In this TEDxQUT talk, titled "Mathematics of Weight Loss", Ruben Meerman, a reporter on ABC television's Catalyst program and Play School's first ever 'resident scientist', answers the question: When you lose weight, where does it go?

All right. Well I might get myself into a position here. And on the red carpet. I don't think I need to introduce myself, do I? But this is the last talk for the day.

We will have a little bit of wrap up after this. And we'll have a little time to reflect and maybe some questions. I know that some of you will want to get home. But let's get cracking, because we've got about 12 minutes. My talk maybe might go for 15, so don't panic if that thing goes over.

Here we go, t**he mathematics of weight loss**. Well, let me start with this. Last year, I went surfing in Fiji. And the resort had a photographer following us around, taking photos. Which is really great, except that I couldn't help but notice this.

Somehow, I'd managed to become five kilograms overweight. Couldn't believe my eyes. So I did what they tell you to do, I ate less and I moved more. And within just three months, I discovered that I'd lost six kilograms. So then I did what a normal person does. I did physics, but anyone would do this. I graphed my weight.

And when I did the linear regression, I discovered that, lo and behold, on average I'd been losing 85 grams a day. Which got me thinking, in fact it got me very curious about this question that I've since discovered most people have no clue about. In fact they've never even thought about this.

And to prove my point, I've made a little video on Bondi Beach. And the question was this: **When somebody loses weight, where does it go?** What does it become? How does it get out of your body? You're probably dumbstruck by the question.

These people were, so listen to this. Where does it go? Where does the weight go? Where does it go? *Um. Um. Um. Well… Well… I don't know. – I don't know. That, I don't know. I don't have an answer for that. These are the mysteries of science. I have no idea.*

I'd like to say into the ether. Into the ether? Ether? It gets used up. The universe. Another dimension. It doesn't go anywhere.

When she loses it, it comes over to me. It becomes nothing. It doesn't exist anymore I guess. That's a very good question. Good question. What a fascinating question.

What would you say? It goes right in the crapper, mate. Sweat. Moisture. And sweat. It evaporates. Out of your ass. It's poo. Ends up on Bondi Beach. That's were it goes.

Well, basically, you burn it up as energy. You burn it as energy? Heat energy. Burnt. Energy. Burn it as energy.

So, what the heck is going on? We're in the middle of an obesity epidemic. I don't need to tell you about it. So why don't these people know the answer to this fundamental question? Because not one of them was right. And we do know the answer.

This is not ground-breaking stuff I'm about to tell you. So let me just remind you of a few things you do know.

What's the chemical formula for water? H_2O. Chemical formula for carbon dioxide? You all know it. CO_2. Right, so you know what human fat is made of. So what is the chemical formula for human fat? There is such a thing, believe it or not, it's been known since the 60's. It's $C_{55}H_{104}O_6$. That's the chemical formula for the average fat molecule in a human body.

Some of the molecules might have a few more carbon atoms and hydrogen. Some might have less. They all have just six oxygen atoms. That's very important and helpful for later. But this is the average fat molecule. $C_{55}H_{104}O_6$.

So let's be very clear about this. The difference between that…and that…is $C_{55}H_{104}O_6$. I kid you not.

And the difference between that… and that? Same thing, $C_{55}H_{104}O_6$.

So how does this stuff get out of a human body? Well, here's the general equation. Looks pretty interesting, slightly complicated. Not if you've done some year-ten chemistry. Surely this is year ten chemistry. Well, it's not, really. But here's what it says.

Fat + oxygen => carbon dioxide and water.

That's what it becomes. Biochemists have known this for ages. You inhale that. You exhale that. That's what happened to it. Amazing.

Now that little arrow there is kind of oversimplifying something called Biochemistry. That's three years at university. My apologies to the biochemists. I don't mean to oversimplify. But I'm trying to get to the crunch. It's really complicated. It doesn't just come out of you for no reason. You've got to do stuff. Eat less, move more. We'll come to that in a minute.

Look, when you lose weight, you want to lose kilograms. That's all kilograms. All the stuff there. So why do people say heat? It burns up as energy. Because that's what we've been telling them all this time. And it's very confusing because energy has different units, kilojoules, or you might use calories. And yes, that's heat. That's motion, when you move. Or it's thinking. Your brain needs energy. Or it's growing. But that's not where the fat goes.

So what are we talking about here? Let me just show you a couple more things. I've got some carbon dioxide here in its frozen form. We call it dry ice. It's carbon dioxide. It has mass. The thing is you're not used to seeing it. But here's some dry ice. It's heavy, and if you put it in water…Lo and behold, it does this cool thing and bubbles. You've all seen that before. That's carbon dioxide and water.

That's what fat is kind of made out of, but it's not fat. I'm not making fat. That is not fat.

So, how does that become fat? Well it doesn't, just like that. It becomes sugar first. Plants make fat. Well, they start the whole thing. A plant takes six molecules of carbon dioxide and six molecules of water, uses an amazing chemical called chlorophyll, holds them together and then sunlight comes in and binds those molecules together and that becomes sugar. C6 H12 O6 is glucose.

Fructose, same formula, C6 H12 O6. Sucrose is glucose plus fructose stuck together minus some H2O molecules. So it's, do the maths…C29 H22 O5.

Well here's some. This is sucrose. Plants make it. It's this stuff joined together. It's now got chemical energy holding these molecules together so they don't just fly around like that. And by the way if you drink that 600 mil of lemon-flavored soft drink, you'll get 17 teaspoons of this stuff in there. 'll just quickly show you what that looks like.

Here's one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, right. So if you drink that, it's the equivalent of doing what I just did with a spoon, except munching it all down. Exactly the same, no difference.

So if you do that, then what happens? Well, let me explain something else that I've been telling kids for a little while, and they get this. When you eat food, it's not in your body straight away. If you swallow that sugar, it's not in you yet. So, here's a pool noodle with a hole running through it. And here's an almond.

Now, if you put the almond in there, it can go all the way through and out the other end. Here's another almond. If I put an almond in here, where's the almond? You would say the almond is in the pool noodle. But is it the foam that the pool noodle is made of? No, of course not, it's just in the hole that runs through it. That's food.

You swallow food, it's not in you. It's in the hole that runs from here to the back door. Getting food into you is called digestion. So with this stuff, you've got to break the bond that's holding the fructose to the glucose. And as soon as you do that, then that stuff can cross the barrier into your skin and into your body and then it can go around in your blood. That's digestion, but it's not metabolism yet. It's got to go into your cells and then you've got to burn it up.

And if you don't burn it up, if you eat all that sugar after you've had your three meals in the day, your body doesn't waste it, it doesn't come out here. The stuff that comes out the back door was never in you. Apart from a few molecules of cholesterol, it's just fiber that you couldn't digest plus the bacteria that live in your gut. You lose about 500 billion of those in one single sitting. They're tiny. That's many times the population of the Earth, every time you flush the toilet. It's amazing. But that stuff was never really in you.

Here's what happens if you don't then metabolize that sugar. Well, then it's going to get converted into the stuff that we all have a problem with fat. Now I'm just going to prove that you do breathe this stuff out. If you metabolize sugar you turn it back into carbon dioxide and water.

So…every time you exhale, out comes a bit of carbon dioxide. You can't see it, this is the problem. This is why people don't know how you lose weight. So, there you go, I've trapped some breath, I've inhaled that. Five percent of the air in there is now carbon dioxide, because it's come out of my lungs. I've got some liquid nitrogen here, and I'm going to use that to freeze this air. Liquid nitrogen's minus 196 degrees. Very handy. It's right there.

In fact, I'll just pour it straight on. So, be a little bit careful with this stuff, I use it all the time. If I look a little blasé, I don't mean to. Please respect this stuff if you play with it. The way you would respect boiling hot water.

Now, if you pour it onto a balloon the balloon does not pop. Which is incredible. The nitrogen's minus 196. Oxygen turns into a liquid at minus 183 degrees. So, the oxygen in the balloon is turning into liquid. Carbon dioxide turns solid. I've got a big bowl of it there. But it turns solid at minus 78 degrees.

So, in the balloon now, I have liquified oxygen and frozen carbon dioxide. And when I take it out, you'll see them. It will just take a while for the balloon to go a little bit clear at the top. The nitrogen's in here. Air is 79% nitrogen. The nitrogen is in the top of the balloon. But now look at that liquid down there. Can you see that? That's the oxygen from my breath that I hadn't used.

But once it's all gone, there'll be some white powder left. The white powder is breakfast. That's the carbon dioxide, the carbon atoms I ate in the last 24 hours. And when I blow on them, they get warm enough to turn back into gas. And they vanish, and people think there's nothing in the balloon. The balloon has mass. Those atoms have mass.

You see carbon dioxide has mass when you solidify it. But when you breathe it out, you don't see it. And we've been confusing people by talking about kilojoules or calories. And they're really important. But people do not seem to understand that when you lose weight, you're losing atoms. You can't just turn atoms into nothing.

In fact, science teachers out there, you need to change the way you teach chemistry. Because those people and many in this room think that you can turn atoms into energy. Well, it's one of the founding principles of modern chemistry. You cannot turn an atom into pure energy. It's called the conservation of mass. Before a reaction and after a reaction, we teach kids, you've got to have the same number of atoms. It's called stoichiometry.

Well, we haven't been teaching it very well at all, because people think you can turn fat, which is kilograms, into nothing, or just kilojoules. Can't do it!

So, here was my big fat question. I'm a physicist, I knew that bit. But my question was, if I've got 10 kilograms of this stuff, then how much carbon dioxide does that become, and how much water? It turns out that that's really simple too. This is year ten chemistry and year ten maths. You need the periodic table of elements. You have to look up hydrogen, carbon and oxygen. There they are.

Now the periodic table has some important information on it. The weight of a single atom of these elements. So, the weight of a single atom of carbon is 12.011 atomic mass units. It doesn't matter what they are in kilograms just yet, I'll show you why in a minute.

We've got 55 of those in an average fat molecule. So there's 660.59. Okay, great, what about the hydrogen? There's 104 of those. So, we have in one molecule of fat, 95.996 atomic mass units. The oxygen's a little trickier, this stumped me for quite some time. In fact, I rang around, and I couldn't get a very clear answer on this, because not many biochemists have thought about it this way. That's not because they're silly or whatever. They just haven't thought about it in this way. Which really surprised me.

Because this bit of information is the most motivating bit of information I had in my personal little journey of losing 17 kilograms in six months. It's all gone. (Exhales)Breathed it out. Amazing.

Anyone can do this. This is not hard.

So, how much carbon dioxide and water? Well, the oxygen's important. There's six atoms of it in a molecule. But what are they going to become? Will they go out as carbon dioxide or are they going to go as water or are they going in some ratio of the two? How do you figure this out? Took me ages.

ALSO READ: The Obesity Pandemic: Andrew Newton at TEDxDouglas (Full Transcript)

And then the answer turned up in a very old paper from the 1940's where they'd taken water, labeled the oxygen atoms, put an isotope of oxygen onto those, oxygen 18. Gave it to mice. The mice had it go into their belly. But then it came out in their breath. So water had the oxygen in it but then that oxygen turned up in the exhaled breath. Which showed that oxygen atoms are exchanged between carbon dioxide molecules and water molecules.

There's a really good reason for that. Here's some phenolphthalein in water. It's a bit hard to pronounce. It's gone a bit murky because I've left it sit. But if you blow in here…Changes color. Great, whop-de-do.

What does it show you? Shows you that carbon dioxide dissolves in water, forms carbonic acid. There's an exchange of oxygen atoms. So what this told me is that the way these six atoms are going to leave your body is in the same ratio that they existed in the molecule. So that's a two-to-one ratio. So that means four will go out as carbon dioxide and two will go out as water. That's great, now I know the answer.

So, now you do the maths. So we've got the first two answers. I'm going to add to the carbons the weight of four of these oxygen atoms. They're going to go out with carbon. So I'll chuck that up there. And I've got two to go. So two times that, there we go, chuck that with the hydrogen because they're going out with some hydrogen. And now I can figure out the ratio of carbon dioxide and water from my fat. So there's the total.

And now we've just got to divide it by the total. And you get 84% will go out as carbon dioxide and 16% will go out as water. So here's the answer, then, to my big fat question. 84% of fat is exhaled, 16% is excreted as water somehow. Can be in the urine, in the feces, sweat. That means that 10 kilograms of fat becomes 8.4 kilograms of invisible gas that you breathe out. That's amazing!

Every time you're doing some exercise and your breathing rate goes up, you're losing more weight than when you're sitting down and not breathing as rapidly. And 1.6 kilograms will come out as water. Now, we don't know if that comes out in your poo or in your wee or in your sweat or in your tears because you cry a lot, who knows.

But now, I've got some frequently asked questions that I need to answer because there's lots of them.

Well, there's three main ones. **One, can I just sit around and breathe more?** Everyone asks straight away. Well, you can sit around and breathe more but it's called hyperventilation. You've got to coax the C55 H104 O6 out of the fat cells, they're called adipocytes. And to do biochemistry, man, it's amazing what really goes on.

It's a long story but you need to get them out by first of all moving more or eating less. You've got to starve yourself of energy so that you start turning these big molecules of fat, they get broken into three fatty acids each. They're called a triglyceride, but they have to be broken apart before they can come out of the cells, the hidey-holes that they live in. In your bingo wings or your double chins or your butts or your muffin tops or wherever it is. It's hanging around in there. It's not going to come out until this hormone breaks them apart into its fatty acids and goes into your blood stream and then you can oxidize and beta oxidize, a big long story. Really complicated. Amazing that we know.

But FAQ number two is: **Does weight loss cause climate change?** Well this is another really disturbing little thing, because it means people don't understand climate change. They just don't. Because if you did, you wouldn't even think that. But people think, "So why doesn't it cause climate change?" Because food was made by plants just in the last couple of years. And the way it did it was it took sunlight and glued water to carbon dioxide. When you eat you're actually, the energy is sunlight. It was put there by the sun. I'm not a hippie, but I just about am, because I think that this is amazing. You eat sunlight. That's the energy that you get. But it's modern sunlight.

When you burn fossil fuels, that's ancient sunlight. It's locked up in the ground as carbon in wood, dead wood. Ancient fossilized coal. Oil is ancient dead fossilized critters that lived in the sea that photosynthesized, that died, that got buried. That eventually turned into oil. This does not cause climate change. And the fact that people don't know that means we need to teach them more about climate change. No wonder there are so many myths about both these things. There are myths about weight loss. There are so many diet gurus out there. Mate, if they didn't know this, are you going to trust anything else they have to say to you? No, hopefully not.

Stop buying their books, their pills, they're rubbish. Why did you not know this until today? I don't know the answer. But it certainly makes me very, very skeptical about any health claim that anyone makes who's supposedly a guru.

The third question, that you don't get asked but I should get asked. That I don't get asked at all. Except a biochemist would be wondering it right now. **Did you take into account ketosis?** And no, not really. I did not.

Ketosis is when you starve yourself of carbohydrates. When there's no glucose in your blood. And you can do this thing called ketogenesis. Your liver does it and it can convert fat molecules into ketone bodies. Acetone is one of them. You go to a nail shop. Get your nail polish removed. Acetone. Your body makes that stuff. But you don't want to make it in huge quantities because you'll go into acidosis.

So, I'm not going to comment on whether or not eating low protein diets is a good idea because I'm not an expert on that. I would be careful, because in some papers it's linked to depression. I don't know. I'm not making any health claims about low-protein diets. What I'm saying is that this is very simple.

If you just do what I did and what lots and lots of other people did…I don't want a medal, it's easy. All you have to do to lose weight is turn it into carbon dioxide and water.

And to do that, all you have to do is eat less, move more and keep breathing. Thank you.

Sharing is caring! Share on FacebookShare on TwitterShare on LinkedinShare on Pinterest
Multi-Page