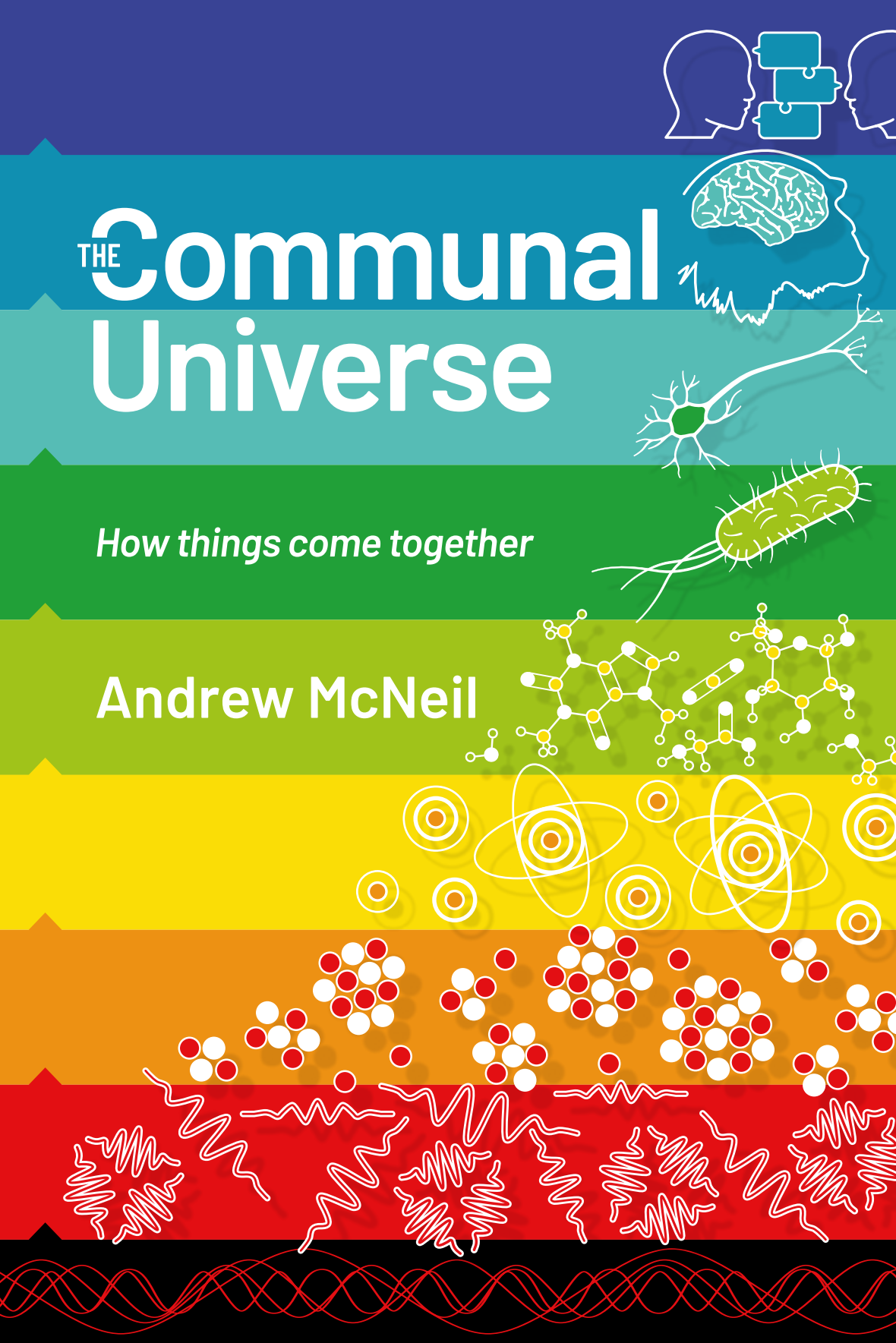
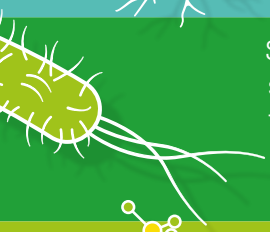

THE Communal Universe
How things come together
Andrew McNeil

This book will take you on a journey through our physical universe, based on current, established science. The journey starts with the simplest fundamental particles, such as quarks and electrons, and ends with the most complex of all material objects – our human brains.

Our universe has evolved through forming communities of things, with simpler things coming together in new groupings to make more complex things. So, every "thing" in the universe is a community of things, and at every level a community is greater than the sum of its separate parts.

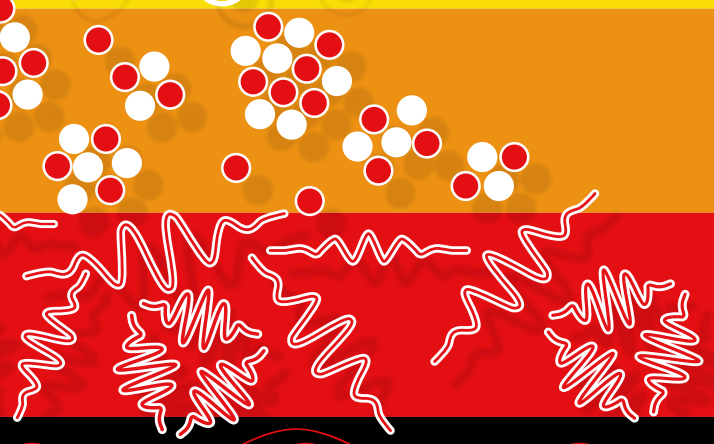
If we view the universe in terms of communities, it takes the form of a hierarchy of eight levels of communities, from protons and neutrons to human societies. And at every level in this universal hierarchy, the communities are bound together by ceaseless interactive exchanges.



So, our universe reveals itself as a dynamic hierarchy, sustained by endless exchanges between members of the communities at every level. Each of us is the universe in microcosm, for we each embody all eight levels of the universal hierarchy.

It is through things coming together and forming communities that the universe, with us now in it, has come to be what it is.

Andrew McNeil has a PhD in metallurgy. He first worked in university research and then, for twenty years, he taught secondary school science.



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This book is dedicated to all who ask, “How does *that* work?”.

Contents

Preface

This book is about the way things have come together to make our universe what it is. This preface outlines how its author has "come together" and how the book got written. After a somewhat unsettled time as an undergraduate, I received a very ordinary first degree in metallurgy and was very fortunate to be accepted to do a PhD. I then worked for several years as a university post-doctoral researcher and published a handful of specialist papers. I enjoyed experimenting and finding out how "stuff" works, but I became increasingly aware that I was working in a specialised area, just looking at details.

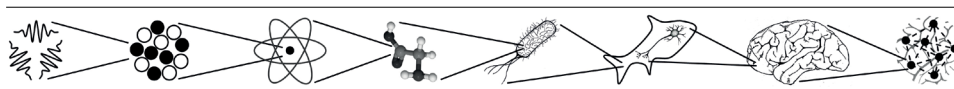
I wanted to share my knowledge and enthusiasm on a broader basis, so I left university research and worked for 20 years in an 11–18 secondary school. I taught all the sciences and electronics to all years. So, for example, I would teach the first ideas of chemical reactions to 12-year-old students through rôle play, with the students playing the parts of the reacting atoms; I taught genetics and the Big Bang theory of the expanding universe to 16-year-olds; and I introduced the quantum mechanics of particle-waves to 18-year-olds. Sometimes, I taught all these within the same week!

I started wondering how all these different aspects of our physical universe fit together. If our universe has its origins in a singular Big Bang, then they must all be part of a unified evolutionary narrative. We're familiar with the idea that all living things are connected through the genes in their DNA, in an unbroken chain that goes back to the very first biological ancestor. Similarly, every one of the atoms in our bodies and our physical world is connected in an unbroken chain of transformations to the very first particles created in the universe.

So, how did we get from there to here? By what processes have self-awareness, wonder and laughter emerged out of fundamental particles and forces and energy?

I had discovered that teaching science greatly improved my own understanding of the subject. It seemed that the best way – perhaps the only way – to understand something fully is to explain it to someone else. So, I decided that I would write my own account of the universe's evolution, and I started on this when I left teaching, with the distant idea that it might turn into a book. At first, the account was just a series of unconnected sections joined by "and then..." links, with no overall structure. But after a while, I realised that the whole scheme fitted a simple hierarchical pattern, and this is the basis of "The Communal Universe".

The remit is very broad, taking in disciplines such as particle and atomic physics, chemistry, biochemistry, cell biology, neuroscience, primatology, and anthropology. I have no particular expertise or authority in any of these specialist fields. I am a moderately literate practical scientist with a basic understanding of a fairly broad range of scientific disciplines, and a tendency to ask, "How does *that* work?".

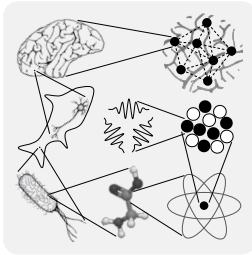


A crime novel has many characters who interact in lots of ways, and in the end, you discover "whodunnit". Similarly, this account of the universe has many material "characters" that interact in a variety of ways, and we see that it's things coming together in communities over a series of levels that have "dunnit". My account of the universe's story is intricate and full of details – but I believe it can be understood by someone with a reasonable scientific education, say, a good pass in Science at 16+ level.

Our universe appears to have evolved by the formation of *communities* of things, whereby simpler things come together in new groupings to make more complex things. Every "thing" in the universe is, in fact, a community of things, and at every level, a community is greater than the sum of its separate parts, and so the universe has grown ever more complex. Everything is incessantly active, interacting with other things, creating and sustaining communities. The entirety of our universe, the vast, rich complexity of it all, fits into a scheme of a hierarchy of communities.

In this book, I will take you on a journey through our physical universe, from the simplest fundamental particles, such as quarks and electrons, to the most complex things – our human brains. It is through things coming together and forming communities that the universe, with us now in it, has come to be.

Chapter 0: introduction



0.1 what this book is about

This book is about our universe – what it is made of, how it works, and how it has come to be what it is. We now have a well-established scientific description of the universe, and its evolution from very shortly after the Big Bang to the present time. The breadth and detail of this description shows how much we have learned, but it's clear from the many loose ends and unanswered questions that there is much that we don't yet know. This book is based on the current scientific description, and introduces a new idea – the concept of *communities* as a fundamental principle in the universe's evolution and organisation.

If we follow the progress of the universe as it evolves, we see physical matter coming together in ever more complex communal arrangements. So, every "thing" in the universe is, in fact, a community of things. In this book, I present a view of the universe as a hierarchy of material communities, which rises in just eight levels from fundamental sub-atomic particles to human society.

The members of the communities at each level of the hierarchy are bound together by endless exchanges between themselves. Each successive level is then sustained by the activities in the levels below it. Our universe is not a static edifice, like stones piled one on top of another, but is a dynamically stable pattern of activity, in which nothing is ever still.

Every community is greater than the sum of its separate parts. And so, as we climb the universal hierarchy, level by level, we see new material communities emerge with new properties and powers. Thus, fundamental particles of mass-energy come together in a sequence of emergent transitions, each one creating a new level in the hierarchy, ultimately becoming human beings. We are complex material communities with our own thoughts and feelings, and we can empathise with the thoughts and feelings of others, and thereby sustain our human society.

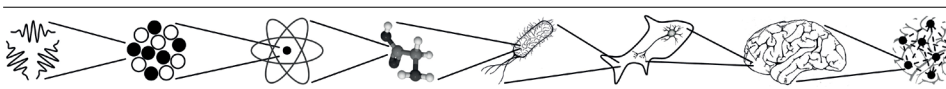
It is through forming a sequence of eight levels of communities of increasing complexity that the universe has evolved from its origin to the present time. This book is a journey through those eight levels of the universal hierarchy.*

0.2 the universal hierarchy

0.2.1 taking things apart

You, the reader, are one individual in a global human society, connected to all other humans by shared thoughts and inherited DNA, and also by social and economic links. Someone who is with you from day to day would observe your empathy with others,

* The text is supported by a full set of notes and references; see the end of the book.



your rational behaviour, your emotions and your sense of humour. This behaviour is enabled by the coordinated activities of the billions of nerve cells in your brain, which are endlessly passing signals between themselves. You are a complex biological organism, with a body that is made of many types of specialist cells, such as muscle, bone, and nerve cells. When we look inside each one of your body's cells, we find many different types of molecules, such as carbohydrates and proteins.

Each of these molecules comprises a number of specific atoms in a particular configuration. When we take the atoms apart, we find that each one has a number of electrons gathered around a tiny central nucleus. The hydrogen atom's nucleus is a single proton, but in all other atoms, the nucleus is a cluster of protons and neutrons. Finally, when we look inside individual protons and neutrons, we find that each is made of a trio of quarks.

We can't take things apart any further because quarks are fundamental particles – they are "*substance without inside*". We have arrived at what appears to be the basic stuff of the universe – "*mass-energy*". Matter is, in a sense, "*frozen energy*", and so "*a material particle is nothing more than a highly concentrated and localized bundle of energy*". In short, energy *is* matter *is* energy.

We have "unpacked" physical matter like a set of Russian dolls, and have found a series of things made of smaller things, most of which are fairly familiar. But there appears to be no overall pattern or scheme.

0.2.2 the universe evolves by forming communities of things

However, we have been taking apart things that have already been created, and this is the reverse of how the universe has actually evolved. When we follow the universe's evolution, we see a simple, consistent pattern, in which things come together in communal groupings to make new things, with novel, emergent properties. A universal hierarchy of communities naturally emerges, in which everything has its own level – this is shown in figure 0.1. As we ascend this hierarchy, we follow the universe's evolution from its beginning to the present time. At each level, things become bound together to make a community that brings the next hierarchical level into being, and then sustains its existence.

So, a trio of fundamental quarks, shown as "wiggly" quantum particle-waves, come together to create and sustain a proton or a neutron (Level 1). A communal cluster of protons and neutrons create and sustain a nuclide, which is generally known as an atomic nucleus (Level 2). A nuclide becomes the centre for a community of electrons, which we know as an atom (Level 3). A community of specific atoms then bind together to create and sustain a molecule, such as the amino acid glycine that is shown in figure 0.1, at Level 4.

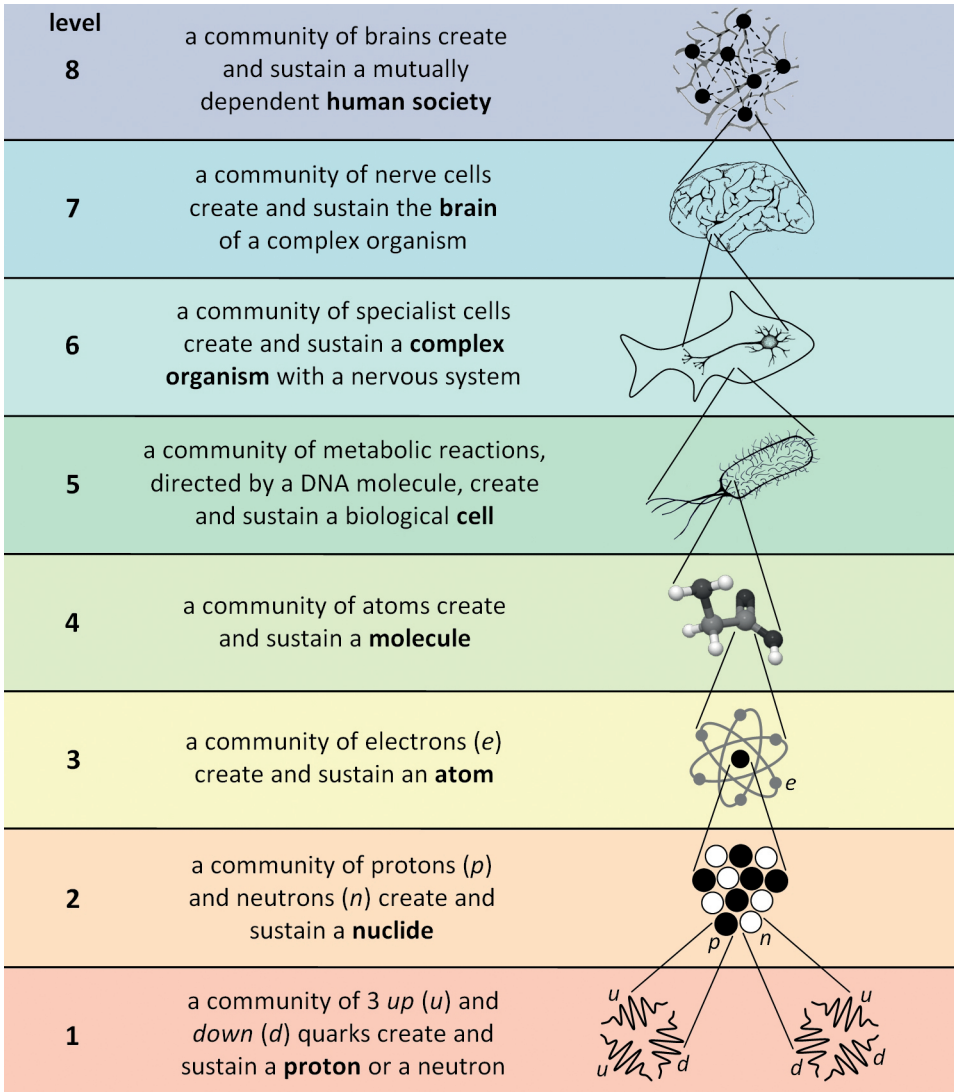


Figure 0.1. The eight levels of the universal hierarchy. Each level is defined and has a simple graphic icon. The hierarchy has built up, level by level, as the universe has evolved.

Inanimate matter does not progress beyond the 4th level, for while substances can aggregate on ever-larger scales, to make crystals, mountains, planets, and stars, none of these has the properties of the tiniest biological cell. However, the molecules at Level 4 are capable of endless chemical reactions with each other, and this activity sustains Levels 5–8, which are the biological world of "living" organisms.

Thus, a select community of chemical reactions between molecules, directed by a DNA molecule, create and sustain a self-sufficient biological cell, such as the

E. coli bacterium shown in the figure (Level 5). A community of specialised cells create and sustain a complex organism with a nervous system – represented by the enlarged neuron inside the fish outline (Level 6). A community of inter-connected neurons create and sustain a brain that controls an individual organism, such as the chimpanzee brain shown in the figure (Level 7). Finally, a community of empathic brains, each capable of accommodating diverse and conflicting individual perspectives, create and sustain a mutually dependent human society, in which people share their knowledge and feelings with each other (Level 8).

This is the universal hierarchy of communities in a nutshell, and in just eight levels, it goes from quarks to human consciousness. Each of us is a "*local embodiment of a Cosmos grown to self-awareness*", for we all have the eight levels of the evolved universal hierarchy within ourselves.

When we consider the ascent from Level 1 to Level 8, we can begin to comprehend the universe, not in terms of unitary things, but in terms of *communities* of things. Communities assemble into communities of communities, and so it goes on in a cumulative progression that builds up a hierarchy of communities. Each community is brought into existence and sustained by the community below, and in turn, creates and sustains the community above. This leads to a natural hierarchy of systems of matter, in which things are made of smaller things, and are themselves part of bigger things.

Each level of the universal hierarchy is sustained by the same principle – a group of matter systems exchange "things" between themselves, and so bind together in a stable community. The principle is simple, and perhaps it seems too simple to explain the complexity of our universe, but the natures of the matter systems, and the things they exchange are different at every level. For example, atoms bind themselves into a molecule at Level 4 by the exchange of light photons. At Level 6, biological cells bind themselves into a complex organism by the exchange of specific molecules. At Level 8, humans bind themselves into a shared society by the exchange of thoughts and feelings. Each level builds on the one below, and so, step by step, the universe becomes more complex.

Each of the eight communities is represented in figure 0.1 by a visual symbol or icon, and these also appear in the inset figure at the start of this chapter, and in the footer at the bottom of the right-hand pages of this chapter. Each of the following chapters has an inset icon and a footer that show the number of levels in the universe at that stage of its evolution. We won't see all eight symbols again until we reach chapter 8.

0.2.3 right here, right now

It is through forming a hierarchy of eight levels of material communities of ever-increasing complexity that the universe has evolved from its origin to the present

time – with us now in it. A hierarchical scheme can lead one to think that higher, more complex levels are somehow better than lower, simpler levels. But a higher level is not inherently superior to the level below it. For example, Level 4 can only exist because it is sustained by the three levels below it; Level 4 then plays its part in sustaining the next level above. It could be argued that Level 1, the lowest level, is the most important because without it, none of the other levels can come into existence.

Humanity is at the 8th and highest level of the hierarchy, and it is tempting to think of ourselves as superior to all the "lower" levels of creation. But if we're inclined to see ourselves as lofty intellectual beings, distinct from and greater than everything else in the created universe, then we need the humility to accept that our existence at the 8th level depends utterly on the ceaseless activities of the seven underlying levels.

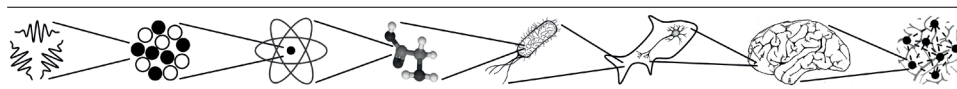
For example, right here, right now, millions of cells in your body are dividing, your muscles are holding you up, your stomach is digesting your last meal, your lungs are breathing in and out, your heart is pumping blood, while your eyes flick from one word to the next, so that your brain can take in the meaning of … this … particular … sentence. Your existence, from moment to moment, is sustained by the activities of your body's organs and cells, and by the molecules and atoms of which they are made.

Each of us can function as an independent consciousness at the 8th level of the hierarchy only because this level is sustained by the ceaseless activities of the seven levels below. We live our daily lives almost totally unaware of this.

0.3 the emergence of new properties and powers

We're familiar with the idea that there is a chain of genetic inheritance from the first biological cells to every organism alive today. If we extend this idea, there must be a continuous narrative that links events at the beginning of the universe to the present time. Every particle in our bodies and our physical world is connected in an unbroken chain of transformations to the very first discrete particles created in the Big Bang. So, how did we get from *there* to *here*? How have empathy, laughter, music and mathematics emerged from raw energy and fundamental particles?

As we ascend the universal hierarchy in figure 0.1, we see simpler entities come together to become parts of a more complex whole with novel properties, which can then act as a unitary entity in its own right. Thus, a nucleus and a cluster of electrons come together to make an atom; atoms can combine to make molecules; molecules interact in biological processes; and biological processes can sustain a self-conscious mind. At each stage, a new whole emerges, with new properties that transcend the separate parts.



0.3.1 the emergent properties of water

We can use water as an example that illustrates how totally novel properties can emerge when a large number of single molecules come together. A single molecule of water is not wet; it cannot flow or freeze, boil or evaporate, and it's incapable of dissolving anything. All these are bulk properties of large numbers of water molecules, from a teardrop to an ocean.

These bulk properties emerge naturally from the interactions between water molecules, and this is illustrated in figure 0.2. All the water molecules are attracting or repelling each other as they randomly spin, move around and collide within the liquid. In even the tiniest droplet of water, there are billions upon billions of interactions every second, and the water's overall, bulk properties are the sum of them all. The surging ocean waves crashing on a beach, the skin of ice on a puddle, the bubbling of soup simmering in a saucepan, the chill of sweat drying, and the saltiness of tears – these properties only emerge and have any meaning when large numbers of water molecules come together.

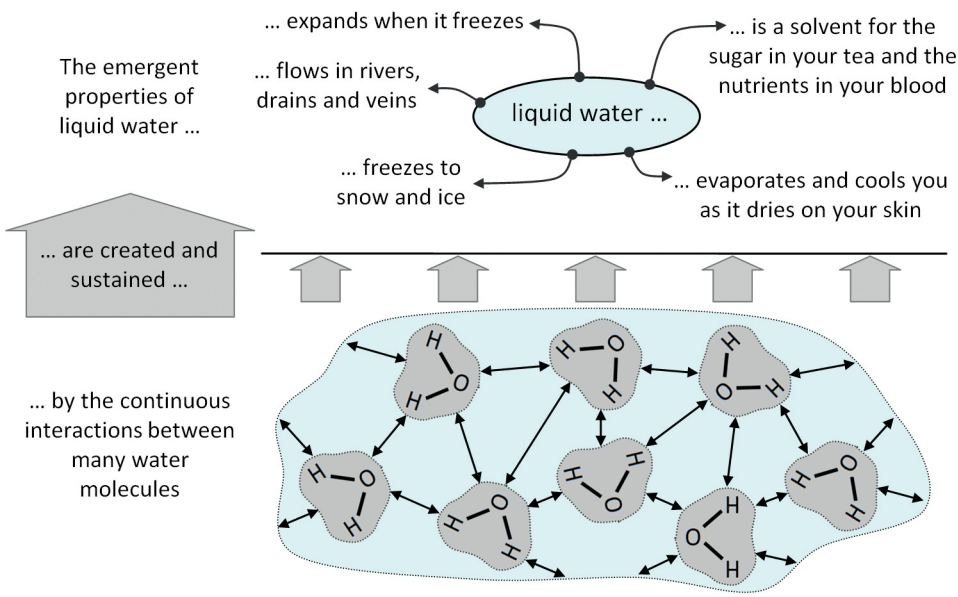


Figure 0.2. The emergence of the bulk properties of liquid water from the ceaseless interactions between individual H_2O molecules. The interactions are shown simply as double-headed arrows, which can be attractions or repulsions.

In the following chapters, we'll see how, as the universe evolves, new and more complex communities emerge at each level, with ever greater capabilities, properties, and powers.

0.4 communities are bound by endless exchanges

Figure 0.1 shows the eight communities that comprise our universe, but says nothing about the exchange processes that sustain each community. We can gain some idea of how the members of a community are bound together by continuous exchanges by looking at our human society at Level 8.

We live in a social and economic culture that encompasses the whole Earth. Materially, there is not one of us that is truly self-sufficient, and we support ourselves collectively by exchanging goods and services with each other. We also share and exchange our thoughts and feelings in various ways. We talk to and about each other, and share our responses to the books we read, the TV programs we watch, the video clips we like, and often, we just chat about the news and weather. For a sizeable portion of our waking moments, we are engaged with someone else's actions and thoughts, so that each of us lives as much in the minds of others as in our own.

For humans at Level 8, meaningful exchanges can involve physical objects, such as gifts and purchases, or they can make use of a shared symbolic language, which may be spoken or written. The communities at levels 1–7 are all bound together by the exchange of physical objects, which are different at each level; they can be photons (particles of light), sub-atomic particles, or whole molecules.

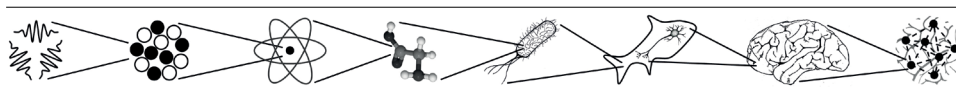
0.5 explanations at their appropriate levels

Because the communities and their exchange processes are different at each level of the hierarchy, each level has its own particular laws and principles. So, there is no all-encompassing explanation that covers all levels, and rather than a single "*Theory of Everything we appear to face a hierarchy of Theories of Things*". This means that we can only explain events at their appropriate level.

For example, we can *describe* thoughts and feelings in terms of the collective actions of atoms, for thoughts and feelings arise from what the matter at the lower levels is doing. But we can't *explain* thoughts in terms of atoms, for thoughts only arise at the level of a community of interconnected neurons.

If we could observe a thought enacted in the brain, we would see a pattern of coordinated activities of atoms. If we could recreate this pattern of activities, then we could recreate the thought. But while each atom plays its part in the overall pattern, a collection of atoms will not spontaneously enact this pattern of coordinated activities. To do this, they must be organised into molecules, then into specialised neurons, and then into a specifically connected community of neurons – a brain. And finally, it must be a brain that has been shaped by a particular genetic inheritance and environmental experience.

So, a thought, a collective event arising from the coordinated behaviour of a great number of atoms, can only be explained in terms of the level of the universal hierarchy



at which it occurs. In short, we can break down a thought into a pattern of actions of individual atoms, but we can't go the other way and explain a thought in terms of the properties of those atoms. Our existence as conscious human beings rests ultimately on quarks, but our actions are not explained by them.

0.6 our journey begins

Our universe has evolved to become a hierarchy of eight levels of material communities of increasing complexity. This book is an account of that evolution in terms of the emergence of a series of communities with increasingly complex properties, rather than being a history of a series of unconnected events. So, there is no timeline, and only an occasional reference to when things occurred. The universe evolved when it was ready, in its own time, and we will follow its progress accordingly.

The following eight chapters will describe how physical matter evolves, level by level, from wiggly particle-waves, which are the merest gestures in space-time, to become capable of holding independent thoughts, and empathising with the thoughts of others.

Each chapter is a journey through one level of the hierarchy, and describes the matter systems and their exchanges, and how they naturally create the community at that level. Each chapter starts with a chapter map, which outlines the journey through that chapter. Just as you might use a geographical map to monitor your progress through unfamiliar terrain, you can use the chapter maps to monitor your progress through each chapter.