

the wood among which the trees are found

*But of course, for those of us who understand life,
we could not care less about figures.*

The Little Prince, Antoine de Saint Exupéry

biodiversity – what was that again?

Like it or not, ‘biodiversity’ is one of the big buzzwords of our time. You can hear it on the radio and in conversation, on TV and in films. Talk of the ‘biodiversity debate’, our ‘biodiversity crisis’, ‘threats to biodiversity’ (from climate change, a new motorway or GM crops), and ‘conserving biodiversity’ (by setting up nature reserves, stopping a new housing estate being built, paying to adopt a lion, panda or dolphin, letting your garden run wild) is everywhere. It’s a word frequently found on the lips of politicians, ecowarriors, broadcasters, business people, university students, your friends and acquaintances down at the pub or cafe, conservationists, and even schoolchildren. And yet trying to pin down exactly what all of these different types of people mean by biodiversity is difficult. It seems to mean different things to different

people. So we have a subject that many of us would agree is essential to know something about, even to get to grips with, but one for which few of us have a clear definition.

Fortunately, if you know where to look you can find some definitions for the word – the problem is, if you look quite hard you can find more than eighty different definitions. There is, however, one that has gained international currency, signed up to by the 150 nations that put together the Convention on Biological Diversity at Rio de Janeiro, Brazil in 1992.^{www#1} Here biodiversity was defined as ‘the variability among living organisms from all sources including [among other things] terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part ... [including] diversity within species, between species and of ecosystems’. In short, biodiversity is the variety of life – in all its different forms and relationships. This sounds quite satisfying until we ask the question that should let us know if the study of biodiversity is a science: how do we measure biodiversity? This is not so straightforward. And yet it goes to the very heart of what we mean when we talk about biodiversity or the biodiversity of a particular area, country or region. A simple example will help us see where the difficulties lie.

life – in abundance

I live a few minutes' walk from Wembury Bay (Figure 1). It's an incredibly beautiful bay on the south-west coast of Devon, just a few miles east of the city of Plymouth.^{www#2} It was one of the first voluntary marine reserves in the UK. This was in recognition of the tremendous variety of life found there; the biodiversity of Wembury Bay is certainly impressive. Between the tides, on this shore alone, nearly all the different major ‘types’ or ‘designs’ of the things that characterize life on earth can be found. There are fish, sea urchins, crabs, worms, sea squirts, sponges, sea anemones, seaweeds, sand flies, bootlace worms, limpets, periwinkles, sea mats and lichens in abundance. Even the rocks in the vicinity of the bay harbour the remains of sea creatures which lived here



Figure 1 *Wembury Bay, Devon, UK*

more than 400 million years ago. There are armoured fish and crinoids (upturned starfish with stalks), quite different from today's marine animals but also eerily familiar. As John Steinbeck wrote of a similar, but totally different, seashore, 'Here we have life, and life in abundance.'

And there is the unseen microworld of Wembury Bay. A world within a world, ubiquitous on the surfaces of rock, animals, plants, refuse, between and around single sand grains, enclosed in a water droplet, and even living inside the bodies of the animals, plants and other microforms of life on the beach. Within this microworld viruses and bacteria abound, as do many minibeasts and plants that are so unfamiliar they have no common name or title. They range from nondescript, wormlike forms through to exquisitely formed, delicate and bizarre water bears living beneath the rims of barnacle shells.

Let us return to where we started: how do we measure biodiversity, and, in this case, the biodiversity of Wembury Bay? How should we go about answering this question?

The simplest way might be to count how many different types of things are there. This is no mean task, and could potentially take

not just weeks and months but even years and tens of years, even for such a small area – and that's leaving out all of the land animals, plants and microbes that form part of the larger landscape that is the bay. It is just about conceivable that for most of the largish marine animals we could put this list together by drawing on an amazing book that compiles scientific records from Plymouth (and Wembury in particular) stretching back into the nineteenth century, the *Plymouth marine fauna*.^{www#3} The seaweeds too we could probably get from a number of published scientific sources. However, for many microscopic animals, plants, fungi, bacteria and viruses our current information is sketchy at best. It's not just the process of finding them that is problematic either. Many of these little specks of life are yet to be described, let alone the number of different types counted.

Even if it were possible to count the numbers of different types of everything, would such a list really be the measure of the biodiversity of Wembury Bay? Well, perhaps. But it ignores the fact that there are rarely equal numbers of everything. Some creatures are extremely numerous and ubiquitous, others are rare or only occur in particular, sometimes very localized, areas. Periwinkles are absolutely everywhere, sometimes in large piles two or three animals deep. Sea cucumbers such as the white cotton spinner can be found under rocks at most times of the year but you really do have to search. Surely biodiversity must encompass not just differences but the actual numbers of different things present? But even that is not all.

Up until now all the differences we've considered have been determined by what the creatures look like and how that differs from how others look. It does not take into account that other differences may be equally, or even more, important; an example would be differences in the way individual types of creature 'work', i.e. how they acquire energy and what they do with that energy to maintain themselves and what they actually contribute (if anything) to the working of the ecosystem to which they belong. (We've already come across the term 'ecosystem' when we looked at the definition of biodiversity but I didn't say what one was. An ecosystem is a dynamic complex of plant, animal and microbial

communities and their non-living environment interacting as a functioning unit. It can be small, e.g. a rock pool, or large like the Arizona desert, and anything in between.) We know that at Wembury limpets and sea hares, two different types of animal, often 'do' the same sort of thing – they do what cows do on land, they graze. And then there are the interrelationships between the different species – predators (the eaters) and prey (the eaten), for example – or the multitude of ways that species and even groups of species influence other species or groups.

If you've been following all this you may find yourself at a mental crossroads. This is a well-trodden road. It is a place where many scientists, philosophers and theologians find themselves periodically, and it is a place that we will return to time and again in what follows. You can go down the 'Oh, but the world's a complicated place and we'll never get to grips with it' road, which leads to a comfy armchair, subdued lighting, a stiff drink, and an abandoning of intellectual pursuit and its partner hope. Or you can opt for 'OK, it is complicated and I may never find the truth, but I'll settle for a little less if it keeps me from stalling and keeps me walking down this particular road'. This said, in the face of such complexity it is fair to say that there is no one way of measuring or quantifying 'biodiversity'. We cannot measure the biodiversity of Wembury Bay, or any other bay, or of the oceans, or of the earth for that matter. We can talk and think about the notion of biodiversity, but we cannot measure it – we can only measure *selected aspects* of it. Don't despair, though. It may not be ideal, but even that is a start.

directions

To put together a beginner's guide to biodiversity, based on current scientific knowledge and understanding, much of our time will be spent on looking at measures of biodiversity and how those measures change in time and space. Some will be better than others. In many cases, though, we will find that the measure has been decided for us. Scientists often have to rely on the total number of

species, the species richness, in a given geographical area just because that is the only information available. Much work has gone into producing alternative measures. But given the data we already have in scientific literature and museums, the relative ease of putting together inventories of different types of creature, particularly for very large areas, and the fact that it often encompasses numerous aspects of biodiversity, species richness is not a bad measure. So much of what follows will use biodiversity and species richness almost as interchangeable terms: but not all the time.

There is no one way to write a beginner's guide to biodiversity. It could take the form of an exhortation to save the planet; it could be encyclopaedic, cataloguing the types of living creature and the places they live; it could centre on how to preserve biodiversity; or it could combine aspects of all three. So what will be the approach of this beginner's guide? Many theologians, philosophers and educators believe that the only way you can ever say anything general and all-embracing, is by starting with something tangible, specific, familiar. In the nineteenth century Thomas Huxley, for example, used the crayfish for the title and subject of a book he wrote to introduce interested readers to the study of zoology. In that same tradition, throughout this book I use Wembury Bay, and other aspects of my own experience, as a way into some of the big biodiversity issues and patterns. In that respect this is a very personal book.

What will be the key features of this beginner's guide? In the next chapter we ask the questions how many species are there currently on the earth, and how are they distributed between the different large groupings of organisms we currently recognize. What are these large groupings and how have we ended up with them? This will involve trying to determine what makes a species a species anyway. We will spend some time looking at numbers of species found in a particular area as an indication of, indeed as a surrogate for, the biodiversity of that region. In chapter 3 we will see that biodiversity is not distributed evenly across the earth's surface. There are hotspots and there are coldspots. We will look at the current patterns of biodiversity (or at least measures of biodiversity), in particular how the number of organisms varies with

latitude, altitude and depth. That should take us neatly on to the fourth chapter, where we delve into the origin and development of biodiversity, concentrating particularly on the ups and downs of the past 600 million years. We'll enter into a debate on the origins of biodiversity which goes to the very centre of what we think about ourselves and the other organisms with which we share this planet. Much of our attention will be on extinction, both in the past and in the present.

Up to this point in the book biodiversity is discussed, at least as much as is possible, as an objective scientific body of knowledge. But part of the reason we find it difficult to get a handle on the term biodiversity is because, in the minds of many, it is a value-laden concept. Furthermore, because we have to rely on measures of biodiversity, and the measures we pick often reflect what it is we value about biodiversity, how could the whole subject not be value laden – whether we like it or not? So the remainder of the book is devoted to the threats to, and value(s) of biodiversity, including direct and indirect monetary value. The main threats are discussed and illustrated, paying particular attention to one of the main drivers – us. We will take a path that leads us to an attempt by economists to cost the earth and its services, a project by scientists to create a living life-support system for eight people, a current scientific controversy on how many species we actually need, and a survey of religious thought on the place of biodiversity, and nature in general, in our thoughts and beliefs. The penultimate chapter leads on from talk of value, to what have we done, and what are we doing, to conserve biodiversity. The final chapter, for me personally, draws the whole book together, but in other ways it's optional. It is a personal view on what all of this biodiversity stuff means.

This beginner's guide to biodiversity is aimed mainly at those with little formal training in biology who want to find a way into some of the most interesting biology questions and some of the most pressing biodiversity issues of our time. The worldwide web is to someone interested in biodiversity what a refuse skip is to an ecologist like myself – filled with a lot of filthy or irrelevant material, often of dubious worth, but sometimes containing really neat

stuff that, once salvaged under cover of night, can be extremely useful for your research. For this reason I have included some references to websites (marked in the text by a 'www' superscript) which the reader can use to 'go further' and pursue in greater detail some of the material that we can only skate over the surface of here. In my experience it seems much easier and more convenient to direct people to a website than ask them to get hold of a book or an article. But knowing where to look for good stuff is everything, and some direction as to why it's good and relevant is invaluable. I hope that I'll give the reader a few starting places. At the end of the book I'll also list just a few 'must-read books': but this is a beginner's guide, an attempt to get you interested, so the books and websites are hardly exhaustive.

I've tried to make what follows quantitative rather than go for the 'ooh-ah' factor. After all, the bread and butter of science is what you can measure or quantify in some way. But that is not to say this is all that I personally value about biodiversity – facts and figures, calculations and guesstimates. I have felt the wonder of peering down a microscope for hours on end watching an embryonic shrimp or snail develop, seeing the separation of its cells, witnessing its first heart beat. I have been overwhelmed by the beauty and complexity of the living world, from tens of different little microscopic creatures inhabiting and working their sandgrain 'planet' to patterns of life spread majestically across a much bigger planet. But this is not the time, or the place. The majesty and wonder of biodiversity is always better 'felt than tell't'. Just now we live at a time in history where, I will argue, our living world will at best diminish, at worst disappear. It is good to try to understand the facts of the matter, to help inform us about how we feel about it, and what we should do about it.

For some, there will not be enough rigour here. They will want a more balanced, more detailed, more comprehensive (there's lots of stuff that many would consider essential that I don't even mention, let alone discuss), less personal account and discussion. They will want a much more academic approach. To those people, I suggest putting this book down and buying a copy of the textbook *Biodiversity. An Introduction* written by Kevin Gaston and

myself.^{www#4} Admittedly I'm biased, but I think it's pretty good for such a comparatively small book. Alternatively, you could read Christian Lévêque and Jean-Claude Mounolou's *Biodiversity* or Mike Jeffries' textbook *Biodiversity and Conservation* (1997). They too are good, but in different ways.

For those of you still with me, we'll start by asking how many different living things there are on the earth and how they are related.