SUPER SHOES

HOW ADVANCED TECHNOLOGY REVOLUTIONISED RUNNING

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Chapter 1

A moonshot in Monza

'Any human being can go beyond their limits, beyond their thoughts, but self-belief is crucial'
— Eliud Kipchoge, 2019

THE SOUND of chirping birds is punctuated by an air horn. The hush of anticipation quickly turns to cheers as feet scamper across the tarmac. It is finally happening. Under the cover of morning darkness, nine men take off running and, suddenly, everything becomes more than just chasing records. Conversations turn philosophical, about human limits, how those are defined and what it takes to rewrite them. Here, Eliud Kipchoge, Zersenay Tadese and Lelisa Desisa are the chosen three – 'the big three' as one Nike employee calls them over a walkie-talkie. Years of work, research, planning and testing are to be reduced into 17 laps of the iconic Monza race track. That totals a full marathon (26.2 miles/42.195km) and Nike is hoping, planning and believing that at least one of them can make history. This is Nike's Breaking2 project, its self-described 'moonshot' attempt to facilitate a sub-two-hour marathon. To achieve it, Nike is more than prepared to circumvent traditional race rules. It matters not that the sport's governing body, World Athletics, will, for various

reasons, never ratify the event. The times here will have an asterisk beside them and not be considered official. Really, that is the entire point of it all. Something bigger, sporting immortality, is at stake. Nike was prepared to bend some rules in the quest of breaking new ground.

There is truth to the notion that winners write history and, depending on who you ask, there are alternative universes where it is not Nike, not Kipchoge and not the now-famous Vaporfly 'super shoe' in Monza. But on 6 May 2017, at 5.45am – 63 years to the very day since Sir Roger Bannister broke the four-minute mile barrier in perhaps the watershed moment in athletics – it was Nike which was launching its 'moonshot' at the race track nicknamed the 'Temple of Speed'. The Vaporfly was the company's hypothetical rocket, a fitting metaphor really, considering the impacts on propulsion and performance. The distinctive colourway paired a light, turquoise upper with a white midsole. It was a modest look, quite the contrast to the loudness of its performance capacities. The stack height, the term for how tall the midsole foam is, was 38mm, about double what was traditional. The Vaporfly featured a midsole made from ZoomX foam, which Nike advertise as deriving from materials and technology 'traditionally used in aerospace innovation'. The moonshot analogy was not just a concept drawn up in a meeting room. This maximalist shoe drew particular attention for featuring a carbon plate, which started at the back of the shoe and ran the full length to the front, curving down under the balls of the feet and then rising back up to the toes. Nike marketed it as having an 85 per cent energy return, its best-performing shoe ever, and the company was so impressed with its internal testing performance

that it sent it for independent analysis at the University of Colorado, which published its findings in a 2017 paper. Those researchers had top-level runners wear a prototype on a treadmill and compared their performance to how they ran in the market-leading Nike and adidas shoes. The results were immortalised forever in giving the shoe its name: the '4%' shoe. When running in the Vaporfly, the tested athletes had an average of 4.16 per cent 'reduced energy cost' compared to the then-currently available marathon shoes. Simply, they were more efficient and meant runners needed less oxygen (what researchers call 'running economy') to run at the same pace.

'I think that Nike, with the 4%, really threw out the rule book for what a racing flat is,' says Andy Barr over a video call from Eugene. With him being an adidas employee for 16 years, including in 2017 when Nike launched the Vaporfly and Breaking2, this is as big as recognition can come – from a former rival. 'We started to see them here in Portland, on people's feet, prior to them [officially] coming out. I think everyone was a bit like "what's that?" But, then, there's a benefit and you see it. What I'd heard was that athletes didn't like the shoes to begin with because they didn't fit into that zone of what they thought a racing flat [should be]. But the minute they tried them and could see the benefit, they were like "right, yeah, these are brilliant".' Barr speaks with a thick Scottish accent, graceful and respectful in his appreciation of excellent craft, which he puts down to completely novel thinking. He explains how 'counterintuitive' the design approach was, based on traditional ways of working. 'In general, you create product [and] normally it's [focused on] consumer obsession, athlete obsession. Athletes have got to love it and if they don't, then you've got to change it.

Where that flipped on it's head was the benefits – you can't argue with them.' Andy Jones, a professor at the University of Exeter and who has a PhD in exercise physiology, was part of Breaking2's science team and recalled to me his first experience of trying on a Vaporfly: 'I was amazed – just the way your foot was configured in the shoe. It felt as if, just walking in it, let alone running, you were being sort of rocked into the next step. You were not really propelled but rocked forward without having to think about it or expend as much energy. It did feel revolutionary when I first laced those up. It was absolutely very, very stiff. Despite being a bit bigger – and reasonably well cushioned – it did still feel well-cushioned as you ran. It was also light. So, it was like "how do they make this light *and* cushioned at the same time?"' These feelings are shared by Alistair Foster, now the director of marketing at ASICS for their global performance running team, who was working in the running event space in 2017. 'I remember it felt like a really seminal moment for the running industry,' he says over a video call from his office. 'From a performance perspective but also it obviously opened up a lot of kind of questions around the ethics of the shoes and mechanical doping. Everyone realised that the game was changed for the future.'

Running, whether on the track or roads, is an objective sport, which is what makes science and innovation such an integral part. Everything can be measured. At the time of Breaking2, Nike knew it needed to improve on the world record (2:02:57 set by adidas athlete Dennis Kimetto in Berlin in 2014) by 2.5 per cent to land the moonshot. A shoe which could improve performance by much more than that offered significant promise to bridge the gap. Sandy Bodecker, the New Yorker who

had worked at Nike since 1979 – and is the abstract thinker behind the infamous Nike SB range – was VP of special projects at the time. 'I'm a dreamer,' he told the Nike website one month before Monza. 'The best of the best live for this.' Bodecker had overcome cancer (he sadly passed away in 2018) and was so obsessed with the barrier that he had 1:59:59 inked on his left wrist. 'The sub-two-hour marathon barrier is one of those rare ones that, if broken, can transform a sport. It will impact the way runners view distance running and human potential forever,' Bodecker told the Nike website. He called it 'the last big, once-in-a-generation barrier' that would sit in the pantheon with Bannister's four-minute mile of 1954 and Jim Hines's 9.95 seconds 100m time that first cracked the ten-second mark in 1968. Breaking2 had the look and sound of an actual rocket launch, with the ten to one countdown at the start of the 'race' and the Nike employees in the control room at the track with their over-ear headphones on and spreadsheets churning. As Wouter Hoogkamer, the lead researcher on the aforementioned University of Colorado paper that gave the Vaporfly its 4% name, told me: 'Breaking2 had a lot of elements to it. So, it wasn't just the shoe.' What did and did not happen on that fateful day are equally important. Kipchoge held pace for most of the race, running in that relaxed, fluid, metronomic, gliding style of his and was led by a rotating cast of pacemakers who operated in an arrowhead formation, with the Kenyan behind them. Hydration was delivered to the athletes directly, by bicycle, with 17 bottles per athlete (ranging from 60ml to 100ml), mostly 'standardised' drinks but with three to five which were specifically tailored to Kipchoge, Desisa and

Tadese, where the amount of fluid, amount and type of sugar and caffeine had all been crafted for the individual athlete. Because of that and the rotating pacemakers – as well as the fact that the course had not been ratified – Breaking2 would not be record-eligible.

Kipchoge was brave and bold in Monza and came close. So close. The clock stopped at 2:00:25. It was significantly quicker than Kimetto's world record and Kipchoge, then the third fastest of all-time, had gone more than two and a half minutes better than his own personal best. The conditions were good – not perfect, being a little cold – and Nike was largely vindicated for how much it had committed in time, money and expertise. It also conveniently doubled up as a marketing campaign, with Nike then launching the Vaporfly to market (retailing at $250 per pair). 'As well as something that they believed was going to be performance-enhancing – all of the internal testing suggested so – it was obviously something that they could then launch and sell off the back of it,' says Andy Jones, one of the science team on the project. 'Because it was a hell of a lot of money spent on Breaking2. So, Nike being a commercial enterprise, they want to recoup some of that.' Kipchoge looked a bit like he was walking in space after he crossed the line. After giving everything for just over two hours, his efficient and smooth running gait was reduced to a stagger as he slowed to a stop, suddenly stiffening. The Kenyan rested his hands on his hips, gave a few hugs and gingerly lowered his aching body to the floor. He lay on his back only momentarily, embodying the disbelief of everyone by then getting straight back up, unaided but uncomfortably. The 31-year-old looked around, wiped his nose and mouth with the bottom of his

red vest, like a bloodied gladiator emerging from battle, and summed it all up without saying a word. Kipchoge upturned both his palms to face the sky, shrugged both shoulders slightly and raised his eyebrows, as if to ask what more he might have given. 'You can aim for something and then it slips out of your hands,' he told reporters afterwards. Andy Jones simplified just how close the moonshot was to landing and how fine the margins were. Kipchoge's average mile pace, Jones pointed out, was just one second off what was needed for a 1:59:59. The speed had been so intense and demanding from the start that Desisa fell off the pace from eight miles in and, by halfway, Kipchoge had broken Tadese, too (the 35-year-old Eritrean was the wildcard pick in the group and, with a time of 2:06:51, went way under his 2:10:41 personal best). There were, eventually, celebrations. Kipchoge was given a guard of honour by the extensive team of 30 pacemakers – all Nike athletes – before they picked him up and raised him aloft. Then, some of them danced on the track. It was not quite the glitz of the champagne-spraying podium celebrations that Monza sees with F1 but, still, was recognition for greatness. 'It didn't seem to last two hours and the longer it went on, the more excited we became,' Jones told me. 'At one stage, I gave this look to Brad [Wilkins, another Nike employee], like "this actually could happen".' The tipping point moment came at 7.5 miles out when Kipchoge's projected pace first dipped outside two hours and never quite recovered, even with the optimism that he had shown the capacity in previous marathons to finish fast. With 5km to go, Kipchoge's manager, Valentijn Trouw, pulled up alongside him on a bicycle, telling him things he already knew – that he had 5km to go and could recover the time –

perhaps in the desperate hope that his athlete might have forgotten them after nearly two hours of such demanding performance. There was an honest conversation during the last lap between Brett Kirby, Breaking2's lead physiologist, and one of Nike's control room staff. 'We'd still need an increase,' came the call from the control room, speaking about his pacing and winding up. 'This is all he can do,' responded Kirby. It was an emotional acceptance that they were going to get so heartbreakingly close.

In my 50-minute video call with Wilkins, he is remarkably open in sharing details and his own emotions from such a unique experience. I seem to catch him off guard when I ask if he remembers how it felt when Kipchoge crossed the line. 'Um, you know, it was, so I …,' he says, bashfully starting multiple sentences at once and momentarily looking away. Even with it so far in the past, there are clearly many powerful emotions that Wilkins still attaches to it. He recalls 'an interaction' between himself and Phil Skiba. 'Phil was like "oh, he can make that up" and I didn't say anything back. I knew, with probably about a lap and a half to go, that he wasn't going to do it, because I understand the math. I had some time to process before the end. I was hoping I was wrong. I made my way to the finish line to see the end. There was an immediate reaction of "oh, we're so close" and maybe a little bit of disappointment but that disappointment went away quite quickly, because it became very clear how excited everybody was and how excited the running community and the world was by how close he got.' Wilkins moves from slightly rueful and subdued to proud and moved. 'I think everybody there [...] had this sense of we proved – "we" meaning Eliud – that it was possible. Like, I think *that* time there kind of

said "all right, the whole world now, the running world now knows that this is possible".' His sentences become longer and more flowing, as if it is a soliloquy. 'It didn't get done but 25 seconds, 26 seconds away from sub-two; like, that's something – you're right there. So, that, I think, was what people were focused on more than the frustration that he didn't do it. That initial kind of "oh man, he didn't do it" passed really quickly to, like, "wow, look at what collectively we were able to do and what Eliud was able to do physically".' Jones shares those feelings: 'Nobody was disappointed. Well, one person was disappointed at the end and that was Eliud himself. Nobody felt it was a failure other than Eliud, who felt like he'd let everybody down for not breaking two hours. We all thought that was just a magnificent performance. It took more than two and a half minutes off the then-world record. I think that made sub-two inevitable.' Jones gesticulates frequently on the trip down memory lane, at one stage mimicking how he remembered seeing Kipchoge eating porridge at 3am in the dining hall in the dark. 'The whole thing was amazing, actually. I remember being up really early. We needed to be at track before dawn, because we wanted to get that window when it was supposed to be really still. There was a bit of rain early on and we were, like, "oh, we don't know". But then the forecast was correct and then it didn't rain for long. Any sort of sense of disappointment [post-event] was quite fleeting. By the time he crossed the line, I remember feeling an exhilaration, really.'

Nike hard launched its inarguable, market-leading – and redefining – shoe in March 2017, four months after Breaking2 was announced to the public, in December 2016. There would later be contention over the men's

marathon at the 2016 Rio Olympics, where it eventually emerged that there had been some cloak and dagger: the three podium athletes were all Nike-sponsored and had secretly been racing in disguised Vaporfly prototypes, which had the same upper as the yellow and pink Streak 6 (Nike's leading on-market shoe at the time) but featured superior foam and a carbon plate and were not yet available to the public. Rio showcased the largest field in Olympic marathon history (155 starters, 139 of whom finished), which was also the most internationally representative. Even with an Olympic record-breaking 62 men finishing in less than 2:20, the medallist trio were not to be caught, a result which, retrospectively, has added fuel to the fire for those arguing about an unlevel playing field that day. Kipchoge won in 2:08:44 in soaking conditions, a slower time than the previous two Olympic marathons. He was more than a minute clear of second-placed Feyisa Lilesa (Ethiopia, 2:09:54). Galen Rupp, of the USA, took third, 11 seconds behind Lilesa and more than a minute clear of the rest of the field in what was only his second marathon, eight days after racing the 10,000m final. Kipchoge, Lilesa and Rupp had raced smartly, with a 50-strong lead pack at halfway moving at an elite-level conservative 2:12 pace. They had it down to single digits at 30km and the three had gapped the field by 35km. Kipchoge covered the final 13.1 miles just over three minutes faster than the first half, showing the type of race craft, adaptability and finishing speed which would one day transcend him beyond the marathon. He was a deserved winner and described the race as 'a bit slow, so I decided to take over. It was comfortable, very comfortable. This is the best win of my life'.

Breaking2 was staged less than a year after the Rio marathon. Two months out, Nike conducted a test event in Monza. Kipchoge ran 59:17 for the half marathon there, eight seconds faster than his official PB at the time (59:25 from Lille in 2012; he had repeatedly clocked times just outside an hour throughout the mid-2010s). It featured a dry run of the specific details that Nike hoped would make the difference that May. There was a Tesla pace car with a clock strapped to its roof, pacemakers, pre-'race' weigh-ins and tape that the athletes put on their legs to improve aerodynamics. Hydration was delivered to them by bicycle on the course. 'Honestly, the test event was for the team to practice, not the runners,' remembers Brad Wilkins eight years on. He talks via video call from the University of Oregon, where he is now faculty at their performance research laboratory. 'We do human performance-related research,' he explains. 'In a previous life, I worked at Nike and had the honour to lead the scientific team going after the two-hour marathon or the Breaking 2 project.' He adds with a chuckle: 'That's probably why most people want to talk to me these days.' It's why I want to speak to him. There were hypotheticals that needed falsifying in March before they tried it for real in May: 'How are we going do this and how are we going to run this? [It was about] getting the pacers, the operations team and the logistics team to do what we wanted them to do – seeing where they were from a readiness standpoint and making minor adjustments from there.' Much like Mike Tyson's famed quote about having a plan until being punched in the face, Wilkins and the science team found some answers. 'There were a bunch of takeaways. We made a lot of decisions that were

kind of veering away from our original plan, because of some of the things that happened during that test event. To be honest, some of the athletes weren't as ready as we wanted them to be and it also gave us a little bit of a moment to try to readjust some of their training to optimise things. We weren't in charge of any of their training. Their coaches were still doing all their training but it did give us a chance to kind of work with their coaches and say "hey, based on the physiology of what we just saw, you probably want to do this or that and try to optimise in a little bit of a different way".'

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In Natural Geographic's Breaking2 documentary, the very first scenes after the opening credits are cut shots of computer screens showing VO_2 max trendlines and bodyweight differentials for Tadese, Desisa and Kipchoge (i.e., water loss and weight changes) in warm and cool conditions. Then we see Wilkins and Kirby stood in front of a large whiteboard on which they have plastered numbers. It is various simulation data organised in table format. Wilkins was clean shaven then but when I speak to him he has a grey beard with patches of brown, as if to emphasise how long eight years – two Olympic cycles – feels in sport. Hence his phrasing of 'a different life'. Nike publicly announced Breaking2 five months before it happened. 'I tell people it was about four years of my life at different levels of work at one point or another,' Wilkins remembers. 'Some initial conversations happened, at least four or five years before Breaking2 actually happened, with a number of folks that were interested in this project and just kind of interested in

this idea of "what if we went after something like this? What would that look like?" Then, about four to three years before it happened, we really started getting serious and there were a couple of meetings where I was able to show people that we had the math and the science that predicted that this *is* a possibility and that all it would really take is somebody [with a] really intentionally and focused effort going after something like this.' One assumes 'the math' is similar to the numbers and predictions that he and Kirby were mulling over on the whiteboard. Wilkins speaks with all the academic sensibility and parlance that you would expect from someone with a PhD who directs the performance research laboratory at the University of Oregon, with the famous Ducks track and field team one of the most successful and prestigious in NCAA (American collegiate) history. He also talks arrhythmically sometimes, repeating words as he thinks for a better synonym; perfection and accuracy matter in his line of work. 'It was a long period,' he says of planning Breaking2. 'The rest of the world really knew about it for about a year. I was really focused for about two years before it happened. That was the timeline that it takes, in my opinion, to go after these kinds of things. Maybe it doesn't take four years but it definitely takes a year-plus, probably two years, to really put all the things in place to go after an intentionally-focused effort like this.' Before picking the course, before selecting the athletes and the pacers, Wilkins had to assemble what Nike was terming its 'science team'. He points out that there was also 'a footwear innovation team, an apparel innovation team, a marketing team. It was those groups, those different teams kind of coming together' that led to success. The footwear

innovation team were perhaps the most lauded, having produced the famous, market-breaking 4% Vaporfly shoe (more on that in later chapters) which publicly-available research showed could improve metabolic energy costs (i.e., the physical demands of running at a given pace) by more than enough to turn a 2:03 guy – a Kipchoge – into a sub-two-hour marathoner. But the performance of the athlete and their capacity to maximise performance with any footwear needed the right course and conditions. Fundamentally, Wilkins says, 'we wanted people with the right expertise, so we got experts in bioenergetics – how your body uses energy, how fast you can turn over that energy and how your muscles fatigue'. Wilkins found and hand-picked four others to make up the quintet.

Nike's Breaking2 "Science Team":

- Dr Brad Wilkins: director of Nike explore team generation research in the Nike Sports research lab — led the science team on Breaking2.
- Dr Brett Kirby: researcher at the Nike Sport research lab — lead physiologist on Breaking2.
- Professor Andy Jones PhD: physiologist and an external advisor, Wilkins says he is a 'world-leading expert in bioenergetics, especially in running'.
- Dr Philip Skiba: a medical doctor and performance engineer and another external advisor. Wilkins described him as 'one of the top in the world at being able to do the math and the models and being able to mathematically understand training adaptations and performance predictions'.
- Robby Ketchell: expert in mathematical modelling and environmental science. A third external advisor.

'So, that team, we felt like we had the expertise that we needed but not just the expertise – we were a bunch of like-minded people, like-minded scientists who understood the problem that we were trying to solve,' Wilkins recalls. It was a group which must have had, collectively, thousands of academic papers bearing their names. 'I think Brad was superb at coordinating that [team], making sure everyone was heard but also being ultimately in control,' Jones remembers. 'Everybody knew they could chip in. It was very, very open and transparent and everyone was encouraged to have their input. But the good thing about Breaking2 was it was very much science-led. Sometimes it isn't just the science in the big organisation; you've got marketing and there's multiple [other departments] and they all want to influence it or control it to some extent. All the decisions were made in the best interest of giving us the best scientific chance of success.'

Jones speaks to me on a video call from his home, with a backdrop of wardrobes and family portraits that, fittingly, humanise him. Even after 25 years at the University of Exeter, where he is a professor of applied physiology, he is – in stereotypically British fashion – a little awkward when speaking about his own achievements. 'I suppose I have the reputation both as a basic scientist but also as an applied scientist. I think that was something that was attractive to Nike, because, while they had an in-house team of very well-qualified scientists, I think what they really felt they needed was someone who was [he takes a long pause here, mindful of his phrasing] really expert in the specific physiology of distance running – and how you'd go about selecting an athlete who might be capable of breaking a two-hour marathon.' Jones's strength was

not just his academic background but having previously been a consultant physiologist to UK Athletics, spending just as much time working with athletes as the books. 'So, in the UK, everybody that had been … not everybody that had been any good but a lot of them [worked with me],' he explains, with sincere humility. He worked with Paula Radcliffe from her late teens all the way through to the Briton's world records.

The biggest challenge, Wilkins explains to me, is not about getting enough expertise into the room but actually managing it and knowing where to put it. 'We were able to work together, work through the solutions and then try to have the right group of people to apply those solutions. But, from a scientific standpoint, we didn't want perspectives from everybody that had one,' he says, with a chuckle, 'because that starts to cloud and it starts to bring too much information into the problem that probably doesn't need to be solved. We first outlined everything. The first thing that you do when you come up against something like Breaking2, is you put everything on a chalkboard or a whiteboard and you say "why isn't somebody doing this now?" You list all the physiological problems, all the physics problems, product innovation problems, all the things that you can think of that is currently limiting somebody from doing this. Then you start to break those down. Where do you get the biggest bang for your buck? Because you can't solve for all of that.' His description manages to condense physiological limitations, performance demands, group dynamics, personality and communication styles into a mathematical equation. At no point does Wilkins say this directly but he implicitly explains that the problem with Breaking2 as a project and as a goal is that the target

is so clear and so much clearer than the reality of the actions and decisions that go into making it happen. Jones dissolves into metaphors at one stage when recalling the project: 'You just need all your ducks in a row, you need all of the stars to align.'

There were five things, Wilkins explains, 'that we had to solve for someone like Eliud to be able to run a two-hour marathon'. These were the non-negotiables, seen as the big wins, where getting those right could make the difference, as opposed to trying an approach focused on marginal gains. 'Then we really went after those things. Having the like-minded group that could really focus intentionally on these problems that needed to be solved was why I kind of said we needed the right kind of small team.' His answer veers into over-explanation – using the idiom of too many cooks in the kitchen at one stage – and I feel compelled to say that, in spite of being a journalist, I wish for him to not feel cross-examined on specific words from eight years prior. He had said in the National Geographic documentary on Breaking2 that he wanted the 'right' team over a big one and the phrasing piqued my interest. Wilkins chuckles, teeth borne, and insists he has no issues with the question. That shows in how candidly he answers when I then ask just how big and crazy some of the ideas for locations and courses were. 'There was a lot of different locations that would come up. We had a guy by the name of Robby Ketchel who was mapping out different weather conditions and going through historically, like ten years, 15 years back, and saying, like, "how can we model the optimal weather and wind and all that kind of stuff at a specific location?" There's a bridge in Europe somewhere that's miles long

and we were just, like, "oh, it's flat, it's straight, let's just put them on that and go". But Robby was, like, "the wind across the bridge is too unpredictable. We can't do it". Those things were what we really took into account when we were making the decision for Monza. It's quite protected – the track, the course – by trees and other things, so differences in wind would be quite minimal.'

Even settling on Monza, it transpires, was a win for Wilkins and the science team. 'Once we decided where it was going to happen and around the time that it was going to happen, that was extremely freeing, because now we knew the problem we were solving for. Now we know "this is what the temperature is going to be like, this is the course, this is what everything's going to be like". We can't engineer for every possible location on the earth, right? So, once you kind of hone in and say "all right, we're committing to this", then that allows you to engineer and allows you solve a problem specific for that condition and specific for that circumstance.' He is back to speaking about the project like a mathematician solving for a variable and, as he explains the decision to make Monza the place, Wilkins gesticulates quite flamboyantly. At no point is he ever making out clear shapes and I interpret it as a reminder of just how long he must have obsessed over the project and the adrenaline that must rush from reliving it, as though he can still almost tangibly reach out and touch something which defined so many years of his life. And yet, in spite of being 'extremely freeing', a phrase Wilkins repeats in talking about Monza, it was not a perfect decision. 'There's always a give and take, right?' he asks, rhetorically, and I silently nod anyway. 'We actually lost a little bit, I think, in temperature; it was probably one

degree warmer than we wanted it to be, because we didn't want it windy and we didn't want some of the other things that would have come with a colder climate than Monza.' He then explains that the early start, with the gun going off at 5.45am, was 'because the earth warms much slower than it cools'. Then he corrects himself; 'wait, is that? … no, it's the opposite. Yes! It warms much slower than it cools.' One gets the impression talking to Wilkins that, with so much knowledge in his brain and neurons firing so rapidly, that, at times, he formulates sentences as he says them. It makes him captivating to talk to; it would be unsurprising and understandable for those on the project to give cookie-cutter, script-like general responses. Wilkins talks genuinely and even invites me cross-Atlantic to see his lab in Oregon if I wish. 'Back to temperature,' he says, midway through a monologue on the 'give and take' when picking Monza. 'We knew that we had a timeline of which it was going to stay cool enough for us in the morning. Hormone levels are a little bit more optimal in the mornings, especially if you get a good night's sleep. There's those kinds of physiological aspects as well. If you look at the timing of when those athletes usually train, when you take the time zone changes into account – which actually weren't that much – it pretty much matched with when they were training anyway.'

Then it came to testing. Interesting research emerged in 2021, three years after the event. A paper featuring nine authors – including Wilkins and Jones – publicised, in the *Journal of Applied Physiology*, some of the details about the testing process and their findings. 'It was close to 20 [athletes] that we tested; there might be 16 complete data sets that we included in the article,'

Jones remembers. 'It started with a much wider pool of athletes that we would perhaps wanted to have tested. I mean, some of them were considered and then thought not to be ready at this stage. Some weren't available or were injured – that kind of thing.' Nike had the luxury – or the earned right – as a powerhouse athletics brand to take their pick of contracted elite marathoners. How it works in top-level athletics – track and field, as well as the marathon – is that professionals sign to brands and are required to exclusively race in their gear (there can be exemptions for this at major championships, because brands sponsor national teams). Because of this, when it came to staging Breaking2 and, later, the INEOS 1:59 challenge, the pacemaking teams were made up not just of Nike's best marathoners but other long-distance athletes who were world class over 5,000m and 10,000m – athletes for whom running 14:13 for a 5km was well within their capabilities. Those athletes ran 5kms twice, with 45 minutes to an hour of rest in-between. 'We just tried to match their ability quite well,' Jones explains of the pacemaking teams, who operated in groups of six, running in a triangle formation which had been picked – based on wind tunnel experiments and computational fluid dynamics – for maximal drafting benefits: one athlete at the front, two behind them and then another three, creating an arrowhead-like shape, with Kipchoge, Desisa and Tadese protected in tow. 'Good coverage,' as Jones put it. Every lap, the front three pacers would break away, the trio behind them would take their place and, like clockwork, three more would emerge from the sides and slot in. 'They rotated their position at the front, because, obviously if you're at the front, you're taking in

the brunt of the headwind,' Jones says. 'I don't think we gave a lot of thought to the constitution of each of those little pods, because they were all very highly qualified athletes who have raced 5km at that speed.' But there was one key principle to follow: 'We wanted people who were relatively big closer to Eliud where we could.'

Wilkins distills the testing process for the candidates to quantifying 'three main physiological things', which the science team believed, to a high likelihood (absolutes do not really exist in any science and not exercise science), would tell them if an athlete was a sub-two-hour marathon contender or not. 'That is their maximum capacity, their max VO_2 — what is their capacity to use oxidative metabolism, called oxidative power, actually, to turn over oxidative metabolism at their max,' Wilkins explains. This was the marathon equivalent of looking under the hood of a fast car. They wanted to understand what kind of horsepower each athlete had. Wilkins continues, the words tellingly flowing from him as questions, with answers that were unknown before they started the project. 'We're looking at their running economy. So, how economical are they with the oxygen costs to run at that speed that's required to run a fast marathon? In this case, a two-hour marathon? So, can they turn over energy in an efficient way and use the least amount of oxygen possible while they're running at those speeds? The third thing is what we call the sustainable speed, [alternatively known as] critical speed or critical velocity. That speed that you can sustain for long periods of time without fatigue; we want that to be a very high percentage of their max capacity or of their VO_2 max.' It was not a straightforward case of selecting the athletes with the biggest engine. To continue

the metaphor, some had poor mileage per gallon (worse running economy) while others were not able to sustain speeds for long enough. Elite marathoners can be deceptive to watch. Some have textbook, rhythmic forms, where they move smoothly and, seemingly, without wasting any energy. Their faces stay relaxed, heels come up high and their strides look long and loping. Kipchoge is a perfect example. Many do not run like him. Paula Radcliffe, the former marathon world record holder, ran with her head bobbing when she tired. Haile Gebrselassie, the Ethiopian, who won two Olympic golds and four world titles over 10,000m before setting two marathon world records (he was the first man to break 2:04), notoriously ran with his right arm swinging in conventional style but his left arm stayed locked. He explained in a 2002 interview that this was a product of his upbringing in Oromia, where he ran 10km each day to school and carried books in his left arm, and that never left him. The point being, Wilkins, Jones and the rest of the team knew they needed to rely on the objective data and avoid being deceived by their own eyes. 'A lot of the protocols, treadmill tests and stuff that we use with those athletes was something that I developed as part of my PhD,' Jones says. He explains that they had various 'testing protocols, which allowed us to, first of all, predict what an athlete was capable of over a variety of different events, including the marathon. Also, I developed the way of interpreting that data to not only identify athlete strengths or weaknesses but, from my own background as a distance runner myself, conducting those tests, interpreting them and helping those athletes. Having identified those that might be best qualified to actually even attempt the thing, actually help working with the

athlete and their coach to make them even more ready to go for it when the time came'. This goes back to Wilkins's comments about wanting a small team. So much of the project was about navigating noise and trying to find the signal within it. Athletes, after having their height, weight, body fat and 'pulmonary function' measured, completed an 'incremental treadmill test' wearing a face mask with a connecting tube that allowed for gaseous exchange, heart rate and blood lactate to be analysed. They started running at 2:29 marathon pace (17km/h), increasing speed by 1km/h every three minutes for the first two stages, then by 0.5km from 2:13 pace (19km/h) onwards until they hit exhaustion. Between intervals, the researchers rushed to take finger-prick samples to test blood lactate, which would give them a reading to see how close the athlete was to hitting the 'red zone' of unsustainable performance. Notably, athletes were not given Vaporfly prototypes to run on the treadmill, instead running in traditional 'lightweight racing flats'. The testing was split across Nike's campus in Beavertown, Oregon (where Wilkins is based) and the University of Exeter (where Jones works at the department of sport and health sciences). In Exeter, they also had athletes, separately to the treadmill testing, run over force plates and between high-speed cameras, with markers on to give them the stickman-looking biomechanical videos that were useful for form analysis. The final part of the lab trials was to take athletes outside to the track, where they ran wearing a heart rate monitor and a 'portable gas analysis device'. Athletes warmed up however they wished, then completed a workout of two laps at 5:41/mile pace (2:29 marathon) and then six laps (2.4km) at two-hour marathon speed, including an all-out final lap.

This was another piece of the testing puzzle, allowing the science team to see how athletes could manage the pacing themselves and in real world, open air conditions, giving a more complete picture on their performance capacity. They reported 'no significant difference' in athlete results on the treadmill versus the track but that did not mean it was wasted time. Wilkins, Jones and company wanted as much information as possible.

Jones says the work in the lab was 'really quite useful. But, of course, it's just a snapshot. You haven't necessarily got all the athletes in their best condition when you test them'. He says they also looked at their previous best performances and analysed past races. No stone was left unturned, with the sense being that, if Nike was to achieve what nobody had done before, it needed to do what nobody had and that required such a rigorous, intensive and controlled research period. 'We also did some sweat testing on them to know how much water they lost, to know how much electrolytes they lost at specific environments,' Wilkins says, 'so that we could then prescribe how much we wanted to put back or give them back to make sure that they didn't lose too much body weight and then didn't become too dehydrated during that race.' The top line from the paper published in 2021 was incredible: most of the elites they tested did not have the physiological capacity to break two hours. 'Only seven [of 16], when you run them at 21.1km/h, could attain a steady state which was below the O_2 max,' says Jones. 'All the others were on a collision course; it was clearly unsustainable for them. But it goes to show that it's a phenomenal achievement [to target a sub-two marathon] and we were just running for, like, ten minutes

and only seven could do it. It didn't surprise me, really. If more of them were able to do it, then two hours might already have been broken [in a major marathon].'

The selection process was as cruel as it was crude but it had to be that way. This was not a football team overlooking a goalkeeper for being too small or a baseball pitcher not being drafted because their fastball was too slow. Athletics has its 'technical' events and those involve jumping and throwing. While there would be no amount of heart or willpower that could compensate for any physiological limitations (a harsh use of the word when talking about elite athletes), Wilkins explains that they did test for a 'fourth thing that was kind of a little more squishy'. He starts to chuckle when talking about it, because he knows, at first, it sounds a lot less significant than the key physiological markers. They wanted 'to get at the psyche and to get the psychology of these athletes', Wilkins says. 'There's definitely some that would complain a lot when we asked them to run really fast on a treadmill; just, like, "I don't want to do that" or whatever. But then there were those that were, like, "yeah, I'll do that".' He recalls testing Tadese, who ended up being the oldest – and slowest – of the trio (2:10:35) in Monza but was a wildcard pick because of his unmatched half marathon times. 'When we were done testing him, he could have just gone back to the hotel room. But we were, like, "Hey, we want to see like what it would look like to run at two-hour marathon speed. Would you get on the treadmill and run? Just kind of see how it goes?"' Wilkins wanted fearless athletes. 'You could clearly see that some athletes were completely fazed by it and thought it was impossible,' Jones remembers. In Tadese, they had found

fearlessness. Wilkins recalls: 'He's, like, "yeah, sure". I think his answer was "how long do you want me to go?" So, that gives you an insight into that fourth thing – and all three of those guys had that. They were just, like, "yeah, we're in, let's do this". That was another important component that we were looking at and that doesn't get talked about a lot but I think it was an important one.' Jones, after reminiscing on Kipchoge and his desire to have the transcendence of Neil Armstrong or Roger Bannister – 'I think he genuinely believed he could do it, more so than any of the others' – recalls testing another athlete. 'He was, like, "how much are you going to pay me?", so was immediately off the list because that's not what it was all about.' In the end, they picked three.

Kipchoge was the newly-minted Olympic champion, who was seven wins and eight races into his marathon career, with the only race he came second in being the 2013 Berlin Marathon, where Wilson Kipsang had run a world record. Kipchoge, then aged 32, was third on the all-time list with a course record 2:03:05 from London in 2016. He consistently ran 2:04s and was, apart from Kenenisa Bekele (the 34-year-old, second-fastest all-time in May 2017), the obvious candidate. Out of pure interest, I asked Wilkins and Jones directly why they picked three athletes and what they saw in Tadese and Desisa to think that 2:10 and 2:04 marathoners might have enough to break the two-hour barrier. 'Honestly, so many things can go wrong in a marathon that we wanted to make sure that we didn't just have one try,' Wilkins says. The answer for one of their biggest and most significant project questions had the simplest of answers. 'We didn't want more than three. Trying to get logistically more than three … five,

ten … like, it would have been a logistical nightmare. So, I think that the three was kind of the perfect number. We knew that, believed that, one person could do it. We had the data to demonstrate or suggest that one person could it. We believed all of them had the physiology. It was those three because we – I don't want to call them back-ups, because they weren't back-ups – didn't want put all of our eggs in one basket. If Eliud had been sick that day … those kinds of things can happen.'

Tadese, who was three months out from his 36th birthday at Breaking2, ran 2:06:51 in Monza, a time he would never better. His backstory was an interesting one, having initially wanted to be a professional cyclist before forging a running career, first as a 10,000m runner, then finding success in cross country and the half marathon. His 10,000m bronze in Athens in 2004 was the first Olympic medal in Eritrean history and five years later he became a world medallist over the same distance. Tadese was the sixth-quickest 10,000m runner of the 2000s (26:37:25) and would claim five half marathon world titles in a six-year spell between 2007 and 2012. He held the world record and the second-fastest half marathon at the time of Breaking2 and had run sub-60 minutes for the half on ten occasions. 'You're just, like, "why isn't this guy popping off in a marathon?" He should be able to do that,' Wilkins explains. 'We believed in his physiology and we were, like, "okay, I think we can tweak some things, we can help them, make some changes to his hydration, his nutrition". He didn't have those strategies like Eliud, who always had a team around him. Eliud should have been running as fast as he was running, because he had the resources and he had a team around him. Some of the others, we were, like,

"let's give them that and see what they can do, because they have the potential". That was kind of the idea around not just going after the top marathoner in the world, which at the time was Eliud – or close to it.' Jones is defiant about all three picks being on equal merit in 2017. 'We honestly didn't necessarily think that Kipchoge would be the one to shine. We really didn't know.'

Wilkins says trust and belief took time to build, with the testing data, to get full buy-in. '[When we said] "we think you guys can do this", a couple of them needed convincing – even Eliud. He was just, like, "what are you talking about?" But he came around quite quickly and once he came round, he was all in, as they all were. As time went on, their belief in themselves grew and grew and grew, especially Eliud's belief in his ability to do this. He was totally switched on. He had total confidence in himself and the team. He believed in this kind of big … we called it a "moonshot",' Wilkins says, taking a moment to pause and remember. Even eight years on, the significance of the project seems to have stayed with him. 'Putting somebody on the moon was the analogy, this big thing that nobody's ever done before. He was 100 per cent in belief that we could do that.'

Jones explained how he used the testing data in his conversations with the trio to help instil belief. 'When you show them the numbers and they know that you're the expert team, they know you've evaluated a load of athletes and you're putting your faith in them [by saying] "actually, you, you're one of our best prospects, it's not beyond the realms of possibility that you could do it". Then they do start to believe in it; they certainly all trained with the intention of being the first man to break through that.'

Tadese made for a justified wildcard and was a contender who needed to find a way to convert his excellence in the half to the full distance. Desisa was the prospect pick. An Ethiopian born in the province Shewa, in which the capital Adidas Ababa lies, Desisa had run 2:04.45 on debut to win the Dubai Marathon in 2013. That was one of the fastest-ever debut marathons at the time and, at 27, he was much younger than Kipchoge and Tadese. Jones recalls the questions the scientists' team asked themselves: 'We wanted to see whether we still felt they had potential to get faster. Were they at the twilight of their career? Or perhaps they hadn't enough experience at this stage?' In Desisa, there was potential to be realised, especially with him being a two-time winner of the Boston Marathon (2013 and 2016). He hit the wall hard in Monza, dropping off the pace before the halfway mark to cross the line in 2:14:10. Three very different times and almost equidistantly-spaced athletes showed how hard it was for the elites in Breaking2 to get things perfect, even with all the planning and preparation that went into it.

'The world now is just 25 seconds away from under two hours,' Kipchoge said at the finish line in Monza. 'We are human. We are going up the tree ... I have lifted a branch and I am going on to the next one.' The performance, even in artificial race conditions like these, immediately changed the conversation around a sub-two-hour marathon from 'if' to 'when?'. The moonshot got that bit closer. Wilkins remembers agonising over the details afterwards: 'You start thinking "okay, where can we get a tenth of a second per metre? Where can we get a hundredth of a second per metre here and there?" There's definitely possibilities for that, because

in the INEOS project, he did it, right? I have learned from Eliud – and from that experience – that there's a difference between believing and knowing. That's what the difference was between Breaking2 and INEOS' 1:59 project.' Wilkins reflects with content on what Kipchoge achieved at Prater Park in Vienna on 12 October 2019, two years after Breaking2, when he ran 1:59:40. INEOS, the British petrochemical giant which sponsors what was formerly Team Sky in cycling, took charge. It meant a largely different support team but many of the same principles for their 1:59 project. A flat, minimal-turn course was picked in Prater Park, with trees either side protecting the path from wind; there were better conditions (it did not rain at all this time) and the presence of fans provided an added boost, something Kipchoge had missed in Monza. Vienna is on an almost identical latitude to Kipchoge's training base in Kenya, seen as an added benefit to minimise jet lag. INEOS set aside an eight-day window between the 12th and 20th of October for the event, 'to compete in the best possible conditions', Kipchoge noted in a training diary.

'He no longer *believed* he could do it; he *knew* it and that was the biggest thing that made that difference,' Wilkins says. Neither he nor Jones were formally part of the event. Robbie Ketchell, who had been instrumental in picking out the Monza course in 2017, was the only performance-related member of staff to feature on both projects, operating as a data scientist for Project 1:59. INEOS took a risk, putting all their stock in Kipchoge. Hydration was again delivered by bicycle and a lead car ran ahead. There was a 41-strong pacemaker team, much more international than the one in Breaking2,

which featured more middle distance runners (including Olympic champion Matthew Centrowitz Jr and all three of the Ingebrigtsen brothers – Jakob, Filip and Henrik). This time, the pacers ran seven at a time in a V formation, with Kipchoge at the base behind five pacers, and two more behind him, a subtle tweak on the arrowhead that Wilkins *et al* had opted for. Kipchoge's 5km splits were as metronomic as they can come in a marathon, all between 14:10 and 14:13, which meant he was under the two-hour barrier enough on the home straight for the pacemakers to fall away and let him run through the line on his own, pointing to a cheering crowd with a beaming smile stretched across his face. 'It was good that he got another opportunity at it, because he deserved that,' Jones reflects. 'Having got so close, there was no way it wasn't going to happen the next time. I think he got a big lift from the training that he'd done for Breaking2, lots of positive vibes and all of that. He took that training into preparing for Berlin,' he adds, speaking about the September 2017 race where Kipchoge became the first man to break 2:02, running a world record of 2:01:39. 'He was just on a roll then, wasn't he? Really, he was on top of the world. It all kind of came together over those next two or three years.' Wilkins is in accordance with that: 'I think that's all from his training. You can see that it can happen. So, I think the training, his ability to focus and train harder now that he knew he could run that fast, was the reason why he did it the second time. Everybody's had that experience where they try something that they've never tried before and they're, like, "oh, that wasn't that bad, I didn't make it but I think I can do it". Then you know you can do it and you go after it even harder the next time.'

These are sentiments shared by Kipchoge, who had his training diaries intermittently published throughout 2019 on a website dedicated to the INEOS 1:59 challenge. 'I did not expect a second opportunity to come about this year, because such events take a long time to organise, but I am very grateful. I believe it has come at the right time,' he said. 'This is a golden chance for me to make history.' At this stage of his career, Kipchoge had mastered the balance of racing one marathon in the spring and another in the autumn. His last half marathon had been in 2016 and he skipped the biannual World Championships because they would clash with his preference to race the Berlin Marathon in September. I spoke to Kipchoge about the mentality shift post-Breaking2 when I interviewed him in November 2025. Did he know he would break two hours in Vienna, I asked? 'Absolutely. After Monza, I had a great team. I took the experience I got and we got as a team. We transpired the whole experience for 2019 with the INEOS Challenge. We had huge experience on how to handle the project and how it worked. I had that huge belief in my heart. "Do you trust in my mind that I will really run under two hours?" So, what made me to run under two hours is actually what happened in 2017. The whole trial that we did, all of us as a team – we were like boxers. When you are going to the ring, you don't know whether you will win, whether you'll be knocked out, whether you win by knockout or technical knockout or if you are a UFC fighter and you'll be submitted or be knocked out,' he says with a laugh, snowballing the metaphor. 'So, we were just going there [Monza] to try to see what will happen. I think we won by knockout. Although we missed by 25 seconds, it was a hugely successful project.' For Wilkins

and Jones, that added confidence counted for as much as his extended winning streak, improved times and refined training scheme.

Jones is right to point out a 'combination of things' making for a 65-second difference between Kipchoge's runs in Monza and Vienna. After Breaking2, Kipchoge raced and won four more marathons before his second moonshot. That included his Berlin world record, where the Kenyan went through halfway in 61:06, aided by pacemakers, before closing in 60:34 to run a negative split, making the single biggest improvement to the marathon world record since the 1960s. At 34, Kipchoge looked fitter and wiser, refining his style every race. 'It was my aim to smash the world record and I felt confident before the race,' he said. 'I've now run 2:04, 2:03 and now 2:01. Who knows what the future will bring?' A teasing question … as if he knew. While he had attempted Breaking2 as an Olympic champion, Kipchoge was not a world record holder at the time. Marathoners tend to get better with age, because they refine their training, understand their weak spots and maximise their strengths, in addition to becoming smarter racers who can intuitively adapt to different courses and conditions. The Kipchoge who arrived in Vienna was not just faster and more of a winner but smarter and wiser. on the advice of his long-time physio, he introduced twice-weekly core workouts into his training routine in 2018, which helped to reduce hamstring strain and make him more bulletproof to injury. Seven months after his 2:01 in Berlin, Kipchoge produced the second-fastest marathon ever, clocking 2:02:37 in London to better his own course record there, becoming the first man to win that marathon four times. More impressive than what Kipchoge did

was how he did it, with another negative split. Starting on a downhill, London is notorious for runners starting fast and grinding out times, yet Kipchoge had opened in 61:37 and completed the second 13.1 miles in exactly 61 minutes. There, he ran in Nike's Air Zoom Alphafly Next %, a better researched and designed sibling to the Vaporfly from 2017. He wore a prototype of the Alphafly on that famous day in Vienna, with the shoe featuring three plates and four blocks of foam intricately connected together. World Athletics' laws on shoes eventually outlawed the Alphafly, specifically because they required designs to only feature, at most, one plate. The laws permitted shoes to be 40mm high in stack height (Nike's Vaporfly and Alphafly were both around 39mm) and no restrictions were put in place for the materials used for plates or shoe foam. The technological evolution had kept pace with Kipchoge's progression, contributing to the performance improvement, which was only 0.77 per cent – but it was the precious seconds that mattered to break the barrier.

'That was the best moment of my life,' Kipchoge said afterwards. 'I was really calm and followed the instructions and what the pacemakers were doing. All throughout my mind, I was thinking of running under two hours. With 500m to go, it was the time to break history. I had a lot of pressure before the event. I had calls from people like the president of Kenya.' Jones speaks about Kipchoge's 'magnetic personality and all of his philosophical ways'. The sub-two quest seemed to take him on as much of a spiritual journey as a physical one. 'I can tell people that no human is limited. I expect more people all over the world to run under two hours,' Kipchoge said in Vienna, adding how proud he was to write his name into history,

as Bannister had 65 years earlier. 'Today we went to the moon and came back to earth.'

When Kipchoge and I spoke, six years and almost one month exactly to that day, I asked – knowing the likely answer – about his favourite race and if he had any moments framed. 'In my house, I have a photo of [me] breaking the two-hour barrier. That's my favourite,' he said. 'It's what makes me appreciate that sport is a beautiful thing.' The Kipchoge of 2012, who moved to the marathon after placing seventh over 5,000m at Kenya's Olympic trials and not making the team, had not even begun to consider these lofty ambitions. 'I decided to move to the road, just to run, to see how it feels to run half marathons and marathons. I didn't know that one day I would actually try to push the limits, run the fastest marathon ever, make history. So it's step by step and those things were not actually in mind. It came to my mind later, when I actually adapted to the marathon and I ask myself "what can I do that nobody has actually done?"'