A Healthy Liver Will Always Deliver!

Concept & story: Mireia Alemany i Pagès · Script: João Ramalho-Santos
Illustration: Rui Tavares · A participatory approach with editorial support by Anabela Marisa Azul
Do you know what your liver is?
Do you know the many important things it does for us, keeping us healthy and alive?

Did you know that our dietary habits can affect the wellbeing of our liver?
Or that a sedentary lifestyle can harm it?

You probably are not aware, but one in every four people in the world has Non-Alcoholic Fatty Liver Disease (NAFLD), which can go unnoticed for years and result in severe liver damage, cirrhosis and even hepatic cancer. Are you one of them?

The excessive accumulation of fat in the liver is caused by unhealthy diets and sedentary lifestyles. Are you at risk?

Although you can have it without being overweight, people that are obese and those with Type 2 Diabetes have a higher risk of developing NAFLD. So, how can we fix this?

Get to know your liver better with this comic and find out how to treat and prevent this form of liver disease!

Think of your liver the next time you eat, and don’t forget to stay active for its health and your wellbeing.

Remember that a Healthy Liver will Always Deliver!
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When we are told we are ill, we learn many new things... that at times, even show up in our dreams.

So much bad behavior is getting your liver fatty...

You'll end up with a cirrhosis... Do something before it's too late...
When we are told we are eating, we learn many new things… That at times, even show up in our dreams. So much bad behavior is going your liver away… Giving out advice, warning or frightening us… And we must wake up. You’ll end up with a cirrhosis… Do something before it’s too late…

And we must wake up.
How long until we get to Aunt Alice's home?

Just a bit longer sweetie...

I don't get why you would want to spend the holidays with my sister...
How long until we get to aunt Alice's home? Just a bit longer…

I don't get why you would want to spend the holidays with my sister…

You are not helping dad… it isn't easy to deal with all this. It takes a long time to solve this fatty liver thing. There is so much we need to change…

Nonsense! I've always drunk and eaten well!

And look at the outcome…

Whatever the case, Vic and I need to be careful…

Young people these days…
Dear family,

I went shopping.

Brother: use your key and get yourselves in...

See you soon!

Alice

Victoria, come, do you want to see something?

Yes, grandpa!

Look, it's dad!

But that's not mom!
NO...THAT'S ME AND AUNT ALICE WHEN WE WERE YOUNG.

HERE, THESE ARE YOUR PARENTS...

WOW! DAD USED TO BE VERY SLIM AND YOU LOOKED A LOT ALIKE! TWO GOOD-LOOKING GUYS!

HELLO, HELLO! HOW WAS YOUR TRIP?

IT WAS FINE, SIS.

THANK YOU FOR HAVING US AUNT ALICE.
Jaime, did you bring the glucose monitor that I asked for? I really need it to control my diabetes.

Yes... you and your modern widgets...

I'm hungry! Can I have some cookies?

But I always eat cookies...

Not now, we'll have dinner soon. You can set up the table!

Precisely, we are gonna try something new Vic...

Doctor's orders.

Is Vic sick?
She is overweight and the pediatrician is worried.

There is a lot of obesity in children these days and they are getting serious diseases in the liver.

Like your father's cirrhosis...

He never got himself to stop drinking.

Don't tell Dad...

Yeah, the doctor said that people that don't drink can have cirrhosis, even kids...

And Maria thinks that it is my fault...

I am not the best role model and I give in to everything she wants...
That's why she didn't come with us, I am trying to see if I make some changes in my life...

But Vic has cirrhosis?!

What do I have, dad? What is a mitosis?

Cirrhosis, love... and you have nothing of the sort. It's Grandpa who has it.

Bah!
Our body is a highly functional machine, but sometimes one of its organs gets sick.

One of these organs is the liver, that has to take control of a lot of stuff, from the quality of the blood to the energy levels of our body.
When the liver has been suffering for a very long time it can stop working and develops a disease called cirrhosis. There are people that even need a new liver...

Just as a wound in our skin heals, our liver too mends its injuries with a scar.

The scars of the liver are called fibrosis.
When the liver has been suffering for a very long time it can stop working and develops a disease called cirrhosis. There are people that even need a new liver...

Just as a wound in our skin heals, our liver mends its injuries with a scar. Cirrhosis develops over a long time, as fibrosis accumulates.

Injuring the liver over and over again causes inflammation. That is called hepatitis and forces scarring on the liver.

Cirrhosis develops over a long time, as fibrosis accumulates.

What an exaggeration! You all want to die full of health...

Steatohepatitis
It is a very long process. We don’t even notice… How was the gym?

Do you want some salmon with veggies?

I’ll defrost something later, go ahead.

Don’t give that to the kid!

But I feel fine, nothing hurts.

There are no obvious symptoms like stains or aches.

But over time, some of our behaviors force our liver to accumulate a lot of fat…

It’s not the liver’s fault, but getting fatty can cause inflammation.

Do you drink?

Not much…

Another glass?
Don't give that to the kid!

There are no obvious symptoms like stains or aches.

But I feel fine, nothing hurts.

Don't give that to the kid!

Several things can lead to the same result.

There are no obvious symptoms like stains or aches.

But over time, some of our behaviors force our liver to accumulate a lot of fat...

It's not the liver's fault, but getting fatty can cause inflammation.

Do you drink?

Not much... Another glass?

That's enough Jaime.
Sometimes the liver gets fatty when infected by the hepatitis virus, but in most cases, it depends on our behaviors.

So, it's not a disease that you can catch, like the flu?

If we eat badly, drink too much and don't exercise, the liver has to work overtime, and eventually it gets tired… it deteriorates and becomes fatty.

It doesn't stop working all of a sudden, but if we don't do anything about it, it keeps on getting worse…

Non-Alcoholic Fatty Liver

The doctor calls it NAFLD. Probably, I have the liver inflamed, which is what comes next, right before the cirrhosis. Just like me… I was diagnosed with Fatty Liver.

Healthy Liver

Fatty Liver

Alcoholic Fatty Liver

Unhealthy diets, the lack of physical activity, the excess of alcohol…

1 in every 4 people

Hepatitis Virus
If we eat badly, drink too much and don't exercise, the liver has to work overtime, and eventually it gets tired... it deteriorates and becomes fatty.

It doesn't stop working all of a sudden, but if we don't do anything about it, it keeps on getting worse...

Healthy Liver

Non-Alcoholic Fatty Liver, because I never drank alcohol. The doctor calls it NAFLD. Probably, I have the liver inflamed, which is what comes next, right before the cirrhosis.

Just like me... I was diagnosed with fatty liver.
Maybe it's genetic? Transmitted from parents to children.

That's what I asked... The doctor said it's partly genetic, but mostly due to our bad dietary habits and the lack of physical activity. And unlike our genes, those things we can control.

The alcohol thing I can understand. Many of my friends drink and have liver problems... but food being harmful for the liver...

It's not the food... It's the excess of food, or the wrong kinds of food, basically when we eat more than what we spend.
This can make us gain weight. It's enough to divide our weight by twice our height to know whether we are in range or overweight.

\[ \text{BMI} = \frac{\text{Weight}}{\text{Height}^2} \]
When we become overweight, our fat reservoirs fill up...

They don't manage to store it all correctly and the fat spills into the blood...

And it has to be the poor liver the one that deals with it.

The liver works as a filter that catches the fat from the blood and retains it. That's how it becomes fatty.

Its intention is to help, but in doing so, he suffers...

Diabetes? My aunt Alice has that... Having a fatty liver gives you diabetes?

Easy George, one step at a time...
When we become overweight, our fat reservoirs fill up... And even with this sacrifice it might not be enough...

The real problem is having too many nutrients in our body, sugars and fats that won’t be used and that damage our organs...

The fat in the blood can block the arteries, cause atherosclerosis and heart problems. And the sugar lead to Type 2 Diabetes.

Diabetes? My aunt Alice has that... Having a fatty liver gives you diabetes? Easy, George, one step at a time...
If one thing leads to the other, you better shape up! I can assure you that having diabetes is not fun...

Yeah... you know, I've known about this fatty liver thing for a while now...

But knowing that Vic could have the same thing scared the hell out of me!

I can also get that thing you have dad?

No!

So, what do you think we should do?

Exactly!

Start eating better and exercising more. But we have to be persistent...

I've tried to lose weight so many times already...

You have to have a plan, go step by step, avoid exaggerating and never give up! When I found out I had diabetes, I had to go through this too! You'll see you'll succeed!
I'm going out. Behave yourselves!

Still like this?! This won't work! You have to move. It doesn't take much. Start by tidying the house, watering the plants, doing the dishes!

This won't work! You have to move. It doesn't take much. Start by tidying the house, watering the plants, doing the dishes!

Let's go for it kiddo?

Let's do it, dad!
A good walk is easy and cheap. Five kilometers a day would do the world of good to you!

Ah, luckily you've kept the bike!

Good effort. Well done!

Let's see how long it takes us today Vic.
It’s easier every day Dad! I get less and less tired!

That’s because we are habituating ourselves, the more we do the more we can do! This way we spend more energy!

And if we eat less often and low-calorie foods all the better!

Can I help you cook dinner?

Of course!
Can we make lasagna, Aunt Alice?

It's not very convenient for my diabetes...

Let's go shopping!

You know, Vic, it's not only about the quantity but also about the quality. Some foods are healthier than others...

For example, vegetables have a lot of vitamins, antioxidants and fiber.

Fiber fills us up more quickly and makes us less hungry.
They are also low in sugars and the few fats they have are the healthy kind, polyunsaturated fats, like omega-3!

Oh my, these names are very weird...

The name is not important... but it's good to know these fats are also inside nuts and seeds.

And in fatty fishes like the salmon, the omega-3 help reduce inflammation in our liver and lower the cholesterol in our blood, keeping a healthy heart.

The meat has another type of fats, saturated fats. They are not as good... but the white meat from the fowl has much less fat than red meats like beef or pork.
That's why it is better to eat less meat and preferably white meats.

In the end, it's all about following a Mediterranean diet.

And this auntie? I love fried chicken so very much!

No, Vic, not this... it's frozen, pre-cooked, fried and has the wrong kind of fats...

Worse is difficult.

Oh, what a pity...

Are we all set?

Yes!

Everything was delicious Vic!

I could've had more...

Shut up you!
ONE WEEK LATER

SO, HOW WAS THE RIDE TODAY?

AWESOME! WE’D NEVER GONE FARTHER NOR FASTER!

I’M HUNGRY!

HAVE A BIT OF MY SODA.

JAIME! I AM SICK OF TELLING YOU THAT THOSE ARE FULL OF CHEMICALS AND SUGAR...

SHE NEEDS ENERGY BUT NOT THAT KIND!

TAKE A LOOK IN THE MIRROR. DO YOU WANT MORE OF THE SAME FOR YOUR GRANDDAUGHTER?

WHAT AN EXAGGERATION...
But this is not food, Aunt Alice! It's a drink!

Is it bad for me?

Does it have too many fats?

No Vic, but it has too many sugars. Our liver transforms the excess of sugar into fat.

That's why it's the same as if it was fat!

We shouldn't overload the liver with one more thing to do... it's better not to abuse from foods and drinks high in sugar... they can make our liver fatty.
But this is not a drink, aunt Alice!

It's bad for me?

Does it have many fats?

No Vic, but it has many sugars. Our liver transforms the excess of sugar into fat. That's why it's the same as if it was fat!

We shouldn't overload the liver with one more thing to do… It's better not to abuse from foods and drinks high in sugar… They can make our liver fatty.

And not all the things high in sugar are sweet. Starches like pasta, rice or potatoes also have a lot of sugar.

But we can use whole-grain pasta or rice. It's much healthier and has more fiber, that stays in our gut instead of going to our liver and fills us up.
ONE WEEK LATER

MOM!

DARLING! HOW ARE YOU?

SUPER. I'VE LEARNED SO MANY THINGS WITH AUNT ALICE AND DAD!

REALLY?

WHAT A NICE MEAL! VERY DIFFERENT FROM WHAT WE EAT AT HOME.

BAM...

IT'S ALL PART OF THE PLAN!
What plan is that?

Changing our lifestyle!

Let's go for a walk and she can explain...

Remember that we'll have to carry on when the holidays are over...

OK!

You've lost a bit of weight sweetie. Good job!

My BMI looks better!

I didn't get where I should be yet, but I'm better...

Jorge

Vic - Normal

Weight

BMI
SHALL WE GO?

LOOK VIC, THIS IS FOR YOU. TAKING CARE OF OTHER THINGS TEACHES US TO TAKE CARE OF OURSELVES.

THANK YOU FOR THE HOLIDAYS ALICE! SEE YOU SOON!

NOW YOU JUST NEED TO KEEP GOING!

YOU SHOULD TOO DAD...

COME ON GRANDPA! IT’S EASY... I WANT TO BE WITH YOU FOR MANY YEARS TO COME!

BAH...
Type 2 diabetes and NAFLD are different diseases with similar causes, as the name indicates, the first affects the pancreas and the second the liver. The problem with both is insulin resistance. When we abuse, insulin stops working and our body no longer wants to store energy.

My aunt helped me, the one that has Type 2 diabetes...

Yeah...I remember that.

Type 2 diabetes and NAFLD are different diseases with similar causes, as the name indicates, the first affects the pancreas and the second the liver.

The problem with both is insulin resistance. When we abuse, insulin stops working and our body no longer wants to store energy.

Insulin is what the diabetics take...

Some of them do, others don’t. It depends on the diabetes.

Listen, here’s a thing that might help explaining this...

A Healthy Liver Will Always Deliver!
Some are directly burned for energy, but just as we put the food away in the cupboard or fridge, our body stores some of the sugars and fats we eat for later use.

Through its long journey along the digestive system, the food is transformed into nutrients…that are absorbed into the blood and transported all over the body.

Let’s see if we manage to understand this…
Equipped with sugar detectors, the pancreas is the first to notice the huge amount of nutrients circulating and sends insulin to work its charm.

Under insulin’s orders, the nutrients are stored away, each on its rightful cabinet. Sugars in the muscle, fats in the adipose tissue, and a bit of both in the liver. These organs go on storing and storing until the levels go back to normal.
Equipped with sugar detectors, the pancreas is the first to notice the huge amount of nutrients circulating and sends insulin to work its charm. Under insulin’s orders, the nutrients are stored away, each on its rightful cabinet. Sugars in the muscle, fats in the adipose tissue, and a bit of both in the liver. These organs go on storing and storing until the levels go back to normal.
Thanks to insulin we don’t need to eat all the time and we can sleep, resting at ease.

As the blood runs out of nutrients, the fat tissue and the liver replenish the nutrient levels. We never run out of energy!

The brain and other tissues constantly need nutrients from the blood to work.
Thanks to insulin we don’t need to eat the time and we can sleep, resting at ease. As the blood runs out of nutrients, the fat tissue and the liver replenish the nutrient levels. We never run out of energy!
But just as we have to throw food away when we buy or cook too much, when we eat too much our storing organs cannot cope with all the nutrients...

Eventually, completely full and fed up, they decide to store no more! Just like in a rebellion or a strike, they refuse to obey to insulin's orders.
But just as we have to throw away when we buy or cook much, when we eat much our storing organs cannot cope with the nutrients...

Eventually, completely full and fed up, they decide to store no more! Just like in a rebellion or a strike, they refuse to obey to insulin's orders. This is called insulin resistance, and can cause many problems…
Not only do they refuse to store nutrients when we eat, but they spend all day throwing sugars and fats into the blood...
Not only do they refuse to store nutrients when we eat, but they spend a/unsigned day throwing sugars and fats into the bladder... No matter how much effort insulin puts into it or how many reinforcements it gets, the blood remains full of sugars and fats...
...the liver in trying to filter the excess of fats can become fatty and end up with cirrhosis...

...the excess of fats in the blood can form atherosclerosis, narrowing the space for blood to flow and increasing the risk for heart attacks...

Non-Alcoholic Fatty Liver (NAFL)
Non-Alcoholic Steatohepatitis (NASH)
Cirrhosis
Liver Cancer

Perhaps I have fatty liver?
And if you two kip it up you' never have diabetes.
Maybe I should have that checked...
I already changed my habits due to diabetes, though, so at least I'm on the right track!

Sugar Levels

Non-Alcoholic Fatty Liver (NAFL)
Non-Alcoholic Steatohepatitis (NASH)
Cirrhosis
Liver Cancer
...and the excess of sugar can overwhelm the detectors of the pancreas leading to Type 2 Diabetes.

Perhaps I have fatty liver too?

Maybe I should have that checked... I already changed my habits due to diabetes, though, so at least I'm on the right track!

And if you two keep it up you'll never have diabetes.

Yay!

Sugar Levels

Non-Alcoholic Fatty Liver (NAFL)
Non-Alcoholic Steatohepatitis (NASH)
Cirrhosis
Liver Cancer
Heart
Pancreas

Sugar Levels
Character biographies
Alice is 70 years old, and is the younger sister of Jaime. She is retired and owns a house where she likes to have the family over for the holidays. Alice has Type 2 Diabetes Mellitus (T2DM), a disease in which the pancreas does not produce enough insulin to adequately regulate the levels of sugar circulating in the blood (glycemia). As a result of this disease, Alice has to take insulin shots and needs to be very careful with her diet and lifestyle. Over the years, she has learned what food products make the glycemia go dangerously high and that exercise makes her feel better because it helps lower the stubbornly high glycemia. As an expert on keeping this balance, Alice is now full of wisdom, tips and tricks that can support other characters on their journey to change the lifestyle.
Jaime is 75 years old and is George’s father. Jaime was diagnosed with Alcoholic Fatty Liver Disease (AFLD) many years ago when the doctor saw signs of liver injury in his blood test results. He was shocked to be called an alcoholic for drinking more than 2 standard drinks per day and met the doctor’s recommendation of ceasing alcohol consumption with skepticism. He also disregarded clinical advice on improving his diet and exercise habits. Bound to his routine, over time, his liver started to scar and now Jaime has a form of liver disease called cirrhosis. This time, the seriousness of the doctor reminded him of some old friends that had died from cirrhosis, but what really scared him was finding himself unable to cut down on his drinking. Embarrassed of his failures, Jaime put up a front of indifference, for others and especially himself, renouncing to change and unintentionally becoming a barrier for others’ change.
George is 40 years old and is Jaime’s son and Vic’s father. George was recently diagnosed with Non-Alcoholic Fatty Liver Disease (NAFLD). He knew that he had started to gain weight a few years back but had never crossed his mind the fact that his diet and exercise habits would have an effect on his liver. After the doctor explained the risks associated with having a fatty liver, he attempted to lose some weight to prevent the development of cirrhosis, T2DM and cardiovascular diseases like heart attacks. The real reckoning came after Vic’s overweight diagnosis, when he realized the kinds of environment and the behavior he was providing and modeling for his daughter. Motivated to overcome the dissuasive effect of previous failed attempts, George has now decided to learn how to balance his diet and physical activity habits to defat his liver and regain a healthy lifestyle for his family. He hopes his aunt Alice will help him on this journey.
Vic is 6 years old and is George’s daughter. For Vic everything is new. She is still discovering what she likes and doesn’t like, what eventually will become her lifestyle habits. She adores her parents and her grandfather Jaime and everything she does with them. Her mom makes her eat vegetables and go to swimming lessons, but when her dad is in charge they order fast food and play videogames. On her last visit to the pediatrician, the doctor said that she is a bit on the heavy side and this caused a big quarrel between her parents. Over the summer, Vic will learn about the importance of a healthy diet and an active lifestyle for maintaining a normal weight, but also for the wellbeing of the liver, the pancreas and the heart. Soon, without realizing it, what once seemed like unappealing meals and activities will become enjoyable experiences that will carve healthy lifestyle habits for life.
This comic is the result of a collaborative academic endeavor aiming at raising Non-Alcoholic Fatty Liver Disease (NAFLD) awareness and promoting healthy lifestyles amongst the general public, with effective and participatory science communication understood as a mandatory effort required of all biomedical researchers involved.

The conceptualization, design and production of this comic emerged from a co-creation process between biomedical researchers, illustration academics and metabolic patients. In fact, the biomedical content was tailored to the information needs and background knowledge shared by type 2 diabetic patients in a formative qualitative research study performed at the Portuguese Diabetes Association (APDP)1. The narrative structure and imagery of the comic were also strategically selected, designed and co-created combining the results of this empirical research with principles of narrative engagement and persuasion, storytelling, health promotion and models of behavior change.

The comic was developed under the FOIE GRAS project (ID: 722619), a European consortium funded by the European Union’s Horizon 2020 – Marie Skłodowska-Curie Actions (MSCA) and coordinated by the Center for Neuroscience and Cell Biology (CNC) at the University of Coimbra, Portugal. Alongside state-of-the-art research to better understand the pathophysiology and treatment of NAFLD, the FOIE GRAS network is deeply committed to science communication and public outreach.
Following the long-lasting dedication of CNC to science communication and to the production of science-based comics, this project was born from the collaboration between two PhD theses on science communication of two students of the Doctoral Program in Experimental Biology and Biomedicine, hosted at the Institute for Interdisciplinary Research of the University of Coimbra (IIIUC). Those students were Mireia Alemany i Pagès (FOIE GRAS early-stage researcher) and Rui Tavares (holder of a PhD scholarship from FCT- SFRH/BD/136900/2018), with the assistance of senior researcher and comic-book expert João Ramalho-Santos, Professor at the Department of Life Sciences, and the additional support of CNC Researcher Anabela Marisa Azul.

Title
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Institutional Support

[Logos]
Do you know what your liver is? Do you know the many important things it does for us, keeping us healthy and alive?

Did you know that our dietary habits can affect the wellbeing of our liver? Or that a sedentary lifestyle can harm it?

You probably are not aware, but one in every four people in the world has Non-Alcoholic Fatty Liver Disease (NAFLD), which can go unnoticed for years and result in severe liver damage, cirrhosis and even hepatic cancer. Are you one of them?

The excessive accumulation of fat in the liver is caused by unhealthy diets and sedentary lifestyles. Are you at risk?

Although you can have it without being overweight, people that are obese and those with Type 2 Diabetes have a higher risk of developing NAFLD. So, how can we fix this?

Get to know your liver better with this comic and find out how to treat and prevent this form of liver disease!

Think of your liver the next time you eat, and don’t forget to stay active for its health and your wellbeing.

Remember that a Healthy Liver will Always Deliver!

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