TED talks for IELTS

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Chapter 1 Inside The Mind of A Master Procrastinator

So in college, I was a government major, which means I had to write a lot of papers. Now, when a normal student writes a paper, they might spread the work out a little like this. So, you know – (Laughter)

you get started maybe a little slowly, but you get enough done in the first week that, with some heavier days later on, everything gets done, things stay civil. (Laughter)

And I would want to do that like that. That would be the plan. I would have it all ready to go, but then, actually, the paper would come along, and then I would kind of do this. (Laughter)

And that would happen every single paper. But then came my 90-page senior thesis, a paper you're supposed to spend a year on. And I knew for a paper like that, my normal work flow was not an option. It was way too big a project. So I planned things out, and I decided I kind of had to go something like this. This is how the year would go. So I'd start off light, and I'd bump it up in the middle months, and then at the end, I would kick it up into high gear just like a little staircase. How hard could it be to walk up the stairs? No big deal, right?

But then, the funniest thing happened. Those first few months? They came and went, and I couldn't quite do stuff. So we had an awesome new revised plan. (Laughter) And then – (Laughter)

But then those middle months actually went by, and I didn't really write words, and so we were here. And then two months turned into one month, which turned into two weeks. And one day I woke up with three days until the deadline, still not having written a word, and so I did the only thing I could: I wrote 90 pages over 72 hours, pulling not one but two all-nighters – humans are not supposed to pull two all-nighters – sprinted across campus, dove in slow motion, and got it in just at the deadline.

I thought that was the end of everything. But a week later I get a call, and it's the school. And they say, "Is this Tim Urban?" And I say, "Yeah." And they say, "We need to talk about your thesis." And I say, "OK." And they say, "It's the best one we've ever seen." (Laughter) (Applause) That did not happen. It was a very, very bad thesis. (Laughter)

I just wanted to enjoy that one moment when all of you thought, "This guy is amazing!" (Laughter) No, no, it was very, very bad. Anyway, today I'm a writer-blogger guy. I write the blog Wait But Why. And a couple of years ago, I decided to write about procrastination. My behavior has always perplexed the non-procrastinators around me, and I wanted to explain to the non-procrastinators of the world what goes on in the heads of procrastinators, and why we are the way we are. Now, I had a hypothesis that the brains of procrastinators were actually different than the brains of other people. And to test this, I found an MRI lab that actually let me scan both my brain and the brain of a proven non-procrastinator, so I could compare them. I actually brought them here to show you today. I want you to take a look carefully to see if you can notice a difference. I know that if you're not a trained brain expert, it's not that obvious, but

just take a look, OK? So here's the brain of a non-procrastinator. (Laughter) Now ... here's my brain. (Laughter)

There is a difference. Both brains have a Rational Decision-Maker in them, but the procrastinator's brain also has an Instant Gratification Monkey. Now, what does this mean for the procrastinator? Well, it means everything's fine until this happens.

[This is a perfect time to get some work done.] [Nope!]

So the Rational Decision-Maker will make the rational decision to do something productive, but the Monkey doesn't like that plan, so he actually takes the wheel, and he says, "Actually, let's read the entire Wikipedia page of the Nancy Kerrigan/ Tonya Harding scandal, because I just remembered that that happened. (Laughter)

Then – (Laughter) Then we're going to go over to the fridge, to see if there's anything new in there since 10 minutes ago. After that, we're going to go on a YouTube spiral that starts with videos of Richard Feynman talking about magnets and ends much, much later with us watching interviews with Justin Bieber's mom. (Laughter) "All of that's going to take a while, so we're not going to really have room on the schedule for any work today. Sorry!"

(Sigh) Now, what is going on here? The Instant Gratification Monkey does not seem like a guy you want behind the wheel. He lives entirely in the present moment. He has no memory of the past, no knowledge of the future, and he only cares about two things: easy and fun.

Now, in the animal world, that works fine. If you're a dog and you spend your whole life doing nothing other than easy and fun things, you're a huge success! (Laughter)

And to the Monkey, humans are just another animal species. You have to keep well-slept, well-fed and propagating into the next generation, which in tribal times might have worked OK. But, if you haven't noticed, now we're not in tribal times. We're in an advanced civilization, and the Monkey does not know what that is. Which is why we have another guy in our brain, the Rational Decision-Maker, who gives us the ability to do things no other animal can do. We can visualize the future. We can see the big picture. We can make long-term plans. And he wants to take all of that into account. And he wants to just have us do whatever makes sense to be doing right now. Now, sometimes it makes sense to be doing things that are easy and fun, like when you're having dinner or going to bed or enjoying well-earned leisure time. That's why there's an overlap. Sometimes they agree. But other times, it makes much more sense to be doing things that are harder and less pleasant, for the sake of the big picture. And that's when we have a conflict. And for the procrastinator, that conflict tends to end a certain way every time, leaving him spending a lot of time in this orange zone, an easy and fun place that's entirely out of the Makes Sense circle. I call it the Dark Playground.

(Laughter)

Now, the Dark Playground is a place that all of you procrastinators out there know very well. It's where leisure activities happen at times when leisure activities are not supposed to be happening. The fun you have in the Dark Playground isn't actually fun, because it's

completely unearned, and the air is filled with guilt, dread, anxiety, self-hatred – all of those good procrastinator feelings. And the question is, in this situation, with the Monkey behind the wheel, how does the procrastinator ever get himself over here to this blue zone, a less pleasant place, but where really important things happen?

Well, turns out the procrastinator has a guardian angel, someone who's always looking down on him and watching over him in his darkest moments – someone called the Panic Monster. (Laughter)

Now, the Panic Monster is dormant most of the time, but he suddenly wakes up anytime a deadline gets too close or there's danger of public embarrassment, a career disaster or some other scary consequence. And importantly, he's the only thing the Monkey is terrified of. Now, he became very relevant in my life pretty recently, because the people of TED reached out to me about six months ago and invited me to do a TED Talk. (Laughter)

Now, of course, I said yes. It's always been a dream of mine to have done a TED Talk in the past. (Laughter)

(Applause) But in the middle of all this excitement, the Rational Decision-Maker seemed to have something else on his mind. He was saying, "Are we clear on what we just accepted? Do we get what's going to be now happening one day in the future? We need to sit down and work on this right now." And the Monkey said, "Totally agree, but let's just open Google Earth and zoom in to the bottom of India, like 200 feet above the ground, and scroll up for two and a half hours til we get to the top of the country, so we can get a better feel for India."

(Laughter) So that's what we did that day. (Laughter) As six months turned into four and then two and then one, the people of TED decided to release the speakers. And I opened up the website, and there was my face staring right back at me. And guess who woke up?

(Laughter) So the Panic Monster starts losing his mind, and a few seconds later, the whole system's in mayhem.

(Laughter) And the Monkey – remember, he's terrified of the Panic Monster – boom, he's up the tree! And finally, finally, the Rational Decision-Maker can take the wheel and I can start working on the talk.

Now, the Panic Monster explains all kinds of pretty insane procrastinator behavior, like how someone like me could spend two weeks unable to start the opening sentence of a paper, and then miraculously find the unbelievable work ethic to stay up all night and write eight pages. And this entire situation, with the three characters – this is the procrastinator's system. It's not pretty, but in the end, it works. This is what I decided to write about on the blog a couple of years ago.

When I did, I was amazed by the response. Literally thousands of emails came in, from all different kinds of people from all over the world, doing all different kinds of things. These are people who were nurses, bankers, painters, engineers and lots and lots of PhD students.

(Laughter)

And they were all writing, saying the same thing: "I have this problem too." But what struck

me was the contrast between the light tone of the post and the heaviness of these emails. These people were writing with intense frustration about what procrastination had done to their lives, about what this Monkey had done to them. And I thought about this, and I said, well, if the procrastinator's system works, then what's going on? Why are all of these people in such a dark place?

Well, it turns out that there's two kinds of procrastination. Everything I've talked about today, the examples I've given, they all have deadlines. And when there's deadlines, the effects of procrastination are contained to the short term because the Panic Monster gets involved. But there's a second kind of procrastination that happens in situations when there is no deadline. So if you wanted a career where you're a self-starter – something in the arts, something entrepreneurial – there's no deadlines on those things at first, because nothing's happening, not until you've gone out and done the hard work to get momentum, get things going. There's also all kinds of important things outside of your career that don't involve any deadlines, like seeing your family or exercising and taking care of your health, working on your relationship or getting out of a relationship that isn't working.

Now if the procrastinator's only mechanism of doing these hard things is the Panic Monster, that's a problem, because in all of these non-deadline situations, the Panic Monster doesn't show up. He has nothing to wake up for, so the effects of procrastination, they're not contained; they just extend outward forever. And it's this long-term kind of procrastination that's much less visible and much less talked about than the funnier, short-term deadline-based kind. It's usually suffered quietly and privately. And it can be the source of a huge amount of long-term unhappiness, and regrets. And I thought, that's why those people are emailing, and that's why they're in such a bad place. It's not that they're cramming for some project. It's that long-term procrastination has made them feel like a spectator, at times, in their own lives. The frustration is not that they couldn't achieve their dreams; it's that they weren't even able to start chasing them.

So I read these emails and I had a little bit of an epiphany – that I don't think non-procrastinators exist. That's right – I think all of you are procrastinators. Now, you might not all be a mess, like some of us,

(Laughter) and some of you may have a healthy relationship with deadlines, but remember: the Monkey's sneakiest trick is when the deadlines aren't there.

Now, I want to show you one last thing. I call this a Life Calendar. That's one box for every week of a 90-year life. That's not that many boxes, especially since we've already used a bunch of those. So I think we need to all take a long, hard look at that calendar. We need to think about what we're really procrastinating on, because everyone is procrastinating on something in life. We need to stay aware of the Instant Gratification Monkey. That's a job for all of us. And because there's not that many boxes on there, it's a job that should probably start today. Well, maybe not today, but ...

(Laughter) You know. Sometime soon. Thank you. (Applause)

Chapter 2 How Great Leaders Inspire Action

How do you explain when things don't go as we assume? Or better, how do you explain when others are able to achieve things that seem to defy all of the assumptions? For example: Why is Apple so innovative? Year after year, after year, they're more innovative than all their competition. And yet, they're just a computer company. They're just like everyone else. They have the same access to the same talent, the same agencies, the same consultants, the same media. Then why is it that they seem to have something different? Why is it that Martin Luther King led the Civil Rights Movement? He wasn't the only man who suffered in pre-civil rights America, and he certainly wasn't the only great orator of the day. Why him? And why is it that the Wright brothers were able to figure out controlled, powered man flight when there were certainly other teams who were better qualified, better funded – and they didn't achieve powered man flight, and the Wright brothers beat them to it. There's something else at play here.

About three and a half years ago, I made a discovery. And this discovery profoundly changed my view on how I thought the world worked, and it even profoundly changed the way in which I operate in it. As it turns out, there's a pattern. As it turns out, all the great inspiring leaders and organizations in the world, whether it's Apple or Martin Luther King or the Wright brothers, they all think, act and communicate the exact same way. And it's the complete opposite to everyone else. All I did was codify it, and it's probably the world's simplest idea. I call it the golden circle.

Why? How? What? This little idea explains why some organizations and some leaders are able to inspire where others aren't. Let me define the terms really quickly. Every single person, every single organization on the planet knows what they do, 100 percent. Some know how they do it, whether you call it your differentiated value proposition or your proprietary process or your USP. But very, very few people or organizations know why they do what they do. And by "why" I don't mean "to make a profit." That's a result. It's always a result. By "why," I mean: What's your purpose? What's your cause? What's your belief? Why does your organization exist? Why do you get out of bed in the morning? And why should anyone care? As a result, the way we think, we act, the way we communicate is from the outside in, it's obvious. We go from the clearest thing to the fuzziest thing. But the inspired leaders and the inspired organizations – regardless of their size, regardless of their industry – all think, act and communicate from the inside out.

Let me give you an example. I use Apple because they're easy to understand and everybody gets it. If Apple were like everyone else, a marketing message from them might sound like this: "We make great computers. They're beautifully designed, simple to use and user friendly. Want to buy one?" "Meh." That's how most of us communicate. That's how most marketing and sales are done, that's how we communicate interpersonally. We say what we do, we say how we're different or better and we expect some sort of a behavior, a purchase, a vote, something like that.

Here's our new law firm: We have the best lawyers with the biggest clients, we always perform for our clients. Here's our new car: It gets great gas mileage, it has leather seats. Buy our car. But it's uninspiring.

Here's how Apple actually communicates. "Everything we do, we believe in challenging the status quo. We believe in thinking differently. The way we challenge the status quo is by making our products beautifully designed, simple to use and user friendly. We just happen to make great computers. Want to buy one?" Totally different, right? You're ready to buy a computer from me. I just reversed the order of the information. What it proves to us is that people don't buy what you do; people buy why you do it.

This explains why every single person in this room is perfectly comfortable buying a computer from Apple. But we're also perfectly comfortable buying an MP3 player from Apple, or a phone from Apple, or a DVR from Apple. As I said before, Apple's just a computer company. Nothing distinguishes them structurally from any of their competitors. Their competitors are equally qualified to make all of these products. In fact, they tried. A few years ago, Gateway came out with flat-screen TVs. They're eminently qualified to make flat-screen TVs. They've been making flat-screen monitors for years. Nobody bought one. Dell came out with MP3 players and PDAs, and they make great quality products, and they can make perfectly well-designed products – and nobody bought one. In fact, talking about it now, we can't even imagine buying an MP3 player from Dell. Why would you buy one from a computer company? But we do it every day. People don't buy what you do; they buy why you do it. The goal is not to do business with everybody who needs what you have. The goal is to do business with people who believe what you believe.

Here's the best part: None of what I'm telling you is my opinion. It's all grounded in the tenets of biology. Not psychology, biology. If you look at a cross-section of the human brain, from the top down, the human brain is actually broken into three major components that correlate perfectly with the golden circle. Our newest brain, our Homo sapien brain, our neocortex, corresponds with the "what" level. The neocortex is responsible for all of our rational and analytical thought and language. The middle two sections make up our limbic brains, and our limbic brains are responsible for all of our feelings, like trust and loyalty. It's also responsible for all human behavior, all decision-making, and it has no capacity for language.

In other words, when we communicate from the outside in, yes, people can understand vast amounts of complicated information like features and benefits and facts and figures. It just doesn't drive behavior. When we can communicate from the inside out, we're talking directly to the part of the brain that controls behavior, and then we allow people to rationalize it with the tangible things we say and do. This is where gut decisions come from. Sometimes you can give somebody all the facts and figures, and they say, "I know what all the facts and details say, but it just doesn't feel right." Why would we use that verb, it doesn't "feel" right? Because the part of the brain that controls decision-making doesn't control language. The best we can muster up is,

"I don't know. It just doesn't feel right." Or sometimes you say you're leading with your heart or soul. I hate to break it to you, those aren't other body parts controlling your behavior. It's all happening here in your limbic brain, the part of the brain that controls decision-making and not language.

But if you don't know why you do what you do, and people respond to why you do what you do, then how will you ever get people to vote for you, or buy something from you, or, more importantly, be loyal and want to be a part of what it is that you do. The goal is not just to sell to people who need what you have; the goal is to sell to people who believe what you believe. The goal is not just to hire people who need a job; it's to hire people who believe what you believe. I always say that, you know, if you hire people just because they can do a job, they'll work for your money, but if they believe what you believe, they'll work for you with blood and sweat and tears. Nowhere else is there a better example than with the Wright brothers.

Most people don't know about Samuel Pierpont Langley. And back in the early 20th century, the pursuit of powered man flight was like the dot com of the day. Everybody was trying it. And Samuel Pierpont Langley had, what we assume, to be the recipe for success. Even now, you ask people, "Why did your product or why did your company fail?" and people always give you the same permutation of the same three things: under-capitalized, the wrong people, bad market conditions. It's always the same three things, so let's explore that. Samuel Pierpont Langley was given 50,000 dollars by the War Department to figure out this flying machine. Money was no problem. He held a seat at Harvard and worked at the Smithsonian and was extremely well-connected; he knew all the big minds of the day. He hired the best minds money could find and the market conditions were fantastic. The New York Times followed him around everywhere, and everyone was rooting for Langley. Then how come we've never heard of Samuel Pierpont Langley?

A few hundred miles away in Dayton, Ohio, Orville and Wilbur Wright, they had none of what we consider to be the recipe for success. They had no money; they paid for their dream with the proceeds from their bicycle shop. Not a single person on the Wright brothers' team had a college education, not even Orville or Wilbur. And The New York Times followed them around nowhere.

The difference was, Orville and Wilbur were driven by a cause, by a purpose, by a belief. They believed that if they could figure out this flying machine, it'll change the course of the world. Samuel Pierpont Langley was different. He wanted to be rich, and he wanted to be famous. He was in pursuit of the result. He was in pursuit of the riches. And lo and behold, look what happened. The people who believed in the Wright brothers' dream worked with them with blood and sweat and tears. The others just worked for the paycheck. They tell stories of how every time the Wright brothers went out, they would have to take five sets of parts, because that's how many times they would crash before supper.

And, eventually, on December 17th, 1903, the Wright brothers took flight, and no one was

there to even experience it. We found out about it a few days later. And further proof that Langley was motivated by the wrong thing: the day the Wright brothers took flight, he quit. He could have said, "That's an amazing discovery, guys, and I will improve upon your technology," but he didn't. He wasn't first, he didn't get rich, he didn't get famous, so he quit.

People don't buy what you do; they buy why you do it. If you talk about what you believe, you will attract those who believe what you believe.

But why is it important to attract those who believe what you believe? Something called the law of diffusion of innovation, if you don't know the law, you know the terminology. The first 2.5% of our population are our innovators. The next 13.5% of our population are our early adopters. The next 34% are your early majority, your late majority and your laggards. The only reason these people buy touch-tone phones is because you can't buy rotary phones anymore. (Laughter)

We all sit at various places at various times on this scale, but what the law of diffusion of innovation tells us is that if you want mass-market success or mass-market acceptance of an idea, you cannot have it until you achieve this tipping point between 15 and 18 percent market penetration, and then the system tips. I love asking businesses, "What's your conversion on new business?" They love to tell you, "It's about 10 percent," proudly. Well, you can trip over 10% of the customers. We all have about 10% who just "get it." That's how we describe them, right? That's like that gut feeling, "Oh, they just get it."

The problem is: How do you find the ones that get it before doing business versus the ones who don't get it? So it's this here, this little gap that you have to close, as Jeffrey Moore calls it, "Crossing the Chasm" – because, you see, the early majority will not try something until someone else has tried it first. And these guys, the innovators and the early adopters, they're comfortable making those gut decisions. They're more comfortable making those intuitive decisions that are driven by what they believe about the world and not just what product is available. These are the people who stood in line for six hours to buy an iPhone when they first came out, when you could have bought one off the shelf the next week. These are the people who spent 40,000 dollars on flat-screen TVs when they first came out, even though the technology was substandard. And, by the way, they didn't do it because the technology was so great; they did it for themselves. It's because they wanted to be first. People don't buy what you do; they buy why you do it and what you do simply proves what you believe. In fact, people will do the things that prove what they believe. The reason that person bought the iPhone in the first six hours, stood in line for six hours, was because of what they believed about the world, and how they wanted everybody to see them: they were first. People don't buy what you do; they buy why you do it.

So let me give you a famous example, a famous failure and a famous success of the law of diffusion of innovation. First, the famous failure. It's a commercial example. As we said before, the recipe for success is money and the right people and the right market conditions. You should have success then. Look at TiVo. From the time TiVo came out about eight or nine years ago to

this current day, they are the single highest-quality product on the market, hands down, there is no dispute. They were extremely well-funded. Market conditions were fantastic. I mean, we use TiVo as verb. I TiVo stuff on my piece-of-junk Time Warner DVR all the time. (Laughter)

But TiVo's a commercial failure. They've never made money. And when they went IPO, their stock was at about 30 or 40 dollars and then plummeted, and it's never traded above 10. In fact, I don't think it's even traded above six, except for a couple of little spikes. Because you see, when TiVo launched their product, they told us all what they had. They said, "We have a product that pauses live TV, skips commercials, rewinds live TV and memorizes your viewing habits without you even asking." And the cynical majority said, "We don't believe you. We don't need it. We don't like it. You're scaring us."

What if they had said, "If you're the kind of person who likes to have total control over every aspect of your life, boy, do we have a product for you. It pauses live TV, skips commercials, memorizes your viewing habits, etc., etc." People don't buy what you do; they buy why you do it, and what you do simply serves as the proof of what you believe.

Now let me give you a successful example of the law of diffusion of innovation. In the summer of 1963, 250,000 people showed up on the mall in Washington to hear Dr. King speak. They sent out no invitations, and there was no website to check the date. How do you do that? Well, Dr. King wasn't the only man in America who was a great orator. He wasn't the only man in America who suffered in a pre-civil rights America. In fact, some of his ideas were bad. But he had a gift. He didn't go around telling people what needed to change in America. He went around and told people what he believed. "I believe, I believe, I believe," he told people. And people who believed what he believed took his cause, and they made it their own, and they told people. And some of those people created structures to get the word out to even more people. And lo and behold, 250,000 people showed up on the right day at the right time to hear him speak.

How many of them showed up for him? Zero. They showed up for themselves. It's what they believed about America that got them to travel in a bus for eight hours to stand in the sun in Washington in the middle of August. It's what they believed, and it wasn't about black versus white: 25% of the audience was white.

Dr. King believed that there are two types of laws in this world: those that are made by a higher authority and those that are made by men. And not until all the laws that are made by men are consistent with the laws made by the higher authority will we live in a just world. It just so happened that the Civil Rights Movement was the perfect thing to help him bring his cause to life. We followed, not for him, but for ourselves. By the way, he gave the "I have a dream" speech, not the "I have a plan" speech. (Laughter)

Listen to politicians now, with their comprehensive 12-point plans. They're not inspiring anybody. Because there are leaders and there are those who lead. Leaders hold a position of power or authority, but those who lead inspire us. Whether they're individuals or organizations,

we follow those who lead, not because we have to, but because we want to. We follow those who lead, not for them, but for ourselves. And it's those who start with "why" that have the ability to inspire those around them or find others who inspire them.

Thank you very much. (Applause)

Chapter 3 How I Held My Breath for 17 Minutes

As a magician, I try to create images that make people stop and think. I also try to challenge myself to do things that doctors say are not possible. I was buried alive in New York City in a coffin, buried alive in a coffin in April, 1999, for a week. I lived there with nothing but water. And it ended up being so much fun that I decided I could pursue doing more of these things. The next one is I froze myself in a block of ice for three days and three nights in New York City. That one was way more difficult than I had expected. The one after that, I stood on top of a hundred-foot pillar for 36 hours. I began to hallucinate so hard that the buildings that were behind me started to look like big animal heads. So, next I went to London. In London I lived in a glass box for 44 days with nothing but water. It was, for me, one of the most difficult things I'd ever done, but it was also the most beautiful. There was so many skeptics, especially the press in London, that they started flying cheeseburgers on helicopters around my box to tempt me. (Laughter) So, I felt very validated when the New England Journal of Medicine actually used the research for science. My next pursuit was I wanted to see how long I could go without breathing, like how long I could survive with nothing, not even air. I didn't realize that it would become the most amazing journey of my life. As a young magician, I was obsessed with Houdini and his underwater challenges. So, I began, early on, competing against the other kids, seeing how long I could stay underwater while they went up and down to breathe, you know, five times, while I stayed under on one breath. By the time I was a teenager, I was able to hold my breath for three minutes and 30 seconds. I would later find out that was Houdini's personal record. In 1987 I heard of a story about a boy that fell through ice and was trapped under a river. He was underneath, not breathing for 45 minutes. When the rescue workers came, they resuscitated him and there was no brain damage. His core temperature had dropped to 77 degrees. As a magician, I think everything is possible. And I think if something is done by one person, it can be done by others. I started to think, if the boy could survive without breathing for that long, there must be a way that I could do it. So, I met with a top neurosurgeon. And I asked him, how long is it possible to go without breathing, like how long could I go without air? And he said to me that anything over six minutes you have a serious risk of hypoxic brain damage. So, I took that as a challenge, basically. (Laughter) My first try, I figured that I could do something similar, and I created a water tank, and I filled it with ice and freezing cold water. And I stayed inside of that water tank hoping my core temperature would start to drop. And I was shivering. In my first attempt to hold my breath, I couldn't even last a minute. So, I realized that was completely not going to work. I went to talk to a doctor friend – and I asked him, "How could I do that?" "I want to hold my breath for a really long time. How could it be done?" And he said, "David, you're a magician, create the illusion of not breathing, it will be much easier." (Laughter) So, he came up with this idea of creating a rebreather, with a CO2 scrubber, which was basically a

tube from Home Depot, with a balloon duct-taped to it, that he thought we could put inside of me, and somehow be able to circulate the air and rebreathe with this thing in me. This is a little hard to watch. But this is that attempt. So, that clearly wasn't going to work. (Laughter) Then I actually started thinking about liquid breathing. There is a chemical that's called perflubron. And it's so high in oxygen levels that in theory you could breathe it. So, I got my hands on that chemical, filled the sink up with it, and stuck my face in the sink and tried to breathe that in, which was really impossible. It's basically like trying to breathe, as a doctor said, while having an elephant standing on your chest. So, that idea disappeared. Then I started thinking, would it be possible to hook up a heart/lung bypass machine and have a surgery where it was a tube going into my artery, and then appear to not breathe while they were oxygenating my blood? Which was another insane idea, obviously. Then I thought about the craziest idea of all the ideas: to actually do it. (Laughter) To actually try to hold my breath past the point that doctors would consider you brain dead. So, I started researching into pearl divers. You know, because they go down for four minutes on one breath. And when I was researching pearl divers, I found the world of free-diving. It was the most amazing thing that I ever discovered, pretty much. There is many different aspects to free-diving. There is depth records, where people go as deep as they can. And then there is static apnea. That's holding your breath as long as you can in one place without moving. That was the one that I studied. The first thing that I learned is when you're holding your breath, you should never move at all; that wastes energy. And that depletes oxygen, and it builds up CO2 in your blood. So, I learned never to move. And I learned how to slow my heart rate down. I had to remain perfectly still and just relax and think that I wasn't in my body, and just control that. And then I learned how to purge. Purging is basically hyperventilating. You blow in and out – (Breathing loudly) You do that, you get lightheaded, you get tingling. And you're really ridding your body of CO2. So, when you hold your breath, it's infinitely easier. Then I learned that you have to take a huge breath, and just hold and relax and never let any air out, and just hold and relax through all the pain. Every morning, this is for months, I would wake up and the first thing that I would do is I would hold my breath for, out of 52 minutes, I would hold my breath for 44 minutes. So, basically what that means is I would purge, I'd breathe really hard for a minute. And I would hold, immediately after, for five and a half minutes. Then I would breathe again for a minute, purging as hard as I can, then immediately after that I would hold again for five and a half minutes. I would repeat this process eight times in a row. Out of 52 minutes, you're only breathing for eight minutes. At the end of that you're completely fried, your brain. You feel like you're walking around in a daze. And you have these awful headaches. Basically, I'm not the best person to talk to when I'm doing that stuff. I started learning about the world-record holder. His name is Tom Sietas. And this guy is perfectly built for holding his breath. He's six foot four. He's 160 pounds. And his total lung capacity is twice the size of an average person. I'm six foot one, and fat. We'll say big-boned. (Laughter) I had to drop 50 pounds in three months. So, everything that I put into my body, I considered as medicine.

Every bit of food was exactly what it was for its nutritional value. I ate really small controlled portions throughout the day. And I started to really adapt my body. [Individual results may vary] (Laughter) The thinner I was, the longer I was able to hold my breath. And by eating so well and training so hard, my resting heart-rate dropped to 38 beats per minute. Which is lower than most Olympic athletes. In four months of training, I was able to hold my breath for over seven minutes. I wanted to try holding my breath everywhere. I wanted to try it in the most extreme situations to see if I could slow my heart rate down under duress. (Laughter) I decided that I was going to break the world record live on prime-time television. The world record was eight minutes and 58 seconds, held by Tom Sietas, that guy with the whale lungs I told you about. I assumed that I could put a water tank at Lincoln Center and if I stayed there a week not eating, I would get comfortable in that situation and I would slow my metabolism, which I was sure would help me hold my breath longer than I had been able to do it. I was completely wrong. I entered the sphere a week before the scheduled air date. And I thought everything seemed to be on track. Two days before my big breath-hold attempt, for the record, the producers of my television special thought that just watching somebody holding their breath, and almost drowning, is too boring for television. (Laughter) So, I had to add handcuffs, while holding my breath, to escape from. This was a critical mistake. Because of the movement, I was wasting oxygen. And by seven minutes I had gone into these awful convulsions. By 7:08, I started to black out. And by seven minutes and 30 seconds, they had to pull my body out and bring me back. I had failed on every level. (Laughter) So, naturally, the only way out of the slump that I could think of was, I decided to call Oprah. (Laughter) I told her that I wanted to up the ante and hold my breath longer than any human being ever had. This was a different record. This was a pure O2 static apnea record that Guinness had set the world record at 13 minutes. So, basically you breathe pure O2 first, oxygenating your body, flushing out CO2, and you are able to hold much longer. I realized that my real competition was the beaver. (Laughter) (Laughter ends) In January of '08, Oprah gave me four months to prepare and train. So, I would sleep in a hypoxic tent every night. A hypoxic tent is a tent that simulates altitude at 15,000 feet. So, it's like base camp, Everest. What that does is, you start building up the red bloodcell count in your body, which helps you carry oxygen better. Every morning, again, after getting out of that tent, your brain is completely wiped out. My first attempt on pure O2, I was able to go up to 15 minutes. So, it was a pretty big success. The neurosurgeon pulled me out of the water because in his mind, at 15 minutes your brain is done, you're brain dead. So, he pulled me up, and I was fine. There was one person there that was definitely not impressed. It was my ex-girlfriend. While I was breaking the record underwater for the first time, she was sifting through my Blackberry, checking all my messages. (Laughter) My brother had a picture of it. It is really – (Laughter) (Laughter ends) I then announced that I was going to go for Sietas' record, publicly. And what he did in response, is he went on Regis and Kelly, and broke his old record. Then his main competitor went out and broke his record. So, he suddenly pushed the record up to 16 minutes and 32 seconds. Which

was three minutes longer than I had prepared. It was longer than the record. I wanted to get the Science Times to document this. I wanted to get them to do a piece on it. So, I did what any person seriously pursuing scientific advancement would do. I walked into the New York Times offices and did card tricks to everybody. (Laughter) So, I don't know if it was the magic or the lure of the Cayman Islands, but John Tierney flew down and did a piece on the seriousness of breath-holding. While he was there, I tried to impress him, of course. And I did a dive down to 160 feet, which is basically the height of a 16 story building, and as I was coming up, I blacked out underwater, which is really dangerous; that's how you drown. Luckily, Kirk had seen me and he swam over and pulled me up. So, I started full focus. I completely trained to get my breath-hold time up for what I needed to do. But there was no way to prepare for the live television aspect of it, being on Oprah. But in practice, I would do it face down, floating on the pool. But for TV they wanted me to be upright so they could see my face, basically. The other problem was the suit was so buoyant that they had to strap my feet in to keep me from floating up. So, I had to use my legs to hold my feet into the straps that were loose, which was a real problem for me. That made me extremely nervous, raising the heart rate. Then, what they also did was, which we never did before, is there was a heart-rate monitor. And it was right next to the sphere. So, every time my heart would beat, I'd hear the beep-beep-beep-beep, you know, the ticking, really loud. Which was making me more nervous. And there was no way to slow my heart rate down. Normally, I would start at 38 beats per minute, and while holding my breath, it would drop to 12 beats per minute, which is pretty unusual. (Laughter) This time it started at 120 beats, and it never went down. I spent the first five minutes underwater desperately trying to slow my heart rate down. I was just sitting there thinking, "I've got to slow this down. I'm going to fail." And I was getting more nervous. And the heart rate just kept going up and up, all the way up to 150 beats. Basically it's the same thing that created my downfall at Lincoln Center. It was a waste of O2. When I made it to the halfway mark, at eight minutes, I was 100 percent certain that I was not going to be able to make this. There was no way for me to do it. I figured, Oprah had dedicated an hour to doing this breath-hold thing, if I had cracked early, it would be a whole show about how depressed I am. (Laughter) So, I figured I'm better off just fighting and staying there until I black out, at least then they can pull me out and take care of me and all that. (Laughter) I kept pushing to 10 minutes. At 10 minutes you start getting all these really strong tingling sensations in your fingers and toes. And I knew that that was blood shunting, when the blood rushes away from your extremities to provide oxygen to your vital organs. At 11 minutes I started feeling throbbing sensations in my legs, and my lips started to feel really strange. At minute 12 I started to have ringing in my ears, and I started to feel my arm going numb. And I'm a hypochondriac, and I remember arm numb means heart attack. So, I started to really get really paranoid. Then at 13 minutes, maybe because of the hypochondria, I started feeling pains all over my chest. It was awful. (Laughter) At 14 minutes, I had these awful contractions, like this urge to breathe. (Laughter) (Laughter ends) At 15 minutes I was suffering major O2 deprivation

to the heart. And I started having ischemia to the heart. My heartbeat would go from 120 to 50, to 150, to 40, to 20, to 150 again. It would skip a beat. It would start. It would stop. And I felt all this. And I was sure that I was going to have a heart attack. So, at 16 minutes what I did is I slid my feet out because I knew that if I did go out, if I did have a heart attack, they'd have to jump into the binding and take my feet out before pulling me up. I was really nervous. I let my feet out, and I started floating to the top. And I didn't take my head out. But I was just floating there waiting for my heart to stop, just waiting. They had doctors with the "Pst," you know, sitting there waiting. And then suddenly I hear screaming. And I think that there is some weird thing – that I had died or something had happened. And then I realized that I had made it to 16:32. So, with the energy of everybody that was there, I decided to keep pushing. And I went to 17 minutes and four seconds. (Applause) (Applause ends) As though that wasn't enough, what I did immediately after is I went to Quest Labs and had them take every blood sample that they could to test for everything and to see where my levels were, so the doctors could use it, once again. I also didn't want anybody to question it. I had the world record and I wanted to make sure it was legitimate. So, I get to New York City the next day, I'm walking out of the Apple store, and this kid walks up to me he's like, "Yo, D!" I'm like "Yeah?" He said, "If you really held your breath that long, why'd you come out of the water dry?" I was like "What?" (Laughter) And that's my life. So – (Laughter) As a magician, I try to show things to people that seem impossible. And I think magic, whether I'm holding my breath or shuffling a deck of cards, is pretty simple. It's practice, it's training, and it's – (Sobs) It's practice, it's training and experimenting, (Sobs) while pushing through the pain to be the best that I can be. And that's what magic is to me, so, thank you. (Applause)

Chapter 4 Never, Ever Give Up

As a magician, I try to create images that make people stop and think. I also try to challenge myself to do things that doctors say are not possible. I was buried alive in New York City in a coffin, buried alive in a coffin in April, 1999, for a week. I lived there with nothing but water. And it ended up being so much fun that I decided I could pursue doing more of these things. The next one is I froze myself in a block of ice for three days and three nights in New York City. That one was way more difficult than I had expected. The one after that, I stood on top of a hundred-foot pillar for 36 hours. I began to hallucinate so hard that the buildings that were behind me started to look like big animal heads. So, next I went to London. In London I lived in a glass box for 44 days with nothing but water. It was, for me, one of the most difficult things I'd ever done, but it was also the most beautiful. There was so many skeptics, especially the press in London, that they started flying cheeseburgers on helicopters around my box to tempt me. (Laughter) So, I felt very validated when the New England Journal of Medicine actually used the research for science. My next pursuit was I wanted to see how long I could go without breathing, like how long I could survive with nothing, not even air. I didn't realize that it would become the most amazing journey of my life. As a young magician, I was obsessed with Houdini and his underwater challenges. So, I began, early on, competing against the other kids, seeing how long I could stay underwater while they went up and down to breathe, you know, five times, while I stayed under on one breath. By the time I was a teenager, I was able to hold my breath for three minutes and 30 seconds. I would later find out that was Houdini's personal record. In 1987 I heard of a story about a boy that fell through ice and was trapped under a river. He was underneath, not breathing for 45 minutes. When the rescue workers came, they resuscitated him and there was no brain damage. His core temperature had dropped to 77 degrees. As a magician, I think everything is possible. And I think if something is done by one person, it can be done by others. I started to think, if the boy could survive without breathing for that long, there must be a way that I could do it. So, I met with a top neurosurgeon. And I asked him, how long is it possible to go without breathing, like how long could I go without air? And he said to me that anything over six minutes you have a serious risk of hypoxic brain damage. So, I took that as a challenge, basically. (Laughter) My first try, I figured that I could do something similar, and I created a water tank, and I filled it with ice and freezing cold water. And I stayed inside of that water tank hoping my core temperature would start to drop. And I was shivering. In my first attempt to hold my breath, I couldn't even last a minute. So, I realized that was completely not going to work. I went to talk to a doctor friend – and I asked him, "How could I do that?" "I want to hold my breath for a really long time. How could it be done?" And he said, "David, you're a magician, create the illusion of not breathing, it will be much easier." (Laughter) So, he came up with this idea of creating a rebreather, with a CO2 scrubber, which was basically a

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to the heart. And I started having ischemia to the heart. My heartbeat would go from 120 to 50, to 150, to 40, to 20, to 150 again. It would skip a beat. It would start. It would stop. And I felt all this. And I was sure that I was going to have a heart attack. So, at 16 minutes what I did is I slid my feet out because I knew that if I did go out, if I did have a heart attack, they'd have to jump into the binding and take my feet out before pulling me up. I was really nervous. I let my feet out, and I started floating to the top. And I didn't take my head out. But I was just floating there waiting for my heart to stop, just waiting. They had doctors with the "Pst," you know, sitting there waiting. And then suddenly I hear screaming. And I think that there is some weird thing – that I had died or something had happened. And then I realized that I had made it to 16:32. So, with the energy of everybody that was there, I decided to keep pushing. And I went to 17 minutes and four seconds. (Applause) (Applause ends) As though that wasn't enough, what I did immediately after is I went to Quest Labs and had them take every blood sample that they could to test for everything and to see where my levels were, so the doctors could use it, once again. I also didn't want anybody to question it. I had the world record and I wanted to make sure it was legitimate. So, I get to New York City the next day, I'm walking out of the Apple store, and this kid walks up to me he's like, "Yo, D!" I'm like "Yeah?" He said, "If you really held your breath that long, why'd you come out of the water dry?" I was like "What?" (Laughter) And that's my life. So – (Laughter) As a magician, I try to show things to people that seem impossible. And I think magic, whether I'm holding my breath or shuffling a deck of cards, is pretty simple. It's practice, it's training, and it's – (Sobs) It's practice, it's training and experimenting, (Sobs) while pushing through the pain to be the best that I can be. And that's what magic is to me, so, thank you. (Applause)

Chapter 5 The Boiling River of The Amazon

As a boy in Lima, my grandfather told me a legend of the Spanish conquest of Peru. Atahualpa, emperor of the Inca, had been captured and killed. Pizarro and his conquistadors had grown rich, and tales of their conquest and glory had reached Spain and was bringing new waves of Spaniards, hungry for gold and glory. They would go into towns and ask the Inca, "Where's another civilization we can conquer? Where's more gold?" And the Inca, out of vengeance, told them, "Go to the Amazon. You'll find all the gold you want there. In fact, there is a city called Paititi – El Dorado in Spanish – made entirely of gold." The Spanish set off into the jungle, but the few that return come back with stories, stories of powerful shamans, of warriors with poisoned arrows, of trees so tall they blotted out the sun, spiders that ate birds, snakes that swallowed men whole and a river that boiled. All this became a childhood memory. And years passed. I'm working on my PhD at SMU, trying to understand Peru's geothermal energy potential, when I remember this legend, and I began asking that question. Could the boiling river exist? I asked colleagues from universities, the government, oil, gas and mining companies, and the answer was a unanimous no. And this makes sense. You see, boiling rivers do exist in the world, but they're generally associated with volcanoes. You need a powerful heat source to produce such a large geothermal manifestation. And as you can see from the red dots here, which are volcanoes, we don't have volcanoes in the Amazon, nor in most of Peru. So it follows: We should not expect to see a boiling river. Telling this same story at a family dinner, my aunt tells me, "But no, Andrés, I've been there. I've swum in that river." (Laughter) Then my uncle jumps in. "No, Andrés, she's not kidding. You see, you can only swim in it after a very heavy rain, and it's protected by a powerful shaman. Your aunt, she's friends with his wife." (Laughter) "¿Cómo?" ["Huh?"] You know, despite all my scientific skepticism, I found myself hiking into the jungle, guided by my aunt, over 700 kilometers away from the nearest volcanic center, and well, honestly, mentally preparing myself to behold the legendary "warm stream of the Amazon." But then ... I heard something, a low surge that got louder and louder as we came closer. It sounded like ocean waves constantly crashing, and as we got closer, I saw smoke, vapor, coming up through the trees. And then, I saw this. I immediately grabbed for my thermometer, and the average temperatures in the river were 86 degrees C. This is not quite the 100-degree C boiling but definitely close enough. The river flowed hot and fast. I followed it upriver and was led by, actually, the shaman's apprentice to the most sacred site on the river. And this is what's bizarre – It starts off as a cold stream. And here, at this site, is the home of the Yacumama, mother of the waters, a giant serpent spirit who births hot and cold water. And here we find a hot spring, mixing with cold stream water underneath her protective motherly jaws and thus bringing their legends to life. The next morning, I woke up and – (Laughter) I asked for tea. I was handed a mug, a tea bag and, well, pointed towards the river. To my surprise, the water was clean and

had a pleasant taste, which is a little weird for geothermal systems. What was amazing is that the locals had always known about this place, and that I was by no means the first outsider to see it. It was just part of their everyday life. They drink its water. They take in its vapor. They cook with it, clean with it, even make their medicines with it. I met the shaman, and he seemed like an extension of the river and his jungle. He asked for my intentions and listened carefully. Then, to my tremendous relief – I was freaking out, to be honest with you – a smile began to snake across his face, and he just laughed. (Laughter) I had received the shaman's blessing to study the river, on the condition that after I take the water samples and analyze them in my lab, wherever I was in the world, that I pour the waters back into the ground so that, as the shaman said, the waters could find their way back home. I've been back every year since that first visit in 2011, and the fieldwork has been exhilarating, demanding and at times dangerous. One story was even featured in National Geographic Magazine. I was trapped on a small rock about the size of a sheet of paper in sandals and board shorts, in between an 80 degree C river and a hot spring that, well, looked like this, close to boiling. And on top of that, it was Amazon rain forest. Pshh, pouring rain, couldn't see a thing. The temperature differential made it all white. It was a whiteout. Intense. Now, after years of work, I'll soon be submitting my geophysical and geochemical studies for publication. And I'd like to share, today, with all of you here, on the TED stage, for the first time, some of these discoveries. Well, first off, it's not a legend. Surprise! (Laughter) When I first started the research, the satellite imagery was too low-resolution to be meaningful. There were just no good maps. Thanks to the support of the Google Earth team, I now have this. Not only that, the indigenous name of the river, Shanay-timpishka, "boiled with the heat of the sun," indicating that I'm not the first to wonder why the river boils, and showing that humanity has always sought to explain the world around us. So why does the river boil? (Bubbling sounds) It actually took me three years to get that footage. Fault-fed hot springs. As we have hot blood running through our veins and arteries, so, too, the earth has hot water running through its cracks and faults. Where these arteries come to the surface, these earth arteries, we'll get geothermal manifestations: fumaroles, hot springs and in our case, the boiling river. What's truly incredible, though, is the scale of this place. Next time you cross the road, think about this. The river flows wider than a two-lane road along most of its path. It flows hot for 6.24 kilometers. Truly impressive. There are thermal pools larger than this TED stage, and that waterfall that you see there is six meters tall – and all with near-boiling water. We mapped the temperatures along the river, and this was by far the most demanding part of the fieldwork. And the results were just awesome. Sorry – the geoscientist in me coming out. And it showed this amazing trend. You see, the river starts off cold. It then heats up, cools back down, heats up, cools back down, heats up again, and then has this beautiful decay curve until it smashes into this cold river. Now, I understand not all of you are geothermal scientists, so to put it in more everyday terms: Everyone loves coffee. Yes? Good. Your regular cup of coffee, 54 degrees C, an extra-hot one, well, 60. So, put in coffee shop terms, the boiling river plots like this. There you have your hot coffee.

Here you have your extra-hot coffee, and you can see that there's a bit point there where the river is still hotter than even the extra-hot coffee. And these are average water temperatures. We took these in the dry season to ensure the purest geothermal temperatures. But there's a magic number here that's not being shown, and that number is 47 degrees C, because that's where things start to hurt, and I know this from very personal experience. Above that temperature, you don't want to get in that water. You need to be careful. It can be deadly. I've seen all sorts of animals fall in, and what's shocking to me, is the process is pretty much the same. So they fall in and the first thing to go are the eyes. Eyes, apparently, cook very quickly. They turn this milky-white color. The stream is carrying them. They're trying to swim out, but their meat is cooking on the bone because it's so hot. So they're losing power, losing power, until finally they get to a point where hot water goes into their mouths and they cook from the inside out. (Laughter) A bit sadistic, aren't we? Jeez. Leave them marinating for a little longer. What's, again, amazing are these temperatures. They're similar to things that I've seen on volcanoes all over the world and even super-volcanoes like Yellowstone. But here's the thing: the data is showing that the boiling river exists independent of volcanism. It's neither magmatic or volcanic in origin, and again, over 700 kilometers away from the nearest volcanic center. How can a boiling river exist like this? I've asked geothermal experts and volcanologists for years, and I'm still unable to find another non-volcanic geothermal system of this magnitude. It's unique. It's special on a global scale. So, still – how does it work? Where do we get this heat? There's still more research to be done to better constrain the problem and better understand the system, but from what the data is telling us now, it looks to be the result of a large hydrothermal system. Basically, it works like this: So, the deeper you go into the earth, the hotter it gets. We refer to this as the geothermal gradient. The waters could be coming from as far away as glaciers in the Andes, then seeping down deep into the earth and coming out to form the boiling river after getting heated up from the geothermal gradient, all due to this unique geologic setting. Now, we found that in and around the river – this is working with colleagues from National Geographic, Dr. Spencer Wells, and Dr. Jon Eisen from UC Davis – we genetically sequenced the extremophile lifeforms living in and around the river, and have found new lifeforms, unique species living in the boiling river. But again, despite all of these studies, all of these discoveries and the legends, a question remains: What is the significance of the boiling river? What is the significance of this stationary cloud that always hovers over this patch of jungle? And what is the significance of a detail in a childhood legend? To the shaman and his community, it's a sacred site. To me, as a geoscientist, it's a unique geothermal phenomenon. But to the illegal loggers and cattle farmers, it's just another resource to exploit. And to the Peruvian government, it's just another stretch of unprotected land ready for development. My goal is to ensure that whoever controls this land understands the boiling river's uniqueness and significance. Because that's the question, one of significance. And the thing there is, we define significance. It's us. We have that power. We are the ones who draw that line between the sacred and the trivial. And in this age, where everything seems mapped, measured

and studied, in this age of information, I remind you all that discoveries are not just made in the black void of the unknown but in the white noise of overwhelming data. There remains so much to explore. We live in an incredible world. So go out. Be curious. Because we do live in a world where shamans still sing to the spirits of the jungle, where rivers do boil and where legends do come to life. Thank you very much. (Applause)

Chapter 6 Machine Intelligence Makes Human Morals More Important

So, I started my first job as a computer programmer in my very first year of college – basically, as a teenager. Soon after I started working, writing software in a company, a manager who worked at the company came down to where I was, and he whispered to me, "Can he tell if I'm lying?" There was nobody else in the room. "Can who tell if you're lying? And why are we whispering?" The manager pointed at the computer in the room. "Can he tell if I'm lying?" Well, that manager was having an affair with the receptionist. (Laughter) And I was still a teenager. So I whisper-shouted back to him, "Yes, the computer can tell if you're lying." (Laughter) Well, I laughed, but actually, the laugh's on me. Nowadays, there are computational systems that can suss out emotional states and even lying from processing human faces. Advertisers and even governments are very interested. I had become a computer programmer because I was one of those kids crazy about math and science. But somewhere along the line I'd learned about nuclear weapons, and I'd gotten really concerned with the ethics of science. I was troubled. However, because of family circumstances, I also needed to start working as soon as possible. So I thought to myself, hey, let me pick a technical field where I can get a job easily and where I don't have to deal with any troublesome questions of ethics. So I picked computers. (Laughter) Well, ha, ha, ha! All the laughs are on me. Nowadays, computer scientists are building platforms that control what a billion people see every day. They're developing cars that could decide who to run over. They're even building machines, weapons, that might kill human beings in war. It's ethics all the way down. Machine intelligence is here. We're now using computation to make all sort of decisions, but also new kinds of decisions. We're asking questions to computation that have no single right answers, that are subjective and open-ended and value-laden. We're asking questions like, "Who should the company hire?" "Which update from which friend should you be shown?" "Which convict is more likely to reoffend?" "Which news item or movie should be recommended to people?" Look, yes, we've been using computers for a while, but this is different. This is a historical twist, because we cannot anchor computation for such subjective decisions the way we can anchor computation for flying airplanes, building bridges, going to the moon. Are airplanes safer? Did the bridge sway and fall? There, we have agreed-upon, fairly clear benchmarks, and we have laws of nature to guide us. We have no such anchors and benchmarks for decisions in messy human affairs. To make things more complicated, our software is getting more powerful, but it's also getting less transparent and more complex. Recently, in the past decade, complex algorithms have made great strides. They can recognize human faces. They can decipher handwriting. They can detect credit card fraud and block spam and they can translate between languages. They can detect tumors in medical imaging. They can beat humans in chess and Go. Much of this progress comes from a method called "machine learning." Machine learning is different than traditional

programming, where you give the computer detailed, exact, painstaking instructions. It's more like you take the system and you feed it lots of data, including unstructured data, like the kind we generate in our digital lives. And the system learns by churning through this data. And also, crucially, these systems don't operate under a single-answer logic. They don't produce a simple answer; it's more probabilistic: "This one is probably more like what you're looking for." Now, the upside is: this method is really powerful. The head of Google's AI systems called it, "the unreasonable effectiveness of data." The downside is, we don't really understand what the system learned. In fact, that's its power. This is less like giving instructions to a computer; it's more like training a puppy-machine-creature we don't really understand or control. So this is our problem. It's a problem when this artificial intelligence system gets things wrong. It's also a problem when it gets things right, because we don't even know which is which when it's a subjective problem. We don't know what this thing is thinking. So, consider a hiring algorithm – a system used to hire people, using machine-learning systems. Such a system would have been trained on previous employees' data and instructed to find and hire people like the existing high performers in the company. Sounds good. I once attended a conference that brought together human resources managers and executives, high-level people, using such systems in hiring. They were super excited. They thought that this would make hiring more objective, less biased, and give women and minorities a better shot against biased human managers. And look – human hiring is biased. I know. I mean, in one of my early jobs as a programmer, my immediate manager would sometimes come down to where I was really early in the morning or really late in the afternoon, and she'd say, "Zeynep, let's go to lunch!" I'd be puzzled by the weird timing. It's 4pm. Lunch? I was broke, so free lunch. I always went. I later realized what was happening. My immediate managers had not confessed to their higher-ups that the programmer they hired for a serious job was a teen girl who wore jeans and sneakers to work. I was doing a good job, I just looked wrong and was the wrong age and gender. So hiring in a gender- and race-blind way certainly sounds good to me. But with these systems, it is more complicated, and here's why: Currently, computational systems can infer all sorts of things about you from your digital crumbs, even if you have not disclosed those things. They can infer your sexual orientation, your personality traits, your political leanings. They have predictive power with high levels of accuracy. Remember – for things you haven't even disclosed. This is inference. I have a friend who developed such computational systems to predict the likelihood of clinical or postpartum depression from social media data. The results are impressive. Her system can predict the likelihood of depression months before the onset of any symptoms – months before. No symptoms, there's prediction. She hopes it will be used for early intervention. Great! But now put this in the context of hiring. So at this human resources managers conference, I approached a high-level manager in a very large company, and I said to her, "Look, what if, unbeknownst to you, your system is weeding out people with high future likelihood of depression? They're not depressed now, just maybe in the future, more likely. What if it's weeding out women more likely to be pregnant in the next year or two but aren't pregnant

now? What if it's hiring aggressive people because that's your workplace culture?" You can't tell this by looking at gender breakdowns. Those may be balanced. And since this is machine learning, not traditional coding, there is no variable there labeled "higher risk of depression," "higher risk of pregnancy," "aggressive guy scale." Not only do you not know what your system is selecting on, you don't even know where to begin to look. It's a black box. It has predictive power, but you don't understand it. "What safeguards," I asked, "do you have to make sure that your black box isn't doing something shady?" She looked at me as if I had just stepped on 10 puppy tails. (Laughter) She stared at me and she said, "I don't want to hear another word about this." And she turned around and walked away. Mind you – she wasn't rude. It was clearly: what I don't know isn't my problem, go away, death stare. (Laughter) Look, such a system may even be less biased than human managers in some ways. And it could make monetary sense. But it could also lead to a steady but stealthy shutting out of the job market of people with higher risk of depression. Is this the kind of society we want to build, without even knowing we've done this, because we turned decision-making to machines we don't totally understand? Another problem is this: these systems are often trained on data generated by our actions, human imprints. Well, they could just be reflecting our biases, and these systems could be picking up on our biases and amplifying them and showing them back to us, while we're telling ourselves, "We're just doing objective, neutral computation." Researchers found that on Google, women are less likely than men to be shown job ads for high-paying jobs. And searching for African-American names is more likely to bring up ads suggesting criminal history, even when there is none. Such hidden biases and black-box algorithms that researchers uncover sometimes but sometimes we don't know, can have life-altering consequences. In Wisconsin, a defendant was sentenced to six years in prison for evading the police. You may not know this, but algorithms are increasingly used in parole and sentencing decisions. He wanted to know: How is this score calculated? It's a commercial black box. The company refused to have its algorithm be challenged in open court. But ProPublica, an investigative nonprofit, audited that very algorithm with what public data they could find, and found that its outcomes were biased and its predictive power was dismal, barely better than chance, and it was wrongly labeling black defendants as future criminals at twice the rate of white defendants. So, consider this case: This woman was late picking up her godsister from a school in Broward County, Florida, running down the street with a friend of hers. They spotted an unlocked kid's bike and a scooter on a porch and foolishly jumped on it. As they were speeding off, a woman came out and said, "Hey! That's my kid's bike!" They dropped it, they walked away, but they were arrested. She was wrong, she was foolish, but she was also just 18. She had a couple of juvenile misdemeanors. Meanwhile, that man had been arrested for shoplifting in Home Depot – 85 dollars' worth of stuff, a similar petty crime. But he had two prior armed robbery convictions. But the algorithm scored her as high risk, and not him. Two years later, ProPublica found that she had not reoffended. It was just hard to get a job for her with her record. He, on the other hand, did reoffend and is now serving an eight-year

prison term for a later crime. Clearly, we need to audit our black boxes and not have them have this kind of unchecked power. (Applause) Audits are great and important, but they don't solve all our problems. Take Facebook's powerful news feed algorithm – you know, the one that ranks everything and decides what to show you from all the friends and pages you follow. Should you be shown another baby picture? (Laughter) A sullen note from an acquaintance? An important but difficult news item? There's no right answer. Facebook optimizes for engagement on the site: likes, shares, comments. In August of 2014, protests broke out in Ferguson, Missouri, after the killing of an African-American teenager by a white police officer, under murky circumstances. The news of the protests was all over my algorithmically unfiltered Twitter feed, but nowhere on my Facebook. Was it my Facebook friends? I disabled Facebook's algorithm, which is hard because Facebook keeps wanting to make you come under the algorithm's control, and saw that my friends were talking about it. It's just that the algorithm wasn't showing it to me. I researched this and found this was a widespread problem. The story of Ferguson wasn't algorithm-friendly. It's not "likable." Who's going to click on "like?" It's not even easy to comment on. Without likes and comments, the algorithm was likely showing it to even fewer people, so we didn't get to see this. Instead, that week, Facebook's algorithm highlighted this, which is the ALS Ice Bucket Challenge. Worthy cause; dump ice water, donate to charity, fine. But it was super algorithm-friendly. The machine made this decision for us. A very important but difficult conversation might have been smothered, had Facebook been the only channel. Now, finally, these systems can also be wrong in ways that don't resemble human systems. Do you guys remember Watson, IBM's machine-intelligence system that wiped the floor with human contestants on Jeopardy? It was a great player. But then, for Final Jeopardy, Watson was asked this question: "Its largest airport is named for a World War II hero, its second-largest for a World War II battle." (Hums Final Jeopardy music) Chicago. The two humans got it right. Watson, on the other hand, answered "Toronto" – for a US city category! The impressive system also made an error that a human would never make, a second-grader wouldn't make. Our machine intelligence can fail in ways that don't fit error patterns of humans, in ways we won't expect and be prepared for. It'd be lousy not to get a job one is qualified for, but it would triple suck if it was because of stack overflow in some subroutine. (Laughter) In May of 2010, a flash crash on Wall Street fueled by a feedback loop in Wall Street's "sell" algorithm wiped a trillion dollars of value in 36 minutes. I don't even want to think what "error" means in the context of lethal autonomous weapons. So yes, humans have always made biases. Decision makers and gatekeepers, in courts, in news, in war ... they make mistakes; but that's exactly my point. We cannot escape these difficult questions. We cannot outsource our responsibilities to machines. (Applause) Artificial intelligence does not give us a "Get out of ethics free" card. Data scientist Fred Benenson calls this math-washing. We need the opposite. We need to cultivate algorithm suspicion, scrutiny and investigation. We need to make sure we have algorithmic accountability, auditing and meaningful transparency. We need to accept that bringing math and computation to messy, value-laden human affairs does not bring

objectivity; rather, the complexity of human affairs invades the algorithms. Yes, we can and we should use computation to help us make better decisions. But we have to own up to our moral responsibility to judgment, and use algorithms within that framework, not as a means to abdicate and outsource our responsibilities to one another as human to human. Machine intelligence is here. That means we must hold on ever tighter to human values and human ethics. Thank you. (Applause)

Chapter 7 What Does It Mean To Be A Citizen of The World

I want to introduce you to an amazing woman. Her name is Davinia. Davinia was born in Jamaica, emigrated to the US at the age of 18, and now lives just outside of Washington, DC. She's not a high-powered political staffer, nor a lobbyist. She'd probably tell you she's quite unremarkable, but she's having the most remarkable impact. What's incredible about Davinia is that she's willing to spend time every single week focused on people who are not her: people not her in her neighborhood, her state, nor even in her country – people she'd likely never meet. Davinia's impact started a few years ago when she reached out to all of her friends on Facebook, and asked them to donate their pennies so she could fund girls' education. She wasn't expecting a huge response, but 700,000 pennies later, she's now sent over 120 girls to school. When we spoke last week, she told me she's become a little infamous at the local bank every time she rocks up with a shopping cart full of pennies. Now – Davinia is not alone. Far from it. She's part of a growing movement. And there's a name for people like Davinia: global citizens. A global citizen is someone who self-identifies first and foremost not as a member of a state, a tribe or a nation, but as a member of the human race, and someone who is prepared to act on that belief, to tackle our world's greatest challenges. Our work is focused on finding, supporting and activating global citizens. They exist in every country and among every demographic. I want to make the case to you today that the world's future depends on global citizens. I'm convinced that if we had more global citizens active in our world, then every single one of the major challenges we face – from poverty, climate change, gender inequality – these issues become solvable. They are ultimately global issues, and they can ultimately only be solved by global citizens demanding global solutions from their leaders. Now, some people's immediate reaction to this idea is that it's either a bit utopian or even threatening. So I'd like to share with you a little of my story today, how I ended up here, how it connects with Davinia and, hopefully, with you. Growing up in Melbourne, Australia, I was one of those seriously irritating little kids that never, ever stopped asking, "Why?" You might have been one yourself. I used to ask my mum the most annoying questions. I'd ask her questions like, "Mum, why I can't I dress up and play with puppets all day?" "Why do you want fries with that?" "What is a shrimp, and why do we have to keep throwing them on the barbie?" (Laughter) "And mum – this haircut. Why?" (Laughter) The worst haircut, I think. Still terrible. As a "why" kid, I thought I could change the world, and it was impossible to convince me otherwise. And when I was 12 and in my first year of high school, I started raising money for communities in the developing world. We were a really enthusiastic group of kids, and we raised more money than any other school in Australia. And so I was awarded the chance to go to the Philippines to learn more. It was 1998. We were taken into a slum in the outskirts of Manila. It was there I became friends with Sonny Boy, who lived on what was literally a pile

of steaming garbage. "Smoky Mountain" was what they called it. But don't let the romance of that name fool you, because it was nothing more than a rancid landfill that kids like Sonny Boy spent hours rummaging through every single day to find something, anything of value. That night with Sonny Boy and his family changed my life forever, because when it came time to go to sleep, we simply laid down on this concrete slab the size of half my bedroom with myself, Sonny Boy, and the rest of his family, seven of us in this long line, with the smell of rubbish all around us and cockroaches crawling all around. And I didn't sleep a wink, but I lay awake thinking to myself, "Why should anyone have to live like this when I have so much? Why should Sonny Boy's ability to live out his dreams be determined by where he's born, or what Warren Buffett called 'the ovarian lottery?'" I just didn't get it, and I needed to understand why. Now, I only later came to understand that the poverty I'd seen in the Philippines was the result of decisions made or not made, man-made, by a succession of colonial powers and corrupt governments who had anything but the interests of Sonny Boy at heart. Sure, they didn't create Smoky Mountain, but they may as well have. And if we're to try to help kids like Sonny Boy, it wouldn't work just to try to send him a few dollars or to try to clean up the garbage dump on which he lived, because the core of the problem lay elsewhere. And as I worked on community development projects over the coming years trying to help build schools, train teachers, and tackle HIV and AIDS, I came to see that community development should be driven by communities themselves, and that although charity is necessary, it's not sufficient. We need to confront these challenges on a global scale and in a systemic way. And the best thing I could do is try to mobilize a large group of citizens back home to insist that our leaders engage in that systemic change. That's why, a few years later, I joined with a group of college friends in bringing the Make Poverty History campaign to Australia. We had this dream of staging this small concert around the time of the G20 with local Aussie artists, and it suddenly exploded one day when we got a phone call from Bono, the Edge and Pearl Jam, who all agreed to headline our concert. I got a little bit excited that day, as you can see. (Laughter) But to our amazement, the Australian government heard our collective voices, and they agreed to double investment into global health and development – an additional 6.2 billion dollars. It felt like – (Applause) It felt like this incredible validation. By rallying citizens together, we helped persuade our government to do the unthinkable, and act to fix a problem miles outside of our borders. But here's the thing: it didn't last. See, there was a change in government, and six years later, all that new money disappeared. What did we learn? We learned that one-off spikes are not enough. We needed a sustainable movement, not one that is susceptible to the fluctuating moods of a politician or the hint of an economic downturn. And it needed to happen everywhere; otherwise, every individual government would have this built-in excuse mechanism that they couldn't possibly carry the burden of global action alone. And so this is what we embarked upon. And as we embarked upon this challenge, we asked ourselves, how do we gain enough pressure and build a broad enough army to win these fights for the long term? We could only think of one way. We needed to somehow turn that short-term

excitement of people involved with the Make Poverty History campaign into long-term passion. It had to be part of their identity. So in 2012, we cofounded an organization that had exactly that as its goal. And there was only one name for it: Global Citizen. But this is not about any one organization. This is about citizens taking action. And research data tells us that of the total population who even care about global issues, only 18 percent have done anything about it. It's not that people don't want to act. It's often that they don't know how to take action, or that they believe that their actions will have no effect. So we had to somehow recruit and activate millions of citizens in dozens of countries to put pressure on their leaders to behave altruistically. And as we did so, we discovered something really thrilling, that when you make global citizenship your mission, you suddenly find yourself with some extraordinary allies. See, extreme poverty isn't the only issue that's fundamentally global. So, too, is climate change, human rights, gender equality, even conflict. We found ourselves shoulder to shoulder with people who are passionate about targeting all these interrelated issues. But how did we actually go about recruiting and engaging those global citizens? Well, we used the universal language: music. We launched the Global Citizen Festival in the heart of New York City in Central Park, and we persuaded some of the world's biggest artists to participate. We made sure that these festivals coincided with the UN General Assembly meeting, so that leaders who need to hear our voices couldn't possible ignore them. But there was a twist: you couldn't buy a ticket. You had to earn it. You had to take action on behalf of a global cause, and only once you'd done that could you earn enough points to qualify. Activism is the currency. I had no interest in citizenship purely as some sort of feel-good thing. For me, citizenship means you have to act, and that's what we required. And amazingly, it worked. Last year, more than 155,000 citizens in the New York area alone earned enough points to qualify. Globally, we've now signed up citizens in over 150 countries around the world. And last year, we signed up more than 100,000 new members each and every week of the whole year. See, we don't need to create global citizens from nothing. We're already everywhere. We just need to be organized and motivated to start acting. And this is where I believe we can learn a lot from Davinia, who started taking action as a global citizen back in 2012. Here's what she did. It wasn't rocket science. She started writing letters, emailing politicians' offices. She volunteered her time in her local community. That's when she got active on social media and started to collect pennies – a lot of pennies. Now, maybe that doesn't sound like a lot to you. How will that achieve anything? Well, it achieved a lot because she wasn't alone. Her actions, alongside 142,000 other global citizens', led the US government to double their investment into Global Partnership for Education. And here's Dr. Raj Shah, the head of USAID, making that announcement. See, when thousands of global citizens find inspiration from each other, it's amazing to see their collective power. Global citizens like Davinia helped persuade the World Bank to boost their investment into water and sanitation. Here's the Bank's president Jim Kim announcing 15 billion dollars onstage at Global Citizen, and Prime Minister Modi of India affirmed his commitment to put a toilet in every household and school across India

by 2019. Global citizens encouraged by the late-night host Stephen Colbert launched a Twitter invasion on Norway. Erna Solberg, the country's Prime Minister, got the message, committing to double investment into girls' education. Global citizens together with Rotarians called on the Canadian, UK, and Australian governments to boost their investment into polio eradication. They got together and committed 665 million dollars. But despite all of this momentum, we face some huge challenges. See, you might be thinking to yourself, how can we possibly persuade world leaders to sustain a focus on global issues? Indeed, the powerful American politician Tip O'Neill once said, "All politics is local." That's what always got politicians elected: to seek, gain and hold onto power through the pursuit of local or at very best national interests. I experienced this for the first time when I was 21 years old. I took a meeting with a then-Australian Foreign Minister who shall remain nameless – [Alexander Downer] (Laughter) And behind closed doors, I shared with him my passion to end extreme poverty. I said, "Minister – Australia has this once-in-a-lifetime opportunity to help achieve the Millennium Development Goals. We can do this." And he paused, looked down on me with cold, dismissive eyes, and he said, "Hugh, no one gives a funk about foreign aid." Except he didn't use the word "funk." He went on. He said we need to look after our own backyard first. This is, I believe, outdated, even dangerous thinking. Or as my late grandfather would say, complete BS. Parochialism offers this false dichotomy because it pits the poor in one country against the poor in another. It pretends we can isolate ourselves and our nations from one another. The whole world is our backyard, and we ignore it at our peril. See, look what happened when we ignored Rwanda, when we ignore Syria, when we ignore climate change. Political leaders ought to give a "funk" because the impact of climate change and extreme poverty comes right to our shore. Now, global citizens – they understand this. We live in a time that favors the global citizen, in an age where every single voice can be heard. See, do you remember when the Millennium Development Goals were signed back in the year 2000? The most we could do in those days was fire off a letter and wait for the next election. There was no social media. Today, billions of citizens have more tools, more access to information, more capacity to influence than ever before. Both the problems and the tools to solve them are right before us. The world has changed, and those of us who look beyond our borders are on the right side of history. So where are we? So we run this amazing festival, we've scored some big policy wins, and citizens are signing up all over the world. But have we achieved our mission? No. We have such a long way to go. But this is the opportunity that I see. The concept of global citizenship, self-evident in its logic but until now impractical in many ways, has coincided with this particular moment in which we are privileged to live. We, as global citizens, now have a unique opportunity to accelerate large-scale positive change around the world. So in the months and years ahead, global citizens will hold world leaders accountable to ensure that the new Global Goals for Sustainable Development are tracked and implemented. Global citizens will partner with the world's leading NGOs to end diseases like polio and malaria. Global citizens will sign up in every corner of this globe, increasing the frequency, quality and

impact of their actions. These dreams are within reach. Imagine an army of millions growing into tens of millions, connected, informed, engaged and unwilling to take no for an answer. Over all these years, I've tried to reconnect with Sonny Boy. Sadly, I've been unable to. We met long before social media, and his address has now been relocated by the authorities, as often happens with slums. I'd love to sit down with him, wherever he is, and share with him how much the time I spent on Smoky Mountain inspired me. Thanks to him and so many others, I came to understand the importance of being part of a movement of people – the kids willing to look up from their screens and out to the world, the global citizens. Global citizens who stand together, who ask the question "Why?," who reject the naysayers, and embrace the amazing possibilities of the world we share. I'm a global citizen. Are you? Thank you. (Applause)

Chapter 8 How We Read Each Other's Minds

Today I'm going to talk to you about the problem of other minds. And the problem I'm going to talk about is not the familiar one from philosophy, which is, "How can we know whether other people have minds?" That is, maybe you have a mind, and everyone else is just a really convincing robot. So that's a problem in philosophy, but for today's purposes I'm going to assume that many people in this audience have a mind, and that I don't have to worry about this. There is a second problem that is maybe even more familiar to us as parents and teachers and spouses and novelists, which is, "Why is it so hard to know what somebody else wants or believes?" Or perhaps, more relevantly, "Why is it so hard to change what somebody else wants or believes?" I think novelists put this best. Like Philip Roth, who said, "And yet, what are we to do about this terribly significant business of other people? So ill equipped are we all, to envision one another's interior workings and invisible aims." So as a teacher and as a spouse, this is, of course, a problem I confront every day. But as a scientist, I'm interested in a different problem of other minds, and that is the one I'm going to introduce to you today. And that problem is, "How is it so easy to know other minds?" So to start with an illustration, you need almost no information, one snapshot of a stranger, to guess what this woman is thinking, or what this man is. And put another way, the crux of the problem is the machine that we use for thinking about other minds, our brain, is made up of pieces, brain cells, that we share with all other animals, with monkeys and mice and even sea slugs. And yet, you put them together in a particular network, and what you get is the capacity to write Romeo and Juliet. Or to say, as Alan Greenspan did, "I know you think you understand what you thought I said, but I'm not sure you realize that what you heard is not what I meant." (Laughter) So, the job of my field of cognitive neuroscience is to stand with these ideas, one in each hand. And to try to understand how you can put together simple units, simple messages over space and time, in a network, and get this amazing human capacity to think about minds. So I'm going to tell you three things about this today. Obviously the whole project here is huge. And I'm going to tell you just our first few steps about the discovery of a special brain region for thinking about other people's thoughts. Some observations on the slow development of this system as we learn how to do this difficult job. And then finally, to show that some of the differences between people, in how we judge others, can be explained by differences in this brain system. So first, the first thing I want to tell you is that there is a brain region in the human brain, in your brains, whose job it is to think about other people's thoughts. This is a picture of it. It's called the Right Temporo-Parietal Junction. It's above and behind your right ear. And this is the brain region you used when you saw the pictures I showed you, or when you read Romeo and Juliet or when you tried to understand Alan Greenspan. And you don't use it for solving any other kinds of logical problems. So this brain region is called the Right TPJ. And this picture shows the average activation in a group of what we call typical human adults. They're

MIT undergraduates. (Laughter) The second thing I want to say about this brain system is that although we human adults are really good at understanding other minds, we weren't always that way. It takes children a long time to break into the system. I'm going to show you a little bit of that long, extended process. The first thing I'm going to show you is a change between age three and five, as kids learn to understand that somebody else can have beliefs that are different from their own. So I'm going to show you a five-year-old who is getting a standard kind of puzzle that we call the false belief task. Rebecca Saxe (Video): This is the first pirate. His name is Ivan. And you know what pirates really like? Child: What? RS: Pirates really like cheese sandwiches. Child: Cheese? I love cheese! RS: Yeah. So Ivan has this cheese sandwich, and he says, "Yum yum yum yum yum! I really love cheese sandwiches." And Ivan puts his sandwich over here, on top of the pirate chest. And Ivan says, "You know what? I need a drink with my lunch." And so Ivan goes to get a drink. And while Ivan is away the wind comes, and it blows the sandwich down onto the grass. And now, here comes the other pirate. This pirate is called Joshua. And Joshua also really loves cheese sandwiches. So Joshua has a cheese sandwich and he says, "Yum yum yum yum yum! I love cheese sandwiches." And he puts his cheese sandwich over here on top of the pirate chest. Child: So, that one is his. RS: That one is Joshua's. That's right. Child: And then his went on the ground. RS: That's exactly right. Child: So he won't know which one is his. RS: Oh. So now Joshua goes off to get a drink. Ivan comes back and he says, "I want my cheese sandwich." So which one do you think Ivan is going to take? Child: I think he is going to take that one. RS: Yeah, you think he's going to take that one? All right. Let's see. Oh yeah, you were right. He took that one. So that's a five-year-old who clearly understands that other people can have false beliefs and what the consequences are for their actions. Now I'm going to show you a three-year-old who got the same puzzle. RS: And Ivan says, "I want my cheese sandwich." Which sandwich is he going to take? Do you think he's going to take that one? Let's see what happens. Let's see what he does. Here comes Ivan. And he says, "I want my cheese sandwich." And he takes this one. Uh-oh. Why did he take that one? Child: His was on the grass. So the three-year-old does two things differently. First, he predicts Ivan will take the sandwich that's really his. And second, when he sees Ivan taking the sandwich where he left his, where we would say he's taking that one because he thinks it's his, the three-year-old comes up with another explanation: He's not taking his own sandwich because he doesn't want it, because now it's dirty, on the ground. So that's why he's taking the other sandwich. Now of course, development doesn't end at five. And we can see the continuation of this process of learning to think about other people's thoughts by upping the ante and asking children now, not for an action prediction, but for a moral judgment. So first I'm going to show you the three-year-old again. RS.: So is Ivan being mean and naughty for taking Joshua's sandwich? Child: Yeah. RS: Should Ivan get in trouble for taking Joshua's sandwich? Child: Yeah. So it's maybe not surprising he thinks it was mean of Ivan to take Joshua's sandwich, since he thinks Ivan only took Joshua's sandwich to avoid having to eat his own dirty sandwich. But now I'm going to show you

the five-year-old. Remember the five-year-old completely understood why Ivan took Joshua's sandwich. RS: Was Ivan being mean and naughty for taking Joshua's sandwich? Child: Um, yeah. And so, it is not until age seven that we get what looks more like an adult response. RS: Should Ivan get in trouble for taking Joshua's sandwich? Child: No, because the wind should get in trouble. He says the wind should get in trouble for switching the sandwiches. (Laughter) And now what we've started to do in my lab is to put children into the brain scanner and ask what's going on in their brain as they develop this ability to think about other people's thoughts. So the first thing is that in children we see this same brain region, the Right TPJ, being used while children are thinking about other people. But it's not quite like the adult brain. So whereas in the adults, as I told you, this brain region is almost completely specialized – it does almost nothing else except for thinking about other people's thoughts – in children it's much less so, when they are age five to eight, the age range of the children I just showed you. And actually if we even look at eight to 11-year-olds, getting into early adolescence, they still don't have quite an adult-like brain region. And so, what we can see is that over the course of childhood and even into adolescence, both the cognitive system, our mind's ability to think about other minds, and the brain system that supports it are continuing, slowly, to develop. But of course, as you're probably aware, even in adulthood, people differ from one another in how good they are at thinking of other minds, how often they do it and how accurately. And so what we wanted to know was, could differences among adults in how they think about other people's thoughts be explained in terms of differences in this brain region? So, the first thing that we did is we gave adults a version of the pirate problem that we gave to the kids. And I'm going to give that to you now. So Grace and her friend are on a tour of a chemical factory, and they take a break for coffee. And Grace's friend asks for some sugar in her coffee. Grace goes to make the coffee and finds by the coffee a pot containing a white powder, which is sugar. But the powder is labeled "Deadly Poison," so Grace thinks that the powder is a deadly poison. And she puts it in her friend's coffee. And her friend drinks the coffee, and is fine. How many people think it was morally permissible for Grace to put the powder in the coffee? Okay. Good. (Laughter) So we ask people, how much should Grace be blamed in this case, which we call a failed attempt to harm? And we can compare that to another case, where everything in the real world is the same. The powder is still sugar, but what's different is what Grace thinks. Now she thinks the powder is sugar. And perhaps unsurprisingly, if Grace thinks the powder is sugar and puts it in her friend's coffee, people say she deserves no blame at all. Whereas if she thinks the powder was poison, even though it's really sugar, now people say she deserves a lot of blame, even though what happened in the real world was exactly the same. And in fact, they say she deserves more blame in this case, the failed attempt to harm, than in another case, which we call an accident. Where Grace thought the powder was sugar, because it was labeled "sugar" and by the coffee machine, but actually the powder was poison. So even though when the powder was poison, the friend drank the coffee and died, people say Grace deserves less blame in that case, when she

innocently thought it was sugar, than in the other case, where she thought it was poison and no harm occurred. People, though, disagree a little bit about exactly how much blame Grace should get in the accident case. Some people think she should deserve more blame, and other people less. And what I'm going to show you is what happened when we look inside the brains of people while they're making that judgment. So what I'm showing you, from left to right, is how much activity there was in this brain region, and from top to bottom, how much blame people said that Grace deserved. And what you can see is, on the left when there was very little activity in this brain region, people paid little attention to her innocent belief and said she deserved a lot of blame for the accident. Whereas on the right, where there was a lot of activity, people paid a lot more attention to her innocent belief, and said she deserved a lot less blame for causing the accident. So that's good, but of course what we'd rather is have a way to interfere with function in this brain region, and see if we could change people's moral judgment. And we do have such a tool. It's called Trans-Cranial Magnetic Stimulation, or TMS. This is a tool that lets us pass a magnetic pulse through somebody's skull, into a small region of their brain, and temporarily disorganize the function of the neurons in that region. So I'm going to show you a demo of this. First, I'm going to show you that this is a magnetic pulse. I'm going to show you what happens when you put a quarter on the machine. When you hear clicks, we're turning the machine on. So now I'm going to apply that same pulse to my brain, to the part of my brain that controls my hand. So there is no physical force, just a magnetic pulse. Woman (Video): Ready, Rebecca? RS: Yes. Okay, so it causes a small involuntary contraction in my hand by putting a magnetic pulse in my brain. And we can use that same pulse, now applied to the RTPJ, to ask if we can change people's moral judgments. So these are the judgments I showed you before, people's normal moral judgments. And then we can apply TMS to the RTPJ and ask how people's judgments change. And the first thing is, people can still do this task overall. So their judgments of the case when everything was fine remain the same. They say she deserves no blame. But in the case of a failed attempt to harm, where Grace thought that it was poison, although it was really sugar, people now say it was more okay, she deserves less blame for putting the powder in the coffee. And in the case of the accident, where she thought that it was sugar, but it was really poison and so she caused a death, people say that it was less okay, she deserves more blame. So what I've told you today is that people come, actually, especially well equipped to think about other people's thoughts. We have a special brain system that lets us think about what other people are thinking. This system takes a long time to develop, slowly throughout the course of childhood and into early adolescence. And even in adulthood, differences in this brain region can explain differences among adults in how we think about and judge other people. But I want to give the last word back to the novelists, and to Philip Roth, who ended by saying, "The fact remains that getting people right is not what living is all about anyway. It's getting them wrong that is living. Getting them wrong and wrong and wrong, and then on careful reconsideration, getting them wrong again." Thank you. (Applause) Chris Anderson: So, I have a question. When you start

talking about using magnetic pulses to change people's moral judgments, that sounds alarming. (Laughter) Please tell me that you're not taking phone calls from the Pentagon, say. RS: I'm not. I mean, they're calling, but I'm not taking the call. (Laughter) CA: They really are calling? So then seriously, you must lie awake at night sometimes wondering where this work leads. I mean, you're clearly an incredible human being, but someone could take this knowledge and in some future not-torture chamber, do acts that people here might be worried about. RS: Yeah, we worry about this. So, there's a couple of things to say about TMS. One is that you can't be TMSed without knowing it. So it's not a surreptitious technology. It's quite hard, actually, to get those very small changes. The changes I showed you are impressive to me because of what they tell us about the function of the brain, but they're small on the scale of the moral judgments that we actually make. And what we changed was not people's moral judgments when they're deciding what to do, when they're making action choices. We changed their ability to judge other people's actions. And so, I think of what I'm doing not so much as studying the defendant in a criminal trial, but studying the jury. CA: Is your work going to lead to any recommendations in education, to perhaps bring up a generation of kids able to make fairer moral judgments? RS: That's one of the idealistic hopes. The whole research program here of studying the distinctive parts of the human brain is brand new. Until recently, what we knew about the brain were the things that any other animal's brain could do too, so we could study it in animal models. We knew how brains see, and how they control the body and how they hear and sense. And the whole project of understanding how brains do the uniquely human things – learn language and abstract concepts, and thinking about other people's thoughts – that's brand new. And we don't know yet what the implications will be of understanding it. CA: So I've got one last question. There is this thing called the hard problem of consciousness, that puzzles a lot of people. The notion that you can understand why a brain works, perhaps. But why does anyone have to feel anything? Why does it seem to require these beings who sense things for us to operate? You're a brilliant young neuroscientist. I mean, what chances do you think there are that at some time in your career, someone, you or someone else, is going to come up with some paradigm shift in understanding what seems an impossible problem? RS: I hope they do. And I think they probably won't. CA: Why? RS: It's not called the hard problem of consciousness for nothing. (Laughter) CA: That's a great answer. Rebecca Saxe, thank you very much. That was fantastic. (Applause)

Chapter 9 The Unheard Story of David and Goliath

So I wanted to tell a story that really obsessed me when I was writing my new book, and it's a story of something that happened 3,000 years ago, when the Kingdom of Israel was in its infancy. And it takes place in an area called the Shephelah in what is now Israel. And the reason the story obsessed me is that I thought I understood it, and then I went back over it and I realized that I didn't understand it at all. Ancient Palestine had a – along its eastern border, there's a mountain range. Still same is true of Israel today. And in the mountain range are all of the ancient cities of that region, so Jerusalem, Bethlehem, Hebron. And then there's a coastal plain along the Mediterranean, where Tel Aviv is now. And connecting the mountain range with the coastal plain is an area called the Shephelah, which is a series of valleys and ridges that run east to west, and you can follow the Shephelah, go through the Shephelah to get from the coastal plain to the mountains. And the Shephelah, if you've been to Israel, you'll know it's just about the most beautiful part of Israel. It's gorgeous, with forests of oak and wheat fields and vineyards. But more importantly, though, in the history of that region, it's served, it's had a real strategic function, and that is, it is the means by which hostile armies on the coastal plain find their way, get up into the mountains and threaten those living in the mountains. And 3,000 years ago, that's exactly what happens. The Philistines, who are the biggest of enemies of the Kingdom of Israel, are living in the coastal plain. They're originally from Crete. They're a seafaring people. And they may start to make their way through one of the valleys of the Shephelah up into the mountains, because what they want to do is occupy the highland area right by Bethlehem and split the Kingdom of Israel in two. And the Kingdom of Israel, which is headed by King Saul, obviously catches wind of this, and Saul brings his army down from the mountains and he confronts the Philistines in the Valley of Elah, one of the most beautiful of the valleys of the Shephelah. And the Israelites dig in along the northern ridge, and the Philistines dig in along the southern ridge, and the two armies just sit there for weeks and stare at each other, because they're deadlocked. Neither can attack the other, because to attack the other side you've got to come down the mountain into the valley and then up the other side, and you're completely exposed. So finally, to break the deadlock, the Philistines send their mightiest warrior down into the valley floor, and he calls out and he says to the Israelites, "Send your mightiest warrior down, and we'll have this out, just the two of us." This was a tradition in ancient warfare called single combat. It was a way of settling disputes without incurring the bloodshed of a major battle. And the Philistine who is sent down, their mighty warrior, is a giant. He's 6 foot 9. He's outfitted head to toe in this glittering bronze armor, and he's got a sword and he's got a javelin and he's got his spear. He is absolutely terrifying. And he's so terrifying that none of the Israelite soldiers want to fight him. It's a death wish, right? There's no way they think they can take him. And finally the only person who will come forward is this young shepherd boy, and he goes up to

Saul and he says, "I'll fight him." And Saul says, "You can't fight him. That's ridiculous. You're this kid. This is this mighty warrior." But the shepherd is adamant. He says, "No, no, no, you don't understand, I have been defending my flock against lions and wolves for years. I think I can do it." And Saul has no choice. He's got no one else who's come forward. So he says, "All right." And then he turns to the kid, and he says, "But you've got to wear this armor. You can't go as you are." So he tries to give the shepherd his armor, and the shepherd says, "No." He says, "I can't wear this stuff." The Biblical verse is, "I cannot wear this for I have not proved it," meaning, "I've never worn armor before. You've got to be crazy." So he reaches down instead on the ground and picks up five stones and puts them in his shepherd's bag and starts to walk down the mountainside to meet the giant. And the giant sees this figure approaching, and calls out, "Come to me so I can feed your flesh to the birds of the heavens and the beasts of the field." He issues this kind of taunt towards this person coming to fight him. And the shepherd draws closer and closer, and the giant sees that he's carrying a staff. That's all he's carrying. Instead of a weapon, just this shepherd's staff, and he says – he's insulted – "Am I a dog that you would come to me with sticks?" And the shepherd boy takes one of his stones out of his pocket, puts it in his sling and rolls it around and lets it fly and it hits the giant right between the eyes – right here, in his most vulnerable spot – and he falls down either dead or unconscious, and the shepherd boy runs up and takes his sword and cuts off his head, and the Philistines see this and they turn and they just run. And of course, the name of the giant is Goliath and the name of the shepherd boy is David, and the reason that story has obsessed me over the course of writing my book is that everything I thought I knew about that story turned out to be wrong. So David, in that story, is supposed to be the underdog, right? In fact, that term, David and Goliath, has entered our language as a metaphor for improbable victories by some weak party over someone far stronger. Now why do we call David an underdog? Well, we call him an underdog because he's a kid, a little kid, and Goliath is this big, strong giant. We also call him an underdog because Goliath is an experienced warrior, and David is just a shepherd. But most importantly, we call him an underdog because all he has is – it's that Goliath is outfitted with all of this modern weaponry, this glittering coat of armor and a sword and a javelin and a spear, and all David has is this sling. Well, let's start there with the phrase "All David has is this sling," because that's the first mistake that we make. In ancient warfare, there are three kinds of warriors. There's cavalry, men on horseback and with chariots. There's heavy infantry, which are foot soldiers, armed foot soldiers with swords and shields and some kind of armor. And there's artillery, and artillery are archers, but, more importantly, slingers. And a slinger is someone who has a leather pouch with two long cords attached to it, and they put a projectile, either a rock or a lead ball, inside the pouch, and they whirl it around like this and they let one of the cords go, and the effect is to send the projectile forward towards its target. That's what David has, and it's important to understand that that sling is not a slingshot. It's not this, right? It's not a child's toy. It's in fact an incredibly devastating weapon. When David rolls it around like this, he's turning the

sling around probably at six or seven revolutions per second, and that means that when the rock is released, it's going forward really fast, probably 35 meters per second. That's substantially faster than a baseball thrown by even the finest of baseball pitchers. More than that, the stones in the Valley of Elah were not normal rocks. They were barium sulphate, which are rocks twice the density of normal stones. If you do the calculations on the ballistics, on the stopping power of the rock fired from David's sling, it's roughly equal to the stopping power of a [.45 caliber] handgun. This is an incredibly devastating weapon. Accuracy, we know from historical records that slingers – experienced slingers could hit and maim or even kill a target at distances of up to 200 yards. From medieval tapestries, we know that slingers were capable of hitting birds in flight. They were incredibly accurate. When David lines up – and he's not 200 yards away from Goliath, he's quite close to Goliath – when he lines up and fires that thing at Goliath, he has every intention and every expectation of being able to hit Goliath at his most vulnerable spot between his eyes. If you go back over the history of ancient warfare, you will find time and time again that slingers were the decisive factor against infantry in one kind of battle or another. So what's Goliath? He's heavy infantry, and his expectation when he challenges the Israelites to a duel is that he's going to be fighting another heavy infantryman. When he says, "Come to me that I might feed your flesh to the birds of the heavens and the beasts of the field," the key phrase is "Come to me." Come up to me because we're going to fight, hand to hand, like this. Saul has the same expectation. David says, "I want to fight Goliath," and Saul tries to give him his armor, because Saul is thinking, "Oh, when you say 'fight Goliath,' you mean 'fight him in hand-to-hand combat,' infantry on infantry." But David has absolutely no expectation. He's not going to fight him that way. Why would he? He's a shepherd. He's spent his entire career using a sling to defend his flock against lions and wolves. That's where his strength lies. So here he is, this shepherd, experienced in the use of a devastating weapon, up against this lumbering giant weighed down by a hundred pounds of armor and these incredibly heavy weapons that are useful only in short-range combat. Goliath is a sitting duck. He doesn't have a chance. So why do we keep calling David an underdog, and why do we keep referring to his victory as improbable? There's a second piece of this that's important. It's not just that we misunderstand David and his choice of weaponry. It's also that we profoundly misunderstand Goliath. Goliath is not what he seems to be. There's all kinds of hints of this in the Biblical text, things that are in retrospect quite puzzling and don't square with his image as this mighty warrior. So to begin with, the Bible says that Goliath is led onto the valley floor by an attendant. Now that is weird, right? Here is this mighty warrior challenging the Israelites to one-on-one combat. Why is he being led by the hand by some young boy, presumably, to the point of combat? Secondly, the Bible story makes special note of how slowly Goliath moves, another odd thing to say when you're describing the mightiest warrior known to man at that point. And then there's this whole weird thing about how long it takes Goliath to react to the sight of David. So David's coming down the mountain, and he's clearly not preparing for hand-to-hand combat. There is nothing about him

that says, "I am about to fight you like this." He's not even carrying a sword. Why does Goliath not react to that? It's as if he's oblivious to what's going on that day. And then there's that strange comment he makes to David: "Am I a dog that you should come to me with sticks?" Sticks? David only has one stick. Well, it turns out that there's been a great deal of speculation within the medical community over the years about whether there is something fundamentally wrong with Goliath, an attempt to make sense of all of those apparent anomalies. There have been many articles written. The first one was in 1960 in the Indiana Medical Journal, and it started a chain of speculation that starts with an explanation for Goliath's height. So Goliath is head and shoulders above all of his peers in that era, and usually when someone is that far out of the norm, there's an explanation for it. So the most common form of giantism is a condition called acromegaly, and acromegaly is caused by a benign tumor on your pituitary gland that causes an overproduction of human growth hormone. And throughout history, many of the most famous giants have all had acromegaly. So the tallest person of all time was a guy named Robert Wadlow who was still growing when he died at the age of 24 and he was 8 foot 11. He had acromegaly. Do you remember the wrestler André the Giant? Famous. He had acromegaly. There's even speculation that Abraham Lincoln had acromegaly. Anyone who's unusually tall, that's the first explanation we come up with. And acromegaly has a very distinct set of side effects associated with it, principally having to do with vision. The pituitary tumor, as it grows, often starts to compress the visual nerves in your brain, with the result that people with acromegaly have either double vision or they are profoundly nearsighted. So when people have started to speculate about what might have been wrong with Goliath, they've said, "Wait a minute, he looks and sounds an awful lot like someone who has acromegaly." And that would also explain so much of what was strange about his behavior that day. Why does he move so slowly and have to be escorted down into the valley floor by an attendant? Because he can't make his way on his own. Why is he so strangely oblivious to David that he doesn't understand that David's not going to fight him until the very last moment? Because he can't see him. When he says, "Come to me that I might feed your flesh to the birds of the heavens and the beasts of the field," the phrase "come to me" is a hint also of his vulnerability. Come to me because I can't see you. And then there's, "Am I a dog that you should come to me with sticks?" He sees two sticks when David has only one. So the Israelites up on the mountain ridge looking down on him thought he was this extraordinarily powerful foe. What they didn't understand was that the very thing that was the source of his apparent strength was also the source of his greatest weakness. And there is, I think, in that, a very important lesson for all of us. Giants are not as strong and powerful as they seem. And sometimes the shepherd boy has a sling in his pocket. Thank you. (Applause)

Chapter 10 The Mathematics of Love

Today I want to talk to you about the mathematics of love. Now, I think that we can all agree that mathematicians are famously excellent at finding love. (Laughter) But it's not just because of our dashing personalities, superior conversational skills and excellent pencil cases. It's also because we've actually done an awful lot of work into the maths of how to find the perfect partner. Now, in my favorite paper on the subject, which is entitled, "Why I Don't Have a Girlfriend" – (Laughter) Peter Backus tries to rate his chances of finding love. Now, Peter's not a very greedy man. Of all of the available women in the UK, all Peter's looking for is somebody who lives near him, somebody in the right age range, somebody with a university degree, somebody he's likely to get on well with, somebody who's likely to be attractive, somebody who's likely to find him attractive. (Laughter) And comes up with an estimate of 26 women in the whole of the UK. (Laughter) It's not looking very good, is it Peter? Now, just to put that into perspective, that's about 400 times fewer than the best estimates of how many intelligent extraterrestrial life forms there are. And it also gives Peter a 1 in 285,000 chance of bumping into any one of these special ladies on a given night out. I'd like to think that's why mathematicians don't really bother going on nights out anymore. The thing is that I personally don't subscribe to such a pessimistic view. Because I know, just as well as all of you do, that love doesn't really work like that. Human emotion isn't neatly ordered and rational and easily predictable. But I also know that that doesn't mean that mathematics hasn't got something that it can offer us, because, love, as with most of life, is full of patterns and mathematics is, ultimately, all about the study of patterns. Patterns from predicting the weather to the fluctuations in the stock market, to the movement of the planets or the growth of cities. And if we're being honest, none of those things are exactly neatly ordered and easily predictable, either. Because I believe that mathematics is so powerful that it has the potential to offer us a new way of looking at almost anything. Even something as mysterious as love. And so, to try to persuade you of how totally amazing, excellent and relevant mathematics is, I want to give you my top three mathematically verifiable tips for love. (Laughter) OK, so Top Tip #1: How to win at online dating. So my favorite online dating website is OkCupid, not least because it was started by a group of mathematicians. Now, because they're mathematicians, they have been collecting data on everybody who uses their site for almost a decade. And they've been trying to search for patterns in the way that we talk about ourselves and the way that we interact with each other on an online dating website. And they've come up with some seriously interesting findings. But my particular favorite is that it turns out that on an online dating website, how attractive you are does not dictate how popular you are, and actually, having people think that you're ugly can work to your advantage. (Laughter) Let me show you how this works. In a thankfully voluntary section of OkCupid, you are allowed to rate how attractive you think people are on a scale between one and five. Now, if we compare this score, the average score, to how

many messages a selection of people receive, you can begin to get a sense of how attractiveness links to popularity on an online dating website. This is the graph the OkCupid guys have come up with. And the important thing to notice is that it's not totally true that the more attractive you are, the more messages you get. But the question arises then of what is it about people up here who are so much more popular than people down here, even though they have the same score of attractiveness? And the reason why is that it's not just straightforward looks that are important. So let me try to illustrate their findings with an example. So if you take someone like Portia de Rossi, for example, everybody agrees that Portia de Rossi is a very beautiful woman. Nobody thinks that she's ugly, but she's not a supermodel, either. If you compare Portia de Rossi to someone like Sarah Jessica Parker, now, a lot of people, myself included, I should say, think that Sarah Jessica Parker is seriously fabulous and possibly one of the most beautiful creatures to have ever have walked on the face of the Earth. But some other people, i.e., most of the Internet ... (Laughter) seem to think that she looks a bit like a horse. (Laughter) Now, I think that if you ask people how attractive they thought Jessica Parker or Portia de Rossi were, and you ask them to give them a score between one and five I reckon that they'd average out to have roughly the same score. But the way that people would vote would be very different. So Portia's scores would all be clustered around the four because everybody agrees that she's very beautiful, whereas Sarah Jessica Parker completely divides opinion. There'd be a huge spread in her scores. And actually it's this spread that counts. It's this spread that makes you more popular on an online Internet dating website. So what that means then is that if some people think that you're attractive, you're actually better off having some other people think that you're a massive minger. That's much better than everybody just thinking that you're the cute girl next door. Now, I think this begins to make a bit more sense when you think in terms of the people who are sending these messages. So let's say that you think somebody's attractive, but you suspect that other people won't necessarily be that interested. That means there's less competition for you and it's an extra incentive for you to get in touch. Whereas compare that to if you think somebody is attractive but you suspect that everybody is going to think they're attractive. Well, why would you bother humiliating yourself, let's be honest? But here's where the really interesting part comes. Because when people choose the pictures that they use on an online dating website, they often try to minimize the things that they think some people will find unattractive. The classic example is people who are, perhaps, a little bit overweight deliberately choosing a very cropped photo, (Laughter) or bald men, for example, deliberately choosing pictures where they're wearing hats. But actually this is the opposite of what you should do if you want to be successful. You should really, instead, play up to whatever it is that makes you different, even if you think that some people will find it unattractive. Because the people who fancy you are just going to fancy you anyway, and the unimportant losers who don't, well, they only play up to your advantage. OK, Top Tip #2: How to pick the perfect partner. So let's imagine then that you're a roaring success on the dating scene. But the question arises of how do you then convert that success into longer-term happiness, and

in particular, how do you decide when is the right time to settle down? Now generally, it's not advisable to just cash in and marry the first person who comes along and shows you any interest at all. But, equally, you don't really want to leave it too long if you want to maximize your chance of long-term happiness. As my favorite author, Jane Austen, puts it, "An unmarried woman of seven and twenty can never hope to feel or inspire affection again." (Laughter) Thanks a lot, Jane. What do you know about love? (Laughter) So the question is then, how do you know when is the right time to settle down, given all the people that you can date in your lifetime? Thankfully, there's a rather delicious bit of mathematics that we can use to help us out here, called optimal stopping theory. So let's imagine, then, that you start dating when you're 15 and ideally, you'd like to be married by the time that you're 35. And there's a number of people that you could potentially date across your lifetime, and they'll be at varying levels of goodness. Now the rules are that once you cash in and get married, you can't look ahead to see what you could have had, and equally, you can't go back and change your mind. In my experience at least, I find that typically people don't much like being recalled years after being passed up for somebody else, or that's just me. So the math says then that what you should do in the first 37 percent of your dating window, you should just reject everybody as serious marriage potential. (Laughter) And then, you should pick the next person that comes along that is better than everybody that you've seen before. So here's the example. Now if you do this, it can be mathematically proven, in fact, that this is the best possible way of maximizing your chances of finding the perfect partner. Now unfortunately, I have to tell you that this method does come with some risks. For instance, imagine if your perfect partner appeared during your first 37 percent. Now, unfortunately, you'd have to reject them. (Laughter) Now, if you're following the maths, I'm afraid no one else comes along that's better than anyone you've seen before, so you have to go on rejecting everyone and die alone. (Laughter) Probably surrounded by cats ... (Laughter) nibbling at your remains. OK, another risk is, let's imagine, instead, that the first people that you dated in your first 37 percent are just incredibly dull, boring, terrible people. That's OK, because you're in your rejection phase, so that's fine, you can reject them. But then imagine the next person to come along is just marginally less boring, dull and terrible ... (Laughter) than everybody that you've seen before. Now, if you are following the maths, I'm afraid you have to marry them ... (Laughter) and end up in a relationship which is, frankly, suboptimal. Sorry about that. But I do think that there's an opportunity here for Hallmark to cash in on and really cater for this market. A Valentine's Day card like this. (Laughter) "My darling husband, you are marginally less terrible than the first 37 percent of people I dated." (Laughter) It's actually more romantic than I normally manage. (Laughter) OK, so this method doesn't give you a 100 percent success rate, but there's no other possible strategy that can do any better. And actually, in the wild, there are certain types of fish which follow and employ this exact strategy. So they reject every possible suitor that turns up in the first 37 percent of the mating season, and then they pick the next fish that comes along after that window that's, I don't know, bigger and burlier than all of the fish that they've seen before. I

also think that subconsciously, humans, we do sort of do this anyway. We give ourselves a little bit of time to play the field, get a feel for the marketplace or whatever when we're young. And then we only start looking seriously at potential marriage candidates once we hit our mid-to-late 20s. I think this is conclusive proof, if ever it were needed, that everybody's brains are prewired to be just a little bit mathematical. OK, so that was Top Tip #2. Now, Top Tip #3: How to avoid divorce. OK, so let's imagine then that you picked your perfect partner and you're settling into a lifelong relationship with them. Now, I like to think that everybody would ideally like to avoid divorce, apart from, I don't know, Piers Morgan's wife, maybe? (Laughter) But it's a sad fact of modern life that one in two marriages in the States ends in divorce, with the rest of the world not being far behind. Now, you can be forgiven, perhaps for thinking that the arguments that precede a marital breakup are not an ideal candidate for mathematical investigation. For one thing, it's very hard to know what you should be measuring or what you should be quantifying. But this didn't stop a psychologist, John Gottman, who did exactly that. Gottman observed hundreds of couples having a conversation and recorded, well, everything you can think of. So he recorded what was said in the conversation, he recorded their skin conductivity, he recorded their facial expressions, their heart rates, their blood pressure, basically everything apart from whether or not the wife was actually always right, which incidentally she totally is. But what Gottman and his team found was that one of the most important predictors for whether or not a couple is going to get divorced was how positive or negative each partner was being in the conversation. Now, couples that were very low-risk scored a lot more positive points on Gottman's scale than negative. Whereas bad relationships, by which I mean, probably going to get divorced, they found themselves getting into a spiral of negativity. Now just by using these very simple ideas, Gottman and his group were able to predict whether a given couple was going to get divorced with a 90 percent accuracy. But it wasn't until he teamed up with a mathematician, James Murray, that they really started to understand what causes these negativity spirals and how they occur. And the results that they found, I think, are just incredibly impressively simple and interesting. So these equations predict how the wife or husband is going to respond in their next turn of the conversation, how positive or negative they're going to be. And these equations depend on the mood of the person when they're on their own, the mood of the person when they're with their partner, but most importantly, they depend on how much the husband and wife influence one another. Now, I think it's important to point out at this stage, that these exact equations have also been shown to be perfectly able at describing what happens between two countries in an arms race. (Laughter) So that an arguing couple spiraling into negativity and teetering on the brink of divorce is actually mathematically equivalent to the beginning of a nuclear war. (Laughter) But the really important term in this equation is the influence that people have on one another, and in particular, something called "the negativity threshold." Now, the negativity threshold, you can think of as how annoying the husband can be before the wife starts to get really pissed off, and vice versa. Now, I always thought that good marriages were about compromise and

understanding and allowing the person to have the space to be themselves. So I would have thought that perhaps the most successful relationships were ones where there was a really high negativity threshold. Where couples let things go and only brought things up if they really were a big deal. But actually, the mathematics and subsequent findings by the team have shown the exact opposite is true. The best couples, or the most successful couples, are the ones with a really low negativity threshold. These are the couples that don't let anything go unnoticed and allow each other some room to complain. These are the couples that are continually trying to repair their own relationship, that have a much more positive outlook on their marriage. Couples that don't let things go and couples that don't let trivial things end up being a really big deal. Now of course, it takes a bit more than just a low negativity threshold and not compromising to have a successful relationship. But I think that it's quite interesting to know that there is really mathematical evidence to say that you should never let the sun go down on your anger. So those are my top three tips of how maths can help you with love and relationships. But I hope, that aside from their use as tips, they also give you a little bit of insight into the power of mathematics. Because for me, equations and symbols aren't just a thing. They're a voice that speaks out about the incredible richness of nature and the startling simplicity in the patterns that twist and turn and warp and evolve all around us, from how the world works to how we behave. So I hope that perhaps, for just a couple of you, a little bit of insight into the mathematics of love can persuade you to have a little bit more love for mathematics. Thank you. (Applause)

Chapter 11 Can We Build AI Without Losing Control over It

I'm going to talk about a failure of intuition that many of us suffer from. It's really a failure to detect a certain kind of danger. I'm going to describe a scenario that I think is both terrifying and likely to occur, and that's not a good combination, as it turns out. And yet rather than be scared, most of you will feel that what I'm talking about is kind of cool. I'm going to describe how the gains we make in artificial intelligence could ultimately destroy us. And in fact, I think it's very difficult to see how they won't destroy us or inspire us to destroy ourselves. And yet if you're anything like me, you'll find that it's fun to think about these things. And that response is part of the problem. OK? That response should worry you. And if I were to convince you in this talk that we were likely to suffer a global famine, either because of climate change or some other catastrophe, and that your grandchildren, or their grandchildren, are very likely to live like this, you wouldn't think, "Interesting. I like this TED Talk." Famine isn't fun. Death by science fiction, on the other hand, is fun, and one of the things that worries me most about the development of AI at this point is that we seem unable to marshal an appropriate emotional response to the dangers that lie ahead. I am unable to marshal this response, and I'm giving this talk. It's as though we stand before two doors. Behind door number one, we stop making progress in building intelligent machines. Our computer hardware and software just stops getting better for some reason. Now take a moment to consider why this might happen. I mean, given how valuable intelligence and automation are, we will continue to improve our technology if we are at all able to. What could stop us from doing this? A full-scale nuclear war? A global pandemic? An asteroid impact? Justin Bieber becoming president of the United States? (Laughter) The point is, something would have to destroy civilization as we know it. You have to imagine how bad it would have to be to prevent us from making improvements in our technology permanently, generation after generation. Almost by definition, this is the worst thing that's ever happened in human history. So the only alternative, and this is what lies behind door number two, is that we continue to improve our intelligent machines year after year after year. At a certain point, we will build machines that are smarter than we are, and once we have machines that are smarter than we are, they will begin to improve themselves. And then we risk what the mathematician IJ Good called an "intelligence explosion," that the process could get away from us. Now, this is often caricatured, as I have here, as a fear that armies of malicious robots will attack us. But that isn't the most likely scenario. It's not that our machines will become spontaneously malevolent. The concern is really that we will build machines that are so much more competent than we are that the slightest divergence between their goals and our own could destroy us. Just think about how we relate to ants. We don't hate them. We don't go out of our way to harm them. In fact, sometimes we take pains not to harm them. We step over

them on the sidewalk. But whenever their presence seriously conflicts with one of our goals, let's say when constructing a building like this one, we annihilate them without a qualm. The concern is that we will one day build machines that, whether they're conscious or not, could treat us with similar disregard. Now, I suspect this seems far-fetched to many of you. I bet there are those of you who doubt that superintelligent AI is possible, much less inevitable. But then you must find something wrong with one of the following assumptions. And there are only three of them. Intelligence is a matter of information processing in physical systems. Actually, this is a little bit more than an assumption. We have already built narrow intelligence into our machines, and many of these machines perform at a level of superhuman intelligence already. And we know that mere matter can give rise to what is called "general intelligence," an ability to think flexibly across multiple domains, because our brains have managed it. Right? I mean, there's just atoms in here, and as long as we continue to build systems of atoms that display more and more intelligent behavior, we will eventually, unless we are interrupted, we will eventually build general intelligence into our machines. It's crucial to realize that the rate of progress doesn't matter, because any progress is enough to get us into the end zone. We don't need Moore's law to continue. We don't need exponential progress. We just need to keep going. The second assumption is that we will keep going. We will continue to improve our intelligent machines. And given the value of intelligence – I mean, intelligence is either the source of everything we value or we need it to safeguard everything we value. It is our most valuable resource. So we want to do this. We have problems that we desperately need to solve. We want to cure diseases like Alzheimer's and cancer. We want to understand economic systems. We want to improve our climate science. So we will do this, if we can. The train is already out of the station, and there's no brake to pull. Finally, we don't stand on a peak of intelligence, or anywhere near it, likely. And this really is the crucial insight. This is what makes our situation so precarious, and this is what makes our intuitions about risk so unreliable. Now, just consider the smartest person who has ever lived. On almost everyone's shortlist here is John von Neumann. I mean, the impression that von Neumann made on the people around him, and this included the greatest mathematicians and physicists of his time, is fairly well-documented. If only half the stories about him are half true, there's no question he's one of the smartest people who has ever lived. So consider the spectrum of intelligence. Here we have John von Neumann. And then we have you and me. And then we have a chicken. (Laughter) Sorry, a chicken. (Laughter) There's no reason for me to make this talk more depressing than it needs to be. (Laughter) It seems overwhelmingly likely, however, that the spectrum of intelligence extends much further than we currently conceive, and if we build machines that are more intelligent than we are, they will very likely explore this spectrum in ways that we can't imagine, and exceed us in ways that we can't imagine. And it's important to recognize that this is true by virtue of speed alone. Right? So imagine if we just built a superintelligent AI that was no smarter than your average team of researchers at Stanford or MIT. Well, electronic circuits function about a million times faster than biochemical ones, so

this machine should think about a million times faster than the minds that built it. So you set it running for a week, and it will perform 20,000 years of human-level intellectual work, week after week after week. How could we even understand, much less constrain, a mind making this sort of progress? The other thing that's worrying, frankly, is that, imagine the best case scenario. So imagine we hit upon a design of superintelligent AI that has no safety concerns. We have the perfect design the first time around. It's as though we've been handed an oracle that behaves exactly as intended. Well, this machine would be the perfect labor-saving device. It can design the machine that can build the machine that can do any physical work, powered by sunlight, more or less for the cost of raw materials. So we're talking about the end of human drudgery. We're also talking about the end of most intellectual work. So what would apes like ourselves do in this circumstance? Well, we'd be free to play Frisbee and give each other massages. Add some LSD and some questionable wardrobe choices, and the whole world could be like Burning Man. (Laughter) Now, that might sound pretty good, but ask yourself what would happen under our current economic and political order? It seems likely that we would witness a level of wealth inequality and unemployment that we have never seen before. Absent a willingness to immediately put this new wealth to the service of all humanity, a few trillionaires could grace the covers of our business magazines while the rest of the world would be free to starve. And what would the Russians or the Chinese do if they heard that some company in Silicon Valley was about to deploy a superintelligent AI? This machine would be capable of waging war, whether terrestrial or cyber, with unprecedented power. This is a winner-take-all scenario. To be six months ahead of the competition here is to be 500,000 years ahead, at a minimum. So it seems that even mere rumors of this kind of breakthrough could cause our species to go berserk. Now, one of the most frightening things, in my view, at this moment, are the kinds of things that AI researchers say when they want to be reassuring. And the most common reason we're told not to worry is time. This is all a long way off, don't you know. This is probably 50 or 100 years away. One researcher has said, "Worrying about AI safety is like worrying about overpopulation on Mars." This is the Silicon Valley version of "don't worry your pretty little head about it." (Laughter) No one seems to notice that referencing the time horizon is a total non sequitur. If intelligence is just a matter of information processing, and we continue to improve our machines, we will produce some form of superintelligence. And we have no idea how long it will take us to create the conditions to do that safely. Let me say that again. We have no idea how long it will take us to create the conditions to do that safely. And if you haven't noticed, 50 years is not what it used to be. This is 50 years in months. This is how long we've had the iPhone. This is how long "The Simpsons" has been on television. Fifty years is not that much time to meet one of the greatest challenges our species will ever face. Once again, we seem to be failing to have an appropriate emotional response to what we have every reason to believe is coming. The computer scientist Stuart Russell has a nice analogy here. He said, imagine that we received a message from an alien civilization, which read: "People of Earth, we will arrive on your planet

in 50 years. Get ready." And now we're just counting down the months until the mothership lands? We would feel a little more urgency than we do. Another reason we're told not to worry is that these machines can't help but share our values because they will be literally extensions of ourselves. They'll be grafted onto our brains, and we'll essentially become their limbic systems. Now take a moment to consider that the safest and only prudent path forward, recommended, is to implant this technology directly into our brains. Now, this may in fact be the safest and only prudent path forward, but usually one's safety concerns about a technology have to be pretty much worked out before you stick it inside your head. (Laughter) The deeper problem is that building superintelligent AI on its own seems likely to be easier than building superintelligent AI and having the completed neuroscience that allows us to seamlessly integrate our minds with it. And given that the companies and governments doing this work are likely to perceive themselves as being in a race against all others, given that to win this race is to win the world, provided you don't destroy it in the next moment, then it seems likely that whatever is easier to do will get done first. Now, unfortunately, I don't have a solution to this problem, apart from recommending that more of us think about it. I think we need something like a Manhattan Project on the topic of artificial intelligence. Not to build it, because I think we'll inevitably do that, but to understand how to avoid an arms race and to build it in a way that is aligned with our interests. When you're talking about superintelligent AI that can make changes to itself, it seems that we only have one chance to get the initial conditions right, and even then we will need to absorb the economic and political consequences of getting them right. But the moment we admit that information processing is the source of intelligence, that some appropriate computational system is what the basis of intelligence is, and we admit that we will improve these systems continuously, and we admit that the horizon of cognition very likely far exceeds what we currently know, then we have to admit that we are in the process of building some sort of god. Now would be a good time to make sure it's a god we can live with. Thank you very much. (Applause)

Chapter 12 Are Athletes Really Getting Faster, Better, Stronger

The Olympic motto is "Citius, Altius, Fortius." Faster, Higher, Stronger. And athletes have fulfilled that motto rapidly. The winner of the 2012 Olympic marathon ran two hours and eight minutes. Had he been racing against the winner of the 1904 Olympic marathon, he would have won by nearly an hour and a half. Now we all have this feeling that we're somehow just getting better as a human race, inexorably progressing, but it's not like we've evolved into a new species in a century. So what's going on here? I want to take a look at what's really behind this march of athletic progress. In 1936, Jesse Owens held the world record in the 100 meters. Had Jesse Owens been racing last year in the world championships of the 100 meters, when Jamaican sprinter Usain Bolt finished, Owens would have still had 14 feet to go. That's a lot in sprinter land. To give you a sense of how much it is, I want to share with you a demonstration conceived by sports scientist Ross Tucker. Now picture the stadium last year at the world championships of the 100 meters: thousands of fans waiting with baited breath to see Usain Bolt, the fastest man in history; flashbulbs popping as the nine fastest men in the world coil themselves into their blocks. And I want you to pretend that Jesse Owens is in that race. Now close your eyes for a second and picture the race. Bang! The gun goes off. An American sprinter jumps out to the front. Usain Bolt starts to catch him. Usain Bolt passes him, and as the runners come to the finish, you'll hear a beep as each man crosses the line. (Beeps) That's the entire finish of the race. You can open your eyes now. That first beep was Usain Bolt. That last beep was Jesse Owens. Listen to it again. (Beeps) When you think of it like that, it's not that big a difference, is it? And then consider that Usain Bolt started by propelling himself out of blocks down a specially fabricated carpet designed to allow him to travel as fast as humanly possible. Jesse Owens, on the other hand, ran on cinders, the ash from burnt wood, and that soft surface stole far more energy from his legs as he ran. Rather than blocks, Jesse Owens had a gardening trowel that he had to use to dig holes in the cinders to start from. Biomechanical analysis of the speed of Owens' joints shows that had been running on the same surface as Bolt, he wouldn't have been 14 feet behind, he would have been within one stride. Rather than the last beep, Owens would have been the second beep. Listen to it again. (Beeps) That's the difference track surface technology has made, and it's done it throughout the running world. Consider a longer event. In 1954, Sir Roger Bannister became the first man to run under four minutes in the mile. Nowadays, college kids do that every year. On rare occasions, a high school kid does it. As of the end of last year, 1,314 men had run under four minutes in the mile, but like Jesse Owens, Sir Roger Bannister ran on soft cinders that stole far more energy from his legs than the synthetic tracks of today. So I consulted biomechanics experts to find out how much slower it is to run on cinders than synthetic tracks, and their consensus that it's one and a half percent slower. So

if you apply a one and a half percent slowdown conversion to every man who ran his sub-four mile on a synthetic track, this is what happens. Only 530 are left. If you look at it from that perspective, fewer than ten new men per [year] have joined the sub-four mile club since Sir Roger Bannister. Now, 530 is a lot more than one, and that's partly because there are many more people training today and they're training more intelligently. Even college kids are professional in their training compared to Sir Roger Bannister, who trained for 45 minutes at a time while he ditched gynecology lectures in med school. And that guy who won the 1904 Olympic marathon in three in a half hours, that guy was drinking rat poison and brandy while he ran along the course. That was his idea of a performance-enhancing drug. (Laughter) Clearly, athletes have gotten more savvy about performance-enhancing drugs as well, and that's made a difference in some sports at some times, but technology has made a difference in all sports, from faster skis to lighter shoes. Take a look at the record for the 100-meter freestyle swim. The record is always trending downward, but it's punctuated by these steep cliffs. This first cliff, in 1956, is the introduction of the flip turn. Rather than stopping and turning around, athletes could somersault under the water and get going right away in the opposite direction. This second cliff, the introduction of gutters on the side of the pool that allows water to splash off, rather than becoming turbulence that impedes the swimmers as they race. This final cliff, the introduction of full-body and low-friction swimsuits. Throughout sports, technology has changed the face of performance. In 1972, Eddy Merckx set the record for the longest distance cycled in one hour at 30 miles, 3,774 feet. Now that record improved and improved as bicycles improved and became more aerodynamic all the way until 1996, when it was set at 35 miles, 1,531 feet, nearly five miles farther than Eddy Merckx cycled in 1972. But then in 2000, the International Cycling Union decreed that anyone who wanted to hold that record had to do so with essentially the same equipment that Eddy Merckx used in 1972. Where does the record stand today? 30 miles, 4,657 feet, a grand total of 883 feet farther than Eddy Merckx cycled more than four decades ago. Essentially the entire improvement in this record was due to technology. Still, technology isn't the only thing pushing athletes forward. While indeed we haven't evolved into a new species in a century, the gene pool within competitive sports most certainly has changed. In the early half of the 20th century, physical education instructors and coaches had the idea that the average body type was the best for all athletic endeavors: medium height, medium weight, no matter the sport. And this showed in athletes' bodies. In the 1920s, the average elite high-jumper and average elite shot-putter were the same exact size. But as that idea started to fade away, as sports scientists and coaches realized that rather than the average body type, you want highly specialized bodies that fit into certain athletic niches, a form of artificial selection took place, a self-sorting for bodies that fit certain sports, and athletes' bodies became more different from one another. Today, rather than the same size as the average elite high jumper, the average elite shot-putter is two and a half inches taller and 130 pounds heavier. And this happened throughout the sports world. In fact, if you plot on a height versus mass graph one data point for each of two dozen sports in the first half of the 20th

century, it looks like this. There's some dispersal, but it's kind of grouped around that average body type. Then that idea started to go away, and at the same time, digital technology – first radio, then television and the Internet – gave millions, or in some cases billions, of people a ticket to consume elite sports performance. The financial incentives and fame and glory afforded elite athletes skyrocketed, and it tipped toward the tiny upper echelon of performance. It accelerated the artificial selection for specialized bodies. And if you plot a data point for these same two dozen sports today, it looks like this. The athletes' bodies have gotten much more different from one another. And because this chart looks like the charts that show the expanding universe, with the galaxies flying away from one another, the scientists who discovered it call it "The Big Bang of Body Types." In sports where height is prized, like basketball, the tall athletes got taller. In 1983, the National Basketball Association signed a groundbreaking agreement making players partners in the league, entitled to shares of ticket revenues and television contracts. Suddenly, anybody who could be an NBA player wanted to be, and teams started scouring the globe for the bodies that could help them win championships. Almost overnight, the proportion of men in the NBA who are at least seven feet tall doubled to 10 percent. Today, one in 10 men in the NBA is at least seven feet tall, but a seven-foot-tall man is incredibly rare in the general population – so rare that if you know an American man between the ages of 20 and 40 who is at least seven feet tall, there's a 17 percent chance he's in the NBA right now. (Laughter) That is, find six honest seven footers, one is in the NBA right now. And that's not the only way that NBA players' bodies are unique. This is Leonardo da Vinci's "Vitruvian Man," the ideal proportions, with arm span equal to height. My arm span is exactly equal to my height. Yours is probably very nearly so. But not the average NBA player. The average NBA player is a shade under 6'7", with arms that are seven feet long. Not only are NBA players ridiculously tall, they are ludicrously long. Had Leonardo wanted to draw the Vitruvian NBA Player, he would have needed a rectangle and an ellipse, not a circle and a square. So in sports where large size is prized, the large athletes have gotten larger. Conversely, in sports where diminutive stature is an advantage, the small athletes got smaller. The average elite female gymnast shrunk from 5'3" to 4'9" on average over the last 30 years, all the better for their power-to-weight ratio and for spinning in the air. And while the large got larger and the small got smaller, the weird got weirder. The average length of the forearm of a water polo player in relation to their total arm got longer, all the better for a forceful throwing whip. And as the large got larger, small got smaller, and the weird weirder. In swimming, the ideal body type is a long torso and short legs. It's like the long hull of a canoe for speed over the water. And the opposite is advantageous in running. You want long legs and a short torso. And this shows in athletes' bodies today. Here you see Michael Phelps, the greatest swimmer in history, standing next to Hicham El Guerrouj, the world record holder in the mile. These men are seven inches different in height, but because of the body types advantaged in their sports, they wear the same length pants. Seven inches difference in height, these men have the same length legs. Now in some cases, the search for bodies that could push athletic

performance forward ended up introducing into the competitive world populations of people that weren't previously competing at all, like Kenyan distance runners. We think of Kenyans as being great marathoners. Kenyans think of the Kalenjin tribe as being great marathoners. The Kalenjin make up just 12 percent of the Kenyan population but the vast majority of elite runners. And they happen, on average, to have a certain unique physiology: legs that are very long and very thin at their extremity, and this is because they have their ancestry at very low latitude in a very hot and dry climate, and an evolutionary adaptation to that is limbs that are very long and very thin at the extremity for cooling purposes. It's the same reason that a radiator has long coils, to increase surface area compared to volume to let heat out, and because the leg is like a pendulum, the longer and thinner it is at the extremity, the more energy-efficient it is to swing. To put Kalenjin running success in perspective, consider that 17 American men in history have run faster than two hours and 10 minutes in the marathon. That's a four-minute-and-58-second-per-mile pace. Thirty-two Kalenjin men did that last October. (Laughter) That's from a source population the size of metropolitan Atlanta. Still, even changing technology and the changing gene pool in sports don't account for all of the changes in performance. Athletes have a different mindset than they once did. Have you ever seen in a movie when someone gets an electrical shock and they're thrown across a room? There's no explosion there. What's happening when that happens is that the electrical impulse is causing all their muscle fibers to twitch at once, and they're throwing themselves across the room. They're essentially jumping. That's the power that's contained in the human body. But normally we can't access nearly all of it. Our brain acts as a limiter, preventing us from accessing all of our physical resources, because we might hurt ourselves, tearing tendons or ligaments. But the more we learn about how that limiter functions, the more we learn how we can push it back just a bit, in some cases by convincing the brain that the body won't be in mortal danger by pushing harder. Endurance and ultra-endurance sports serve as a great example. Ultra-endurance was once thought to be harmful to human health, but now we realize that we have all these traits that are perfect for ultra-endurance: no body fur and a glut of sweat glands that keep us cool while running; narrow waists and long legs compared to our frames; large surface area of joints for shock absorption. We have an arch in our foot that acts like a spring, short toes that are better for pushing off than for grasping tree limbs, and when we run, we can turn our torso and our shoulders like this while keeping our heads straight. Our primate cousins can't do that. They have to run like this. And we have big old butt muscles that keep us upright while running. Have you ever looked at an ape's butt? They have no buns because they don't run upright. And as athletes have realized that we're perfectly suited for ultra-endurance, they've taken on feats that would have been unthinkable before, athletes like Spanish endurance racer Kílian Jornet. Here's Kílian running up the Matterhorn. (Laughter) With a sweatshirt there tied around his waist. It's so steep he can't even run here. He's pulling up on a rope. This is a vertical ascent of more than 8,000 feet, and Kílian went up and down in under three hours. Amazing. And talented though he is, Kílian is not a physiological freak.

Now that he has done this, other athletes will follow, just as other athletes followed after Sir Roger Bannister ran under four minutes in the mile. Changing technology, changing genes, and a changing mindset. Innovation in sports, whether that's new track surfaces or new swimming techniques, the democratization of sport, the spread to new bodies and to new populations around the world, and imagination in sport, an understanding of what the human body is truly capable of, have conspired to make athletes stronger, faster, bolder, and better than ever. Thank you very much. (Applause)

Chapter 13 To The South Pole and Back — The Hardest 105 Days of My Life

So in the oasis of intelligentsia that is TED, I stand here before you this evening as an expert in dragging heavy stuff around cold places. I've been leading polar expeditions for most of my adult life, and last month, my teammate Tarka L'Herpiniere and I finished the most ambitious expedition I've ever attempted. In fact, it feels like I've been transported straight here from four months in the middle of nowhere, mostly grunting and swearing, straight to the TED stage. So you can imagine that's a transition that hasn't been entirely seamless. One of the interesting side effects seems to be that my short-term memory is entirely shot. So I've had to write some notes to avoid too much grunting and swearing in the next 17 minutes. This is the first talk I've given about this expedition, and while we weren't sequencing genomes or building space telescopes, this is a story about giving everything we had to achieve something that hadn't been done before. So I hope in that you might find some food for thought. It was a journey, an expedition in Antarctica, the coldest, windiest, driest and highest altitude continent on Earth. It's a fascinating place. It's a huge place. It's twice the size of Australia, a continent that is the same size as China and India put together. As an aside, I have experienced an interesting phenomenon in the last few days, something that I expect Chris Hadfield may get at TED in a few years' time, conversations that go something like this: "Oh, Antarctica. Awesome. My husband and I did Antarctica with Lindblad for our anniversary." Or, "Oh cool, did you go there for the marathon?" (Laughter) Our journey was, in fact, 69 marathons back to back in 105 days, an 1,800-mile round trip on foot from the coast of Antarctica to the South Pole and back again. In the process, we broke the record for the longest human-powered polar journey in history by more than 400 miles. (Applause) For those of you from the Bay Area, it was the same as walking from here to San Francisco, then turning around and walking back again. So as camping trips go, it was a long one, and one I've seen summarized most succinctly here on the hallowed pages of Business Insider Malaysia. ["Two Explorers Just Completed A Polar Expedition That Killed Everyone The Last Time It Was Attempted"] Chris Hadfield talked so eloquently about fear and about the odds of success, and indeed the odds of survival. Of the nine people in history that had attempted this journey before us, none had made it to the pole and back, and five had died in the process. This is Captain Robert Falcon Scott. He led the last team to attempt this expedition. Scott and his rival Sir Ernest Shackleton, over the space of a decade, both led expeditions battling to become the first to reach the South Pole, to chart and map the interior of Antarctica, a place we knew less about, at the time, than the surface of the moon, because we could see the moon through telescopes. Antarctica was, for the most part, a century ago, uncharted. Some of you may know the story. Scott's last expedition, the Terra Nova Expedition in 1910, started as a giant siege-style approach. He had a big team using ponies, using dogs, using petrol-driven tractors, dropping

multiple, pre-positioned depots of food and fuel through which Scott's final team of five would travel to the Pole, where they would turn around and ski back to the coast again on foot. Scott and his final team of five arrived at the South Pole in January 1912 to find they had been beaten to it by a Norwegian team led by Roald Amundsen, who rode on dogsled. Scott's team ended up on foot. And for more than a century this journey has remained unfinished. Scott's team of five died on the return journey. And for the last decade, I've been asking myself why that is. How come this has remained the high-water mark? Scott's team covered 1,600 miles on foot. No one's come close to that ever since. So this is the high-water mark of human endurance, human endeavor, human athletic achievement in arguably the harshest climate on Earth. It was as if the marathon record has remained unbroken since 1912. And of course some strange and predictable combination of curiosity, stubbornness, and probably hubris led me to thinking I might be the man to try to finish the job. Unlike Scott's expedition, there were just two of us, and we set off from the coast of Antarctica in October last year, dragging everything ourselves, a process Scott called "man-hauling." When I say it was like walking from here to San Francisco and back, I actually mean it was like dragging something that weighs a shade more than the heaviest ever NFL player. Our sledges weighed 200 kilos, or 440 pounds each at the start, the same weights that the weakest of Scott's ponies pulled. Early on, we averaged 0.5 miles per hour. Perhaps the reason no one had attempted this journey until now, in more than a century, was that no one had been quite stupid enough to try. And while I can't claim we were exploring in the genuine Edwardian sense of the word — we weren't naming any mountains or mapping any uncharted valleys — I think we were stepping into uncharted territory in a human sense. Certainly, if in the future we learn there is an area of the human brain that lights up when one curses oneself, I won't be at all surprised. You've heard that the average American spends 90 percent of their time indoors. We didn't go indoors for nearly four months. We didn't see a sunset either. It was 24-hour daylight. Living conditions were quite spartan. I changed my underwear three times in 105 days and Tarka and I shared 30 square feet on the canvas. Though we did have some technology that Scott could never have imagined. And we blogged live every evening from the tent via a laptop and a custom-made satellite transmitter, all of which were solar-powered: we had a flexible photovoltaic panel over the tent. And the writing was important to me. As a kid, I was inspired by the literature of adventure and exploration, and I think we've all seen here this week the importance and the power of storytelling. So we had some 21st-century gear, but the reality is that the challenges that Scott faced were the same that we faced: those of the weather and of what Scott called glide, the amount of friction between the sledges and the snow. The lowest wind chill we experienced was in the -70s, and we had zero visibility, what's called white-out, for much of our journey. We traveled up and down one of the largest and most dangerous glaciers in the world, the Beardmore glacier. It's 110 miles long; most of its surface is what's called blue ice. You can see it's a beautiful, shimmering steel-hard blue surface covered with thousands and thousands of crevasses, these deep cracks in the glacial ice up to 200 feet

deep. Planes can't land here, so we were at the most risk, technically, when we had the slimmest chance of being rescued. We got to the South Pole after 61 days on foot, with one day off for bad weather, and I'm sad to say, it was something of an anticlimax. There's a permanent American base, the Amundsen-Scott South Pole Station at the South Pole. They have an airstrip, they have a canteen, they have hot showers, they have a post office, a tourist shop, a basketball court that doubles as a movie theater. So it's a bit different these days, and there are also acres of junk. I think it's a marvelous thing that humans can exist 365 days of the year with hamburgers and hot showers and movie theaters, but it does seem to produce a lot of empty cardboard boxes. You can see on the left of this photograph, several square acres of junk waiting to be flown out from the South Pole. But there is also a pole at the South Pole, and we got there on foot, unassisted, unsupported, by the hardest route, 900 miles in record time, dragging more weight than anyone in history. And if we'd stopped there and flown home, which would have been the eminently sensible thing to do, then my talk would end here and it would end something like this. If you have the right team around you, the right tools, the right technology, and if you have enough self-belief and enough determination, then anything is possible. But then we turned around, and this is where things get interesting. High on the Antarctic plateau, over 10,000 feet, it's very windy, very cold, very dry, we were exhausted. We'd covered 35 marathons, we were only halfway, and we had a safety net, of course, of ski planes and satellite phones and live, 24-hour tracking beacons that didn't exist for Scott, but in hindsight, rather than making our lives easier, the safety net actually allowed us to cut things very fine indeed, to sail very close to our absolute limits as human beings. And it is an exquisite form of torture to exhaust yourself to the point of starvation day after day while dragging a sledge full of food. For years, I'd been writing glib lines in sponsorship proposals about pushing the limits of human endurance, but in reality, that was a very frightening place to be indeed. We had, before we'd got to the Pole, two weeks of almost permanent headwind, which slowed us down. As a result, we'd had several days of eating half rations. We had a finite amount of food in the sledges to make this journey, so we were trying to string that out by reducing our intake to half the calories we should have been eating. As a result, we both became increasingly hypoglycemic — we had low blood sugar levels day after day — and increasingly susceptible to the extreme cold. Tarka took this photo of me one evening after I'd nearly passed out with hypothermia. We both had repeated bouts of hypothermia, something I hadn't experienced before, and it was very humbling indeed. As much as you might like to think, as I do, that you're the kind of person who doesn't quit, that you'll go down swinging, hypothermia doesn't leave you much choice. You become utterly incapacitated. It's like being a drunk toddler. You become pathetic. I remember just wanting to lie down and quit. It was a peculiar, peculiar feeling, and a real surprise to me to be debilitated to that degree. And then we ran out of food completely, 46 miles short of the first of the depots that we'd laid on our outward journey. We'd laid 10 depots of food, literally burying food and fuel, for our return journey — the fuel was for a cooker so you could melt snow to get water — and I was forced to make the

decision to call for a resupply flight, a ski plane carrying eight days of food to tide us over that gap. They took 12 hours to reach us from the other side of Antarctica. Calling for that plane was one of the toughest decisions of my life. And I sound like a bit of a fraud standing here now with a sort of belly. I've put on 30 pounds in the last three weeks. Being that hungry has left an interesting mental scar, which is that I've been hoovering up every hotel buffet that I can find. (Laughter) But we were genuinely quite hungry, and in quite a bad way. I don't regret calling for that plane for a second, because I'm still standing here alive, with all digits intact, telling this story. But getting external assistance like that was never part of the plan, and it's something my ego is still struggling with. This was the biggest dream I've ever had, and it was so nearly perfect. On the way back down to the coast, our crampons — they're the spikes on our boots that we have for traveling over this blue ice on the glacier — broke on the top of the Beardmore. We still had 100 miles to go downhill on very slippery rock-hard blue ice. They needed repairing almost every hour. To give you an idea of scale, this is looking down towards the mouth of the Beardmore Glacier. You could fit the entirety of Manhattan in the gap on the horizon. That's 20 miles between Mount Hope and Mount Kiffin. I've never felt as small as I did in Antarctica. When we got down to the mouth of the glacier, we found fresh snow had obscured the dozens of deep crevasses. One of Shackleton's men described crossing this sort of terrain as like walking over the glass roof of a railway station. We fell through more times than I can remember, usually just putting a ski or a boot through the snow. Occasionally we went in all the way up to our armpits, but thankfully never deeper than that. And less than five weeks ago, after 105 days, we crossed this oddly inauspicious finish line, the coast of Ross Island on the New Zealand side of Antarctica. You can see the ice in the foreground and the sort of rubbly rock behind that. Behind us lay an unbroken ski trail of nearly 1,800 miles. We'd made the longest ever polar journey on foot, something I'd been dreaming of doing for a decade. And looking back, I still stand by all the things I've been saying for years about the importance of goals and determination and self-belief, but I'll also admit that I hadn't given much thought to what happens when you reach the all-consuming goal that you've dedicated most of your adult life to, and the reality is that I'm still figuring that bit out. As I said, there are very few superficial signs that I've been away. I've put on 30 pounds. I've got some very faint, probably covered in makeup now, frostbite scars. I've got one on my nose, one on each cheek, from where the goggles are, but inside I am a very different person indeed. If I'm honest, Antarctica challenged me and humbled me so deeply that I'm not sure I'll ever be able to put it into words. I'm still struggling to piece together my thoughts. That I'm standing here telling this story is proof that we all can accomplish great things, through ambition, through passion, through sheer stubbornness, by refusing to quit, that if you dream something hard enough, as Sting said, it does indeed come to pass. But I'm also standing here saying, you know what, that cliche about the journey being more important than the destination? There's something in that. The closer I got to my finish line, that rubbly, rocky coast of Ross Island, the more I started to realize that the biggest lesson that this very long, very

hard walk might be teaching me is that happiness is not a finish line, that for us humans, the perfection that so many of us seem to dream of might not ever be truly attainable, and that if we can't feel content here, today, now, on our journeys amidst the mess and the striving that we all inhabit, the open loops, the half-finished to-do lists, the could-do-better-next-times, then we might never feel it. A lot of people have asked me, what next? Right now, I am very happy just recovering and in front of hotel buffets. But as Bob Hope put it, I feel very humble, but I think I have the strength of character to fight it. (Laughter) Thank you. (Applause)

Chapter 14 The Riddle of Experience vs. Memory

Everybody talks about happiness these days. I had somebody count the number of books with "happiness" in the title published in the last five years and they gave up after about 40, and there were many more. There is a huge wave of interest in happiness, among researchers. There is a lot of happiness coaching. Everybody would like to make people happier. But in spite of all this flood of work, there are several cognitive traps that sort of make it almost impossible to think straight about happiness. And my talk today will be mostly about these cognitive traps. This applies to laypeople thinking about their own happiness, and it applies to scholars thinking about happiness, because it turns out we're just as messed up as anybody else is. The first of these traps is a reluctance to admit complexity. It turns out that the word "happiness" is just not a useful word anymore, because we apply it to too many different things. I think there is one particular meaning to which we might restrict it, but by and large, this is something that we'll have to give up and we'll have to adopt the more complicated view of what well-being is. The second trap is a confusion between experience and memory; basically, it's between being happy in your life, and being happy about your life or happy with your life. And those are two very different concepts, and they're both lumped in the notion of happiness. And the third is the focusing illusion, and it's the unfortunate fact that we can't think about any circumstance that affects well-being without distorting its importance. I mean, this is a real cognitive trap. There's just no way of getting it right. Now, I'd like to start with an example of somebody who had a question-and-answer session after one of my lectures reported a story, and that was a story – He said he'd been listening to a symphony, and it was absolutely glorious music and at the very end of the recording, there was a dreadful screeching sound. And then he added, really quite emotionally, it ruined the whole experience. But it hadn't. What it had ruined were the memories of the experience. He had had the experience. He had had 20 minutes of glorious music. They counted for nothing because he was left with a memory; the memory was ruined, and the memory was all that he had gotten to keep. What this is telling us, really, is that we might be thinking of ourselves and of other people in terms of two selves. There is an experiencing self, who lives in the present and knows the present, is capable of re-living the past, but basically it has only the present. It's the experiencing self that the doctor approaches – you know, when the doctor asks, "Does it hurt now when I touch you here?" And then there is a remembering self, and the remembering self is the one that keeps score, and maintains the story of our life, and it's the one that the doctor approaches in asking the question, "How have you been feeling lately?" or "How was your trip to Albania?" or something like that. Those are two very different entities, the experiencing self and the remembering self, and getting confused between them is part of the mess about the notion of happiness. Now, the remembering self is a storyteller. And that really starts with a basic response of our memories – it starts immediately. We don't only tell stories when we set out to tell stories. Our memory tells

us stories, that is, what we get to keep from our experiences is a story. And let me begin with one example. This is an old study. Those are actual patients undergoing a painful procedure. I won't go into detail. It's no longer painful these days, but it was painful when this study was run in the 1990s. They were asked to report on their pain every 60 seconds. Here are two patients, those are their recordings. And you are asked, "Who of them suffered more?" And it's a very easy question. Clearly, Patient B suffered more – his colonoscopy was longer, and every minute of pain that Patient A had, Patient B had, and more. But now there is another question: "How much did these patients think they suffered?" And here is a surprise. The surprise is that Patient A had a much worse memory of the colonoscopy than Patient B. The stories of the colonoscopies were different, and because a very critical part of the story is how it ends. And neither of these stories is very inspiring or great – but one of them is this distinct ... (Laughter) but one of them is distinctly worse than the other. And the one that is worse is the one where pain was at its peak at the very end; it's a bad story. How do we know that? Because we asked these people after their colonoscopy, and much later, too, "How bad was the whole thing, in total?" And it was much worse for A than for B, in memory. Now this is a direct conflict between the experiencing self and the remembering self. From the point of view of the experiencing self, clearly, B had a worse time. Now, what you could do with Patient A, and we actually ran clinical experiments, and it has been done, and it does work – you could actually extend the colonoscopy of Patient A by just keeping the tube in without jiggling it too much. That will cause the patient to suffer, but just a little and much less than before. And if you do that for a couple of minutes, you have made the experiencing self of Patient A worse off, and you have the remembering self of Patient A a lot better off, because now you have endowed Patient A with a better story about his experience. What defines a story? And that is true of the stories that memory delivers for us, and it's also true of the stories that we make up. What defines a story are changes, significant moments and endings. Endings are very, very important and, in this case, the ending dominated. Now, the experiencing self lives its life continuously. It has moments of experience, one after the other. And you can ask: What happens to these moments? And the answer is really straightforward: They are lost forever. I mean, most of the moments of our life – and I calculated, you know, the psychological present is said to be about three seconds long; that means that, you know, in a life there are about 600 million of them; in a month, there are about 600,000 – most of them don't leave a trace. Most of them are completely ignored by the remembering self. And yet, somehow you get the sense that they should count, that what happens during these moments of experience is our life. It's the finite resource that we're spending while we're on this earth. And how to spend it would seem to be relevant, but that is not the story that the remembering self keeps for us. So we have the remembering self and the experiencing self, and they're really quite distinct. The biggest difference between them is in the handling of time. From the point of view of the experiencing self, if you have a vacation, and the second week is just as good as the first, then the two-week vacation is twice as good as the one-week vacation. That's not the way it works at all

for the remembering self. For the remembering self, a two-week vacation is barely better than the one-week vacation because there are no new memories added. You have not changed the story. And in this way, time is actually the critical variable that distinguishes a remembering self from an experiencing self; time has very little impact on the story. Now, the remembering self does more than remember and tell stories. It is actually the one that makes decisions because, if you have a patient who has had, say, two colonoscopies with two different surgeons and is deciding which of them to choose, then the one that chooses is the one that has the memory that is less bad, and that's the surgeon that will be chosen. The experiencing self has no voice in this choice. We actually don't choose between experiences, we choose between memories of experiences. And even when we think about the future, we don't think of our future normally as experiences. We think of our future as anticipated memories. And basically you can look at this, you know, as a tyranny of the remembering self, and you can think of the remembering self sort of dragging the experiencing self through experiences that the experiencing self doesn't need. I have that sense that when we go on vacations this is very frequently the case; that is, we go on vacations, to a very large extent, in the service of our remembering self. And this is a bit hard to justify I think. I mean, how much do we consume our memories? That is one of the explanations that is given for the dominance of the remembering self. And when I think about that, I think about a vacation we had in Antarctica a few years ago, which was clearly the best vacation I've ever had, and I think of it relatively often, relative to how much I think of other vacations. And I probably have consumed my memories of that three-week trip, I would say, for about 25 minutes in the last four years. Now, if I had ever opened the folder with the 600 pictures in it, I would have spent another hour. Now, that is three weeks, and that is at most an hour and a half. There seems to be a discrepancy. Now, I may be a bit extreme, you know, in how little appetite I have for consuming memories, but even if you do more of this, there is a genuine question: Why do we put so much weight on memory relative to the weight that we put on experiences? So I want you to think about a thought experiment. Imagine that for your next vacation, you know that at the end of the vacation all your pictures will be destroyed, and you'll get an amnesic drug so that you won't remember anything. Now, would you choose the same vacation? (Laughter) And if you would choose a different vacation, there is a conflict between your two selves, and you need to think about how to adjudicate that conflict, and it's actually not at all obvious, because if you think in terms of time, then you get one answer, and if you think in terms of memories, you might get another answer. Why do we pick the vacations we do is a problem that confronts us with a choice between the two selves. Now, the two selves bring up two notions of happiness. There are really two concepts of happiness that we can apply, one per self. So you can ask: How happy is the experiencing self? And then you would ask: How happy are the moments in the experiencing self's life? And they're all – happiness for moments is a fairly complicated process. What are the emotions that can be measured? And, by the way, now we are capable of getting a pretty good idea of the happiness of the experiencing self over

time. If you ask for the happiness of the remembering self, it's a completely different thing. This is not about how happily a person lives. It is about how satisfied or pleased the person is when that person thinks about her life. Very different notion. Anyone who doesn't distinguish those notions is going to mess up the study of happiness, and I belong to a crowd of students of well-being, who've been messing up the study of happiness for a long time in precisely this way. The distinction between the happiness of the experiencing self and the satisfaction of the remembering self has been recognized in recent years, and there are now efforts to measure the two separately. The Gallup Organization has a world poll where more than half a million people have been asked questions about what they think of their life and about their experiences, and there have been other efforts along those lines. So in recent years, we have begun to learn about the happiness of the two selves. And the main lesson I think that we have learned is they are really different. You can know how satisfied somebody is with their life, and that really doesn't teach you much about how happily they're living their life, and vice versa. Just to give you a sense of the correlation, the correlation is about .5. What that means is if you met somebody, and you were told, "Oh his father is six feet tall," how much would you know about his height? Well, you would know something about his height, but there's a lot of uncertainty. You have that much uncertainty. If I tell you that somebody ranked their life eight on a scale of ten, you have a lot of uncertainty about how happy they are with their experiencing self. So the correlation is low. We know something about what controls satisfaction of the happiness self. We know that money is very important, goals are very important. We know that happiness is mainly being satisfied with people that we like, spending time with people that we like. There are other pleasures, but this is dominant. So if you want to maximize the happiness of the two selves, you are going to end up doing very different things. The bottom line of what I've said here is that we really should not think of happiness as a substitute for well-being. It is a completely different notion. Now, very quickly, another reason we cannot think straight about happiness is that we do not attend to the same things when we think about life, and we actually live. So, if you ask the simple question of how happy people are in California, you are not going to get to the correct answer. When you ask that question, you think people must be happier in California if, say, you live in Ohio. (Laughter) And what happens is when you think about living in California, you are thinking of the contrast between California and other places, and that contrast, say, is in climate. Well, it turns out that climate is not very important to the experiencing self and it's not even very important to the reflective self that decides how happy people are. But now, because the reflective self is in charge, you may end up – some people may end up moving to California. And it's sort of interesting to trace what is going to happen to people who move to California in the hope of getting happier. Well, their experiencing self is not going to get happier. We know that. But one thing will happen: They will think they are happier, because, when they think about it, they'll be reminded of how horrible the weather was in Ohio, and they will feel they made the right decision. It is very difficult to think straight about well-being, and I hope I

have given you a sense of how difficult it is. Thank you. (Applause) Chris Anderson: Thank you. I've got a question for you. Thank you so much. Now, when we were on the phone a few weeks ago, you mentioned to me that there was quite an interesting result came out of that Gallup survey. Is that something you can share since you do have a few moments left now? Daniel Kahneman: Sure. I think the most interesting result that we found in the Gallup survey is a number, which we absolutely did not expect to find. We found that with respect to the happiness of the experiencing self. When we looked at how feelings, vary with income. And it turns out that, below an income of 60,000 dollars a year, for Americans – and that's a very large sample of Americans, like 600,000, so it's a large representative sample – below an income of 600,000 dollars a year... CA: 60,000. DK: 60,000. (Laughter) 60,000 dollars a year, people are unhappy, and they get progressively unhappier the poorer they get. Above that, we get an absolutely flat line. I mean I've rarely seen lines so flat. Clearly, what is happening is money does not buy you experiential happiness, but lack of money certainly buys you misery, and we can measure that misery very, very clearly. In terms of the other self, the remembering self, you get a different story. The more money you earn, the more satisfied you are. That does not hold for emotions. CA: But Danny, the whole American endeavor is about life, liberty, the pursuit of happiness. If people took seriously that finding, I mean, it seems to turn upside down everything we believe about, like for example, taxation policy and so forth. Is there any chance that politicians, that the country generally, would take a finding like that seriously and run public policy based on it? DK: You know I think that there is recognition of the role of happiness research in public policy. The recognition is going to be slow in the United States, no question about that, but in the U.K., it is happening, and in other countries it is happening. People are recognizing that they ought to be thinking of happiness when they think of public policy. It's going to take a while, and people are going to debate whether they want to study experience happiness, or whether they want to study life evaluation, so we need to have that debate fairly soon. How to enhance happiness goes very different ways depending on how you think, and whether you think of the remembering self or you think of the experiencing self. This is going to influence policy, I think, in years to come. In the United States, efforts are being made to measure the experience happiness of the population. This is going to be, I think, within the next decade or two, part of national statistics. CA: Well, it seems to me that this issue will – or at least should be – the most interesting policy discussion to track over the next few years. Thank you so much for inventing behavioral economics. Thank you, Danny Kahneman.

Chapter 15 The Gospel of Doubt

There we were, souls and bodies packed into a Texas church on the last night of our lives. Packed into a room just like this, but with creaky wooden pews draped in worn-down red fabric, with an organ to my left and a choir at my back and a baptism pool built into the wall behind them. A room like this, nonetheless. With the same great feelings of suspense, the same deep hopes for salvation, the same sweat in the palms and the same people in the back not paying attention. (Laughter) This was December 31, 1999, the night of the Second Coming of Christ, and the end of the world as I knew it. I had turned 12 that year and had reached the age of accountability. And once I stopped complaining about how unfair it was that Jesus would return as soon as I had to be accountable for all that I had done, I figured I had better get my house in order very quickly. So I went to church as often as I could. I listened for silence as anxiously as one might listen for noise, trying to be sure that the Lord hadn't pulled a fast one on me and decided to come back early. And just in case he did, I built a backup plan, by reading the "Left Behind" books that were all the rage at the time. And I found in their pages that if I was not taken in the rapture at midnight, I had another shot. All I had to do was avoid taking the mark of the beast, fight off demons, plagues and the Antichrist himself. It would be hard – (Laughter) but I knew I could do it. (Laughter) But planning time was over now. It was 11:50pm. We had 10 minutes left, and my pastor called us out of the pews and down to the altar because he wanted to be praying when midnight struck. So every faction of the congregation took its place. The choir stayed in the choir stand, the deacons and their wives – or the Baptist Bourgeoisie as I like to call them – (Laughter) took first position in front of the altar. You see, in America, even the Second Coming of Christ has a VIP section. (Laughter) (Applause) And right behind the Baptist Bourgeoisie were the elderly – these men and women whose young backs had been bent under hot suns in the cotton fields of East Texas, and whose skin seemed to be burnt a creaseless noble brown, just like the clay of East Texas, and whose hopes and dreams for what life might become outside of East Texas had sometimes been bent and broken even further than their backs. Yes, these men and women were the stars of the show for me. They had waited their whole lives for this moment, just as their medieval predecessors had longed for the end of the world, and just as my grandmother waited for the Oprah Winfrey Show to come on Channel 8 every day at 4 o'clock. And as she made her way to the altar, I snuck right in behind her, because I knew for sure that my grandmother was going to heaven. And I thought that if I held on to her hand during this prayer, I might go right on with her. So I held on and I closed my eyes to listen, to wait. And the prayers got louder. And the shouts of response to the call of the prayer went up higher even still. And the organ rolled on in to add the dirge. And the heat came on to add to the sweat. And my hand gripped firmer, so I wouldn't be the one left in the field. My eyes clenched tighter so I wouldn't see the wheat being separated from the chaff. And then a voice rang out above us:

"Amen." It was over. I looked at the clock. It was after midnight. I looked at the elder believers whose savior had not come, who were too proud to show any signs of disappointment, who had believed too much and for too long to start doubting now. But I was upset on their behalf. They had been duped, hoodwinked, bamboozled, and I had gone right along with them. I had prayed their prayers, I had yielded not to temptation as best I could. I had dipped my head not once, but twice in that snot-inducing baptism pool. I had believed. Now what? I got home just in time to turn on the television and watch Peter Jennings announce the new millennium as it rolled in around the world. It struck me that it would have been strange anyway, for Jesus to come back again and again based on the different time zones. (Laughter) And this made me feel even more ridiculous – hurt, really. But there on that night, I did not stop believing. I just believed a new thing: that it was possible not to believe. It was possible the answers I had were wrong, that the questions themselves were wrong. And now, where there was once a mountain of certitude, there was, running right down to its foundation, a spring of doubt, a spring that promised rivers. I can trace the whole drama of my life back to that night in that church when my savior did not come for me; when the thing I believed most certainly turned out to be, if not a lie, then not quite the truth. And even though most of you prepared for Y2K in a very different way, I'm convinced that you are here because some part of you has done the same thing that I have done since the dawn of this new century, since my mother left and my father stayed away and my Lord refused to come. And I held out my hand, reaching for something to believe in. I held on when I arrived at Yale at 18, with the faith that my journey from Oak Cliff, Texas was a chance to leave behind all the challenges I had known, the broken dreams and broken bodies I had seen. But when I found myself back home one winter break, with my face planted in the floor, my hands tied behind my back and a burglar's gun pressed to my head, I knew that even the best education couldn't save me. I held on when I showed up at Lehman Brothers as an intern in 2008. (Laughter) So hopeful – (Laughter) that I called home to inform my family that we'd never be poor again. (Laughter) But as I witnessed this temple of finance come crashing down before my eyes, I knew that even the best job couldn't save me. I held on when I showed up in Washington DC as a young staffer, who had heard a voice call out from Illinois, saying, "It's been a long time coming, but in this election, change has come to America." But as the Congress ground to a halt and the country ripped at the seams and hope and change began to feel like a cruel joke, I knew that even the political second coming could not save me. I had knelt faithfully at the altar of the American Dream, praying to the gods of my time of success, and money, and power. But over and over again, midnight struck, and I opened my eyes to see that all of these gods were dead. And from that graveyard, I began the search once more, not because I was brave, but because I knew that I would either believe or I would die. So I took a pilgrimage to yet another mecca, Harvard Business School – (Laughter) this time, knowing that I could not simply accept the salvation that it claimed to offer. No, I knew there'd be more work to do. The work began in the dark corner of a crowded party, in the late night of an early, miserable Cambridge winter, when three friends

and I asked a question that young folks searching for something real have asked for a very long time: "What if we took a road trip?" (Laughter) We didn't know where'd we go or how we'd get there, but we knew we had to do it. Because all our lives we yearned, as Jack Kerouac wrote, to "sneak out into the night and disappear somewhere," and go find out what everybody was doing all over the country. So even though there were other voices who said that the risk was too great and the proof too thin, we went on anyhow. We went on 8,000 miles across America in the summer of 2013, through the cow pastures of Montana, through the desolation of Detroit, through the swamps of New Orleans, where we found and worked with men and women who were building small businesses that made purpose their bottom line. And having been trained at the West Point of capitalism, this struck us as a revolutionary idea. (Laughter) And this idea spread, growing into a nonprofit called MBAs Across America, a movement that landed me here on this stage today. It spread because we found a great hunger in our generation for purpose, for meaning. It spread because we found countless entrepreneurs in the nooks and crannies of America who were creating jobs and changing lives and who needed a little help. But if I'm being honest, it also spread because I fought to spread it. There was no length to which I would not go to preach this gospel, to get more people to believe that we could bind the wounds of a broken country, one social business at a time. But it was this journey of evangelism that led me to the rather different gospel that I've come to share with you today. It began one evening almost a year ago at the Museum of Natural History in New York City, at a gala for alumni of Harvard Business School. Under a full-size replica of a whale, I sat with the titans of our time as they celebrated their peers and their good deeds. There was pride in a room where net worth and assets under management surpassed half a trillion dollars. We looked over all that we had made, and it was good. (Laughter) But it just so happened, two days later, I had to travel up the road to Harlem, where I found myself sitting in an urban farm that had once been a vacant lot, listening to a man named Tony tell me of the kids that showed up there every day. All of them lived below the poverty line. Many of them carried all of their belongings in a backpack to avoid losing them in a homeless shelter. Some of them came to Tony's program, called Harlem Grown, to get the only meal they had each day. Tony told me that he started Harlem Grown with money from his pension, after 20 years as a cab driver. He told me that he didn't give himself a salary, because despite success, the program struggled for resources. He told me that he would take any help that he could get. And I was there as that help. But as I left Tony, I felt the sting and salt of tears welling up in my eyes. I felt the weight of revelation that I could sit in one room on one night, where a few hundred people had half a trillion dollars, and another room, two days later, just 50 blocks up the road, where a man was going without a salary to get a child her only meal of the day. And it wasn't the glaring inequality that made me want to cry, it wasn't the thought of hungry, homeless kids, it wasn't rage toward the one percent or pity toward the 99. No, I was disturbed because I had finally realized that I was the dialysis for a country that needed a kidney transplant. I realized that my story stood in for all those who were expected to pick

themselves up by their bootstraps, even if they didn't have any boots; that my organization stood in for all the structural, systemic help that never went to Harlem or Appalachia or the Lower 9th Ward; that my voice stood in for all those voices that seemed too unlearned, too unwashed, too unaccommodated. And the shame of that, that shame washed over me like the shame of sitting in front of the television, watching Peter Jennings announce the new millennium again and again and again. I had been duped, hoodwinked, bamboozled. But this time, the false savior was me. You see, I've come a long way from that altar on the night I thought the world would end, from a world where people spoke in tongues and saw suffering as a necessary act of God and took a text to be infallible truth. Yes, I've come so far that I'm right back where I started. Because it simply is not true to say that we live in an age of disbelief – no, we believe today just as much as any time that came before. Some of us may believe in the prophecy of Brené Brown or Tony Robbins. We may believe in the bible of The New Yorker or the Harvard Business Review. We may believe most deeply when we worship right here at the church of TED, but we desperately want to believe, we need to believe. We speak in the tongues of charismatic leaders that promise to solve all our problems. We see suffering as a necessary act of the capitalism that is our god, we take the text of technological progress to be infallible truth. And we hardly realize the human price we pay when we fail to question one brick, because we fear it might shake our whole foundation. But if you are disturbed by the unconscionable things that we have come to accept, then it must be questioning time. So I have not a gospel of disruption or innovation or a triple bottom line. I do not have a gospel of faith to share with you today, in fact. I have and I offer a gospel of doubt. The gospel of doubt does not ask that you stop believing, it asks that you believe a new thing: that it is possible not to believe. It is possible the answers we have are wrong, it is possible the questions themselves are wrong. Yes, the gospel of doubt means that it is possible that we, on this stage, in this room, are wrong. Because it raises the question, "Why?" With all the power that we hold in our hands, why are people still suffering so bad? This doubt leads me to share that we are putting my organization, MBAs Across America, out of business. We have shed our staff and closed our doors and we will share our model freely with anyone who sees their power to do this work without waiting for our permission. This doubt compels me to renounce the role of savior that some have placed on me, because our time is too short and our odds are too long to wait for second comings, when the truth is that there will be no miracles here. And this doubt, it fuels me, it gives me hope that when our troubles overwhelm us, when the paths laid out for us seem to lead to our demise, when our healers bring no comfort to our wounds, it will not be our blind faith – no, it will be our humble doubt that shines a little light into the darkness of our lives and of our world and lets us raise our voice to whisper or to shout or to say simply, very simply, "There must be another way." Thank you. (Applause)

Chapter 16 What Will Humans Look Like In 100 Years

Here's a question that matters. [Is it ethical to evolve the human body?] Because we're beginning to get all the tools together to evolve ourselves. And we can evolve bacteria and we can evolve plants and we can evolve animals, and we're now reaching a point where we really have to ask, is it really ethical and do we want to evolve human beings? And as you're thinking about that, let me talk about that in the context of prosthetics, prosthetics past, present, future. So this is the iron hand that belonged to one of the German counts. Loved to fight, lost his arm in one of these battles. No problem, he just made a suit of armor, put it on, perfect prosthetic. That's where the concept of ruling with an iron fist comes from. And of course these prosthetics have been getting more and more useful, more and more modern. You can hold soft-boiled eggs. You can have all types of controls, and as you're thinking about that, there are wonderful people like Hugh Herr who have been building absolutely extraordinary prosthetics. So the wonderful Aimee Mullins will go out and say, how tall do I want to be tonight? Or Hugh will say what type of cliff do I want to climb? Or does somebody want to run a marathon, or does somebody want to ballroom dance? And as you adapt these things, the interesting thing about prosthetics is they've been coming inside the body. So these external prosthetics have now become artificial knees. They've become artificial hips. And then they've evolved further to become not just nice to have but essential to have. So when you're talking about a heart pacemaker as a prosthetic, you're talking about something that isn't just, "I'm missing my leg," it's, "if I don't have this, I can die." And at that point, a prosthetic becomes a symbiotic relationship with the human body. And four of the smartest people that I've ever met – Ed Boyden, Hugh Herr, Joe Jacobson, Bob Lander – are working on a Center for Extreme Bionics. And the interesting thing of what you're seeing here is these prosthetics now get integrated into the bone. They get integrated into the skin. They get integrated into the muscle. And one of the other sides of Ed is he's been thinking about how to connect the brain using light or other mechanisms directly to things like these prosthetics. And if you can do that, then you can begin changing fundamental aspects of humanity. So how quickly you react to something depends on the diameter of a nerve. And of course, if you have nerves that are external or prosthetic, say with light or liquid metal, then you can increase that diameter and you could even increase it theoretically to the point where, as long as you could see the muzzle flash, you could step out of the way of a bullet. Those are the order of magnitude of changes you're talking about. This is a fourth sort of level of prosthetics. These are Phonak hearing aids, and the reason why these are so interesting is because they cross the threshold from where prosthetics are something for somebody who is "disabled" and they become something that somebody who is "normal" might want to actually have, because what this prosthetic does, which is really interesting, is not only does it help you hear, you can focus your hearing, so it can hear the conversation going on over there. You can have superhearing.

You can have hearing in 360 degrees. You can have white noise. You can record, and oh, by the way, they also put a phone into this. So this functions as your hearing aid and also as your phone. And at that point, somebody might actually want to have a prosthetic voluntarily. All of these thousands of loosely connected little pieces are coming together, and it's about time we ask the question, how do we want to evolve human beings over the next century or two? And for that we turn to a great philosopher who was a very smart man despite being a Yankee fan. (Laughter) And Yogi Berra used to say, of course, that it's very tough to make predictions, especially about the future. (Laughter) So instead of making a prediction about the future to begin with, let's take what's happening in the present with people like Tony Atala, who is redesigning 30-some-odd organs. And maybe the ultimate prosthetic isn't having something external, titanium. Maybe the ultimate prosthetic is take your own gene code, remake your own body parts, because that's a whole lot more effective than any kind of a prosthetic. But while you're at it, then you can take the work of Craig Venter and Ham Smith. And one of the things that we've been doing is trying to figure out how to reprogram cells. And if you can reprogram a cell, then you can change the cells in those organs. So if you can change the cells in those organs, maybe you make those organs more radiation-resistant. Maybe you make them absorb more oxygen. Maybe you make them more efficient to filter out stuff that you don't want in your body. And over the last few weeks, George Church has been in the news a lot because he's been talking about taking one of these programmable cells and inserting an entire human genome into that cell. And once you can insert an entire human genome into a cell, then you begin to ask the question, would you want to enhance any of that genome? Do you want to enhance a human body? How would you want to enhance a human body? Where is it ethical to enhance a human body and where is it not ethical to enhance a human body? And all of a sudden, what we're doing is we've got this multidimensional chess board where we can change human genetics by using viruses to attack things like AIDS, or we can change the gene code through gene therapy to do away with some hereditary diseases, or we can change the environment, and change the expression of those genes in the epigenome and pass that on to the next generations. And all of a sudden, it's not just one little bit, it's all these stacked little bits that allow you to take little portions of it until all the portions coming together lead you to something that's very different. And a lot of people are very scared by this stuff. And it does sound scary, and there are risks to this stuff. So why in the world would you ever want to do this stuff? Why would we really want to alter the human body in a fundamental way? The answer lies in part with Lord Rees, astronomer royal of Great Britain. And one of his favorite sayings is the universe is 100 percent malevolent. So what does that mean? It means if you take any one of your bodies at random, drop it anywhere in the universe, drop it in space, you die. Drop it on the Sun, you die. Drop it on the surface of Mercury, you die. Drop it near a supernova, you die. But fortunately, it's only about 80 percent effective. So as a great physicist once said, there's these little upstream eddies of biology that create order in this rapid torrent of entropy. So as the universe dissipates energy, there's these upstream eddies that create biological order. Now,

the problem with eddies is, they tend to disappear. They shift. They move in rivers. And because of that, when an eddy shifts, when the Earth becomes a snowball, when the Earth becomes very hot, when the Earth gets hit by an asteroid, when you have supervolcanoes, when you have solar flares, when you have potentially extinction-level events like the next election – (Laughter) then all of a sudden, you can have periodic extinctions. And by the way, that's happened five times on Earth, and therefore it is very likely that the human species on Earth is going to go extinct someday. Not next week, not next month, maybe in November, but maybe 10,000 years after that. As you're thinking of the consequence of that, if you believe that extinctions are common and natural and normal and occur periodically, it becomes a moral imperative to diversify our species. And it becomes a moral imperative because it's going to be really hard to live on Mars if we don't fundamentally modify the human body. Right? You go from one cell, mom and dad coming together to make one cell, in a cascade to 10 trillion cells. We don't know, if you change the gravity substantially, if the same thing will happen to create your body. We do know that if you expose our bodies as they currently are to a lot of radiation, we will die. So as you're thinking of that, you have to really redesign things just to get to Mars. Forget about the moons of Neptune or Jupiter. And to borrow from Nikolai Kardashev, let's think about life in a series of scales. So Life One civilization is a civilization that begins to alter his or her looks. And we've been doing that for thousands of years. You've got tummy tucks and you've got this and you've got that. You alter your looks, and I'm told that not all of those alterations take place for medical reasons. (Laughter) Seems odd. A Life Two civilization is a different civilization. A Life Two civilization alters fundamental aspects of the body. So you put human growth hormone in, the person grows taller, or you put x in and the person gets fatter or loses metabolism or does a whole series of things, but you're altering the functions in a fundamental way. To become an intrasolar civilization, we're going to have to create a Life Three civilization, and that looks very different from what we've got here. Maybe you splice in Deinococcus radiodurans so that the cells can resplice after a lot of exposure to radiation. Maybe you breathe by having oxygen flow through your blood instead of through your lungs. But you're talking about really radical redesigns, and one of the interesting things that's happened in the last decade is we've discovered a whole lot of planets out there. And some of them may be Earth-like. The problem is, if we ever want to get to these planets, the fastest human objects – Juno and Voyager and the rest of this stuff – take tens of thousands of years to get from here to the nearest solar system. So if you want to start exploring beaches somewhere else, or you want to see two-sun sunsets, then you're talking about something that is very different, because you have to change the timescale and the body of humans in ways which may be absolutely unrecognizable. And that's a Life Four civilization. Now, we can't even begin to imagine what that might look like, but we're beginning to get glimpses of instruments that might take us even that far. And let me give you two examples. So this is the wonderful Floyd Romesberg, and one of the things that Floyd's been doing is he's been playing with the basic chemistry of life. So all life on this planet is made in ATCGs, the

four letters of DNA. All bacteria, all plants, all animals, all humans, all cows, everything else. And what Floyd did is he changed out two of those base pairs, so it's ATXY. And that means that you now have a parallel system to make life, to make babies, to reproduce, to evolve, that doesn't mate with most things on Earth or in fact maybe with nothing on Earth. Maybe you make plants that are immune to all bacteria. Maybe you make plants that are immune to all viruses. But why is that so interesting? It means that we are not a unique solution. It means you can create alternate chemistries to us that could be chemistries adaptable to a very different planet that could create life and heredity. The second experiment, or the other implication of this experiment, is that all of you, all life is based on 20 amino acids. If you don't substitute two amino acids, if you don't say ATXY, if you say ATCG + XY, then you go from 20 building blocks to 172, and all of a sudden you've got 172 building blocks of amino acids to build life-forms in very different shapes. The second experiment to think about is a really weird experiment that's been taking place in China. So this guy has been transplanting hundreds of mouse heads. Right? And why is that an interesting experiment? Well, think of the first heart transplants. One of the things they used to do is they used to bring in the wife or the daughter of the donor so the donee could tell the doctors, "Do you recognize this person? Do you love this person? Do you feel anything for this person?" We laugh about that today. We laugh because we know the heart is a muscle, but for hundreds of thousands of years, or tens of thousands of years, "I gave her my heart. She took my heart. She broke my heart." We thought this was emotion and we thought maybe emotions were transplanted with the heart. Nope. So how about the brain? Two possible outcomes to this experiment. If you can get a mouse that is functional, then you can see, is the new brain a blank slate? And boy, does that have implications. Second option: the new mouse recognizes Minnie Mouse. The new mouse remembers what it's afraid of, remembers how to navigate the maze, and if that is true, then you can transplant memory and consciousness. And then the really interesting question is, if you can transplant this, is the only input-output mechanism this down here? Or could you transplant that consciousness into something that would be very different, that would last in space, that would last tens of thousands of years, that would be a completely redesigned body that could hold consciousness for a long, long period of time? And let's come back to the first question: Why would you ever want to do that? Well, I'll tell you why. Because this is the ultimate selfie. (Laughter) This is taken from six billion miles away, and that's Earth. And that's all of us. And if that little thing goes, all of humanity goes. And the reason you want to alter the human body is because you eventually want a picture that says, that's us, and that's us, and that's us, because that's the way humanity survives long-term extinction. And that's the reason why it turns out it's actually unethical not to evolve the human body even though it can be scary, even though it can be challenging, but it's what's going to allow us to explore, live and get to places we can't even dream of today, but which our great-great-great-great- grandchildren might someday. Thank you very much. (Applause)

Chapter 17 Architecture That's Built To Heal

Every weekend for as long as I can remember, my father would get up on a Saturday, put on a worn sweatshirt and he'd scrape away at the squeaky old wheel of a house that we lived in. I wouldn't even call it restoration; it was a ritual, catharsis. He would spend all year scraping paint with this old heat gun and a spackle knife, and then he would repaint where he scraped, only to begin again the following year. Scraping and re-scraping, painting and repainting: the work of an old house is never meant to be done. The day my father turned 52, I got a phone call. My mother was on the line to tell me that doctors had found a lump in his stomach – terminal cancer, she told me, and he had been given only three weeks to live. I immediately moved home to Poughkeepsie, New York, to sit with my father on death watch, not knowing what the next days would bring us. To keep myself distracted, I rolled up my sleeves, and I went about finishing what he could now no longer complete – the restoration of our old home. When that looming three-week deadline came and then went, he was still alive. And at three months, he joined me. We gutted and repainted the interior. At six months, the old windows were refinished, and at 18 months, the rotted porch was finally replaced. And there was my father, standing with me outside, admiring a day's work, hair on his head, fully in remission, when he turned to me and he said, "You know, Michael, this house saved my life." So the following year, I decided to go to architecture school. (Laughter) But there, I learned something different about buildings. Recognition seemed to come to those who prioritized novel and sculptural forms, like ribbons, or ... pickles? (Laughter) And I think this is supposed to be a snail. Something about this bothered me. Why was it that the best architects, the greatest architecture – all beautiful and visionary and innovative – is also so rare, and seems to serve so very few? And more to the point: With all of this creative talent, what more could we do? Just as I was about to start my final exams, I decided to take a break from an all-nighter and go to a lecture by Dr. Paul Farmer, a leading health activist for the global poor. I was surprised to hear a doctor talking about architecture. Buildings are making people sicker, he said, and for the poorest in the world, this is causing epidemic-level problems. In this hospital in South Africa, patients that came in with, say, a broken leg, to wait in this unventilated hallway, walked out with a multidrug-resistant strand of tuberculosis. Simple designs for infection control had not been thought about, and people had died because of it. "Where are the architects?" Paul said. If hospitals are making people sicker, where are the architects and designers to help us build and design hospitals that allow us to heal? That following summer, I was in the back of a Land Rover with a few classmates, bumping over the mountainous hillside of Rwanda. For the next year, I'd be living in Butaro in this old guesthouse, which was a jail after the genocide. I was there to design and build a new type of hospital with Dr. Farmer and his team. If hallways are making patients sicker, what if we could design a hospital that flips the hallways on the outside, and makes people walk in the exterior? If

mechanical systems rarely work, what if we could design a hospital that could breathe through natural ventilation, and meanwhile reduce its environmental footprint? And what about the patients' experience? Evidence shows that a simple view of nature can radically improve health outcomes, So why couldn't we design a hospital where every patient had a window with a view? Simple, site-specific designs can make a hospital that heals. Designing it is one thing; getting it built, we learned, is quite another. We worked with Bruce Nizeye, a brilliant engineer, and he thought about construction differently than I had been taught in school. When we had to excavate this enormous hilltop and a bulldozer was expensive and hard to get to site, Bruce suggested doing it by hand, using a method in Rwanda called "Ubudehe," which means "community works for the community." Hundreds of people came with shovels and hoes, and we excavated that hill in half the time and half the cost of that bulldozer. Instead of importing furniture, Bruce started a guild, and he brought in master carpenters to train others in how to make furniture by hand. And on this job site, 15 years after the Rwandan genocide, Bruce insisted that we bring on labor from all backgrounds, and that half of them be women. Bruce was using the process of building to heal, not just for those who were sick, but for the entire community as a whole. We call this the locally fabricated way of building, or "lo-fab," and it has four pillars: hire locally, source regionally, train where you can and most importantly, think about every design decision as an opportunity to invest in the dignity of the places where you serve. Think of it like the local food movement, but for architecture. And we're convinced that this way of building can be replicated across the world, and change the way we talk about and evaluate architecture. Using the lo-fab way of building, even aesthetic decisions can be designed to impact people's lives. In Butaro, we chose to use a local volcanic stone found in abundance within the area, but often considered a nuisance by farmers, and piled on the side of the road. We worked with these masons to cut these stones and form them into the walls of the hospital. And when they began on this corner and wrapped around the entire hospital, they were so good at putting these stones together, they asked us if they could take down the original wall and rebuild it. And you see what is possible. It's beautiful. And the beauty, to me, comes from the fact that I know that hands cut these stones, and they formed them into this thick wall, made only in this place with rocks from this soil. When you go outside today and you look at your built world, ask not only: "What is the environmental footprint?" – an important question – but what if we also asked, "What is the human handprint of those who made it?" We started a new practice based around these questions, and we tested it around the world. Like in Haiti, where we asked if a new hospital could help end the epidemic of cholera. In this 100-bed hospital, we designed a simple strategy to clean contaminated medical waste before it enters the water table, and our partners at Les Centres GHESKIO are already saving lives because of it. Or Malawi: we asked if a birthing center could radically reduce maternal and infant mortality. Malawi has one of the highest rates of maternal and infant death in the world. Using a simple strategy to be replicated nationally, we designed a birthing center that would attract women and their attendants to come to the hospital earlier and therefore have safer

births. Or in the Congo, where we asked if an educational center could also be used to protect endangered wildlife. Poaching for ivory and bushmeat is leading to global epidemic, disease transfer and war. In one of the hardest-to-reach places in the world, we used the mud and the dirt and the wood around us to construct a center that would show us ways to protect and conserve our rich biodiversity. Even here in the US, we were asked to rethink the largest university for the deaf and hard of hearing in the world. The deaf community, through sign language, shows us the power of visual communication. We designed a campus that would awaken the ways in which we as humans all communicate, both verbally and nonverbally. And even in Poughkeepsie, my hometown, we thought about old industrial infrastructure. We wondered: Could we use arts and culture and design to revitalize this city and other Rust Belt cities across our nation, and turn them into centers for innovation and growth? In each of these projects, we asked a simple question: What more can architecture do? And by asking that question, we were forced to consider how we could create jobs, how we could source regionally and how we could invest in the dignity of the communities in which we serve. I have learned that architecture can be a transformative engine for change. About a year ago, I read an article about a tireless and intrepid civil rights leader named Bryan Stevenson. (Applause) And Bryan had a bold architectural vision. He and his team had been documenting the over 4,000 lynchings of African-Americans that have happened in the American South. And they had a plan to mark every county where these lynchings occurred, and build a national memorial to the victims of lynching in Montgomery, Alabama. Countries like Germany and South Africa and, of course, Rwanda, have found it necessary to build memorials to reflect on the atrocities of their past, in order to heal their national psyche. We have yet to do this in the United States. So I sent a cold email to info@equaljusticeintiative.org: "Dear Bryan," it said, "I think your building project is maybe the most important project we could do in America and could change the way we think about racial injustice. By any chance, do you know who will design it?" (Laughter) Surprisingly, shockingly, Bryan got right back to me, and invited me down to meet with his team and talk to them. Needless to say, I canceled all my meetings and I jumped on a plane to Montgomery, Alabama. When I got there, Bryan and his team picked me up, and we walked around the city. And they took the time to point out the many markers that have been placed all over the city to the history of the Confederacy, and the very few that mark the history of slavery. And then he walked me to a hill. It overlooked the whole city. He pointed out the river and the train tracks where the largest domestic slave-trading port in America had once prospered. And then to the Capitol rotunda, where George Wallace had stood on its steps and proclaimed, "Segregation forever." And then to the very hill below us. He said, "Here we will build a new memorial that will change the identity of this city and of this nation." Our two teams have worked together over the last year to design this memorial. The memorial will take us on a journey through a classical, almost familiar building type, like the Parthenon or the colonnade at the Vatican. But as we enter, the ground drops below us and our perception shifts, where we realize that these columns evoke the lynchings, which happened in the public square.

And as we continue, we begin to understand the vast number of those who have yet to be put to rest. Their names will be engraved on the markers that hang above us. And just outside will be a field of identical columns. But these are temporary columns, waiting in purgatory, to be placed in the very counties where these lynchings occurred. Over the next few years, this site will bear witness, as each of these markers is claimed and visibly placed in those counties. Our nation will begin to heal from over a century of silence. When we think about how it should be built, we were reminded of Ubudehe, the building process we learned about in Rwanda. We wondered if we could fill those very columns with the soil from the sites of where these killings occurred. Brian and his team have begun collecting that soil and preserving it in individual jars with family members, community leaders and descendants. The act of collecting soil itself has lead to a type of spiritual healing. It's an act of restorative justice. As one EJI team member noted in the collection of the soil from where Will McBride was lynched, "If Will McBride left one drop of sweat, one drop of blood, one hair follicle – I pray that I dug it up, and that his whole body would be at peace." We plan to break ground on this memorial later this year, and it will be a place to finally speak of the unspeakable acts that have scarred this nation. (Applause) When my father told me that day that this house – our house – had saved his life, what I didn't know was that he was referring to a much deeper relationship between architecture and ourselves. Buildings are not simply expressive sculptures. They make visible our personal and our collective aspirations as a society. Great architecture can give us hope. Great architecture can heal. Thank you very much. (Applause)

Chapter 18 The History of Our World In 18 Minutes

First, a video. Yes, it is a scrambled egg. But as you look at it, I hope you'll begin to feel just slightly uneasy. Because you may notice that what's actually happening is that the egg is unscrambling itself. And you'll now see the yolk and the white have separated. And now they're going to be poured back into the egg. And we all know in our heart of hearts that this is not the way the universe works. A scrambled egg is mush – tasty mush – but it's mush. An egg is a beautiful, sophisticated thing that can create even more sophisticated things, such as chickens. And we know in our heart of hearts that the universe does not travel from mush to complexity. In fact, this gut instinct is reflected in one of the most fundamental laws of physics, the second law of thermodynamics, or the law of entropy. What that says basically is that the general tendency of the universe is to move from order and structure to lack of order, lack of structure – in fact, to mush. And that's why that video feels a bit strange. And yet, look around us. What we see around us is staggering complexity. Eric Beinhocker estimates that in New York City alone, there are some 10 billion SKUs, or distinct commodities, being traded. That's hundreds of times as many species as there are on Earth. And they're being traded by a species of almost seven billion individuals, who are linked by trade, travel, and the Internet into a global system of stupendous complexity. So here's a great puzzle: in a universe ruled by the second law of thermodynamics, how is it possible to generate the sort of complexity I've described, the sort of complexity represented by you and me and the convention center? Well, the answer seems to be, the universe can create complexity, but with great difficulty. In pockets, there appear what my colleague, Fred Spier, calls "Goldilocks conditions" – not too hot, not too cold, just right for the creation of complexity. And slightly more complex things appear. And where you have slightly more complex things, you can get slightly more complex things. And in this way, complexity builds stage by stage. Each stage is magical because it creates the impression of something utterly new appearing almost out of nowhere in the universe. We refer in big history to these moments as threshold moments. And at each threshold, the going gets tougher. The complex things get more fragile, more vulnerable; the Goldilocks conditions get more stringent, and it's more difficult to create complexity. Now, we, as extremely complex creatures, desperately need to know this story of how the universe creates complexity despite the second law, and why complexity means vulnerability and fragility. And that's the story that we tell in big history. But to do it, you have do something that may, at first sight, seem completely impossible. You have to survey the whole history of the universe. So let's do it. (Laughter) Let's begin by winding the timeline back 13.7 billion years, to the beginning of time. Around us, there's nothing. There's not even time or space. Imagine the darkest, emptiest thing you can and cube it a gazillion times and that's where we are. And then suddenly, bang! A universe appears, an entire universe. And we've crossed our first threshold. The universe is tiny; it's smaller than an atom. It's incredibly

hot. It contains everything that's in today's universe, so you can imagine, it's busting. And it's expanding at incredible speed. And at first, it's just a blur, but very quickly distinct things begin to appear in that blur. Within the first second, energy itself shatters into distinct forces including electromagnetism and gravity. And energy does something else quite magical: it congeals to form matter – quarks that will create protons and leptons that include electrons. And all of that happens in the first second. Now we move forward 380,000 years. That's twice as long as humans have been on this planet. And now simple atoms appear of hydrogen and helium. Now I want to pause for a moment, 380,000 years after the origins of the universe, because we actually know quite a lot about the universe at this stage. We know above all that it was extremely simple. It consisted of huge clouds of hydrogen and helium atoms, and they have no structure. They're really a sort of cosmic mush. But that's not completely true. Recent studies by satellites such as the WMAP satellite have shown that, in fact, there are just tiny differences in that background. What you see here, the blue areas are about a thousandth of a degree cooler than the red areas. These are tiny differences, but it was enough for the universe to move on to the next stage of building complexity. And this is how it works. Gravity is more powerful where there's more stuff. So where you get slightly denser areas, gravity starts compacting clouds of hydrogen and helium atoms. So we can imagine the early universe breaking up into a billion clouds. And each cloud is compacted, gravity gets more powerful as density increases, the temperature begins to rise at the center of each cloud, and then, at the center, the temperature crosses the threshold temperature of 10 million degrees, protons start to fuse, there's a huge release of energy, and – bam! We have our first stars. From about 200 million years after the Big Bang, stars begin to appear all through the universe, billions of them. And the universe is now significantly more interesting and more complex. Stars will create the Goldilocks conditions for crossing two new thresholds. When very large stars die, they create temperatures so high that protons begin to fuse in all sorts of exotic combinations, to form all the elements of the periodic table. If, like me, you're wearing a gold ring, it was forged in a supernova explosion. So now the universe is chemically more complex. And in a chemically more complex universe, it's possible to make more things. And what starts happening is that, around young suns, young stars, all these elements combine, they swirl around, the energy of the star stirs them around, they form particles, they form snowflakes, they form little dust motes, they form rocks, they form asteroids, and eventually, they form planets and moons. And that is how our solar system was formed, four and a half billion years ago. Rocky planets like our Earth are significantly more complex than stars because they contain a much greater diversity of materials. So we've crossed a fourth threshold of complexity. Now, the going gets tougher. The next stage introduces entities that are significantly more fragile, significantly more vulnerable, but they're also much more creative and much more capable of generating further complexity. I'm talking, of course, about living organisms. Living organisms are created by chemistry. We are huge packages of chemicals. So, chemistry is dominated by the electromagnetic force. That operates over smaller scales than gravity, which explains why

you and I are smaller than stars or planets. Now, what are the ideal conditions for chemistry? What are the Goldilocks conditions? Well, first, you need energy, but not too much. In the center of a star, there's so much energy that any atoms that combine will just get busted apart again. But not too little. In intergalactic space, there's so little energy that atoms can't combine. What you want is just the right amount, and planets, it turns out, are just right, because they're close to stars, but not too close. You also need a great diversity of chemical elements, and you need liquids, such as water. Why? Well, in gases, atoms move past each other so fast that they can't hitch up. In solids, atoms are stuck together, they can't move. In liquids, they can cruise and cuddle and link up to form molecules. Now, where do you find such Goldilocks conditions? Well, planets are great, and our early Earth was almost perfect. It was just the right distance from its star to contain huge oceans of liquid water. And deep beneath those oceans, at cracks in the Earth's crust, you've got heat seeping up from inside the Earth, and you've got a great diversity of elements. So at those deep oceanic vents, fantastic chemistry began to happen, and atoms combined in all sorts of exotic combinations. But of course, life is more than just exotic chemistry. How do you stabilize those huge molecules that seem to be viable? Well, it's here that life introduces an entirely new trick. You don't stabilize the individual; you stabilize the template, the thing that carries information, and you allow the template to copy itself. And DNA, of course, is the beautiful molecule that contains that information. You'll be familiar with the double helix of DNA. Each rung contains information. So, DNA contains information about how to make living organisms. And DNA also copies itself. So, it copies itself and scatters the templates through the ocean. So the information spreads. Notice that information has become part of our story. The real beauty of DNA though is in its imperfections. As it copies itself, once in every billion rungs, there tends to be an error. And what that means is that DNA is, in effect, learning. It's accumulating new ways of making living organisms because some of those errors work. So DNA's learning and it's building greater diversity and greater complexity. And we can see this happening over the last four billion years. For most of that time of life on Earth, living organisms have been relatively simple – single cells. But they had great diversity, and, inside, great complexity. Then from about 600 to 800 million years ago, multi-celled organisms appear. You get fungi, you get fish, you get plants, you get amphibia, you get reptiles, and then, of course, you get the dinosaurs. And occasionally, there are disasters. Sixty-five million years ago, an asteroid landed on Earth near the Yucatan Peninsula, creating conditions equivalent to those of a nuclear war, and the dinosaurs were wiped out. Terrible news for the dinosaurs, but great news for our mammalian ancestors, who flourished in the niches left empty by the dinosaurs. And we human beings are part of that creative evolutionary pulse that began 65 million years ago with the landing of an asteroid. Humans appeared about 200,000 years ago. And I believe we count as a threshold in this great story. Let me explain why. We've seen that DNA learns in a sense, it accumulates information. But it is so slow. DNA accumulates information through random errors, some of which just happen to work. But DNA had actually generated a faster

way of learning: it had produced organisms with brains, and those organisms can learn in real time. They accumulate information, they learn. The sad thing is, when they die, the information dies with them. Now what makes humans different is human language. We are blessed with a language, a system of communication, so powerful and so precise that we can share what we've learned with such precision that it can accumulate in the collective memory. And that means it can outlast the individuals who learned that information, and it can accumulate from generation to generation. And that's why, as a species, we're so creative and so powerful, and that's why we have a history. We seem to be the only species in four billion years to have this gift. I call this ability collective learning. It's what makes us different. We can see it at work in the earliest stages of human history. We evolved as a species in the savanna lands of Africa, but then you see humans migrating into new environments, into desert lands, into jungles, into the Ice Age tundra of Siberia – tough, tough environment – into the Americas, into Australasia. Each migration involved learning – learning new ways of exploiting the environment, new ways of dealing with their surroundings. Then 10,000 years ago, exploiting a sudden change in global climate with the end of the last ice age, humans learned to farm. Farming was an energy bonanza. And exploiting that energy, human populations multiplied. Human societies got larger, denser, more interconnected. And then from about 500 years ago, humans began to link up globally through shipping, through trains, through telegraph, through the Internet, until now we seem to form a single global brain of almost seven billion individuals. And that brain is learning at warp speed. And in the last 200 years, something else has happened. We've stumbled on another energy bonanza in fossil fuels. So fossil fuels and collective learning together explain the staggering complexity we see around us. So – Here we are, back at the convention center. We've been on a journey, a return journey, of 13.7 billion years. I hope you agree this is a powerful story. And it's a story in which humans play an astonishing and creative role. But it also contains warnings. Collective learning is a very, very powerful force, and it's not clear that we humans are in charge of it. I remember very vividly as a child growing up in England, living through the Cuban Missile Crisis. For a few days, the entire biosphere seemed to be on the verge of destruction. And the same weapons are still here, and they are still armed. If we avoid that trap, others are waiting for us. We're burning fossil fuels at such a rate that we seem to be undermining the Goldilocks conditions that made it possible for human civilizations to flourish over the last 10,000 years. So what big history can do is show us the nature of our complexity and fragility and the dangers that face us, but it can also show us our power with collective learning. And now, finally – this is what I want. I want my grandson, Daniel, and his friends and his generation, throughout the world, to know the story of big history, and to know it so well that they understand both the challenges that face us and the opportunities that face us. And that's why a group of us are building a free, online syllabus in big history for high-school students throughout the world. We believe that big history will be a vital intellectual tool for them, as Daniel and his generation face the huge challenges and also the huge opportunities ahead of them at this threshold moment in the history

of our beautiful planet. I thank you for your attention. (Applause)