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HERE COMES THE SUN: SUNSHINE AND ITS EFFECTS ON HEALTH, SLEEP AND MEMORY

PROFESSOR STEVE JONES

I am going to be talking about sunshine and why it is important, whether it is good for us, bad for us, neutral for us, and basically, what it is all about. Of course, the title comes from George Harrison's song, "Here Comes the Sun", which he himself says in his writings, he wrote it because he was feeling very depressed at the end of the winter, so if anybody has got a tune going through their minds at the moment, it is time to write it down!

There is a science of sunlight. In fact, in some ways, the whole of biology is the science of sunlight because, without the Sun, we would not have life on Earth, and I am interested in that because I am concerned with the flow of energy through ecological systems. The Sun newspaper has worked out the most depressing day of the year, using this rather baffling formula which I cannot make any sense of, however I try, but anyway, they have put it to the Sun's computers, or at least their hand-calculator, and they work out that the most depressing day of the year, of this year, was January 15th (2018), which was a week last Monday. That is based on how depressed you feel because you have not kept to your New Year's Resolutions, how much you are in debt, how little sunlight there is, and so we have got a good data-field. So, that is certainly true, and they call it Blue Monday. However, this is the Met Office projection for today, and I think it's bloody worse! So, it is Deep Blue Monday today!

But there is hope because, at the other end of the planet, if we go to the Daily Mail, another excellent source of unbiased view, this is the Daily Mail's headline a couple of days, "Sydney gets set for a scorcher – record heatwave, with temperatures soaring to 43, so how hot is it going to be near you?" and you can look it up on the Daily Mail's website, and the answer is "hot", okay. 43 is hot. I have been in Sydney when it has been 43 and it is quite oppressive.

The question is: is that a good thing or a bad thing? We like to think, of course, that having extremely hot weather, in that we don't experience it very much, is, generally speaking, a good thing. However, the culture in Sydney, and indeed in many parts of the tropical world, is exactly the opposite. They are concerned about hot weather on the grounds of health, particularly concerned about the effects of ultraviolet light on skin cancer, which is certainly true. This is Sid the Seagull and he says, "Slip on a shirt, slap on some sunscreen, and slap on a hat!" In fact, there have been cases in Australia of children who have a shortage of vitamins in their blood because they do that so often that they do not get any tan at all. If you put Factor 20 all over yourself, you are not going to get any sunlight into your skin. The reason that they are concerned about that has to do with skin cancer is that there is a fit between ultraviolet light and skin cancer. You see that in many ways. One of the most telling bits of information perhaps is that if you live in a hot country and you drive around, you tend to hang your arm out of the window when you are driving and because, in Australia, they drive on the left, so they have right-hand drive cars, and they stick their right arm out of the window, and in America, they drive on the right and they stick their left arm out of the window. There is a highly significant difference in incidence of skin cancers on left arms and right arms in Australia and the United States. It shows the inferential method in scientific discovery and it is certainly true.

In fact, all this fuss about skin cancer in Australia is not doing all that much good. Here is the incidence of melanoma – that is the dangerous skin cancer which can certainly kill. It is not particularly common, but it can certainly kill and despite all the propaganda and all the information - everybody in Australia knows about this - the incidence is still going up, so it is certainly a dangerous disease.

You will notice, in Australia, which is a populous country, several tens of millions of people, you will see that the deaths per year are around 1,000 to 1,500, which is bad news if you are in those statistics, but it is a rather low death rate. You will see, on the right, this is non-malignant cancers, which do not get malignant, but they are simply related to it.

This effect of sunlight on skin cancer was in fact discovered in the 1930s by a huge survey done by the United States Navy. The United States Navy was concerned about the health of its sailors in relation to the general population, so they did this big and well-planned survey of life and death and disease incidence in Navy personnel, and they found, indeed, that there was an increase in skin cancer among sailors, compared to people who worked on land. Sailors, of course, are generally much more exposed to the sun than people who work in offices on land. That became very well-established and is true. However, what was also established by that discovery was, in fact, that if you looked at other cancers in the American sailors, they had fewer cancers than average, and that has been forgotten. It has not been forgotten, but it certainly has not reached the public mind.

What the public know about ultraviolet light is that it is bad for you. If you look at what the experts say, Cancer Research UK said, "How the Sun and UV cause cancer", the American Cancer Society writes about UV radiation and the dangers of skin cancer. What they are telling us is that sunlight is dangerous, or sunlight is dangerous in some ways, but what they should be telling us is that on balance, it is really good for you.

The story really comes to a peak when you look at the health and the weather in Scotland. I have to say that you soft Southerners do not know how lucky you are! I spent 10 years in Edinburgh, and take it from me, it is a wonderful place, apart from the weather! I sometimes used to say, "apart from the weather and the Scots", but I have stopped saying that! I could say "the weather and the Scottish Nationalists" maybe. It is a wonderful place, apart from the weather. Billy Connolly put it very well. He said, "There are two seasons in Scotland: June and winter", and he was right!

Well, in fact, somebody who died long ago, and is even more well-known than Billy Connolly, wrote about that, and this is R. L. Stevenson. He wrote a piece about the weather in Edinburgh: "The weather is raw and boisterous in winter, shifty and ungenial in summer, and a downright meteorological purgatory in the spring. Happy are the passengers who shake off the dust of Edinburgh and have heard for the last time the cry of the east wind among her chimney-tops." That brings back memories, I can tell you! I can hear the cry of the east wind now. Of course, he left Edinburgh when he was a young man, and he moved first to California and then to Samoa, where he died of tuberculosis. We will come back to that tuberculosis question a little bit later.

Edinburgh, and Scotland in general, has really quite a unique set of climatic challenges. For example, this is a typical Edinburgh summer's day, this is what we call the haar. When I first went there, in 1962, a long time ago, I kept waiting for spring to arrive, and the only thing that happened when spring did not arrive was that the days got longer and then, after a while, they started getting shorter again, and that is because very often in Edinburgh, you have this sea-mist that comes in off the North Sea and condenses on the land and gives you this, often day-long, thick fog which keeps the sun out. But Edinburgh has also a unique position because there are very few places in the world which have large populations as far north as that. These are places with more than 25,000 people at the latitude of Scotland or higher. You will see, Edinburgh and Glasgow, and a few places, Stockholm, for example, and Murmansk, but very few, and in fact, only about 2% of the world's population lives north of Edinburgh and Glasgow, and in fact, only about 1% of the world's population lives north of the Shetland Isles. So, they are unique in their position. It is also the case that Edinburgh, and Glasgow more than Edinburgh, has the joys of the Gulf Stream, which brings in even more cloud.

Edinburgh's position means that it gets less sunshine, because when the sun comes in to a northern part of the world, or a southern part of the world, then it must pass through more of the atmosphere, so it is attenuated more as it comes through.

If you look at Europe, you will see that the effect is very strong. You can see it even on the scale of Britain. This is the amount of ultraviolet that gets through the atmosphere in Edinburgh over the year, in London over the year, and in Bordeaux over the year, and there are really quite striking differences. Even on the scale of Britain, you have a striking difference in the number of hours of bright sunshine from place to place.

In Northern Scotland, you have fewer than 900 hours of bright sunshine most years; in Southern England, you have almost twice that; and in Southern Europe, you have well over twice that.

If you fix that diagram in your mind and look at the next one, these are male life expectancy at birth in England, Scotland, Wales and Northern Ireland, and you will see a striking fit, I think, with the number of hours of bright sunshine and that has been known for a long time. Now, Scotland, in fact, has a famously low life expectancy, particularly Western Scotland. This blob is known as Glasgow, alright, and Glasgow has a uniquely low life expectancy, both in Britain and indeed in most of Europe. But Scotland, as a whole, does not do all that well.

This is the male life expectancy at birth in different places. On the left, you see a place called Calton, where male expectancy is only, on the average, about 54 years. Calton is in inner Glasgow. We see, if we go to India – Calton, life expectancy, on the average, is lower than that of Indian men. We go all the way through to the average of the UK for men, 77, and then we go to the right and there is a place called Lenzie, and Lenzie is an outer Glasgow suburb, five miles from Calton. Britain and Somalia have a 28-year difference in male life expectancy. Lenzie and Calton have a 28-year difference in life expectancy. So, over five miles, we have got a 28-year difference in life expectancy. Now, this has always historically been thought, and no doubt some truth in this, in Lenzie, which is tremendously deprived, people have a very poor diet, there is quite a lot of violence, huge amounts of heavy drinking, very poor housing, and this certainly plays a part, there is no question, but I think the answer to understand it needs a lot more than those rather obvious threats to health.

Scotland is the sick man of Europe and is becoming increasingly so. This is average male and female life expectancy, from the 1950s to 2010. Scotland is the red line, and you will see, Scotland has consistently been lagging the rest of Europe, and it now has the lowest life expectancy in Europe. In fact, the situation – and it is rapidly being overtaken by Eastern Europe, places like Romania, Bulgaria and the like. At the present rate, they will overtake Scotland within the next three or four years, in life expectancy.

The situation is not getting better, it is getting worse. Here we have life expectancy at the age of 85, so it is elderly people in Scotland, and you will see, strangely enough, about the time of the Election in 2010, by a remarkable coincidence, the improvement in life expectancy in elderly Scots came to a complete stop, as indeed it has throughout England, Wales and Scotland, but it has got considerably worse, the gap has got bigger from 2010 to 2015. So, things are not looking particularly good.

I remember I went to a conference a few weeks ago in Edinburgh, about inflammatory bowel disease, not something I know anything about but apparently, I had to talk about it, and a Glasgow doctor quoted some differences he had noticed in the attitude towards mortality in different parts of the world. "Well," he said, "in San Francisco, death is avoidable; in London, death is inevitable; and in Glasgow, death is imminent!" He said that with real relish, as a Glasgow doctor and, as you can see from those figures, that is certainly true!

If you look at some of the causes of death, Scotland is worse than England for MS, cancer, heart disease, rickets, infectious disease, birth defects, depression, suicide and more. The effects are not small. The effects are quite big. For example, if you look at the suicide rates in Scotland and England, let us look at men, who are much more likely to commit suicide, you will see that the Scottish rate, the pale blue line, is almost twice the English rate. The same is true for things like heart disease, so the effects are big. So, one needs to ask: why is that?

Well, we have a fairly clear idea why it is. It has to do with vitamin deficiency. It has to do in particular with Vitamin D deficiency, and I will talk at some length about that in a moment. But Vitamin D is not really a vitamin at all. Vitamin D is in fact a hormone. It is made in large amounts in the skin, when sunlight strikes a relative of cholesterol and it makes a precursor which then moves to the kidneys and the liver and is turned into this stuff, Vitamin D. You can get it from your food – you can get it from fresh fish. You can get it from a pill if you want to. You can get it from fortified foods, which we do not have many of in Britain – they do in the United States. But, overwhelmingly, you get it from sunlight. If you expose your whole body for 20 minutes to bright sunlight, you will get 10,000 units of Vitamin D, which would involve eating about 25 helpings of fresh salmon, which you probably would not particularly succeed in holding down, I do not think. So, sunlight is an extraordinarily powerful source of Vitamin D.

So, we need to ask: what are the patterns of sunlight across the world, and what are the patterns of Vitamin D presence, and what, if anything, do these do to human health? This is a map that shows the ability of white people to synthesise Vitamin D in different parts of the world in relation to latitude, and you will see, in the yellow zone, which basically is the Tropics and a bit outside the Tropics, can people can synthesise Vitamin D all year round. In the pale-yellow zone, there is at least one month a year, and often more than one month a year where you cannot synthesise Vitamin D enough. If you join a line through Birmingham – and many people wish to draw a line through Birmingham – north of that line, you can never synthesise enough Vitamin D to stay healthy. The black marks are just population density. So, the people who live north of Birmingham, let alone north of Glasgow, would find it extremely difficult, or impossible, to synthesise enough Vitamin D to stay healthy. You can see that as you move down through Europe. This is the amount of ultraviolet light you have and whether you can or cannot make Vitamin D. You will see, on the left there, which is the island of Skye, any month which dark blue or pale blue is, you cannot make Vitamin D, in Skye, and Edinburgh, you cannot make Vitamin D for something like eight months of the year. As you go south to London, you gain something from that, but as you go further south to Marrakesh, things change completely, so the effect is really quite big.

This is the patterns of Vitamin D deficiency in different parts of Britain in different seasons of the year. Of course, in the winter, there is almost no sunlight. You will see, the proportion deficient is shown by the colours, from pale brown, at the left, where very few are deficient to dark green, at the right, where very many are deficient, and you will see consistently that Scotland has lower levels of Vitamin D, on average, than the rest of the UK, no doubt largely because of the weather. So, we need to take that on-board, so Vitamin D levels are low in Scotland, and have been for a long time.

You noticed I was talking about white people making Vitamin D because people with dark skins, either of Asian origin or of African origin, are much less able to make Vitamin D than people with light skins, for obvious reasons. They have melanin pigment in their skin which keeps the ultraviolet light out, and indeed, is very much the case that sunlight-related diseases are much more common, in Britain for example, among people of Afro-Caribbean origin or among people of Indian origin and people of European origin. Well, in fact, the light skins of Europeans evolved in response to a shortage of sunlight because, as we moved out of Africa something like 80,000 years ago and began to move across Europe – quite recently, the move across Europe, and really did not get to Western Europe in any numbers until about five or six thousand years ago. Individuals who had relatively light skin, as they moved into the cloudy horrors of the north, tended to survive rather better than individuals with dark skin, so they reproduced more effectively and so the light-skin genes became more common.

This is rather a baffling slide, but I will show it to you because it is a remarkable finding. This is human fossil DNA, and you can now of course get fossil DNA, not just out of recent humans, these are 5,000 years old from the Ukraine, and these are genes which tend to make your skin lighter. 5,000 years ago - we can see, if you look in Africa today, none of these genes are present, there are none of these skin-lightening variants present in African populations. If we look in the modern Ukraine, 65% of Ukrainians nowadays have the light version of the first one, 92% of the second one, and 36% of the third one. But if we look at Ukraine 5,000 years ago, we will see – let us take, for example, the third one, 92% now, only half that, less than half that 5,000 years ago, and for the first one, 65% now, and only one in six 5,000 years ago. So, 5,000 years ago, people in the Ukraine were relatively dark-skinned. They were not as dark-skinned as Africans, but they were certainly much darker-skinned than they are today. So, this has happened very, very quickly indeed, in evolutionary terms.

The Scots, I have to say, are the palest people in Britain, in Europe rather. Here we see a typical Scot on a wonderful sunny Scottish day. He is obviously feeling a bit overheated here, you can see. You will notice that he has got a very, very pale skin.

There is one particular variant, which is at highest frequency, higher frequency in Scotland and the West of Ireland than anywhere else in the world, which is red hair. This is the frequency of the variant which changes the melanin in your hair to be a different form of melanin and takes dark pigment out of your skin altogether. The incidence of red hair is very, very high in Scotland, very high in Ireland, and high in Wales too. In most of the world, it is unknown. Red hair is an interesting gene because it makes you very pale-skinned and it is clearly evolved to allow you to soak up more ultraviolet, even though you pay a price in terms of sunburn and skin cancer. I am sure most of you know that about five years ago, it was discovered that quite a lot of the Europe genome DNA comes from hybridisation with our extinct ancestors, the Neanderthals, who once filled the whole of Europe, and Europe was then much, much colder. We are talking Ice Ages here.
If you look at this gene – this is one particular chromosome, but you can see patches of red, and there, the Neanderthal genes, sections of DNA along that chromosome. There is no Neanderthal stuff found in East Asia, no Neanderthal stuff found in Africa, and it transpires that the red hair gene is on a Neanderthal piece of DNA, so that red-haired people are more Neanderthal than average – I will say nothing about the Scots in this context.

Here we have Ginger, the Neanderthal, looking hairy, and no doubt, the reason that gene was favoured, both within the Neanderthals themselves and, indeed, when they had hybridised with modern humans, it was favoured in a very, very cloudy and unpleasant kind of climate. So, that is the evolved variation in relation to variation in sunshine. So, as I say, Vitamin D is a hormone. It is a hormone which is made best of all in bright sunlight on naked skin – and take it from me, both those commodities are rare in Edinburgh.

So, what happens if you do not have enough Vitamin D? Well, as you probably know, you get rickets. Rickets was once universally known as "the English disease". It was described in the 17th Century by an English medical student, or an English doctor, who submitted a PhD to the University of Leiden. The PhD was five pages long – oh my God! As I say about modern PhDs, well, we do not read them but we sure as hell weigh them! His was only five pages long, but he gave a very precise description of rickets and he said that the people here call it "the English disease". It was the English disease and the Scottish disease because it was much, much rarer in Southern Europe. Rickets is a very nasty disease, which was very common remarkably recently. The oldest case that we know of rickets is here – it is, strangely enough, not by coincidence, it is in a Scot, a Scottish woman, whose bones were found on the island of Tyree in the West of Scotland. She had a severe case of rickets, and almost certainly is due to a very poor diet. One of the strange things about a lot of island people in Scotland, historically, and indeed elsewhere, is that they do not fish. If you eat lots and lots of oily fish, then you are going to be okay, but it seems to be widespread that when farmers get to island communities, they farm, they do not fish, and so she had a very poor intake from her diet, and of course it was northern and cold, and so she got rickets, and, without question, died of it. That was true of many other groups of that period too.

The attack on rickets began just after the Second World War. In the 1930s, rickets was common. Rickets was almost universal among children in inner London. I now live in Camden Town. Camden was then a slum, even more of a slum than it is now. It really was a real slum, and it was because Camden town was close to the railway - there was thick smoke and fog everywhere. Even worse than that was Finsbury, the London borough of Finsbury, now full of yuppies and food shops and expensive restaurants, but in Finsbury in the 1930s, more than half the population lived more than two to a room so people were sharing rooms all the time, so it was tremendously overcrowded and tremendously poor, and at least a third of children showed signs of rickets.

Well, in the 1940s, of course the War had started in 1939, and in 1942, British moral really had fallen to a low point. A secret government survey, people felt we were losing, we might be better off surrendering. Singapore had fallen, Leningrad was under siege, and in North Africa, the British were in retreat. To combat this kind of defeatism, the government decided to commission a series of posters. In fact, there were five of them, which showed handsome houses, beautiful countryside, cathedrals, new schools and a motto, "Your Britain – fight for it now". I said there were five. You only see four here, and the reason you only see four is this one was censored

by Winston Churchill. This is the Finsbury Health Centre, which is worth seeing, it is the most beautiful building of modernist architecture, which is in what used to be the London Borough of Finsbury, behind the Town Hall. It shows this beautiful Health Centre,1938 it opened, by the Russian architect, Lubetkin, and behind it is a piece of filthy urban waste with a clearly ricket-inflicted child, bent and suffering in there, and the hope was – it is making the point that by building these health centres, this is worth fighting for. Churchill was outraged – "This is a disgraceful libel on the conditions prevailing in Great Britain before the War." He did not believe there was any rickets. Of course, he had probably never been to Finsbury in his life. He had probably never been outside Westminster in his life in London. But of course, it was a huge problem. So, that was censored.

Of course, 1945, there was a great upheaval and a new government was brought in, and the NHS was set up in 1947. Indeed, the Finsbury Health Centre is sometimes seen as the founding gesture of the NHS. Ironically enough, five years ago, the NHS tried to sell it off for luxury flats, but there was a tremendous fuss. It was a beautiful building inside, and it is also quite a remarkable, beautiful building outside. You can see the murals there, the fresh air and sun room, so you get to live outdoors as much as you can, get as much daylight as you can, which would have been very difficult in Finsbury in the days of the smog, and then there was a solarium where people could go and have ultraviolet treatment which would push up their Vitamin D levels, and the thing was a great effect. In fact, I suffered, if that is the word, I experienced exactly that because I was born in 1944 and I got the full gamut of government-based health advice in that I was forced, much against my will, to eat lots and lots of cod liver oil. Here we are, taking our Vitamin D. I have vivid memories, Freudian memories perhaps, of sitting naked at the age of five with my young female cousins, being rather baffled at what was on view, and soaking up lots and lots of Vitamin D. That was highly effective. This is what happens if you have a child with Vitamin D – give it half a dozen hours of ultraviolet and the problem will be solved, so it is powerful stuff, and then of course there was the milk, removed by Mrs Thatcher, a now forgotten politician, and that too had Vitamin D in it as well, and it worked remarkably well. We know that rickets was beaten back. In fact, it was defined in 1954 as having been defeated in Britain, and that was quite remarkable that it got down – it was never really defeated, but it certainly got down to very low levels, from 30%, what it had been in children in the 1930s. So, that was a triumph of socialist planning, but that could not be allowed to go on, and it was given up when the new Conservative Government came in, and not much has been done by governments of any colour since then.

We all know about Vitamin D and rickets, but it has come more and more clear that Vitamin D is important in all kinds of other parts of the body. As I said, it is a hormone, and if you look at the cells of any part of the body, every single part of the body has got receptor cells onto which this hormone can latch. They are in the brain, they are in the heart, they are in the liver, they are in the kidney, they are in the muscles – they are everywhere. You can see, these are just some of the conditions we know are associated with lower levels of Vitamin D. You can see that Vitamin D is all-pervasive throughout the body, and if you have low levels of it, perhaps because you get no sunlight, then you are at danger in many, many ways.

A sun cure was already widespread, and the sun cure came from the belief that the Sun, for reasons then unknown, could cure tuberculosis. In fact, R. L. Stevenson, who died of tuberculosis in the 19th Century, quite young, 44 I think he was, he took the sun cure, in California, but it was too late for him. The evidence that it cured tuberculosis was then rather weak, but it was discovered, that it cured another infectious disease called lupus. Tuberculosis is caused by a bacterium that is called mycobacterium tuberculosis. Tuberculosis was once thought to be lots and lots of different diseases. There was this thing, lupus vulgaris, which is the same bacterium except it is attacking the skin. Indeed, in 1907, one of the very first Nobel Prizes in Physiology of Medicine was given to a scientist who discovered that ultraviolet lights would cure this. In the beginning of the 20th Century, something like 2% or 3% of the population were afflicted with this awful disease, which often showed they had TB as well, but this ultraviolet cured it. It cures it because it kills bacteria. Ultraviolet is, as you know - one of the ways you sterilise lab bottles and the like and sterilise water when you drink it is to use ultraviolet light, and it is very, very powerful. Bacteria find it hard to withstand ultraviolet and so they die.

Well, that disease has basically gone, however, there are other infectious conditions. These are the incidence of various respiratory infections, including flu and mainly viral infections, at different time of the year, in people with different levels of Vitamin D in the blood. The darker the shading in the histogram here, the lower the level

of Vitamin D they have, and you see a striking fit between Vitamin D levels and the incidence of respiratory infections. So, that too was unexpected, but it is certainly true.

It goes further than that. Here is cancer. This is the incidence of colorectal cancer in relation to your Vitamin D levels, very low at lower than 25 units, very high at more than 100 units, and there is a difference of about 40% in that cancer, and true of lots of other cancers. One of the ways in which you can see that that is the case is not by measuring Vitamin D levels, although that is quite easy to do, but simply asking: what is the incidence of particular conditions, cancers included, in different parts of the world in relation to the amount of sunlight that they get?

Here is the incidence of breast cancer in relation to latitude. You will see that breast cancer in Uganda, Haiti, Swaziland, Mozambique is very, very low in the Tropics. The capitals are far north, Canada and Sweden, and the far south, New Zealand and Argentina. So, a really striking effect. That is breast cancer. That is breast cancer just showing incidence in relation to latitude. Malaysia near the Equator, Iceland near the Poles, difference in sunshine.

Here is the male equivalent, prostate cancer. It is exactly the same pattern.

We can go further than cancer. We can talk about diabetes, Type 1 diabetes, which is often thought of as being a childhood disease, but it is not. Quite often, it comes on in adulthood. You get the same thing. If we look down in the Tropics, Barbados and so on, Brazil, Dominica, Sudan, almost none. Sweden, Aberdeen in the UK, Finland, up at 40. Sardinia, rather surprisingly, very high. But down in Canterbury, New Zealand, the southern tip of Argentina, exactly the same pattern again: high sunlight, low disease, for a totally different disease which is diabetes.

For multiple sclerosis, the effect is absolutely striking. Here, we have the incidence of multiple sclerosis across the world. The redder it is, the more there is. It is sometimes described in Canada now as "the Canadian disease", because Canada has the highest rate of MS in the world. Scotland has a 50% higher rate of multiple sclerosis than England does.

It's interesting to look at Australia because Australia is fairly sunny, but what is interesting is that, of course, nearly all Australians, historically, came from Western Europe, mainly from Britain, and you will see, when they move to a sunny climate, even though they have got genes that might predispose them to multiple sclerosis – and there certainly are such genes – the sun saves them, to some degree, and they get much less MS than their ancestors did in their native continent.

But you can do more than that. What you can do is you can – what has been done, in Scandinavia in particular, some very, very large surveys have been carried out on ultraviolet in relation to health on cohorts of women. Women are brought into this cohort, they were brought into this cohort when they were 55, and they were followed for 15 years, and asked about their health. The hope was to investigate the effects of ultraviolet on skin cancer. They divided these women into three groups: one group of which really liked sunlight – they went to tanning salons in the winter, they had holidays in the Mediterranean, during the summer, they went outside a lot; one lot was kind of neutral – they just did not really bother very much; and one group was positively anti-sunlight – they had desk jobs inside, they lived in the far north, they made no effort at all to get any sun. There was quite a striking difference in the patterns of survival. You can see that the proportion of people who died in those who avoided sun exposure was much higher than those who had lots and lots of sun exposure, and the biggest effect, effects both in cancer and in cardiovascular disease and in other diseases too, so the effect is strong. In fact, the thing that is remarkable is that the difference in death rates between high ultraviolet women and low ultraviolet women was greater than the difference in death rates of smokers and non-smokers. So, that is not a small difference. That is a big difference. So, it is important I think then to be aware of the importance of ultraviolet light and health.

So, what is happening nowadays? Well, things are not looking particularly good. The incidence of Vitamin D deficiency in UK children has gone up in the past 15 years by 15 times. It is still quite low, but it is going up and

going up fast. British teenagers now, go outside for an hour and a half less a day than they did only 10 years ago. That was of course, 10 years ago, they did not have their mobile phones. Now, 70% of British teenagers have got a television in their bedroom, and so they just spend more and more time inside. The proportion of Scottish children who do not go outside is even higher, and across the world, only the children of Chile go outside less than British children do. So, we stay in. I have vivid memories of my schooldays of being kicked out of Wirral Grammar School, on Liverpool's Left Bank, the Wirral Peninsula – even when it was icy, we were kicked out for a good hour a day, and we thought this was just to allow teachers to smoke their pipes, but in fact, it was exactly this feeling that you had to be out in the sunlight which was good for you.

So, we have moved away from sunlight, we have moved away from eating oily fish, so, understandably, the incidence of Vitamin D deficiency is going up. It is going up more quickly in some groups than others, particularly in people of Asian and African origin, which means, in turn, that the incidence of rickets is going up. I could only get a diagram for England. Look at the red line, which is the best set of data, you see it is shooting up. It was almost none in 1990 or so. It is now going up, and going up fast, and it is going up even faster than this and it has gone up much higher than this now. So, the effect is real, so obviously there is a lot of interest in this.

One of the interests is trying to find out how much sunlight people get. I hope you will excuse me for a moment if I talk about some of my own boring research. I was interested in the effects of the genetic variation on a snail's behaviour. I wanted to know how much time it spent in sunshine, because dark objects soak up more solar energy than light objects do, and I spent 20 years doing this. We tried to look at the way they behaved, just by looking at them, and all they ever did was waggle their tentacles or fall off a branch or something as exciting as that, so we needed a way to add up the amount of sunlight that these snails experienced over a period of some months. This is the technique I used. I was walking along a coastal path in Cornwall, it was, in 1968, a year of miracles, the year after Sergeant Pepper, and I noticed something odd, which was lots of coloured wires attached to a board facing south. I was in the pub that night and I happened to be talking to a local and I said, "What is all that about?" and he said, "Oh, they want to know how much coloured wires fade in sunlight." So, I thought, oh, that is interesting, and put it in the back of my mind, and then, 10 years later, it popped up again, and I thought, just a minute, here is an idea: why don't we take a dye, why don't we take something that fades in sunlight and attach it to these snails? Of course, the first thing I thought of, in those early days of molecular biology, was gene manipulation, which involved taking a pair of jeans and cutting out squares of denim and sticking them onto snail shells because it was very trendy to wear faded jeans. That did not work. But I did find out what the name of the blue dye in the denim was – it was called Coomassie blue. I took blue dye, mixed it with a stable yellow paint to make a green paint – there is the blue and the yellow, make a green, spotted it onto snails, and you can see, the one on the left has spent far fewer hours in the sun than the one on the right, which has faded more. So, we had a method of measuring sunlight exposure.

In fact, I worked for a while in Botswana, and in Southern Africa, there are quite a lot of albinos, people who have no skin pigment, and it is a very damaging state for them to be in because, effectively, all albinos, unless they take the greatest precautions, die of skin cancer at the age of 40. Things are getting better with improved medical care. But I was working in Botswana and I was talking to a colleague of mine who was a doctor, and he was saying, "Oh, we have terrible trouble with these children – we tell their parents they must not go outside in the sun, they must cover themselves with sun cream, but the kids just run off and they do not put the sun cream on and we do not know what to do about it." So, another little light came on and I said, "Here is an idea: why do not we make them caps made of yellow cloth and soak that in the blue dye, and then when they go outside with their caps on, it will fade, and we can tell how long they have been in the sun?" And we thought that is great. He said, "We will have to check with the Ethics Committee." I said, "What?!" Alright, Ethics, so be it. We went to the Ethics Committee, and the Ethics Committee, "Oh, you can't do that because you'll be treating them without them knowing! You have to tell them why you are doing it." And of course, we knew only too well that if we told them, the first thing they had do would be to take their caps off and put them in their pockets so that they did not fade. So, that did not work.

However, since then – and this was 20 years ago we did this – there has developed almost a field of its own that asks how long people do, on the average, stay in the sun. There are various sensors you can use. There is one, a

little plastic called Polycell foam, which you can make badges of and pin it on, and if you go out in the sun, then this will break down and you can work out how long those you are studying have spent in the sun.

The work was initially done in Manchester, which is a good place not to have any sun – it is certainly very cloudy there. In Manchester, in June, the Sun, of course, is at its highest around noon, but even in summer, each of the subjects, and there were hundreds of them, who had these things pinned on, went out at that time, around noon, for no more than nine minutes on weekdays and no more than 18 minutes at the weekend. So, even on the sunniest days, they spend nine minutes a day, Monday to Friday, in the sun. You can still make Vitamin D from 10 in the morning till 3 in the afternoon, but even that was not much better because that was 20 minutes in the sun on weekdays and 40 minutes on Saturdays and Sundays, and only one in four had safe levels of Vitamin D by the end of the summer, and three in four were deficient by the beginning of the next spring. Many of the younger people had thin bones – they did not have rickets, but they had thin bones. Things were much worse for British citizens of Asian ancestry – effectively, none of them had safe levels of Vitamin D, and effectively, all the women in that group had very unsafe levels of Vitamin D and many had signs of rickets because of course they often cover themselves with clothes which keep the sun at bay. Well, that is dangerous.

So, I think we can say, quite clearly, we need more sun. I have to say, I never thought I would do this, but when I started looking into this a couple of years ago – I have never been a great man for food supplements, apart from red wine that is, but I have now, somewhat to my surprise, started taking Vitamin D tablets. In Scotland, there has been an endless palaver with the Government about they are going to give Vitamin D tablets to everybody, '…no, it is too expensive, we are going to give Vitamin D tablets to pregnant women…', which they are now doing. In England, they give Vitamin D tablets to pregnant women, but only if they are on benefits or if they have other children under four. Vitamin D tablets cost almost nothing. If you go to Sainsbury's, I have forgotten how much it costs, but you can buy 200 for about £5, so I strongly recommend – and I do not own any Sainsbury's shares – that you do that. It is very, very hard to overdose. One of the arguments that was used for getting rid of school milk was that people were overdosing on Vitamin D. That is nonsensical! You would have to take heroic amounts to overdose, you really would. I take 25 micrograms. Plenty of people take 100.

So, what is going to happen to the Vitamin D problem in the future? It is certainly there, and it is certainly getting worse worldwide. The World Health Organisation has called it "an international epidemic of frightening proportions". It is happening everywhere, mainly because people are moving indoors. We no longer have the outdoor life we used to have. Artificial light is everywhere. So, it is certainly there. But some things, perhaps, help mitigate the effects. Plenty of things have changed in Edinburgh – that is the time people spent outdoors.

This is the New Club in Princes Street, a magnificent Victorian building. In 1963, the year I went to the University of Edinburgh, well, late 1962, and I remember walking up and down Princes Street, without really realising that you were surrounded by some of the finest architecture in Europe. That was 1963. Then came the '60s and '70s, and great improvement was made to the New Club. That is the New Club in 2017, that vile excrescence! So, that has changed.

The weather in Edinburgh has changed. This is a reduction in the Scottish snow and frost, which reflects the amount of sunlight over the year, 40 years, from 1970, and you can see a dramatic amount of reduction, 30 days less in lots of Scotland, of frost and snow. That, of course, is part of global warming. So, if that carries on, Scotland will get to be, possibly, a rather nice place, in terms of climate – it is a nice place anyway, but in terms of climate. These are various predictions for what might happen to the climate in Scotland. The temperature will probably go up between three and five degrees by 2080, which will be more than the world average because it is starting from a low level. That is going to improve life in Scotland.

A rather well-known European once saw some pictures of Edinburgh in the 1930s, and he came out with a telling phrase. There is a picture of a sunny day in 1930s Edinburgh. That picture was seen by a gentleman who is lost to history, Joseph Goebbels, and in 1938, he wrote: "Edinburgh will make a delightful summer capital when we invade Britain." Well, they are no longer going to invade Britain, but if they wait long enough, it will indeed make a delightful summer capital.