DANNY LENNON: Greg, welcome to the podcast.

GREG POTTER: Hello Danny. Good to be here.

DANNY LENNON: Yeah, thanks for joining me. I'm excited about this because as I'm sure, people who have listen to the podcast, number of times will know we're going to talk about an area that I am particularly fascinated by and given your work in academia in this area, I'm excited to pick your brain on a few things. Before we get to the details and the nitty gritty and get into the particular papers that we've outlined to break down today. First, give listeners and introduction to yourself, to your – what you do and any other relevant information.

GREG POTTER: Sure. Yes. So, I am just brightening up my PhD this at the moment on University of Plaids and I'm totally interest in the areas of circadian rhythm, sleep, tired and metabolism. And previously, I've done an undergraduate degree and the masters degree and the size of zoology. Web some coach for a bit on some personal training and it's just always been fascinated by old things health performance.

DANNY LENNON: Awesome. I think that definitely gives us a bit of context for where we're going and like I said, before

we even get to studies, we're obviously going to talk about things related to circadian biology, circadian rhythms and so which will familiar to I think a number of listeners. But just to get everyone up to speed, how is it best to define or think about what circadian rhythm are and how that in turn relates to human health.

GREG POTTER: Sure. So we have different types of rhythms as the plasty stand. And these are evident in four organisms that have been studied so far. We can boardly classify them into three different categories so you have all trade and rhythms which typically have areas of less than 20 hours. So an example, that would be your heart beat. It predicts – it predictably bits on a regular basis and is roads of the impervious to the external simuli.

And then you have circadian rhythms. These are rhythms for about 20 to 30 hours. Because that will on a daily basis and they evolved in response to the rotation of planet which creates the life dot cycle and examples of these would be the rhythm in your cool body temperature, you sleep wake cycles, and various other things to see. And then other class of rhythms would be infradian rhythms which rhythms which, which recur on a base about 30 hours or more. Examples of those could be your menstrual cycle or in season animals, it could be things like hibernation and in changes in reproductive status, anglers, that kind of thing.

So broadly speaking, all these different rhythms, they've evolved to anticipate and that predictable environmental changes. And therefore, optimized organism fitness. And example of that would be if you experiment in the change, in organism circadian such they have an unusually long or slow internal body clock. And then you let them run rights in environment with other organism that have normal body clocks. Then they actually have lowest survival

so their fitness is impaired by the fact that they don't even synchronized as well with the 24 hour day.

DANNY LENNON: Perfect. And like I mentioned, that the outset for people listening. Today we're looking at these for two specific research paper first that will probably give a good insight into this area and from there, we'll always delve into this is a more general topic. The first paper we're going to look at and again for those of you listening, I will link up to this in the show notes so you can pull this up the text to it if you wish. The first paper is by Stothard et al 2017 entitled Circadian Entrainment to the Natural Light-Dark Cycle across Seasons and the Weekend.

So with this paper Greg, what did the – this was a pair of studies really. What this particular paper set out to answer. What were they trying to address by actually doing the study in the first place.

GREG POTTER: So first, you're looking at how people body clocks adjust to different seasons because I'm living in an environment where not entire light collision won. So about 80 percent of the world surface if covered or lit artificially by light at night. And as a result of that, we almost live in a perpetual summer. So, perhaps, previously, our answers would have experience seasonal changes. Been there in physiology. Whereas now, those nullified because actually, we've spend lots our time endorse perhaps 88 percent or so. This will time out doors and therefore, the hormone melatonin which is our internal mark up of the biological nights change in method across the course of the year, whereas, historically exposed to natural light only, it will change substantially.

So what yours just did was build on a paper they published four years ago. Also in the journal current biology in which they have expense go camping in the rocky mountains, and Colorado – in Colorado. And what they found in that paper was that when you have people who need the environments like you and I go

camping, the beginning of that internal biological night which was signaled by arise in melatonin plot. Because quite close to sunset and the end of their nights so the reduction, substantial reduction in melatonin in the blood. Because right around door, so just before wake type.

And if you look at most people and you see substantial variation in the time of their body clocks. So you have early birds or last and you have night hours. And the variation is so large now that some people will be waking up as other people go to bed.

What they found was that if you have people go to camping, then that variation is substantially reduce such that most people are now going to bed and waking up on the times.

GREG POTTER: Perfect and so with the particular methodology if we look at this paper, what were some of the most important things or most interesting things about how they actually set up these studies that were involved in the paper.

DANNY LENNON: Yeah. So, that important things would be there were five people, four men and one woman in the first study, what they did was they had them state but home six nights before coming into the lab. And then they measure nocturnal melatonin.

So the people sit in deem light less than about four laps and just about one laps is the amount of light submitted, it seems tends to have light submitted by a candle held one meet from this. So that's very light. So they sits in the lab expose to very little light overnight and then every hour, they give slight samples for melatonin measurement and based on that, they can tell the time if somebody's body clock.

In the first study, they then have people go camping for six days in the winter and the rocky mountains once more and they're expose to natural lights only. So light from the sun, light from the moon and light

from camp fire. And then during this time, they look at their physical activity and also their sit during symmetry and those are simply watch like to biases more on the risks like fit bits the – to look at how quickly or whether someone was moving at all. And then they came back into thereafter which and measured melatonin once again to see if the melatonin rhythm had changed substantially during that time.

DANNY LENNON: Why was it specifically the melatonin rhythm that's important or that was the thing that was the thing that they look at while they was out of the metric use.

GREG POTTER: So melatonin is use to look responsible in circadian phase. So if we think about each of the rhythms whether is all trade and or circadian, then they have three main parameters which are board some. Those are amplitude areas and phase. That's used core body temperature to exemplify that, who body temperature there is a course of day for about 36 more degrees, 37 degrees and that's the amplitude. That's the difference between the them.

The period is the amount of time that's elapse from the start at the end of the rhythm. So for example, if you look at, two consecutive days and you look at the body temperature on those two days, then the time from the pick and the first day, the pick on the next day is compared to that rhythm.

And then the phase is the instantaneous states of the rhythm at the given point in time, so that might just mean at what time is your core body temperature at the time and can most people would generally be mid-afternoon or something like that.

Now, melatonin unlike most rhythms is most impervious to to external stimuli. So, you can have people change their physical activities substantially or eat meals and these things will have relatively mental effect on the circadian rhythm. What influence at most is the light dark cycle. So, if we quickly consider

how circadian system at large regulated. Then, the most important time key, that synchronizes our circadian systems, the 24 hour day is the light dark cycle. And what happens is, light tend to use the eye and it's the tech specialized cells immunorectomy and it called entrance can be photo sensitive retinal ganglion cells. They've really information to what's known as master clock in the hypothalamus. That's called the suprachiasmatic nucleus. Or it was just two wing shape nuclei about 10,000 neurons each and they relay time of day information throughout the body.

One place they relate that information to is the pituitary gland and the pituitary gland synthesizes melatonin as the sun goes down each day or as lights return off each day. So melatonin is responsive to our light exposure but other things influence it relatively little. And for that reason, in circadian biology studies, it's the most commonly used marker of circadian phase, on the time we have somebody's internal plot. The other thing to consider is that seasonal animals have darkness signaled in that biology by melatonin. So the coral look of how long the day is the melatonin rhythm. It's effectively a single of the night time outside which is then distributed drop the body.

So if you were interested in whether somebody is biology just to the seasons, then using the melatonin rhythm also makes sense of that reason.

DANNY LENNON: So with that, for that first study that was within that paper where they were looking at winter time. What were some of that kind of stand out results from that particular part or what are the most relevant at these conversation right now.

GREG POTTER: So, one thing relevant to light as always speaking about is that the watches that they used, act to watches. Also measure light exposure and people during camping were exposed to about 13 times more light higher luminance levels than people will stay

during that time. Another thing to consider is the melatonin rhythm was about two and half hours earlier off to camping whereas the melatonin offset was the same, so the end of the biological mind was unchanged.

And knocks that would lack average sleep duration was longer. So sleep starting in two and half house earlier. And then also they compared their study. This first study since 2013 camping study. And they find that people who were exposed only to electric lights and back at home. At very similar melatonin rhythms in the two studies, despite the fact that in the 2013 study they were looking at pick during the summer and in this 2017 study, they were looking at people at the winter. So that suggest that in people in the one electric lights environment, there was no change across the seasons in that bodies biological flats.

DANNY LENNON: Yes. Super interesting. So to pick up on those couple of points, you just mentioned, I think if we first start with the light intensity piece. This is probably something that's probably easily overlooked or maybe not even relatively talked about that much. Of if we're saying there is almost 13 times higher light intensity people are expose to when they're outdoors versus the motor and kind of electrical lighting environment that we have. That probably is important like practical implications for people now when we're talking about specially this idea of like people are pretty clear on avoiding blue light and that's becoming a bigger and bigger message. But maybe not as talk about tends to be the importance of highlight intends the all blue light exposure during the day.

But now, if we're seeing that – you can't just compare the light you – the light bulb you have indoors even though it's bright to you and your eye is very different light intensity to outside, right?

GREG POTTER: Absolutely. And to give you an idea with both difference, indoors, particularly room lighting

environment, might have a lot intensity maybe 500 locks whereas outdoors augment day on a sunny day. Quite often you have intensity levels which exceed 100,000 lots. So that's 200 times higher.

So the differences very, very pronounce and that's important in training circadian system. And also in making sure at least you fell at night.

DANNY LENNON: Sure. So with that then, if we're trying to have that proper circadian and traiment of getting adequate exposure during the day. Then again, the implication becomes that even on a dull day that's not in summer at all were probably better off getting outside for some part earlier in the day as opposed to remaining indoors even if all lights are on. We're looking at blue screens and so on.

GREG POTTER: Absolutely. And one thing that was very interesting from these particular studies was the alignments level during the day and winter and summer, were actually quite similar. So, back at home, that's not necessary the case. People during the summer, in the electric lights environment. Might have substantially lower light exposure during the day in winter. But in the summer, they will get a bit more, they like being outside. And I think that that was probably irrelatively important factor in the different results they found.

DANNY LENNON: Yeah, sure. With the difference in seasonality, when they're comparing winter and summer, I think one of the things that was touch on was the adjustment of that melatonin rhythm depending on the season in the people who are I would say outdoors. Which makes sense based on everything you've outlined first Greg. Just to ask you about that, do you think then and this maybe some really hypothetical, but the fact that if we were to think of whether how we evolved or we didn’t have artificial light that we are set up to have these seasonal variation where that rhythm actually changes over the course of the year depending on the season, do you have any kind of anything to point to the need

for that or is that and important part towards health of having variation or even if we have a static sleep wake cycle or melatonin year around? Is that necessarily a problem if we optimize some other things I guess.

GREG POTTER: I think any answer very expectancy at the moment actually. That said, there is some evidence that historically, we might have seen seasonal changes in our physiology which manifest themselves as they consist in reproduction across the seasons. And I haven't look at this recently but, I remember reading a review asking several years ago which suggested that the four to home thermostats and differences in temperature regulation, there were mark season of variations in reproductive success and since thermostat used to became more comp, some of those have been nullifies and of course, that's entirely and related to the life outside for and the other thing is that, some people don't experience substantial variations in the light-dark cycle across the season. So, an opportunity regions, the length that live about cycles relatively consistent, this change some things like temperature and brain food and perhaps, they could some influence too and that raises an interesting point relevant to the study which is the – you see these change in melatonin rhythms across the seasons and it's usually to assign those to variations in the light-dark cycle alone. Certainly, I think that those are the most important. That is the most important factor in the variation that we see.

But also there are differences in physical activity. People aren't to eat in the same diet. There are differences in temperature too, so if you look at temperature changes across a – for a summer day in the rocky mountains and pets we're bringing today than I think the report suggested that the winter temperature vary from perhaps zero degrees to about 13 degrees. Whereas, during the summer, it was maybe 5 degrees, or 32 degrees.

So, as to some noise that's introduced by those variables, there are other factors too, so things like where somebody consumes more caffeine in the back at home which can also influence the circadian flocks. So, assigning these variations to the light dark cycle alone is probably somewhat misguided. All of that said, I suspect that historically, you would have seen seasonal changes, certainly in the melatonin rhythm in many parts of the world, maybe not part of the regions, maybe not the equations, sorry – maybe not the equator, good again, part of regions. But the significance of those at the moment is completely unclear achievements I think. That said, because of the effects of melatonin in various metabolic functions, it could still have implications for things like when is the best time to bit and that's something that we'll get to you later.

DANNY LENNON: Yeah, perfect. Just to touch on that then, obviously, we're seeing that this melatonin rhythm is – has an adoptive component or can change based on the stimuli we're giving. And as you perfectly outline, there's a number of things that can tie into whole host of things in terms of stimuli.

Obviously, when we're told that melatonin, the most important like you say is light-dark exposure. So with that rather than looking at seasonal variation, if we start thinking on a more shorter term basis of day to day and what people are doing completely outside of the study.

One thing that they, I think mentioned that some stadian the paper was social jet log and this may be tied to these changes in our rhythms based on sleep wake times like dark exposure changing from day to day across say one week period. Can you maybe just talk to people about that concept of social jet log if they haven't came across that term before.

GREG POTTER: So concept was introduced by a group of researchers in Germany and I think an issue was published in

2006. So, first and the heads up that were search week is to run about and the idea here is for many of us, perhaps 70 percent of people in Northern Europe, we – at the start of the working week, effectively fly at least one time zones at least. Because if you look at our average sleep time during the working week, versus our three days, it's about one hour late are on three days. And that variability and sleep timing has since been related to a variety of things including metabolic disorders and also problems of performance. You're likely head to engage in certain behaviors, such as smoking and for that reason, maybe people and that one trusted in ways in which you can reduce the variability in somebody's sleep timing.

DANNY LENNON: With any of the things related to this first paper or any related concept. Is there anything that haven't touch on that you think is important or anything else you wanted to finish off on before you've move away from this particular at paper.

GREG POTTER: Yeah. I think one thing to touch on is the concept of hernia types. So hernia type technique piece of probably best to find as somebody's phase angle of intrament. And all that means is, the difference between the time with somebody's biological bought and the timing of the solo day. So, for example, where you can look at when somebody starts producing significance – significance amounts of melatonin in comparison to dust And what you find is that there is this part range hernia types but aren't average.

People's hernia types are getting later. And that is one contributes to the social jet log phenomenon. Because as you can imagine, if somebody wants to go to bed later, and bedtime is commonly use as an approximation of circadian phase or hernia type, for that reason, immensely for time and particular.

But anyway, if people are going to bed later and they have to use midsleep times, then they are more likely

to need to use alarm clocks during the working week in order to get up on time for the working day. And people was current types and now delaying, the evidence just that. In the last decade or so, on average, during the work in a week, people sleep about 37 minutes less. So that's the sleep state loss from Monday to Friday. About 37 minutes.

So, social jet log really is all mostly to be primarily results of delays in permits, so. And soon really permit – has been associated with all sorts of health problems. So the two concepts of hernia type and social jet log are instrickably is related.

DANNY LENNON: Perfect. So with that and just maybe one final piece to end on this. When people are thinking about their chrono type or they are thinking about their typical sleep and wait times. Does that therefore indicate that potentially, getting a regular sleep wake cycle maybe more important than the actual number hours of them being in bed per se or is it one of these ideas where we can't really separate once familiar or being this is better than this and really, you can – you have to take care of both.

GREG POTTER: Yeah. I didn't think that we can say, this is better than this at the moment. And as I said, it's really due tend somebody hand in hand. With that said, so most people, the important things to take on quarter that regular sleep wake times are important. And you should try to adjust your lifestyle such that you can get rid so you can have good complete sleep each night.

And also, just because somebody else needs six hours of sleep or night hours of sleep, it doesn't mean that you can use how much somebody else needs so you could time in how much you yourself need because there are genetically relatively short long sleepers and all these things change across the lifespan. So if you use an example, then what you find is that when kids are born, they don't have very well organized to

cadian system but during childhood their consolidate into regular passing of the behaviors. And killed irrelatively early permentize. Surely adolescent they're delay and I'm reaching physical maturity so perhaps 18 years old for girls and 21 for boys. You get that latest. They go to (inaudible) and for that reason, people are very interested now and things like what happens if you delays group start times. What happens to how well adolescent function on school. What's there likely to crashing a car? What's there likely to foremast the lesson. What are that grades like?

Now, after reaching the end of adolescence, people then become earlier until towards the end of life such that find the medicals, men and women have very similar times of their own body clocks. So during adulthood at given age women are on average slightly earlier prototypes. But then by the time that people in their 50's or so that's where you get some differences between the sexes.

DANNY LENNON: Perfect. Thanks. So I think that rounds out the particular topics related to that paper at least. And we'll probably circle back to some of those after the second paper. But as I mentioned I'm keen to look at another potential influence on circade in biology. And this time outside of like dark cycles looking at potentially how nutrients and meal timing can influence things. So the second paper for those of you listening that were going to talk about is McHill 2017 title later circadian timing of food intake is associated with increased body fat. And again I will link to that in the shoe notes if you want to pull up this paper at any stage as well.

So soon right before Greg, where is the best place to jump in on this particular study? What were – what were you essentially looking at in this study and how was the study setup initially?

GREG POTTER: What were looking at is whether when somebody eats relative to their own body clock is more important than when they relative to the social clock by which we live because if you think about it each person lives according to three clocks now. So historically our ancestors would have had their own biological clocks. And then also the solar clock, the light-dark side to impose by the environment. But now we have another, the social clock which dictates many of our activities so things like meals perhaps their scheduled more by habits and social norms than our own biology. And that could have implications for our metabolic health, for our risk of being slightly obesity.

DANNY LENNON: Okay, perfect. So in terms of the study methodology here what are the important things for people to know about that?

GREG POTTER: Sure. So in this study they are greeted 110 participants. They were I think probably university students age 18 to 22. And they participated in a 30 day period in which they monitored sleep again using as further study that we spoke about previously. In the middle of this period they completed seven consecutive days of recording that dial. And to do so they used the mobile phone application.

Also during the first day period they attended the laboratory. And they used similar methods in the first study to measure the timing of somebody's biological clock specifically what's good dim light melatonin answer and mark as circadian phase whether somebody is an early bird or a night owl. And then what they did was they classified people into two groups according to their body fat percentage. So they use Bioelectrical Impedance Analysis to measure body fat during the lab visits. And then they split people into a leaning group which was defined as people – men with 5 to 20 percent body fat and women with 8 to 30 percent body fat. The normal lean group have values above those respectively.

DANNY LENNON: So what are the first couple of results of note to mention from this?

GREG POTTER: So the main finding was the normal lean group on average consumed most of their calories just over an hour closer to melatonin onset. So they were interested in somebody's eating chronotype if you will. So you have early eaters and late eaters. The question is when is that occurring relative to somebody's biological day. And to define that they measure choleric intake across the day. And they choose the time at which people had accumulated 50 percent of their daily energy intake as a marker of somebody's diet timing because as you can imagine people eat in a relatively hap hazard fashion.

And quite often it's not the case the time of which somebody's accumulates half of their daily calories is half way between when they start consuming calories and when they stop consuming calories. So they used that as their marker. Again they found the people who had accumulated 50 percent of their calories closer to dim light melatonin onset. So therefore later in their biological day were more likely to be in the normal lean group.

Other findings were the people also consumed the final calories the day later in the non lean group. And interestingly there weren't differences between the two groups, the lean and the non lean groups in the clock hour of food consumption. So it was only the timing of when people are eating relative to their own biological days that was important. It wasn't the timing that were eating relative to the social clock b which we live.

DANNY LENNON: So if we have the same clock time at which both groups are eating. But the non lean people are eating closer to their melatonin onset is then their problem or potential problem rather than late eating per say? Is it more that something is causing their melatonin onset to be an hour different than the other group?

GREG POTTER: The actual timing of their circadian systems also didn't differ between groups which is interesting. And it's slightly difficult to explain too. I think the practical takeaway though is that for most people when they eat relative to their sleep/wake patterns is going to be important. Something that the question that you asked brings up also is what would be the effect of changing light exposure on how somebody processes food.

So if melatonin per say is problematic and the exposure to light offsets melatonin synthesis then would light exposure while you're consuming calories or whatever actually help mitigate a detrimental effect of consuming calories in the presence of melatonin? And it's not a question that to my knowledge has been answered as of yet.

DANNY LENNON: Yeah, that's a super interesting thing again is trying to piece through of if it's not the social clock per say. And it's trying to match or at least theoretically trying to match up choleric intake earlier in our biological day could it'd actually be beneficial for someone to try and shift that backwards if they are going to eat more calories later in the day for social convention or whatever is going on.

And I think that's like you say an interesting question that there's probably not a whole lot of answers to. One thing I'll ask you about in terms of obviously this paper if they're showing this kind of correlation with body fat mass and these meal timing differences. Obviously this is not showing a cause and effect in this particular study. But at least it shows that something could be going on where meal timing might be playing a role in the gain of body fat.

So presumably if we are going to get to a point where a mismatach circadian rhythm is essentially a causative factor in fat gain regardless of say total calories. If that's to be the case then presumably were talking about a mechanism where that's influencing

someone's either energy expenditure or maybe they're influencing their lean body mass to some degree. Is there any mechanism that you seem most that you would think is most likely at this point to explain if we do end up seeing that meal timing can influence body fat gain regardless of total calories for the day?

GREG POTTER: Yeah. There are probably a few. So the one that the author is focused on is dietary induced thermogenesis. And one of the authors Frank Scheer found some lovely work previously showing the variation in dietary induced thermogenesis that you see across today is largely driven by the circadian system such that if somebody eats early in their biological day they end up learning far more calories just in digesting food than they do if they consume the same amounts of food late in the biological day.

And over time perhaps the difference in that energy expenditure we see could accumulate in something meaningful in terms of energy balance at large. But there are other things too I think. One of them perhaps could be physical activity. And there's a lot more work to be done here because you need quite higher resolution measurements to get at this. And there are various things – there are various components of physical activity too. So for example you can look at non exercise activity thermogenesis. And this is something that hasn't been really studied much to my knowledge.

So for example if you took two groups of people who are consuming isocaloric diets during a weight loss period and some people assigned more of their calories earlier in the day. So let's say if they had 400 calories of breakfast and the other group had 400 calories at evening. So perhaps the group that were consuming 400 calories of breakfast would simple move around more following that whereas the group of consumers are thinner because they're consuming closer to sleep.

They have less time in which to accumulate more non exercise activity genesis. There are tends that hint to this too. So there was some great breakfast studies that came out at a few years ago. And they found that people who skip breakfast consume fewer calories. But they also move around less such that over a period of time there was effectively no difference in NT balance. And people don't move or gain weight differently between the two groups.

My question is if you take those people and you put them on match diets and some people have more earlier than in the day then will they lose more weight partly because they move around more. (Inaudible) sat that too. So there was a paper published in 2013. And they found that among women consuming match diets those who have larger breakfasts lost more weight over a 12 week period than those who consume more mainstream. So I think broadly speaking the important thing is probably going to be diet induced thermogenesis. But then also you have things like physical activity.

And in terms of a mechanism to explain potential differences in physical activity and this is speculative. I wonder if there's singling going on in somebody's brain on so to clarify where I'm coming from with this. In the sports nutrition mark there had been some really interesting studies looking at carbohydrate mouth rinses and effect of those on performance. So you can take somebody, you have them do a time trial or you have exhaustion on a bike. And one group just wishes around for a starch solution in their mouths. And the other group just get a placebo. They don't actually consume any of the calories. They just spit it out afterwards.

The people in the starch group will end up performing better. And that's because there are change in their brain which sends the fact that there's energy available to them. Anything okay we can cycle harder because there's energy incoming. If we take that same

idea maybe the people that are getting more energy earlier in the day their bodies think we've got some energy available. Therefore we can move around a bit more. But right now we don't have the kind of studies that had been designed to tease apart whether there are differences in physical activity.

DANNY LENNON: Yeah. I think the really interesting thing is like I said there's so much that we could speculate on. And to some degree it's going to be difficult to tease the exact effects because there's many of these that might only have a real effect in the long term which is going to be difficult to get a study on. So for example if we go along that lines out by partitioning more of your calories earlier in the day. Those that drive more meat but maybe if you're someone who does resistance training or really any form of training and you're training quality goes up. And therefore you accumulate more training volume. That won't show immediately that week. But after many months and years of continuing to do that and better training volume is better training quality.

You could potentially say body composition changes should be different in terms of more lean body mass. And therefore weight changes would proportion mean less body fat mass. But again trying to – so having a clear mechanism for that is going to be one thing. But trying to really tease it out in a if someone's looking for a definitive proof on it it's going to be quite a more difficult task.

GREG POTTER: Absolutely. And I think that worse sport nutritionist and scathing biologist for example has come together then the result would be really productive because to use another example here. Perhaps it's not that easting late in the day is always bad even if it's late in the biological day. So I'm sure for example you are familiar with research which looked at night time protein ingestion. Maybe if you're consuming something like a complete protein source late at night even after dim light melatonin onset. Then actually

that would have favorable effects on body composition versus not consuming it. So there are nuances to this which we haven't really understood well yet.

DANNY LENNON: Yeah, for sure. And a couple of other things on that that I'm sure people listening maybe asking is obviously there seems to be some great potential for this and especially when you look at some of the (inaudible). There's some really interesting results in how body fat levels change, overall body composition in relation to things like where calories are partitioned. And again just because of were still trying to tease apart these mechanisms that's the reason why there has to be most of these done. But from a – I supposed a pragmatic perspective even if we were to get the point where we see clearly how meal timing influences health.

Obviously a lot of talk is around how important simply adhering and complying with an overall healthy diet and lifestyle is. So from a clear practical perspective, how do people consolidate the idea that mean timing maybe very important for health. But at the same time certain people may find it easier overall to stick to healthy habits if they do skip meals earlier in the day or put a bulk of their calories later in the evening. Is there any way to try and consolidate those ideas or which takes kind of precedent.

GREG POTTER: I think a lot of it just comes down to individual experimentation. So sometimes you can have all the best information. But it's not information that you can put to use which is practical for you can out to use which is practical for you in your daily life. So at that point you need to see things in a bigger context and realize the relatively small changes around lighting to make big difference over time.

DANNY LENNON: On that idea especially when were talking about how to influence biological clocks. As supposed we could talk all this stuff about meal timing influencing some of those. And as you say were talking about the

peripheral clocks around the body for something like a feeding stimulus which is obviously going to pale in comparison to the effect of light and dark on our master clock per say. So making small changes to meal timing is probably not a place to start if you're light-dark exposure is just all over the place and completely at odds with what we would think would be a better option.

GREG POTTER: Yeah. And that's – that's going to be a really important area of study I think in especially with certain populations like shift workers. And just to elaborate on some ideas that you raised there. So we have the master clock and the SCN primarily trained by light-dark cycle. But all the clocks outside of the SCN are called virtual clocks. And perhaps every one of the cells in our bodies has it's own clock. And that's driven molecular – molecular mechanisms which produce these fluctuating levels of so called clock gene proteins over the course of 24 hours. And those proteins binds or promote the regions of various genes, clock control genes to control the timing of the expression of those genes.

And the main stimulus that sets the time of those peripheral clocks is probably feeding. It's probably not the light or dark cycle. So in that way if you meet at a time which is very discord and it's the time of your master clock then you can effectively time of your puerperal clocks from the central clock. The question is how problematic is that. And there had been rodent studies which had tried to get to these. So for example we can take rodents and you can fix their feeding time. And then you can expose them to changing light-dark cycles such that the timing of their master clock is flip-flopping back and forth but the time that their peripheral clocks are relatively fixed.

And if you feed them at libertine then those rodents are pre-disposed to obesity. We can fix their feeding time. Then that actually protects them against the obesogenic effects of those variations in light-dark

cycles. Right now they're in humans. The implications of that I think are unclear. What we do know based on recent work is that changes in the timing of our meals does influences our peripheral clocks.

There was a study published by research at the University of Seoul early this year. And they looked at the timing of the clocks. And they found that moving the timing of meals later shifted the expression of some clock genes later accordingly. And also it shifted the timing of like glucose with them too.

The question is – is that by itself problematic. And I think it's somewhat unclear right now. And this conversation also is relevant to things beyond obesity particularly blood glucose I think. So a prime example of this is the fact that melatonin probably inhibits glucose simulators insulin secretion. So if you eat late at night then your blood glucose levels rise. And the problem is that you're body is going to produce less insulin in the presence of melatonin.

And people with a common receptive variants of one of the melatonin genes. It's melatonin receptor 1B genes are predisposed to diabetes. And that could be one of the reasons. So about 51 percent of people with European ancestry carry the risk there in gene. And for those people perhaps eating in the presence of higher melatonin levels is going to be more problematic. Interestingly those people also have a later time of melatonin offset. So if you wake up in the morning then they're going to have more circulating melatonin number into their waking day. And for those people ultimately you might try and find out that it's better to delay breakfast more.

It's just an example of how individual variation in somebody's biological clock has implications for what might be best for that person.

DANNY LENNON: Before we get to kind of the final question or so. Based on what we've look at in these two studies and all the other kind of areas that we've got into today. What are

a few of the I supposed big picture take a ways you'd want to leave people with that are the most important to bear that when it comes to the practicalities of anything that we've talked about today?

GREG POTTER: I think the big picture take a ways is if you consider the first study again would be generally speaking exposure to electric delays the scaling system. And it prevents these seasonal changes that you might otherwise see where the effects of those changes are currently unfit.

I think another take a way would be that if you look at people's lives and the environments the differences between natural lighting are mono lighting are so stark so the question what can we do now in the environments in which we live to perhaps produce light diet cycles which are more reminiscent of those natural ones. And for many of us that can entail things like get some planned specific exposure to light in the morning. Maybe living less convenient lifestyles so that we can walk to work. Half a bit further from your work place for example then that might be a good thing.

It didn't get outside at lunch time. That would also be conducive to advancing chronotypes in general. Other take a ways from the first study will be the circadian system and sleep timing adjust remarkably quickly to large in the light dark cycle. And I supposed other things that we can think about would be nocturnal lighting. So light pollution now is more and more a problem.

And it's not just the scoring of it. It's also the intensification of nocturnal light pollution. So for many of us things that we can do would be things like easing dinners in our homes, using light filtering apps for devices laptops and mobile phones. And then another thing also would be reducing your caffeine intake particularly later in the day. So caffeine has been shown in some in vitro work to prolong the

circadian period. But also to dim light melatonin onset.

So caffeine on average the half life of something like six hours perhaps less than that and if you're consuming it therefore after maybe mid day or something like that. But for many people that could delay their clocks. And also subsequent sleep and that actually seems to take quite a long time for people's sleep to rebound after using caffeine to counter effects of sleep restrictions. So if you take people and you don't let them sleep for as long as they do habitually for a bit you let them use caffeine to offset the deleterious effects of that. Then even when they withdraw on caffeine it take a while for their sleep to actually rebound properly.

And for many people it's going to suck for the first few days. But once you're passed that custom annual caffeine intake whether your winning yourself of it or just going cold turkey can be really conducive to improving your circadian system function and your sleep.

DANNY LENNON: Super, a great breakdown. I think plenty for people to take away there Greg. If they find more of the work that you've put out online if they want to track you down on social media, et cetera, et cetera. Where is the best place for them to go on the internet to find more of your work?

GREG POTTER: Sure. So my work you can find on the Search Gate if you're a nurse. Otherwise I'm on Twitter at gdmbutter, G for Greg, D for David, M for Max. Another thing is come on over to tune the rest of me. So I've been doing some work with Dan Party recently. I know you've had him on the show a couple of times. And demonstrate something really cool and really helpful over there.

So all we've been speaking about today comes down behavior change and what you created as a tool which can meaningfully help people change their behaviors,

see how their behaving and document the effects of change in behavior on their health outcomes. That's human. Another cool thing there is that other people and great of course if it relates to things like fasting. Of course on sleep coming out. And I've created a course on scaling biology. And those will be up soon so for those of you who want to take a deeper dive into some of those topics you'll find some interesting stuff there.

DANNY LENNON: Perfect and for every one listing I will link up to all of that in the show notes. So please do go and click through all of that that Greg has just mentioned. And so with that we end this show on the final question that we always do. And it is simply if you could advise people to do one thing each day that would benefit their life in any aspect what would that one thing be?

GREG POTTER: It's a big question isn't it?

DANNY LENNON: It sure is.

GREG POTTER: I'm 28 so I don't proclaim to have any wisdom what so ever. But I'll offer up a couple of things depending on whose listening. So one of them would be your life will improve if you give back. And most people listening to this are probably in the wealthiest 1 percent of people worldwide. And often that's not the result of our own brilliance. That's good luck. And I think recognizing that's useful. And it's easy to get back. You don't have to give that much. But donations through effective charities can have very profound influence on people's lives. And if you want to pursue that then there's a website called givewell.org which is great because what they do is look up charities and determine which ones are most effective.

How can you have the biggest impact on people's lives per dollar per year or per pound spent. Another one would be for young people, there's a website 80,000 hours per org and they have a career guide. And I found that instrumental in shaping what I want to do and how I can vest out people over the course of my

career. So if you're considering a career change or if you're just young and open to ideas I would say check that out.

And then if neither of those things appeal to you then I would just say write a thank you letter to someone as cheesy as that sounds. Whatever it might be I'm sure will put a smile on their face and would put one yours too.

DANNY LENNON: Perfect, a great way to finish off here. Greg, I want to thank you for taking the time out to do this and for the great information you have given today as well. It's been great chatting today my friend.

GREG POTTER: Thanks very much Danny. Absolutely pleasure.