DANNY LENNON: So, before we get into anything else, I wanted to start right at the start with you. So, can you tell us a bit about if there's any influences in early life that you think kind of led you to any of the points that you got kind of subsequent that people know you for now?

JAMES MORTON: Yeah. So, I grew up in Belfast. I was born in 1982, so I grew up pretty much in the nineties really, which was ... in Belfast, at that time, was the troubles really. That was the area that I grew up in. So, I guess I was a bit of a tearaway kid, growing up and roaming about the streets and getting into trouble and so on. But I think Belfast, like Dublin, one of the things that it teaches you is to work hard and to never take yourself too seriously. And those values are things that have stayed with me and values that will hopefully stay with me til' the end really. So, I'm very proud to come from Belfast. I don't get home as often as what I should do. But I really am proud to say that I'm from Northern Ireland.

DANNY LENNON: And so, in those kinds of early years, I'm just trying to get a gauge for the interest that led you into not only a sports science, but what way around did that, was there always this interest in sport that led you to want to pursue the science of it? Were you always interested in science? Where did those things emerge?

JAMES MORTON: I think I was probably running away from the police so much that I thought I needed to get a little bit faster. So, I was really interested in fitness. I'm not ... I wouldn't say that I'm a nutritionist. I think I'm more of a physiologist, actually. So, I was always interested in playing about with different training sessions and how you can get fit. My interest in sport was predominantly football. I played to a reasonably good level, but I wasn't a skillful player, so I just thought I'm going to be fitter than everyone else. So, I just used to train all the time and basically try and be fitter and stronger than the person I was playing against.

DANNY LENNON: So, can you tell us a bit about undergrad work?

JAMES MORTON: Yeah. Well, it's quite strange, actually. It was by chance actually, Danny. So, I guess all of the guys in the audience will know when you go to university you have to fill in your little EUCAST forms to select the courses that you want to be considered for. For my A-levels, I was doing physics as the main course. And so, my EUCAST actually had six physics courses. It didn't have any sports science courses. And then one day I was in school and I'd seen a prospectus for Liverpool John Moores. I just opened it up and by chance it landed on the sports science page. And to be honest, I didn't really know that sport science even existed as a discipline. And as I was reading this, I thought: That's right up my street, actually. So, I ran over to the headmaster's office and we were still using [08:54 indistinct] in those days. So, I was like, give me that form quickly. [08:59 indistinct] and then put in the course for Liverpool and went to Liverpool. And I think that five-minute chance of reading the perspectives really changed the course of the next 20 years. I don't think I was really suited for physics, if I'm being honest.

DANNY LENNON: Well, you never know what physics has lost as sports nutrition's gain. So, you end up at Liverpool John Moores. You do your studies.

You get into your PhD work. What was it initially that you were pursuing on the research side?

JAMES MORTON: Yeah. I went to Liverpool really to ... I thought the dream was to be a fitness coach. So, I wanted to be the fitness coach for Liverpool football club and win the European Conference and so on. And then as we started doing laboratory practicals in your undergraduate degree and you get exposed to the lab and research, I just loved it. I absolutely loved it. And we were doing real simple studies on ... this is in your teaching practicals, simple studies like hydration. How does hydration affect your heart rate during exercise? And I know it sounds so simple, but to me it was ... I found it fascinating that you could change just by drinking the correct amount of fluid. So, I really got passionate about research and then I thought: I don't want to be a fitness coach anymore, I want to be an academic and I want to try and use that research to influence the practitioners. At that time, we got interested in a group of proteins that are present in all cells actually, called heat shock proteins. And those proteins function as molecular chaperones. So, what that means is they kind of assist other proteins to gain the structure and function. So, they fold the protein to make them work correctly. And no one was really looking at this in the context of exercise. And what happens in an exercise stress is that in the days after you exercise, the muscle responds by making more of these heat shock proteins and in other words, they're involved in the reconditioning of the cell and they give the cell protection actually. So again, I got really interested in heat shock proteins and the stress response of exercise. At that point, I still wasn't really interested in nutrition. It was more the physiology. And then a lot of people started doing those kind of low carbohydrate studies and periodization studies and whatever. And we got some funding from GlaxoSmithKline at the time. There was myself, Lewisburg in Australia and [11:27 indistinct]. And we got funded to do similar types of studies. Those guys were focusing on cycling and we

thought we would do a running study, but I'd written that grant all from a heat shock protein perspective rather than from a mitochondrial biogenesis perspective. And so, we were getting all these muscle biopsies, and nothing was happening. We were restricting carbohydrate, and nothing was happening to our proteins. And then we thought: Let's measure the usual suspects of endurance training adaptations and of course things started to change. So even though we had subjects that were doing exactly the same training session, same intensity, same duration. Simply restricting the carbohydrate before the training session, completely changed how the muscle wanted to respond. And so for someone who had spent the majority of their career thinking about intensities and durations and so on, then all of a sudden I thought ... actually, even before you think about that, you need to think: What are you eating before you exercise and what are you going to eat during exercise? And so really that one study then changed the focus of my research career to more of a physiology, stroke, nutrition.

DANNY LENNON: Do you remember getting some of the data come through from that first study and what was that kind of feeling or thought process for you?

JAMES MORTON: Yeah. The first time we got that particular data in that study, which was basically showing that oxidative enzymes in response to six weeks of training had changed to a greater extent when you restricted carbohydrate. It's the first time we got the data. I didn't believe it. I thought: Oh, we're going to have to go back to the lab and do this next week just to see where it made the mistake and it was the same. We analyzed those samples three times and we took biopsies from the vastus lateralis and also the gastrocnemius and we were seeing the same response in both muscles. So, it was brilliant. It was just one of those moments where you think: Actually, this is ... this is really what I'm excited about now. That interaction of nutrition and training and how you can use the two to maximize the adaptive response.

DANNY LENNON: Yeah. We're definitely going to dive into more of that work and that research and maybe look at a timeline and explain a bit of that out for people. Before that, I do want to talk about this fairly unique position that you and some others actually at Liverpool have where both this foot in academia but also very much as a practitioner in elite level sport. What was the first few places you started getting in as a practitioner? What type of athletes were you helping and how did that come about?

JAMES MORTON: The first athletes I actually worked with was during my undergraduate degree and that was disabled footballers and a disabled football team. And again, I was going down taking the sessions. So, setting up the cogans and thinking about how long we were going to do this little exercise and so on because I was still physiology focused then. And as I was doing my PhD, then I started to get a little bit more interested in other sports apart from football. And one day I just decided to walk into a boxing gym in Liverpool. And Liverpool boxing gyms are ... they're like shops; they're on every street corner. The city is so enriched in that culture. And so, I decided to go in because I wanted to train, and I wanted to have a couple of fights myself and I didn't tell anyone what I did for a job. And then after I built some relationships with the lads in the gym, then they asked me to help them. So, it was really working with amateurs, amateur boxers, first of all, where I learned mistakes. But I also learned how to make people lose weight quite quickly and then the professionals in the city then found out what I was doing with the amateurs and then it just ... things just spiraled, really. So, it was really combat sports is probably where I learned the foundations of being a practitioner. I don't think it was where I learned how to be a practitioner, but it was the foundations of how you become a practitioner.

DANNY LENNON: Yeah. It's kind of this interesting ... where there's you as a practitioner and there's now academic, kind of moving along in parallel as

opposed to being one and transitioning into the other. Do you think that had any inherent benefit or even downside compared to -?

JAMES MORTON: No. I think I've always been interested in the practical application because if you're going to do research, I think it's a crying shame if you spend the majority of your career doing research but not using it. And so, for me, when I think of performance, I just plot it on an axis, actually. So, on the X axis, you'll have the quality of delivery or practical application and on the Y axis, you have researcher innovation. And so, if you want to improve performance, you can get new research and new knowledge, but ultimately you have to take that and deliver it and practically apply it. If you want to improve performance, you can develop your practical application skills without even considering research. But I've always tried to map myself back onto that little axis and think: Am I developing research and innovation? And am I also developing my ability to deliver it and translate it to simple solutions? And if you think of performance improvements that way, then it's a product of research plus your practitioner skills. And I've always just tried to develop both of those at the same time.

DANNY LENNON: Do you think the fact that you were working with people in practice that you'd be able to generate better research questions?

JAMES MORTON: 100%, yes. And I think the best questions come from the athletes and the coaches because those are the guys who live it every day. They wake up every day and there's questions and there's decisions that they have to make in that 24 period. And so, without doubt, working in the front line of elite sport helps you ask better research questions without a shadow of a doubt.

DANNY LENNON: So, let's talk about some of those experiences because I think especially for people in this room that are aspiring sports nutritionists, there's others who are extremely well established, but I think it's just interesting

nonetheless to kind of see this kind of journey and maybe get an insight into some of these experiences. So, for example, if we take, when you started working with Liverpool, how did that come about, first of all? And are there any early memories that stand out to you of that first few days being there?

JAMES MORTON: Yeah. Before I got the job in Liverpool, I was being interviewed for a lot of positions in professional football. I think I was 27 or 28 at the time and I wasn't getting them. I kept getting it down to the last two and the feedback was always, yeah, you gave a good presentation and you can articulate your thoughts, but you have no experience of being in a football club. And I totally understood that. They were entirely correct because it was a risk to take a chance on me. And what happened was I would have three or four interviews and they would say: We don't think you're ready for this position, but I'll recommend you for someone else. And then all of a sudden, my phone kept going off. People saying we'd like you to come and work for us just because of word of mouth from the interviews. But they were all scattered all around England and I wasn't really prepared to drive everywhere, just to get a bit of experience. Then what happened was the Australian Sports Medicine, people like Peter Brookner and Darren Burgess, they went to Liverpool to head up our sports medicine department and they were very much interested in research rather than the practical application. And because Liverpool John Moores was on the doorstep, they then came down to visit us and within 10 minutes they said, yeah, let's come up. We'll work together. And, so, I owe a lot to those guys because they took a chance on me actually when probably I wasn't ready to come and work with them yet. I probably wasn't ready, but they took the chance on me.

DANNY LENNON: So, with that particular role you had, what would your week look like? What were some of the main things you were overseeing at least at first?

JAMES MORTON: I think at that time ... I think sport nutrition has changed quite a lot in the last 10 years, actually. I always remember the first day I went into Liverpool because I'm not actually that confident. I don't think I'm super smart. So, I was quite nervous going into that environment. I remember Steven Gerrard came up to me straight away, introduced himself as Steven Gerrard as if you don't know who Steven Gerrard is. And so, he instantaneously just put you at ease and I was thinking: Am I really good enough to be here? And then I walked up to the counter. You can see the types of foods they serve and then you can see what the lads were doing. And you realize within five minutes, actually, there's quite a lot of differences we can make here quite quickly. But at that year, that particular time, what I felt was that everyone was just eating too much carbohydrate. They were overeating for the training sessions and there was too much sugar everywhere. It was all sugary snacks and sugary foods and sugary drinks. And so, what we tried to do quite quickly, actually, was to shift the mindset that, yes, carbohydrate is great, and you need it on a match day. But for a training day, you don't need the super high carb days because the training load doesn't require it. And, of course, if you start restricting carbohydrate by nature, you're restricting calories. So, then the lot started to lose a little bit of weight. They all started to feel better about themselves and then things just snowballed on me. But the strategy at that time was very much, let's reduce our carbohydrate intake a little bit because it's probably not needed for the training days.

DANNY LENNON: So, just if we fast forward a small bit to when you started getting involved with Team Sky, obviously that's quite a bit down the road from there. What was the major difference in those two roles? In terms of I suppose on one side just logistically what you were required from your role, but then also just from practically working with these athletes in different fields or the major things that stand out to you.

JAMES MORTON: I think the big thing I noticed was that in football and many team sports, actually, if we're being totally honest, nutrition doesn't really make that much of a difference to performance in sports. In endurance sports, nutrition can take you from good to great. Without doubt, it can turn a good rider into a great rider. You can lose two kilos. All of a sudden you can climb better than everyone else in the world. So, the thirst for knowledge from the endurance athletes, it's just on a different level. It comes back to that old reward suffering really. If you want to change someone's behavior, the reward has to be great enough to engage or you can make them suffer and then they'll change their behavior. In the cycling world, the reward from nutrition is so great that they all want to engage. In the team sport world, let's be honest, they're getting paid astronomical amounts of money, the reward to change your diet isn't as great. So, therefore, the behavior change isn't as great.

DANNY LENNON: Yeah. It's not as immediately noticeable that you have that feedback. Right?

JAMES MORTON: Exactly.

DANNY LENNON: Where, like you say, the riders you can ... if they start gaining weight or they start messing up nutrition, immediately you see that decline. Whereas there's probably this lag time that can be pretty long I guess with a team sport like football.

JAMES MORTON: Yeah. 100%. I mean in cycling the simple practice of ensuring that you've eaten enough carbohydrate the day before a big mountain stage can completely change how you perform. It's real simple stuff and again in that ... you go back to that graph of knowledge versus delivery to improve performance. In that instance, you don't need new knowledge. We've had 50 years' worth of knowledge in carbohydrate loading that in that situation, the practical application just wasn't being delivered. So real simple things to improve performance.

DANNY LENNON: When you talk about some of the things you were seeing in practice, being able to inform research or maybe shape your opinion differently compared to if you're only being in academia. One that I remember you saying before to me was about when you were collecting data with Chris Froome. So, I'm sure most people have heard and won ... I think, four of the titles for Team Sky were his. So, obviously, this phenomenal athlete. But I remember you saying collecting this data on him and his physiology testing and it was like this isn't normal human data. These numbers shouldn't be here.

JAMES MORTON: Well, I think when I went to Team Sky I was very nervous going into that environment because the last time I had ridden a bike, again, was probably riding away from the police when I was 10 or 11. So I didn't know anything about cycling. I just didn't know anything about cycling. So you go back to the literature and you're reading studies on people who aren't really that fit and you're reading studies on nutrition on people who aren't really that fit, and then all of a sudden you're working with an athlete who's got a VO2 max of 90 mils per kilo, who can ride for three hours, holding 350 watts. Most people in this room, I don't know if there is any cyclist tier, but they could probably hold 350 watts for two minutes. And so, then you're trying to apply nutrition to an athlete that just hasn't been studied well enough in the literature. So, it was just quickly realizing that you're dealing with a different specimen of person and you can't just use a copy and paste approach from another sport or from another athlete. You have to really think hard about the physiology of this person and what that means then for the fueling strategies.

DANNY LENNON: So, did on a practical level that mean a lot of that became trial and error from your perspective?

JAMES MORTON: Yes. 100%.

DANNY LENNON: What were some of those, if we can think of as trials or experiments, that you might've ran that you weren't too sure of how they pan out? Is there any that come to mind that you tried at first not knowing what would come from it that eventually turned out to be -?

JAMES MORTON: I think the first thing I did was just observe and spend a lot of time trying to understand the sport and the culture of the sport and why people do what they do in the beliefs they have. But the one thing I noticed straight away was that people like Chris could do a six-hour ride on zero carbohydrate; whereas, other riders they would have to feed after 90 minutes. They couldn't get through the six hours and so instantly that starts to tell you there must be a reason why he can do that and what I'd often find was that the top guys could go for longer before they would need to feed, but of course that's trainable. You can train that. So, I think my first big reflection was that the textbook carbohydrate guidelines for endurance sports maybe aren't relevant with these group of athletes, at least in the training situation. Competition is different, but in the training situation, they don't really need super high carb diets in the training days. Competition they do.

DANNY LENNON: Right. I think probably that's worth touching on. I'm sure we'll get to that when we discuss the literature later on. But just to give people a flavor of when we talk about, for example, cycling and fueling for the Tour de France, that isn't like we're fueling for like one specific event, you're doing this thing. It's quite distinct from that and therefore that's why we have this broad range in how you might fuel for that. Can you maybe explain that a bit?

JAMES MORTON: Yeah, yeah. I think the Tour de France, the thing to remember is it's not a one-off event. It's not like you're playing on a Saturday and then you're playing next Saturday. And the reason why I say that is you've got 21 days. Every day is like the Olympics because what you do on stage three could completely influence what happens on

stage six and so literally every meal that those guys have, will have a knock-on effect for their performance. You could under fuel, you could over fuel, you could gain weight quite quickly. So, I spent a lot of time trying to understand the different demands of each stage because every stage is different. There're some flood stages which don't require a lot of fuel. There're obviously the mountain days which require a lot more fuel and then it was trying to periodize the energy intake for each stage. So, believe it or not, on some stages we'll have carbohydrate intake of less than five grams per kilo. On other stages, we'll have carbohydrate intakes over that 24-hour period of 16, 17, 18 grams per kilo because we're trying to fuel for the demands of the stage while also maintain people's weights.

DANNY LENNON: Obviously, a large element is going to be able to use physiology testing that you do with these athletes and trying to get the most advanced things. But based on what you said is a lot of that done kind of retrospectively to try and explain what you've already observed. These guys been able to do ... like the example you gave with noticing Chris Froome can go six hours without needing to fuel the same way other guys do. Is that then you can only retrospectively explain the afterwards by going and testing as opposed to ahead of time, if that makes sense?

JAMES MORTON: Yeah, I mean a good testing program, you should be testing. Well, you're testing every day because you're training every day. So, you're actually getting every pedal stroke monitored. Every beat of the heart is monitored during training. So, you're constantly getting feedback all the time, at least in the field situation. But of course, if you want to understand substitute metabolism, then you have to get someone in the lab and create those conditions where you exercise at different outputs and monitor the carbohydrate and fat use. So, it's really a product of both field-based testing and lab-based testing, but the ultimate test, of course, is performance. That's the ultimate test. If someone's performance is going up, you know

you're doing the right things and if it's going down then you need to quickly change.

DANNY LENNON: Compared to say something like you're working in a team sport environment where you have strategies you want to put in place, you know what the players should be consuming and so on, and then they go play a game on a Saturday versus how a Tour de France is set up and every ... like you say, every meal could make a knock on effect. Does that on a personal level to you raise your stress quite significantly? Or how do you deal with that on a day to day basis during the tour, let's say?

JAMES MORTON: It's an interesting question. I don't mind getting personal if you want to get personal. But I think academia and professional sport are often perceived as two easy jobs. In academia, there's no real rules. You don't have to sign in and sign out every day. So, I often think this isn't a real job. Having said that, there is pressure because the pressure is to publish good research. In professional sport, people think it's a great job because it's glamorous and you might get paid well or you might be on the TV or whatever, but there's pressure to win and if you don't win, then very quickly things change. And so, from my own perspective, because I've been trying to combine an academic career with a career in professional sport, there are days when I go to bed at night and think: What am I even trying to do? There must be an easier way to live your life than trying to do this. But then when you win ... I mean the feeling of winning is brilliant. To be part of a winning team and to also know that you've contributed just even a little small part towards that winning, that's rewarding. Because most of us ... there's an innate drive inside most of us to make a difference to people. We just don't want to go through life and not do anything. We want to make a difference whether that's to your children or your family or in your work. And so, I guess, really, it's that desire to try and make a difference to people. That's what's driven me. Having said that with Christmas coming up now, I think actually

maybe I need to reconsider my career, maybe recalibrate for a while.

DANNY LENNON: So, with obviously demands like you said and as you mentioned to me last night, like almost two actually two full time jobs there and running these in parallel with these pressures from both sides. From the perspective of what allowed you to keep doing that. One thing you said is obviously when you win it's great, but I think there probably has to be something more on a day to day level and I'm assuming probably the environment you're surrounded by probably plays a role there and I'm guessing when you look at something like Team Sky, one of the big things you're known for is this big collection of people with the same goal and this attention to detail and everyone is zero focused on everything. Were the people within that group a big part of what allowed you to actually want to keep doing it even when like you say: Times are going to be tough and stressful and why am I doing this?

JAMES MORTON: Yeah. I think Team Sky is an incredible team. I really believe it's one of the best sports teams in the planet, not just cycling, but professional sports teams. You can't win for so long and not be one of the best sports teams. But the whole environment and the philosophy is that you're proactively looking for progression. It's not perfection because perfection doesn't exist. You drive yourself bananas if you're going for perfection. But the philosophy is progression. So everyday you're trying to progress and then the environment is all about everyone proactively and enthusiastically looking for these gains to improve, but the gains have to come back to the core business, which is making the bike go faster. And so, if everyone is constantly thinking about how can we make the bike go faster, it's just a great environment where everyone's bouncing off each other and it can be uncomfortable at times. The times where I've probably grown most, both professionally and personally, have been the times where I've been most uncomfortable. But once you come

through that, then you realize actually there's a level of performance that I didn't really know I had and then you want to go to the next level. And that's what life's about really, isn't it? For me, that's what life's about. It's just doing the best you can and trying to get better.

DANNY LENNON: What sort of things made you uncomfortable?

JAMES MORTON: Well, it's the pressure to win and it's the pressure that knowing that every single medal or every single decision can have a positive effect or a negative effect. And that can be something as simple as making sure that the bowl of rice that the rider is eating that night has enough carbohydrate. Super simple, but what's on that plate? What matters most is what's going into the athlete's mouth because that's going to dictate performance the next day. Now, to build relationships with people and to coach people as everyone in this room knows, it can be quite challenging, and you need to really build those relationships to influence their behavior. It's hard to do. It's not easy to do, but that's where the ... I think that's where the magic is, is the relationships and your ability to coach people to change their decisions. Your ability to coach people depends on face time and how often you're going to be with the person and the relationship doesn't have to be focused purely on nutrition all the time cause otherwise they see you and they think nutrition straight away. What you want is people to think of you as a person first and then the relationship becomes so much stronger. You might have a thousand conversations before you have the one that really matters, but when you do have that conversation that lands, you've put in so much work to lead up to that, it just lands much better.

DANNY LENNON: Is that something you were very aware of when you were going into these different roles? No matter what athlete was working with of I'm here, first, to build a relationship with this athlete and then maybe we can start working on what we need to.

JAMES MORTON: Yeah. I think I learned that ... I've made mistakes over the years and when I started working with boxers ... I love the boxing environment because it's so raw and authentic. There's no ... like a boxing gym is literally a wooden floor, a ring and a punch bag. It's no glitz or glamour. And so, I love that environment and I love the people because the boxers to me are my type of people, working class people. So, I developed relationships quite quickly in that regard. The mistake that I made was I got too close and I became friends and then when they get beat and things go pear shaped, then you feel it a hell of a lot more. Having said that, some of my best mates are the lads that I started working with from years ago. When I went into the football environment, I thought I ain't gonna make this mistake again. I'm going to build a relationship, a professional relationship, but there's going to be a boundary and that boundary is me not letting myself get too close. And when I did that, I thought that actually I was able to make better professional decisions because I wasn't making decisions based on the emotional or personal judgments. It was professional judgment. So, the five years at Liverpool taught me more how to interact with people, big personalities, like super big personalities. And then when I went to Sky, I just ... it came so much more easier for me than to build a professional stroke, personal stroke, professional relationships to get the job done. And so, it was a journey really. I think relationship building, as everyone in the audience knows, that what we do every day. Every day we talk to people. And so, if you can't talk to people, what chance have you gotten?

DANNY LENNON: Do you think that's something that gets left out of when you see media coverage about what you do with the athletes or Team Sky? It's very much oriented towards this cutting-edge science, this vast ream of data and you're making these very scientific decisions but maybe not as much talking about you and the other members of the team working with athletes as just people.

JAMES MORTON: I think a lot of Team Sky's perception is that we're a machine and we're like robots and we're just super dialed on performance all the time. And to a certain extent we are, but you can't improve performance unless you have the correct relationships in place to do that. So, we spend just as much time thinking about the people and the culture. We have a program called the Winning Behaviors Program, which is every day we have a little app on our phone, kind of like reflective practice really, where you just rate yourself that day. How have you behaved? How have you been proactive? Do you do what it takes to win? Have you spoke to the older members in your team? If you've seen someone struggling, have you helped them? Have you went out of your way to help them? And that's great because it just ... every day, you're constantly then thinking about your behavior rather than your knowledge. You're also thinking about how have I behaved today? Is my behavior gonna lead to performance or have I behaved out of order? Was I grumpy? Was I moody? Did I see someone struggling and just leave them or did I go out of my way to help them? And that's what the team is based on. The team is based on performance of which knowledge is one aspect but also relationships and delivery.

DANNY LENNON: I definitely want to turn to some of the research that you've been, I think, probably very well known for being involved in that area around fuel for the work required. Before I get to that, do want to ask about particular mentors you may have had along the way and whether that's from both the academic point of view or even from some of these roles that you've had. Is there any that particularly stick out or is there any kind of maybe conversation you've had that was particularly impactful on the way that you can remember?

JAMES MORTON: Look, I think, I'm sure a lot of people in the room would agree, but the biggest mentor in my life was my dad. The things that your parents teach you stay with you forever. So, I would

always go back to the lessons of just how to deal with people and treat people. That's by far the biggest lesson I've ever learned. In relation to sports science and performance, if you like, I guess my early lecture Professor Don McClaren had a big influence on me. I remember when I was going into my third year at that stage, the degree was prerequisite modules, so you had to take a certain module to get on to the next year and I didn't take this one biochemistry module, but I knew that I wanted to do it at third year. So, Don was like, you can't do it because you haven't taken the prerequisite. And I kept pestering and pestering and he gave me a biochemistry textbook and he said, "Go away and read this over the summer and if you can prove to me that you've read it when you come back, then I'll think about letting you on." Now, this book was just classic black and white text. It was a miserable book, but I had to go away and read it. I went back and Don brought me into the office. He just grilled me with questions and questions. Thankful, I passed the test and then he took me on the module. But Don was great because his door was always open, and he didn't treat you stupid or super smart. He treated everyone the same. He gave everyone time. So, Don was a big influence on me in the beginning just because he took a chance on me. In the professional environment, I've just liked working with different coaches, and seeing the magic that coaches bring to the environment. I've worked with some great boxing coaches and I really liked working with Brandon Rogers when he was at Liverpool. Probably biased because he was from Northern Ireland, but I just liked his ability to make people feel at ease and just relax. And what I've learned off the real sort of teams' guys that's been like that is his leadership skills and his thirst for performance. I think we're unrivaled in professional sport, actually.

DANNY LENNON: Is there any particular lesson that you can think of when you talk about these things at Team Sky that sticks out?

JAMES MORTON: There's loads of lessons with Dave. Dave's the type of guy who, I'm just looking at coffee cups. Dave will look at that coffee cup and go: Why is that coffee cup blue? Is that the right color for that coffee cup? Is the lead circular enough? Can we make that more of a circle? Now, whether he is really interested in that doesn't matter. What he's doing is creating an environment then where everyone is then questioning everything and then that filters into the whole team.

DANNY LENNON: Right.

JAMES MORTON: That's the environment. That's the thirst for improvement all the time. I write to myself quite a lot, so every night I'll sit down and write what's happened that day or whatever I learned. I'll do it tonight probably after this session. The stuff that I've ... every meeting that we have in Team Sky, there's always something that comes up, some little bit of gold dust that you just write down to yourself and it's great to be in. It's great to be in.

DANNY LENNON: So, let's start talking about some of the research. Why I find it particularly fascinating is not just what you've published on it, but the fact that this has become one of the strategies that's involved with a lot of what you do with the athletes and there's a few different components that are probably related that people have seen terms like fuel for the work required, which has been a big focus of the lab in Liverpool. Carbohydrate puritization, train low, recover low, sleep low, low glycogen, availability training - all these types of kind of interrelated ideas. Where's the best place to start in terms of describing what exactly any of those things are? Where those ideas came from?

JAMES MORTON: It's interesting because a lot of people think that the carbohydrate restriction literature started in the early two thousands with molecular biology when it came into the sports science discipline. But actually, there's a real famous paper back in 1981 which was based on carbohydrate loading and half marathon performance. And what they

did in that study was three different types of carbohydrate loading protocols. That was the focus of the paper and the outcome of the paper was to say that when you want to carbohydrate load, you don't need to do that classic depletion phase. You can just have one or two days of a higher carbohydrate diet and you'll achieve the same loading regimen. So, in that study they did these three different loading strategies. They started the half marathon with about 700 millimoles of glycogen or 450 millimoles of glycogen. They ran the half marathon - good runners, highly trained runners and there was no difference in performance even though you had 300 millimole differences of glycogen to start with. Now, at that time, everyone then they took this paper and they thought the practical application of this is to carbohydrate load. You don't need three days depletion, just one day of a high feed. But buried in the discussion of that manuscript is a fantastic piece of writing and the paragraph is something along the lines of the practical question [44:44 indistinct] but how much do I need every day to sustain the training intensities and durations required? And when you flip it that way, then that's the practical application. 20 or 30 years later when we started doing cell signaling and molecular biology studies, then what we realized was that when you change the pre-exercise glycogen concentration, the cell signaling that you get during that exercise session is different. So, then the practical application becomes actually if you want to maximize endurance training adaptations or mitochondrial biogenesis for instance, maybe it's a good thing to restrict carbohydrate before you exercise, but also you can restrict carbohydrate during exercise. You can also restrict it after exercise and so then it becomes a bit of a minefield. The [45:33 indistinct] literature then isn't just [45:35 indistinct]. It's what you do during and it's also what you do afterwards. And then somehow, you've then got to put that together in a mantra and an application that means something to someone and that's when we just decided, well, let's call it fuel for the work required. Because if

your session tomorrow doesn't require much glycogen, then fuel for what you need. If your session is five, six hours with high intensity efforts, then fuel up because you will need more glycogen for that session. And when I started using that term fuel for the work required, the athletes got it. They caught up within minutes. They were like, oh, it makes sense now. The academics in the world didn't really ... I think it was met with a little bit of resistance at times probably because they hadn't made up the idea themselves. So, we used to get lots of reviewers' comments saying, "I don't believe in this." It was just pathetic really. Doesn't really matter. It's just a term to make people buy into the concept.

DANNY LENNON: So, I think one important thing to probably to touch on is when you're talking about fuel for the work required, it's kind of having this evolution of going from maybe a flawed idea that if someone is an athlete they need to be on this like super high carbohydrate diet all the time. Now obviously we can have periods of low, moderate, high, and again, they're quite arbitrary labels I admit. But basically, changing the carbohydrate intake because they don't necessarily need the high carb intake all the time.

JAMES MORTON: Yes.

DANNY LENNON: However, there's probably two elements. There's one, like you say, certain sessions just don't require you to be fully carbed up and so you can get away with this. But not only that, there's this second element, which is why a lot of your work is looked at that purposely restricting carbohydrates, so someone has less glycogen. Actually, not only is just not a bad thing can actually lead to change that the muscle that could be potentially beneficial. Can you maybe touch on some of those changes?

JAMES MORTON: Yes. So, the whole premise is if you want to make a muscle become endurance like, say, grow more mitochondria or become more oxidative is probably the correct term and it doesn't just

happen. When a muscle cell contracts, there's a whole variety of cell signaling pathways which essentially instruct the DNA to express more of the genes and more of the proteins involved in endurance phenotype. What we know is that if the muscle is loaded with glycogen or you consume sports drinks during exercise, you can pretty much switch off those pathways. So the very thing that you're trying to achieve in the first place, even if you've got the intensity and the duration correct, you think you've got this as the world's best training session, but actually doing it in a high carb state or consuming a sugary drink during exercise can blunt all response. And when we started doing these studies and we would take the biopsies out; it was like nothing had happened inside the muscle. That nothing had changed even though they'd exercised for 60 minutes or 90 minutes. Whereas in the low carbohydrate trial, which was low calorie actually, as well, then things got switched on and so then the practical application was, well, if you want to become an endurance athlete, surely one of the goals is to stress the muscle to stay at ... you're constantly activating these pathways. And maybe one of the ways to do that is to simply change your nutritional state. And that's what we did then. And that's what a lot of us around the world have done in different labs, pretty much all showing the same things, which is nice when people show the same things. And I think that's now filtered into sport nutrition. Lots of the conversations I have in performance nutrition now with other practitioners are generally around how your periodize your carbs.

DANNY LENNON: So, with the idea of you get these changes at the level of the muscle, I presume one of the difficult things is probably showing the clear impact of that in performance because it's incredibly difficult to isolate that this is the thing that's going to cause a change in performance over a certain time frame. Especially if we're going with the idea that it's not so much an acute benefit performance per se, but these change at the muscle over a long period of time should in

theory enhance performance. So, it becomes difficult to tease apart this is directly, or even quantifying this can lead to this much increase in performance. Right? Is that the kind of challenge of -?

JAMES MORTON: I think it's the challenge in all sports science research. I actually think that performance is the hardest thing to measure. It's easier for me to rip open someone's leg, pull out muscle and analyze it, than it is to measure performance. I just think it's so hard to measure reliably. And the other thing that we do when we do performance trials is, we don't do six-hour rides where you have to then ride the Alps afterwards. [50:40 indistinct] It's temperature controlled. Most people would do a three-hour type session. So, the performance that we're measuring in the lab isn't the performance that matters on the road actually. So, even though a lot of those studies haven't shown performance improvements, that doesn't really concern me as much. I'm more interested in the physiology and if the physiology is changing, then you kind of take that leap of faith that in the real world, in that six-hour ride, that might translate to improve performance. I mean there are studies out there that show that it does improve performance, but the literature to support the muscle adaptations is much stronger than the literature to support the performance adaptations.

DANNY LENNON: And so, it's a case of we're going to have to take certain things that we have to build up through mechanistic data and probability of ending of increasing and performance. And if there's no real downside, we can pretty much be or at least should go in the assumption that this is likely to benefit performance?

JAMES MORTON: Yes. I think if you go back to the determinants of performance for an endurance athlete, without doubt, it's [51:49 indistinct] threshold and you need a high VO2 Max. You need to be able to sustain a high percentage of your VO2 Max. Ultimately it comes back to lactate threshold.

Lactate threshold is underpinned by the oxidative capacity of the muscle. All of the adaptations associated with tree and load or carbohydrate restriction feed into that determinant of performance. So, the physiology is changing. Then I've often ... that's enough for me. I'm happy with that because in sport then you're willing to then take the leap that might translate to an improved performance outcome.

DANNY LENNON: So, in terms of how you translate this idea to people in practice and trying to get athletes to understand this idea, and you mentioned when you say fuel for the work required, they can kind of grasp that concept. Are there any other ways that you have found useful of putting across this idea that again, for the practitioners in the room, they might find it useful if they are going to use some degree of carbohydrate?

JAMES MORTON: I think whatever practical strategy you use with your athletes; it has to resonate with them as people and it has to resonate with that sport as well. But more often than not, I'm almost embarrassed to say, but it comes back to a simple red-amber-green, which is: Does your breakfast require high carbohydrate? Well, then that's a green breakfast. Does your post training meal require high? That's a green. Your evening meal might be low carbohydrates. So that's a red meal. But what green-amber-red means for you will be totally different for me and for other people. But for that athlete, they have a framework and we'll decide what the quantities are for that athlete depending on where they are in the phase of their annual cycle. But very simply, they wake up every morning, they get their training ride, they know what the ride looks like, but they also get to color code. The color code is then breakfast, on the bike, recovery after the bike and evening meal, and some days that will all be green. Other days it might be green, green, green, red. Other days it might be red, red, green, green. So, it's super simple, but it has to be simple to get the ... to get the complexity translated into something that's real meaningful and practical.

DANNY LENNON: So, for a practitioner looking at someone's training schedule on paper, it's basically identifying not only for this upcoming session what they may require, but: When is the next session? What is that type of session? And then thinking through, okay, what changes would we get? What sessions are we prioritizing for performance? What do we not really care as much about performance tomorrow, recovery based and kind of piecing this together kind of logically in terms of carbohydrate doses per meal?

JAMES MORTON: Yes. We try and work towards like three- or four-day cycles. So, we train in four-day blocks. So, everyone will know if today's day one, they already know what their nutrition plan should be on day four because we're thinking ahead, because we know that what you do today, and tomorrow can change how the muscle responds on day three and day four. So, we just constantly try and get them to think forward, proactively think forward.

DANNY LENNON: So, with some athletes that are not in endurance sport; so, particularly of interest to me and, of course, to you with some of the athletes you've worked with, say, in something like combat sports. Obviously, the literature is not anywhere as near advanced as it is on the endurance side. What role do you see that playing in practice?

JAMES MORTON: I still think the old traffic lights system can work in that particular sport because I still think carbohydrate periodization has a role to play in that sport. But it just comes back to the person that you're dealing with, Danny, I think, and the sport that you're dealing with. A lot of football teams, a lot of rugby teams all do that traffic light model now. A lot of marathon runners I know engage in that traffic light system. So, I think the principle ... once you've decided what the objective is, you then decide on your tactics to achieve the objective. In my case, the tactics has been carbohydrate paralyzation, red-amber-green. In someone else's case, the tactics

might be something completely different. All I'm trying to say is the tactics and the strategy has to work for your environment. You can't copy and paste it. You've got to work out what it is that's going to resonate with that athlete in that sport.

DANNY LENNON: One thing that's became popular over the last years in a lot of endurance sport and is now even going into fields like combat sports, as well, is popularization of very low carbohydrate or ketogenic diets. And I think maybe in parallel to what we've talked about earlier with this high carb all the time can be problematic. So that shift to more of a smart carb, to turn that phrase, of matching for the fuel they need. Do we see the same thing with a blanket ketogenic or very low carbohydrate diet in both those fields? Or what your kind of feelings towards the kind of growing popularity?

JAMES MORTON: Yeah. Well, the reason I don't believe in a chronic dietary strategy, and what I mean by that is days and weeks of doing the same thing all of the time is because the muscle adapts. And so, if you restrict carbohydrates all of the time, you might increase your ability to use fat, which is great, but at the same time, you suppress your ability to use carbohydrate. That can be at the level of the [57:28 indistinct]. It can also be at the level of the muscle, and then all of a sudden you put carbohydrate back in on race day. You don't know how to digest, absorb and metabolize. With the periodization framework that I believe in, you're never in a state of low carbohydrate for longer than 48 hours, then you're back to high. And so now the muscle is constantly adapting to low, medium, and high, and then in theory, you never lose the capacity to metabolize carbohydrate. You're just developing the capacity to use fat and then hopefully you use both at the same time. And so, it means on race day that you've got a car that's very efficient at gear one, two and three, but you've also got a car that knows how to go to gear four, five and six. That's what you're trying to do with the endurance athlete.

DANNY LENNON: Hmm. Yeah, it's interesting. It's this kind of whole area of metabolic flexibility with this ability to switch back and forth between oxidizing carbohydrate and fat and a chronic ketogenic diet is you're essentially inducing at least transiently some insert resistance that you can't go and burn carbohydrate. Right. And that kind of lends to this idea, I think, I know Louise Burke has used the term and I've talked actually with Brendan about some people thinking of this low carb, high fat paradigm and athletes being glycogen sparing versus you could think of it as glycogen impairing as in you can't tap into it. Where do you come down on it?

JAMES MORTON: I agree 100%. Brendan won't mind me saying this. He's a lot smarter than me, so direct any questions to Brendan.

DANNY LENNON: I think Brendan's smarter than most people to be honest.

JAMES MORTON: But I would see it as a carbohydrate suppressive effect rather than a carbohydrate sparing effect because all you're doing is suppressing the enzymes involved in carbohydrate oxidation, pyruvate dehydrogenase being the key one. You can suppress PDH within 24 hours of restricting carbohydrate, but you can also switch it back on quite quickly as long as you haven't suppressed it for too long of a period. If you go on a high fat diet for five, six, seven days, even if you carbohydrate load for 24 hours after that, you still can't really restore your capacity to fully oxidize the carbohydrate because the damage has already been done. And so, in my practice there and I've taken it back to one day high, one day low, one day medium just to try and keep the muscle constantly adapting to the different stimuli that are being provided.

DANNY LENNON: So, thinking of that time course for some of this down regulation to happen, just a question that I've kind of been struggling back and forth with in relation to some of the combat sport athletes. So, when they're making weight for a fight, for

example, and let's presume they've 24 to 30 hours between weigh in and fight. One way to bring weight down acutely for them to lose weight is in the last week or so to restrict carbohydrate, go on a very low carbohydrate diet. They can lose glycogen and water along with that. Is there potential for that to be problematic for that reason that you're saying? If someone has restricted his carbohydrate for a certain length of time, now they weigh in, they have 24 hours that they load up on carbohydrate. Is there a risk of not being able to utilize that effectively?

JAMES MORTON: Yes. I think there potentially is. I think what you can do on that during the week is to target those sessions that will be high carbohydrate and when we say high carbohydrate it doesn't need to be a muscle that's fully loaded with glycogen. All you need to do is stimulate the flux through that glycolytic pathway. You can do that with having a bowl of cornflakes before you exercise. Not that I'm advising cornflakes, but what I'm trying to say is that anytime you stimulate flux through the glycolytic pathway, by virtue of a substrate coming in, you're activating the enzymes. You can do that by carbohydrate loading. You can do it by consuming a sports drink. You can do it by having your breakfast. So, it's picking sessions during the week across that whole period of making weight for the fight that are more carbohydrate type sessions. I've always done that because I just didn't want any fighters having a sparring session, getting pasted when they haven't had any carbohydrate. So, we've always tried to do it in those real high intensity or sparring type sessions.

DANNY LENNON: So, if we're trying to deplete glycogen, let's say to some extent in that kind of final week, we can still do so with an absolute carbohydrate intake that's fairly low. But at least one meal over that day is going to have enough to prevent this regulation.

JAMES MORTON: But also, the contraction of the muscle because the most potent way to stimulate glycolytic flux

is contraction. So, in the last week before a fight, you're usually sharpening up. You're doing a lot of high intensity efforts. Your hard work will be reduced for the superfast efforts. So, they'll be stimulating glycolytic flux alone. If you can feed some of those sessions, then hopefully you wouldn't induce any negativity once you start to load before a competition. But I don't think anyone has really looked at that. What's the minimal dose required to maintain PDH activity on a low carbohydrate diet? I'm not sure anyone's really looked at that.

DANNY LENNON: There we go. You just came up with -

JAMES MORTON: You did say you wanted to do a PhD yourself, so that's your one.

DANNY LENNON: True. We'll see. So, with that, what other kind of research questions that you think in this area are the kind of next up over the next few years that will really inform practice even more?

JAMES MORTON: Yeah. I think for me, I'm interested in not just carbohydrate periodization but energy periodization because endurance athletes, when they want to peak for performance, they're usually just [1:03:14 indistinct]. They've went to extremes to do it. So, you're constantly walking a tight rope between optimal performance and pushing the boundaries of health, really, I think. A lot of that is dictated by what you've done in the period prior to competition. So, we know that if you restrict energy availability for too low for chronic period of time, then as Kirsty will talk about later, I'm sure, you get all those negative consequences of being in the low energy availability state. But there must be ways that you can periodize that, whether that's within day or between day. So, rather than going on a seven-day low energy, low carb diet, maybe within that seven days you have a day that's maintained energy availability, or it might be higher over the course of the week. You're still building a chronic energy deficit to allow you to lose weight. All you've done is change the time period that you're actually in a state of low

energy availability, which is different to energy deficit. And so, I'm quite interested now in how could you periodize that day to day or week to week?

DANNY LENNON: So, trying to push more of that energy deficit to times where there's less risks essentially associated with that. With any of the energy deficits or even restriction of carbohydrates, as well, and that leads into things like faster training sessions, for example. I think at least maybe this is probably going back a few years. I know you mentioned around the potential role for them in athletes trying to lose body fat or make weight, for example. What is your kind of current position on if we have an athlete who is trying to decrease body fat, is there something with the periodization of nutrients and or energy you think could be useful? And if so, why?

JAMES MORTON: Well, I think, again, the goal to lose weight/body fat as an energy calorie deficit, the tactics by which you achieve that, it depends on you. We can probably all get to the same place with different tactics. In the world of endurance sports, my tactics has been carbohydrate periodization primarily because it's associated with greater muscle training adaptations. But secondary is because it provides a platform to facilitate a calorie deficit. Because if you're doing a fasted ride, you might start that ride at nine o'clock. You might not then have your launch until one or two. So, by virtue of doing a fasted ride, you've created a six-hour period where you're in a calorie deficit. For the endurance athlete, I believe that's great because it facilitates the endurance phenotype. But in the case of losing weight, you've created that energy deficit. And, of course, if you want to lose fat, you have to oxidize. It just doesn't disappear. You have to oxidize fat. And what the carbohydrate restriction does is create an environment where you're oxidizing the fat. But as we all know, it's the energy deficit that dries out. Having said that, the time restricted feeding stuff is interesting because you can change

glycemia control and so if you're changing glycemia control and response to every meal, then maybe down the line that might have little one percenters on losing weight or losing fat, should I say.

DANNY LENNON: Yeah. That's the kind of interesting thing of when you get into anything that's causing some sort of metabolic disturbance and how long you need to give that before you see it translated to something else. Right. So, I think that's interesting, but we're definitely seeing that from a pragmatic standpoint with these athletes. It's allowing them to create a deficit in a very easy to follow away. They don't necessarily need to fuel for that session. So, it's just convenient to say, let's do this one fasted and now we have the rest of your intake.

JAMES MORTON: Yeah. So, what I'm trying to teach carbohydrate period to endurance athletes, I'm teaching it from an endurance training adaptation perspective. That's why we do it. And what it might also allow you to do is create a framework that helps you to achieve weight loss. I've heard border class riders lose weight on a high carbohydrate diet. If they're eating eight or nine grams per kilo or carbs per day, they still lose weight.

DANNY LENNON: Right.

JAMES MORTON: Because they're in a calorie deficit. So, it's the tactics. The objective is always to see them losing weight. It's the tactics that you have to decide for that situation. If I'm in the Tour de France and I'm trying to lose weight over the first eight days, I don't really want to put someone on a low carb diet because they'll blow. But what I will do is put them on a high carb, low fat, low protein diet. So, they've still got fuel to get through the stage, but they're still going to lose weight because every day they're in an energy deficit.

DANNY LENNON: In terms of statements you hear or even recommendations you see given, and this can be

either within the academic field and certain conclusions people come to or it could be in practice or messages you see being put out? Are there any in particular that you either find irritating or just even at least a bit misleading that come to mind?

JAMES MORTON: I try and not get stressed out too much anymore, Danny.

DANNY LENNON: That's a good way to be.

JAMES MORTON: At the end of the day, it's just nutrition. There're more important things in life. So, I don't really let it annoy me. I think probably the biggest misconception is that athletes don't need carbohydrate. And if I'm being honest, I probably feel partially responsible for some of that message because of the low carbohydrate training. But at no point did we say that you don't need carbohydrates. We just said you need to periodize it and in the world of endurance sports, there is no chance that you're going to win the Tour de France on a low carbohydrate diet. Even if you're super fat adapted or whatever. When it gets to the Alps, you ain't going to be able to climb if you haven't got any glycogen or you're not feeding any carbohydrate.

DANNY LENNON: Unfortunately, maybe the people that misrepresent those ideas probably don't want to listen to that part.

JAMES MORTON: I think the thing is, Danny, people say these things, but they haven't seen it. They're not there to see it. I've seen what happens when a rider gets it wrong and it's catastrophic. You can lose the Tour in one day from under fueling. And yet people on social media will say ... it's the classic one of Chris Froome on a rest day eating eggs and salmon. Well, there's a reason why he's eating eggs and salmon on a rest day because he's not doing any exercise.

DANNY LENNON: Right.

JAMES MORTON: That's why we're eating eggs and salmon. But then the misconception is Team Sky are ketogenic, low carb all the time. We're not. We're just not eating enough because it's a rest day and we're fueling for the work required. Once we finish our rest day, then we'll start loading for tomorrow. But then you see all of the other cycling teams, then start thinking: That's what we need to do. Which are happy days for us because they go backwards, and we go forwards.

DANNY LENNON: That's what you should tell people you're doing.