This stand-alone chapter gives an accessible introduction to the problem of biological individuality. It provides vivid and engaging real-life examples that pull our intuitions in different directions, and explains how existing attempts to say what an organism is, by biologists and philosophers, have generated a complex and contested concept. The chapter posits that we typically expect functional and developmental criteria to fit neatly together so that biological individuals have parts that are similar but also work together cohesively. It then details a range of cases, including symbiosis, coloniality, and genetic chimericism, in which those expectations are disappointed and we are left feeling torn between alternative possible conceptualisations of the units in question. It then details some practical consequences of the conceptual confusion, and introduces a range of different criteria that might be applied to arbitrate the situation. Finally, some very general considerations are offered about what form an appropriate solution would take.

organisms, concepts, parts, boundaries, nature, definitions, symbiosis, colony, clones, puzzles

P1

Part I

FINDING OUR TARGET

C1

1

What Is the Problem?

C1P1 *Key puzzle: Why is it hard to say what an organism is? The objective of this chapter is for the reader to be able to differentiate a few key ways in which defining a biological individual is problematic.*

C1P2 When we humans observe the living world, one of the most basic properties that we take for granted is what we might call its ‘lumpiness’. We don’t see a homogeneous living soup around us. Instead, we apprehend living things as bounded objects, as separate, countable things, which can be followed or tracked over time. Some of them are more obvious than others because they are bigger, or brighter, or have all their boundaries in clear sight. Take a glance at the picture in Figure 1.1.

Insert Figure 1.1 here

C1P3 How many organisms do you see? Even if you find it hard to answer—some parts of the photo are blurry, some of the animals are overlapping each other or the edges of the picture—my guess is that you’ll understand it as a coherent question, the kind that deserves a factual answer. If there is any indeterminacy about the number of animals in the picture, you’ll suppose it is because of pictorial inadequacies rather than because such indeterminacy exists in the world.

C1P4 In some ways, nothing is more obvious to us than that organisms can be counted. Consider a typical baby book, full of bright images of ladybirds and smiling monkeys. Parents point to pictures of living things, especially animals, in order to teach their children how to recognise different items as distinct. By repetition over and over, ‘Look at the cat! See how the penguin is smiling!’, we eventually root the idea in a baby’s mind *that the world is divided into separate things*. When I point at the penguin, I’m pointing at the whole thing—everything inside its edges. Those children learn how to count by spotting *two* penguins, three monkeys. Culture is replete with stories in which the individuality of animals is taken for granted. We talk about Noah counting animals onto his Ark, about Buddha receiving his message underneath a particular Banyan tree. The task of counting sheep is assumed to be so mundane it will send a person to sleep.

C1P5 The organisms we knowingly interact with regularly, such as macroscopic companion or domestic animals, come with a suite of features that make them easy to distinguish from one another. They have skin or bark or a shell that visually marks their boundaries. Their life cycles are demarcated by stages with easily recognisable formats, such as eggs and acorns. They follow recurring and familiar trends from small to large, or from large-eyed and cute to wrinkly and slow. They act as wholes—leaping or swimming or barking as singular units with coherent drives and fears. They respond as wholes to threats, diseases, and opportunities.

C1P6 All of us know *what it's like to be* an organism, or a 'biological individual'—I'll mostly use those terms interchangeably. We can all point easily to examples. Most folk would feel confident enough, standing in a zoo, if asked to count a small group of flamingos. If shown a decent colour photo of a little flamingo family—mother, father, and healthy week-old chick— even a child would be able to say how many birds there are. Nobody will hesitate over whether the chick is a separate organism from the mother. If tasked to draw circles around each organism, nobody is going to cut a flamingo up into little pieces, or merge them into one another. Each bird will be given all of its proper parts—head, wings, toes, beak—so that unbroken skin surrounds each individual. Little thought will likely be given as to why, to what justifies such a verdict. It is simply obvious, intuitive.

C1P7 So why does this book exist if we all know an organism when we bump into one? While the full answer to this question is going to emerge over the next couple of chapters, at this point I will note what is going to become a recurring motif within my investigation. When posed with respect to some organisms, these problems can look needlessly complicated—like typical philosopher's questions. Humans occasionally ask serious questions about how many weeks old a foetus must be before we can start to consider it a person, or about the exact moment when a human should be considered to have died. But have you ever worried that you might have mistaken your arm for your daughter? Probably not. But for a starfish this wouldn't be an unreasonable question. In some species of starfish, arms and daughters are effectively the same thing. According to popular legend, fishermen used to rip up the starfish they pulled up in their nets to try to reduce their numbers, because starfish are big consumers of shellfish. These fishermen, the legend goes, puzzled over the fact that despite being literally torn into little pieces in vast numbers, the starfish population never seemed to get smaller. Instead, they became even more numerous. The reason is that starfish are really good at regenerating. Some species even have what's called 'fissiparity' as their primary method of multiplication. Reproduction in these organisms looks like something out of a horror movie. In *Allostichaster polyplex*, for example, the arms appear to become seized with a fervent desire to get away from each other, which eventually causes the whole star to be ripped in half down the middle, over the course of a few hours (see Figure 1. 2). As one specialist puts it, 'the tissues simply tear apart as they are stretched by contrary movement of opposing regions' (Hughes 1989, 33).

Insert Figure 1.2 here

C1P8 Starfish in the *Linckia* genus prefer the somewhat less grisly method of having one arm drop off. Fortunately, the arm regrows, and the cast-off arm regenerates into an entire new star in around forty days (Rideout 1978). The distinction between arms and daughters here seems blurry, arbitrary. In virtue of what does a starfish part become a starfish in its own right? The important change seems to be physical separation—but human arms don't seem to become offspring after they are amputated. Perhaps we do better to keep arms and daughters distinct, and say that starfish points are never arms, that the 'parent' was really a collection of individuals all along. But if we accept the idea that a clump of separate individuals sometimes looks like a single organism, how can we be sure that other organisms, humans for example, aren't really aggregations masquerading as individuals too?

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C1P9 When I ask people to say what they think are defining properties of an individual organism,[1] I always get interesting and varied

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1 As I'll explain in Chapter 5, there is ongoing dispute about terminology here, with some arguing that the term 'organism' should not be used to mean 'one life' but only in an even more specific sense, to name a particular way of defining one life. I

responses. I encourage you to jot your own ideas down, before I contaminate your intuitions with my collected answers.

C1P10 Those young enough to recollect some high school biology are quite likely to reach for some words that end in -tion or -ism and have a reassuring science-y air about them: respiration, metabolism, reproduction, response to stimuli, growth. Although these properties are in the right ballpark, it is important that I clarify right away that they don’t quite latch onto what I’ve got in mind: defining an *organism* is a different matter than defining *life*. To see why, imagine that we sent a probe to the far side of Mars and found what’s called a ‘biomarker’—a sign of possible life. For example, suppose that the atmosphere of Mars was found to contain more methane than we would expect, in the absence of an active source. Given that metabolism

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will leave those matters aside for now, and say that the target of the whole book—the object I’m trying to define—is one life, one creature, one living individual, commonly called an organism.

by living things is the biggest source of methane on earth, we could interpret such a finding as evidence of life on Mars. But notice that it wouldn't tell us anything about *how many* lives there are on Mars. Finding an appropriate biomarker depends on defining life appropriately (Parke 2013; Cleland 2019). But quantifying how many lives there are depends on defining biological individuality appropriately.

C1P11 Life is very difficult to define. Some have tried to define it in terms of thermodynamics, but they have difficulty excluding abiotic forms of organisation such as crystals, which are fantastically and spontaneously well organised. Others have appealed to metabolism, but they have difficulty excluding things like flames, which act as stable centres for conversion of fuel and oxygen into energy. Astrobiologists have searched for carbon or methane or nucleic acids, because life on Earth is known to always involve these, but critics point out that extra-terrestrial life may not be similar to Earth life (Cleland and Chyba 2002). The need to arbitrate *synthetic* and *artificial* life stretches the task of bounding possible life even further (Knuuttila and

Loettgers 2017). Fortunately for me, this book isn’t trying to solve the horribly thorny problem of defining life. In my treatment, the problem of biological individuality is more specific, so we can effectively sidestep the life problem, and ask:

C1P12 Assuming that some stuff or matter is alive . . . in virtue of what is the stuff divided into multiple lives?

C1P13 Knowing that the stuff respires, for example, doesn’t tell us how many things it is. Many things that are not individual organisms can grow, respond, metabolise. My cells do all of these things, for example. So do many aggregates, such as flocks of starlings. Even reproduction, as I’ll argue in detail later, fails to clearly distinguish between organisms, parts of organisms, and groups of organisms. So ‘biological individual’ picks out something different from ‘life’ or ‘living stuff’. It is more specific. To be a biological individual is not merely to be alive, is to be, or to have, *one life*. One biological individual is one organism, one creature or critter, one being or entity.

C1P14 But what do we mean?

C1S1 A folk organism concept

C1P15 I conjecture that there exists what philosophers call a ‘ folk concept’ of the organism. This is basically the way that a typical woman or man on the street conceives the thing. It isn’t necessarily obvious to the said woman that she possesses such an idea—she may never have thought about it at all. And it need not be the case that every woman on every street has the same idea. Rather, a folk concept is the description you get if you try to put together all the different ways that a concept is used or understood by ‘normal’ people, that is, people who are not philosophers or scientists. It combines a rich set of influences, including history and science, with everyday experience and convention, including linguistic convention. But it is normally latent or implicit—it hangs in the background of people’s thoughts, organising those thoughts without the thinker needing to be aware that any such organising is happening. Folk concepts are powerful because their power over us—to make us react in surprise, or to experience something as familiar and perhaps objective—is often invisible, and thus protected from our rational deliberation. We can end up giving them authority, treating them as beyond doubt, without realising we are doing it and thus without holding them up to the light of day. Philosophy's business is in excavating such concepts—bringing them into the light, and checking whether they pick out anything in reality, so that we can decide if their power is deserved or not. My conceptual analysis here will be biased by my particular cultural context in the UK, which is Anglophone and Eurocentric. No doubt different concepts can be uncovered by a post-colonial analysis which looks at indigenous or non-Western concepts, or even looks outside the mainstream in the UK. I'm not favouring this default in order to endorse it, but only to secure a clear starting point for my review.

C1P16 I'd wager that Anglo-European folk organism concepts typically have the following properties, although they'll be implicit rather than anywhere near fully spelled out:

C1P17 - Organisms are assumed to be **units of development**—in which all the parts of the organism descend from a single precursor—a fertilised egg, or other small propagule—and grow or change in concert with one another after that. In modern times, I think most folk assume that all the parts that develop from the propagule share the same genes as one another, so there is one unique genome repeated by all the cells.

C1P18 - Organisms are assumed to be **functional-organisational units**—so that all the parts of the organism are functionally dependent on one another, and together they are functionally autonomous from others of their kind and from the environment. Folk might implicitly give this a behavioural spin, so that all the parts of the organism exhibit a common purpose, or unified agency.

C1P19 Crucially, in the folk view, these properties coincide: the unit of development includes all the very same parts as the unit of function. I am building here on something Philosopher John

Dupré called a ‘monogenomic differentiated cell lineage’ (Dupré 2012). As the name suggests, this combines genetic homogeneity with cellular differentiation—that is, all the cells are organised into a functional division of labour—and descend from a single recent ancestor. I posit this folk view as a sort of best explanation of the intuitions that people tend to have, the verdicts that they tend to give, and the cases they tend to find puzzling. In what follows I am going to describe a number of real-life cases in which this folk view runs into difficulty.

C1S2 A menagerie

C1P20 I like to let the weirdness of nature speak for itself, so there is quite a lot of detail to come. Should the variety of these cases become bewildering at any point, I’ve also herded them into a table on page xx which keeps track of some different ways in which they are challenging.

C1P21 I’ll start with an easy case: a flamingo—a nice charismatic bird, prominent enough in popular culture that most people can get one in mind. A biologist might be upset if I don’t specify a particular flamingo species, since there are several, so let's fix on an American flamingo, *Phoenicopterus ruber*. Provided with Figure 1.3, I'd bet that the average person on the street would be pretty confident about counting exactly two flamingos. Explaining *why* might be a different matter, but I contend that it could be done by appealing to folk assumptions about development and function. On development first. Each flamingo is wrapped all around in skin and feathers, with a beak at one end and toes at the other. All of these parts, and— we'd usually assume— the matter within, are composed of cells that make up a single branching lineage, descended in a series of cell divisions from a single fertilised egg— a zygote. Each of those cellular parts—it is assumed—contains DNA that meets two requirements. First, it is characteristic of the species to which it belongs, so in some sense it is typical American flamingo DNA. Second, it is unique to one flamingo in particular, and homogeneous across all the parts of that individual. None of this can be confirmed by looking at a photo of course, but I contend that it is what the folk are likely to assume about flamingos, by generalising on the fact that flamingos are birds and hatch from eggs.[2] Similarly, it will be assumed that those cells that are within the skin and descended from the zygote will compose a functional unit, in the sense that the bird will feed itself, fly by itself, and generally exhibit behavioural autonomy. Actually, flamingo chicks don’t feed themselves until they’re around three months old, but my sense is that the folk don’t care about that. They care about the fact that the body, composed by cells descended from the zygote, will *go on* to feed itself in the future—that’s enough to qualify the cells as composing an individual unit even at earlier stages.

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[2] Identical twinning potentially confuses things, because then two organisms develop from a single zygote, but twinning is extremely rare in animals that hatch from eggs. Double yolks are relatively common, but it is thought that the extra oxygen requirements, combined with mechanical issues that make it hard for twins to generate enough force to break out of the shell, mean that they mostly fail to hatch.

C1P22 Moreover, the developmental and functional considerations reinforce each other here—they coincide in the same units, giving the result that Figure 1.3 shows two organisms: one adult and one juvenile.

Insert Figure 1.3 here

C1P23 Now for the problem cases. At the coarsest grain of this classification, I divide these cases into two categories. First we'll look at cases in which the folk view stumbles because there is a chunk of living stuff that all shares the same genome, but it isn't stuck together into a single functional unit, like we expect it to be. We already saw this happen in the fissioning starfish— a single genetic unit that fragments into separate functional/organisational units. In fact, this is the case whenever reproduction is clonal, because cloning produces genetic copies that are functionally independent of one another. *Populus tremuloides* (Quaking aspen) are beautiful trees which get their name from delicate silvery leaves that tremble in the slightest breeze.[3] They are also 'stoloniferous', which means they send out runners ('stolons') underground from the ends of their roots, from which new trees grow. We might say they grow babies on the ends of their toes. If you look at an aspen forest, it looks like lots of separate trees. But if you could see underground, where the roots are all connected up, you might decide the trees are just the top section of one vast individual, like the top of a piece of broccoli where the stem is buried in the soil (Bouchard 2004). When a tree grows from a stolon, its genes are copied from the parent—new trees are clones. So the whole forest might be a single developmental individual (see Figure 1.4). But the trees are functionally autonomous—they have their own life cycles, their own reproductive autonomy. Actually sometimes the trees are functionally interdependent, because they exchange resources via their shared roots (Clarke 2012). Never say never in biology!

[3] Fascinatingly, researchers aren't sure why the leaves tremble so—it might have the function of preventing them from overheating in strong sunlight, or might deter insects. Or it might just be a happy accident!

But the aspen trees are at least *capable* of being fully functionally independent, and are so whenever their roots are separated from those of other trees.

Insert Figure 1.4 here

C1P24 Many plants are so good at cloning that they can grow new copies from random fragments. This is possible because the cells which have the capacity to initiate a new life cycle (we can call them 'germ cells') are scattered throughout the body of the plant. Take rosemary, for example, the common fragrant herb *Salvia rosmarinus*. Just about any bit of a rosemary bush can sprout and grow a new plant if you stick it in some soil and water it. We end up with three alternative ways of dividing rosemary bushes into organisms. We could view each growing tip or 'module' as an organism, since each one is able to start a new life cycle. Or we could decide that the organism is the collection of growing tips that are all stuck together, that is, a single bush. Finally, we could take the view that a rosemary organism includes all the stuff that has a single genome, even if it is distributed across different bushes. On this last view, we would take new rosemary plants to be born only when sexual fertilisation occurs. But none of these choices will avoid the tension between the developmental and functional components of the folk view. That is, it isn't possible, in these cases, to satisfy both components at once.

C1P25 Clonality isn't limited to plants, of course. In microbes, such as bacteria and viruses, clonal reproduction is the only option. Clonality is very common in insects. Aphids— the tiny green or black flies that suck the sap out of your tomato plants—have a two-step reproductive strategy in which they clone like crazy over the summer months, producing huge swarms of genetically identical insects by virgin birth ('parthenogenesis') and then switch to sex in the autumn. Quite a few vertebrates clone themselves too—including some fish, sharks, lizards, and birds. Parthenogenesis is not known to occur naturally in mammals, although of course genetic copies are produced every time identical twins or other multiples are born. Identical or 'monozygotic' twinning takes place when the zygote splits into two and then develops as two separate embryos. Monozygotic twins are another case in which the functional and developmental components of the folk view pull in different directions, in so far as monozygotic twins develop from a single zygote, which splits into two independent parts. We generally treat such people as individual organisms, regardless, which implies that we favour functional over developmental considerations, at least in that context.

C1P26 Fissioning starfish, clones, and twins are all cases where we get puzzled by the fact that some stuff with matching DNA is scattered, rather than being fused into a single functional unit like we expect it to be. We also feel challenged, on the other hand, by cases in which multiple developmental or genetic units seem bundled up together into a single functional unit.

C1P27 This is most dramatic in examples where the functional unit includes parts from totally different species. This occurs in any symbiosis—a relationship in which different lineages are mutually beneficial to one another.[4] It is most obvious in cases of *endo*symbiosis—where one partner actually lives *inside* the other. Lichen are one of the best-known examples. Lichens were thought for many years to be plants, but are actually fungi that take on a specific morphology as a consequence of algae or cyanobacteria living inside their filaments. The fungal partner relies on energy from the photosynthetic activity of its partner, while the algae or cyanobacteria benefit from the protection of the fungal encasement. Both partners are thereby able to thrive in places where they would otherwise not survive. So together they make up a single functional unit, but it is comprised of cell lineages from completely different taxa.

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[4] Although biologists define symbiosis more strictly as cases in which two different lineages have been selected for their mutual benefits. This is stricter because it means the mutual benefit must have been going on for a long time—it is not only about proximate effects, i.e. what is happening *right now* (West, Griffin, and Gardner 2007).

C1P28 Another striking example is the lurid green sea slug—*Elysia chlorotica*— which is able to photosynthesize, an ability not usually possessed by animals (see Figure 1.5). It turns out that *Elysia* have acquired the trick by eating algae. Instead of digesting the entire algae, the slug steals its chloroplasts and houses them within its skin, as its own personal source of solar power. The stolen chloroplasts can be so efficient at producing energy from sunlight that these slugs can live up to nine months without eating (Prager 2011).

Insert Figure 1.5 here

C1P29 Symbiosis was once thought to be exceptional, but it is now broadly recognised as ubiquitous in nature. When a symbiotic association is very old and tight it can become hard to distinguish the separate parts at all. For example, symbionts are often selected to lose genes for traits that are made redundant by the partner (Ochman and Moran 2001). They can lose so many functions that they appear more like appendages than organisms, because they haven’t got all the parts that we think of as minimally necessary. Some intestinal worms, for example, have completely lost their own internal digestive system because they don’t need it— the host takes care of digestion for them (Hayunga 1991).

C1P30 Some symbiotic relationships are so close that without complex scientific work there is no reason to think that multiple lineages are present. My favourite example was uncovered by Lynne Margulis, starting in the 1960s (Sagan 1967). As we’ll see later, it is commonplace to assume that if anything is a clear case of a biological individual, it’s a human. But Margulis found out that some of our parts are symbiotes. Way back before our ancestors were multicellular, an ancestor cell (which was probably an archaeon) engulfed a different kind of cell (a bacterium). Instead of digesting it, the bacterium became a fixed endo-symbiont. Each of us has thousands of these— called mitochondria—inside most of our cells. They live there, and divide to produce offspring there. Our cells depend upon them, because they produce energy by metabolising what we eat. Every time one of our cells divides, a few mitochondria are packed into each daughter cell.

C1P31 All eukaryotes—that's all plants, animals, fungi, and some protists[5]— were formed by this ancient merger. It is interesting to think about how the origin of eukaryotes contradicts the folk view. Modern school kids are taught that all the developmental products of a zygote—all the cells in a human body, say— have the same DNA, because they are all copied from one single genetic template.[6] But one of the reasons we're now confident that mitochondria were a separate lineage is that they still have some of their own DNA. You might have heard of it—mitochondrial DNA. It is useful to phylogeneticists

[5] Protists are unicellular organisms that have complex cells with nuclei.

[6] This is a fairly modern view, because until around 1915 most scientists followed August Weismann in assuming that during development different cells received different portions of the genome, to allow them to do different tasks (Radick 2023, 243). The assumption now is that cells become different during development because different portions of the genome are expressed, while others are silenced.

because it is passed down only from mothers, not fathers, which makes it handy for measuring relatedness across populations. Technically, mitochondrial DNA is classified as partof the human genome. But I think lots of us, when thinking about the human genome, tend to think of it as only the DNA that is organised into twenty-three chromosome pairs and bundled up inside a cell nucleus (see Figure 1.6). Mitochondrial DNA is separate to this; it sits outside the cell nucleus, inside the mitochondria. And it is really qualitatively different, because mitochondria had a different ancestor—they came from a different Domain of Life—from the cell that engulfed them.[7] So the genetic ‘template’ is itself already a hybrid, in the case of eukaryotes, because mitochondrial DNA gets copied when a new eukaryotic organism develops, but in a totally separate process from mitosis,

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[7] Domains are the most general categories in taxonomy. Maureen O’Malley provides a wonderful overview of the way that mitochondria have forced us to rearrange our most basic taxonomies—and even threatened the very coherence of arranging life into distinct Domains (O’Malley 2014).

in which chromosomal DNA is copied (Pangou and Sumara 2021).

Insert Figure 1.6 here

C1P32 Sometimes the species in a symbiotic relationship are associated in a much looser way, in the sense that the relationship is only facultative for one or both partners (i.e. they can manage without it), or the benefit received is only marginal. For example, most plants engage in metabolic interaction with a variety of mycorrhizal fungi. The fungi live inside specially adapted nodules on the plant roots and provide the plant with scarce nutrients such as phosphorus in exchange for sugar. The relationship is loose in the sense that the partners aren't committed to each other. The plant can expel its fungal partners and admit new ones if they don't perform satisfactorily—unlike a person, who is stuck with one population of mitochondria for life. Likewise, the fungi can live outside of root nodules and switch between plants to find a better deal. The plants and fungi can be usefully compared to traders in a marketplace (Kiers et al. 2011). The traders can make a living through the market, but it is not like their lives depend on any single trading partner.

C1P33 The folk organism concept is also challenged by cases where a single functional unit has parts that are genetically heterogeneous, even if they aren't from different species. This occurs in chimeras—organisms in which cellular products of multiple zygotes develop together into a single functional unit (see Figure 1.9). Wied's marmosets are beautiful New World monkeys with long ear tufts (see Figure 1.7). They are unusual because they are always genetic chimeras—their bodies are composed of two cell lineages, derived from different zygotes. All marmosets gestate alongside a non-identical twin, but in Wied's marmosets, the two developing twins exchange cells early in their gestation. This means that every monkey has two genomes, either of which can be passed on to its young. When males ejaculate, some of their sperm contains their brother's DNA, because their gonads are chimeric—they contain two, genetically distinct, cell lineages (Ross, French, and Ortí

2007).[8] Experts have proposed that this unusual pattern of development might have evolved to promote social cooperation.

Insert Figure 1.7 here

Insert Figure 1.8 here

Insert Figure 1. 9 here

C1P34 A second sort of genetic heterogeneity is mosaicism, which occurs when the cells of a living thing acquire different genes by divergent mutation from a common zygote. Mosaicism is particularly noticeable in variegated plant leaves, in which part

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[8] Of course, in some sense it is *generally* true that a man's sperm contains his brother's DNA, because brothers inherit their DNA from the same parents, so it would be fantastically unlikely that they share no genes in common. It can help to think of each parent's DNA as like a deck of cards— each offspring gets half the cards in the deck, but the deck is shuffled each time. In the case of Wied's marmosets, however, a male's ejaculate contains some sperm that have the brother's exact genome—not just some of the same genes.

of each leaf carries a mutation that disrupts chlorophyll production (see Figure 1.8). But, in fact, all macroscopic organisms are mosaic—it is just inevitable, if a large number of cell divisions takes place during the organism's lifetime, that some of those division events will introduce mutation.[9] So the folk view is naïve about flamingos. We assume that their cells all carry exactly the same DNA, but that isn't realistic. Flamingos, like all macroscopic organisms, will be riddled with mutations that leave them falling short of genetic homogeneity.

C1P35 Another important class of problem cases concerns organisms that biologists call 'eusocial'. This means that several relatives live in a group where only some reproduce, while the others pitch in to raise the young. Here there is functional integration among units that don't come from different species, and are in fact closely related, but are still separate

[9] Godfrey-Smith calculated that we should expect human cells to acquire an average of about 1.8 point mutations every time they divide (Godfrey-Smith 2009a).

developmental individuals. Social insects—such as termites, honeybees, leafcutter ants, and paper wasps—exemplify this. In developmental terms, each termite develops from a unique zygote, hatches from its own egg, and has its own genome, albeit one that is closely related to the others in its nest. In some ways, termites are functional units too—they walk around independently of one another, have their own physiological systems of injury repair and digestion. Each termite has its own life cycle—it hatches, grows bigger, finally ages, and dies. But in other ways, termites function as mere parts of the whole colony. The separate insects can't reproduce on their own—most insects are sterile, and devote themselves to serving the others. Only the queen(s) and the small number of males can make babies. Each termite carries out different tasks that are collectively needed for the colony to survive.

C1P36 The extent of the selflessness of workers in eusocial insects can be shocking. Some 'exploding' ants are able to self-detonate in order to protect their nest from attackers (see Figure 1.10). They literally squeeze muscles in their abdomen, causing their own bodies to rupture, spraying toxic glue from a special gland all over their enemy. It’s lethal for both parties. Some people think that it makes sense to think of these insects as analogous to white blood cells, so that they are mere parts whose function is to defend the boundaries of the higher-level whole. On that view, the whole colony or nest is the organism, and the separate insects are like cells in that whole. They just aren’t all physically stuck together the way that cells in a multicellular usually are.

Insert Figure 1.10 here

C1P37 Extreme division of labour isn’t restricted to insects. The naked mole rat is a weird-looking hairless rat with enormous teeth. Their social organisation is parallel to that of social insects, because each colony has a dominant queen who does all the childbearing and suppresses the fertility of the other females. The other female rats are effectively sterile workers who support her parenting success. But these are mammals—the queen gestates and suckles her pups like all mammals do.

C1P38 I have argued that some cases puzzle us because the two halves of the folk concept pull us in different directions—functional considerations take us one way, developmental/genetic considerations take us another. We are not sure which to prioritise. Other times it is unclear even how to apply these considerations. Some biological cases are just so different from the human or ‘charismatic vertebrate’ template from which we model our ideas about organismality that we just cannot intuit how to categorise them at all. A pet example in this literature is the slime mould, *Dictyostelium discoiideum* in particular, also known as ‘Dicty’ to its friends (Bonner and Savage 1947; Nanjundiah and Sathe 2011). In respect of this creature, neither developmental nor functional considerations are decisive. Dicty spend most of their time in the form of single-celled amoebae, so small they are invisible to the naked eye. They hang around in dirt, looking for bacteria to eat and reproducing clonally. But in times of famine, they send out chemical signals which attract them to one another, and they coalesce. They aggregate into motile slug-like masses, which are composed of thousands of cells. The slug responds to light and crawls to the surface of leaf litter, where it starts to differentiate—the cells assume different morphologies. Some of them form a rigid stalk, which others climb up to form a reproductive spore at the top. The spores then catch a breeze and sail off to, hopefully, better food sources before hatching into baby amoebae. But all the unlucky cells in the stalk die without reproducing (see Figure 1.11).

C1P39 The slug has many of the properties of an organism. It crawls along in a directed and integrated manner, seeking light. It is spatially localised with edges, and its parts achieve an elegant division of labour. On the other hand, most of the time Dicty exists as scattered, single-celled amoebae living independent existences and reproducing asexually. Only if they start to starve do they start sending out chemical signals to others, to call to them to aggregate and form a slug. And they form a slug with any cells that happen to be around—they don't have to be related, let alone genetically identical (Sathe et al. 2010). What do your intuitions tell you about the individuality of a creature which usually does its thing on its own, but occasionally pulls off an astonishing and life-saving act of complex coordination with others of its kind; which instantiates novel sensory and motile abilities; which demands the ultimate sacrifice from around a third of the participants? There are clear arguments for and against viewing the slug as an individual. We could see the single-celled clonal stage as analogous to the growth of a multicellular organism, with the only difference being that the cells are not stuck together in the early stages of development. Conversely, we could view the slug as a social strategy undertaken by individuals in extreme circumstances— the kind of feat that army generals could only dream of. My own intuitions are eerily silent.

Insert Figure 1.11 here

C1P40 For another example, take *Physalia physalis*, the Portuguese man o'war. It looks like a large jellyfish and is aptly named for a warship, thanks to its large air-filled float and deadly stinging tentacles (See Figure 1.12). The man o'war is sometimes called colonial, even though its parts are well integrated and genetically homogeneous (or at least as homogeneous as mid-sized organisms ever are). The reason is that its developmental trajectory is weird. A single zygotic embryo buds into four parts that develop separate morphologies—one becomes the float, one the sting, one the digestive system, and another the reproducer. We might think that this is true in most metazoans—in humans for example, the early embryo divides into mesoderm, ectoderm, and endoderm, which specialise in different ways. What confuses matters in *Physalia physalis* is that each of the four zooids is homologous to the polyp stage of a free-living jellyfish (Munro et al. 2019). This makes it tempting to infer that *Physalia* evolved by incomplete separation, and subsequent specialisation, of jellyfish quadruplets.

Insert Figure 1.12 here

C1P41 A further way in which a case can be challenging is if it's not clear that they have *enough* of some relevant property. For example, volvocine algae are a clade of microscopic plants that float in the light column of fresh water. Some of the species in the group—such as *Chlamydomonas reinhardtii*— are clearly single-celled. One of its sister species— *Volvox carteri*— looks pretty multicellular. It presents as a spherical ball of around two thousand cells, with a complex developmental programme which positions little whip-like tails around the outside of the ball. The tails beat in a coordinated fashion to give the ball swimming motility in the water. Each ball also contains around sixteen cells that have no tail at all, and are specialised for reproduction, while the others don't reproduce (Michod and Herron 2006; Michod 2007; M. D. Herron 2016). Many people find *Volvox carteri* compelling as simple examples of multicellular organisms. The trouble is, even if we were to agree that *Volvox carteri* be classified differently from *Chlamydomonas reinhardtii*, there remain a whole range of other, sister species in the volvocine clade that fall somewhere between the two extremes. There is more than one cell in each clump, but less complexity and specialisation than in *Volvox carteri*. It seems impossible to resist the conclusion that the other species constitute halfway-houses in some sense. They seem a bit multicellular and a bit unicellular. But this is puzzling in itself.

Suppose we fix our attention on a cluster from one of the intermediate cases. What are we looking at? Is it an organism? Is it only an organism *to some extent*? Does that imply that it is an organism that exists only to some extent?! That starts to sound paradoxical, because we don't usually think of existence as something an object can have more or less of. You either exist or you don't. And this sort of ambiguous or gradient individuality seems to be ubiquitous, because the properties we associate with individuality are themselves properties that an object can have more or less of. Does my immediate atomic family qualify as a single developmental unit? Do ecosystems have sufficient functional integration to qualify as units of function in their own right? If we accept even very low levels of integration or causally distant forms of interaction as sufficient to treat something as a unit of function, then even James Lovelock's Gaia— the whole living ecosystem of Earth— becomes a candidate organism (Lovelock and Margulis 2007). But that might seem to be letting things go too far. The organism concept would have little discriminatory value if it applied to just about everything. But where to draw the line?

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Insert Figure 1.13 here

C1P42 For each of the examples we met above, there is a sort of ‘gestalt-shift’ available, like when we observe a Necker cube (see Figure 1.13). We make an assumption about which unit is the organism, but we can flip that assumption by moving to a larger or smaller focal scale. First we see the exploding ant as an individual, bravely sacrificing herself to save her nest mates. Then we flip and see the ant as just one element of a larger whole—the colony, which has multiple specially adapted parts. First we see the aspen tree as an organism, stretching from its roots to its shoots, bounded by bark. Then we flip and see the whole aspen stand as one huge and ancient interconnected whole. We might even flip again and view an aspen tree as a colony of aspen bud individuals perched atop a common trunk.

C1P43 One example which I’ll keep coming back to is coral, because they illuminate multiple facets of the organism puzzle at once. One perspective sees corals as polyps: small marine invertebrates which often spend the first part of their life floating around in the ocean, before settling on a rock with their tentacles up. Each one is equipped with its own spring-loaded harpoon with which to ensnare passing food. Each polyp lives only for a couple of years. Settled polyps produce copies of themselves clonally—either budding or splitting to produce identical copies which occupy a neighbouring spot on the rock.

C1P44 Now let’s shift by emphasising the fact that coral multiplication produces colonies which can be many thousands of polyps strong and, together with the accumulated calcium carbonate exoskeletons that the polyps secrete, as large as mountains. The polyps in a colony are clones—genetic copies of one another. There are nervous connections between the neighbouring polyps, so that if one polyp is disturbed, a wave of retracting tentacles passes across the colony as the signal is passed between neighbours. We can treat an entire coral colony as one huge organism, with a lifespan of hundreds of years and polyp parts which continually replace themselves. These organisms only reproduce by spawning to make new sexually fertilised floating babies which settle new areas.

C1P45 Now for a third perspective, corals live in symbiosis with a kind of microscopic algae, called *Symbiodinium*. The tiny algal cells live inside the tissues of the coral and photosynthesis e to provide the coral with carbon. In return the guest workers get comfortable housing and a supply of carbon dioxide and other nutrients. The coral and *Symbiodinium* lineages have been working together like this for millions of years. Coral symbiosis opens up a further dimension of the coral individuality Necker cube: treat the corals as including only parts that have coral DNA? Or treat the *Symbiodinium* as parts of the coral too? Defenders of the second view argue that we should treat the coral and all its hundreds of symbionts as parts of a single organism,[10] a fusion of plant and animal parts.

C1P46 Coral are as disorientating as they are beautiful. But what is the status of these different perspectives? Is there some ranking among them, so that one is correct, or better than the alternatives in some way? If so, which one, and how could we know? What are the relevant criteria for even attempting such an evaluation? What are the questions we should ask, the data that we should gather, in order to arbitrate the different perspectives so that we can work out what coral are?

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[10] One term that has become popular for such symbiotic organisms is a 'holobiont', adapted from Margulis's label which was originally intended to describe very tight associations such as between eukaryotic cells and their resident mitochondria (Margulis and Sagan 2000; O'Malley 2017a). See (Clarke 2020) for my argument that the usefulness of this term is more limited than some think.

C1P47 Many scholars have noted that our intuitions about biological individuality seem to converge in the context of what are called *paradigm* organisms. Only, as Jack Wilson put it, ‘when we try to extend folk notions of individuality beyond folksy examples, things get strange’ (J. Wilson 1999, 1). But what are paradigm organisms? Many people converge on the idea that if anything at all should qualify as an individual organism, then people should. For Aristotle horses were high on the list. I have suggested that flamingos belong there too. Whatever we mean by ‘organism’, it is well exemplified in these cases. But how do paradigm organisms come to gain such status? Stephen Jay Gould argued that the designation of some creatures as paradigmatically organismal is a feature of anthropocentric bias. He suggested that we give the status to ‘furred “n” feathered’ things that we deem relevantly similar to ourselves, or relatively familiar (Gould 1992). This was part of a larger worry about evolutionary biology tending to prioritise such creatures, at the expense of our understanding of less familiar lineages, such as microbes, deep sea creatures, fungi, and so on.

C1P48 Certainly, it is plausible that we have our own biases**.** But I don't want to give the impression that individuality puzzles only occur in exotic contexts—the kind you only meet on holiday, or through a microscope. We don't need to travel at all far from home to be confronted with cases that leave our intuitions challenged, or absent altogether. Just think about grass—your everyday, side-of-the-kerb green stuff. We often use a mass noun—you point to *some* grass, not *a* grass or *the* grasses, unless you're pointing to species exemplars in a museum, perhaps. You can buy turf by the metre. Or apply a count noun and talk about *the* lawn. But on further reflection, grass is plants, right? Loads of little plants. How many? Here is a problem. Grass seeds grow into plants that we can call 'ramets'—a single functional unit which includes roots and stems. But ramets reproduce clonally—they extend their roots underground and then grow new ramets up out of the roots. So it is possible for grass to grow clonally to cover an entire lawn—but all from a single seed. Furthermore, commercially bought grass seed is often so inbred that the seeds in a packet are more or less genetically identical to one another. Plus each ramet might be dependent on fungi in the soil for all the nutrients it needs, as well as on the mitochondria and chloroplasts living inside its cells for energy. In short, looking at a lawn won’t tell you how many plants there are. You need to decide first what you mean—whether it matters how many genomes there are, whether a new grass ramet is an offspring of its parent or just a new arm, and so on.

C1P49 Now look to your belly. See that button? That used to be a portal, connecting you to your mother, keeping you alive. When did you separate from her? Was it when the portal was closed, that is, at birth? Was it when you finally became able to feed yourself (I’m told that this is normally around eighteen years later, though this may be over optimistic)? Or was it much earlier—were you always separate from her, as soon as you gained your own genome? It is remarkable that even though every single one of us has first-hand experience with conception and pregnancy, philosophers are more likely to think about personal identity as being challenged by teleportation or brain transplants. It falls mostly to those with *adult* experience of pregnancy to try to reconcile our conception of the human person as discrete and well bounded with the messy, drawn-out realities of pregnancy and parenting (de la Rosa 2010; Kingma 2019). For example, pregnancy gives rise to a small but persistent 'microchimerism' (Gammill and Nelson 2010). That is, a small number of the developing foetus' cells cross the placenta into the mother's bloodstream, where they have been picked up by DNA tests as many as thirty years later. In this way, women carry tiny fragments of all of their children, born or unborn, including genes that came from the father.[11] Macro chimerism occurs in humans too. Although Wied's marmosets are unusual in being chimeric as standard, chimerism happens occasionally in all mammals, because whenever a multiple pregnancy occurs, there is a chance that one of the twins will stop developing and will instead become absorbed within its

[11] See (Madan 2020; Wu 2024) for more about the fascinating consequences of this surprising phenomena.

sibling. Sometimes chimeric cell lineages are visible in humans as patterns of different skin pigmentation or eye colour.

C1P50 If you could see *inside* your belly you might notice your intestines are swarming with microbes—bacteria especially. Some of them are on their way to being evicted, but many have been welcomed and even courted as long-term and good-mannered house guests. Some of them serve important functions in helping us digest our food and maintain robust immune functions. They’ve even been implicated in neurological health (Cryan et al. 2020). Is the language of house guests appropriate here or—gestalt shift—should we conceive them as our true parts? Could even adult male human beings, the most paradigmatic of all organisms, be more appropriately conceived as coalitions (Gilbert, Sapp, and Tauber 2012)?

C1P51 Bewildering though this romp through nature may have been, it gives a mere glimpse of the extent and diversity of real-life cases that are puzzling in respect of their individuality. I have not attempted to give an exhaustive description of ‘problem cases’, but only to illustrate some different ways in which cases can be problematic. Table 1.1 gives a slightly more systematic impression.

Insert Table 1.1 here

C1T1 Table 1.1

Categorises some different ways in which our ideas about biological individuals can be challenged.

Category	Sub-categories	Sub- sub-categories	Exemplar species
Functional unit incorporates multiple genetic or developmental units	Functional unit incorporates multiple species	Symbiosis	Mitochondria-eukaryote; *Elysia chloratica*; aphid-*Buchnera*; plant-mycorrhizae; human-gut bacteria; plant-rhizobia; lichen; coral-*Symbiodinium*
	Functional unit incorporates multiple developmental units	Eusociality	*Dictyostelium* slug; eusocial insects: all termites, many bees, including honey bees, most ants, and some wasps such as *Polistes versicolor*;

			naked mole rat
	Functional unit incorporates genetically heterogeneous parts	Chimera	Wied's marmosets; post-partum women; grafted grape vines; some people
		Mosaic	Cancer patients; variegated plants
	Partial integration of separate genetic or developmental units		Human tribes; ecosystems; Gaia; mother-foetus; fungi; squid-vibrio
Single genetic unit but ambiguous as a functional or developmental unit			Volvocine algae; filamentous cyanobacteria; Portuguese man o'war; sponge
Genetic unit is split into separate functional units	Clonal	Parthenogenesis	Aphids; whiptail lizard; sharks; bony fish; stick insects; California condors
		Somatic embryogenesis	Bracken fern; grass; quaking aspen; strawberry plants; dandelions

		Fission	Bacteria; coral polyps; starfish; freshwater planaria
		Scaffolded replication	Viruses
	Multiple birth	Monozygotic twins/triplets	Mary-Kate and Ashley Olsen[a]
		In vitro cell cultures	HeLa cell cultures[b]
Other		Alternating generations	Algae, mosses, ferns
		Multinucleated cells	Codium seaweed
Paradigms			Man; horse; oak tree; flamingo; cactus finch

[a] Only if they are monozygotic twins, which I am unable to confirm. Joel and Benji Madden are less famous, but certainly identical.

[b] I'll talk about these in Chapter 7.

C1P52 Here ends the tour of the biological store cupboard, for now, although we'll meet more enigmatic critters later. I have tried to show that in these cases we often get conflicting intuitions, which pull us towards different spins of the Necker c ube. In some cases we get no intuitions at all, our folk concept just draws a complete blank. Maybe you have different intuitions from me, but the point is that there is room for reasonable disagreement.

C1P53 Puzzles are clearly not in short supply here. But what about solutions? In subsequent chapters, I will provide detailed analysis of some ways that scientists and philosophers have tried to clear up the puzzles. After all, the folk aren't experts, so it shouldn't be surprising if they get confused about biology. It makes sense to move past intuitions and consult the experts to help us to choose between the components of the folk view. What we'll see is that there is no single way that biologists understand biological individuality. In cutting-edge science a multiplicity of different definitions of the biological individual are in play. Scientists disagree and get into arguments among themselves about which definition to apply, and how best to understand the nature of organismality. What's significant about the different views is that they pull in different directions—they generate different verdicts, different twists of the Necker cube, regarding some or all of the ‘problem cases’ surveyed previously. That is, a particular concrete living thing will qualify as a biological individual according to some definitions, but not others. They disagree about which objects are included in the class. Some definitions make the class of biological individuals larger than others. This is crucial because it means we cannot simply settle disagreements about individuality by aggregating the different accounts. Whether some living stuff qualifies as an organism or not depends upon which definition of organism we apply (Clarke 2010). And rather than helping to adjudicate clashes between the functional and developmental intuitions, science adds more options to the table.

C1P54 For example, and to preview arguments which will be developed at greater length in Chapters 3 and 5, consider a human and the bacteria which inhabit its gut. Are they parts of a single organism? If an organism is defined to include only cells that descend from a common ancestral bottleneck cell, as developmental views insist, then all the cells descended from the human zygote form one organism, and every single bacterium is a separate organism. But if we apply Thomas Pradeu's immunological definition, which insists that an organism includes any cells that interact with the immune system and aren't rejected by it, then at least some of the bacteria are true parts, because the human immune system accepts them (Pradeu 2010). If we shift to an evolutionary view instead, we might classify the bacteria as separate organisms on the grounds that, unlike mitochondria, they come and go throughout the human's lifetime. So the status of human gut bacteria as biological individuals or not depends on which definition we apply.

C1P55 As indicated, these definitions often compete within particular contexts—it's not, for example, that one definition is only meant to apply to plants, and another only to bacteria. This wouldn't be too surprising, given how different living things can be across different lineages. But the status quo is less neat. In respect of eusocial insects, for example, disagreement about the appropriate criterion to apply in determining individuality comes from *inside* the relevant research area. It is not the case that entomologists all apply one definition, while people who study plants use a different definition. Rather, entomologists (insect experts) argue among themselves about whether ants are individuals or not, and on what grounds (Helanterä 2016; Smith‑Ferguson and Beekman 2019).

C1P56 In so far as that is the case, we cannot solve the problem of biological individuality by simply asking science. For one thing, ‘following the science’ doesn’t give us any way of arbitrating disputes *between* scientists.

C1S3 A possibility: maybe it doesn’t really matter!

C1P57 These conceptual acrobatics can be fun, if you like that sort of thing. But are they merely games? Some have speculated that worrying about how to define a living individual is one of those pastimes taken up only by people in the ‘philosophical vacuum’.[12] I think there are two different kinds of motivation for this view. One might be of the opinion that explicit definitions are the kind of thing only cared for by professional

[12] A place full of silent screaming, presumably.

philosophers, and that professional biologists, while much less inclined to spend time arguing about what words mean, are perfectly competent where it matters, that is, in actually applying distinctions and generalisations in their lab work or in the field. Karen Kovaka has argued something like this—that only philosophers have a ‘problem’ of biological individuality, because biologists themselves are quietly effective in applying individuality concepts, and in choosing the concept most relevant to their purposes, without necessarily bothering to formulate them explicitly (Kovaka 2015). To me there is a large amount of faith involved in this view. It is entirely possible that scientists achieve various kinds of success while operating with disjunctive or even incoherent concepts. Proper interrogation of such concepts could enable them to achieve even more success! And in any case, it certainly isn’t the case that all biologists feel their organism concepts (or their biological practices) are adequate, or that biologists never get puzzled by organism concepts and seek philosophical advice.

C1P58 Some other scholars argue that disagreements about biological individuality are best ignored, because nothing turns on them anyway. For Betsy Dyer, the gestalt shifts I have described really are alternative gestalts, which reflect different tastes or preferences in the eyes of the beholder, rather than anything more mind-independent (Dyer 1989). Sofie Wikberg argues that it doesn't matter whether you view something like a stand of aspen trees as an individual or not—that both options are fine, and you should just choose whatever is most convenient (Wikberg 1995). Jack Wilson, argues, on the other hand, that biological individuality should be eliminated as a concept, because it is grievously incoherent but, fortunately, inconsequential (J. A. Wilson 2000). Common to all three is the view that the concept of the biological individual does not actually do any work in biology—that it is arbitrary, trivial, inert.

C1P59 The best antidote to this way of thinking is to explore the work done. I'll do this in more detail in Chapters 3 onwards, but here are some general reasons to think that there are biological contexts in which an organism concept does work:

C1P60 - For physicians and veterinarians who have to deal with cases of conjoined twinning, individuality is not a game or a matter of preference (Boyle 2020). Rather, they rely on a body of empirical experience combined with bioethical considerations to answer questions about which parts an individual can lack while still remaining viable. Conjoined twins 'force us to reflect on the conditions for ownership of organs' (Savulescu and Persson 2015) and to decide whether separations that lead to one or both twins dying constitute homicide or simply a failed attempt to fix a birth defect (Aprodu, Gavrilovici, and Hanganu 2009).

C1P61 - Bioethicists recently had to debate the meaning of 'reproduction' in order to decide whether a person who donates mitochondria to a child (in contexts where the child's life is in danger because their own mitochondria don't function properly) should be considered by law as a third parent to that child (Piotrowska 2019).

C1P62 - Individuality comes up for physiologists in the context of cancer science, where some view it as profitable to treat cancer as a conflict between levels of selection— one acting on whole organisms, the other on separate cell lineages within the body (Lean and Plutynski 2016).

C1P63 - For transplant medicine and immunology, it is of foremost importance that specialists understand how phenomena as diverse as twinning, gut bacteria, microchimerism, and relatedness can impact upon a body's likelihood of rejecting something (Pradeu 2010).

C1P64 - For botanists seeking to propagate favourite plants there is a body of accumulated wisdom relating which species can be grown from which fragment, and how. Some species will only grow from sexually fertilised seed, some can self-fertilise their seed, some can grow from shoots, some only from tubers. Some, such as many grapevines, grow best when planted into the body of a second plant![13]

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[13] Wine producers in Europe standardly graft their chosen variety of plant onto the root stock of a different variety, which allows

C1P65 - Conservationists need an operational organism concept so that they can count how many representatives there are of a given species in an area, as part of their measurement of biodiversity (Purvis and Hector 2000). When a species is endangered, it is important that conservationists keep track of the size of their population, to work out whether it is viable or not, as well as the amount of variation in the population, and the mode of reproduction.

C1P66 - Experimental evolutionists need a serviceable organism concept by which to arbitrate whether a team has succeeded in selecting for evolution of a new kind of organismality, such as multicellularity (Rainey and Kerr 2010; Ratcliff et al. 2012a; Hammerschmidt et al. 2014;

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them to evade diseases which would otherwise ravage their chosen variety. This is a totally different phenomenon from the growth of mistletoe upon a host tree. Mistletoe is a parasite, and succeeds by extracting resources from the host, which the host attempts to resist. Grape grafts do not face resistance from the root stock plant, if all goes well (Tedesco et al. 2022).

Segrè et al. 2023). Will Ratcliff's lab are running a long-term project attempting to evolve de novo multicellularity in vitro. They have already succeeded in selecting a unicellular yeast to evolve multicellular 'snowflake' clusters, but an ongoing challenge for them consists in convincing everyone that there are clear enough success criteria for their projects. In other words, opinion is divided as to the circumstances under which we can claim that de novo multicellularity has in fact evolved.[14]

C1P67 - Ecologists need a consensus organism concept to arbitrate claims about what is the oldest or largest living organism. In 1992, *Armillaria bulbosa* was declared a 'Champion thallus', a.k.a. the largest organism alive (M. L. Smith, Bruhn, and Anderson 1992) only for other mycologists to query the claim on definitional grounds (Brasier 1992). Whether or not the fungus counts as humungous depends,

[14] See the end of Chapter 4 for my analysis of this case.

claimed Clive Brasier, on whether you require the mycelia in question (sticky threads within which fungal nuclei flow) to form an organisational whole as well as a genetic clone. In general, the debate about biological individuality in fungi is still a work in progress (Molter 2017).

C1P68 - Organismality also comes up in life history theory, an area of evolutionary biology in which explanations of traits depend on understanding how selection acts differently on organisms at different parts of their life cycle. It often depends upon making comparisons across species, for example of the larval phase. It is thus presupposed that the traits in question attach to juvenile organisms, rather than, say, developing organs in an organism, or stages in the development of a colony (Pepper and Herron 2008).

C1P69 - Palaeontologists and phylogeneticists need an organism concept to make sense of claims about the evolution of new kinds of organismality, such as how many times multicellularity has evolved (Ruiz-Trillo and Nedelcu 2015).

C1P70 - Switching speciality to metaphysics for a moment, some personal identity theorists rely on organismality as the foundation of personal identity, and on biological concepts of the organism to answer questions about our persistence and modal status (van Inwagen 1990, 84; Olson 1997, 136).

C1P71 - And, last but not least, in evolutionary biology scientists lean on the concept of the organism to bear fitness, a phenotype and a genotype; to occupy niches; to compose species; and to compete against conspecifics in the great struggle of life. They count organisms to keep track of the differential success of different traits and/or genes in that struggle.

C1P72 A list of this kind is highly unlikely to persuade everyone. Some biologists simply hold no truck with this sort of thing. In physics, this demeanour has been characterised with the slogan ‘Shut up and calculate!' to communicate the conviction that wordplay is a waste of time. According to this view, scientists' proper work is in gathering data, performing experiments, crunching numbers, and *not* in what they'd call empty theorising. They are only rarely aware that this attitude is a legacy of Positivism and Karl Popper. It is more often a symptom of an implicit culture in science that celebrates scepticism, and positions 'facts' and numbers as more secure, more trustworthy, than theories or concepts. In the next chapter, I will explain why such an attitude is naïve. There I will argue that we cannot ignore concepts or avoid worrying about the meanings of words, in favour of doing experiments, because empirical facts underdetermine our concepts. Likewise, we cannot replace natural language with data, because unless our terms are clearly defined it is not clear what our numbers are about.

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C1P73 Both historical and contemporary science are replete with examples of non-philosophers worrying about how to individuate living things, of biologists arguing about it in print, and running into difficulties because of the challenges of carrying out individuation—actually counting the things—in practice. But before anyone can say what an organism is, or evaluate an attempt to say what an organism is, we need to have an idea about what kind of answer we're looking for. Shall I answer by pointing at one? Or should I start by surveying people's ideas? Do we want a precise answer, or would we trade, say, a certain amount of ambiguity for broad applicability? Do we want a simple answer; an answer that serves our political and emancipatory goals; an answer that fits well with intuitions; or an answer that respects the Latin root of a word? What do we *mean* by 'What is an organism?'

C1P74 In the following chapter, I'll evaluate some proposals about ways to arbitrate among different 'desiderata' of a concept, but for now let's just set out some of the variety. Here are some different, although overlapping, attributes that we might value in a concept:

C1P75 - Is it clear? Easy to understand? Is it obvious what it applies to? Does it draw sharp distinctions between things, or is it legitimate that it leaves zones of ambiguity? Is it free of logical inconsistency or circularity? Is it fully spelled out? Are its consequences precise? Is it specific about details? Is it richly descriptive? Does it simplify things? Does it have to be readily intelligible by non-experts or is it okay if only some people can fully understand it?

C1P76 - Is it general? Does it apply to lots of different things/across domains? Does it need to avoid being *too* general? Does it integrate neatly with other concepts? Does it subsume or make sense of other concepts? Does it accommodate intuitions? Or scientific practice? Or etymology?

C1P77 - Is it fruitful? Does it stimulate lots of ideas? Is it testable? Does it have explanatory value? Is it revisable? What would be the pragmatic/social/political consequences of the definition being widely used?

C1P78 - Is it aesthetically pleasing? Is it vivid, memorable? Inspiring? Elegant? Rich in associations? Suggestive? Surprising? Does it have broad appeal? Is it amusing or fun?

C1P79 It is all very well to decry a definition for being hopelessly unclear; or for judging the wrong things to be organisms; or for being at odds with what scientists say. But claims such as these only qualify as motivating if there is some good reason for thinking that the context in question requires a concept that is clear; for being confident that some things mustn't qualify as organisms; for being certain that scientists never say the wrong thing, and so on.

C1P80 A related and important question is 'Is there a correct number of organism concepts?' Is it fine for us to maintain a multiplicity of different ways of understanding and defining it, or should we be arbitrating at least some definitions as rivals? Many authors think that a plurality of concepts is no cause for alarm. They argue that a diversity of definitions is a faithful reflection of the heterogeneity that is endemic to the evolved world. In other domains where there is a multiplicity of scientific definitions in play (gene and species concepts are conspicuous examples), philosophers have tended to divide into two groups. ‘Monists’ assume that multiplicity is not desirable, and that in the ideal scenario a single definition is established as the winner, or different definitions are clarified as belonging to different domains or question sets. They’ll point out that scientists are liable to miscommunicate, if they use different understandings of their shared terms. ‘Polysemy’—when a single word has multiple meanings—can give rise to cross-talk. Marc Ereshefsky has argued in the context of species that acceptable scientific concepts are not polysemous—if a concept has multiple meanings then we should disambiguate it by defining the more specific meanings separately, and eliminating the catch-all term (Ereshefsky 1992; 1998). Furthermore, if one of the definitions generates a sort of benefit—for example, supports true predictions—while the others do not, then scientists who seek that benefit really need to use the ‘right’ definition.

C1P81 ‘Pluralists’, on the other hand, think multiplicity is fine, good even. Some recommend interpreting a diversity of scientific definitions as revealing the true metaphysical state of the world, so that there really are multiple ways of being a gene, being a species. Others adopt a more anti-realist understanding of the definitions, so that there aren’t objective matters of fact about what a gene is, what a species is. Of course, pluralism is most plausible in cases where it isn’t clear whether or not one definition has an advantage over the other. Ingo Brigandt has argued, for example, that polysemous concepts can be very valuable in contexts where scientists haven’t yet figured all the details of an object out. What they need then is a flexible, open-texture concept that leaves their options open, not foreclosing any possible routes in their investigation (Brigandt 2003). All I’ll claim at this point is that in order to work out which of pluralism and monism is most appropriate for the case of biological individuality, it is necessary to sort through the details of different definitions to establish whether they have value, what sort of value it is, whether the value of each is independent of the others, and so on.

C1S4 Summary of Chapter 1

C1P82 I have been arguing that when we try to determine what counts as an individual organism, we encounter difficulties. This is true both in the respect of ‘non-paradigm’ cases, which we treat as more unusual than they actually are, and much more everyday or mundane contexts. We don’t know whether to prioritise functional considerations or developmental considerations, or how to choose among more technical criteria developed in particular domains of biological science. Like a starfish, we feel torn. This has the potential to create confusion, error, and cross-talk. Before we can arbitrate the opposing forces, we need to work out what counts as a good reason for going one way, or the other. There are many different ways in which we might conceive of a concept as having value. But before we can decide which properties to treat as defining, there is a meta-level set of questions that have to be settled, about what sort of approach we want to take, which values we want to prioritise, and in general which criteria we will apply in adjudicating what qualifies as a good solution to the problem.

C1P83 By design, this chapter has generated many more questions than answers. Together, these questions make up the problem(s) of biological individuality:

- C1P84 What are the biological individuals in problem cases—which are their parts? Where are their boundaries?
- C1P85 In virtue of what do they have that status/those parts/those boundaries?
- C1P86 Which of the many different answers given by science should we apply?
- C1P87 In virtue of what do we judge an answer good or bad? What are the criteria for evaluating definitions of organismality?

Further reading

Santelices, Bernabé. ‘How Many Kinds of Individual Are There?’ *Trends in Ecology & Evolution*, 14/4 (1999), 152–155.

Pepper, John W., and Matthew D. Herron. ‘Does Biology Need an Organism Concept?’ *Biological Reviews*, 83/4 (2008), 621–627.

Clarke, Ellen. ‘The Problem of Biological Individuality’, *Biological Theory* 5/4 (2010), 312–325.

Clarke, Ellen. ‘The Post-human Body: How Human Do You Think You Are?’ *The Philosopher* (2020).

C1F1 Figure 1.1

Flamingos at a watering hole.

Photo by Kat Spence on Pixnio.

C1F2 Figure 1.2

Binary fission in *Allostichaster polyplax.*

Line drawing by Guido Prieto, based on a photo by R. H. Emson.

C1F3 Figure 1.3

Flamingo mother and child.

Photo from pxfuel.

C1F4 Figure 1.4

Schematic showing how parts (called modules) are clonally iterated to produce wholes at larger scales. Many modules (A) make up a ramet— a single functionally autonomous tree (C). Many ramets make up a genet— a stand or forest that is a single genetic/developmental unit (D).

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C1F5 Figure 1.5

Elysia chlorotica.

C1F6 Figure 1.6

A canonical representation of the human genome, as an ideogram organised into twenty-three pairs of chromosomes. Notice there is no mention of MtDNA—mitochondrial DNA here, although technically it is also part of the human genome.

C1F7 Figure 1.7

An adult Wied’s marmoset.

C1F8 Figure 1.8

Rare rainforest plant, *Cryptocarya williwilliana*, showing variegated leaves caused by mosaicism. The white parts of each leaf are a result of mutation, which interferes with chlorophyll production.

C1F9 Figure 1.9

Bizzaria is a chimera, produced by grafting a lorentine citron onto a sour orange.

Labrina, CC BY-SA 3.0, via Wikimedia Commons.

C1F10 Figure 1.10

A c arpenter a nt *(Camponotus cylindricus)* has just exploded her own abdomen to release the sticky substance inside, killing both herself and the larger attacker (on the left) from a different c arpenter a nt species.

Line drawing by Guido Prieto.

C1F11 Figure 1.11

Scanning electron microscope combined image showing different stages in life cycle of a Dicty slug.

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Electron Microscopy Laboratory, Texas Tech University.

C1F12 Figure 1.12

Portuguese man o' war.

Image courtesy of Islands in the Sea 2002, NOAA/OER., Public domain, via Wikimedia Commons.

C1F14 Figure 1.14

A Necker cube, the famous optical illusion created by Louis Albert Necker in 1832. Most people can move between two perspectives on the image, one which has the lower left corner of the cube jutting forwards, and the other which has the upper right corner jutting forwards.

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