on the achievements of European men like Carl Linnaeus, who are celebrated for 'discovering' new plants and inventing new classificatory systems. But this is misleading. Often ignored in the history of science, a diverse range of people from across Africa, Asia, and the Americas contributed to the development of eighteenth-century natural history. They brought with them their own scientific traditions, upon which Europeans often relied in order to understand and classify foreign environments. In some cases, this was straightforward appropriation, as with much of the botanical information extracted under the threat of violence from enslaved Africans. But in other cases, this scientific relationship was more collaborative, as we'll see in the case of Tokugawa Japan. From African healers to Indian priests, this chapter uncovers the forgotten contributions of people like Graman Kwasi to the development of natural history during the Enlightenment.

Whilst the previous chapter focused on state-sponsored voyages of exploration, this one uncovers the role of global trade in the development of Enlightenment science. Over the course of the seventeenth and eighteenth centuries, the world was transformed by the expansion of European trading companies: the Dutch East India Company in Southeast Asia and Japan, the Royal African Company in the Atlantic, and, most famously, the British East India Company in India and China. These lucrative enterprises made immense profits by controlling the supply of goods: sugar, spices, tea, and indigo all reached Europe aboard trading company ships. Crucially, much of this trade was in products derived from the natural world. This provided the impetus for a more detailed study of natural history, as trading companies needed to be able to classify and assess the goods they were dealing with.

To give a sense of the scale of change: at the beginning of the seventeenth century, European naturalists had identified around 6,000 different species of plant. By the end of the eighteenth century, they had identified over 50,000 species, the majority of which originated outside of Europe. As we saw in the previous chapter, trading companies like the Royal African Company and the British East India Company maintained close links to the major scientific institutions of the day, such as the Royal Society in London. Knowing the difference between gold and platinum, or cinnamon and nutmeg, was a key commercial concern, not just a scientific one. In some cases, trading companies even commissioned chemical tests, using the latest laboratory techniques in order to ascertain the purity of a metal or a dye.[5]

Natural history during the Enlightenment was therefore an economic science as much as a biological one. Linnaeus himself certainly saw his work this way. Like many others, he worried that global trade was weakening European economies, making them dependent on others for goods. In particular, Linnaeus feared that the 'balance of trade' was not in Europe's favour – countries like his native Sweden imported far more than they exported. In response to this, Linnaeus suggested that Sweden start to cultivate alternative crops, or even try and grow locally the products it was importing. 'Nature has arranged itself in such a way, that each country produces something especially useful; the task of economies is to collect from other places and cultivate such things that don't want to grow,' argued Linnaeus. For him, this was the point of natural history: not simply to catalogue the world, but to find a way to tip the balance of trade in favour of Europe. Linnaeus even suggested it might be possible to grow mulberry trees in Sweden, reducing the reliance on Chinese imports of silk.[6]

Unsurprisingly, Linnaeus found it difficult to cultivate tropical plants in Sweden, with its bitterly cold winters. But countries with larger empires were much more successful. Over the course of the eighteenth century, European naturalists helped to establish hundreds of botanical gardens across the colonial world. These were created with the explicit goal of growing tropical plants in order to reduce reliance on imports. For example, in 1735 the French East India Company established a botanical garden on Isle de France, modern-day Mauritius. The French naturalists there were tasked with growing pepper, cinnamon, and nutmeg with the hope of breaking the Dutch monopoly on the spice trade. (At the time, the only place anyone in Europe could get these spices was from the territories in Southeast Asia controlled by the Dutch East India Company.) The French East India Company even employed a missionary – named Pierre Poivre, no less – to smuggle seeds and saplings out of Southeast Asia to be grown in the new garden. The British did a similar thing in India, establishing a botanical garden in Calcutta in 1786 with the hope of growing cinnamon in order to break the Dutch monopoly. By the end of the eighteenth century, most European colonies – including Jamaica, New South Wales, and the Cape Colony – had a botanical garden. These, connected to the major botanical gardens in Europe, such as Kew Gardens in London, acted as important sources of information on the natural history of the world.[7]

I. Slavery and Botany

Arriving in Jamaica in 1687, Hans Sloane headed for the mountains. Riding on horseback, and accompanied by an enslaved African guide, Sloane began collecting as many plants as he could: ferns, orchids, and grasses filled his bag. Sloane needed to be careful. The mountains were a dangerous place for Europeans to travel, as runaway slaves and pirates might attack. But the risk was worth it. Over the following year, Sloane managed to collect over 800 plant specimens, each of which was carefully dried and stuck into a bound volume. Officially, Sloane had come to Jamaica to act as personal physician to the new governor of the island, the Duke of Albemarle. But Sloane wasn't particularly interested in the governor's health. (In fact, the governor died less than a year after Sloane's arrival.) What Sloane really wanted to do was study the natural history of the island. On his return to London in 1689, Sloane began to write up an account of what he had discovered. This was published in two large illustrated volumes entitled *The Natural History of Jamaica* (1707–25).[8]

Sloane went on to become one of the most influential naturalists of the early eighteenth century. Following the publication of his book, Sloane was elected as both President of the Royal Society and President of the Royal College of Physicians. Carl Linnaeus also consulted Sloane, visiting him in London, and incorporating some of the information in *The Natural History of Jamaica* into his *System of Nature*. When Sloane died in 1753, his entire collection – by that point consisting of over 70,000 specimens of plants, animals, minerals, and antiquities – was purchased by Parliament, forming the basis of the British Museum and later the Natural History Museum in London. Sloane was successful in large part because he understood the relationship between natural history and the economy. On the opening page of his book on Jamaica, Sloane reminded his readers that the island was 'The Largest and Most Considerable of Her Majesty's Plantations in the Americas'. *The Natural History of Jamaica* described all kinds of valuable crops, just at the time when the British, through the expansion of slavery, were transforming the West Indies into a full-blown plantation economy. Sloane himself profited from this world. Through marriage he had access to one third of the profits of a large sugar plantation on Jamaica. He also invested in a number of financial schemes in the Americas, including one to sell 'Jamaican bark', another possible alternative to cinchona.[9]

Sloane's success also depended on the enslaved Africans he met in the West Indies. However, this was often only partially recognized at the time. Like many of the European naturalists we will encounter in this chapter, Sloane's approach towards African knowledge, as well as his use of language, reflected the typical racist attitudes of the period. In *The Natural History of Jamaica*, Sloane described how he had asked for botanical information from 'the Inhabitants, either Europeans, Indians, or Blacks'. One plant in particular caught Sloane's attention. 'It is called Bichy by the *Coromantin* Negroe's [sic] and is both eaten and used for Physick in Pains of the Belly,' explained Sloane. The kola nut, or 'Bichy' as it was known in Jamaica, acted as a stimulant. It also seemed to make stale water taste fresh, and calmed the stomach. Later, in the nineteenth century, the kola nut formed one of the original ingredients of the soft drink Coca-Cola. Despite appearing in Sloane's *Natural History*, this nut was not in fact native to Jamaica. Instead, it was originally from West Africa. Sloane himself realized this, noting that the kola nut was grown from 'seed brought in a Guinea ship'. In West Africa, these nuts had long been used medicinally, as well as exchanged between neighbours or guests at ceremonies, as a symbol of goodwill. 'Who brings kola nut, brings life,' went a typical saying amongst the Igbo people of West Africa. It is a grim irony, then, that the kola nut, a traditional token of friendship, found its way to Jamaica. Enslaved Africans would chew the nut, trying to keep going in the unbearable conditions.[10]

Sloane soon noticed that many other plants in Jamaica were in fact native to Africa. Typically, Sloane came across these on the 'provisioning grounds' assigned to enslaved people. Rather than providing proper food supplies, European plantation managers would simply allocate a small plot of unproductive land on which the enslaved were expected to grow their own food. In Jamaica, Sloane spent a good amount of time investigating these 'Negro Plantations', as he called them. He would interview the Africans working on the plots, finding out about the different foods they had brought from their native countries. In Jamaica, then, Sloane was learning as much about African botany as he was about the West Indies. In the provisioning grounds he was shown yams, millet, and black-eyed peas, all crops that had been brought across the Atlantic aboard slave ships. For the enslaved Africans in Jamaica, these vegetables provided a taste of home, even in the most desperate of circumstances.[11]

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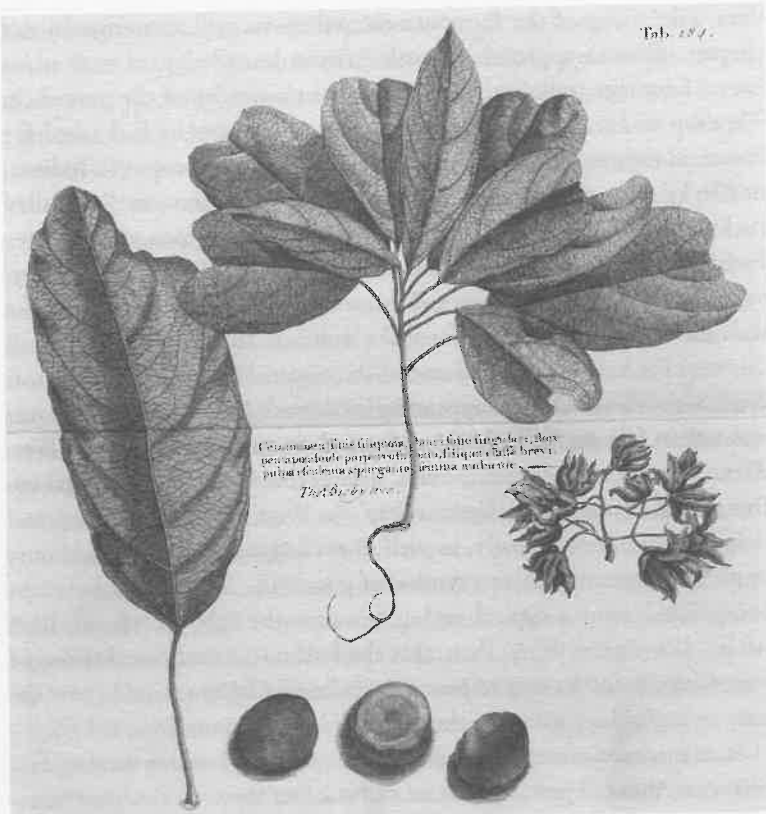


20. The kola nut from the 'Bichy' tree as depicted in Hans Sloane, *The Natural History of Jamaica* (1707–25).

Across the Americas, European naturalists quizzed enslaved people, hoping to discover new plants that might turn a profit, particularly if they had medicinal qualities. It is important to remember the violent power dynamics at play here. European slaveowners treated both African people and African knowledge as property to be exploited. In 1773, the Scottish planter Alexander J. Alexander described conducting a number of experiments on what he called a 'Negro Dr's Materia Medica', referring to the medicinal plants used by enslaved Africans. Alexander, who had studied chemistry at the University of Edinburgh, had learned of a bark used by the enslaved people on his plantation in

Grenada. It was said to act as an effective treatment against the yaws, a painful and widespread infection of the skin. 'The Negroes Method [sic] is making them stand in a Cask where there is a little fire in a pot & sweating them powerfully in it twice a day giving them decoctions of 2 woods in this country called Bois Royale & Bois fer,' explained Alexander. In a letter to Joseph Black, Professor of Chemistry at the University of Edinburgh, Alexander reported the 'astonishing' results. All those treated with the medicine were cured within a fortnight. Alexander sent a sample to Black, suggesting he conduct some chemical tests on the composition of the bark.[12]

The physician Henry Barham, who exchanged letters with Sloane, reported a similar experience in Jamaica. After suffering a severe fever and inflammation of the legs, Barham had almost given up hope. However, one of the enslaved Africans on the plantation suggested using the bark of a tree known as 'hog plum'. Barham recalled that 'a negro going through the house when I was bathing . . . said, "Master, I can cure you". Immediately he brought me bark of this tree, with some of the leaves, and bid me bathe with that.' According to Barham, after bathing in the solution, 'I was perfectly recovered, and had the full strength and use of my legs as well as ever.' Similarly, Patrick Browne, another physician in Jamaica, described the curative properties of 'worm grass'. 'This vegetable has long been in use among the Negroes and Indians, who were first acquainted with its virtues, and it takes its present denomination from its peculiar efficacy in destroying of worms,' reported Browne. Naturalists back in Europe also paid attention to what Africans knew about plants. James Petiver, an influential naturalist in London at the beginning of the eighteenth century, published an account of 'Some Guinea-Plants' collected by a Royal African Company employee in West Africa. Petiver listed the African names and medicinal uses of each of the plants, including 'concon' for killing worms and 'acroe', a tonic for restoring strength.[13]

By the end of the eighteenth century, some European physicians began to admit, tentatively, that Africans might know more than them about certain plants. In Surinam, one Dutch doctor wrote that 'the Negroes and Negresses . . . know the virtues of plants and offer cures that put to shame physicians coming from Europe'. Others were less convinced. Some argued that, whilst Africans clearly did know a great deal about plants, they nonetheless lacked a systematic approach based on classification. Edward Long, a notorious planter in Jamaica, made exactly this argument, claiming that 'brutes are botanists by instinct'. Long, however, was wrong. African botanical knowledge was rarely written down, but it was nonetheless systematic. Igbo healers in West Africa categorized plants by habitat, distinguishing between those growing in the 'forest' and the 'savannah'. This taxonomy of plants then mapped on to the classification of disease, with different illnesses requiring plants from particular environments. Despite what Long suggested, and many subsequent historians have repeated, Africans not only knew about the healing properties of plants, but also integrated this knowledge into a complex classificatory system.[14]

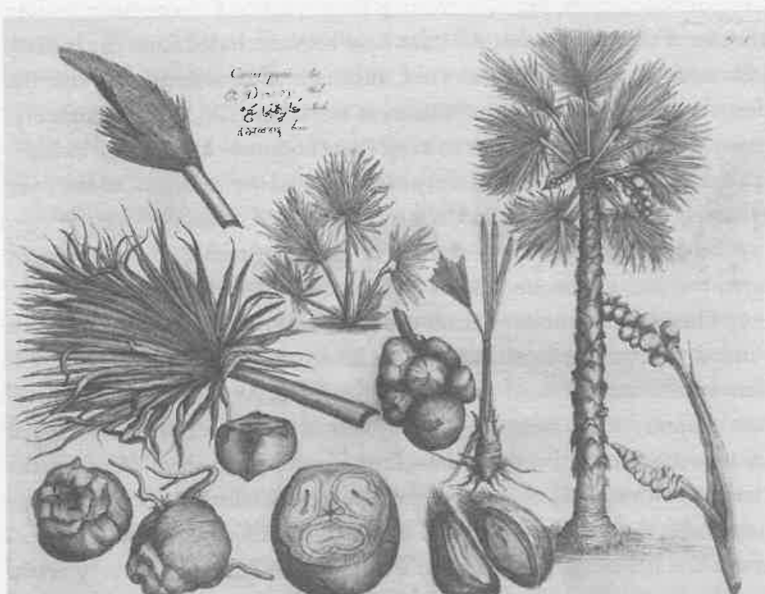
Not all plants were used for healing. In 1705, the German naturalist Maria Sibylla Merian published an account of a plant used to induce abortion in Surinam. As a European woman, Merian was unusual. Very few women in the eighteenth century were able to travel such long distances, as employment in trading companies was reserved for men. Merian, who had earlier divorced her husband, travelled to Surinam in 1699, accompanied by her youngest daughter. She supported herself by selling subscriptions to a book she intended to write on her return, entitled *The Metamorphosis of the Insects of Suriname* (1705). (Many of the most famous naturalists of the age, including Carl Linnaeus and Hans Sloane, later consulted Merian's book.) Over the next two years, Merian and her daughter travelled across Surinam, staying on plantations and collecting plants and insects. In her book, Merian described learning about a plant called the 'peacock flower' from some of the 'slave women' on a plantation. According to Merian, enslaved women in Surinam used the seeds of the peacock flower in order to 'abort their children, so that their children will not become slaves like they are'. She also described how enslaved Africans, both men and women, used the roots of the peacock flower to commit suicide – an act of resistance against the institution of slavery, as well as another reminder of the hopeless condition that had been forced upon them. According to Merian, 'they believe they will be born again, free and living in their own land'.[15]

Reports of dangerous plants frightened European doctors in the Americas. After all, if a flower could be used to induce abortion, or commit suicide, then it might also be used as a poison. In 1701, Henry Barham described a fellow physician in Jamaica who was 'poisoned . . . by his negro woman'. After ingesting a tea laced with the juice of a savanna flower, the man was 'seized with violent griping, inclining to vomit . . . he had small convulsions in several parts of him'. African botanical knowledge therefore formed part of the resistance against slavery. However, European fear of poisoning created a somewhat paradoxical situation. As we've seen, European naturalists relied on Africans for knowledge about many of the plants they found in the Americas. Yet at the same time, colonial laws were being passed that effectively barred Africans from working with medicinal plants. In 1764, the French colonial government in Saint-Domingue, modern-day Haiti, outlawed all persons of African descent from 'exercising medicine or surgery and from treating any illness under any circumstance'. A similar law was passed in South Carolina, recommending the death penalty 'in case any slave shall teach or instruct another slave in the knowledge of any poisonous root, plant, herb, or poison whatever'. Laws such as these are one of the reasons that Africans have been excluded from the history of science as traditionally written, although of course there is also the deeper problem of structural racism at work here too. Understandably, many enslaved people chose to keep their botanical knowledge hidden, for fear of punishment. It is only recently that we've begun to uncover what one historian has called 'the secret cures of slaves'.[16]

The growth of Atlantic slavery in the seventeenth and eighteenth centuries had a profound effect on the development of European society. The wealth generated from the forced labour of enslaved Africans funded everything from art and architecture to ports and factories. Slavery also transformed the world of science. As we saw in the previous chapter, Isaac Newton and his followers relied on astronomical observations made by those travelling aboard slave ships. And in this chapter, we've seen how famous European naturalists, such as Carl Linnaeus and Hans Sloane, depended upon enslaved Africans to tell them about the plants of the West Indies and South America. Slavery was a deeply exploitative system, one that relied on the constant threat of violence. The same is true of empire more generally, a theme we explore in more detail in the rest of this chapter. As European trading empires expanded, so too did interest in Asian natural history. In some cases, scientific exchange was on a slightly more even footing. At other times, European naturalists still relied on coercion. Nonetheless, wherever we look, the development of natural history in this period cannot be separated from the commercial world of trade and empire. In the following section, we explore how this relationship between empire and natural history played out in the East Indies. We begin with a Dutch military commander and his Indian servant.

II. Natural History in the East Indies

Hendrik van Rheede watched as his Indian servant climbed a nearby palm tree. On reaching the top of the palm, nearly thirty metres high, the servant pulled out a knife. Cutting into the shoots, he began to collect some of the sap. On climbing back down, the Indian servant told



21. The 'Carim-pana', or palmyra palm, in Hendrik van Rheede, *The Garden of Malabar* (1678–93). The name of the palm is given in three different languages (written in four different scripts) at the top.

Van Rheede that this particular tree was called the 'Carim-pana'. The sap was used to make a kind of alcoholic beverage, known as palm wine or 'toddy'. Van Rheede wrote down the name of the tree, along with its use, adding a cutting to his growing collection of Indian plants. The 'Carim-pana', or palmyra palm as it is known today, was just one of the 780 species of plant listed in Van Rheede's monumental *Garden of Malabar* (1678–93). Consisting of twelve volumes, and containing over 700 illustrations, this book was the first European work to provide a comprehensive account of Indian botany. *The Garden of Malabar* was consulted by many of the most important naturalists of the Enlightenment, including Carl Linnaeus. It was also a work that drew heavily on Indian scientific and medical traditions.[17]

Van Rheede had arrived in India, not as a naturalist, but as a military commander. Born in Utrecht to a wealthy merchant family, he had joined the Dutch East India Company at the age of just fourteen. In 1670, after rising through the ranks, Van Rheede was appointed Commander of Malabar, a Dutch colony on the southwest tip of India. He was astonished by the lush landscape he found himself in, filled with palm trees and spices. 'There was no place, not even the smallest, which did not display some plants,' recalled Van Rheede. The 'large, lofty and dense forests' of Malabar 'radiated such fertility'. He concluded that 'this part of India was truly and rightly the most fertile part of the whole world'. From coconuts and bananas to cardamom and pepper, Malabar was a luxurious environment, one which the Dutch East India Company was keen to exploit commercially.[18]

With this in mind, Van Rheede began an ambitious project to collect, sketch, and describe all the different species of plant in Malabar. This was not something that Van Rheede could accomplish on his own. As in the Americas and Africa, European naturalists in the East Indies relied on the existing knowledge of local people in order to understand the flora and fauna of the region. These individuals, after all, had far greater expertise in the natural history of South Asia than any European could possibly hope to possess. In the first instance, Van Rheede enlisted an army of over 200 Indian collectors, sent out far and wide searching for different plants. As a military governor, he had the power to get what he wanted, by force if necessary. Van Rheede also made use of his diplomatic contacts, writing to local Indian princes, asking them to forward specimens. The Raja of Cochin and the Raja of Tekkumkur both obliged, sending a considerable number of rare plants. Van Rheede then employed three Indian artists to make sketches of the different specimens. It was these Indian drawings which later featured in *The Garden of Malabar* when it was published in Amsterdam. Most significantly, Van Rheede assembled a group of Indian scholars in order to name and identify the uses of the different plants. The group consisted of three Brahmin priests – Ranga Bhatt, Vinayaka Bhatt, and Apu Bhatt, high-caste Hindus with expertise in ancient religious and scientific texts. Alongside the Brahmin priests, Van Rheede also employed a local doctor named Itti Achuden. Trained in the traditional Indian medical system known as Ayurveda, Achuden was an expert in identifying the different healing properties of Malabar plants.[19]

Unlike in Africa, much of this knowledge was written down. Achuden kept what Van Rheede described as a 'famed medical book', another reminder of the existing scientific knowledge of South Asian peoples. This, however, wasn't your typical printed book. In seventeenth-century southern India, people didn't write on paper. Instead, they wrote on dried palm leaves, bound together with string. This had the advantage that you could always add to an existing text, simply by tying another palm leaf to the collection. Itti Achuden's medical text, written in the local language of Malayalam, had been passed down through the generations. It contained hundreds of palm leaves detailing the different medicinal uses of local plants. Similarly, the Brahmin priests drew on their knowledge of the *Vedas*, a series of ancient Hindu texts. A number of these texts, which were written in Sanskrit verse, described the medicinal uses of plants. For example, the *Atharva Veda*, originally composed sometime in the second millennium BCE, contains a description of 288 plants. These include the flannel weed, said to help heal wounds, as well as 'goat's horn', a shrub said to drive away mosquitos when burned.[20]

Van Rheede valued the knowledge contained in the *Vedas*, noting that 'as regards medicine and botany, the knowledge of these sciences is preserved in verses'. There was clearly a wealth of information contained within these ancient texts. 'The first line . . . begins with the proper name of the plant, whose species, properties, accidents, forms, parts, location, season, curative virtues, use, and the like they described highly accurately,' Van Rheede explained. Consulting with the Brahmin priests, he began to understand how the naming of plants reflected an Indian classificatory system. Plants were typically assigned names with a suffix that indicated the species. For example, 'Atyl-alu', 'Itty-alu', and 'Are-alu' were all local names for different types of fig tree, identified by the suffix '-alu'. These names were then reproduced in *The Garden of Malabar*. In the final work, the plants are listed in three different languages: Malayalam (written in both the Arabic script and the local Aryaezuthu script), Konkani (written in the Devanagari script used for Sanskrit religious texts such as the *Vedas*), and Latin (written in the Roman script).[21]

The Garden of Malabar was a typical work of Enlightenment science. It brought together the scientific traditions of different cultures, presenting a unique view of the natural history of southern India. At the same time, *The Garden of Malabar* was a work that reflected the growing influence of European trading companies. Van Rheede's book listed all kinds of valuable commodities: sandalwood, cardamom, ginger, and black pepper. It was this economic concern which motivated a renewed interest in the study of natural history at the end of the seventeenth century.

Georg Eberhard Rumphius could feel the ground trembling. At first, it was just a little, but then the whole house began to shake violently. On 17 February 1674, 'the most terrible earthquake' struck the small island of Ambon, part of what is now Indonesia. Rumphius, a Dutch East India Company merchant, had been living on the island for over twenty years. He had never experienced anything like this before, but there was worse to come. After the initial tremors, Rumphius spotted something on the horizon. 'Three dreadful waves . . . they stood tall like walls,' he later recalled. It was a tsunami. The population of Ambon was devastated. Entire villages were washed away, with over 2,000 people reported dead, mostly local Ambonese. For Rumphius, it was a particularly tragic day as his wife, Susanna, along with two of their children, was killed. He decided to name a flower in memory of his wife. After all, the two had often collected plants together on the island. The flower Rumphius chose was a white orchid and he named it *Flos susannae*, 'to commemorate the person who, when alive, was my first Companion and Helpmate in the gathering of herbs and plants, and who also was the first to show me this flower'.[22]

At the time of the earthquake, Rumphius was in the middle of a major study of the natural history of Ambon. This was later published in two parts. The first, which covered shellfish and minerals, was titled *The Ambonese Curiosity Cabinet* (1705). The second, which covered plants, was titled *The Ambonese Herbal* (1741–50). Both works were beautifully illustrated, including hundreds of plates depicting all kinds of plants and animals, from horseshoe crabs to durian fruits. Carl Linnaeus, who consulted both works, even copied a number of the images from *The Ambonese Curiosity Cabinet* into his influential *System of Nature*.[23]

As with Hendrik van Rheede in Malabar, Rumphius believed that understanding the natural history of Ambon would aid the Dutch East India Company. European mortality in Southeast Asia was notoriously high, with medicines hard to come by. 'We experience every day, and to our detriment, that the European medicaments which the Company dispatches at considerable cost, are either obsolete or spoiled,' noted Rumphius. Instead, he suggested that Europeans study the properties of local medicinal plants. These, Rumphius claimed, were not only more accessible, but more likely to be effective against local diseases. 'All countries have their particular diseases, which should be cured with native remedies,' he argued. At the same time, many plants in Southeast Asia were known to be especially valuable. The Dutch already controlled the supply of cloves, nutmeg, and mace from the Moluccas. Rumphius was in search of other potentially valuable commodities.[24]

Rumphius relied on local people to teach him about the flora and fauna of Southeast Asia. In the first instance, Rumphius learned a lot from his wife. Although she had a European name, Susanna was in fact a native of Ambon. Most likely of mixed ancestry, Susanna converted to Christianity and married Rumphius shortly after he arrived on the island in 1653. She knew a lot about local botany, as Indonesian women often acted as healers and herbalists, another reflection of the existing scientific expertise of local people. It was Susanna who first led Rumphius around Ambon, pointing out which plants might be worth including in his *Herbal*. By this point, Rumphius had started to lose his eyesight, so he was completely reliant on Susanna, as well as other

Ambonese guides, to identify, collect, and even sketch the plants that later appeared in his book. When Susanna died, Rumphius lost, not only his soulmate, but also a major source of botanical information.[25]

Much like Van Rheede, Rumphius listed all the plants he discovered in multiple languages. *The Ambonese Herbal* gave the names of plants in Latin, Dutch, Ambonese, and Malay. In some cases, Rumphius also noted down the Chinese, Javanese, Hindustani, or Portuguese name for the same plant. This reflected the diversity of people and cultures found in Southeast Asia at the end of the seventeenth century. Alongside the Dutch, rulers from China, India, and Africa sent merchants to Southeast Asia in order to acquire spices. Knowing the different local names was therefore crucial, not just for scientific purposes, but also for trade.[26]

When he wasn't collecting plants in the countryside, Rumphius would head to the market. In the bazaars of Ambon, Rumphius – who could speak several Asian languages – learned a great deal about local wildlife, simply from chatting to merchants and travellers. Local fishermen taught him about a species of giant octopus, known as the Greater Argonaut, or the 'Ruma gorita' in Malay. The female of the species produced an intricate spiralled eggcase, which looked rather like a shell. 'Fishermen consider it a great boon if they catch one,' explained Rumphius. 'This whelk is found so rarely that it is priced very highly, even in the Indies,' he noted. Similarly, on the nearby island of Buru, a Muslim priest taught Rumphius how to distil oil from the wood of a local tree. Rumphius also reported how Chinese merchants in Manilla sold candied orchid roots, most likely as an aphrodisiac.[27]

Before long, Rumphius had compiled a catalogue of many of the most valuable natural goods in Southeast Asia. In fact, Rumphius's work was considered so economically important that the Dutch East India Company initially declared *The Ambonese Herbal* a 'secret document'. This delayed its printing until after Rumphius's death. The Dutch East India Company, keen to maintain its monopoly on the spice trade, didn't want word getting out about all these other potential commodities. When *The Ambonese Herbal* was finally published, the Dutch East India Company only agreed on condition that certain sections, including those detailing the harvest of nutmeg, were censored.[28]

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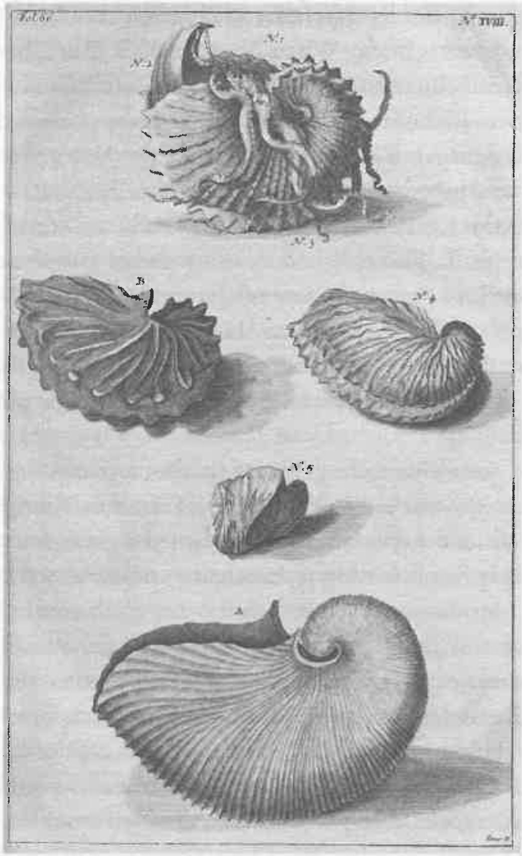


22. The 'Ruma gorita', or Greater Argonaut, depicted alongside its eggcase, in Georg Eberhard Rumphius, *The Ambonese Curiosity Cabinet* (1705).

The Dutch were right to be worried about competition. In the seventeenth century, a variety of European trading companies operated in Asia. However, over the course of the eighteenth century, the British came to dominate, particularly in India. Through a series of military conquests, the British East India Company seized control of a significant portion of the Indian subcontinent. By the late eighteenth century, the Dutch and French were largely forced out, confined to tiny trading stations. Even the Mughals, the rulers of much of India for the previous 200 years, were eventually defeated by the British. The expansion of the

British East India Company was in part fuelled by the new scientific work being done in the field of natural history. The British saw what the Dutch had achieved, and wanted to emulate it. The idea was to transform India into a tropical plantation economy, one that could supply all the different commodities Asia had to offer, from spices and sugar to timber and tea.

With this in mind, the British East India Company established the Calcutta Botanical Garden in 1786. Calcutta, in northeastern India, was the capital of Bengal, a territory that the British East India Company had recently acquired following the defeat of the local ruler. Appropriately, the first director of the garden, Robert Kyd, was a military officer. He explained the purpose of the new botanical garden to the directors of the British East India Company back in London. The Calcutta Botanical Garden was 'not for the purpose of collecting rare plants . . . as things of mere curiosity'. Rather, it was 'for establishing a stock for disseminating such articles as may prove beneficial to the inhabitants, as well of the natives of Great Britain'. Crucially, Kyd believed that such a garden, stocked with 'useful' plants, would 'ultimately tend to the extension of national commerce and riches'.[29]

The Calcutta Botanical Garden was therefore an economic initiative as much as a scientific one. It was designed to cement the status of the British East India Company in Bengal, as well as provide a source of valuable plants that might then be cultivated in plantations across India. Kyd immediately set to work. He sent for black pepper from Malabar and cinnamon from Southeast Asia. In each case, the idea was to break existing monopolies and reduce British reliance on foreign imports. By growing these valuable plants itself, the British East India Company hoped to lower costs and thus increase profit margins. By 1790, the Calcutta Botanical Garden housed over 4,000 plants representing 350 different species, most of which were not native to Bengal.[30]

When Kyd died in 1793, the position of director of the Calcutta Botanical Garden was taken up by a Scottish surgeon named William Roxburgh. Unlike Kyd, Roxburgh was trained in natural history and medicine. As a student at the University of Edinburgh, he had learned how to dissect plants and identify different species based on Linnaean classification. In 1776, Roxburgh arrived in India, employed as an assistant surgeon. Before being transferred to Calcutta, he set up a small experimental plantation in Samalcottah, part of the Madras Presidency in southern India. On the plantation, Roxburgh grew black pepper, coffee, and cinnamon. He also experimented with growing breadfruit, imported all the way from Tahiti, a plant that many naturalists thought might provide a cheap and high-energy source of food.[31]

Alongside this, Roxburgh identified an alternative source of indigo dye, another valuable commodity. Traditionally, this deep blue dye was manufactured from the leaves of the indigo plant. At the time, the majority of indigo was grown in the Americas, and the trade was largely controlled by the Spanish. Indigo had been cultivated in India, but not on a large scale or with much success. Roxburgh was therefore keen to promote an indigenous alternative. He claimed to have discovered a totally different species of plant, classified by Carl Linnaeus as a *Nerium*, whose leaves also seemed to secrete a similar blue dye. Roxburgh quickly wrote to the British East India Company directors in London, sending a sample of his 'Nerium Indigo' for chemical testing, and suggesting it might prove 'infinitely profitable'.[32]

On the back of this, Roxburgh was the obvious candidate to take over the Calcutta Botanical Garden. He combined Kyd's emphasis on commerce with a deep understanding of the latest scientific work on biological classification. On taking up the position, Roxburgh set about expanding the garden. He began cultivating a variety of other tropical plants, many of which originated far from India. These included Jamaican all-spice, as well as sweet potato and papaya from South America. Roxburgh also sent collectors to the Moluccas, charged with smuggling out samples of nutmeg and cloves. With such a large number of different plants, Roxburgh began to expand the staff in the garden. Many of the foreign species of plant needed expert care. Like other European naturalists, Roxburgh quickly realized that the most knowledgeable people with regards to Asian plants were those from the region. To this end, Roxburgh recruited 'two Malay Gardeners' from Ambon, named Mahomed and Gorung, most likely because of their expertise as either herbalists or spice farmers. These two men were employed solely to care for the nutmeg, which proved exceptionally difficult to grow outside of Southeast Asia. Similarly, Roxburgh employed a number of Chinese gardeners in order to help grow tea trees, as well as Tamils, in order to cultivate spices from southern India.[33]

This diversity of cultures was reflected in Roxburgh's first major scientific publication. With the support of the British East India Company, Roxburgh published *Plants of the Coast of Coromandel* (1795). This book detailed many of his early botanical findings. Plant names were given in English, Latin, and the local Indian language of Telugu. The book also contained over 300 life-size, hand-coloured illustrations, depicting each of the plants Roxburgh described. These illustrations, however, weren't done by Roxburgh himself. Rather, they were produced by 'two native artists'. Since its foundation, the Calcutta Botanical Garden had employed Indian artists to sketch and catalogue the different species of plant. The British employed them because of their familiarity with the local environment, as well as their skill in depicting what, to Europeans, were previously unknown species. These artists typically combined both European and Indian traditions, developing a style that came to be known as 'Company School'. Many of the artists employed in Calcutta had previously worked for the Mughals, producing illustrated manuscripts, often with botanical or zoological themes. In some aspects, then, the illustrations in *Plants of the Coast of Coromandel* looked like a typical Mughal court painting, with clear blocks of colour and a relatively flat appearance. But at the same time, these illustrations reflected the demands of Linnaean classification. Roxburgh ensured that the Indian artists carefully separated out the sexual organs of the plants, as well as the seeds, as these were crucial for identifying different species under the Linnaean system.[34]

In the Calcutta Botanical Garden we can ultimately see Enlightenment science in microcosm. It was an institution, established by the expanding British Empire, for the purpose of economic gain. And it was built on land that the British had seized, by military force, from local Indian rulers. At the same time, the Calcutta Botanical Garden was also a place in which a diversity of cultures and scientific traditions came together, from Scottish surgeons to Indian artists. In the following section, we explore the history of natural history in seventeenth- and eighteenth-century China. This was a region that the British East India Company was also trying to expand into, although with much greater difficulty. And there was one Chinese plant that British merchants and naturalists were desperate to get their hands on.

III. The China Drink

In 1658 an exotic new drug reached the streets of London. Some doctors promoted it as a miracle cure, using it to treat diseases ranging from kidney stones to depression. Others, however, thought it might be a harmful intoxicant, potentially as dangerous as alcohol or even opium. The British certainly seemed addicted. One doctor claimed that the drug was responsible for 'the introduction of a numerous class of nervous ailments'. Another that 'sipping this decoction, one may sometimes spend entire nights working . . . without being otherwise overcome by the need for sleep'. What was this controversial new remedy? Samuel Pepys, the famous diarist, called it 'the China drink'. We know it better as tea.[35]

When tea first arrived in Britain in the middle of the seventeenth century, it was an exotic commodity. Imported all the way from China, it cost ten times as much as coffee per pound weight. However, by the end of the eighteenth century, tea had become an article of everyday consumption. The British were considered a 'tea-drinking nation', with people from all walks of life partaking in the habit. The first tea leaves arrived in Europe in 1610, aboard a Dutch East India Company ship. Initially, the British purchased their tea from the Dutch. However, as demand continued to grow, the British East India Company focused its efforts on acquiring tea directly from China, bringing back the first shipment in 1713. Alongside tea, European trading companies imported vast quantities of Chinese silk and ceramics, as well as other medicinal herbs such as gingko. In fact, the eighteenth century witnessed a craze for all things Chinese. European doctors experimented with acupuncture, whilst British gardens filled with Chinese shrubs including peonies and magnolias.[36]

The growth in trade with China also sparked interest amongst European naturalists. Tea in particular caused much scientific debate, as people puzzled over how to classify it. The tea that Europeans purchased in China came in a number of different varieties. In the eighteenth century, these were referred to as 'bohea' (black tea), 'singlo' (green tea), and 'bing' (imperial tea). The leaves of each variety were of a different colour, and produced distinct tastes when made into an infusion.

However, at this time very few Europeans had actually seen a tea tree growing in its native environment. Rather, tea was purchased at Chinese coastal ports – such as Canton and Amoy – once it had already been processed. This processing involved repeated stages of drying and rolling the leaves by hand. European naturalists were therefore unsure if these different varieties of tea came from one plant or many different species. Carl Linnaeus co-authored a book, titled *The Tea Drink* (1765), addressing this very problem. He incorrectly argued that the different varieties of tea must represent different species. (In fact, all tea comes from the same plant, something European naturalists weren't completely sure of until well into the nineteenth century.)[37]

As we've seen elsewhere, these scientific questions also had a commercial dimension. European traders arriving in China needed to be able to distinguish between different teas, as well as spot a fake. This was crucial in order to avoid getting ripped off. You didn't want to pay for an expensive imperial tea, if in fact you were just getting a regular green tea. Some British East India Company officers even reported finding sage leaves or other cheap alternatives mixed in amongst the tea crates. There was also a big financial incentive to experiment with growing tea in Europe. Linnaeus himself promoted this idea, complaining of the vast sums of money that left Europe in exchange for Chinese goods. 'Let us bring the Tea-tree here from China,' Linnaeus wrote. He hoped that 'in the future not a pence would leave us for those leaves'. This was all part of an argument we saw earlier concerning the 'balance of trade'. The Chinese only accepted payment in silver bullion, and Linnaeus – along with many others – worried that trade with China was weakening European economies. Imported goods, like tea, far exceeded those exported.[38]

With this in mind, European naturalists devoted considerable effort to studying Chinese plants. In 1699, James Ovington published the first detailed account of tea written in the English language. In *An Essay upon the Nature and Qualities of Tea*, Ovington described the different varieties as well as the cultivation of the tea tree. However, he hadn't actually seen tea growing in its native environment. Instead, he had learned about tea whilst working for the British East India Company in Gujarat, in western India. The merchants in Gujarat had been trading tea, spices, and silk with the Chinese for centuries. According to

Ovington, tea was 'a common Drink with all the Inhabitants of India', where it was mixed with sugar and lemon. Whilst in Gujarat, Ovington also met a Chinese envoy at the local court. The envoy had apparently 'brought with him several kinds of tea'. From his conversations in India, Ovington was able to piece together some of the basic facts about tea, including how it was processed. 'The Leaf is first green, but is made crisp and dry by frying twice . . . and as often as it is taken off the Fire it is roll'd with the Hand upon the Table, till it curls,' explained Ovington. He also suggested it might be possible to grow tea in Europe, if only a specimen could be acquired, writing 'the Shrub itself is of a strong and hardy Constitution . . . the winter in *England*, in some places where it grows, is not more cold'.[39]

Ovington got a lot right, but there was only so much Europeans could learn about tea without actually going to China. Shortly after the publication of this book, however, the problem was solved. Landing on Chusan Island in 1700, James Cuninghame became one of the first Europeans to observe tea growing in its native Chinese environment. A surgeon in the employment of the British East India Company, Cuninghame had been sent to Chusan – a small island just off the coast of eastern China – in order to help set up an early trading station. The station was ultimately a failure, and the British East India Company quickly abandoned the project. Cuninghame, however, decided to stay behind, hoping to learn something about Chinese natural history. During his stay, Cuninghame corresponded with the influential British naturalist James Petiver, promising to acquire a specimen of the tea tree. Petiver also asked Cuninghame to 'inquire what variety theirs is of it & wherein the Bohea Tea differs from the common'. In short, Petiver wanted to know if black and green tea came from the same plant. Cuninghame did his best to answer Petiver's questions. He visited multiple tea plantations, recalling the sweeping hills lined with neat rows of green shrubs, Chinese men and women picking the leaves by hand. Tea was 'a flowering plant, with leaves serrated like nettles and whiteish underneath', Cuninghame explained. Spending over a year on Chusan, he was ultimately able to observe the complete life cycle of the tea tree, including its harvest and processing. This allowed him to produce the first accurate description of the tea tree outside of China.[40]

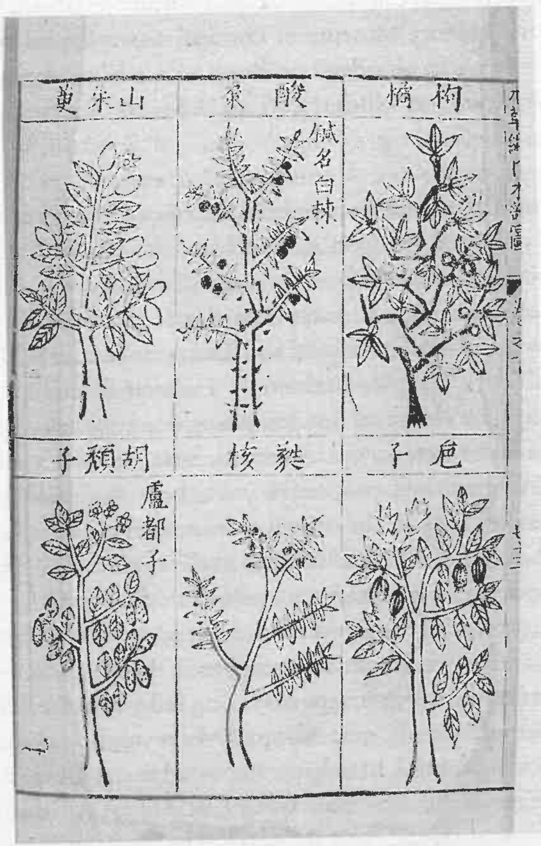
Cuninghame's account of the tea tree was published in the

Philosophical Transactions, the prestigious journal of the Royal Society in London. In the article, Cuninghame made a crucial observation. 'The 3 sorts of Tea commonly carry'd to *England* are all of the same Plant,' he explained. What mattered was when the tea leaves were picked, and then how they were processed. In the article, Cuninghame went on to explain how 'Bohe', or black tea, 'is the very first bud gather'd, in the beginning of *March*, and dry'd in the *shade*'. In contrast, 'Bing', a variety of imperial tea, 'is the second growth in *April* . . . dry'd a little in *tatches* or Pans over the Fire'. Alongside this article, Cuninghame sent hundreds of specimens of different Chinese plants back to Britain. In fact, the oldest surviving specimen of tea held outside of China, kept today at the Natural History Museum in London, was collected by Cuninghame. It sits in a tiny wooden box along with a label, dating from the eighteenth century, on which the words 'A Sort of Tea from China' are written.[41]

Carl Linnaeus was not the only one developing a new way of classifying the natural world in this period. In China, there was already a well-established tradition in the study of natural history, dating back thousands of years. The Chinese even developed a specific literature dedicated to the scientific study of tea. The most famous of these texts, titled *The Classic of Tea*, was written by a scholar named Lu Yu in the eighth century. Lu's book set out everything you could possibly want to know about tea: where it was cultivated, how different varieties were processed, its medicinal properties, even how it should be served. According to Lu, tea was 'the common drink of every household'. And, unlike alcohol, it did 'not lend itself to extravagance'. *The Classic of Tea* was the first of over a hundred 'tea books' published in China, many of which were written in the seventeenth and eighteenth centuries, just at the time when Europeans started to engage in the tea trade.[42]

As in Europe, the development of trading links with the wider world from the fifteenth century onwards sparked a revolution in the study of natural history in China. Merchants imported maize from the Americas, spices from India, and fruit from East Africa. All this increased demand for new works of natural history. The most significant of these was published in Nanjing at the end of the sixteenth century. Titled *The Compendium of Materia Medica* (1596), this monumental book – which ran to over two million Chinese characters – contained 1,892 entries of different plants, animals, and minerals, many of which had never been classified before. Its author, Li Shizhen, was born in 1518 to a family of doctors in central China. Li wanted to enter the prestigious Chinese civil service, but failed the competitive examinations. However, thanks to his background in medicine, Li was able to obtain a post at the Imperial Medical Office in Beijing.[43]

Li's job was to help regulate medicine across China, setting examinations, awarding licences, and assessing new drugs. Working at the



23. An illustration of different plants, including the Chinese bitter orange and cape jasmine, from Li Shizhen, *The Compendium of Materia Medica* (1596).

Imperial Medical Office, Li had access to a vast collection of medicines. He was also able to read many of the ancient Chinese works on natural history, such as *The Classic of Tea*. However, he soon realized that regional diversity in the naming of plants made it exceptionally difficult for the Imperial Medical Office to do its job. How could the Chinese state assess new drugs or collect taxes on medicines if the same plants went by different names? Tea is a good example of this. In Canton, it was referred to as *ch'a* (from which we get 'chai'), whereas in Amoy it was called *te* (from which we get 'tea'). This was all made harder still by the arrival of various foreign plants, as China traded with the rest of the world. Li decided that there needed to be a standardized way to describe all the different plants, animals, and minerals found within the Chinese Empire.[44]

Li then spent the next thirty years of his life travelling across China, collecting specimens as well as interviewing local doctors and farmers, gathering information for *The Compendium of Materia Medica*. In the introduction to his book, Li explained his taxonomic system, writing, 'my overall system of classification consists of sixteen sections (*bu*) that form the upper level (*gang*) and sixty categories (*lei*) which form the lower level (*mu*)'. The upper level was organized around the 'five phases', a traditional Chinese division of the world, much like the four elements in ancient Greek philosophy. The five phases were wood, fire, earth, metal, and water. These then corresponded to particular qualities (such as warm or cold) as well as particular tastes (such as acidic or sweet). Below this, there was then a further subdivision, often based on the environment in which a particular plant or animal could be located, for example, 'mountain herbs' or 'aquatic birds'. Li also needed to classify various foreign plants, such as maize. The tea tree featured as well, correctly identified as a single species, and said to act as an effective anti-inflammatory. Indeed, as a doctor Li spent a lot of time detailing the medicinal properties of all the plants and minerals listed in the book. He even wrote a separate chapter cross-referencing hundreds of specific illnesses with different medicines.[45]

Li ultimately provided a standardized way to classify the natural world, one that could be used by doctors and bureaucrats across the Chinese Empire. His book proved a phenomenal success. The final publication was accompanied by two volumes of detailed illustrations, depicting many of the plants and animals described in the book. The Chinese emperor was presented with a copy, whilst multiple updated editions were printed throughout the seventeenth century. It became even more popular in China following the rise of the Qing dynasty in 1644. By the middle of the eighteenth century, the Qing controlled an area twice as large as the Ming dynasty, mainly thanks to a series of military conquests to the west. This territorial expansion brought Chinese naturalists into contact with even more new plants and animals, as well as new systems of taxonomy. There was once again an explosion in scientific publishing, as eighteenth-century Chinese naturalists looked to update Li's work.[46]

During the same period, copies of Chinese works of natural history started to reach Europe. In 1742, a French naturalist named Pierre Le Chéron d'Incarville wrote a letter from Beijing describing how he had 'found a book containing drawings of Chinese medicinal plants, a few animals and insects: really a book of natural history'. This was none other than Li's *Compendium of Materia Medica*. D'Incarville quickly purchased two volumes, forwarding them to the King's Garden in Paris. Translated extracts soon appeared in French and English. Joseph Banks, President of the Royal Society, even purchased a copy of Li's book, hoping it would help him identify different Chinese plants sent to London by British merchants. It continued to be consulted by European naturalists well into the nineteenth century, something we'll explore in more detail in the following chapter.[47]

The Compendium of Materia Medica is an important reminder of just how closely the development of natural history in Europe and China mirrored one another. Li, after all, was not so different from Carl Linnaeus. He was a trained doctor who, in the context of a growing world of trade and empire, saw the need for a standardized system of classifying the natural world. Li's taxonomy, again like Linnaeus's, was based on a mixture of physical characteristics and environmental considerations. And it was prompted by economic and bureaucratic demands. Yes, there were differences in some of the specifics, particularly Li's use of the five phases. But ultimately, when we think on a global scale, it is clear that the growth of natural history in Europe was not unique. Scientific thinkers in Asia were also developing new ways to classify nature in order to make sense of an increasingly connected world, and as we'll see in the following section, this was also the case in early modern Japan.

IV. Studying Nature in Tokugawa Japan

The shogun wanted an elephant. In 1717, Tokugawa Yoshimune, the ruler of Japan, was browsing the castle library in Edo, modern-day Tokyo. He came across a book his uncle had been given by a Dutch merchant: Johann Jonston's *Natural History of Quadrupeds* (1660). Originally published in Leiden, this lavishly illustrated work featured engravings of many animals the shogun had never seen before: camels, lions, and reindeer. But what most fascinated Yoshimune was the image of an elephant. Yoshimune quickly ordered his personal physician, Noro Genjo, to begin translating Jonston's book from Dutch into Japanese. Yoshimune particularly wanted to know where elephants came from, and what they might be used for. 'These animals exist in great numbers in countries visited by the Dutch . . . the tusks are used for medical purposes,' reported Noro.[48]

Books were all well and good. But what Yoshimune really wanted was an elephant of his own. In 1729, he got his chance. The Dutch East India Company, which was keen to secure favourable trading relations with Japan, agreed to import two Asian elephants from Vietnam, one male and one female. In April, the elephants arrived in Nagasaki, where the Dutch East India Company occupied a small trading station. Crowds lined the streets cheering as the elephants were paraded across Japan. They were first brought from Nagasaki to Kyoto, before finally being delivered to Yoshimune in Edo. Unfortunately, the male elephant died shortly after arriving. But the female elephant survived for another thirteen years, and she was kept on display in the beautiful gardens surrounding Edo Castle. The elephants were just the start. Over the following decades, Yoshimune and his successors acquired a range of different exotic animals, many of which were previously unknown in Japan. By the end of the eighteenth century, Edo Castle housed a porcupine from North Africa, two orangutans from Borneo, horses from Persia, and an entire flock of sheep imported from Europe.[49]

The Enlightenment was a period of major transformation in the study of natural history, not just in Europe, but also in Asia. This was especially true in Japan. In the ancient and medieval periods, most Japanese studies of natural history were undertaken by Buddhist monks or Shinto priests. Natural history served an important religious function. Shinto shrines were often dedicated to sacred animals, whilst Buddhists thought that natural history might help them better understand the cycle of reincarnation. However, by the beginning of the eighteenth century, things had changed considerably. With the growth of global trade, natural history in Japan, just as in Europe, started to take on a much more commercial dimension. This was particularly the case following the foundation of the Tokugawa shogunate in 1600, which brought together Japan's different warring states under one ruler. Although the Tokugawa shogunate followed a policy of *sakoku*, meaning 'closed country', in which foreign access to Japan was restricted, this did not mean a complete cessation of trade. Somewhat counterintuitively, the 'closed country' policy in fact led to an intensification of trade, with only a small number of European, Chinese, and Japanese merchants – sanctioned by the shogun – controlling the flow of valuable goods in and out of the country.[50]

Yoshimune's interest in exotic animals was therefore not simply down to curiosity. He was deeply concerned about the economic and political future of Japan, and believed that studying the natural world might help unlock the key to prosperity. This was all the more important given that Japan also suffered in the balance of trade, importing far more than it exported, in part as a consequence of the 'closed country' policy. With this in mind, Yoshimune commissioned a series of surveys of Japanese natural history, hoping to identify home-grown alternatives to expensive imports. The largest of these surveys was conducted in the 1730s by Niwa Shohaku, another of Yoshimune's court physicians. Niwa travelled right across Japan, much as Li Shizhen had done in China. He distributed questionnaires in every domain, requesting that local lords report 'all produces generating from the earth' along with 'all species in that region without exception'. The questionnaires were accompanied by a letter, signed by Yoshimune himself, reminding Japanese lords of their obligation to the shogun in Edo. The final survey, titled *A Classification of All Things*, included 3,590 entries, encompassing not just plants and animals, but also metals, minerals, and gemstones.

Niwa's survey confirmed what Yoshimune had suspected. Japan possessed incredible natural wealth, particularly in copper and camphor oil, two commodities that European trading companies were keen to purchase.[51]

Yoshimune also supported the expansion of botanical gardens in Japan, particularly the Koishikawa Botanical Garden on the outskirts of Edo. Originally founded in the seventeenth century, it transformed into a site of commercial botanical research during the eighteenth century. There is a remarkable parallel here with what was happening in Europe. At just the same time that Carl Linnaeus was trying to grow exotic plants in Uppsala, Japanese naturalists were doing the same thing in Edo. By the 1730s, the Koishikawa Botanical Garden housed thousands of foreign plants, many of which had previously been imported at great expense, including ginseng from China, sugar cane from Southeast Asia, and sweet potatoes from the Americas. The garden was so successful that, by the 1780s, Japan actually went from importing ginseng to exporting it.[52]

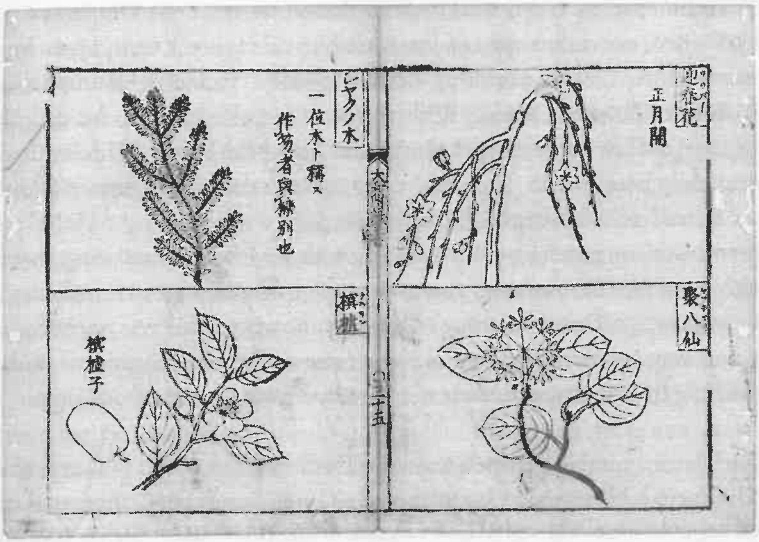
Trading links brought Japan into contact with, not just exotic goods, but also a variety of scientific cultures. Initially, the most significant of these links was with China. The two countries shared a long history of intellectual and commercial exchange, dating back well over 1,000 years. The Japanese language, along with much of Japanese philosophy, borrowed heavily from China. This flow of goods and ideas intensified in the seventeenth century, particularly following the foundation of the Tokugawa shogunate in 1600. Alongside silk and tea, Chinese merchants started selling more and more books. They brought with them copies of Chinese works on astronomy, medicine, and natural history. In 1604, just a few years after its publication in Nanjing, Li Shizhen's *Compendium of Materia Medica* was being sold in Nagasaki. The shogun himself purchased a copy, adding it to the castle library in Edo. By 1637, Li's book had been reprinted in its entirety in Japan. It proved incredibly influential, forming the basis of the majority of studies of natural history in seventeenth-century Japan.[53]

At the beginning of the eighteenth century, a Japanese naturalist decided to write a new book, one that would combine the best bits of Chinese natural history with an updated survey of the plants of Japan.

Kaibara Ekiken came from a humble background. He was born in 1630 on the southern island of Kyushu, the son of a village doctor. However, Kaibara went on to become one of the most influential naturalists in Tokugawa Japan. Unlike other Japanese naturalists at the time, he was not content simply to follow the teachings of Chinese scholars. Kaibara complained that *The Compendium of Materia Medica* 'treats many exotic species that do not live or grow in Japan'. He therefore decided to leave Kyushu and travel across Japan in order to 'record in one single text all those species that people can actually see in our country'. Kaibara's approach represented an important shift in Japanese natural history. Rather than basing his knowledge solely on existing Chinese books, Kaibara emphasized the importance of personal experience. 'I climbed tall mountains. I penetrated into deep valleys. I followed steep paths and walked through dangerous grounds. I have been drenched by rains and lost my way in the fog. I endured the coldest winds and the hottest sun. But I was able to observe the natural environment of more than eight hundred villages,' explained Kaibara.[54]

On returning from his travels, Kaibara published *Japanese Materia Medica* (1709–15). This was a classic fusion of different scientific traditions. Kaibara still borrowed a lot from Li Shizhen. The organization of *Japanese Materia Medica* mirrored that of *The Compendium of Materia Medica*, particularly the use of the five phases. Many of the species common to both Japan and China were also copied straight from Li's book. However, even in these cases, Kaibara listed Japanese names, as well as regional varieties, rather than simply relying on the Chinese text alone. On top of this, Kaibara added a further 358 species of plant that could only be found in Japan. These included the famous Japanese cherry tree, known as the *sakura*, with its beautiful pink and white blossom. 'The Japanese cherry-tree, however, does not exist in China, as Chinese merchants testified when I interviewed them in Nagasaki,' explained Kaibara; 'if such a tree did exist, it would have been mentioned in Chinese books.'[55]

As it happens, Kaibara was only half right. Although very few Chinese works of natural history specifically identified the Japanese cherry tree, it did in fact grow in some areas of China, and around the Korean Peninsula. Nonetheless, what really mattered was the idea that Kaibara started to promote. It wasn't enough to simply rely on existing Chinese texts. Japanese naturalists needed to travel, to observe, and collect. Only



24. Botanical illustrations from Kaibara Ekiken, *Japanese Materia Medica* (1709–15).

then, Kaibara argued, would natural history 'be of concrete help to the people of *this* country'.[56]

Alongside China, the other major source of scientific knowledge in Japan was the Dutch East India Company. As discussed earlier, the Tokugawa shogunate had operated a policy known as *sakoku*, or 'closed country', since the early seventeenth century. Under this policy, European access to Japan was severely restricted. Christian missionaries were excluded entirely, as were most European merchants. Only the Dutch East India Company was granted permission to trade with Japan, and even then, the Dutch were confined to Deshima, a tiny island off the coast of Nagasaki. Over time, however, Japanese and European scientific cultures began to come into contact with one another. Dutch merchants not only presented scientific books at the court in Edo, but Japanese naturalists started to learn Dutch, hoping they might be able to learn something about distant lands. Indeed, the 'closed country' policy ultimately created a particularly intense form of cultural exchange, with a small number of Japanese and Dutch thinkers working very closely together.

Yoshimune, as we've seen, was impressed by what the Dutch knew. He owned, not only a copy of Jonston's *Natural History of Quadrupeds*, but many other Dutch works of natural history, including Rumphius's *Ambonese Curiosity Cabinet*. With this in mind, Yoshimune decided to relax an old law forbidding the import of European books. (This law had originally been put in place in the seventeenth century in order to stop the spread of Christianity.) Yoshimune gave a select group of scholars permission to purchase Dutch books with a view to translating them into Japanese. Before long, there were even specialist schools dedicated to *rangaku*, or 'Dutch learning'. Crucially, however, this was not simply a one-way relationship. At the same time as Japanese naturalists were learning from Europe, European naturalists were learning from Japan.[57]

Carl Peter Thunberg longed to escape Deshima. Employed as a surgeon, Thunberg had arrived in Japan aboard a Dutch East India Company ship in August 1775. He intended to start collecting exotic plants immediately. However, Thunberg soon found his movements severely restricted. 'It grieves me in my heart to see these rare and beautiful hills, cultivated by the industrious Japanese . . . without having the liberty to go there,' Thunberg grumbled in a letter to a friend. The island of Deshima consisted of just two streets, lined with wooden houses and storerooms. There was also a building for the Japanese interpreters, employed to translate for the Dutch, as well as a single bridge connecting Deshima to the city of Nagasaki. Thunberg started to despair. He had studied under Carl Linnaeus at the University of Uppsala and hoped to be the first to apply the binomial system of classification to Japanese plants. But Thunberg could achieve nothing if he couldn't explore beyond Nagasaki, or even the island of Deshima. 'I have indeed never been circumscribed within such narrow limits, never less free, never more secluded from my beloved flora,' he complained.[58]

Thunberg soon realized that he would need to make some friends. Each day, he would pop into the Japanese interpreters' building. As luck would have it, many of the Japanese interpreters, who were officially there to assist with trade, were also trained in medicine. In Japan, some doctors chose to learn Dutch in order to read European works of natural history and medicine. The interpreters were impressed by what Thunberg knew, as he advised on various new medical treatments, including the use of mercury to treat syphilis, at that point endemic in Japan. (Unfortunately, this treatment probably did more harm than good.) Thunberg had also brought with him some exotic specimens he hoped to trade, including a rhino horn purchased in Java.[59]

One of the Japanese interpreters, Shige Setsuemon, finally agreed to help Thunberg. In exchange for books and medical advice, he promised to supply Thunberg with specimens from the Japanese mainland. This was an incredibly risky thing to do, given the harsh punishments enacted against anyone caught smuggling. Every day, Shige crossed the bridge onto Deshima, hoping the guards would not search his bags, stuffed as they were with seeds and dried plants. The two men would meet in the evenings at the interpreters' building, quickly swapping bundles under the table, hoping no one would notice. Thunberg was delighted, writing that Shige brought him 'various beautiful and rare plants, previously unknown and peculiar to the country'. These included seeds of a Japanese chestnut as well as prints from various Japanese books of natural history.[60]

Still, there was only so much Thunberg could learn from one person. He still wanted to explore Japan for himself, and luckily for Thunberg, his chance came in March 1776. Every year, the Dutch East India Company sent a delegation to visit the shogun in Edo. For the first time, Thunberg was allowed to leave his island home. Perhaps, Thunberg hoped, he would finally get to explore Japan properly? As it turned out, things weren't quite that straightforward. Thunberg was forced to travel to Edo aboard a *norimono*. This was a large cabin in which the occupant would be carried by servants, similar to an Indian palanquin. Thunberg was not allowed to exit the cabin without the permission of his Japanese guards, and certainly wasn't free to roam as he pleased. Over the next few months, he was carried aboard the *norimono* over 700 miles from Nagasaki to Edo. It must have been exceptionally frustrating, rocking from side to side, as the beautiful scenery passed him by. Whenever he could, Thunberg did try and hop out, and collect a few plants. Crossing Mount Hakone, close to Edo, he even managed to lose his Japanese guards for a bit, trekking around in the undergrowth before he was summoned back to his *norimono*. In the end, Thunberg managed to collect sixty-two species of plant, all previously unknown in Europe, including a Japanese maple.[61]

On arriving in Edo, Thunberg presented himself at court. For the occasion, he wore a black silk cloak with gold trim, much like a traditional Japanese kimono. Although he enjoyed the ceremony, and was pleased to have escaped Deshima, Thunberg once again found himself confined. Along with the rest of the Dutch East India Company delegation, he was forced to stay in a small house on the outskirts of Edo Castle. He was not allowed to roam the city, nor the surrounding countryside. Still, he made the best of the situation. At court, Thunberg befriended two influential Japanese physicians: Nakagawa Jun'an and Katsuragawa Hoshu. Both Nakagawa and Katsuragawa were fluent in Dutch. They had also been part of a team responsible for translating one of the first European anatomy textbooks into Japanese. Nakagawa and Katsuragawa visited Thunberg every day for nearly a month, discussing the latest European medical theories, as well as sharing their knowledge of Japanese natural history. Nakagawa brought Thunberg a 'small collection of drugs, minerals, and numerous fresh plants', identifying each with its Japanese name. He also gave Thunberg a copy of a Japanese book titled *Splendours of the Earth*. This book, published in Edo in the early eighteenth century, included illustrations of hundreds of Japanese plants, as well as advice on their proper cultivation.

After a month in Edo, Thunberg returned to Nagasaki. On the way back, he visited a botanical garden in Osaka, full of 'the rarest shrubs and trees, planted in pots'. He even managed to convince the director of the garden to sell him some specimens, including a sago palm. (Technically, this too was illegal, Thunberg noting that 'the exportation of it is strictly prohibited'.) In November 1776, Thunberg finally left Japan, boarding a Dutch East India Company ship bound for Europe. Despite all the obstacles, he had managed to amass a vast collection of Japanese plants and books. In total, Thunberg returned to Europe with over 600 specimens. These formed the basis of his *Flora of Japan* (1784). This was the first work to apply the Linnaean system of classification to Japanese plants. It made Thunberg's name. A few years after returning to Europe, Thunberg was appointed to Linnaeus's old position as Professor of Medicine and Botany at the University of Uppsala.[62]

At first glance, *The Flora of Japan* looks like a typical work of European natural history. But look a little closer, and we can see the traces of Thunberg's time in Japan. Many of the plants are cross-referenced against their traditional Japanese names. The sago palm is a good example. Thunberg gave the sago palm its Latin name, *Cycas revoluta*, indicating it was a member of the same genus as various other palms growing across Asia. However, Thunberg also noted that the sago palm was called 'sotits', or *sotetsu*, in Japanese. This, of course, is something he could only have learned from the Japanese naturalists he met in Nagasaki and Edo. Thunberg's *Flora of Japan* is therefore a perfect example of how eighteenth-century science relied on the exchange of knowledge between different cultures. On the one hand, it was a work of European natural history, extending the reach of Linnaeus's system of classification as far east as Japan. But on the other hand, Thunberg could not have written this book without the help of the many Japanese naturalists he met during his travels.[63]

V. Conclusion

As shown throughout this book, the best way to understand the history of modern science is to examine key moments in global history. In the case of natural history, we need to look to the expansion of global trade during the seventeenth and eighteenth centuries. This expansion was fuelled by the growth of European empires. Agents working for trading companies, such as the Royal African Company and the British East India Company, returned to Europe with specimens from far-off lands. At the same time, naturalists across the colonial world helped establish botanical gardens, with the hope of growing exotic plants for export. The expansion of European empires also brought a variety of different scientific cultures into contact with one another. People from across Africa and Asia possessed a sophisticated understanding of the natural world that is often forgotten today. African healers were responsible for identifying many of the plants in Hans Sloane's *Natural History of Jamaica*, whilst Hendrik van Rheede relied on Brahmin priests to write his *Garden of Malabar*. In China and Japan, knowledge of natural history was particularly advanced, part of a long tradition of scientific texts dating back well over 1,000 years. By the end of the eighteenth century, European naturalists were collecting, not just exotic plants, but also foreign books. Joseph Banks, President of the Royal Society in London, even owned a copy of Li Shizhen's *Compendium of Materia Medica*. Crucially, this was all happening at exactly the same time that the scientific cultures of China and Japan were themselves being transformed by connections to the wider world.

How then should we characterize the history of science during the Enlightenment? Traditionally, the Enlightenment was understood as the 'age of reason'. However, as the previous two chapters demonstrated, we need to remember that the Enlightenment was also the age of empire. In my view, it is that connection to empire – along with the violence and appropriation that went with it – which best explains the development of Enlightenment science. That's certainly true of the two most important sciences of the eighteenth century: astronomy and natural history. Without empire, Isaac Newton could not have discovered the laws of motion, relying as he did on observations made during the voyages of slave traders. And without empire, Carl Linnaeus could not have developed his system of biological classification, as this too depended upon botanical information collected during the expansion of European trading empires in Asia and the Americas. In the next two chapters, we follow the history of science into the nineteenth century, a period in which the link between science and empire only grew stronger. This was a world of factories and machines. A world of nationalism and revolution. And a world of capitalism and conflict. Science was about to enter the industrial age.

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4. Economy of Nature

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5. *Struggle for Existence*

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