Matthew P. Walker is an assistant professor of Psychology and Neuroscience at the University of California at Berkeley. He has received several honors and awards from institutions such as Harvard and the National Academy of Sciences for his work in neuroscience and psychiatry. Dr. Walker's research at Berkeley is focused on sleep and the brain, using tools such as functional magnetic resonance imaging (fMRI). His research investigates the role of sleep in human society and its relation to memory processing, brain plasticity, and learning. Furthermore, this research explores the impact of loss of sleep and how it correlates with mood disorders, such as major depression and aggression.

Matthew Walker

Interviewed by: Alexander Gagnon, Tiffany Horne, Stacy Hsueh, Mio Kitayama, Barry Ko, Felicia Linn, Michael Moses

SJ: Your research is very interesting, could you maybe say first off what kind of opportunities there are for undergraduates to research with you?

Walker: Sure. I actually just moved my lab here from Boston in the past September [2007], so my lab is not fully built, so now the opportunities are a total of zero, since I haven't a lab. But it will arrive, it will be built, in August. At that point we will be looking for bright but committed people, because sleep research—unlike some other aspects of psychology where you can pull people any time of day to sit them down and do some tests, stick them inside a brain scanner, monitor brain activity, etc.—we tend to be much more intensive. They have to come in and get wired up to electrodes, have their whole night recorded, or we deprive them of sleep completely and keep them up all of the next day, take them out on walks, you name it. For people that get involved, it's a weird type of involvement, that requires so much more than just, you know, okay you're going to be testing subjects between four and six P.M. and everything is golden after that. But hopefully what they get is something a little more rewarding, because they are seriously immersed in the research. So they have to be very interested in sleep, to the point of irony because what you end up trying to study is the same thing you have to deprive yourself of to actually understand what it is you are trying to study. There's this delightful paradox in the whole world of sleep research. But we think it's very exciting and I'm not trying to be arrogant, but we tend to be idea rich and hand poor, meaning we usually have many more ideas than we have people to carry out our ideas. So, the more people we can get interested and bring on board the better.

BSJ: Mostly as subjects?

Walker: Well definitely we need them too, but the nice thing is that we pay rather handsomely. Some of you guys will deliberately go without sleep for a night for whatever reasons you've got, and we'll pay people anywhere between $80 and $150 to stay up all night. If they want to complete their essay in that time, they are going to do anyway so why not get paid for it? And then we'll just, well, use and abuse you in psychological terms, stick you in brain scanners and such, but that's a small price to pay. So that's where we are at in terms of the lab and where it's set up, so come August we'll hopefully be firing on all cylinders.

BSJ: Unlike the brains of the people you will be testing.

Walker: Exactly.

BSJ: I recall from your interview with 60 minutes, the French girl they kept showing, I think that was from another lab. Well she could barely respond to anything, her brain was just not working.

Walker: The odd thing was that at the time, and this is one of the nasty hallmark features of sleep deprivation, is that if someone were to ask you how you thought you were doing on this task, you would say, "well, I'm not doing great but I'm doing okay," but yet your performance is horrid. Your subjected opinion of how you are doing is at odds with objectively how your physiology is behaving. And that's nasty because people will get behind the wheel and they'll think, "Well, I know it's four o'clock in the morning, but I'm just going to have a cup of coffee and I'll be fine" It just does not work that way.
So don't rest on your judgments, its a very bad idea. What's great is that to everybody else whose had a good night of sleep, and you are a good example of that just watching that person on TV, she's saying, "I feel okay," and you are looking at her thinking, "You are Jello upstairs!" There's nothing going on that is cognitive or rational in [her] brain right now but yet [she] think[s], "I'm going to be okay."

BSJ: The problem is, I remember hearing, that it's cumulative, right? The first night you may be a little messed up but as the nights go on you sleep less and less, your function just declines.

Walker: Yes, that's the nasty thing. With sleep deprivation, most everybody knows for the most part your performance is not going to be good, but let's say that if we just took the three of you and for seven days we had you short sleeping for say, five or six hours a night. Now instantly what's probably going on in your head is, oh my goodness he's saying five or six hours a night, that sounds like a normal amount to me. Wrong! Let's stop that right there. That's a curtailed amount by any means. And as you go through that, as you keep accumulating what we would call "sleep debt"; the first night you lose two hours, the second night now you are down four hours, six hours, eight hours, etc. You would think that how badly your performance is suffering relative to total sleep deprivation is going to be completely different, because when you are totally sleep deprived, when you haven't slept for thirty-six hours versus when you are cut five nights of just six hours per night, you are going to be completely different. But it turns out that after about eight nights of sleeping for six hours you are as bad as you would be after not sleeping for thirty-six hours totally.

BSJ: Wow that's horrible.

Walker: And we kind of giggle and laugh but what's interesting is that there are people out there right now—probably a lot of your student colleagues—who have not just been sleeping for six hours five nights, but who may be sleeping only six hours a night for the past two or three years. I don't know how it works, but my suspicion is that people are not getting enough sleep. What's the most worrying about it is that you say, okay, so maybe I'll do what I call sleep bulimia, which all of you suffer from by the way. During the week when you've got classes, you just try and hang in there and get five or six hours, and then you come to the weekend and you binge right? You have that bulimia type condition but with sleep, and so you well at least I can pay back what I've lost. But what we find is that after two nights of all the sleep that you want after being sleep-curtailed for a week, your performance is not back down to where it would be baseline before coming into that study. So let's say that for two weeks prior to the study we had you all sleeping for eight hours, and then we test you for a baseline, and you've got good performance. Then one week of short sleeping: you get worse and worse. Then we give you two full nights of all the sleep you want and you don't get back to where you were at the start of the study. So at least for these kinds of studies two nights is not enough to get back short-sleeping.

It's the same with memory actually. We'll come on to discussions of memory I hope. What we've been finding is that when you learn new material, if you sleep after, you get a benefit to memory. And we can talk about the type of benefit you get. But what happens if you learn new material, then you don't sleep, i.e. you pull the all-nighter, but you know the weekend is coming, and you're gonna have two or three nights of recovery sleep? Well, if we bring people into the lab and we do that same thing: we teach them new material, then we deprive them the first night, then they have all the recovery sleep they want on the second and third night and then we test them, and they show no evidence of any benefit to memory, which tells you that if you don't sleep within the first 24 hours after learning new memories, you lose the chance to hang onto them. What it tells you though is that sleep is not like the bank; you've got to get that out of your head. You cannot accumulate a debt and then think that you can pay it off at a later point in time. Sleep in terms of these cognitive processes is an all-or-nothing event. "If you don't snooze you lose," I guess is the take-home message there. It's a really odd notion that all of us—and I'm just as guilty as anyone else—that sleep is this kind of disposable luxury. That, you know well: if there's one thing that can go, then it can be sleep.

BSJ: That's the way I look at it all the time.

Walker: It's this odd thing because we are the only species on planet earth who think that ridiculous, idiotic way. Because human beings are the only species that will deliberately deprive themselves of sleep. Every other organism that sleeps will not do that. So, presumably they've got it figured out. I mean they are far more intelligent than us because they know that you just don't do that.

BSJ: They don't have any papers to write.

Walker: But you know if you get a good solid sixteen hours everyday, what's with that deal? What's bad if I gave you a paper to write?

It's particularly in industrialized nations; we think of sleep as a like a luxury that you can choose or choose not to engage in with no ramification whatsoever. At some point what's going to happen, and I think were getting close to it, is that the system has some play in it. Maybe the system has some coping mechanism to survive on seven hours for a while, but then at some point the less and less you sleep, and society over the last 100 years has shaved off about an hour and half of sleep. We used to be sleeping about a little over eight and a quarter hours, and as a nation now were down to now below seven hours on average, and if you look at the coastal regions—east and west coast—that figure is actually even lower. The band is stretched. Soon—and we may already be seeing the consequences—its gonna snap, and I would actually argue that we are already at the snapping point, because if you look for example at things like obesity, sleep is being now I think linked, without a doubt to changes, in the metabolism. Again, if we put you on five hours of sleep for two weeks, your ability to clear your glucose is that impaired that you look pre-diabetic. If you went to your doctor at that stage, you'd be classified as pre-diabetic. It does terrible things to appetite and obesity. Is the country suffering from an obesity epidemic? I'll leave the answer up to you.

We're starting to understand a bit more about sleep in terms of emotional regulation. There's a reason you have the emotional stability of Britney Spears when you're sleep deprived, and we've got some very good evidence as to why that is in your brain. If you believe the news reports—and I don't know if I do—about just simply anti-social behavior and aggressive behavior in the human being, you would be led to believe that it is increasing exponentially. Just in terms of societal behavior. So obesity, emotionality.

If you look at immune function as well, again if we put you on that system—not total sleep deprivation, just short-sleeping—your ability to mount an immune response to the common influenza A virus, which is just a flu shot: slashed in half. If you look at rates of just admittance for infections in hospitals, it's increased significantly as well.

Now if you plot all of these things: aggressive behavior going up, infection rate going up, obesity going up, and then if you plot again on that same graph the amount of sleep, the amount of sleep has just gone down. And I don't think that those three things, in terms of things going up and sleep going down, are coincidental. I think they are perhaps causally related. So we can go well beyond the research that we do, and think more globally about what this sleep deprivation pandemic is doing, and I would argue it is catastrophic, absolutely catastrophic.

BSJ: Do you think that there's a self-regulating mechanism; that people will eventually start sleeping more once they reach this snapping point?

Walker: I would like to think they do, and the one thing that makes me think they won't is that everybody always keeps asking me when are the drug companies gonna make the pill that will allow me never to sleep. And at that point I don't even know how to react to the question, because you have to remember that in every species that we've studied, that we've been able to record, sleep is prevalent. Even now in fruit flies, if you can believe it: fruit flies sleep. And they have a rebound, they get all things in their brain and downstairs in their body go wrong when they don't get sleep. When this works through down to humans and primates, what that means is that if sleep has fought its way through each and every one of those evolutionary steps and all those biogenetic levels, sleep has to be at the most basic biogenetic level: utterly, fundamentally important.

That is the best evidence of any process, of anything I can think of that has reviled through evolution. Evolution is pretty harsh, and so if it remains with us, it tells me that it is of the utmost importance. And to think that you can get away [without sleep] by taking some simple pill that will get over all of the need for sleep... I understand why people as that question, but simply glossing over the complexity of what this thing called sleep is... I don't think human beings will appreciate it unless we get the word out (and I don't think research does it). I don't understand why human beings have such a profound ignorance to sleep.

BSJ: Hm... We all know why we don't sleep, but we don't realize what we lack by not getting sleep. It seems that since there is such a need for sleep, why aren't we doing it? Because we have all these social concerns that keep mounting, and there is more and more of them every year.

Walker: So, I'll give you a quick experiment. One last thing to note: of all the things we will talk about here for the most part in terms of functions of sleep and benefits of sleep is

everything your mother has told you. Turns out all I am doing in my research is just adding imperical data. So you've got a problem: “Well stop thinking about it, sleep on it.” You've got an emotional concern: “Things will feel different tomorrow.” Even being sick: “Well are you sleeping enough?” Your mum knew it all!

I say this in part for effect, but actually these are all clichés. And the reason a cliché is a cliché, is that it tends to be true. And, goodness me, mothers are pretty sharp judges of biological and psychological processes.

...So I was going to say something in response to [your comment], you can tell that I haven't got enough sleep because I have completely forgot. Well I'm sure it will come up again.

BSJ: One of your papers referred to the hippocampal region in the brain and how that was affected by sleep deprivation. Could you elaborate on that and why the hippocampal region is so integral compared to other regions.

Walker: Let's back up for a moment. When you think of sleep

as important for memory, it is a little more complex because we actually have different types of sleep, we have different types of memory. For example, the type of memory you have to ride a bike is different, located in a different part of the brain than memory for facts. One is more explicit to you, one is more implicit, more conscious.

For example, if I asked you, "How do you turn a corner [on a bicycle]?" Simple question, right? Most people would say, "Well I'd just turn the wheel." If you turn the wheel, you'll fall over. What you actually do is lean. These are all skills you learn, learn being the operative word, and when you learn something you form a memory.

Firstly, I just stated as a general thing when we say that sleep is connected to memory, don't just think of it as, does sleep helps with textbook learning? While that may be the important thing to all of you guys right now. It turns out that you as a human species basically there is so much more to it than that. That is just probably the tip of the iceberg in terms of your repertoire of learned information.

But let me get back to that question. You can ask about the ---role of sleep in two places: Is sleep important after learning to consolidate and sort of solidify those new memories? When you first form a new memory, its not like a Polaroid snapshot, its not done instantly. New memories actually take a long time to become stable, and if you don't stabilize them somewhat quickly, then they can get overridden or destructed by new memories coming in. One memory can get knocked out of place by the second. Newly born memories are fragile and you have to go through this process of memory consolidation. It is this off-line process where the brain seems to build new connections and synapses to complete the circuit. So we can see that when we ask do we need sleep after learning, the answer seems to be "Yes!" And for different types of memories too.

What about sleep before learning? OK, so I attended Professor Walker's class today and was very attentive, which P.S. Is not going to happen... I was really attentive, I learned a lot, I'm going to sleep well tonight. But what happens when you hadn't sleep well the night before coming into the class? And, it turns out that you do need sleep, not just after the learning, but also before. [T]ake two groups of college undergraduates, one that you deprive of sleep and one that you give a full night of sleep to, and then you try and have them learn a whole series of words or pictures on a computer. Firstly, what you find is that those who are in the sleep deprivation group are about forty percent worse at making new memories than those that have had a full night of sleep.

You can say, "Well, what does that mean?" Well that is the difference between acing a midterm exam or failing it miserably.

The question from a scientific perspective is, "What's going on in the brain?" Is it that you are just so sleepy that you just can't attend to the information. [Is it] your memory circuits are working just fine, it's just simply that the brain can't focus down on it, or is it that your memory circuits are actually failing.

Now the one structure in human psychology that has been associated with forming new facts and new pieces of factual information is the structure called the hippocampus – which is just actually a Greek name for seahorse – when you slice the brain up, it kind of looks like a seahorse, the hippocampus.

And the structure has been well known to be important because if you damage it, for example, if you suffer from herpes encephalitis, which will actually attack the area, or if you have brain trauma, damage to that part, or if you have intractable epilepsy, which tends to occur in little champagne bursts of epileptic activity; they will commonly occur close to that region, and when these people cannot be treated, neurosurgeons at a last gasp chance go in and cut that whole part of the brain out, because it is so dysfunctional.

So in all three cases, the disease that attacks that structure, a traumatic brain event that damages it or a surgeon that cuts it out because of epilepsy, those patients, from that point forward, can never make any new memories. They all by all count are amnesic. You've all heard of these amnesic patients. The best example of that is the movie, Memento. It is a great documentary of exactly what happens when you don't have a functioning hippocampus – that guy had a hippocampal lesion.

BSJ: He was doing okay.

Walker: And so, what was most remarkable about that paper was that we affirmed for sure that people wouldn't be able to make memories as efficiently as they could when they have full nights of sleep, though we didn't expect 40% impairment.

But when we saw them inside the scanner when you actually were able to image the brain as they were trying to make new memories... So you can see which parts of the brain were involved in recording new experiences and you get that brain activity map of the control group and the deprivation group and you simply compare the two to see if there is difference between those groups.

What we find is that rather than finding gross deficits in concentration networks of the brain or nervous networks, there's

a very selective, highly significant impairment in the deprivation group right within that region of the hippocampus. I actually don't know if it's reversible; I don't quite know what I did to that group of undergraduates. I never tested them back when they had recovery sleep.

When we speak in neurology about the lesion, what we tend to mean is a structural problem in the brain, something has changed in the structure. What we are arguing here is that we can have what we call functional lesions, where the structure of the brain is presumably still intact, but the function of that structural piece of the brain actually goes awry, and that's what seems to be happening in sleep deprivation state. So sleep deprivation was actually almost attacking your memory structures and you just had far less activity in that region.

Theoretically its interesting to say but why would it have less activity, what's going on? And one theory is that that structure actually forms a short term relay station for gathering new information during the day, but then at night, what we've been discovering is that that structure actually plays out like a video tape at night its information up to the cortex, which is basically a hard drive of the brain. So the hippocampus is like the RAM that you can kind of load information up there quickly and manipulate it, but it has a limited storage capacity. Then at night, the hippocampus actually will replay its events up to your cortex like a ski gondola transferring packages of information, and so that you can kind of push them up and start putting them into long-term storage systems.

And they did some crazy experiments in rats, where they actually record the signature of memory in this hippocampal structure. Rats run around the maze and you hear the signature because they can sort of plug them in to different amplifiers to get sound from these cells, and so the rat runs around the maze and you hear the signature of learning these different cells popping as they code for where the rat is. So it goes "ba-ba-bum, ba-ba-bum," and what's crazy about it is when the rats fall asleep, and you keep recording, and what you hear is, "ba-ba-bum, ba-ba-bum." The rat is literally replaying what it's learned. It's insane!

So, coming back to how this affects the sleep before learning, though, what happens if you don't sleep? Well you don't get the chance to replay out up into the cortex. You don't transfer your information. So you come back the next day, and you've still gone a full buffer of RAM, and your cache is not being cleared from the computer. And so the brain is simply saying, I know you are trying to learn, but it's like a sponge, you haven't wrung me out at night, and so I'm still completely waterlogged with what I've been learning the next day and so there is no more room. So it is just like your inbox in the email is full. Until you delete some emails or, better still, store them somewhere else, I'm not going to be able to learn any more information, and I'm not going to switch on.

BSJ: So would you lose memory if your sleep got disrupted, when they are transferring the information?

Walker: It's a cute idea and nobody I know yet has actually tried at that version. With science you tend to lock on to a process and then to show that it's causal, you try to dial that process up or you dial it down and see does that consequence in the direction you predict. So I don't know anybody yet who's tried to deprive of that type of sleep to disrupt it, i.e. dial it down. What I do know is that we've been playing around is actually dialing it up.

So you can actually in a sense it's a bit strange but that specific type of sleep, which actually turns out as deep dreamless sleep when this replay goes on. You think it goes on during the Rapid Eye Movement, but it's actually not. What you can do, because these deep non-REM sleep is actually filled by those really slow, lazy brain waves, and you can strap electrodes onto people's heads, essentially wind them up to a Duracell battery and you can juice that frontal brain up with electricity. You can think of stream of waves, and what you are trying to do is not change how many waves there are on the sea, but you want to change the height of them.
The bigger those waves are, the more concentrated the sleep is, the more of the process of transfer of memory we believe goes on. When you do that to people, when you juice up the deep non-REM sleep, you improve their memory by almost double the next day.

BSJ: Where can I get one of those?

Walker: You can actually do it, and it's a really crazy idea, you can do it non-electrically. You can imagine that those memories are ready to be replayed at night, and they're being reactivated and replayed. Wouldn't it be great if there was someway you can kind of almost help that reactivation of the memory, you can kind of give the memory a bit of a nudge and get it going, kind of rev it up even more.

You know that experience with somebody walks past you and they have certain perfume or cologne, and its one you realize, and all of a sudden it triggers this context-dependent memory.
You get this whole flood of memories of that same event or person that's associated with the smell. So your memories are being cued by a smell. You sort of associate, it's kind of like the Pavlovian conditioning a little bit. You have an experience, Christmas in your house always has that certain smell of, lets say pine needles or your mum burning the turkey or something like that. What you do is you associate the smell

with the experience, and there's two get paired together.

What this [study] did, which is amazing, is that they got people to learn facts. They were actually learning a card game, where these cards were located in a spacial learning task. At the time they were learning, they had them put this face mask on, and profuse a rose scent into their nostrils, and so they would associate the learning with the rose scent. The most cool thing about it is that when they go to bed at night, they profuse the same rose smell, and what they found out was that they could reactivate that memory even more strongly. The group that had the rose smell at night, as opposed to those that didn't, had about a double increase in memory.

So now you're thinking I don't have a mask, I don't have any of that fancy rose stuff... All you need to do (perhaps, and I'm not advocating this) is just get a specific incense that you like, take your books, light it up, and just study. And before you go to bed at night, burn the incense. I don't know if it works...

BSJ: Have you tried it?

Walker: No, no I haven't.

So, what happens if you decrease it? We don't know the answer. What happens if you increase it? We do. The decrease is also interesting because the cognitive hallmark of getting old is bad memory. It turns out the physiological hallmark of getting old is bad sleep, and a specific loss of this type of sleep we're talking about. Maybe the experiment is done by nature, which is the relationship between sleep and memory. And we know that in aging you get bad memory and poor sleep. Putting those two together they tell a very suggestive story: which is that perhaps aging in part is a sort of sleep. The cool thing about that is that we know the other factors that cause aging are very hard to cure because it involves brain atrophy, changes in blood flow, a decrease in blood flow, these things in medicine we don't know how to solve yet. We don't know how to regrow those parts of the brain. We don't know how to get vasculature to regrow and innovate those regions of the brain. We do know, in very good ways, how to improve sleep in people who are aging. So its not just the potential, interesting cofactor that can cause aging. It's a factor that it's treatable in a way that other factors may not be. So maybe we should go after the aging question.

BSJ: What do you think about a subject who would have continuous sleep deprivation of five hours a night but perform that electrical enhancement every night as well.

Walker: It's interesting to ask whether you can increase quality and decrease quantity. For that specific function of sleep that might be possible. For memory, maybe you can do that and get away with it. My guess is that since sleep is not unifunctional, its multifunctional, that there are some things you just can't get away with doing that. So if you're willing to not suffer the decrement of memory, do suffer the obesity, the problems of metabolism, the lack of immune system, then maybe that's an okay recipe for you. My suspicion is that there is just nothing quite like natural sleep and a good amount of it. Understanding that even if you resurrect one function, you still don't know about the five or six others that we think sleep serves; and what you want to gamble on, that's a Vegas bet to me.

BSJ: How about people who are having trouble sleeping, sometimes taking medication like Ambien. How does that effect sleep? And what about the side effects reported on the news about binge eating or going out for a drive while you are supposedly asleep?

Walker: The newer medications, Ambien among them, are better than the old medication. The old medications were basically sedative hypnotics, and were classified as "sleeping pills". The state you would go into is hardly justified as sleep. These pills would just knock out your cortex and, I would suggest, take you into a state of non-consciousness. Notice I don't use the word "sleep" because the state you're in is not necessarily like sleep. and so you wake up the next morning thinking "wow I didn't wake up during the night," well you didn't because you were unconscious; but did you have a naturalistic sleep architecture? No, you didn't. These newer medications work in slightly different ways, but there are still some from the old path. I expect in the next five years there will be new medications that actually change how they act, completely different. They won't work by simply going in and completing its work in the cortex, but a virtually more subtle way, which is learning intricate sub-cortical mechanisms and chemistries that change the ballet across the night, of course, these different sleep architectural shifts. Since we know that, we can now create better drugs that do it much more sophisticatedly. So I think there is a hope we have in coming pharmacology that will put you into more naturalistic sleep.

As for now, the jury is out. It's surprising that only now, in 2008, are starting to ask all these functions, brain functions, that we know are dependent on sleep. When you take these medications, all those functions enhanced, unchanged, or impaired. And there is no literature out there in the scientific domain that will answer that question right now. The sleep part of your question we kind of know what the consequence of sleep is. The even more interesting part is then what's the consequences to what that sleep should be doing for you the next day. And if you are having an abnormal type of sleep because of the drug, will have abnormal brain functions the

next day.

BSJ: So we talked a lot about the causal relationship of sleep, memory, and learning. But it seems ambiguous in the scientific community, what are the physiological things happening during sleep? Why is this happening? What's going on at the molecular level?

Walker: What actually goes on in the brain, it's actually quite well known right now. So as you go deeper into slow-wave sleep, what we call deep non-REM sleep. I call it slow-waved because when you look at the brain wave patterns, the brain slows down and becomes very lazy and the brain waves become very large. And people have often thought about is the brain becoming dormant. That's the worst thing you could ever assume, because what those large brain waves mean is that massive groups of brain cells are all singing at the same time in unison. And thats why you get these huge brain waves.

Think about [a Cal football game], all the people to represent brain cells individually, and before the game if they're all talking to each other, saying different things at different times. You just hear noise, you hear no coherent message. But all of a sudden, the sudden the game gets going, and everyone is chanting "Stanford sucks!" and everybody is chanting it at the same time. Outside the stadium, you hear this really clear signal, this loud signal, this slow oscillation of a signal, it's exactly what's going on in the brain during deep non-REM sleep.

There is no other brain state normally that mimics that type of synchronized activity. Huge schlops of the cortex, all the certain start singing in time. It's for some purpose, kind of like this weird close encounter for the third time, playing back music that we don't know quite why, but it's probably very intelligent. And one idea is that the best way the cortex knows to start getting this part of the brain to be able to at least speak to this part of the brain in unison, and why is that important? Its probably important because when you form these different memories, you form them in different parts of the brain, and one thing that you may want to do to solidify it, is get them all talking together at once. What I mean by that is when you form a memory of this experience today, you're going to have a memory not just of the actual facts, you're going to have the memory of the sound of my voice, the weird accent, what I look like, what time of day it was, just all of these additional factors that form that piece of the

BSJ interviewers (from left to right) Barry Ko, Mike Moses and Alex Gagnon speak to Matthew Walker (left center).

memory, and different parts of your brain will store those different pieces of the puzzle.

And you could imagine that by getting the brain synced up at night, it basically like a group therapy session, where everybody finally gets in the same room and starts talking to each other, and by doing so, bonds together more strongly. So physiologically, we start to know what's going on and that gives us a model of prediction as to how that relates to cognitive operation. Actually, going into REM sleep, all things change. Now the brain becomes less synchronized—lots of different parts of the brain doing different things at different times. Some parts of your brain become thirty percent more active during REM sleep than when you're awake, which is odd because you're asleep.

BSJ: Yeah, some of those dreams are vivid.

Walker: It only took us about three centuries of research to figure out, that despite when we woke up we have all these crazy experiences, that our brain wasn't dormant. And if you're having florid hallucinations, you would imagine that this part of your brain that's floridly active , and that's exactly now what we're finding when we put people in brain scanners. So parts of the emotional brain, the visual brain, your memory structures, they all light up, but what's interesting is that your rational brain, which is called your peripheral cortex, left and right here, shifts down and becomes even more impaired in REM than in slow wave sleep.

So, your brain goes into this kind of hypersensitive, hyperemotional, but completely irrational network, and you would predict from that, if you built a computer system that what it would come up with is just utter fantasy—that's exactly what dreams are. So we're starting to understand, in the brain exactly what could be causing the cognitive changes both that come after sleep as a benefit, but also the cognitive operations that occur during sleep, i.e. dreaming. And that's amazing stuff, being able to understand the brain basis of dreaming. It's a strange state, for all intensive purposes, you all here will, tonight, become flagrantly psychotic. And you'll actually become psychotic many times. Now you may say, well that's a bit harsh, why am I going to become psychotic? I'll give you five good reasons. Firstly, you start to see things which are not there, so you are hallucinating. Secondly, you believe things that couldn't possibly be true, so you're delusional. Thirdly, you get confused about time, place, and person, so psychiatrically you're suffering from disorientation. And then next you have these wildly fluctuating emotions, dials going all over the place, again it's what psychiatrists call being affectively labile. Then what's cool is that you wake up the next morning and you forget most if not all of that experience. So, you are suffering from amnesia. If you were to experience any one of those five symptoms whilst you're awake, you'd be seeking psychiatric treatment, but yet for reasons that when now we're starting to understand, it seems to be a both normal biological, but also psychological, process.

BSJ: And its important in some way that's not completely understood?

Walker: Well, therein lies the trick. I would like to think it's important, and I'm desperately disappointed to think that dreams serve [no purpose]. In REM sleep, I think absolutely serves a function. But, dreams which come from REM sleep, maybe utterly depressingly epi-phenomenal, because we've gotten no good theory or data that suggests dreams are beneficial—we've got good data to say REM sleep is a beneficial physiological process, but dreams could be simply an offshoot.

BSJ: A waste of time?

Walker: Well, it could be entertainment.

BSJ: Yeah, like a relief from rationality.

Walker: Right, which is not the most daft thing. Liken it to a light bulb, for example, the reason that you create the apparatus of a light bulb, just like the way the brain creates the apparatus to generate REM sleep, is to create light, as is an apparatus in the brain to create REM sleep. Now it turns out a byproduct of creating light in that way, is heat, it's never the reason that you designed the light bulb, it's just what happens when you create light in that way. And so too, may it be the case of dreaming, that to actually produce REM, this thing that we call REM sleep, to produce it in a way that we just evolved to do so, as a consequence has this conscious bizarre off-spin, which is dreaming. And there may be no function, just like blood is red. The redness of blood has no functionality; it's a complete epi-phenomenon. We started to play around with it, because we can use it to actually fractionate how much oxygen, but it was never the purpose. I mean blood could be green and still serve its function. In fact, it's just the way that we see light through its frequency, to us it looks red—no purpose. Just like REM sleep may be useful, but dreaming not at all. Now I don't buy that.

BSJ: You think it's useful?

Walker: Well, if I put my scientific hat on, I absolutely have to entertain the possibility that dreams are epi-phenomenal. No doubt. As a layperson, if I take my scientific hat off, and I think, well, if this one thing that runs through my waking life it is my dreaming life. I never have people proving this beyond a doubt, I never have a veridical replay of what I experienced during the day, at night. It never happens, you

never actually replay what happened during the day, but there is something that is a red thread that runs through your waking life into your dreaming life, and it seems to be emotional concerns. And I think now, some of our new results are suggesting that REM sleep has a lot to do with regulation of your emotional brain. I mean, it's overnight therapy, essentially, during REM sleep. I think dreaming is a good place to start doing that. I think dreams in some way actually serve to try and understand your emotional circumstances, but also integrate and work through those problems. So when you come back the next day, you feel differently than you did the day before. You've had that feeling right, having this kind of emotional concern or problem, where you've got this emotional spike from yesterday. You know, you failed your exam or you got dumped or whatever. For some reason, it's not just time, when you come back the next day, life just seems a bit different after having slept. And again, it's in a way that having thinking about the problem in the morning and then thinking about it again in the evening after the same amount of time, say eight hours, it just doesn't do it. It's not time, it's sleep. And so, we're starting to argue that dreaming actually may be, and this is almost Freudian, that your brain basically red flags emotional experiences through the day and then what the dreaming brain does is basically look at your informational reservoir from that day and will pluck out all the things with emotional tags on them and it will start to try and process them and strip them down and maybe try to understand the information within it and strip away the emotion. If you cast your mid toward emotional memories, and it turns out that most of your old memories are emotional, what you'll realize is that you're remembering the experience now without the emotion. So at the time you had the experience it was a highly emotional experience, but over time, as you recall the experience you don't regurgitate that whole emotional tone within your brain and body. Somewhere between learning it and recalling it over time, your brain is holding on to the information of that experience, but doing away with the emotion. And thats a good thing, because if you don't you end up in a state of chronic anxiety.

BSJ: But people do have that.

Walker: And the best example of that is PTSD [Post-Traumatic Stress Disorder]. What you hear from these people is, "I just can't get over it." They just don't seem to be able to strip the emotional tone from the experience. They can't process it, integrate it, and come back the next day still feel disdain. Every time the relive that memory, they get that whole emotion all over again. And I don't think it is inconsequential that one of the diagnostic symptoms is lack of sleep and perpetuate nightmares. I would almost argue now is what happens at night is that they have this emotional charged memory, the brain offers it to sleep saying, "Please do your thing, strip it away, dream about it, smooth the emotional edges." For some reason that process fails, and we don't know why. So then what happens the next night. The brain goes, "Well, I've still got this highly charged emotional memory, please can you do something with it. Strip it down, smooth it off," and it keeps failing, and hence, becomes like a broken record. This explains one of the hallmark features of PTSD, and that is repetitive nightmares.

For all these reasons, I'd hate to think that all dreams are epiphenomenal. I don't know of any evidence to suggest, yet, they are not, but I believe that if they have a function, I think it is all about our emotional lives.

BSJ: It must be a lot more difficult to check the presence of dreaming in fruit flies?

Walker: Yea, you often get very short reports when you wake them up.

BSJ: I don't know how emotional they are either.

Walker: It'd be hard to imagine what an emotional day would be like to a fruit fly.

BSJ: What about the inherent differences in the need for sleep between individuals in the human population: duration, frequency? And how about the tendency of some individuals to not be able to sleep as well as others?

Walker: So there are two questions. One is if people can sleep, and you measure it, there is large variability. And the other is people need it, but can't seem to get it. We have much more evidence for the first part than the second part.

The first part, there is dramatic variability. There are people who seem to need maybe just six and a half hours and some people need nine hours. Need is an odd thing, because how do you measure need? But lets just say

In some people it makes sense. Some people will ask me, "What's the recommended amount of sleep I should get?" Its kind of tricky. Its like saying "How many calories do we need a day?" It turns out its just different to different people, it depends on your unique physiology. And so too is the case for sleep. Some people can achieve what sleep tries to achieve within six and a half hours. Yet, poor buggers like me who are completely inefficient need nine hours of sleep a night. Certainly what most groups have found, depending on what you are measuring down in the body and up in the brain, anything less than six hours is a huge red flag. That seems to be rather binary because the point, if there is one, is all or nothing. After six hours and above, where you sit on that spectrum really will just depend on how efficient you are at sleep.