

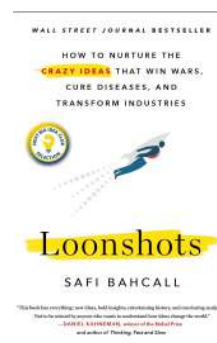


**Loonshots: Innovation Through
the Lens of a Physicist
with
Safi Bahcall**



By Mark Bidwell

Safi Bahcall is the bestselling author of “Loonshots: How to Nurture the Crazy Ideas that Win Wars, Cure Diseases, and Transform Industries.” Previously he founded and led a biotechnology company specializing in cancer drugs, served as a consultant at McKinsey and Company, and worked with President Obama’s council of science advisors (PCAST). Safi received his BA in physics from Harvard and his PhD in physics from Stanford.



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Safi, it's great to have you on the show. You are a second generation physicist. How does the training as a physicist prepare you for the world of business?

Well, as a physicist you're trained to see through noise and to try to find out what really matters, and in the business world that was a surprisingly valuable skill set. Obviously, this stuff's about quarks, gluon, string theory, gravity, general relativity, black holes, it isn't specifically relevant. But the critical thinking about how you see through a swarm of data if you're managing a business, whether you're at the top or the middle, or even at the lower layers, you're presented with a ton of data - what are your competitors doing, what are regulators doing, what they might do, what are your customers doing, your products... Just a ton of data points and you have to extract what is important. And that's what you learn in physics, how to see through lots of data and figure out what's important that tells you something useful about the world. In some ways, that's a critical skill when you're managing or running a business as well.

You got your PhD from Stanford, and after you graduated you went to the other side and joined McKinsey, right? What was behind that? I guess there might have been some peer pressure at home to continue the family business.

There was a lot of peer pressure. Both my parents were scientists, and they didn't understand what would possibly possess me to abandon the faith. I remember there was a very senior, very well known business figure on the board of directors of the institute where my father worked. And he asked him for a meeting to discuss a serious problem, and that was me. Could he tell him a little bit about this corporate world? And didn't it seem really dangerous that I wanted to do this business stuff? And he reassured him that it really wasn't such a big problem, that McKinsey was not such a horrific company, I would be okay and taken care of. For me, it was mostly curiosity. That's been a guiding principle in how I go through life, when I'm fine that I wake up in the morning and I'm really curious to go to work, whatever I am working on. I want to learn more, I want to learn how to be better at it, I want to understand the mysteries of that particular field. Whether it was in one area of science that I worked in, or a second area, or in the business world, I realized “you know what, more than 99.9% of the people don't live full time on universities and publish academic papers and write grant proposals.” And I said “that's really interesting, I wonder what they do for a living?” I remember I was dating somebody at the time, and I was like “could you take me to an office building? What do people do there? I don't understand.” And she took me to an office building and it was happy hour. She was a legal intern, or whatever you call it, a paralegal. I remember going around and asking people, “so what do you do? Walk me through, what is it? Do you like it?” and 100% of them said “No.” I didn't realize that's not uncommon in a law firm, especially around happy hours on Fridays. But that actually turned me off from the business world for a while. Then I realized that there was more to it and I got curious. McKinsey was a nice, halfway house between academia and the real business world.

And then you founded a biotech company. I'm not a physicist, I'm an anthropologist, but physics - there are some fundamentals of physics that drive the economy, the concept of supply and demand, or the idea of modern portfolio theory that is also based on physics. But you've gone further, you've taken your physics lens and applied it to your experiences as a founder and CEO to look at the world through the lens of phase transitions. How did that come about?

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When I was starting as a manager, a leader, I was in my early 30s and it was a biotech company that developed new drugs for treating cancer. I read everything I could find in the literature - popular books, articles about how to be a better manager and leader, build a terrific company and so forth, and so much was about culture. The first few articles or books that you read about creating a great culture are interesting when you're new to all of that, and many of the points resonate. By the time you read a thousand books saying more or less the same thing about culture, culture, culture, after a while, I would just hear culture and I would think "yogurt." I just wanted something that felt more like there was real substance and a hard science to it. You could say one thing about culture, and here's a company that did that and it worked, then you say exactly the opposite and here's a company that did that and it worked, and then the company that had this great culture would suddenly tank. That's not a very satisfying explanation if you have any kind of science background. If you look at the data, people with all sorts of variations in culture succeed, and people with all sorts of variations fail. Even though you get these studies, they're fairly anecdotal or they are after the fact retrospective. That's not very satisfying. It's like you analyze 10 people who won the lottery and you say what pants they were wearing, what color their socks were or something, and you find that there's a tendency. Or the CEOs who outperform the market tend to drink whiskey rather than scotch, so does that mean everybody should drink whiskey? You get these sort of correlative studies, and certainly to a scientist that raises a red flag. So many of those books and articles are these correlative studies that don't really tell you anything. I was looking for a more satisfying answer, and I started to get more interested in it when I was doing work with President Obama's Council of Science Advisors. The specific project I was called in for was to think about the future of national research, which is how we structure innovation as a nation. At the first day the chairman of that group stood up and said "your job is to write the next generation of the Vannevar Bush report." And unfortunately I've been running a company, and when you run a public company you don't really have a lot of time for leisure reading, or at least I didn't, you're putting out fires, investors, quarterly reports and so forth. So I had no idea who was Vannevar Bush or what his report was. Oops, I think I've stumbled into the wrong assignment here, I'm clearly not the person for this job. But I did some quick reading and the more I learned about it, the more I realized that he had struggled with the same thing that we in the business world have been struggling with for a long time - how do you make a large organization innovate faster and better? In his case, it was the US military, and in his case it was a national crisis. World hung in the balance, it was the start of World War II and the US and the Allies were far behind Nazi Germany and crucial technologies that would end up turning the course of the war. It wasn't just a profit or loss statement that hung in the balance, it was a nation and a world war that hung in the balance. He came up with a different model for innovating astonishingly fast within a large organization, the largest one, the US military of a couple million people. How he did it was interesting to me, and some of the things that he said and he wrote about were very interesting and reminded me of the behavior of systems, something that has nothing to do with culture, but rather everything to do with what you might call structure. And I can explain more what I mean by that.

Let's get then into the specifics, because you are a CEO of a startup which you took through funding and IPO. Maybe you can talk about the structure in the context of that journey, when did the phase transition concept occur? Was it after your second round of funding that you realized that you were transitioning from one phase to another?

Sure, I had the benefit of working in both small and inside very large companies. When I was at McKinsey our job was to work inside large companies and help them solve problems. Then I was working within a small company, and one of the things that I observed, that was really

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interesting, is that there is this widespread myth that the small companies are more innovative because the people there are different, they're more risk taking. But the reality was very different than the myth. From my experience in working on both sides for quite a long time, but also as a small company, when we started to do partnerships with the larger companies, there was really no difference between the people. We at a small company, we're incredibly excited about developing a new product that could save more lives and give people more time on earth with their loved ones. And the scientists, managers, and leaders we worked with in a large company, exactly the same thing, everybody wanted to go home to their spouse, their significant other, to their loved ones, their families, and tell them about how they've worked on something that could change the world. Everybody wants to do that, it doesn't matter what company. Yet, the smaller groups would embrace wild new ideas, and the larger groups would reject them, even though the people inside were the same. It was the same idea, and if you took a person from the larger group and put them in the smaller group, they would flip, they would suddenly embrace the wild new idea. That was an odd paradox, but it reminded me of something we're all familiar with, which is a glass of water. If you think about a glass of water, it will be liquid molecules will slosh around under all conditions, except as you change the temperature all of a sudden at 32 Fahrenheit or zero Celsius, the behavior of those molecules will completely transform. They'll become completely rigid, they'll freeze into ice and then you can't stick your finger in it anymore. The behavior that you see is totally different and the question is why. Those molecules are exactly the same. So why did they suddenly change behavior so completely? There isn't a CEO molecule inside saying "okay, it's one degree centigrade or two degrees, so everybody slosh around and move around and be free. Okay, wait a minute, it's minus one centigrade, everybody line up rigidly." There isn't a leader molecule driving that pattern of behavior. There's something else, there's something structural at the forces of those molecules. That made me think about how that might play out inside teams and companies. Because the example I just mentioned of the behavior, the same person can go from a project killing conservative to a flag waving entrepreneur and it's the same person, depending on which environment he or she is in, that's very similar to a drop of a molecule of water. If I take a molecule of water and drop it onto a block of ice, what happens? It freezes, it locks into place rigidly with the others. If I take the same exact molecule of water and I drop it into a glass of water, what happens? It sloshes around with all the other molecules. And that's the same in a certain sense, an important sense with individuals and how they react to new ideas. Although that sounds like an analogy or metaphor, you can actually tease that out into a mathematical and economics model of incentives. And you realize something very interesting. The underlying idea of a phase transition or a sudden change in a system, in a group, comes down to essentially having two forces acting on each of the molecules or parts of that group. In the case of water, one of those forces wants to make them slosh around and be free, and another one wants to lock them rigidly in place. It's called entropy and binding energy, but those are just fancy words, it just means those two things. As you change an aspect of structure, which in this case is temperature, you change the relative balance of those two forces. At high temperatures, the run around be free wins. At low temperatures, the binding energy, the lock rigidly into place, every molecule 2.8 angstroms from its nearest neighbor wins. As you gradually lower the temperature, the run around be free force gets weaker and weaker, and the binding energy gets stronger and stronger, and at zero centigrade, boom, they cross and the system suddenly change. That's why there is no CEO molecule telling them how to behave. In a team or company, you can think of culture as that pattern of behavior, it's the thing that you see on the surface. Structure is what's underneath that's driving it. For example, you may have a very political culture, that's something you see on the surface, or you may have an innovative culture, that's something you see on the surface, and we all want to get from A to B. A CEO, however, yelling at his or her employees to innovate faster and better is not very effective. Changing culture is very hard. No amount of watching videos, or holding hands, or singing Kumbaya is very effective, as any manager or leader knows, just like yelling at the molecules and a block of ice to loosen up a little and be fluid isn't going to melt that ice. But a small change in temperature will get the job done. A small change of temperature can melt steel. So the book is about what are those equivalent control parameters that can transform the behaviors of groups. It ultimately boils down to - whenever you organize a team, or a company or a group into an organization, into some kind of unit that there's a mission and a reward tied to it, you create two underlying forces that are competing. One is, for every individual, when you create that group or hierarchy, what is their stake in the outcome? When you're small, let's say a five person company, everybody has an enormous stake in the outcome. Let's say you divide things equally. Your outcome is 20% and that's a huge stake in outcome. If you're in a small biotech company and developing a cancer drug, if

the drug works, everyone's a hero and a millionaire. And if it fails, everyone's unemployed and looking for a job. Your stake in outcome is enormous. If you're five people, yeah, one person probably needs to be the team captain, gather team members. How much does that matter? Not very much if you're five people. Maybe the team captain gets a little bit higher salary, but it's irrelevant compared to that stake of outcome. Now, let's say you work at a giant, let's say pharmaceutical company. It could be the same five people, but now their stake in outcome if they create a good drug, which might sell a few hundred million a year, but the revenue of the giant pharma company might be 50 billion, so the stake in outcome is really quite small. On the other hand, there are many levels of rank, and now when you get promoted, your base salary might go up 20% or 30%, from being Vice President, Senior Vice President, Executive Vice President and so on. All of a sudden, the perks of rank become extremely important, and the stakes in outcome become much smaller. So what you have, whenever you organize people into a team or company, or any kind of group, is the same kind of two underlying forces. Rather than think about yelling at those people to innovate faster, better, like you yell at a block of ice, how do we think about what are the equivalents of temperature, or the smallest changes in structure? There are actually many little parameters for systems, temperature is just one example. But let's say I sprinkle a little salt and water. Why would I do that? Well, when it snows overnight, that's exactly what I want to do, I want to sprinkle some salt on the sidewalk. Why? Because it lowers the binding energy, it makes molecules less sticky, makes it more likely to slosh around and therefore more likely to stay liquid. That little sprinkling of salt is another control parameter that can change that behavior, which is much more effective than just yelling at people to do what you want. That's what's fascinating once you write it down, and you asked about how does being a physicist help you think differently. Let's set aside all this stuff about culture, it's not super effective to talk to people about culture. It's not wrong, there are certain things you obviously want. You want to celebrate victories, empower employees, and treat people with respect, of course those are good things. But there hasn't been enough discussion about structure. What are those small changes that can affect the balance of forces between individuals, that can make them more likely to collaborate?

And you talk a lot about the CEO living on the edge at 32 degrees. I'm curious as you've done this, what does it feel like? What does it look like being the CEO who's permanently living in this, not kind of liminal space, but in this transitional space between the two forces?

Here's why this matters so much, because there's this myth out there, of the great leader, the person who stands on top of a mountain and raises his or her staff like Moses, and then anoints the chosen project, whether that's the iPod or whatever, this drug or this thing. And that is popularized in articles and books, this hero worshiping stuff. But if you peel back the real history of what really happened, and the great leaders who built a sustainable innovation system, that's not what happened at all, and that's not how they lead at all despite the popular stuff, and it comes back to the idea of creating life at 32 Fahrenheit. Here's what I mean by life at 32 Fahrenheit. It starts with a big problem. Just the idea that there are two phases, whenever you organize people into a team or company, is a problem. The idea that there's one phase in which people embrace a wild new idea, and another phase in which they focus on the tight discipline and execution is a problem, because companies, teams, nations need both. If they want to survive, they need not only to create surprising new ideas faster and better than their competitors, that will delight and satisfy customers. But they need to translate those ideas into real products that they can deliver on time, on budget, on spec, consistently to customers. They need to do both. And those are two different phases of organization, and they're mutually exclusive. A system can't be in two phases at the same time, for the same reason that a glass of water can't be solid and liquid at the same time. You can't be totally rigid and totally fluid, it just doesn't make any sense. There's one exception to the rule that a system CAN be in two phases at the same time, and that's right on the cusp of a phase transition, right at 32 Fahrenheit, Zero Celsius if you are in Europe. Right on the edge of a phase transition, a system can in fact be in two phases at the same time, in equilibrium. By the way, occasionally, I get asked "oh, what about Slurpee?" I was just giving a talk in California when I got asked this. Just for the record, it's one of these things you buy at grocery stores like 7/11, which is liquid sugar full of particles...

And typically neon colored as well.

Yes, they are these horrific things, no offense to people who like Slurpees or whatever, but they're not in equilibrium. It's a liquid with little pieces of ice suspended that are melting. If you wait five minutes it will be all liquid. What I'm talking about is equilibrium, meaning can you create a sustainable organization that does both? I mentioned Vannevar Bush in the beginning, his problem and his challenge, and that was the insight that I got, which is he didn't try to change the US military culture, it's a giant organization and many before him had said "let's try to change the culture." He realized that was a mistake. You needed the tight discipline, execution, hierarchy, redundancy and focus on quality metrics to make millions of guns, to build thousands of planes and ships, and direct millions of soldiers in battle across four continents. You needed that tight discipline and execution, you didn't want to get rid of it or change it in fact. On the other hand, you needed a very different system, this sort of liquid phase to create these wild new technologies. I'll give you an example of why these are two totally different things, and why you need to separate what I would call, just for lack of any better word, the soldiers and the artists. The soldiers are focused on tight discipline and quality metrics, on time, on budget, on spec, and the artists are focused on coming up with crazy new ideas. The English word risk is one word, four letters, so you would think it would have one meaning. But it doesn't. To a soldier risk is a very bad thing. If you are about to go on a battlefield, and it's a high risk situation, that's a bad thing, that's a problem. If you are the commander of that battle, and you tell your general "I have de-risked the situation," the general says "big thumbs up, fantastic, you have taken all the risk out of that situation, you have de-risked that battle." Imagine going to an artist and say "you have really taken all the risk out of your art." That's a horrific insult. That's a terrible thing to say to an artist. If you're an artist, you want to try 10 wacky crazy things, nine of which will fail, and then keep the one that works. Imagine you're a soldier and your job is to build planes. You don't want to sit back in a chair, launch 10 planes into the sky, see which nine crash, and then say you'll keep that one. That's not what you try to do as a soldier. You need to separate these two groups, because they speak different languages, they respond to different things. You absolutely want to decrease risk, and have very quantifiable metrics on the soldier side, but you don't want that on the artist side, the Six Sigma stuff and so forth will smother an artist, you can't say I'd like four ideas on Monday, and 3.7 on Tuesday and so on, you don't want to track that. So life at 32, the one exception when the system can be in two phases at the same time is as I mentioned, right on the cusp of the phase transition, and here's what happens. Imagine you bring a bathtub to 32 Fahrenheit, what you get is what's called phase separation. You'll get blocks of ice and pools of liquid, and they coexist in harmony, the two phases separate. In some sense, that's the easy part, that's step one. Step two is what's called dynamic equilibrium, those two phases don't exist in isolation, you constantly have molecules going back and forth and back and forth, meaning a molecule of water will swim around, it will swim pass the surface of a block of ice, and then lock on and freeze. Molecules on the surface of the ice may start vibrating, and eventually they'll vibrate off and swim into a pool of liquid, and there's a constant dynamic cycle back and forth. When I think of life at 32 Fahrenheit, I think of three things that are critical for a large organization. Since I don't have a good memory, I remember them visually. So a block of ice, a garden hoe and a heart, and these are the three rules for innovating well, that I more or less took out of Vannevar Bush and a few organizations that have managed to succeed. So the block of ice is phase separation, separate your artists and soldiers. In some sense that's the easy thing, that a lot of companies build innovation labs and so forth. It really means more than that, it means applying completely different metrics to both, almost 180 degree opposite. In one case you want to minimize risk, in one case you want to maximize risk. So that's the block of ice, that's number one. The garden hoe is number two, and what I mean by that is be a gardener, not a Moses. I mentioned this myth of the Moses that stands on top and picks the chosen project. That's not really what happened. That's not what Vannevar Bush did in World War II. Vannevar Bush was a genius level engineer, he invented the first analog computer and a dozen remarkable inventions that ended up having a very big impact on technology, and the history of science of technology and so on. But he was very proud of saying "I made no technical contribution to the war whatsoever. There are those, for example, who call me an atomic scientist, it would be just as accurate to call me a child psychologist, I didn't do anything." He was very proud that he saw his job as managing the touch and balance between the artist and the soldiers.

A gardener, creating the environment.

Creating the environment, and by a gardener I mean helping those baby ideas come out of the new little nursery for ideas, not too early, not too late, bringing them the feedback, bringing the feedback from the soldier group, because no good idea ever works right the first time, so bringing that idea back to the artist to help fix that. And the reason is because the failure point in innovation is almost never the supply of new ideas. If you put twenty people in a room, you could come up with 200 creative ideas. The failure point is almost never the supply of new ideas. It's in the transfer to the field. It's in the transfer between the artists and soldiers, between those two groups. That's what Bush did as a leader. He managed the transfer, not the technology. He focused on when the idea is ripe enough to take it out, and then there will always, always be resistance in the soldier group to new ideas. It's not their job, they're not incentivized for that, they're not paid for that, they're paid for how the things that they've been doing for a while are working and continuing to grow, not intaking time from their valuable day to learn what some crazy scientist has to tell them and try to figure out what that scientist is talking about. It almost never works the first time, so then they have to go back and say why it doesn't work, they take it to a customer, it blows up in their face, now they are embarrassed in front of the customer. It's just incredibly time consuming, it's not their job, it's not what they're trained for. The failure point is almost always in that transfer. In one way transfer sounds reasonably obvious, like ok, crazy artist, crazy scientist, crazy engineer, crazy designer has some idea. The product marketers, the soldiers, they're going to resist to ideas, obviously, it's very time consuming, it's not their business. That seems obvious and you can understand, as a leader you want to step in and figure out the processes and systems to help make that transfer go better. The one that's usually missed is the other way back, which is ideas almost never work the first time. For example, the technology that ended up turning the course of the war, which was microwave radar, allowing the Allies to see the U-boats, which were strangling the Atlantic and cutting off the US from resupplying Western Europe and England. When the scientists finally invented that idea, and realized it could spot the boats in the sea, which would help the pilots shoot them down and sink them, they put it in the planes and nothing happened for a year. And Bush stepped in and said "look what's going on? Why are people not using this?", and finally convinced the scientists to get in the cockpit with these pilots. The scientists realized, they had this black box that worked, they had demonstrated in their prototypes that it could help spot U-boats far away, and pilots would see things they could never see before. What they didn't realize is that when the pilots were flying at hundreds of miles an hour and they were trying to evade enemy gunfire, pilots just didn't have time to flip these 13 complicated switches on these black boxes. They just said screw that, and they were just trying to fight for their lives and get out of there. Oh, so our technology works but our user interface is lousy. So they went back to the lab and they created these oscilloscope screens with a sweeping line that you see in movies, and the little dots that were the object, which is called a PPI display, put that in the planes and boom! Instantly, the pilot started using it. Within weeks after suffering exponentially growing losses, coming close to England, close to running out of oil and the war essentially being over and won by the German U-boat force, within weeks they'd sunk a third of the German U-boat fleet. And within another six weeks, the head of the German Navy sent a radio message across the entire Atlantic "Withdraw all U-boats. Withdraw. The Battle of the Atlantic has been lost."

So the power of the reverse translation back from the market to the science.

That's the power of those first two rules, the ice cube and the garden hoe, because Bush as a leader saw his job as managing the transfer. And the second part of the transfer, the feedback from the field to the scientist or the artist, or the engineers, or the designers is as critical if not more so. Why? Because the soldiers are busy, they're trying to sell, they're either on commission or they're fighting battles. They don't have blocks of time or patience, or interest to say "let me stop everything I'm doing." Let's say you're paid by commission - let me decrease my commissions because I'm not making sales phone calls. I'm being measured on certain quality metrics, I'm going to suffer on those metrics if I take three days out of my life to go back to a lab, and walk the scientists or the product designers through everything I hear from customers and why it isn't quite working, why our competitors are doing this or doing that. They're just not set up for that, they're not paid or being measured for that. So that

second transfer back is what people miss.

And the heart, the third one?

So that was the ice cube, that was a garden hoe, and the heart. The heart may be the most important one, and by that I mean love your artists and soldiers equal. And here's where that fails so often, especially in popular books and magazine articles. The popular books and articles lionize and celebrate these crazy idea inventors. They kind of worship this guy who had this great idea, da da da da...

The high priests.

Exactly. But what does that do to the 95% of people who are actually getting the job done? It demotivates them, demoralizes them. I had a friend at a major magazine and we were talking about these ideas. And she said "you know what, my job is to put out a magazine every 30 days. That's a very difficult job, and we're working our butts off. Yet our senior management and leadership is always focused on whoever's squeaking the loudest about the latest, shiny, innovation penny, and that really pisses us off. Because it's easy to squeak loudly about some nice innovative thing. And the rest of us are trying to get a very hard job done, and we hear nothing. When you favor the artists too much, you demotivate the soldiers. And anyone who's worked in any kind of entrepreneurial environment, or invention or discovery, knows that just having the idea is equivalent to getting the ball from your own goal to your five yard line, or five meter line or whatever. And then marching, turning that idea into a real product and delivering it on time to customers, on spec, on budget, with features that meet or exceed a competitor's is the rest of the 95 yards down the field. If you just focus on the first five yards and just celebrate that, what's going to happen is the following, it's the same idea that the CEO doesn't order molecules to be liquid or solid. The CEO can pound the table about innovate, innovate, innovate, and you have artists and soldiers in the room. And then when the CEO turns and leaves that conference room, what happens, that's where the real work gets done. Now if the soldiers are pissed off, they're just going to reject those ideas, it doesn't matter. They're going to drag their feet, they're not going to give the appropriate feedback, and those early ideas are going to die. So it comes back to the ice cube, the garden hoe and the heart.[46:33] And the heart, the leader, the manager has to celebrate both sides. If you want both sides, and any manager or leader who is worth their salt knows that, you don't do the real work. It's your executive team and the people lower down, who are actually nucleating the important ideas and then converting them into real products. So if you're celebrating one side and not the other, you're creating subconsciously dysfunction, you're creating roadblocks. If you want to succeed, you need to love both your artists and soldiers equally. There's a famous example of where this popular myth goes wrong, and in fact this popular myth is exactly 180 degrees opposite of what really happened, is the case of Steve Jobs. Talking about him is almost a cliché, there's just so much written about him. But so much is so wrong and misses the key point. When Steve Jobs saw himself as this great Moses and this wonderful innovator, when he praised the crazy artist when he was in his first incarnation as a young leader at Apple and working on the Apple 2 and then Apple 3, and then the Mac, it was a disaster when he had that mindset. He stumbled across this Macintosh project which was a small project, and he had not done very well, the franchise after Apple 2 hadn't succeeded, Apple 3 was sort of struggling, and Apple was rapidly losing to competitors. He kicked off the Apple 3 project, the franchise project, and the Lisa project, and moved on to this small project called the Macintosh. And he said "alright, everybody who's working on the Macintosh, you are the great artists, and everyone who's working on Apple 3 and growing that franchise, you are the regular soldiers, you're just a bunch of bozos." The dysfunction that that created people took to wearing a button with a picture of Bozo the Clown, and a red circle and a red sash saying "we're not bozos." His friend and co-founder and partner who created the Apple 2, Steve Wozniak who was working on cool new technologies for the Apple 3 franchise, he left the company, it was so dysfunctional. The street between their two buildings was called the DMZ, the demilitarized zone, because there was so much hostility between the two groups. So he had separated, but he didn't have the garden hoe, he wasn't managing the balance, and he certainly didn't have the heart of loving his artists and soldiers equally. In fact, when the Macintosh launched, it was

a complete flop. Great publicity and advertising, but the product didn't work, it overheated, it was too slow, didn't have enough memory, so people really couldn't use it and they moved on to other stuff. Then of course, the Apple 3 franchise did really poorly, and Apple very quickly became irrelevant in the personal computer space, and Jobs was asked to leave. Eventually Scully came in and turned the Macintosh around, and that did gain some traction, but was eventually superseded again. When Jobs came back 12 years later, who did he appoint as his chief artists? It was Jony Ive, the ultimate product designer artist. If anybody is wearing an Apple product on their wrist or in their pocket, it was probably designed by him and his group. And who he got to run operations was a guy named Tim Cook, who in his previous job was called the Attila the Hun of inventory at Compaq. If there's a better name for a soldier, I don't know it. This myth of Jobs as this great artist and chief visionary, that's not the reality. The reality is ice cube, he had separated his artists and soldiers, garden hoe, he focused on the touch and balance between those two, and heart, he loved his artists and soldiers equally. In fact, when he died, who ended up being a successor? It was not the artist, it was the soldier. So that's an example of what the popular myth gets wrong, and the better model which is the ice cube, the garden hoe and the heart.

One of the things we said before we started this was that you dispel some of the myths. One of the myths you dispel is the one of the godlike innovator. There's a couple of other myths, we've touched on the structure versus culture one. One that I'm interested to touch on is the third one, the idea of the pivot versus the three deaths. Maybe you can say a little bit about that?

Sure, the idea of the three deaths came from, when I was running my biotech company, we had a legendary scientist who at the time was in his 80s, on a flyover from Scotland, a guy named Sir James Black who won the Nobel Prize for developing two of the great medical breakthroughs of the 20th century, the histamine antagonists and the beta blockers. And he would come and advise us on one night, after actually flying through thousands of miles, arrived in the morning and met with us for 12 hours straight and then a dinner. I was exhausted and ready to just crawl home into bed. And he grabbed me and said "No Safi, stay a little bit longer, have a chat!" And I was like, how is it possible that this guy in his eighties was outlasting me? But anyways we started talking, I was saying I was feeling kind of depressed about a project in the lab that we'd been really excited about and it showed some negative results. He leaned over, patted my knee and he said "Oh, Safi, it's not a good drug unless it's been killed three times." I thought about that, and it turns out when you look at the real histories, as opposed to the revisionist histories of so many great breakthroughs, whether it's in medicine or technology, or so many others, they stumbled many times before they succeeded. In retrospect that makes a lot of sense, because if they were pretty obvious and they didn't have roadblocks, then a lot of people would have gotten there pretty quickly around the same time. But the ones that really changed the industry were things that failed many times before they succeeded. An example is the statin, which was one of the great medical breakthroughs before Lipitor, Crestor, Zocor and so forth, that was introduced in the 80s and has probably saved 10s of millions of lives, around 10s of millions of heart attacks by lowering cholesterol. When people first realized cholesterol might be associated with heart attacks, they rapidly designed a bunch of trials and studies to lower cholesterol, whether diet or some standard drugs that were out there, all of those trials failed. Most people gave up and they came up with a reason. They said "wait a minute, every cell in your body contains cholesterol. So of course a drug that lowers cholesterol could never work." No big surprise that all these trials failed, so everybody moved on, except for a scientist in Japan, who said "I think I have a different idea about how to stop production in a more targeted way." And he worked on it and worked on it, and came up with a drug, a lead molecule, early what you would call a prototype. He did what you do in drug discovery, which is you give it to the small animal models and see if it works, and that's the key step. He gave it to the mice and rats and found nothing. It did zero. That's the second death. Almost everyone in the industry moved on. He persisted and he had an idea, and he said "let me just try to understand better what's going on, because I really think this should work." He had an idea that maybe cholesterol is different in mice and rats and humans. Of course he persisted. And today, we know that the statins, the cholesterol lowering drugs work by lowering bad cholesterol, what's called LDL cholesterol, and they leave untouched the good cholesterol, the HDL. It turns out nobody knew rats and mice only have HDL, they didn't have LDL. It was what you might call a false fail, it was a flaw in the

experiment rather than the idea. Because he persisted past those three deaths, and there were more down the road, the statin class became a third of a three billion drug class and saved millions of lives. So why is this so important? Because there's this popular mantra of fail fast and pivot, that you read with these popular trendy things like Agile or Lean, or whatever. It's good to cooperate and get feedback quickly, but the problem with fast fail and pivot is that you wouldn't have gotten a penny of that third of a trillion dollars from the statin class if at the first stumble you failed fast and you pivoted. Same with the transistor, same with essentially every major discovery, jet engines, all of those digital cameras, personal computers, all of those things that have changed our world. The Google search engine - almost everybody passed on search, because the first dozen or so search companies didn't amount to much.

Same with Facebook, I think you mentioned that in the book.

Social networks, they all failed, 10 or 15 of them until Facebook found the little twist. These are all half a trillion dollar companies now, and they all failed many times, and the reason they succeeded was that they went past the fail fast and pivot.

Beginning to wrap up, the book has been out for a couple of months. What kind of feedback have you had from readers? Because you're going after some of the big myths that underpin lots of the publishing industry and Silicon Valley, and a lot of the media approach to high priests of innovation. What has been the response from some of your readers, or listeners, or people who've come across your materials?

It's been kind of amazing, the breath or diversity. Just in the last ten days, I think I've gotten cold called by four or five well known CEOs. I'm not going to mention names, it's entertainment industry, tech industry, media publishing, finance, and also a military leader, totally different audience. What resonates is, firstly I don't think there's been a business book in history with an equation, that starts from a hard science - let's just look at the incentives, and let's work out the balance, and then let's tease out these control parameter, and then builds from there to actionable things that you can apply in practice. I think that's unusual, because people are pretty used to, and certainly people who have been in my position, managers or leaders for a decade or so, got a little tired of the same old culture books and want something different. So I think people respond to an equation, and where is that coming from, and what does that mean?

Well, someone described it as Da Vinci Code meets Freakonomics. There are some lovely reviews, which give us a sense of the eclectic nature, of the waterfront of the work, but also of the range of examples through history. It's a very eclectic group of examples you're bringing out.

I think the other interesting connection is with Daniel Kahneman's and Richard Thaler's work on behavioral economics, if we're going to go a little more academic route. They really gave a fresh perspective of thinking about individual choice. In some sense it was answering the question of why do individuals make choices that seem to be irrational. What are the rational reasons why individuals will make choices that seem on the surface to be irrational? How are the individuals predictably irrational? That was essentially the theme of the behavioral economics stuff. This is the same principle but applied to groups. Why do groups make choices that seem on the surface to be irrational? What are the underlying rational reasons that they do that? And in both cases in behavioral economics there's a certain set of logically consistent rules. Once you understand them, it makes the individual choice a lot more clear. That's what this book is about. Underneath all the stories of World War II, and Pan Am and Steve Jobs, is a set of rules, a way to think about the rational reasons that make sense why groups will do these things that seem irrational, like everybody is excited about a new idea, they get together in a group and they kill it. That seems on the surface irrational, but there are logical, rational reasons why that makes a lot of sense. And just like with behavioral economics, once you

understand those things, you can begin to apply those rules.

And these CEOs, the military folks who've contacted you, what are they interested in specifically?

I get two types of calls. One is from rapidly growing companies, the leaders of rapidly growing organizations, and their number one concern is - how do we avoid getting stale? We have one product or one thing that's done really well when we were 10 people, or 20 or 50 people, we were all super excited about it and we grew it. And now we're x hundred or x thousand people, and that thing is still going well, but we know that it will eventually plateau and start to come down. So how do we maintain that and go to the next level, and the next level beyond that? How do we avoid getting stale? So that's one call. The second call is the opposite - we've already passed that plateau, we're at tens of thousands or whatever. And it's the same thing I've heard from entertainment industry media, well known larger companies. All of our focus today is on franchises. How do we get better at nurturing loonshots inside, what do we do? Because we are so focused on franchises, how do we better balance? I've heard this now three or four times just in the last week from totally different industries. We are in a rapidly, rapidly changing industry. We're going to die unless we find some new loonshots, we are being squeezed. Let's say even entertainment industry, Amazon and Netflix are just dominating, and now Disney is dominating. So what can everybody else do? If they just keep doing the same old stuff, they're going to be squeezed out and get killed. They just nurture franchises, the next Avengers, the next Transformers, so they are inevitably going to be squeezed out. So I get those two types of calls, which is we're growing and we want to preserve that, or we're sinking and we need to be saved, kind of like Vannevar Bush came in and turned around a US military franchise, where the franchise was important, but they were rapidly losing. It's like Steve Jobs, Apple had a franchise but it was rapidly sinking and he turned it around. I traced many of these ideas back to another franchise that had grown and was rapidly sinking, and a guy came in and turned it around. That was the Bell Telephone Company, they had a phenomenal phone franchise, and in the early part of the last century they started rapidly sinking as all these competitors came up, and Theodore Veil came in and did the same things I just mentioned, just to simplify, with the ice cube, the garden hoe, and the heart, and he succeeded in turning that around. The reactions I'm getting are A: thank God, there's a business book that actually has some real science and equation for once. B: thank God, I'm not at a university, so I don't particularly care about what people in university say, so I'm a little free about saying things that I think are silly, and that's a little refreshing. And C: here are some fresh ideas that have never been discussed before about those situations, about how to nurture loonshots better and how to balance that with franchise. So those are the reactions, very broad, and for me it's enormously fun, I get to talk to people who make movies for living, these young tech billionaires who have just found themselves riding some incredible wave of success on some product, or I get to talk to people who are running major newspapers or magazines. It's interesting how they find stories in one area like military fascinating, and then they translate them into lessons that they can apply. Just watching that is for me both fun and fascinating.

Yeah. Have you developed any plans? I'm interested what you're going to do next, are you going to get back into the consulting world to go and help these organizations, respond to some of these calls from some of these billionaires? What's emerging now as a result of this book?

I've always been driven by curiosity about how the world works, and moved from one field of science to another. So that really drives me, and while I'm curious, I will pursue what I find curious. One of the things I've seen in the last six months or so is a very high appetite for "Okay, help me now. Here's a very different way of thinking about the world, it helps us understand some things that were kind of mysterious, it helps dispel some very common myths. But can you get more practical? Like day to day when I sit down with my people, I should say x and not say y", that sort of thing. I think some of that is fun, connecting and learning about new industries, meeting interesting people who are having interesting challenges, helping them think through that, and talking to them about it is fun, I learn a lot from that. I think a next book which gets a little bit more practical with what has been learned

about applying these things from all these discussions in the military, or in this or that industry, and some good stories about real practical level, like what works, what are some common traps and how to avoid them, that would be fun for me.

Interesting. I think what's clear is, where we started, looking at the world through different lenses, it opens up all sorts of things because we're all biased, we all live in our bubbles. I think someone described the internet as this giant confirmation bias engine. We live in these worlds, and coming out of these bubbles and looking at the world differently opens up new insights and new horizons, new ways of moving forward. I know we're a little bit over time, but are you okay just to go after these three questions very quickly, the first one being, what have you changed your mind about recently?

Well, kind of unrelated to some of the stuff we were talking about, but I've had some very interesting discussions with neuroscientists just through random interactions. I had this view of certain mental disorders, whether it's depression, or compulsive disorders, that there were mental techniques you could use, not self-help but cognitive techniques. And it's been fascinating to me to see how much that is not the case. You can stick a little electrode into the brain and fire it in one particular region, and someone who is completely obsessive compulsive or can't move because of depression, just gets up and walks around like a normal human being. And that tells you that it's an injury in the brain, it's not something that there are straight forward behavioral techniques for. I found that fascinating, I think it's changed my view of how I think about mental disorders. It's an injury to an organ, just like you break a knee or you damage your liver, there's a genuine physical injury to a part of the brain. PTSD, post traumatic stress disorder in the military is a genuine physical dysfunction in the brain, and no amount of talk therapy is going to help that, but there are certain physiological changes that you can do, not all drugs, but actually other stimulation things that are remarkably effective. That's been fascinating and certainly changed how I think about that.

Interesting. Second, where do you go to get fresh perspectives, especially when you're facing complex challenges?

For me, it's varying the input sources. The worst thing is to keep reading the same person. It's sort of a temptation. People connect to people, they don't really connect to ideas, and you get comfortable listening to or reading one person. If you keep reading that person, you're just going to be in that bubble. I love my spouse, but if you keep talking to your spouse as your only source of ideas, you're going to get one perspective. So for fresh perspective I like to ask people what book has influenced them enormously over the last year or two, and actually a question you asked, what has changed their thinking. But specifically who have they read, or which one or two or three people have they read that have changed their thinking. And then I go around asking folks, that was suggested to me by a friend, and I found that very powerful. And then I will read to vary the input sources. I will read things that I might think are not for me, I'm not interested, and if my reaction is that I don't think there's something there that I will relate to, that's exactly who I want to read.

So you actively seek out cognitive diversity in your reading sources?

Yes, if you want to make it multi syllabic, then yes.

You read lots of different stuff, that's what you were saying.

I try to just change who I read and who I listen to. One really great way is podcasts actually. I'm new to that world, I didn't know what it was a year or two ago. But now as an author, you better know what that is. You can tune into these podcasts, and some of them are just like going to dinner with a really interesting person, but you don't have to pick up the check, you

don't have to pay anything, you don't have to get changed, go to a car and drive somewhere. You just tune in and you're like sitting at a very interesting dinner table, and then you hear very different perspectives. It's especially the ones that you think "oh, I don't think there's anything there for me," that you actually want to listen to.

Yes, fascinating. And thirdly, what's been your most significant low, what did you learn from it, and how have you applied that learning? We touched a little bit on failure in terms of 3 deaths and false fail?

Anyone who's been an entrepreneur has experienced failure after failure, and I'm no exception. That has certainly been the case. More recently, I remember when me and my literary agent went out to discuss this idea of writing a book that combines physics, business and history, with sort of an equal blend of three. And publishers were like "no way, those kind of books mixing physics and business never work." And I remember thinking like "I'm sorry, could you point me to an example of that?" But it was a real low, and I put a lot of energy and time into saying what I think I'm going to do. And people just shrugged and were like that'll never work. That was really depressing. Like I said, I put a lot of time into it, and I had hoped, obviously, that it would go well, and they didn't like the title Loonshots. Now everybody seems to like the title, but at the time were like "well it sounds too much like the word moonshots with an M, and when our sales person calls a store, and they say 'I got this book by this author, it's called Loonshots', and they say 'Oh, it's the moonshots?' 'No, it's Loonshots with an L.'" They said "that 22nd discussion will ruin your book." "Really? Is that how it works?" I didn't know that. What I learned from that is something a guy named Judah Folkman that I worked with told me. Judah Folkman is a guy who came up with this new way of treating cancer. When he was in his early 30s, he came up with this idea of blocking the blood vessels that supply blood to growing tumors, and essentially every year for the next 30 years he was ridiculed. We treat cancers with chemotherapy and radiation, and there's no mysterious signal for growing new blood vessels. So 30 years after his idea, a company unveiled results from a drug built on his idea, and it extended survival in patients with colon cancer more than anything in history. Hundreds of thousands of patients have benefited. It turns out to work in the eye, because a certain kind of blindness is caused by overgrowth of blood vessels, and it's helped blind people see literally, it's given to millions of people. And he persisted for 30 years, and I asked him, as we were quite close, I was in fact having dinner with him and his wife just shortly before he passed away, I asked him at one point "how did you persist, what kept you going?" And I thought about it and he said, "there are no experts of the future." And that stayed with me for a long time. So when people said "you know, this crazy book idea will never work, and don't use that title, that sucks" or whatever, I just kept that in mind. Well, you know what, there are no experts of the future. That's a lesson that has stayed with me and keeps me going through ups and downs.

Lovely. Where can people get in touch with you? We'll put the details of the book and everything in the show notes, but where can people get in touch with you if they want to reach out?

Two places - www.loonshots.com is my website, or Twitter, my handle is just my full name @SafiBahcall.

Great. Thank you very much for your time, I know we ran over a little bit. This was great. Very nice to meet you and best of luck with following up on those conversations.

Thanks, it was a great show.

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