

## Transcript - Long

### Robert Lawrence Kuhn:

Seth, we're both at this – start again. Seth, we're both at this FQXi Conference in Banff, this beautiful area, um, about the physics of events, the importance of events and understanding what physics is, and one of the topics that we're looking at is the nature of time and how events can help us understand what time really is. How – how does that work? How can events help us understand what time is?

### Seth Lloyd:

Well, now, that is something that unfolds in time, like a clock ticking or a – an electron moving from here to there, or a bit flipping in a computer. Or, you know, just our thoughts moving on and our conversation progressing. Um, now time is a mysterious thing and we don't understand it well. Heraclitus said that time is like a river, like this beautiful river here [clears throat], the water flowing and then time ever moving onward and, um – ah, but what makes us feel and perceive that time is going? Um, so, ah – the first answer is I don't know.

### Robert Lawrence Kuhn:

Almost every question is the same. [Laughter.]

### Seth Lloyd:

Yeah, um, but – but there are, ah, different eras of time. There's a perceptual era of time where we don't know something and then we know – know something that we didn't know. This is about getting information. Um, there's a – a conversation, talking back and forth, interacting, where – where you tell me some information, I get the information. I tell you something, you get the information. We both completely fail to comprehend each other, but that's cool. That's normal. Um, then there's the second law of thermodynamics which says that entropy, which is a form of information, tends to increase.

### Robert Lawrence Kuhn:

Which is disorder.

### Seth Lloyd:

Yeah, it's a kind of disorder. This is related to the idea of an event in quantum mechanics, because in quantum mechanics an event can be, ah, thought of as something where, you know, an electron moves from here to there, where there's an interaction with the environment, the interaction kind of randomizes what happens, decoheres that happens, as – as it's said, and then – and then this adds a little bit of randomness into the system and it makes something happen. You know, suddenly an electron was here and there at the same time, now it's either here or there. That can be considered an event in quantum mechanics.

### Robert Lawrence Kuhn:

So – so to understand time, though, I – I perceive there are two different ways of thinking about it. One, is that the events, as you say, sequence, occur in time and the other way to think about it is that there is no time, there is just an event and then another event and we call that time but it's not really time. Ah, so, it – is this – and – and people get really angry, you know, in an intellectual way, about both – which position they're for. Is time real, in other words, events occurring in time, or is time an illusion or something artificial or emergent or coming out of other things that – that – that – and that the real reality are – are events, time is a derivative of events. Now, is this a distinction without a difference or is there something fundamental here?

### Seth Lloyd:

I can answer that question in one word, Robert, and the word is whatever. [Laughter.] No--

### Robert Lawrence Kuhn:

But that's a significant point, what you're saying.

### Seth Lloyd:

—it is a significant point. Yeah.

### Robert Lawrence Kuhn:

If it's whatever that's important but most people say it's not whatever. Most people say either side is – is a fundamental, what – because time is such a fundamental part of – of existence.

### Seth Lloyd:

So, um – ah, the other position, which is from the ancient Greek philosopher, Paracelsus said, time is laid out all for once, nothing is fixed, nothing happens and this, of course, is the position in Einstein's theory of general relativity where space and time are manifold and all the events are laid out in time once and for all, and you know, they're just sitting there. And then, of course, we experience things as changing because we're moving through time, but it's all just – all these events are just [Crosstalk].

### Robert Lawrence Kuhn:

Just like you're moving through space, that you're moving through this spacetime--

### Seth Lloyd:

Yeah.

**Robert Lawrence Kuhn:**

—four-dimensional block universe, so to speak.

**Seth Lloyd:**

Yeah.

**Robert Lawrence Kuhn:**

And that's a very deterministic, ah, it's, ah, you know, somebody dies, they're – they're still there in part of this system, as Einstein supposedly said to the wife of friend who died, and understand it. But--

**Seth Lloyd:**

That's not a big consolation, frankly. [Laughter.] I mean, oh, God, Einstein, God. Shut up! [Laughter.]

**Robert Lawrence Kuhn:**

But I – I – I always wonder, is this just literary metaphor or is there a real ontological deep meaning and deep structure in terms of the positions about time?

**Seth Lloyd:**

Well, look, the Heraclitan and Paracelsian points of view, they sound very different but they are equivalent to each other in terms of our experience.

**Robert Lawrence Kuhn:**

One being flow and one being it's – it's all there all the time.

**Seth Lloyd:**

Yeah. That's right. That's right. That – they're – you know, they describe the same situation in different fashions. They're equivalent to each other from an empirical fashion so – so that's why I said--

**Robert Lawrence Kuhn:**

So, is that right? You can't get – you can't do measurements, you can't do experiments that can distinguish between the two, is that what you just said?

**Seth Lloyd:**

Sure. I mean, yeah, absolutely. Like – like let's suppose we think of – of a Heraclitan view of – of general relativity where you think of time flowing like a river from the past to the future, and then we are riding along this river experiencing what's going on and we compare that to the Einstein picture as if the whole history of the river is just laid out.

**Robert Lawrence Kuhn:**

And we're traveling through it, as – as traveling through space.

**Seth Lloyd:**

We experience it the same way. So, my feeling is whatever. It doesn't matter. It's like you – you can pick this picture, the Einsteinian picture, the Paracelsian picture, we can pick the Heraclitan picture, and they're equivalent in terms of our experience.

**Robert Lawrence Kuhn:**

Okay. That – that's – that – I – I think I – I – I would agree with that, but I think you're missing a – a deep fundamental reality. I want to know what's – what's below it. I mean, it's whatever for, ah, whether – in terms of experiments or our personal lives or going to the movie, certainly agree. But I – I want to know what deep reality is all about. You mean I – I can't know?

**Seth Lloyd:**

That's why you--

**Robert Lawrence Kuhn:**

That's why I'm talking to you.

**Seth Lloyd:**

Well, Robert, that's why you are the host of a show called Closer to Truth because you want to find this deep underlying reality.

**Robert Lawrence Kuhn:**

[Laughs.] I do. That's why I'm coming to you in this beautiful setting. I could just be looking at the environment instead of talking. I want to learn.

**Seth Lloyd:**

What if I were to tell you there is no deeper underlying reality, that if we have two equivalent pictures of what's going on they're both equally real, would that be upsetting to you?

**Robert Lawrence Kuhn:**

Well, it would be – if – if that were the truth, it doesn't matter whether it's upsetting or not. At – at a mental level I'd be – I'd be happy that if that's reality, that there's this uncertainty, I – I would then still ask is the uncertainty in an epistemological and knowledge sense or is it an uncertainty at a deep reality

ontological sense?

**Seth Lloyd:**

Look. If – if, um, from the perspective of physics, if I have two pictures, you know, two theories, physical theories, one in which time flows and one in which time is static, but they give the same empirical content--

**Robert Lawrence Kuhn:**

Yeah. Yeah, yeah.

**Seth Lloyd:**

—you cannot distinguish between them, they're both equally good.

**Robert Lawrence Kuhn:**

Well why do your colleagues fight so much about this?

**Seth Lloyd:**

Well, because, I don't know. They need something to do in the afternoon. [Laughter.] They've got to justify their jobs. I don't know. Um, no, I think actually people are, you know, some people like the kind of river flowing, being sitting by this river, it's so beautiful and flowing by. I happen to be a Heraclitan at the moment, I'm going to – going to go with the flow here. Um, some people like the everything is just laid out in a static, ah, position for all time, like the Einstein picture. Um, you know, some people just have a feeling that they prefer this rather than another but that's just a preference. You know, the – the – the two are equivalent to each other, so from the – the perspective of science they're the same.