1. Introduction.

Quantum mechanics, also called quantum physics, is a mathematical theory that gives a correct and very accurate description of virtually all the phenomena of nature. It explains the properties of the semiconductors used in all electronic devices (and thereby underlies 30% of our economy); it explains the chemical properties of and light emitted by molecules and atoms; it explains the stability of and radiation given off by the nuclei of atoms; and it explains the properties of the more elementary particles—quarks, neutrinos, electrons, photons, gluons, the Higgs boson and so on. Further, if we include gravity, it predicts the different types of stars and the radiation they give off. Many of these properties are correctly predicted to an accuracy of 1 part in a million or sometimes even to one part in a million million. In addition, there is no instance where experiment and theory disagree.

Mysteries.

And yet, in spite of all these successes, we find there is no easy way to understand how the mathematics of quantum mechanics relates to our everyday view of the physical world. How can this be? How can quantum mechanics give so many correct answers and yet not relate to the perceived world in a simple way? The answer lies in the basic "substance" used in quantum mechanics. In classical physics, the world was made up of particles, easily visualized, small spheres of matter. But in quantum mechanics, the only quantities that enter the mathematics are the **wave functions**. These will be discussed in Ch. 4 in more detail, but the basic problem is that the wave function can often contain within it **more than one version of reality**! Schrödinger's cat can be both alive and dead at the same time (at least in the mathematics)!

This presents us with a mystery: How can quantum mechanics be so successful and yet not give us just a single version of reality, as we see in our everyday perceptions? This initial mystery leads to three others—wave-particle duality, probability, and the 'actual nature' of matter—which are briefly described in Ch. 2 and the rest of Part I. It is these four mysteries that we will attempt to solve.

Why try to understand quantum mechanics

Once the mysteries are solved, or solved to the best of our current knowledge and ability, what will we have gained? Ideally we will know a good deal about the structure of existence. Is it just as we normally picture it—particles moving in space and time—or is it more abstract? Is quantum mechanics the final theory of the physical universe? Does the mathematical description of the physical world give us a complete and self-consistent description of existence, or do we need something outside the current mathematical description? We shall see.

Reality is as it is and we can't change that, so why should we seek to further understand a theory that already gives so much information? Partly it is just pure curiosity. But it is more than that; our knowledge of the basic structure of reality is crucial to understanding our place in the universe. In particular, one of the results here is that there is no support in physics for materialism—the concept that existence consists of matter alone. And if we build our world-view on potentially erroneous concepts such as materialism, we may not reap all the benefits of our life here. "It's not what you don't know that hurts you. It's what you think you know that just ain't so," said Mark Twain.

Vanilla vs. non-vanilla quantum mechanics. Basic principles

In addition to plain old vanilla quantum mechanics, which is what we will deal with, there are currently many variations of the theory: there is quantum field theory; string theory; supersymmetry; theories with more than three space dimensions; elementary particles beyond the Higgs boson and the Standard Model; theories of dark energy and matter; theories of how gravity and quantum mechanics fit together; and so on. Do these different varieties of quantum mechanics complicate or possibly invalidate the arguments given here?

No they do not. The reason is that our reasoning is based on **three basic principles** (see appendix A1.1) and these principles are shared by all versions of quantum mechanics. So in concentrating on the basic principles of vanilla quantum mechanics, we will be addressing the 'interpretive' concerns raised by all the forms of quantum mechanics at once. We will call the mathematics of basic, vanilla quantum mechanics, **basic** mathematics. The three mathematical principles are our baseline assumption.

Evaluations. Questions.

Many readers will not be experts in the intricacies of quantum mechanics and so will not be able to judge the correctness and completeness of the arguments given here. Like all authors, I have a point of view and think the arguments are more than adequate. Nevertheless, to try to make the presentation as even-handed as possible, I will give an honest—as far as I am able—evaluation of the contents of many chapters by indicating whether or not the majority of physicists would agree. Also if you have questions or comments, you can submit them either at **Comments** or at CaseyBloodQM4@gmail.com and they will be answered in a reasonable period of time.