Heisenberg, Schrödinger and others launched a revolution in physics almost 80 years ago. Their matrix and wave mechanics were soon unified as quantum mechanics. Theories of quantum fields were developed within the same conceptual framework, until today quantum theory in its many forms provides a phenomenally successful foundation for much of physical science, with applications to other sciences including biology. But this empirical success has been achieved despite disagreement and lively debates among the active interdisciplinary group of scholars now probing the conceptual foundations of quantum theory itself. There has been notable progress in our understanding since the early discussions between intellectual giants like Einstein and Bohr. But there is still no consensus on how to answer puzzling basic questions about the meaning of central concepts of quantum theory such as measurement, probability, the nature of quantum states, locality and determinism.

I’ll begin by introducing quantum concepts as applied in some recent experiments, laying out the mathematics we’ll need, and posing the main questions an interpretation of quantum theory needs to answer. Then we’ll focus on two quite different current attempts to answer these questions: the Everettian approach (popularly known as the many worlds interpretation) and a Copenhagen-like approach I have recently been developing myself which I call a pragmatist interpretation. As you’ll see, pursuing either of these approaches quickly leads to issues that are at least as philosophical as scientific in character. But the issues are quite different in each case. An Everettian must try to develop a concept of probability that applies when what appears to be a chance process has incompatible outcomes that all occur at once. This involves her in problems of decision theory, personal identity, and distributive justice. A pragmatist must say how claims about quantum states, quantum probabilities and quantum fields can be objectively true even though these are not physical things. And his dissolution of the notorious measurement problem commits him to a philosophically controversial inferentialist account of conceptual content.