What to Make of All These Interpretations of QM?
A Dialogue

A: Hey, you're in 24.111 with me, aren't you?

B: Yes, I think so.

A: Class is getting pretty silly. It's all a bunch of nonsense, talking about these "different" interpretations of quantum mechanics that all make the same predictions.

B: Well, maybe it's boring, but do you really think it's *nonsense*?

A: You've heard of John Slater?

B: Uh, no...

A: He was a professor of physics here MIT in the 1930s. He was a smart guy. He wrote: "Questions about a theory which do not affect its ability to predict experimental results correctly seem to me quibbles about words." Man, was he right about that.

B: Okay...

A: I see I'll have to spell it out for you. Okay. What is a scientific theory, anyway?

B: It's steer roast. This is the senior house courtyard, not a classroom. Drop the leading questions. Just tell me.

A: Okay. Science's "job" is to predict the future. That's an abstract way to say it, but I'm not trying to sound deep or anything. If we're about to launch a rocket to the moon, science's job is to tell us how long it will take to get there, and how much fuel it needs, and so on. Making accurate predictions is what science is for. People have always needed to know as much about the future as possible, but for a long time, in the "dark ages," they had no good way to find out. Astrology, prayer, they tried those, but they were lousy methods. Science is the *good*, *accurate* method for predicting the future. You could put "predict the future" as "predict the outcome of experiments"---that's how Slater put it---but that's not quite right. It's too limiting. We use science to predict when the rocket will make it to the moon, and when the next solar eclipse will be, but neither of these things is the outcome of an experiment, in any ordinary sense. Anyway, science, scientists, have tools for predicting the future, just like mechanics have tools for changing tires. We call those tools scientific theories. Quantum mechanics is a scientific theory; it is a tool for predicting what will happen when, say, two globs of plutonium slam into each other. Now in 24.111 we hear that there are several different interpretations of quantum mechanics: the orthodox interpretation, GRW, Bohmian mechanics... but they all make the same predictions. That is, they all "validate" the statistical algorithm. So really, there can't be any interesting difference between them. That is, it would be silly to have a debate about which interpretation is "right," which is "true," and which is false. It would be like a mechanic, who had two different tools that were equally good when it came to changing a tire, wondering which tool was "true." Truth is not a property of tools; thus, it is not a property of scientific theories.

B: Hmmm. I'm confused. Maybe it's because I haven't been going to class much since spring break. Anyway, tell me again what GRW and Bohmian mechanics say?

A: Oh, well, one difference is that GRW says that individual particles often lack definite positions, though macroscopic things almost always have definite positions; Bohmian mechanics, on the other hand, says that everything always has a definite position. Also, ---

B: Wait, wait, now I'm even more confused. You just said that Bohmian mechanics says that everything always has a definite position.

A: Right.

B: Which means, more or less, that *according to Bohmian mechanics*, everything always has a definite position.

A: Right...

B: But tools don't say anything. If I ask the mechanic, "what does that wrench say?" or "What are things like, according to that wrench?" He'd think I was nuts. If scientific theories say things, if it makes sense to ask what things are like according to some scientific theory, doesn't that show that scientific theories are not tools?

A: Well, maybe some tools do say things (in the relevant sense). Anyway, this is a distraction. My main point is that theories aren't true or false, just useful (if they make accurate predictions) or not.

B: Doesn't that just raise the same problem? You said, again, that "according to Bohmian mechanics, everything always has a definite position." What does "according to Bohmian mechanics" mean? More generally, what does "according to X" mean?---for we use this phrase quite generally. According to Donald Trump, America is not great. What does that mean? Presumably: if what Donald Trump says IS TRUE, America is not great. But then "according to Bohmian mechanics, everything has a definite position" means "if Bohmian mechanics is true, everything has a definite position." And now you're in trouble: as soon as you try to tell me what things are like according to Bohmian mechanics, you assume that Bohmian mechanics COULD be true, that it's the sort of thing that could be true; which is what you were trying to deny.

C: Hey you two, I couldn't help overhearing your conversation. I'm in 24.111 too, and I've thought the stuff we've done since spring break has been really interesting. I think you're right, B, A is confused. At most one of these interpretations: GRW, Bohmian mechanics,... can be true. They're not like equally useful tools. But I do think that A is right that discussing *which* interpretation is true is a silly thing to do. It's not a silly thing to do because the question of which is true *makes no sense*; instead, it's a silly thing to do because we couldn't have any evidence that supported one interpretation more strongly than another.

B: Well, why not?

C: We gather evidence by making observations, doing experiments. The theories we have are hypotheses about what is going on in those experiments. The whole point of doing experiments to test hypotheses is to do an experiment where one of the hypotheses says that the experiment will have one given outcome, and the other hypothesis says that the experiment will have a different outcome. So we see what outcome happens, and then we know: the hypothesis that predicted the other outcome is wrong, because it made a false prediction. There are well-known famous cases: Einstein's general theory of relativity predicted that light would bend around massive bodies, while Newton's theory of gravity predicted that it wouldn't. When there was going to be a solar eclipse, Eddington went and looked to see if the light bent. It did; Newton's theory was refused, and Einstein's confirmed. But these interpretations of quantum mechanics we are looking aren't like these two theories of gravity. There's no experiment where they predict different outcomes. So we could never do an experiment to definitively rule out as false one of the theories.

A: Okay, let me play devil's advocate a little bit. Aren't you asking too much? You say that the only way to have evidence that favors one theory over another is to do an experiment where the theories predict different outcomes. The problem with the interpretations of quantum mechanics, of course, is that they rarely predict any outcome with certainty. They only give probabilities.

C: That's right.

A: But even when we only have probabilities, we can get evidence that favors one theory over another. Here's a simple example: suppose five people are going to play cards. They're pretty evenly matched in ability. Fred and Lois know each other, so we consider two theories: they are going to cheat; they are going to play fair. Now we do our experiment: they play a bunch of rounds of poker. The experiment has lots of possible outcomes. Let's just focus on these possible outcomes: Fred wins every time when Lois deals; Fred wins 1/2 the time when Lois deals; Fred wins 1/5 the time when Lois deals; etc. Now suppose the outcome of our experiment is: Fred wins every time when Lois deals. No hypothesis predicted this with certainty. Instead, the hypothesis that they were going to play fair gave it a rather low probability, while the hypothesis that they were going to cheat gave it a rather high probability. Still, doesn't the evidence confirm the cheating hypothesis? In general, can't evidence confirm one hypothesis over another if one hypothesis says that the evidence is more likely? Then it confirms that hypothesis, the one that says our evidence is more likely.

B: That sounds right to me, but I think C was just overplaying her case. These interpretations of quantum mechanics assign the same *probability* to each outcome of any experiment. Because they all "validate" the statistical algorithm. And if each interpretation assigns the same probability to each outcome, then certainly it is true that we couldn't have evidence that favored one over another.

A: It sounds like you're coming around to my idea that it's silly to debate which of them is right, though not for the reason I originally offered. But let me continue to play devil's advocate. Here's an extremely simplified example about finding evidence for a theory. I've got a function in mind.

C: This doesn't sound like a very fun game.

A: What I'm going to do is tell you some values of that function, one by one. Your job is to give me your best guess as to what the function is. I'll make things easy: it's a continuous, differential function. In fact it's a polynomial. So for each polynomial, you should entertain the hypothesis that the function I'm thinking of is that polynomial. When you guess, I want you to guess the hypothesis you think is best supported by the evidence I've given you so far. Ready?

B: Wait, how about instead of you just telling us some values, we give you a number n, and you tell us f(n). That way, you can't pick and choose misleading evidence. We get to do the "experiment" by specifying which number we want you to apply f to.

A: Yeah, that sounds good. Let's do that.

C: Okay, I go first.Tell us f(0).

A: f(0) = 0. What's your guess?

B: No idea. Too many options.

C: Yeah, me too. We need more data to even begin to guess.

A: Okay, give me a bunch of numbers.

B: 2! pi! sqrt(3)!

C: 10^9! -e!

A: Great! f(n) = 0 for all of those.

B: Okay, now I have a guess: It's the function f(x) = 0 for all x.

C: That's my guess too.

A: Why?

B: Obviously that's the one that best fits the data.

A: What about the function x(x-2)(x-pi)(x-sqrt(3))(x-10^9)(x+e)? That's a polynomial that is also zero at all the points you picked. Why does your evidence support f(x) = 0 over this one? They make exactly the same predictions about the outcomes of the "experiments" you guys did.

B: We can do more experiments to test which of these is true.

A: True, but we can't wait forever to decide which hypothesis to prefer. We could always change our mind when we have more evidence, but the question is, given the evidence you have NOW, which hypothesis is best supported? You think it's f(x) = 0. Why?

B: Well f(x) = 0 is a much simpler hypothesis than that one you gave. It's a much simpler function.

A: Are you allowed to say that, given your convictions about evidence and hypotheses? I thought you said that when two hypotheses make the same predictions, the evidence can't favor one over the other. Now you're saying that it can: even if the hypotheses make the same predictions about the experiments you've done, if one hypothesis is simpler than the other, then the evidence you have favors the simpler hypothesis. And if that's right, then shouldn't you say that we can fruitfully discuss which interpretation of quantum mechanics to believe? Since they make the same predictions, we should believe the simplest one.

C: I don't like where this is going, and I don't understand why you're taking us there. Don't you, A, think these theories can't be true or false in the first place?

A: Yes, I was just playing devil's advocate. I think this is all a muddle. I was just trying to show B that the way the two of you are trying to argue for the silliness of discussing these interpretations isn't going to work.

C: So what's wrong with the argument you just gave, concerning the polynomials?

A: I think you guys were wrong to start talking about simplicity. I don't know what that's supposed to be. Is there really such a thing as "objective simplicity"? If there's just what I find simpler, and what you find simpler, but no sense in which one of us is "right" about which theory is simpler, then preferring simpler theories isn't really tracking the truth. Maybe an alien would find that high-degree polynomial simpler than f(x) = 0. And anyway, even if we accept objective simplicity, do you really think there’s a sense in which GRW is simpler, or maybe less simple, than Bohmian mechanics? If so, which is it?

B: You’re asking a lot of questions as if they don’t have answers, but I have some idea about how to answer them….

C: Hey, wait, the steer is done. Time to eat!