1 How Species Matter

There are several 'enigmatic canid' species in North America. One of them is the *red wolf* (*Canis rufus*, Figure 1.1), and another is the *Great Lakes Wolf*. Red wolves are seriously endangered, with a re-released population in North Carolina and breeding programmes being the last populations. Red wolves weren't even studied closely until the 1960s, after having been hunted nearly to extinction in the nineteenth and twentieth centuries.

In 1966, as part of the burgeoning awareness of human impact on wildlife extinctions, the United States passed the *Endangered Species Preservation Act*, later revised in 1973 as the *Endangered Species Act* (ESA) under President Nixon. Under these Acts, the unit of conservation is the species, and any population that does not meet the criteria of specieshood is not worthy of having resources allocated to its conservation.

As a result, much argument has been had about whether the red wolf is a species, a subspecies, or just a population of either coyotes (*Canis latrans*) or the grey wolves (*C. lupus*). Initially, an argument was made by conservation biologists in 1996 that red wolves were 'just' hybrids of these two 'original' species, which meant they did not qualify for these resources. This was rebutted by Ronald Nowak, a Fisheries and Wildlife biologist, who is most responsible for the prominence of the red wolf in conservation debates and policy making.

Hybridisation is, in fact, a common way that the evolution of new species occurs. It can happen in two ways: usually remnant individuals from a population that has been made almost extinct will mate with the nearest approximation. As canids (the 'wolf–dog' group) are widespread and share

Figure 1.1 A typical red wolf.

much of their genetic and developmental machinery, sometimes the hybrids are fertile, and so genetic material is moved from one species to another in a process called *introgression* (the passing of genetic material from one population to another, obviously via mating and having fertile progeny). This means the recipient species now has more genetic variation and can evolve in response to environmental challenges into what is a new species. This evolution into new species becomes evident if a population can no longer interbreed when it gets back in contact with the original species. As we will see, this happened with our ancestors.

The other way is for the hybrids to be different enough from both of the 'parental' species that they form a new species immediately (in geological terms; it could take hundreds or thousands of years). In some plants (e.g., ferns) this is common. It's harder in animals and harder still in vertebrates, but it does happen in lizards and some fishes, as we will see. Or they could just form a subspecies, with a different *phenotype* (the term biologists use for the characteristics that are the products of the organism's *genotype*, which is the entire suite of genetic resources it has) from the parental species but more closely similar to and likely to interbreed with one of the parents.

That wolves interbreed with coyotes is not at issue. The question in the light of the ESA is whether the hybrid form qualifies as its own species. There are three or four major hypotheses: the red wolves are a species derived from a common ancestor with the grey wolf, or they are a hybrid species, or they are a subspecies of one or another of the grey wolves or coyotes, or they are a regional population of one of them. Recent molecular genetic work tends to support the idea that the red wolf is a hybrid. Whether or not this makes it a true species depends upon the species definition one adopts. Depending on which species most of its genetic material comes from, and which species it mates with more successfully, it may be considered a subspecies. Or we may have to revise our notion of species altogether, along with the motivating concepts of conservation biology such as biodiversity and evolutionary uniqueness.

Natural historians (the term for those who studied earthly phenomena in the pre-modern era, including what we now call biologists and geologists, etc.) thought of the world ascending statically and in gradations from inanimate rocks through to nearly angelic humans, with no gaps or separate kinds, and if we haven't found the intermediates locally – the 'missing links' – then it's just that we haven't explored everywhere. In fact, until the eighteenth century, the idea that kinds of animals went extinct was quite literally unimaginable. A beneficent God would not, could not, allow his creations to disappear. This idea was called – in Latin – the *scala naturae*, or in English, the ladder of nature. Historians call it *the Great Chain of Being*. This expected continuity was indeed why many natural historians thought that there were only individuals and not species.

But life *is* characteristically clustered and clumped together at all scales, at least in our world. If there is a 'carpet' of life, it is very wrinkled with many intervening bare patches. No matter what we call them, there are groups of things that live, and there are groups of their parts considered in terms of their structures (both organs and genes). So, if we are to understand the living world about us, and to know what we are dealing with, we need to get a grip on the concepts that we use. Imagining scenarios like the carpet above is a good way to stress-test our intuitions. But there is a better way – we can look at what species are and what they do within science.

The Meaning of *Species*

Species has many traditional meanings and definitions. Chapter 4 will give the short history, and there's a detailed historical and philosophical account in my 2018 book if you want to follow matters further. Still, knowing how ideas and terms were used in the past, while it explains many facets of the use of those words both by specialists and in ordinary use, doesn't help us in how they should be used and for what purposes, any more than the etymology of a dictionary tells us how to use a word today.

However, to consider the purpose of *species* in biology and the wider world, we need to know what they are. And therein lies the rub. Despite school and university textbooks and numerous popular books that treat the idea as uncontroversial, biologists do not agree with one another about what *species* are. And they do not agree in the extreme. By my count, there are around 27 or 28 species 'concepts', up from 22 in a famous 1997 paper by Richard Mayden, an ichthyologist in Saint Louis. Recently, Frank Zachos, a mammalogist in Vienna, has claimed 32 definitions. Since his book, at least three new definitions have been proposed, though they may not really be new. To confuse matters, specialists will also talk about *species concepts* (specifications of the diagnostic characters) of a particular group, say, colobus monkeys or black salamanders. A few words are needed if we aren't to get too tangled up.

First, having a 'concept' does not need to include having a definition. If you disagree with me here (and are not a specialist) try to define your concept of 'dog' in a way that is both precise and marks out only dogs (and not, say, wolves, coyotes or foxes). Children have concepts of dogs, but they do not have definitions of dogs. A species concept, as opposed to a definition of what the species concept refers to, is something we can have naively, so to speak. By extension we could say that scientists can use the term without being able to define it, even by their practice, and indeed they often do. But we need basic terms in science to be consistent, or else what we say about one species might be wrongly extended to species of a different group. Such confusions in science delay understanding. Hence, scientists, and those who rely upon their work such as legislators and conservationists, try to define their terms as precisely as they can.

Second, a definition is not a concept separately from the term or name of the concept. If I can define ‘human’ in six different ways, for example, that doesn’t mean there are six concepts of *human*. There is the one concept, defined in six different ways. (This is an oversimplification. There might be two or more concepts – say, of ‘human person’ and ‘human organism’, and so forth. But that raises questions in the philosophy of language that are not relevant to us now.) The different definitions may be in competition with each other, or they may be consistent with each other. So, the fact that there are, say several hundred ‘definitions’ in the scientific literature (at least!) of the term and idea of *species* doesn’t mean there are several hundred concepts of *species* in the literature. There are a smaller number of *conceptions* (definite ideas) of the one concept (*species*), and each conception can itself have numerous definitions and formulations. This is not generally the case with biology – for instance, *gene* has numerous distinct meanings depending on whether you are approaching it as a molecular biologist, a Mendelian geneticist, or a journalist with the latest breathless ‘there is a gene for…’ story. But *species* is something biologists seem to agree is a unitary concept, even though they dispute what it is. This is the reason that there is a ‘species problem’.

Third, a specification of how a concept of species applies in a particular and restricted range of cases (species concepts of orangutans, for instance) is not a reason to think this multiplies the number of species concepts. A description of many dog breeds doesn’t mean there are many dog concepts. There is a singular concept *dog* which is applied to numerous varieties or ‘breeds’.

Fourth and finally, even if a species conception does apply neatly to a certain group, such as crows or cats or corals, it does not follow that this definition is valid for all groups of species. Sometimes adherence to a particular definition leads scientists and philosophers to deny that anything that fails to meet the criteria is a species. I’ll deal with these questions in Chapter 5.

On another tack: technical terms in science often mark out competing schools of thought, and function as *boundary markers*. If scientist *A* uses *X* in one way, and scientist *B* uses *X* in another way, and they are unable to reconcile these two senses, then very often, in the words of Wittgenstein, ‘each [person] … calls the other a fool, and a heretic’. So, scientists will compete to have their preferred definition accepted or even coin new technical terms in order to demarcate the 'good' guys (= 'those I agree with') from the 'bad' guys (= 'those who oppose my view'). It's unsurprising, since scientists are human beings and do what human beings do, including play political games in their disciplines. What I do find agreeably surprising, though, is the tendency of scientists to honestly review these terms from time to time to bring them in line with the evidence. Not many human traditions or institutions do that, and this is what marks out biology, and science in general, from armchair intuitions or 'common knowledge'.

Who Uses Species, Anyway?

The most obvious answer to the question of who uses species names, classifications and even members of species is: biologists. Well, to be fair, humans in general first, but as a term of science, *species* is made for biologists. But biology is not a single profession, and it can even be argued it is not a single topic of science. Each discipline, subdiscipline, and application of biology has a different way of treating *species*.

A primary use is to organise shelves and exhibits in museums. Like a library with a classification scheme, a natural history museum needs to arrange things so they can be found, connections made with other specimens, and new trainees (also known as graduate students) taught from them.

But classification is a means to a lot of ends. Ecologists and conservation biologists need to know what species are in a region being protected. Also, they need to be able to communicate to policy makers – politicians, bureaucrats, law enforcement – what species need protection in an area and when a member of a protected species has been illicitly poisoned or shot, for example.

Biomedical researchers use species to identify model organisms used for studying how organs and processes that we humans share work. For this reason, if a species is not closely related to us (say, an octopus), we cannot draw straightforward conclusions from studying its immune system, for instance. Mice, being much more closely related, are more useful, primates more useful still.

Botanists often need to be able to identify a difference between a species and a local variety in order to study how plants behave in the wild, and so too do mycologists with fungi, microbiologists with bacteria and algae, and so on. Diatoms play a particularly important role in soils, sea and lake floors, and the ecologies that rely upon them, and diatom specialists need to be able to determine which diatoms contribute to, among other things, ocean carbon capture or food for other ocean animals.

Molecular biologists know that the biochemistry of a cell differs between species. While some processes and structures – cell membranes, Krebs cycle, DNA transcription – varies little, other aspects of cell biology are highly species-particular.

Another use is economic. Businesses depend upon proper identification of species in agriculture, horticulture, food production and so on. Fisheries, for example, need to know what species they are catching, especially when if they overfish juveniles of a species they may deplete a species their livelihood will depend on in future seasons. If you do not know that a certain species is a juvenile (too young to breed) when it is a certain size, you will not release them back into the sea correctly. Recreational fishers also need a relatively good knowledge of their prey.

Agricultural uses of species are critical, both for producing the right (and marketable) products, and for identifying pests that interfere with them. In forestry, knowledge of companion species encourages growth of trees. And of course, locals need to know which species are poisonous (or venomous) and which are safe or good to eat. Woe betide the mushroom collector who does not know the local species!

We all use species. Or do we? I mentioned that museums need to classify to store specimens. What they actually use is a name for a *specimen*. Ecologists use species names too: as a way to either identify the role played in the ecology of an area by an identified organism, or to identify a type of organism needing to be researched to find out what its role is. And so on through all of biology and biological economics. It is, I think, the *name* that is most used. The actual species itself, if the name does name an actual species, is simply the thing that anchors whatever the researchers are interested in.

So, this raises the issue why biologists are so protective of species names and descriptions. If the name is all they need to focus on ecological roles, biochemical pathways and such, why not abandon *species*? That is what we shall look at.

A Fake Story Is Essential

One of the ways in which political science-games are played is by re-engineering history. There is a story told for half a century about the notion of species and the arrival of evolutionary theory. This was created, either deliberately or not, to give status to a particular view of species in the mid-twentieth century, particularly by two architects of the 'modern synthesis', George Gaylord Simpson, an American palaeontologist, and Ernst Walter Mayr, a German-American ornithologist. It was expanded upon in 1954 by Arthur J. Cain at Oxford, in a very influential book, *Animal Species and Their Evolution*, which was reissued several times as a teaching text. The story was a way of raising the importance of Darwin against a prior group of biologists known collectively as 'neo-Lamarckians', who had adopted non-Darwinian mechanisms of evolution. This story, the 'essentialism story', has become the staple of textbook potted histories for over 60 years, and it is false.

In philosophy, an *essence* is what makes things a kind of thing; or, as we say to undergraduates, what makes a thing a member of, part of, or instance of, a *natural kind*. According to the story, only those things which have necessary and sufficient features are members of the natural kind that is defined by those features, the 'essence' of the kind. And since philosophers have been using terms for kinds in the natural, biological, world as examples of natural kinds since, well, forever, the story went that until Darwin introduced evolutionary theory, species were thought to be natural kinds with essences, which meant that they could not evolve gradually because once a single essential character changed in an organism of one species, it was immediately to be seen as a member of a new species (or maybe one that already existed, if you adopted the Great Chain of Being).

Historian Polly (Mary P.) Winsor, now emeritus at Toronto University, is the scholar who called it the 'essentialism story'. Around the time I completed my PhD attacking that story, I got in touch with Polly and found that (of course) my conclusion was not original to me. Polly was gracious enough to cite my thesis anyway in her published attack on the same story. Here's briefly how the essentialism story goes:

> When Darwin introduced the idea of species originating from previous species by a gradual process, he undercut the older creationist consensus that species had permanent essences, an idea that began with either Plato (according to Simpson) or Aristotle (according to Mayr). Since species were no longer thought to have essential properties (like body shape, inherited constitution, and so on), Darwin caused a revolution in biological systematics and in genetics.

The notion that species were thought to have essential characters before Darwin became the standard view in biology and philosophy for over 60 years, and even persists today. I'll get into the confusions and errors later, but for now I want only to ask why this story even exists in science.

Both Simpson and Mayr had their own definitions of *species*, which they wanted to be adopted by biologists generally. In science, credit for empirical and conceptual work is the coin of the realm. The more credit you are given, the more chance you have of getting students, grants, positions, assistants and the other human resources of science. This is not meant to be a cynical comment. Individual scientists may be motivated by anything from a personal desire to show some foe they are wrong, to a desire to reach truth and serve humanity. In the end, though, the proof of the pudding is in the eating. Without credit, you become a footnote in the history of your discipline, if you are remembered at all (apart from by specialist historians of biology).

Mayr, in particular, used the essentialist story as a rhetorical and partisan weapon to attack those who disputed the Modern Synthesis that he and Simpson promoted. If being non-Darwinian was equivalent to being sympathetic to pre-Darwinian ideas, then you must be an essentialist if you disputed Mayr's own species concept, which he claimed to be *the* Darwinian position (spoiler: it isn't). And being sympathetic to pre-Darwinian ideas meant you were in effect a creationist. This was the kiss of professional death in evolutionary circles, and the charge was used against many who today would be seen as clearly in line with the consensus in biology. Anyone with the least training in logic or reasoning knows this fallacy as *affirming the consequent*.

In general, species concepts in the twentieth century and beyond have been used as 'tribal flags', as banners to rally the troops during battle. It's not unusual in science, but for us not-scientists it is important to remember that just because a definition of species has been adopted widely, it isn't necessarily the most universally applicable or even conceptually the most elaborated. It may merely have had better marketing.

The Philosophy of Species

Species tend to be identified because there is breeding, and the progeny look similar to their parents. The thing that puts two organisms into members of the same species is, in keeping with the etymology of the word *species*, their appearance. But this is not the cause of being a species. This is the cause of them being put into the same species. In Chapter 3, we will consider the proposed causes of species. But we do need to make some distinctions.

There are three major tasks in philosophy, and they apply to *species* as they do to everything else. As we look at species taxa and the species concept, we shall consider all three of them. So, we distinguish between the following philosophical questions:

- What is it that constitutes something being a species (their causes, or *ontology*) and what does this say of their natures?
- How is it we know, identify, discover and refer to species (the ways we know or mark out species, or *epistemology*)?
- What value do species have for us in moral and social contexts (the ethical considerations in their use or protection, and our obligations towards them, or the *axiology*)?

I hope this book will help the reader to unravel and resolve these great questions for themselves. I shall not be presenting a 'solution' to the 'species problem' since the beginnings of the twentieth century. But all philosophers of biology, let alone all biologists, ecologists and conservationists, are required by their respective guilds to either sign on to a solution or definition of species, or try to present a new one. As my friend Matt Barker has said to me, some are allowed or even encouraged to sign on to dissolution or deflation! Think of this book as a guide to that end for you to attempt a solution for yourself.