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CHRISTOF KOCH: Zombie is a set of sensory motor systems that can do very complicated behaviors in the absence of consciousness.

JOE BOGEN: Consciousness is like the wind, you don't see it, what you see are the effects of it.

STUART HAMEROFF: Proto consciousness, something from which consciousness is derived, is fundamental and irreducible, it's something like spin, or charge.

JOE BOGEN: You want to talk more about zombies or are you done with that?

SHOW OPEN

JOE BOGEN: According to some people, consciousness is the hard part of that problem.

ROBERT KUHN: Why do we call consciousness a hard problem?

LESLIE BROTHERS: I think we have to be careful not to toss this term around too readily, as though somehow it's a given that there is such an entity as consciousness just because we have that word and we use it. It could be, as other people have pointed out, that they're, just like we have the word "aliveness," okay, we have a concept, doesn't mean that there is a single thing called consciousness, there may be many processes, many ways that we engage with the world with our own sensations and with the sensations that we get from the outside world, but to say that that means there's some overarching entity, may be a mistake.

STUART HAMEROFF: I, I think we have a semantic problem here, consciousness is used incorrectly, well incorrectly or not, to group consciousness to all kinds of things. But I have to disagree with what you said, Leslie, because I think that consciousness, when used properly, or in a restrictive sense is something very specific, it's experience, it's awareness that biological systems have, and only biological systems have, as far as we know.

JOE BOGEN: So far.

STUART HAMEROFF: So far, and it's just a matter of figuring out exactly what it is, I think the, the, we've gotta be careful of sort, sort of post modern deconstruction of the term "consciousness."

Is Consciousness Definable?

JOE BOGEN: If we're going to find a scientific explanation for something, we have to be, try to be a little bit restrictive about what we're trying to explain. Because if we try to explain all of those things that all of the different people mean, in all of the different ways they use the word "consciousness," you're not going to be able to do that. You gotta have, kind of focus down on what we're after, which is closer to the idea of qualia.

STUART HAMEROFF: I have to agree with that, sensations are qualia, our experience our, contribute to our inner life that distinguish us from computers, as far as we know who don't have consciousness, who don't have sensations, flavors, emotions, feelings, what philosophers call qualia.

LESLIE BROTHERS: **A**nd Joe has just said what's important is to find one aspect of it to work on, for example some people, like for example Christof, uh, and, and Francis Crick have said, let's look at visual awareness as sort of a paradigmatic case, and start with that feature. And see if we can find the neural correlates of consciousness beginning with one aspect of consciousness. My question would still be, is that going to generalize in some way, or are all we are going to find is the neural con-, uh, correlates of visual awareness in a specific experimental setting?

CHRISTOF KOCH: The hope is, it's a hope, it's an experimental program right now, you uncover any one aspect of consciousness: sensual consciousness visual consciousness, pain, self consciousness, whatever, that, that the other aspects of consciousness are probably closely related in kind, the same program was in effect when people tried to study heredity in the origin of life and the belief was that, you know by studying that aspect of heredity and how the genetic informations transmitted in this very simple case probably will illuminate the way humans pass on genetic information to the children, we don't know.

ROBERT KUHN: One, one of the theories would be that each of the different aspects of consciousness, the visual, the auditory, all the things are each separate systems that somehow get integrated together and give an illusion like what we say an epiphenomenona, something that does, it's not real but it seems like it's real because ewe have all these things working together, all these different facets of consciousness.

JOE BOGEN: Well I have a big difference with you, I don't think that this integrating all this stuff together is what's crucial about consciousness.

ROBERT KUHN: What's important, in your view what's important?

JOE BOGEN: What's important about consciousness is the experience.

CHRISTOF KOCH: When you have tooth ache, when you have tooth pain, it might override everything else because it can be so bad, it hurts so bad. Why does it hurt, I

mean why is it that, that the release of sci- some ions sloshing on your brain, some calcium and potassium ions that move around your brain give rise to this really bad feeling?

LESLIE BROTHERS: That's the hard problem.

CHRISTOF KOCH: That, that is a hard problem. [LAUGHTER] And so in that case there is very little information integration going on, it's all that one tooth that hurts so it doesn't have to be, I agree with Joe, it doesn't have to be the integration, it's just the sensation, how can a physical system, how can any physical system, a human, a fly, robot, how can a physical system have subjective states?

ROBERT KUHN: Now you talk about some things that we do, a lot of things that we do that we're not consciousness of. And we use the term zombies in consciousness. What's a zombie, Christof?

CHRISTOF KOCH: Okay, zombie, I mean, I mean it's used in different connections, Francis Crick and I define zombie as a set of sensory motor systems that can do very complicated behaviors in the absence of consciousness. So, for example, when I talk to you and I, I do this, turns out that's a very complicated move and we have, you know, it's difficult to get a robot to carefully grasp this, to judge how far this away, to judge the distance to my mouth, to tilt it just the right distance, that's a really difficult problem for robotics, yet I do it all the time effortlessly. Now there's some pa-, there's some patients that, for example, I'm unable to see this glass, or they don't see how big it is, they can't see is it here or here, yet if you ask them just to, just to grab it and drink it, they can do that. So here you have a beautiful dissociation, you have part of the visual system that mediates a zombie behavior that's intact, yet the other part of this system that mediates the conscious sensation that they can actually see this glass of water, that is destroyed in this case.

ROBERT KUHN: So they can't see the glass if you ask them, "do you see a glass?"

CHRISTOF KOCH: Correct, they cannot see it, yet they can still do certain highly trained, highly trained behaviors like taking it and, and, and, and drinking from it.

ROBERT KUHN: And so your, the point is that the zombies into conscious of that, the zombie part of the brain is not conscious but is still able to do what looked like sophisticated things.

CHRISTOF KOCH: That's correct, and there's a whole range of these systems inactive that move your eyes, adjust your gait, that, you know, when you shake somebody's hand…

JOE BOGEN: Let me, let me just say one thing. You've gotta understand that using the word zombie this way, right, is a marketing ploy.

LESLIE BROTHERS: Yes, that's what I was going to say, a concept like zombie is a creative game that we play with our everyday notions of people, it's the body without the mind, it does all the things the bodies do without the subjective locus of experience, but that person concept is fundamental, and each of us has it. For example, when I look at what's on this table I believe that I am, seeing, having my experience, I don't think I'm having Christof's experience, that's part of my concept of myself.

ROBERT KUHN: **D**oes the concept of zombie help us understand consciousness?

CHRISTOF KOCH: Yes, because if you look at the, at the brain basis of this, so if you can identify what brain part, what part of the brain or what brain systems are responsible for mediating unconscious behavior, zombie behaviors, call it whatever you like, what part of the brain is responsible for mediating unconscious behavior, and compare that with part of the brain that is responsible for meeting let's looking in your brain or in animal brain when you or when the animal does a conscious act and when it does unconscious acts, where is the difference, is it a special type of neuron involved, it's, it doesn't behave in a particular way, does it look different, those questions we can ask.

ROBERT KUHN: Different systems involved.

LESLIE BROTHERS: Again, assuming that all conscious and unconscious acts as though they are two kind of separate categories, that there is a category of conscious acts. It may be that visual awareness, being awake as opposed to asleep, being in a light state of anesthesia as opposed to being fully awake, feeling toothache pain, these may not be unified in any overarching way.

CHRISTOF KOCH: **B**ut biology has shown, the history of biology in the last 150 years has shown that there for all, for every specific function that you can identify, there's always one or more specific gadgets, specific molecules, specific, you know, molecular machineries, specific nuance, specific cell that carries out its function, that's just, I meant that's how biology works.

LESLIE BROTHERS: So for each of these forms of engaging with the world, visual awareness, or being awake, or being attentive may have their own specific systems, it's not to say they don't have systems and each of these could be elucidated, the question is, is there some overarching system.

JOE BOGEN: My answer to that is, you bet you there is. But, but let me come back to, are you really interested, I mean that's my answer, we can talk about it some more, but what about, you want to talk more about zombies or are you done with that?

ROBERT KUHN: Well I think we're pretty much done with zombies

JOE BOGEN: Can I say one thing, you certainly have not made it clear for an ordinary audience about zombies. You got the Hollywood zombie, you got the Haitian zombie, you got the philosopher's zombie, and you got Christof's zombie

ROBERT KUHN: I like, I like Christof's the best.

JOE BOGEN: Well, Christof's is a very different from all of the rest. So when he uses the word, he's going to stir up in people, thoughts which are not relevant to what he's talking about, and that's the problem.

ROBERT KUHN: That, that's a good point.

CHRISTOF KOCH: Am I being deconstructed?

STUART HAMEROFF: You have to be careful about not confusing attention with consciousness because it could be that, that our sensory inputs give us this, kind of this, this slate that is really not conscious until other systems like the colonurgic system come along and select for attention, for conscious attention, particular subsets of that wide screen.

ROBERT KUHN: Stuart, I have to ask you, you at this table literally have your hands on consciousness, you're in the operating room, you see it go down, you see it effectively disappear, and then you bring it back. What can you tell us?

STUART HAMEROFF: Well, it's amazing thing, even though I do it daily, I still wonder, you know, where my patients go, but then it makes me wonder why are they conscious in the first place, you know, and of courser I am very happy to have them come back every day.

ROBERT KUHN: I hope you also think bout the mix of gasses at that time.

STUART HAMEROFF: Well of course, but in fact it's interesting
because the gasses that go from the circuit into the, uh, lungs and into the blood and into the brain don't form any chemical bonds at all, they actually form very weak quantum mechanical forces and that's all they do.

CHRISTOF KOCH: Well no, that's not quite true, there are some that go to very specific…

STUART HAMEROFF: I'm talking about gases, I'm talking about the gases.

CHRISTOF KOCH: But some of them go to very specific receptors.

STUART HAMEROFF: And they form quantum mechanical forces only, they don't form any chemical bonds whatsoever, they don't form any ionic bonds, it's strictly quantum mechanical, which implies that what they are interfering with, what they are erasing, consciousness involves uh quantum mechanical interactions.

ROBERT KUHN: It wouldn't have to do that. It could just be creating something at one level which affects something at another level that has nothing to do with quantum mechanics.

STUART HAMEROFF: **W**ell I disagree with that.

ROBERT KUHN: I'm saying, I'm, I'm not saying that what I said was correct, I'm saying that what you said doesn't necessarily follow.

STUART HAMEROFF: Well I think it does, Robert, because I think…

LESLIE BROTHERS: You have to be careful to say, you have to be careful not to say, if nobody knows, it must be quantum mechanical, because they're both black boxes, they must go together.

STUART HAMEROFF: Well, that's true, the confluence of mystery theory. But what I'm saying is proteins changing their shape depend on quantum mechanical forces in these pockets inside the proteins, anesthetics get in there, form their own quantum mechanic reactions and prevent the protein from working.

ROBERT KUHN: Suppose that's true, so what? What follows?

STUART HAMEROFF: **I**t implies that there's a quantum coherent state among these proteins throughout given nerves and given systems.

JOE BOGEN: You can say that of the liver, couldn't you?

STUART HAMEROFF: No.

JOE BOGEN: Why not?

STUART HAMEROFF: Liver function is not inhibited by anesthetics.

JOE BOGEN: Well all right, that's a good answer.

ROBERT KUHN: Okay let's talk a little bit about the social brain because we as individuals define ourselves, as you said, we only know what we know, I don't know what you're thinking. So what is it about the social relationship among people that helps define who we are?

LESLIE BROTHERS: I think you can think of it like language, language is a system that is outside of us essentially, but we all participate in it, and our brains seemed to be well adapted to do it. And I think that's the same thing with the social system that I'm talking about, the person system, where I am a person with a mind, you are a person with a mind, and our brains are well adapted to essentially to perceive both ourselves and other people as persons, that is, bodies with minds. in a sense what gives us the feeling of unity is that each of us has, and I will call it an illusion, that there is a source of perception, feeling, awareness that resides in us.

ROBERT KUHN: The I, capital I.

LESLIE BROTHERS: The I, doesn't mean that we have to be self consciously reflecting on the self, that's something else. But the sense that my experience somehow emanates from me or belongs to me and I believe that Robert has experienced, Christof, each other person here has experienced, I believe that that's an illusion, if you like, and that we participate in that in a sense in the same way that we do in language.

JOE BOGEN: **S**omething that we really need to say here. Number one is, is there such thing as consciousness and you have some reservations about that, but you're kind of willing to go along.

LESLIE BROTHERS: I'll play the game.

JOE BOGEN: Step number two is, where does it come from, and, most of us here, we believe that brains produce consciousness, all right. Now the question is, at what level, and where are we going to emphasize our searches, we can look at the subcellular level, at the cytoskeleton, the microtubules, we could look at the cellular level, some people think that there's some cells which are conscious and other cells are not conscious, or have the capacity for it. You can look at the circuit level, that's what I happen to be interested in, I happen to believe that consciousness emerges at the circuit level. Or you could do, like some people who think you have to have big, great systems that, before you have consciousness. And then there's some people who think you have to have the whole brain, and, and only whole brains can be conscious.

ROBERT KUHN: And some people think that you need more than the brain.

JOE BOGEN: Yes, some people don't want to use the word consciousness unless you have the, a brain interacting with a lot of other brains. I don't, I'm not very happy with

that because I think that a totally isolated individual, a cat or a dog that never saw another cat or dog can experience pain and hunger and thirst.

ROBERT KUHN: But first of all, don't we find this to be absolutely fascinating that we go from one level of subcellular, to cellular, to systems of neurons, to connections, to brain systems, to whole brains, to beyond. Is that to stay to play today?

STUART HAMEROFF: **Y**ou started too high, substrate, proto consciousness, something from which consciousness is derived, is fundamental and irreducible, a component of the universe that's been there all along, something like spin, or charge, or mass, it's down there probably at the most basic, uh, fundamental level of space time geometry, it's probably been there since the big bang.

CHRISTOF KOCH: Okay, that's a mystical statement that is totally untestable, I mean, you know…

STUART HAMEROFF: Christof, nothing you've said so far is testable about consciousness.

CHRISTOF KOCH: It's untestable, no, there are lots of exponents, you can do in mice, you can do in monkeys, you can do in humans, that's what progress is, progress is not at, all these fundamental, so I mean, I think for the record, the experimental program, many people are doing now is to avoid all these philosophical arguments because otherwise we will be sitting here 100 years from now having the same, and just focus on where in the brain are the correlates for certain emotions…

STUART HAMEROFF: Oh, correlates, so you're going to give up on consciousness and just worry about correlates.

CHRISTOF KOCH: For the foreseeable future because we have not made any progress, philosophers and scientists have not made progress…

STUART HAMEROFF: **B**ecause you're tunnel visioned, you're just looking in one direction, you're looking under the lamp post for the keys cause that's where the light is.

CHRISTOF KOCH: Okay, possible, but, but the way we will undoubtedly make progress, if you look at the spectacular progress in molecular science and neuroscience, so if we just focus for now, you know, for the next let's say 10 or 20 years, most of us will focus, you know, that's where the funding is, that's where the interest, ideas are, that's where the experiments are, we'll focus on the experimental approach, where are the correlates of specific conscious, perception, acts and memories.

ROBERT KUHN: What about animals, we've touched, we've touched…

JOE BOGEN: Let me just say something that is crucial when it comes right to animals. From my point of view, this is how I look at it, okay? If you think that consciousness is produced by a brain, then you say to yourself, which parts of that brain are more important in production of consciousness than other parts? Unless you're one of those people who thinks it takes the whole brain, which I don't believe for a minute and I don't think anybody here does. So the question is which parts of a brain are the most important, and how do you decide. You see which parts of brain you can take away and the person, or the cat or whatever it is still conscious, okay? And which parts do you have to leave there unimpaired for the creature to be conscious.

ROBERT KUHN: And you in fact can lose large parts of your brain

JOE BOGEN: The fact of the matter is you can take out great cups fulls, there are two places where you can make little teeny, the size of a, the head of a kitchen match, and a person is going to be totally unresponsive.

STUART HAMEROFF: But that doesn't mean they're not conscious, because that could be attention if you're talking about the…

JOE BOGEN: Now wait a minute when we're trying to decide if somebody is conscious, we never see conscious, consciousness is like the wind, you don't see it, what you see are the effects of it…

STUART HAMEROFF: You can't measure consciousness, Joe.

JOE BOGEN: No, you're trying to determine the level of consciousness.

CHRISTOF KOCH: **Y**ou asked a question about animal, animal consciousness so most of us, at least most biologists would assume that we are all nature's children, in other words most biologists would assume that a rat and a cat have some sensation, they might not know who they are, they might not know about death, but they certainly have pain and pleasure and sensation, you can see that. And so if that's true you can now do popular, many experiments of the type Joe that was suggesting where you go in either with a surgeon's knife, or today using molecular techniques, using molecular knockout or knock-ins, where you can manipulate the brain and study is this mouse still capable of doing certain things that in humans requires conscious behaviors.

ROBERT KUHN: You say knockout, that, that means eliminating some genes so it doesn't have a certain function and then you see what it does when it doesn't have that function.

CHRISTOF KOCH: Exactly.

JOE BOGEN: Turn it into a zombie, if you're lucky.

LESLIE BROTHERS: Zombie mice!

CHRISTOF KOCH: Zombie mice, that's exactly the point. That is an experiment of feasible proportion

LESLIE BROTHERS: That's my question.

ROBERT KUHN: We converge, we converge on zombie mice.

CHRISTOF KOCH: I can tell you, I can tell you exactly why because if you are zombie there are many things that you cannot do, you don't have access…

LESLIE BROTHERS: **H**ow can I tell a zombie mouse from a non-zombie mouse?

CHRISTOF KOCH: Because the mouse is not able to do, just like in a human, is not able to do certain types of planning, it cannot do, for example, it doesn't have access to long-term memory, so in humans you can see…

LESLIE BROTHERS: Well, that's a mouse without a memory and a mouse without planning.

CHRISTOF KOCH: **Y**ou do exactly what you do in disease, let's say you're trying to study a mouse model for autism or a mouse model for schizophrenia, you establish a few, you know, relative facts in humans that have autism and normal humans that don't have autism, and you try to replicate the same phenomenology in mice, you can do the same thing consciousness…

LESLIE BROTHERS: Well you have to be careful, you might end up with some beautiful mice that won't be able to remember or won't be able to plan, but it doesn't mean that you can then say, you can generalize from them about zombieness, about consciousness, about the human consciousness.

CHRISTOF KOCH: You have to be careful, I totally agree, but the history has shown in the last 50 years that if you do this carefully, molecular biology works.

ROLBERT KUHN: What is it that we can see about brain systems and how they work together and different things in the brain that you are working with that can help us make progress?

CHRISTOF KOCH: Usually people take visual illusions, but it doesn't have to be visions, they are just very convenient, and folks, I mean you have an illusion where

sometimes you see something and sometimes you don't, either you can see a vase or you can see two people looking at each other. One very popular technique involves studying, okay, so you're consciousness switches constantly, you either see people or the vase. Where are the neurons that are involved in this switching? If they are the ones that generate my consciousness then they should show the same switching dynamic as my conscious perception.

ROBERT KUHN: Because that's exactly what we're seeing, we're seeing an image in one way or the other, so if you can find the neurons that are doing that, at least we know those neurons are involved in consciousness.

CHRISTOF KOCH: Exactly.

ROBERT KUHN: **H**ow does consciousness impact our sense of humanness, or does it? Is it relevant?

STUART HAMEROFF: Okay, I got an answer.

ROBERT KUHN: Go ahead.

STUART HAMEROFF: What was the question?

LAUGHTER

STUART HAMEROFF: I think it depends on how you look at consciousness, if it's epiphenomenal, which I think Leslie maybe…

ROBERT KUHN: It's artificial, in a way.

STUART HAMEROFF: Then it doesn't, however if it's causal, if it's something kind of unique and, and has a fundamental role in the universe, then we're not merely helpless spectators, we actually have something like free will and causaul efficacy in this world.

CHRISTOF KOCH: Whoa, wait, okay we jumped several levels there, I mean consciousness and volition are two _____ subjects, they might or might not relate, I don't see that they have to relate, you can be perfectly conscious, consciousness can perfectly well exist, and free will might be an illusion.

STUART HAMEROFF: I don't think so.

JOE BOGEN: No, no, usually consciousness has two aspects, it has, had for a long time. And that doesn't mean you can't separate them but they usually are together, one is the awareness thing that it's on the sensory side, we have quali. The other thing is that

we've, we had volition, that we, that we do some things consciously rather than automatically, okay. So that's another, that's the other side of consciousness, that is that we had, we have a conscious…

ROBERT KUHN: And both are intrinsic to our humanness.

JOE BOGEN: Well yeah, but they are intrinsic to cats and dogs too, I mean what makes humans special is not being conscious, I mean, aren't we all agreed about that or are we?

STUART HAMEROFF: It depends if you believe in free will. I think the best model for volition…

CHRISTOF KOCH: Well, cats should also, can also have free will…

STUART HAMEROFF: Well, we don't know that it doesn't.

JOE BOGEN: Cats do things deliberately, dogs make up their minds, what, I don't understand what you…

ROBERT KUHN: Stuart, in a hundred years are you going to use the word "consciousness?"

STUART HAMEROFF: That could be, if I'm still alive. That could be a copout, cause life could be a quantum coherent state.

CHRISTOF KOCH: That's a meaningless statement.

STUART HAMEROFF: Let me talk about volition because choice is something very important, and the best way that I understand it is through this quantum paradigm. Quantum computing is coming along like a freight train, I think it's going to really revolutionize information technology. Utilizes the property of quantum super position in which things can be in multiple states at the same time, so whereas in a classical computer we have bits of **1** or **0**, in quantum computation we have cue bits of **1** and **0** for example which communicate. So let's say we're making a choice, we're going to decide what to have for lunch: spaghetti, pasta, sushi whatever. One possibility is we have a quantum super position of all these possibilities that then collapse, collapse of the wave function to the specific choice, I'll have sushi.

ROBERT KUHN: A lot of concepts there. [OVERLAPPING]

CHRISTOF KOCH: **T**his is what people know, this is what Gell-Mann described as quantum mysticism, you, you're using these words, there's no, the brain, the brain…

JOE BOGEN: Let me, let me follow-up what he just said, get back to the question of will, okay, free will, whatever you want to call it. And it has specifically connected with what Christof said. Some things you do you take responsibility for, you say, "I did that." Other things, like dropping something for example, stumbling, or somebody elicits reflexes from you, you don't take responsibility for that okay? And in fact there are certain conditions which he mentioned and to which you eluded where human beings have some brain damage, they do some things that they don't feel that they did it. So what we're talking about is the conviction of volition, the feeling that you did it, okay. And you can take exactly the same outwardly observable behavior, okay, a knee jerk, or turning the head to look at something, whatever you want, and sometimes it is volitional and sometimes it is not. And what makes it volitional is the person saying, "I did that I, I am responsible for the knee jerking or for the foot kicking or for the head turning, or whatever." That feeling on the part of the individual, that they did it must have some physiological correlate in the brain of that person, and that's what you want to go looking for. So when you have a situation where you can do it either volitionally or automatically, what you want to know is what's the difference in nerve cell activity that characterizes that conviction of volition.

ROBERT KUHN: Well said.

STUART HAMEROFF: How do we know that difference isn't happening?

ROBERT KUHN: I want to ask a final question for everyone, and this is as if we were here 100 years from now discussing the same subject. Where will we be at that time?

LESLIE BROTHERS: We'll find out that we had to leave behind the ideas that we were going to discover anything about the human feeling of being aware, we're going to leave behind the idea that that was to be discovered at the level of the subcellular, the cellular, the neuronal, that all of those were too low, and that while we use the techniques that we had to look at these low levels, ultimately we had to be able to understand the brain in its highest and most complex kinds of cognition and the interaction of brain and brain, social systems, at that high level of complexity to understand the phenomenon.

ROBERT KUHN: Joe?

JOE BOGEN: I think it's going to take 100 years for people to accept what I already believe.

ROBERT KUHN: That's it, that's the show.