The **Shedding Light on Energy** series allows teachers to teach the topic of Energy without actually using much energy! With a perfect mix of biology, chemistry, and physics, we explore every aspect of energy including what it is and how we measure it.

**In Episode 2, Measuring Energy**, we look at the “joule”, the unit for energy. We look at how much energy is stored in different foods by comparing apples and oranges (normally a no-no) and we discuss how much energy we need to do certain things including nothing much at all. We then explore the concept of energy balance and reveal the two simple rules for weight loss. That’s right, there are only two!

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**Part A: Introduction.** Energy is measured in Joules.

**Part B: Joules:** What is a Joule? What is a kilojoule? How much change can it make?

**Part C: Energy Expenditure:** How much energy do you need to sit down and relax? How much energy do you need to go for a run? And how many days can a kilogram of fat keep you going for?

**Part D: Energy Intake:** A car can’t run without fuel, and neither can we. But how much energy does a glass and a half of full-cream, dairy milk actually contain?

**Part E: Energy Balance and Getting It Right:** How do people put on weight or lose weight? And if someone loses weight, where does the fat go?
Shedding Light on Energy Episode 2: Measuring Energy

Kinetic, Chemical, Light, Electrical, Sound, Heat, Elastic Potential, Gravitational Potential, Nuclear

Part A: Introduction

Energy. There’s no way of defining exactly what it is, but energy is needed to make things change and to make things happen. We can describe it and describe what it does AND we can also measure it!

In our last episode, we saw that energy comes in different forms: kinetic, chemical, light, electrical, sound, elastic potential, gravitational potential, and nuclear. We also saw how energy can transform from one form to another. In a light globe, electrical energy is transformed into light energy. Plants transform light energy coming from the sun into chemical energy.

Energy can also be transferred from one thing to another. Here, the kinetic energy of the wind is being transferred to the blades of the wind turbine.

Now as I said, even though we can’t define exactly what energy is, we can actually measure it. The unit that we use for energy is the Joule. So in this episode, we’re going to look at measuring energy in joules. Let’s begin.

Part B: Joules

We typically measure lengths in metres. This ruler is one meter long. The “metre” is what we call a unit for length. We can also use centimetres and kilometres as units for length. We typically measure the mass of something in kilograms or grams. Energy is measured in joules which has the symbol capital J. So how much energy is one joule of energy, and how much change can it make?

If I take exactly 1 kilogram of water (which is 1 litre of water) that has a temperature of 23°C and heat it up to 24°C so that its temperature changes by 1°C, then it has absorbed 4200 Joules of energy. Putting it another way, if 1kg of water absorbs 4200 Joules of energy, it will increase in temperature by 1°C. The starting temperature doesn’t matter; if it had started at 50°C and was heated up to 51°C, a change of 1°C, then it will have absorbed 4200 Joules of energy.

Quite obviously, 1 single Joule of energy is a very small amount of energy. It takes 4200 Joules to heat up just 1 kg of water by 1°C!

So, if 1 kg of water increases in temperature by 1°C when it absorbs 4200 Joules of energy, how much energy will it have to absorb for its temperature to rise by 2°C? Well perhaps fairly obviously it will have to absorb twice as much energy: 8400 Joules of energy.

To increase the temperature by 10°C, you need 10 times as much energy as what you need to increase the temperature by 1°C, or in other words, 42,000 Joules.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Mass (kg)</th>
<th>Temperature Change</th>
<th>Energy Absorbed (Joules)</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td>1</td>
<td>1°C</td>
<td>4200 Joules</td>
</tr>
<tr>
<td>water</td>
<td>1</td>
<td>2°C</td>
<td>8400 Joules</td>
</tr>
<tr>
<td>water</td>
<td>1</td>
<td>10°C</td>
<td>42,000 Joules</td>
</tr>
</tbody>
</table>
Quite often energy is quoted in kilojoules instead of joules.

1000 Joules is 1 kiloJoule, so 4200 J is 4.2 kilojoules, 8,400 J is 8.4 kilojoules and of course 42,000 J is the same as 42 kJ.

Now it probably would come as no surprise to you that a small amount of water will heat up much faster than a large amount of water.

In this simple experiment, I heated up 1 kg of water from an initial temperature of 25°C to a final temperature of 85°C, a change of 60°C, and it took 4 minutes and 50 seconds. I then did exactly the same experiment with 2 kg of water, same initial temperature, same pot, same burner, same thermometer, same everything but a different mass of water, and found that to reach a final temperature of 85°C, a change of 60 °C, it took 9 minutes and 30 seconds, almost double the amount of time. Obviously, you need more energy to heat a larger amount of water by a given amount than you need to heat a smaller amount of water by the same amount.

It’s probably fairly obvious. Twice as much stuff needs twice as much energy. Three kilograms of water needs 12,600 Joules of energy for every degree Celsius increase.

(So, as water heats up, it absorbs 4200 Joules of energy per kilogram per degree Celsius. If you’ll allow me to get a little technical for a moment, this value is called water’s specific heat capacity.)

We can write a simple formula that puts all these facts together.

The Energy absorbed by an amount of water in Joules = 4200 J/kg°C × the mass of the water × the temperature change of the water; not the temperature that it starts at or finishes at, but how much the temperature changes. For example, if 4 kg of water is heated from 20°C to 100°C, how much energy has the water absorbed?

The energy absorbed = 4200 J/kg°C × 4 kg × (100°C - 20°C), a temperature change of 80°C, which equals about 1,344,000 Joules of energy, or 1,344 kJ.

In this case, all the energy comes from the chemical energy in the natural gas that is being burned. The chemical energy transforms into heat energy.

When hot water cools down, heat energy passes from the water to the surroundings and all the same maths as before applies. For example, if 4 kg of water cools down from 100°C to 20°C, it will lose 1,344,000 J of energy while the surrounding air and the bench will gain that amount of energy and heat up of course.

Remember, energy can’t just disappear, it can only pass from one object to another, or transform from one form to another.
Part C: Energy Expenditure

So now that we know roughly what a joule is, let’s look at the energy associated with living things. Our bodies get all the energy that they need from the chemical energy in the food we eat. The chemical energy we take in is called our energy intake!

This energy is then converted by our bodies into kinetic energy, heat energy, and other forms of energy as we do all the things that we do. The amount of energy that we use is called our energy expenditure. But how much energy do we use in doing the things that we do?

Right now, if you’re sitting down watching this program, you are using about, about, 100 Joules of energy per second. It depends on things like your size, your fitness level, your sex, how cold or hot you feel, and other factors, but as I said, the amount of energy you’re using right now if you’re sitting down is about 100 Joules per second.

And what is the energy being used for? Well, for example, your brain is controlling the things happening in your body, your heart is beating, you’re breathing, the food that you ate earlier is being digested, and you’re generating heat energy to maintain a constant body temperature of about 37°C. In fact, about 3/4 of the chemical energy that we take in is used specifically to generate heat.

Mammals (including humans) are what we call endothermic or warm blooded, which means that they (or we) maintain a constant body temperature. The advantage of being warm blooded is that you’re always ready to do whatever you need to do, even in freezing conditions. The disadvantage is that you have to eat more food to gain the energy you need to generate the heat. Many animals however, like reptiles for example, are ectothermic or cold-blooded. Many reptiles move really slowly when it’s cold and have to warm up in the sun before they’re ready to attack their prey. However, a crocodile for example that has the same mass as me, 85 kg or so, which would make it a very small crocodile, would only eat about one quarter of what I eat, because it doesn’t need the extra energy intake to generate heat.

So, if we use about 100 joules of energy per second just sitting down, how much energy do we use in one minute? Well, quite simply 100 J/s x 60 seconds which = 6000 Joules (or 6 kJ). We use about 6 kJ of energy per minute just sitting down.

Standing, not surprisingly, requires a little more energy per second than sitting does, about 120 joules per second. Walking requires even more. The faster you walk the more energy you need per second.

Running requires still more energy per second, but it’s interesting to note than on a bike you need less than half the number of joules per second than you do running at the same speed. But, how do they calculate the amount of energy that people use to do various things?

<table>
<thead>
<tr>
<th>ACTION</th>
<th>Approximate Energy Expenditure (Joules/Second)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting still</td>
<td>100</td>
</tr>
<tr>
<td>Standing still</td>
<td>120</td>
</tr>
<tr>
<td>Walking 3 km/hr</td>
<td>210</td>
</tr>
<tr>
<td>Walking 5 km/hr</td>
<td>300</td>
</tr>
<tr>
<td>Running 9 km/hr</td>
<td>700</td>
</tr>
<tr>
<td>Running 16 km/hr</td>
<td>1300</td>
</tr>
<tr>
<td>Cycling 9 km/hr</td>
<td>300</td>
</tr>
<tr>
<td>Cycling 16 km/hr</td>
<td>500</td>
</tr>
</tbody>
</table>
Well, in a lab, test subjects put on a mask that they have to breathe through while they’re doing some activity. Their heart rate is monitored and the air that they breathe out passes through a sensor that measures how much oxygen is in it. From this data, the computer works out what percentage of the oxygen that they breathed in originally actually entered the blood, and this then gives an indication of their energy expenditure. The more oxygen they take in, the more energy they’re expending.

We typically expend about 8000 to 10,000 kJ per day, depending on our activity level, and as I said earlier other factors such as our size.

And where does all the energy that we need come from. As we’ve seen, it comes from the chemical energy that is stored in the food that we eat. So let’s take a look at the numbers.

**Part D: Energy Intake**

We saw in our last episode that foods are made of certain essential nutrients that we need to live and to grow. Carbohydrates and fats and oils are our fuel, that is, our source of energy.

On average we typically need an energy intake of about 8,000 to 10,000 kJ/day.

By the way, fats and oils are put together because chemically speaking they are very similar, even though fats are solids and oils are liquids. From now on I’m just going to say fats when I mean both! Carbohydrates have no purpose other than to provide energy, but fats provide energy and perform other important tasks in the body, one of which is to help insulate us against the cold.

The amount of energy in fats and carbohydrates has actually been measured.

![Energy Intake Diagram]

Fats contain 37 kJ of energy per gram, while carbohydrates like sugar (this is sucrose sugar) contain about 17 kJ of energy per gram. That’s kilojoules, not joules.

One kilogram of fat therefore, I got all this from my local butcher, contains 37,000 kJ, while 1 kg of carbohydrates contains 17,000 kJ. Remember, we typically only need about 8-10 thousand kilojoules per day, although really active people may need more of course.

This 1 kg of fat therefore contains enough energy to fuel you for about four whole days, while this 1 kg of carbohydrates can fuel you for about two whole days.

Mathematically, it’s fairly easy to work out. If you have 37,000 kJ of energy and your energy expenditure is about 8000-10,000 kJ per day, let’s just average it out to 9,000 kJ, then 37,000 kJ / 9,000 kJ per day = just over 4 days (4.1 days). 17,000 kJ of carbohydrates gives us 17,000 kJ / 9,000 kJ per day which = just under 2 days (1.9 days).

Of course, that doesn’t mean you can just eat a kilogram of fat in one go and then not eat for the next four days. Human bodies don’t work that way. However, lions might only kill and eat, say, a zebra every two or three or four days. They fill up on the zebra and this keeps them going until the next kill, as I said a few days later. Humans can’t really do that. I mean we can survive without eating for days and even weeks, but we can’t do it and operate normally.
Some animals, like certain species of bears, gorge themselves every day while food is available and then they don’t eat for months while they hibernate in caves or under fallen trees in the winter when there isn’t much food around. Their hibernation, which is kind of like a deep sleep, lasts for a lot of the winter. While hibernating their energy comes from the fat that they’ve stored during the warmer months. Once again, humans and in fact most animals can’t really do that.

Different foods contain different amounts of energy depending on their fat and carbohydrate content.

Packaged foods that you buy at the supermarket nearly always have information on the packaging about how much energy they contain and quite often other information is also included like what other nutrients the food contains.

So, for example, 200 mL of orange juice contains, according to the label on the bottle, 340 kJ. (1 mL is short for 1 millilitre, which is 1/1000 of a litre.) 200 mL is considered, again according to the label, 1 serve of the drink. 250 mL of milk contains 650 kJ, and a 375 mL can of sugary drink (this is lemonade) about 700 kJ. Let’s move on to solids.

Two slices of bread (76 grams) contain about 740 kJ, two slices of tasty cheese (21 g) about 355 kJ, 5 grams of butter about 150 kJ, 2 Weet-Bix (30 grams) about 450 kJ, and one sausage (70 g) (well this particular brand anyway) about 700 kJ.

A 200 gram block of chocolate contains 4500 kJ. The package says on the back “Be Treat Wise – Enjoy a balanced diet”. In other words, don’t eat too much of this stuff!

An apple depending on its size contains about 300 kJ of energy, a banana about the same, and an orange about 200 kJ.

The amount of energy in the food is usually quoted not just like I’ve done here, 5 grams of butter or 2 Weet-Bix for example, but in kilojoules per 100 mL if it’s a liquid or kilojoules per 100 grams if it’s a solid. This allow us to compare the amounts of energy in different foods more easily. So let me create a new column in the table showing the energy content in kilojoules/100 mL or kilojoules/100 g.

This brand of orange juice contains about 170 kJ per 100 mL, milk contains about 260 kJ/100 mL and lemonade about 190 kJ/100 mL. And how did I calculate these figures? Well, the first one is easy. If it’s 340 kJ for 200 mL, then it must be half of 340 kJ for 100 mL, and half of 340 is 170 kJ.

To calculate the energy content of 100 mL of milk, it’s easier to use a simple two-step mathematical process. If milk contains 650 kJ per 250 mL, then we can divide 650 kJ by 250 mL which gives us 2.6 kJ/mL. We then multiply this value by 100 to get the energy content per 100 mL. This equals 260 kJ/100 mL.

The number of joules per 100 grams of the solid foods can be calculated in exactly the same way. On this list, butter has the highest concentration of energy, since butter is made mostly of the cream that comes from milk, which is mostly fat. Margarine has exactly the same energy content, but the fat comes from plants, not milk.
Now how do we know that, for example, an apple has 300 kJ of energy in it? How do we measure the energy content of different foods?

To find out the amount of chemical energy in a food, scientists use what’s called a bomb calorimeter.

At a simple level, a small amount of food is dried out and then burned. The heat energy produced is absorbed by water and by measuring how much the temperature of the water rises, the amount of energy that was in the food can be calculated. Here, the chemical energy that the food has is being converted into heat and light energy, but in the body it’s converted mainly into heat and kinetic energy. In this simple set up, a lot of the heat energy that is being produced is not being absorbed by the water of course.

In a lab, the sample of food to be tested is burned in a so-called “bomb”. No, not this kind of bomb, but this thing which is also called a bomb. The bomb is placed inside a container of water so that 100% of the heat produced when it burns (or as much as possible anyway) is absorbed by the water. The whole set up with a little stirrer to stir the water, a thermometer and an electrical source that creates a spark to initiate burning is called a bomb calorimeter. The food sample is completely dried out first and then ground into a powder before being placed into the bomb. High-pressure, pure oxygen is then pumped into the bomb from an oxygen tank so that the sample can actually burn; things can’t burn without oxygen. The “bomb” is then placed into the container of water, the mass of which is carefully measured. Once everything is prepared and covered up, a spark ignites the sample which burns and heats the water. The more energy the food has in it, the hotter the water will get. If, for example, 1 kg of water is used and its temperature rises by 1°C, then the sample of food must have contained 4.2 kJ of energy.

We can see that there’s a huge variation in the amount of chemical energy stored in different foods. We can use this data and the data showing the energy expenditure for different activities to work out how much time it would take to expend the chemical energy in a particular food.

For example, if an apple contains about 300 kJ of energy but sitting requires about 6 kJ of energy per minute, how much time does it take for the energy in the apple to be expended by the body as it sits there (and converted into heat and kinetic energy)? Well, it will take 300 kJ over 6 kJ per minute which is 50 minutes. An apple contains enough energy to keep you alive, to fuel you, for about 50 minutes. Remember all these figures are approximate.

What if you eat a burger instead that contains 2300 kJ? A burger will provide enough energy for you to sit for 2300 kJ over 6kJ/minute, which is about 383 minutes or nearly 6 ½ hours (6.4 hours).

Running uses about 42 kJ per minute, so you would expend the energy in the burger in about 55 minutes. That’s a lot of running (2300kJ / 42kJ/min).

Now the energy content of food isn’t always given in kilojoules. An older unit, called the calorie is often used. 1 calorie = 4.2 kJ. So an apple that has 300 kJ of energy has about 71 calories. 71 is 300/4.2. Food energy tables often quote both amounts, but kilojoules is the preferred scientific unit.
We take in energy in the form of chemical energy every day of our lives of course and we are constantly expending that energy as mostly heat and kinetic energy as we live our lives. But what happens if you take in more energy than you expend or less energy than you expend? That’s what we’ll look at next.

**Part E: Energy Balance and Getting It Right**

In order to answer the question of what happens when we take in more energy than we expend or less energy than we expend, let’s simplify things by looking at cars first.

Cars, like humans, need fuel to operate. When a car is low on fuel, you go to a service station and you put more fuel in. The fuel is burned inside the car’s engine and the chemical energy that was in the fuel is converted mostly into heat energy (the engine gets hot) and kinetic energy (the energy of movement). (chemical \(\rightarrow\) heat + kinetic)

Now regular unleaded petrol (which, if you’re reading this in the USA or Canada, is what you guys call gasoline) is made up mostly of a chemical called octane. Its chemical formula is \(\text{C}_8\text{H}_{18}\), which means that it has 8 carbon atoms and 18 hydrogen atoms. When octane is squirted into the engine along with oxygen, and the spark plug makes it burn, the atoms that make up the octane and the oxygen rearrange and produce carbon dioxide and water. The same chemical reaction is happening here in the round glass dish. (octane + oxygen \(\rightarrow\) carbon dioxide + water) The carbon dioxide and water molecules produced in the engine are then expelled from the engine and come out through the exhaust pipe. As you drive around the fuel tank slowly empties and the car effectively gets lighter and lighter.

So the chemical energy that was stored in the octane, which, as I said is the main ingredient of petrol, is converted into heat and kinetic energy, but the octane itself and the oxygen chemically react and produce carbon dioxide and water. The fuel is an actual thing that you can touch while the chemical energy that it stores is something different.

A fuel gauge tells us how much petrol is in the tank. When the tank is nearly empty, you put more fuel in.

What happens though if, let’s just say, you start with 30 litres in the tank on Day 1 and put in 5 litres of fuel, but only burn off 4 litres of fuel by the end of the day as you drive around? Quite obviously, your petrol tank is going to have 1 more litre in it than it started the day with. If on Day 2 you repeat what you did on Day 1, and put in 5 litres but only burn off 4, and you then did that every day, the tank will get more and more full, and your car will effectively get heavier and heavier. If you keep putting in more fuel than you burn off, what else can happen?!

Let’s look at a different scenario. If you put in only 3 litres of fuel every day but burn off 4 litres by the end of each day, then your tank over time will get emptier and emptier. You can probably see where I’m heading with all this.

Last scenario. If you put 4 litres of fuel into the tank every day and then burn off 4 litres per day as you drive around, then, over time, the car’s weight will stay more or less the same. (Of course in reality we only put petrol in when we’re running low.)

Now the human body is obviously a lot more complicated than a car, but, at its most basic level, there’s an obvious similarity.
We take in our fuel, the carbohydrates and the fats and oils that we eat, digest them, and then burn the fuel in our cells to get energy. Of course it’s not really burning, even though we often use that word.

The process of using the chemical energy that is in the food that we eat to provide energy for our cells to operate is called “cellular respiration”.

As we saw in our last episode, wheat flour, and potatoes, corn, and rice, which together make up a huge percentage of the food that humans eat worldwide, are made in large part of starch. Starch is made of hundreds of glucose molecules that the plant has chemically joined together in a long chain. The digestive system of our bodies (label in diagram: mouths, stomach and intestines) breaks down the starch into individual glucose molecules (this process is called digestion) and these individual glucose molecules then enter the blood and are transported to our cells.

Meanwhile the oxygen in the air that we breathe in also enters the blood via our respiratory system and it too is delivered to our cells by the blood.

In cellular respiration, the glucose and the oxygen chemically react releasing the chemical energy that is stored in them and this powers the activities of our cells, muscle cells for example. Carbon dioxide and water are produced as waste products.

The carbon dioxide and quite a lot of the water are then transported by the blood to the lungs and we then exhale them. The fat that we eat also takes part in cellular respiration. The waste products of burning fat are also CO₂ and H₂O, which are removed from the body, again, mostly through the respiratory system.

Our respiratory system is not just there to get oxygen into our bodies, it’s also like a car’s exhaust pipe that gets rid of the carbon dioxide.

So, as we go about our business we burn off our food and slowly get lighter and lighter, just like a car gets lighter as it burns off its fuel.

The atoms that had originally made up the carbohydrates and fats that we ate are expelled from our bodies via our lungs mostly as CO₂, but with a fair amount of H₂O as well, though a lot of the H₂O produced is just recycled and used for the million and one other jobs that water does in our bodies.

People often think that our poos and wees (our faeces and urine) are our main waste products, but in fact the biggest waste products of the cells of our body are the carbon dioxide and water molecules produced when our cells “burn” carbohydrates and fats to provide the energy that the cells need. All of the carbon dioxide molecules produced and a percentage of the water molecules produced are expelled from our bodies via the lungs and our mouth and nose.
Since different foods are made of different combinations of nutrients and they all contain different amounts of water, rather than measuring the amount of food we eat in kilograms or grams, we typically express the amount of food we eat in kilojoules.

These foods, which consist of a fairly healthy mix of fats and oils, carbohydrates, protein, vitamins, minerals and fibre, contain about 8½ thousand kilojoules of energy stored in the fats and the carbohydrates that are in them, and so they provide enough energy for a person whose energy expenditure in one day is also about 8½ thousand kJ. If, over time, our energy intake is greater than our energy expenditure, our bodies store the extra fat (that we haven’t needed to burn off) in specialized fat cells, which are mostly just under our skin. We would therefore gain weight. If, on the other hand, our energy intake is less than our energy expenditure, that is, the fuel that we’ve eaten is not enough to supply the energy that we need, then our bodies use the fat that we’ve stored in the past as fuel. The fat that is stored is burned off and all of the carbon dioxide that is produced is breathed out along with a fair amount of the water, although much of the water produced is also used by our cells for other purposes. As a result of the fat burn off, we would lose weight, just as a car gets lighter as it’s driven around.

(I might just make that point again. The waste products from burning fats and glucose don’t leave our bodies in our poos and wees, but rather out of our mouth and nose via our lungs. Fat can’t just disappear or melt off as some internet ads say, and the wastes we get rid of in the toilet have different sources. In fact, by far our biggest waste product is carbon dioxide. We just don’t notice it as much because it’s an invisible gas.)

If our daily energy expenditure is the same as our daily energy intake, then, over time, we’ll stay the same weight, more or less.

So for example, what happens if the person here keeps their energy expenditure the same every day, but decides to include, on top of their daily energy intake of 8½ thousand kJ a can of sugary drink every day? A can contains 700 kJ of energy, all of it in the sugar they put into it, sucrose sugar; 40.5 grams of it, in fact, or about 10 teaspoons.

<table>
<thead>
<tr>
<th>Meal</th>
<th>Foods Eaten</th>
<th>Energy Intake (kJ) (All values are approximate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast</td>
<td>3 Weet-Bix (30 g) 1 cup milk 1 orange</td>
<td>670 650 200</td>
</tr>
<tr>
<td>Snack</td>
<td>1 banana</td>
<td>300</td>
</tr>
<tr>
<td>Lunch</td>
<td>4 slices of bread 10 g butter 2 slices of cheese 30 g ham 1 apple</td>
<td>1,480 300 160 300</td>
</tr>
<tr>
<td>Snack</td>
<td>30 grams cashews 1 tub yoghurt</td>
<td>765 540</td>
</tr>
<tr>
<td>Dinner</td>
<td>90 g rice 1 piece of chicken bowl of salad 75 grams steamed broccoli carrot corn 10 g salad dressing</td>
<td>1350 800 100 174 350</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>8,494</strong></td>
</tr>
</tbody>
</table>
After just thirty days, their extra energy intake will be 700 kJ a day times 30 days which is 21,000 kJ. When our bodies have enough carbohydrates, our bodies prefer to burn off the carbohydrates rather than the fat in our diet. It’s just much more efficient that way. So, in this example, because the person is consuming extra carbohydrates, there’s a whole lot of spare fat, 21,000 kJ worth, that the body doesn’t need to burn off anymore since there’s all the extra carbohydrates around. So the body will simply store away the unburnt fat that we’ve eaten. And what weight gain will the person experience after 30 days? Well, 1 kg of fat stores 37,000 kJ of energy. So 21,000 kJ is about 0.57 kilograms of fat! (0.57 is 21,000/37,000ths) It’s about this much fat in just one month. In 12 months, we’re talking nearly 7 kilograms (0.57 x 12 = 6.8). So we obviously have to be careful about the foods that we eat.

Of course this is a very simple example. In reality our energy intake and our energy expenditure vary a lot day by day, but there is little doubt that we in western countries eat too much sugary food and drink too much sugary drink that we simply don’t need to eat and drink.

Once again, applying a little maths, if you do take in an extra 700 kJ but you want to expend it by, say, going for a run at about the speed I’m running now (about 700 J/s at 9 km/hr), which is using about 42 kJ/minute, then quite simply the approximate time it will take to expend the energy is 700 kJ/42 kJ/minute which is about 17 minutes. A can of sugary drink has a lot of sugar. (9 km/hr = 2.5 m/s = 100 m in 40 seconds.)

Now we have to remember that it’s not only the energy content that we should be concerned about when we’re talking about food. All the nutrients that the food contains are important to our health.

Milk has 260 kilojoules per 100 mL, which is more than sugary drinks have, but it also has protein, vitamins, and minerals which your body benefits from. It fills you up and so you feel less hungry afterwards. Sugary drinks have no nutrients except for carbohydrates in the form of sugar (and most people would say that drinks like these definitely don’t leave them feeling satisfied.)

Now since there’s so much variation between people, it’s hard to generalize, but most teenagers have the right balance between energy intake and energy expenditure.

However, the statistics suggest that as people get older and older, they often increase the amount of fat that they store in their bodies, if you know what I mean. I hope that I’m being polite enough.

Teenagers and younger kids are often involved in sports, or they participate in Physical Education classes. They often have to walk or ride their bikes to school or wherever else they go so their energy expenditure is relatively high.

By the time they’ve reached, say, their 30’s or 40’s though, many have cut down on the amount of physical activity that they do, they drive everywhere instead of walking, and their jobs often require them to sit for long periods of time, but they don’t necessarily cut down on their energy intake.

If you eat as much when you become less active as you did when you were more active, then your body is going to store the extra fuel you’ve taken in as fat.

Many people also increase their energy intake as they get older, eating more snacks and sweets and treats.

When I was in my 20s, I was playing Australian Rules football on Saturdays, I was training twice a week and I was often playing other...
sports like indoor soccer. I was eating a lot of food. For breakfast I was having a big bowl of cereal, and for lunch I was having three full sandwiches, an apple, and a banana. When I stopped playing for the football club, I kept eating the same way I was before and found that a few months later, I had put on about 5 kilograms. I changed my breakfast to 2 toasts, cut down on the sandwiches, stopped drinking sugary drinks and then lost it all again.

Now because a lot of people do put on more weight than they think is ideal, weight-loss programs, and diets, and dieting, and diet books, and weight-loss pills and powders and potions and stuff all form part of a huge industry worth who knows how many millions of dollars. But there are only two simple rules for weight loss.

**Rule 1 For Losing Weight:** Firstly, you can only lose weight if your energy expenditure is greater than your energy intake. You have to burn off more than you take in. To do that you can either

- increase your energy expenditure (by doing a little extra physical activity every day), or you can
- decrease your energy intake, (You can do this by eating less or by changing what you eat or both). This one chocolate bar contains about the same number of kilojoules as all the fruit. 1 Boost Bar (1310 kJ) = 1 apple (300 kJ) + 1 banana (300 kJ) + 1 orange (200 kJ) + 150 g of strawberries (200 kJ) + 50 g of blueberries (100 kJ) + 1 kiwi fruit (200 kJ). So replacing a sugary snack with a selection of fruit will allow you to decrease your energy intake without necessarily eating less.
- Of course, it’s probably best to increase your energy expenditure and decrease your energy intake.

As we’ve seen, to burn off just 1 can of sugary drink needs about 20 minutes of jogging, which might be hard to do every day, so as I said, it’s probably best to do a combination of a little extra activity combined with a reduction in energy intake.

**Rule 2 For Losing Weight:** The second simple rule for anyone trying to lose weight is that you have to do it in a way that doesn’t leave you feeling constantly hungry and unable to function properly.

Here once again, the key is to change not just the amount that you eat, but also what you eat. For example switch from this to a selection of these. You’ll feel full without having taken in as many kilojoules. (You can basically eat as many fruits and vegetables as you want really.)

So, instead of eating a chocolate bar for a snack, just eat a banana.

This change alone, without doing anything else, reduces your energy intake by about 1000 kJ.

Which means that the body has to dig into its fat reserves. After only 37 days, you will have burned off an extra 37,000 kJ which is equal to, as I said earlier, a kilogram of fat. Not bad for such a minor change.

So there’s no need to go on special diets or to pop pills or anything. Just stay fairly active and eat well without overeating.

(Although having said that, most of the publishers of these magazines and books would say that they’re simply providing ideas for nutritious and filling foods or ideas for fun and effective exercises.)

Now I mentioned earlier, that most of the chemical energy that we take in is transformed in our bodies into heat energy. This is also true of, for example, light globes. Light globes are supposed to convert electrical energy into light energy and they do, but they also produce a significant amount of unwanted and wasted heat energy. The
amount of useful energy you get out of something compared to the energy that you put into it is called energy efficiency, and it’s what we’ll be looking at in our next episode. See you then.

Credits Voice Over!

Actually, before I go, I might just mention that while making this series, I actually lost about 4 kilograms. A significant proportion of the series was shot in Greece and while we were over there filming, I put on about 2 kilograms. I must have eaten too many souvlakia. When we got back, I stopped eating crackers and spring onion dip for afternoon snack, which I quite like, and just ate a banana. After about 3 months, I had lost all the weight I had put on and then another 2 kilograms. Fruit and veg are the best! Anyway, as I said, I’ll see you next time.

Credits:

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Fresh salmon dinner is served! and Veni, vidi, vici by Katherine T. Creative Commons license.

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The Energy Expenditure Tables used in this program are approximate and based on the following sources:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4448542/
https://www.ncbi.nlm.nih.gov/pmc/articles/11101470

The preference of the body in burning carbohydrates (glucose) in preference to fats was researched by Hellerstein MK in the paper “De novo lipogenesis in humans: metabolic and regulatory aspects” (see https://www.ncbi.nlm.nih.gov/pubmed/10365981) and by J M Schwarz, R A Neese, S Turner, D Dare, and M K Hellerstein in the paper “Short-term alterations in carbohydrate energy intake in humans. Striking effects on hepatic glucose production, de novo lipogenesis, lipolysis, and whole-body fuel selection” (see https://www.ncbi.nlm.nih.gov/pmc/articles/PMC185982/).