LET'S SCIENCE!

5

Mauro Manconi

SLEEP AND DREAMS

Why we sleep
and what happens when
we don't sleep well

IBSA FOUNDATION for scientific research

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Repubblica e Cantone Ticino
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PREFACE

How familiar are we with the repercussions of scientific research and medical practice for our daily lives? What are the "passions" and motivations that drive researchers and healthcare professionals? What do we know about their professions?

Society strives to make science and its implications known to ordinary people in many different ways. Just think, for example, of the variety of leaflets promoting the importance of a healthy lifestyle and well-being in general. Of course, school does its part as well, introducing the principles of scientific literacy and raising awareness of a series of issues that help foster scientific thinking among young people.

These considerations are in fact the starting point for the *Let's Science!* project, carried out by the IBSA Foundation for Scientific Research in collaboration with the Department of Education, Culture, and Sport of the Canton of Ticino (DECS). The partnership has made it possible to identify interesting topics that have been addressed by the project, getting scientists working in the canton involved. Two different worlds that are often far apart – scientific research and school – have thus been brought together, promoting dialogue between professionals and students through themed workshops, in order to develop awareness of both the topic itself and how to communicate it.

But what was the range of topics the project would address and what considerations led to certain strategic decisions? Science and research are advancing rapidly, especially in biomedicine and related disciplines, and the continuous expansion of fields of investigation requires a constant effort to stay up to date, in order to both maintain a historical perspective and accommodate the numerous innovations. Access to scientifically accurate information, conveyed in accessible language, opens up the opportunity for children to get to know and become passionate about topics that are generally considered "difficult".

And that's the idea behind the *Let's Science!* series, which aims to broaden the range of scientific topics that can be explored at school. The topics, which are interdisciplinary and directly related to individual health and well-being, are presented in an innovative way: the scientific text is in fact accompanied by a story that draws on the experience of cantonal middle school classes, who,

under the guidance of their teachers, developed original scripts, which were then translated into comics by professionals in the industry.

The only thing left for us to do is invite young readers to explore the fascinating fields of research presented by *Let's Science!*, which in turn open up opportunities for further questions and insights. Who knows, one of these readers might in turn one day become the one taking important steps forward in understanding the complexity of life and the delicate balance that allows us to be healthy and happy. Enjoy reading!

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Sleep and dreams

PART ONE

INTRODUCTION

Human beings have always needed to sleep since they first appeared on Earth and they spend about a third of their life asleep; yet the study of this mysterious and fascinating phenomenon only began less than 70 years ago.

The science of sleep is therefore a young but flourishing discipline, which has led to great scientific discoveries. Before scientists became interested in sleep, this strange state of mind was considered just a mundane period of rest needed to recover energy. In antiquity, literature and religion always viewed sleep as a kind of apparent death that took place lying down, with your eyes closed. Dreaming was seen as a magical moment when humans could come into contact with the afterlife and communicate with the dead. Death is in fact still spoken of as an "eternal sleep".

This rather gloomy view of sleep did not help ignite the interest of science, which only began trying to study the complex mechanism underlying sleep after the 1950s. Today, thanks to this research, we can partially answer some fundamental questions: what is sleep? What happens during sleep? What is sleep for? And how long can you survive without sleep? How are sleep disorders diagnosed and how are they treated?

In this booklet, we try to provide initial answers to these questions based on the scientific and medical knowledge currently available to us.

WHAT SLEEP IS

It's hard to define what sleep actually is. Sleep **is a state of rest of the body** that occurs **periodically**, usually every night, in which the mind isolates itself from the outside world and enters a state of reduced consciousness. That's all well and good, but then what is consciousness? Again, it's hard to give a definition. Put simply, **consciousness** is a state in which a **human being is awake** and, at the same time, **knows that they are awake**. That is, their eyes are open and they are able to communicate with the world around them. When we sleep, we lose consciousness for a certain period and regain it in the morning

Table 1 States of consciousness

Consciousness	Being awake and able to recognize your surroundings and communicate with others.
Sleep	Temporary loss of consciousness. It only takes a small stimulus to wake the person up.
Stupor	Loss of consciousness. It requires a painful stimulus to wake the person up.
Coma	Prolonged loss of consciousness. A painful stimulus is not enough to wake the person up.

when we wake up. Consciousness can also be lost for other, often more serious, reasons, such as a **coma**, which is a serious condition usually caused by brain damage [**table 1**].

So we know that sleep is a different state than the consciousness we experience during the day. But what is sleep exactly? Perhaps the best way to define sleep is to consider it like an **instinct**.

What is an instinct?

Instincts are those **behaviors that we are able to perform without anyone having to teach them to us**. For example, eating and walking are instincts. No one teaches a newborn baby how to eat, but the infant can still suckle milk. The same goes for sleep: we sleep without anyone teaching us how. All instincts always take place in three stages:

- the appetitive phase;
- the consumption phase;
- the restorative phase.

In the first (**appetitive**) phase, the desire to perform that action appears: hunger gives rise to the desire to eat, just as drowsiness is the phase in which we get the desire to sleep. The desire to do something usually arises on its own and drives us to do that thing. Desires are very important; if we did not, for example, have the desire of thirst, we might forget to drink.

In the second phase of the instinct (**consumption**), we carry out that action; for example, we eat or sleep.

In the third (**restorative**) phase, we get a sense of well-being due to having carried out the action: we feel satiated if we have eaten or we feel rested if we have slept. Basically, we are pleased that we have done something and therefore we no longer feel the desire to do it, at least for a certain period.

Another aspect that all instincts have in common is the fact that they are **vital**, meaning that they are essential for life. If we don't eat or drink, we won't survive. Likewise, if we don't sleep, we can't survive. Without sleep, we die.

DO ALL ANIMALS SLEEP?

Not all animals sleep in the same way we humans do, but almost all species sleep, or at least need to break up the waking period with one or more periods of rest or sleep.

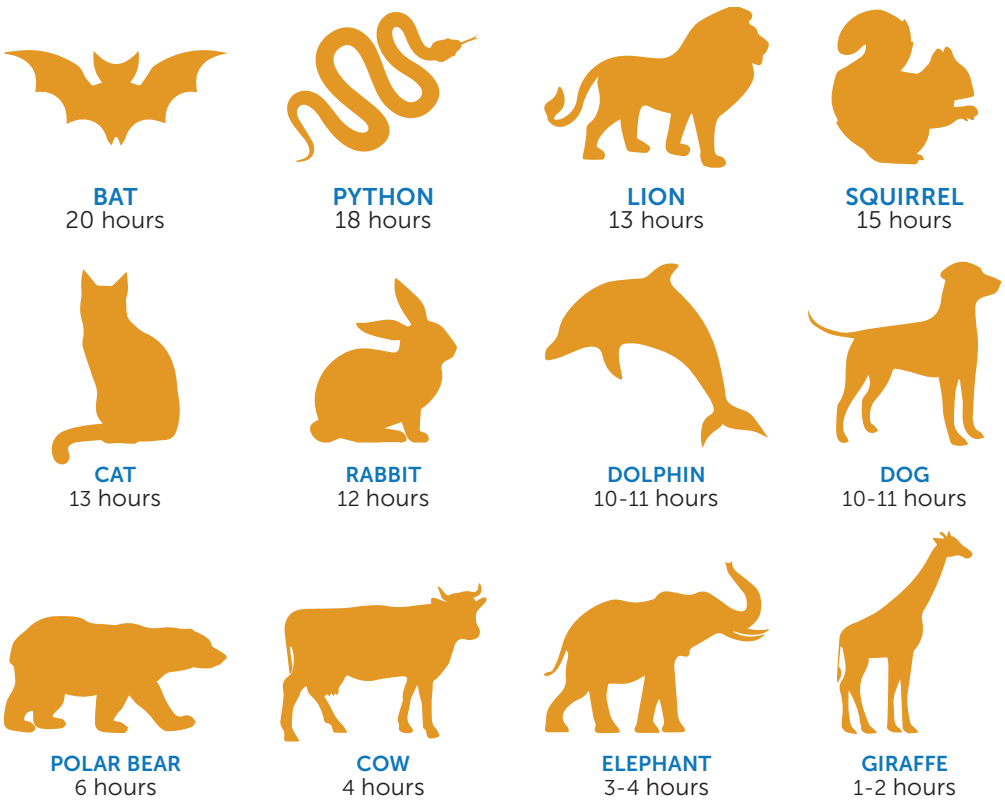
All animals sleep in their own way and at a certain time of day. Some mainly sleep at night and are active during the day, like humans: these are called **diurnal animals**. Others mainly sleep during the day and are active at night: they are called **nocturnal animals**. Some animals sleep for many hours at a time, while other species take lots of short naps over the course of 24 hours. Some, such as giraffes and horses, can sleep standing up; others can also sleep while flying, such as birds, or while swimming, like dolphins. Cats often sleep rolled up like a snake, while koalas and some felines are able to sleep on tree branches without falling off.

The total amount of sleep needed within 24 hours also differs depending on the animal. Usually, the size rule applies; according to this, the larger an animal is, the less it sleeps, while smaller animals need more sleep. For example, bats sleep almost 20 hours a day, squirrels sleep 15 hours, while large

animals such as elephants sleep less than 4 hours a day and giraffes even less than 2 hours. Cats sleep up to 13 hours a day, while dogs sleep a bit less: about 10-11 hours.

We might think that the animal that sleeps the most is the dormouse, but that's not entirely true: the animal that sleeps the most is probably the koala, which gets about 20 hours of sleep a day [**figure 1**]. So where do we get this idea that dormice sleep so much (just think of the Dormouse in Alice in Wonderland)? The reason lies in the fact that dormice have a long **hibernation period**, which can last up to 6 months a year. But be careful not to confuse hibernation with sleep: the two phenomena may seem similar, but in reality, they are very different.

Figure 1 How much animals sleep



HOW MUCH DO HUMAN BEINGS SLEEP?

Because humans are a medium-sized animal, they sleep less than squirrels but more than cows. How much humans sleep depends a lot on their age. A newborn baby needs up to 17 hours of sleep a day, far more than a domestic cat or a big feline like a tiger. By the age of one, the amount a baby sleeps has already been reduced to about 14 hours. At nursery school age, children sleep about 12-13 hours, while in primary school, sleep is reduced to about 11 hours and then to about 9-10 hours in middle school. Adults rarely sleep more than 8 hours a day.

But the amount of sleep needed to be well rested differs from person to person, which is why there are what we call **short and long sleepers**. In fact, there are people who need at least 9 hours of sleep per night to be well, while others only need 6 hours [**table 2**].

Table 2 How much humans sleep depending on their age

AGE	HOURS OF SLEEP NEEDED	APPROPRIATE HOURS OF SLEEP
Infants up to 3 months	14-17	11-19
4 to 11 months	12-15	10-18
1 to 2 years	11-14	9-16
3 to 5 years	10-13	8-14
6 to 13 years	9-11	7-12
14 to 17 years	8-10	7-11
Young adults (18-25 years)	7-9	6-11
Adults (26-64 years)	7-9	6-10
The elderly (>65 years)	7-8	5-9

HOW LONG CAN YOU SURVIVE WITHOUT SLEEP?

A small animal such as a lab mouse usually does not survive more than 7-9 days without sleep, after which it dies. Fortunately, these types of experiments have not been done on humans.

The world record for consecutive days without sleep is held by **Randy Gardner**, a 17-year-old American student who decided to undergo this stressful experiment in December, 1963 [**figure 2**]. Although Randy Gardner had decided to tackle the challenge for personal reasons, Stanford University took advantage of it to study his biological functions during the entire sleep deprivation phase and during the recovery phase at the end of the experiment. He stayed **awake** for a total of 264 hours, i.e., for **11 days and 25 minutes**. But why did Randy have to give up after 11 days? It wasn't because he was physically tired. Above all, he was mentally exhausted; on the tenth day, Randy was no longer able to recognize certain objects and certain flavors, while on the eleventh day he began to hallucinate, lose his memory, and become extremely irritable. He

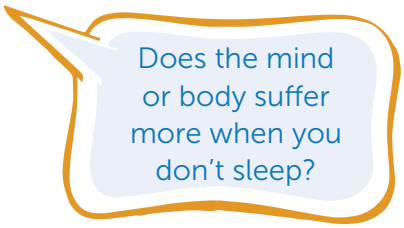
Figure 2 Randy Gardner, sleep deprivation record

was therefore forced to break off his experiment mainly for reasons related to **mental and cognitive**, not muscular, **fatigue**.

At the end of the experiment Randy collapsed into a long sleep. However, he did not recover as much sleep as he had lost during the experiment, i.e., 11 days' worth, but just 14 hours. In fact, we never fully make up for lost sleep. If we do not sleep for an entire night, thus losing 8 hours of sleep, for example, the following night we cannot recover all 8 hours and sleep for 16 hours; instead, usually we recover only 2 or 3. In other words, some of the lost sleep is lost forever.

WHAT HAPPENS IF WE DON'T GET ENOUGH SLEEP?

If you do not sleep or don't get enough sleep, **it is above all the brain that suffers**; the effect is not so much physical as mental. The first signs of poor sleep are **changes in mood**, such as being "in a bad mood", until you fall into a genuine **depression**.



Irritability is also a sign of poor sleep, for example getting angry over nothing or over small things, becoming intractable, sometimes aggressive, as well as feeling increasingly anxious. You yawn often and can have sudden bouts of sleep, where you fall asleep without realizing it. Memory and the ability to learn are impaired, it is difficult to pay attention, and you feel confused and sluggish. In this stage, **brain activity is reduced**, especially in the frontal regions of the brain that are involved in attention, making calculations, and above all in the capacity to make the right decision in situations where we have to make a choice. The latter is also called the capacity for **critical thinking and judgment**, and it is what, for example, makes us able to maintain safe behavior and avoid behaviors that are risky for ourselves or for others. In fact, people who don't get much sleep also tend to underestimate risks. If you don't sleep, you make a lot more mistakes, you risk doing badly at school and, above all, understanding little of what you are doing. Physical fatigue only comes later, if you continue to not get much sleep for several days. If the sleep loss

lasts for months or years, as in some types of insomnia, then all the organs of the body begin to suffer from it. You become more likely to develop heart problems and hypertension (that is, high blood pressure in the arteries), your immune system gets weaker, and the body gets sick more easily.

Your diet also changes; you tend to eat more, especially sugary foods and sweets, and it is easy to gain weight. We know that poor sleep can also reduce fertility, that is, the likelihood of having children, for both men and women. For most human organs, it is not enough just to rest, you need to actually sleep! In fact, the recovery processes that take place during sleep are different from those that occur during simple physical rest. While you are awake, toxic substances build up in the blood, which are then eliminated during sleep. If we sleep little and poorly for a long time, **various substances can build up and damage the body**. Sleeping properly is therefore not only necessary for our body, but is also a matter of mental well-being and a prerequisite for quality of life in general.

WHAT HAPPENS DURING SLEEP

Contrary to what you might think, not all sleep is the same, but it changes profoundly over the course of the night. This means that from the moment we fall asleep to the moment we wake up, even if we are lying still with our eyes closed, the brain is not always doing the same thing.

What are sleep cycles?

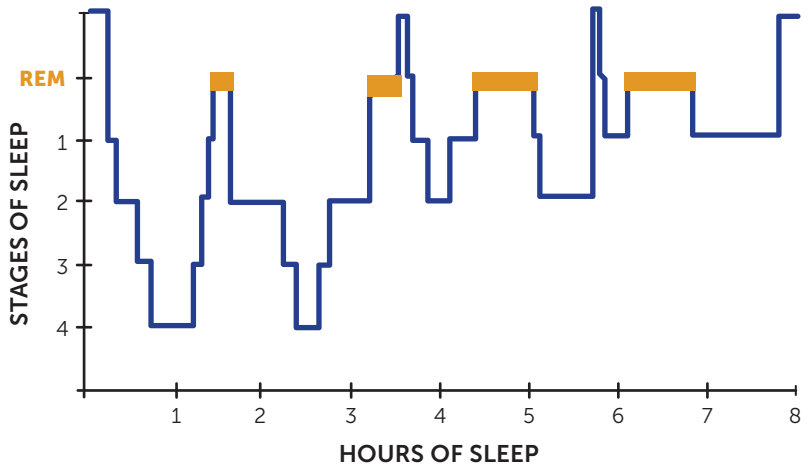
Sleep occurs in cycles. A sleep cycle lasts about **an hour and a half** and is repeated **4 or 5 times in one night**. Each cycle is made up of two very different types of sleep. In the first part of the cycle, the body relaxes physically, the mind rests, and the eyes do not move: this stage is called **non-REM** sleep. The term non-REM in fact means that there are no eye movements. This first stage is followed by a second stage in which the eyes move rapidly in all directions and the brain is very active, as it is dreaming. This stage is called **REM** sleep, which stands for "Rapid Eye Movement". If a person is woken up right in the middle of a REM stage, then they will report

that they were dreaming, while if they are woken up during a non-REM sleep stage, they will only say that they were sleeping and not dreaming. So, we all dream more than once a night, but whether or not we remember it in the morning depends mainly on the moment we wake up.

The non-REM stage is thus the first to occur in each sleep cycle, is repeated about 4 or 5 times per night, and makes up a total of about 75% of a night's sleep. The REM stage, which is when we dream, always occurs at the end of a sleep cycle, likewise repeats 4 or 5 times a night, and makes up a total of about 25% of a night's sleep. A single REM stage lasts about 20 minutes in the first cycle and then tends to lengthen in duration in subsequent sleep cycles, until it reaches about 40 minutes in the last morning cycle.

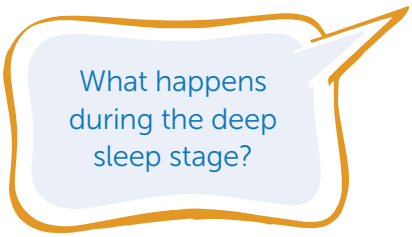
It is possible to take a "photograph" of sleep using a **hypnogram**, which gives us a graphic representation of sleep, that is, a graph that tells us not only how much but also how well the person slept, what stages of sleep they went through, and when these occurred during the night [**figure 3**].

Figure 3 Hypnogram. On the horizontal axis, we can see the hours of sleep, while the vertical axis shows the type (stage) of sleep. The stages indicated by a blue line correspond to non-REM sleep, with levels of depth varying from 1 to 4. The yellow lines correspond to REM sleep. Moments when the person woke up from sleep are indicated by the blue line going back up to the highest level.



WHAT IS SLEEP FOR?

So far, we've seen that there are two different types of sleep: non-REM sleep, during which our eyes do not move and we rest deeply, and REM sleep, during which our eyes move around a lot and we dream. Today, we know that non-REM sleep and REM sleep serve different purposes, which are both very important.

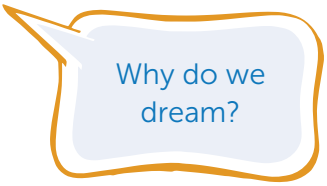


Non-REM sleep, also called **deep sleep**, mainly serves to rest the brain and the brain cells, the neurons. In particular, the number of contacts between the fundamental cells of the brain, the neurons, is reduced during sleep. **Neurons** actually communicate with each other via branches that connect them to other neurons. These connections are called **synapses**. A synapse is the point of contact between two neurons that talk to each other.

During the day, the brain receives a huge amount of information, but not all of this information is useful; rather, there is so much that it could easily confuse us. So during sleep, the brain chooses which information to keep and remember and which information to discard and forget.

Let's look at an example: if a student is studying the geography of Ticino at home, it will be very important for them to remember it, so they can then tell their teacher what the differences between the various regions are and how they originated, what the role of natural phenomena was and what the impact of humans was, why there are major human settlements in certain regions and not in others, as well as a lot of other information that, put together, helps to further contextualize the situation. But while the student is studying, their brain is actually receiving lots of other information that is less useful and that it would be better to forget and discard. For example, it is probably not important for the student to remember what color socks they are wearing, whether there are 2 or 3 pencils on their desk, or if it's sunny or raining outside while they are studying geography. So even if all this information reaches the brain, the brain needs to know which pieces of information to focus on. This phenomenon of

discarding less useful information and contextual processing and strengthening of memories and useful information occurs especially while we are asleep, particularly during non-REM or deep sleep. This process is also called **synaptic pruning**; in fact, just like we prune the branches of a tree, the brain eliminates the less important neural connections and strengthens those that are useful for learning. All this happens while we are asleep and, if we don't get any sleep or sleep poorly, we risk discarding important information and retaining information that is not very useful; in short, we risk making a fool of ourselves when we have to reprocess and transpose that same information!



And what about REM sleep, the stage when we move our eyes and dream, what is that for? We do not know exactly what dreaming is for, but we do know that dreaming is extremely important and we do it every night, even if we do not always remember our dreams in the morning. According to the latest theories, dreaming might be like a kind of gym where we train so we are better equipped to tackle the day. At night, while we are dreaming, we train so we know how to deal with our fears, or happiness, or other emotions that occur in real life.

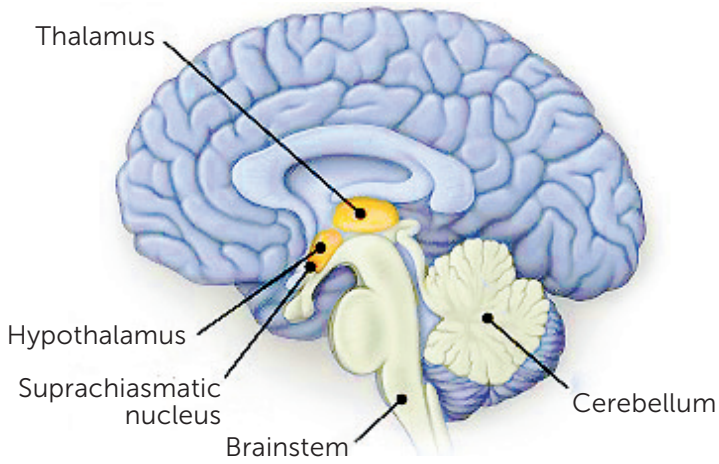
It seems that, for example, dreaming about getting lost or being abandoned serves to make us more resilient in the event that this actually happens. Dreams are like a kind of stage, where we play a part and train ourselves to control our emotions so we are then able to regulate them during everyday life. If, for example, we watch a scary horror movie, at night we might dream of a scene from the movie again. This could be the mind trying to make us more resilient, by making us relive the scary scene to train us so that we won't be afraid if we see it again in the future. But dreaming and sleeping probably have many other functions that we do not know about yet. If any of you become a sleep scientist, maybe one day you could help us understand it better. For example, it would be interesting to keep a dream journal for a long time, to write down the main emotional events that happen during the day and what you dream about at night. Since our memories of dreams tend to fade quickly, anyone who wants to keep a dream journal should write their dreams down in the morning when they wake up.

WHERE ARE THE CENTERS THAT REGULATE SLEEP?

It is the brain that tells the body when and how much to sleep. The centers that regulate sleep are in the brain, especially in the deep part, at the base of the brain. One of the important areas is called the **hypothalamus** [**figure 4**]. Towards evening, the hypothalamus tells a gland called the **pineal gland** to produce **melatonin**, a substance that tells the body it's time to go to sleep. Melatonin is produced as the light level drops. If we expose ourselves to too much light at night, the brain won't be able to produce melatonin and we'll find it hard to fall asleep. That's why, for example, looking at your mobile phone or computer at night can make it difficult to fall asleep: the light from these devices prevents the brain from producing melatonin and therefore from sleeping.

When the sleep centers are activated, the consciousness centers are switched off and the body enters the sleep dimension. During sleep, the brain regulates the main vital functions differently: the breathing and heart rate slow down, less sugar is burned for energy, and the body temperature drops. There are specific centers that regulate non-REM sleep and others that regulate REM sleep. Damage to these brain centers can disrupt sleep, leading to insomnia or excessive daytime sleepiness. The centers that generate non-REM sleep are

Figure 4 Sleep centers in the brain



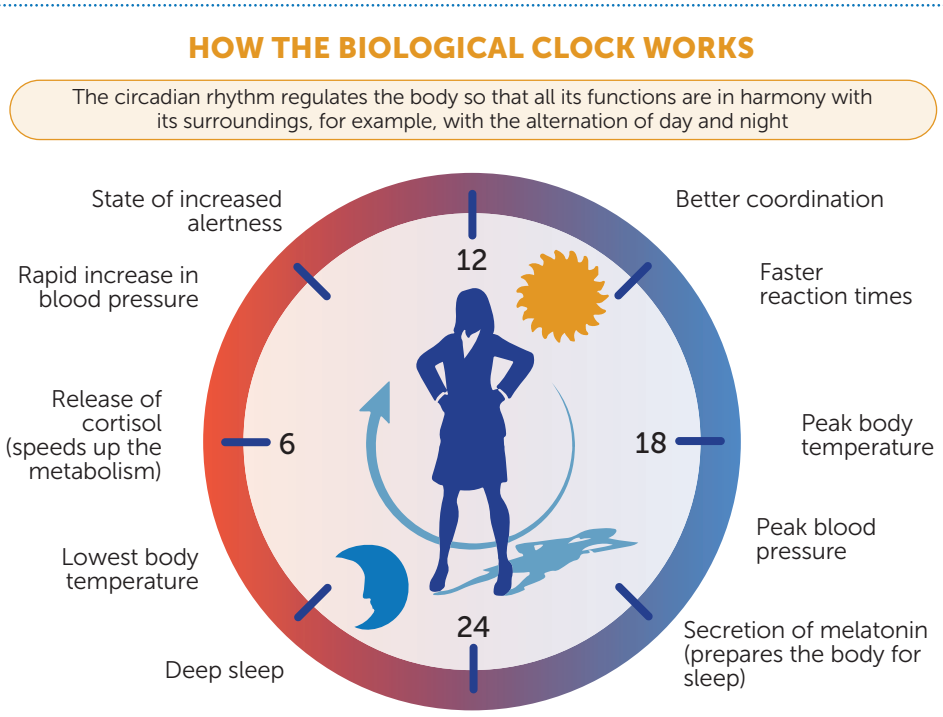
located mainly in the hypothalamus, while those that regulate REM sleep are located lower down, in a structure called the **brainstem**, which is found at the base of the brain.

WHY DO WE SLEEP AT NIGHT?

What is a circadian rhythm?

As diurnal animals, humans tend to sleep at night, when it is dark, quiet, and cooler. Sleep is said to follow a **circadian rhythm**: this means that it is repeated periodically every day, with a rhythm of about 24 hours [**figure 5**]. Not only sleep, but many other functions, such as blood pressure, the production of certain hormones, body temperature, hunger, and attention, also follow a circadian cycle,

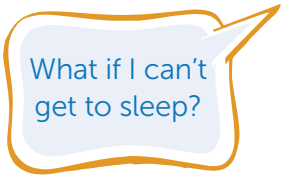
Figure 5 The circadian rhythm



changing over the course of 24 hours. For example, blood pressure and breathing are reduced during sleep and increase during the day; the same is true for body temperature and the production of the hormone cortisol.

The field of science that studies the rhythm of these phenomena over the course of 24 hours is called **chronobiology**. The rhythm of these functions is regulated by a specific area of the hypothalamus, the **suprachiasmatic nucleus**, which functions as a pacemaker. This nucleus activates the production of melatonin by the pineal gland. Damage to this nucleus leads to a dysregulated sleep/wake cycle, in which a person may sleep during the day and stay awake at night.

RULES FOR GETTING A GOOD NIGHT'S SLEEP



So if it is so important to get enough sleep and get good quality sleep, are there any rules that we can follow to sleep better? There certainly are – let's have a look at some of them.

1. **Diet.** Dinner is very important for sleep; you shouldn't eat too late or have a heavy meal. It is better to eat something lighter because if your body is busy digesting during the night, then you are more likely to move around in your sleep, which might make you wake up. But be careful: not eating anything for dinner can also be a mistake and cause you to wake up during the night due to hunger. So have a light evening meal, possibly no later than 7 pm. It should be noted that the timing of the evening meal may vary depending on the cultural context and the season; in Latin countries and in the summer, when it stays lighter for longer in the evenings, people tend to go to bed later.

2. **Daytime naps.** Having a nap after lunch is a good habit up to the age of 5 or 6. You can continue to do this even when you are older, but it should not be longer than 40 minutes and should be taken regularly at the same time, not at a different time every day. If you need to take a lot of naps on the same day, then there may be something wrong and it might be better to contact your doctor and tell them about it.

3. **Tablets, mobile phones, computers, and video games.** Especially in the evening, specifically before going to bed, it is important to avoid exposing yourself to bright light and in particular to the light produced by these electronic devices, which prevents the brain from falling asleep easily. This is why it is important to keep the room where you sleep, i.e., your bedroom, nice and dark. If, in addition to light exposure, we force the brain to be too active and think too much, it will be even harder to fall asleep. That is why, of all electronic devices, the worst enemy of sleep is the video game. In recent years, electronic devices that emit less blue light in the evening and shielded glasses that filter and reduce how much blue light your eyes absorb have become available. These measures are useful for protecting the sleep-wake cycle.

4. **Smoking and alcohol.** When you get older, remember that bad habits like smoking and alcohol are also the enemies of sleep. Let's not forget that cigarettes, in addition to damaging the lungs, also have stimulant properties similar to coffee, so they make it harder to sleep. Alcohol is not a stimulant, but it still makes your sleep lighter and more fragmented. These are therefore other good reasons not to start smoking or to quit, and the same goes for alcohol abuse.

5. **Coffee and cola.** Coffee contains a substance called caffeine, which is a stimulant. Caffeine wakes you up and prevents you getting to sleep and adults would do well not to drink coffee in the evening before going to bed. Be careful though, as there are also other foods and drinks that contain caffeine or other stimulants. Don't forget that these include cola, chocolate, tea, and especially energy drinks. So you should likewise only drink these in small amounts and avoid drinking them in the evening.

6. **The temperature.** Being too hot and therefore sweating is not conducive to sleep. We sleep better in a cool room, at about 18°C. Too high or too low a temperature can cause insomnia.

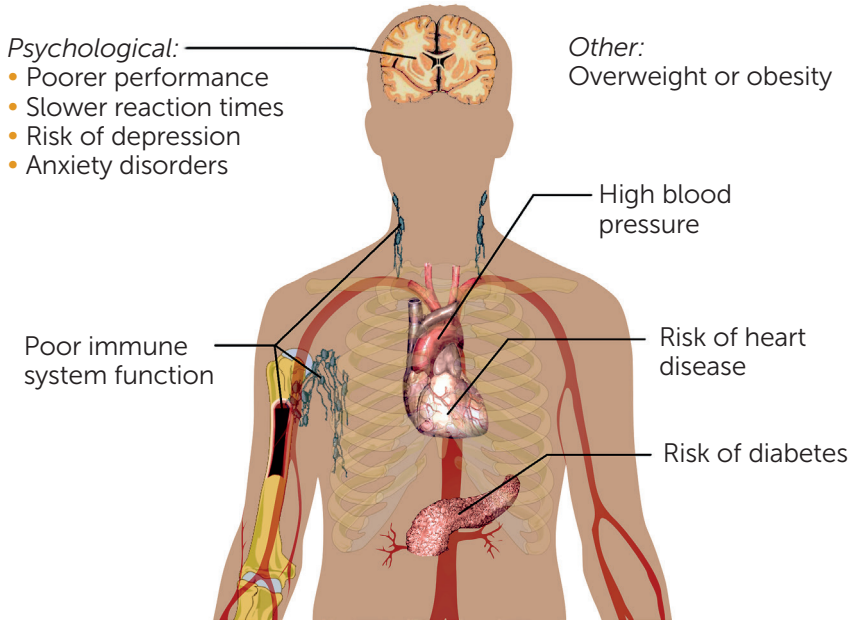
7. **Sports.** Doing overly intense physical activity in the evening is not good for sleep. Fortunately, children and teenagers are unlikely to play sports in the evening. But be careful – not doing physical activity at all is also not good! So, moving and doing sports are very positive things, but it's better to do these in the morning or in the early afternoon.

8. **A regular schedule.** A good night's sleep is one that happens regularly. It is good to get used to going to sleep and getting up at the same time. Sure, it's nice to have a lie-in on Sundays, but if our schedule gets too out of sync, then our brains will struggle to figure out when it's time to fall asleep and when it's time to wake up. The more irregular our routine is, the more we confuse our brains.

INSOMNIA

It is not always easy to sleep; sometimes we cannot get to sleep or we fall asleep, but keep waking up and tossing and turning in bed. Sometimes we simply have a bad night, just like we can have a bad day, and it's nothing to worry about. If, on the other hand, we often sleep little or badly, for example at least once or several times a week, and this makes us tired or irritable during the day, then we may have a problem with insomnia [**figure 6**].

Figure 6 Complications of chronic insomnia



Children or adolescents can also suffer from insomnia. In these cases, it is a good idea to talk about it with an adult, such as with your teacher or doctor. There are lots of different reasons why you might suffer from insomnia and it is important to try to understand the cause. Especially if you are worried, scared, or anxious about anything, then it is good to talk about it without any shame. It could be due to your bedroom being too noisy, or not dark enough, or too hot or cold. You might be sleeping poorly because of pain or discomfort in one part of your body. Insomnia can be treated, but sometimes it takes time and you need to get some tests done by a doctor who specializes in sleep, who will choose the right treatment. Medications can be useful, but, if possible, should be avoided in the adolescent age group; they should always be managed by a doctor with experience in sleep disorders and you should always try to fix any poor sleep habits first.

TECHNOLOGICAL INSOMNIA

A new form of insomnia that mainly affects young people is what is called **technological insomnia** [**figure 7**]. It is a type of insomnia caused by the excessive use of modern electronic devices, such as mobile phones, tablets, or computers. These devices emit a kind of light that prevents the brain from producing melatonin, which, as we have seen, is the substance that promotes sleep. In addition, these devices overstimulate the brain. This happens in particular if we use them in the 2 hours before going to bed; it is even worse if we take our mobile phone or tablet to bed with us. Some young people even keep their mobile phones by their bed and chat with their friends at night as well. It is estimated that teenagers use electronic devices, especially mobile phones, for up to 6 hours a day. Playing video games in the hours leading up to sleep results in even more negative effects, as it causes elevated brain arousal that is not compatible with sleep at all and that also creates addiction. The only real solution is to leave all electronic devices out of the bedroom from dinner time onwards, and try not to use them within 2 hours before going to sleep.

Why is it better not to use electronic devices before going to bed?

Figure 7 Technological insomnia

CIRCADIAN RHYTHM SLEEP DISORDERS

Another issue that can occur is that you get plenty of good-quality sleep, but when you sleep is out of sync with most of your peers. This means you get a good night's sleep, but, for example, prefer to go to bed late and wake up late in the morning, a frequent phenomenon in adolescence. People who experience this are known as **night owls** because they prefer to be awake at night and sleep during the day. Or, as happens more often in the elderly, you might tend to go to bed very early in the evening and get up very early in the morning: people like this are called early birds or **morning larks**.

The preference for being a night owl or a morning lark is often part of an individual's genetic makeup and can be difficult to change. Some young people who suffer from a **delayed circadian rhythm** (delayed sleep phase syndrome or delayed sleep-wake phase disorder) may struggle to fall asleep in the evening and find it hard to wake up in the morning, and may also fall asleep in

morning classes at school. Typically, these young people are particularly awake and active in the evening, while struggling in the morning. The cause of these symptoms is not always due to bad habits, such as excessive evening use of electronic devices. Sometimes it is simply a genetic trait.

Another example of a circadian rhythm disorder is what's known as **jet lag**, typical of people who travel to distant countries with a time zone difference of at least 3 hours compared to where they came from. Likewise in this case, they sleep well but tend to sleep at a different time than is typical in the country where they are going. Typically, how long jet lag lasts depends on just how far away the country is. It is said that we are able to recover one hour of sleep per day, so if I go to the United States of America, for example, which has a time zone difference of 7 hours compared to Switzerland, I will need about 7 days to adapt my sleep schedule to the new American rhythms.

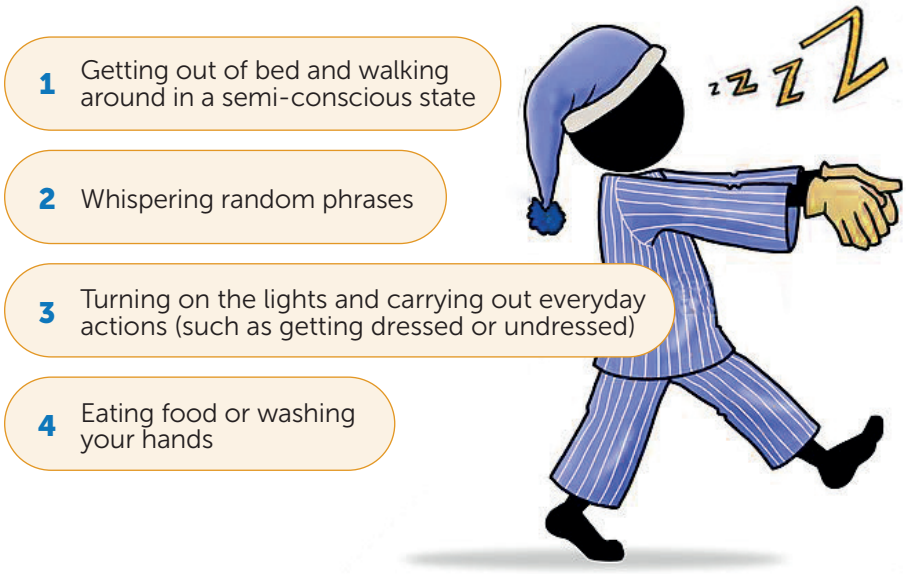
Another circadian rhythm disorder is the one that affects **night shift workers**, that is, people who have to work at night, such as doctors, nurses, or nighttime security staff. In this case, they are asking their body to work right when it should be sleeping and vice versa. Circadian rhythm disorders can be treated using melatonin administered at the most appropriate doses and times.

Given that our brain is also very sensitive to light, we can use a certain type of lighting to correct out of sync circadian rhythms, thanks to something called **light therapy**.

SLEEPWALKING

Sometimes, the brain can be asleep, but the body still moves around. Everyone has occasionally talked in their sleep or wandered around their house without remembering it in the morning. This condition is called **somnambulism** or **sleepwalking**; this is when a person is able to perform actions, including complex ones such as getting dressed or even leaving the house, in a state of abnormal sleep, without realizing it and without retaining any memory of what happened during the night [**figure 8**].

Figure 8 Sleepwalking



Sometimes the sleepwalking person may even answer simple questions or try to interact with someone. It is not easy to wake a sleepwalker: they are in a state of deep sleep, which we have learned is called non-REM sleep, when we don't dream. If we manage to wake them up, they will seem confused and sluggish and will not say they were dreaming; they will be annoyed and will soon go back to sleep without difficulty.

Usually, these events occur in the early part of the night, i.e., about 1 to 2 hours after falling asleep. If it happens often, it is necessary to see a doctor to find out if there are any underlying causes.

Is it dangerous to wake up a sleepwalker?

Sleepwalkers can also hurt themselves during the night, by falling over or bumping into an obstacle. If we realize that a sleepwalker is performing a dangerous action we can, indeed we must, wake them up. It's actually a myth that this is dangerous;

those who believe that doing so can cause harm or severe reactions are mistaken. Sleepwalking is particularly frequent in children and adolescents and disappears spontaneously around the age of 14-15. If it persists, it should always be reported to a doctor and should be taken seriously.

NIGHTMARES

Having a bad dream every now and then is nothing to worry about. But sometimes a dream can be so scary that it makes us wake up suddenly in a panic. Usually, in these dreams, called **nightmares**, someone is chasing us, or we are being attacked by an animal, or we could be dreaming about losing a loved one [**figure 9**].

This phenomenon occurs in the part of sleep that we have learned is called REM sleep. Typically, these intense dreams happen in the second part of

Figure 9 Nightmare

the night, from 3 am onwards. Just like with sleepwalking, what should worry us in this case as well is the frequency of the episodes. If we find ourselves having bad dreams frequently or even every night, we keep thinking about these dreams even during the day, and they are upsetting us, then it is a good idea to talk to someone about it.

There is not always a reason behind these dreams, but they are often caused by an unpleasant event. It could be a serious trauma or a specific fear, or simply watching a horror movie. Understanding and resolving the fears behind the nightmare could solve the problem, but if this does not happen it is a good idea to go to a clinic that deals with these disorders.

NOCTURNAL ENURESIS

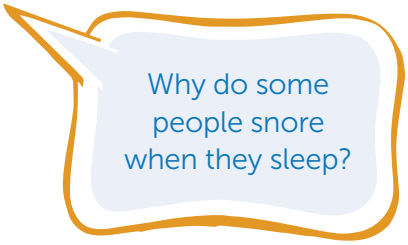
Wetting the bed at night is normal up to a certain age. The ability to produce less urine at night and hold your pee while you sleep develops at around the age of 3-4 on average. If a child still wets the bed without realizing it after the age of 5, then this is called **nocturnal enuresis** or **bedwetting**, a rather annoying but not uncommon disorder. About 1 in 7 children frequently wet the bed at the age of 7-8. Usually, they don't notice the leakage of pee during the night and are wet when they get up in the morning.

In most cases, the disorder tends to go away on its own, but it can persist over time, even into adolescence and adulthood. It is often a source of embarrassment and shame for the child, but it is a mistake to hide it and it is even more serious to make fun of a friend who has this problem. There is nothing to be ashamed of and lots of children suffer from it. Avoiding going on a school trip or sleeping over at a friend's house for fear of wetting the bed is not a real solution: it is essential to talk about it with your parents and doctor.

This disorder can typically be treated, sometimes by discovering the causes, sometimes by using specific techniques or strategies, and sometimes with effective drugs.

SNORING AND SLEEP APNEA

When we snore or stop breathing at night, it means that the air is not passing through our nose and throat properly and oxygen is not reaching the lungs easily. If the flow of air when we breathe is somehow obstructed while we sleep, it makes these obstructions vibrate and it is this vibration that produces **snoring**.



Sometimes, difficulty breathing at night can be so significant that the flow of air is interrupted and we stop beathing for a few dozen seconds. This is called **obstructive apnea** and, if it happens frequently, it breaks up sleep, making it poor quality. People who suffer from it often have restless sleep and feel tired and sleepy during the day.

Children and adolescents can also suffer from this, which can lead to trouble concentrating, feeling sluggish, or have learning difficulties at school. In these age groups, the cause is almost always that the child's tonsils or adenoids are too large; surgically removing them usually solves the problem.

To find out if your snoring is excessive or if you experience too many or excessively long apneas, you need to undergo an examination called **polysomnography**. During the examination, you sleep in a special room with a series of wires and patches attached to your body to hold in place probes that detect multiple biological parameters simultaneously. The most commonly used sensors are:

- a digital oximeter attached to the finger to detect oxygen levels in the blood;
- a series of electrodes attached to the head (electroencephalogram), two electrodes attached to the chin, two electrodes attached near the eyes;
- thoracic and abdominal bands that detect respiratory movements;
- a pressure transducer attached under the nose like a "mustache" that serves to monitor the flow of air from the mouth and nostrils;

- a carbon dioxide sensor;
- an electrocardiogram;
- a position sensor attached to the chest that tells us what position the patient sleeps in;
- two motion sensors attached to the legs.

NARCOLEPSY

What is narcolepsy?

Fortunately, narcolepsy is a rare disease. It can affect children of different ages, but usually starts between the ages of 8 and 15. It is caused by a reduction in or lack of a substance that the brain produces to stay awake called **orexin**, also known as hypocretin. Without orexin, the child becomes extremely drowsy and begins to fall asleep suddenly, up to 3 or more times per day, even during school hours or as soon as they sit down or relax. Children who suffer from it are often also mocked by their classmates or thought of as slackers who don't want to study. This is extremely wrong: it is best to talk about it with an adult or your doctor without any shame.

There are other typical, strange symptoms that are often part of narcolepsy. Children with narcolepsy often also suffer from **cataplexy**, which means they experience sudden losses of muscle strength in one part of their body or in their whole body when they feel strong joyful emotions. Simply put, they risk falling to the ground while laughing. These are short drops in strength, without loss of consciousness.

Other strange symptoms that accompany narcolepsy are **sleep paralysis** and hallucinations. The first one happens above all when we are waking up: the mind is awake, but it is as though we are paralyzed and cannot move. These are moments that can be very scary, but they are short and transitory, then everything goes back to normal. People with narcolepsy dream a lot and sometimes have dreams even before falling asleep or upon waking up. Dreams

that happen as you are falling asleep are also called hypnagogic **hallucinations**, while those that happen as you are waking up are called hypnopompic hallucinations. Narcolepsy is often not recognized and there is a risk that people who suffer from it will not get diagnosed and thus won't receive help. A classmate who falls asleep easily should never be mocked; they might be suffering from narcolepsy or another sleep disorder. Recognizing this condition and going to a clinic that specializes in sleep disorders means being able to receive adequate treatment and then lead a normal life.

CONCLUSIONS

Sleep is a valuable natural instinct, which enables us to live and keep all our biological functions properly balanced. Sleep is a much more intense and vital phenomenon than we have always believed, in which complex brain activities take place, regulated by nerve centers that are specifically responsible for producing sleep every night in a precise sequence.

Sleep is not all the same, but is made up of different types of sleep that follow each other in order during the night, each with a different function and each regulated by specific brain structures. If this delicate mechanism breaks down, sleep disorders can occur, which are real diseases, just like those that affect other organs, and have an impact on the whole body.

It is therefore important to respect sleep, know how to describe it to others, understand if anything is wrong, and, if necessary, undergo tests to see if you have any sleep disorders and find out how to treat them.

Thanks to scientific discoveries, nowadays we are not as in the dark about sleep as we were in the past; it continues to conceal fascinating secrets, of course, like those still waiting to be revealed about the daytime, wakefulness, and conscience. Without sleep, nothing that happens when you are awake would be possible. It is necessary to get a night's sleep in order to tackle the emotions and endeavors of a new day and it is necessary for another night to follow the day, so we have the chance to process all the information we receive while we are awake.

Sharp Knife

PART TWO

TEXTS

By the students of class 4E (formerly 3E) of the Giubiasco Middle School:

Carlotta Airoldi
Giacomo Ambrosini
Chiara Banfi
Martina Beltraminelli
Anna Borghi
Alissa Butti
Gabriele Calcagno
Michela Cima
Linus Coupek
Thomas Faggiano
Ludovica Iacolina
Rafael Martins Santos
Samuele Massera
Gabriel Ruezgarograg
Ivan Salvadé
Joshua Salvatore
Valeria Scaramella
Samuel Viggiano
Jessica Wyss

Under the coordination of the teachers:

Mahmut Filimci (natural sciences teacher)
Davide Ricciardi (Italian teacher)
Saul Savarino (visual education teacher)

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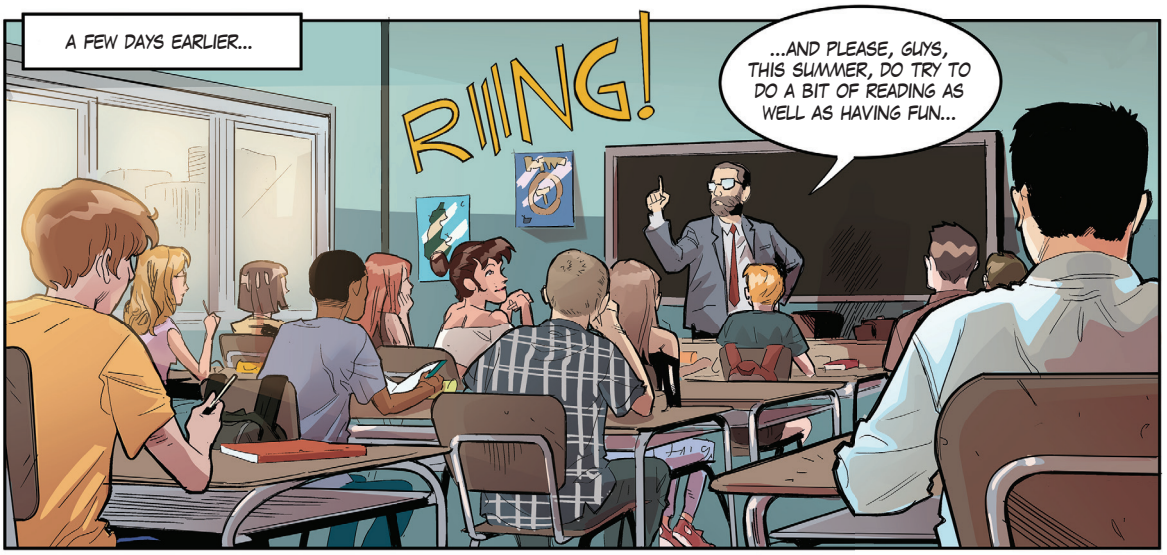
Head teacher: Michel Fregni

The *Let's Science!* adventure led class 3/4E to embark on a much larger project, involving several subjects. In fact, they created an e-book of short horror stories for Italian and a digital comic book for visual education. The students also composed a soundtrack to accompany the comic panels with the help of their music education teacher. All this was presented in the form of an interactive video, which lets the viewer explore the scientific aspects covered in the texts through in depth examinations of the topics with the aid of their science teacher. The whole project can be found on a specially created mini-site: https://scuolalab.ch/letscience

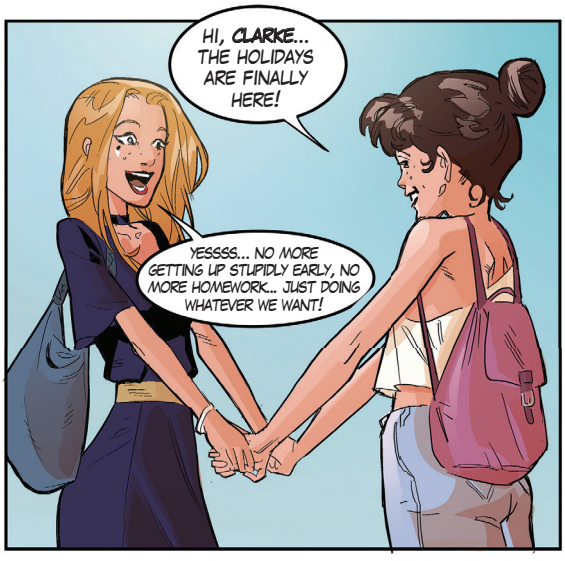
ILLUSTRATIONS

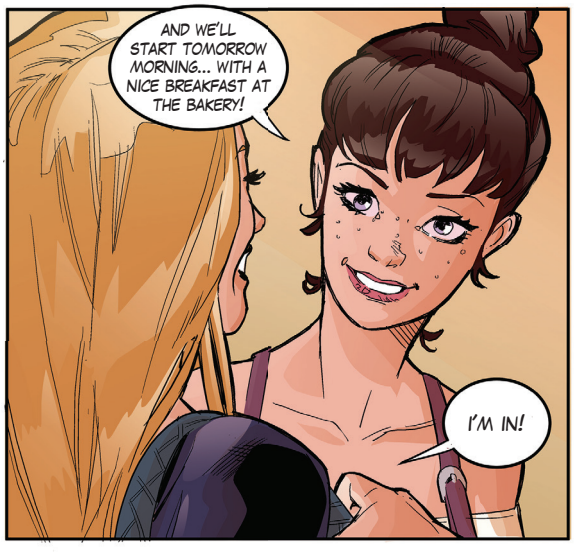
By Daniele Miano (illustrations) and Mirko Milone (coloring and lettering) for the Scuola Romana dei Fumetti.


SHARP KNIFE
LONDON, SUMMER 2017...
BUS LANE


A FEW DAYS EARLIER...
RIIING!
...AND PLEASE, GUYS, THIS SUMMER, DO TRY TO DO A BIT OF READING AS WELL AS HAVING FUN...

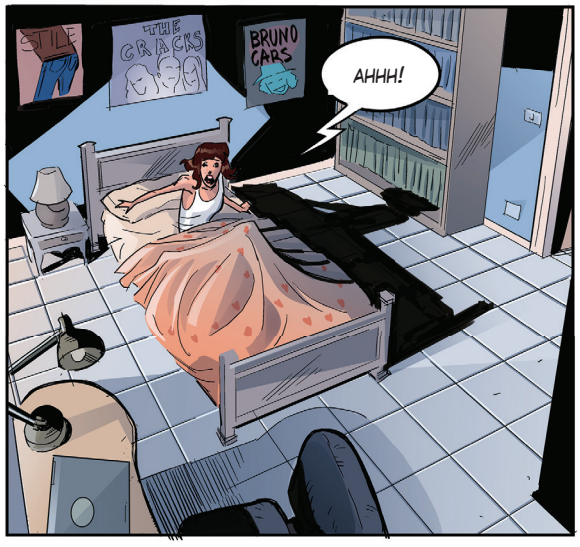

KATHLEEN!


HI, CLARKE... THE HOLIDAYS ARE FINALLY HERE!
YESSSS... NO MORE GETTING UP STUPIDLY EARLY, NO MORE HOMEWORK... JUST DOING WHATEVER WE WANT!

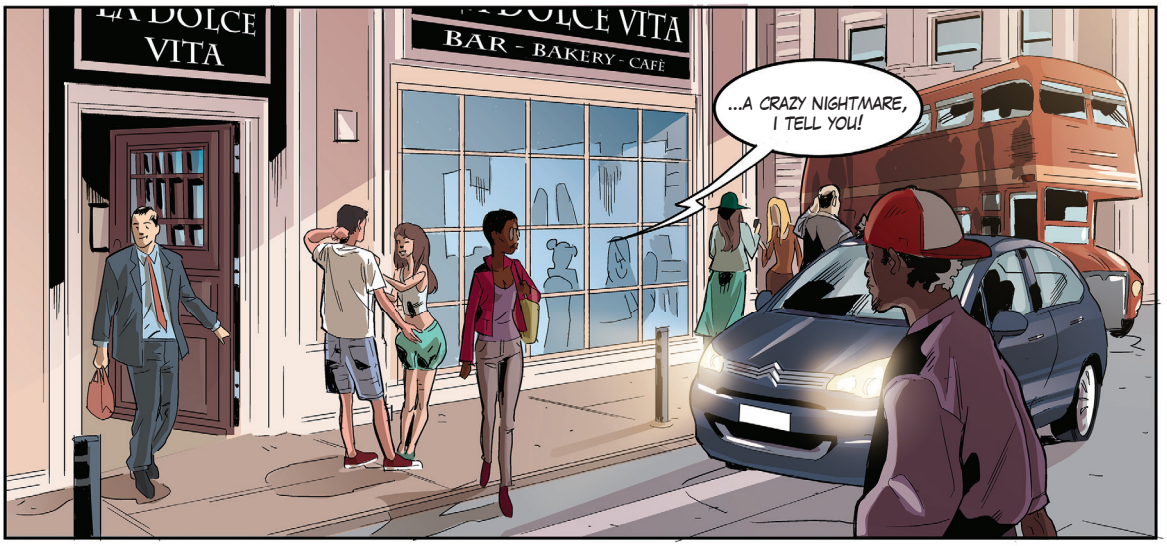

AND WE'LL START TOMORROW MORNING... WITH A NICE BREAKFAST AT THE BAKERY!
I'M IN!

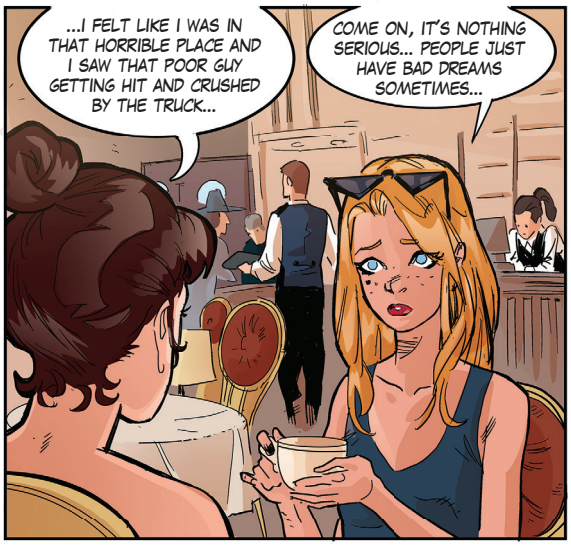

HELP!


AHHH!

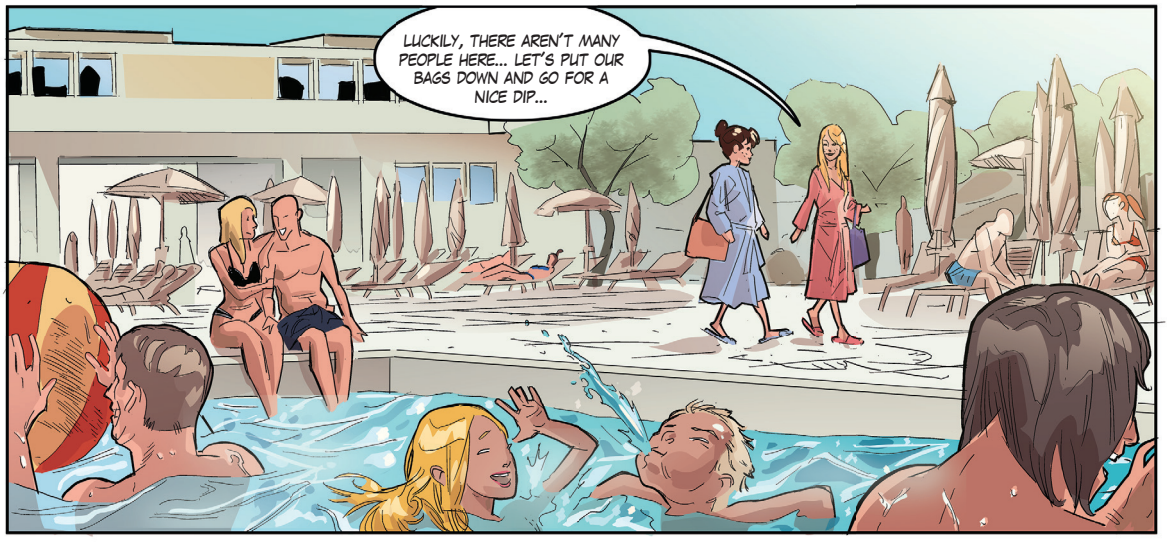

STILE
THE CRACKS
BRUNO CARS
AHHH!

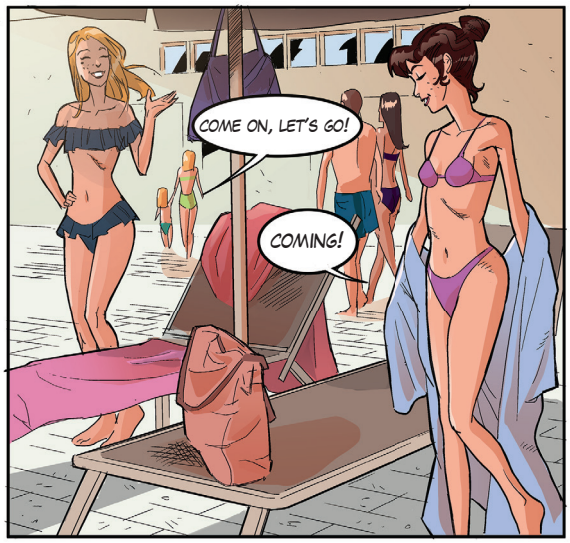

WHAT HAPPENED, DARLING?
NOTHING, MOM... JUST A NIGHTMARE...

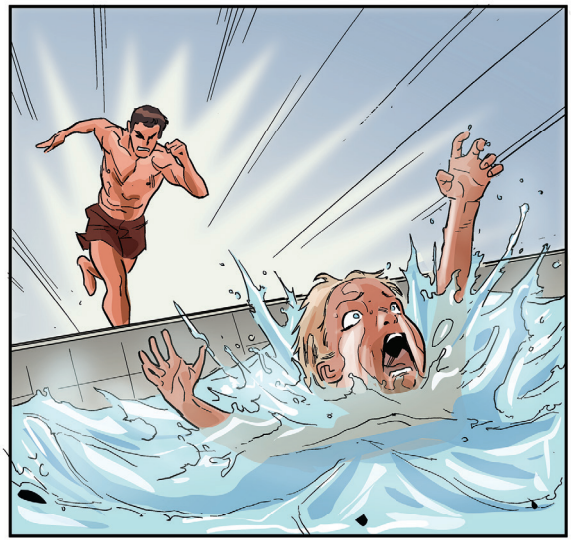

LA DOLCE VITA
BAR - BAKERY - CAFÈ
...A CRAZY NIGHTMARE, I TELL YOU!


...I FELT LIKE I WAS IN THAT HORRIBLE PLACE AND I SAW THAT POOR GUY GETTING HIT AND CRUSHED BY THE TRUCK...
COME ON, IT'S NOTHING SERIOUS... PEOPLE JUST HAVE BAD DREAMS SOMETIMES...


...IT'S ALL BECAUSE OF THOSE HORROR SHOWS YOU WATCH BEFORE YOU GO TO SLEEP!
YOU SOUND LIKE MY MOTHER... COME ON, LET'S GO SWIMMING IN THE POOL...


LUCKILY, THERE AREN'T MANY PEOPLE HERE... LET'S PUT OUR BAGS DOWN AND GO FOR A NICE DIP...

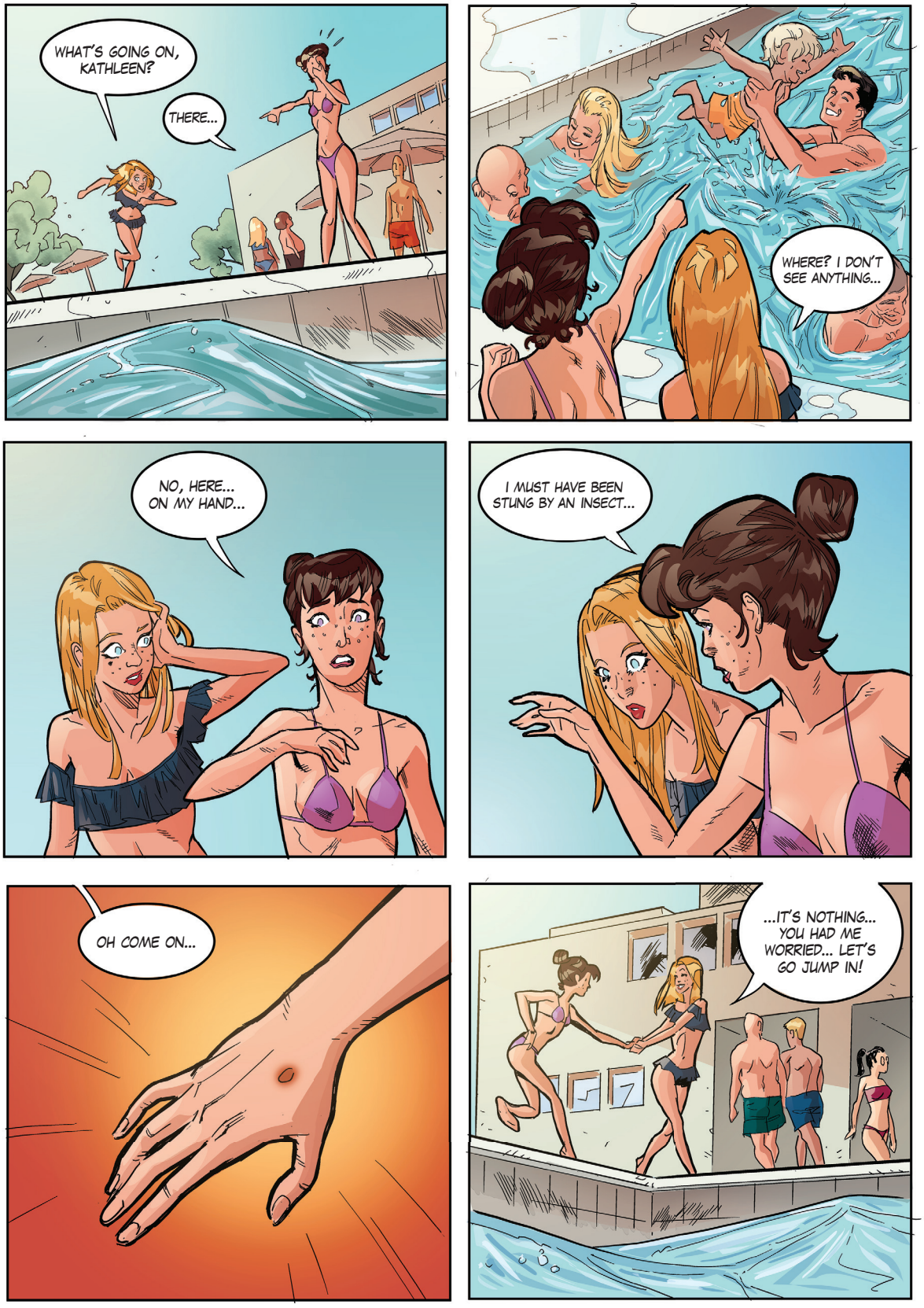

COME ON, LET'S GO!
COMING!



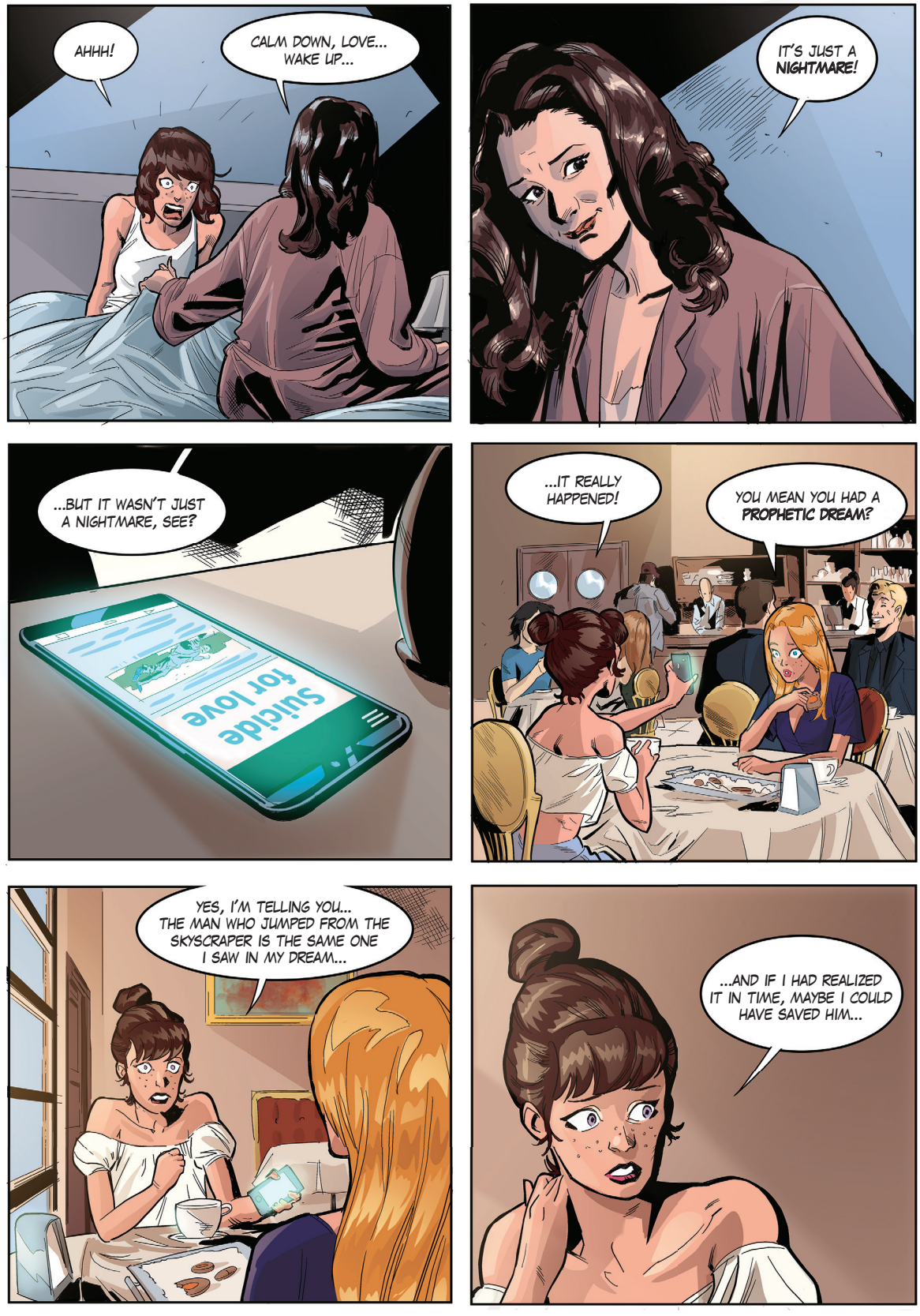

AHHH!


STOCK!

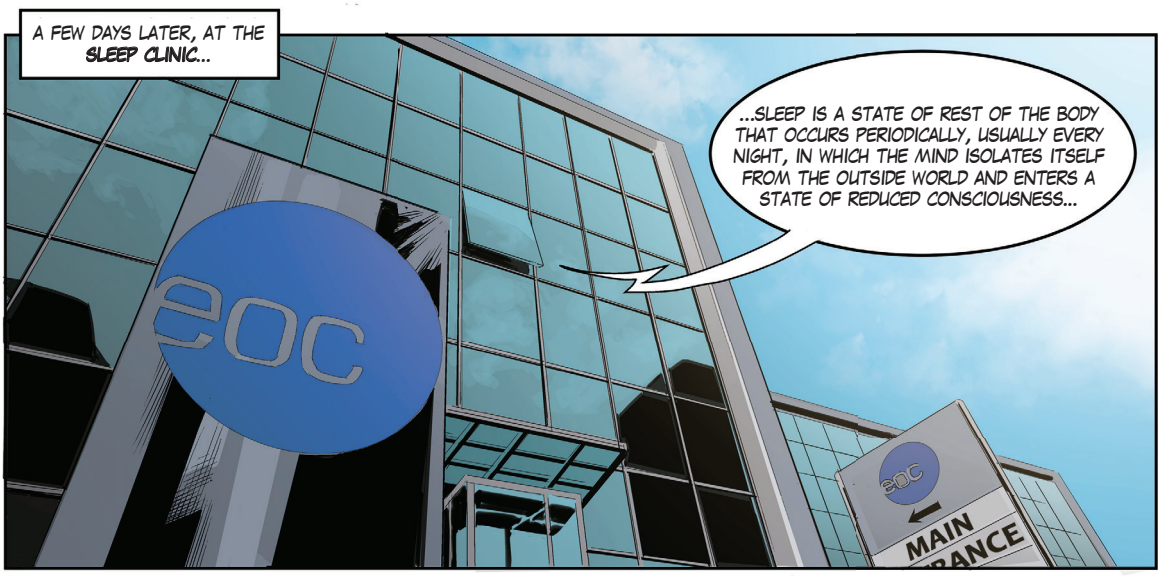

AHHH!


WHAT'S GOING ON, KATHLEEN?
THERE...
WHERE? I DON'T SEE ANYTHING...
NO, HERE... ON MY HAND...
I MUST HAVE BEEN STUNG BY AN INSECT...
OH COME ON...
...IT'S NOTHING... YOU HAD ME WORRIED... LET'S GO JUMP IN!

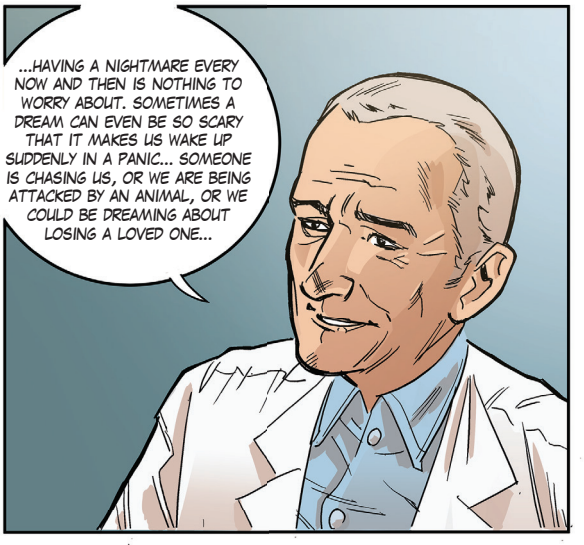

THAT NIGHT...
DON'T!
NOOO!
AHHH!

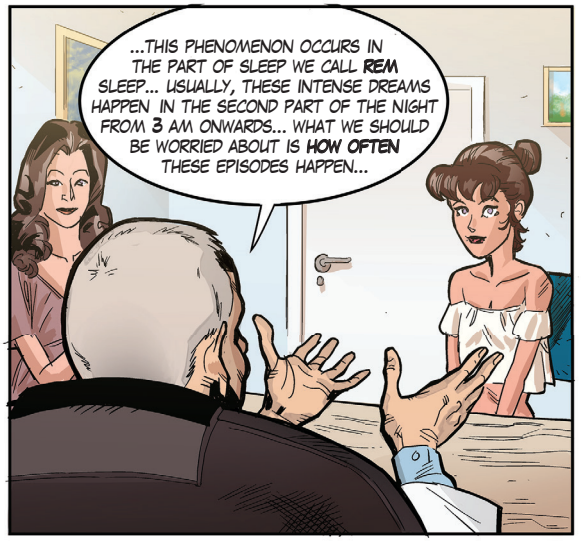

AHHH!
CALM DOWN, LOVE... WAKE UP...
IT'S JUST A NIGHTMARE!
...BUT IT WASN'T JUST A NIGHTMARE, SEE?
Suicide for love
...IT REALLY HAPPENED!
YOU MEAN YOU HAD A PROPHETIC DREAM?
YES, I'M TELLING YOU... THE MAN WHO JUMPED FROM THE SKYSCRAPER IS THE SAME ONE I SAW IN MY DREAM...
...AND IF I HAD REALIZED IT IN TIME, MAYBE I COULD HAVE SAVED HIM...


THE NEXT FEW NIGHTS...
NOOO!
GBRf
66713
AHHH!
HEEEEELP!

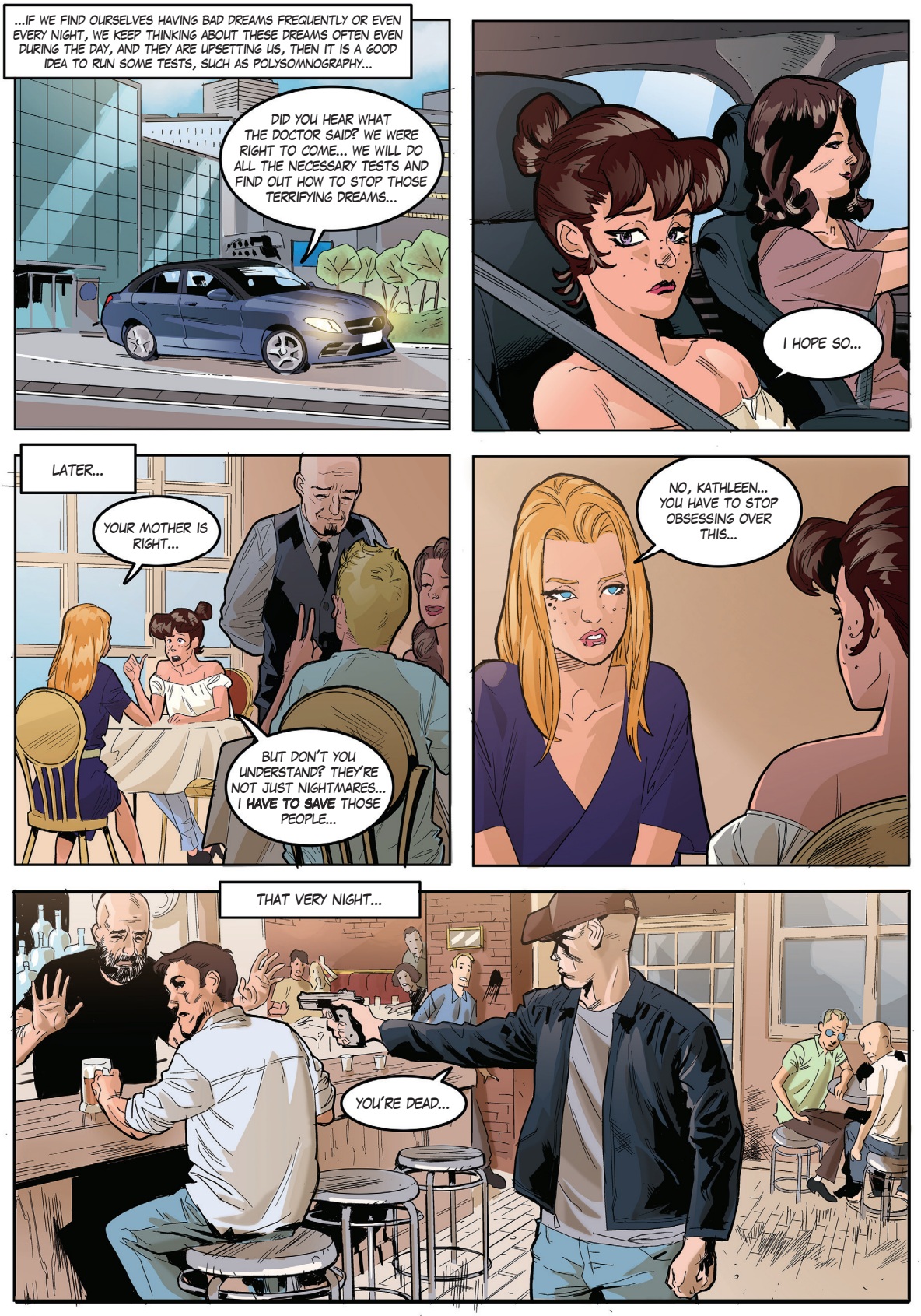

A FEW DAYS LATER, AT THE SLEEP CLINIC...
...SLEEP IS A STATE OF REST OF THE BODY THAT OCCURS PERIODICALLY, USUALLY EVERY NIGHT, IN WHICH THE MIND ISOLATES ITSELF FROM THE OUTSIDE WORLD AND ENTERS A STATE OF REDUCED CONSCIOUSNESS...
eoc
eoc
MAIN


...WHEN WE SLEEP, WE LOSE CONSCIOUSNESS FOR A CERTAIN PERIOD AND REGAIN IT IN THE MORNING WHEN WE WAKE UP. CONSCIOUSNESS CAN ALSO BE LOST FOR OTHER REASONS, SUCH AS IN A COMA, WHICH IS A SERIOUS CONDITION USUALLY CAUSED BY BRAIN DAMAGE...


...HAVING A NIGHTMARE EVERY NOW AND THEN IS NOTHING TO WORRY ABOUT. SOMETIMES A DREAM CAN EVEN BE SO SCARY THAT IT MAKES US WAKE UP SUDDENLY IN A PANIC... SOMEONE IS CHASING US, OR WE ARE BEING ATTACKED BY AN ANIMAL, OR WE COULD BE DREAMING ABOUT LOSING A LOVED ONE...


...THIS PHENOMENON OCCURS IN THE PART OF SLEEP WE CALL REM SLEEP... USUALLY, THESE INTENSE DREAMS HAPPEN IN THE SECOND PART OF THE NIGHT FROM 3 AM ONWARDS... WHAT WE SHOULD BE WORRIED ABOUT IS HOW OFTEN THESE EPISODES HAPPEN...


...THEY COULD BE CAUSED BY A SERIOUS TRAUMA BUT ALSO BY A SPECIFIC FEAR...

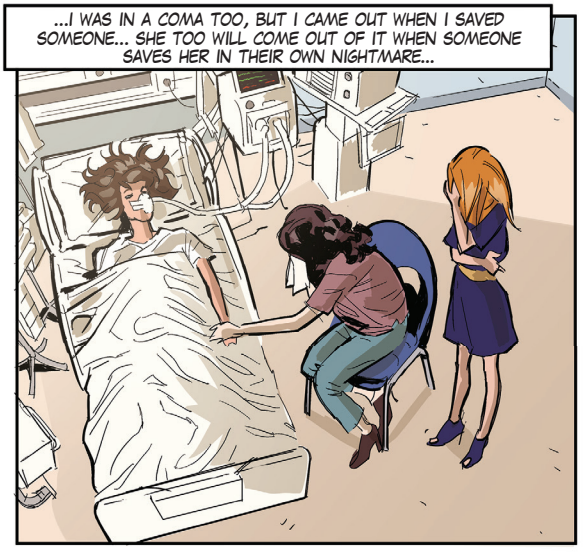

...IF WE FIND OURSELVES HAVING BAD DREAMS FREQUENTLY OR EVEN EVERY NIGHT, WE KEEP THINKING ABOUT THESE DREAMS OFTEN EVEN DURING THE DAY, AND THEY ARE UPSETTING US, THEN IT IS A GOOD IDEA TO RUN SOME TESTS, SUCH AS POLYSOMNOGRAPHY...
DID YOU HEAR WHAT THE DOCTOR SAID? WE WERE RIGHT TO COME... WE WILL DO ALL THE NECESSARY TESTS AND FIND OUT HOW TO STOP THOSE TERRIFYING DREAMS...
I HOPE SO...
LATER...
YOUR MOTHER IS RIGHT...
BUT DON'T YOU UNDERSTAND? THEY'RE NOT JUST NIGHTMARES... I **HAVE TO SAVE** THOSE PEOPLE...
NO, KATHLEEN... YOU HAVE TO STOP OBSESSING OVER THIS...
THAT VERY NIGHT...
YOU'RE DEAD...


BAM!
NO, STOP!


AHHH!


I'VE BEEN WAITING FOR YOU, KATHLEEN!


NO, SHE DOESN'T BELONG TO YOU YET...


...I WAS IN A COMA TOO, BUT I CAME OUT WHEN I SAVED SOMEONE... SHE TOO WILL COME OUT OF IT WHEN SOMEONE SAVES HER IN THEIR OWN NIGHTMARE...


AHHH!
THE END

Anxiety disorder A mental state of fear and panic; it may be a reaction to a stressful event but can also be a spontaneous phenomenon. If it persists and is intense, it is one of the psychiatric disorders that need to be diagnosed and treated.

Brainstem A cylinder-shaped brain structure that is located beneath the brain and has numerous functions including, above all, regulating breathing, the heartbeat, and sleep.

Caffeine A stimulant, also known as theine, contained in several plants including coffee, tea, and cola.

Cataplexy A typical symptom of narcolepsy, characterized by a sudden loss of muscle strength in the whole body or part of it, caused by a positive emotion, usually triggered by laughter.

Cerebellum A neural structure similar to the brain, but much smaller, located under the brain; it has various functions, including controlling the coordination of movement and balance.

Chrono-biology The field of science that studies the periodic rhythms of living beings, in particular those phenomena that are repeated with a rhythm similar to the alternation between day and night.

Circadian rhythm This term refers to all those periodic biological phenomena that are repeated following a rhythm of about 24 hours.

Coma	A state distinguished by the absence of consciousness, in which the individual cannot be woken up even with a painful stimulus. The most frequent causes of coma are brain damage, the use of toxic substances, and metabolic conditions such as a significant drop in blood sugars.
Consciousness	A wakeful state in which the individual is alert and aware of themselves and the world around them.
Cortisol	A hormone produced by the adrenal glands. It is also often referred to as the "stress hormone" because it is produced in greater quantities when the body is under significant physical strain or is in imminent danger.
Depression	A psychiatric disorder characterized by a sharp drop in mood and intense and lasting sadness.
Diabetes	A metabolic disease that involves a stable increase in blood sugar levels. If diabetes is not treated, it has negative consequences for several systems, including the cardiovascular system.
Hibernation	A state typical of some animals, similar to deep sleep, in which the vital functions are reduced to a minimum for a long period of time.
Hypertension	A disorder of the circulatory system in which the blood pressure in the arteries is too high; if it is not treated, it damages the blood vessels themselves.
Hypnogram	A graphic representation of the structure of sleep, i.e., the distribution of the various stages of sleep throughout the night.
Hypothalamus	A brain structure located at the base of the brain that produces numerous substances essential for regulating different hormones, such as thyroid hormones, sex hormones, and cortisol.
Immune system	A set of structures and functions that regulate the body's defensive response to foreign bodies, especially viruses and bacteria.

Instinct	A natural and vital behavior that is carried out spontaneously without needing to be taught.
Jet lag	A sleep-wake cycle disorder caused by intercontinental travel between countries with a time zone difference of at least 3-4 hours.
Melatonin	A substance produced by the pineal gland that serves to regulate the sleep-wake cycle; it is produced when it is dark and is suppressed by light.
Narcolepsy	A rare sleep disorder caused by the lack of an excitatory substance called orexin. It causes sudden bouts of sleep during the day and other symptoms, such as cataplexy or hallucinations while falling asleep or waking up.
Neuron	A typical cell of the nervous system that connects to other neurons via synapses.
Nocturnal enuresis	Also known as bedwetting: unintentional leakage of urine during sleep.
Non-REM stage	The stage of sleep in which we do not move our eyes and brain activity is reduced.
Orexin	A substance produced by the hypothalamus that serves to keep us awake and that is lacking in individuals with the disease narcolepsy.
Pacemaker	A small electronic device that is implanted under the skin and is able to continuously control the heartbeat and compensate for its dysfunction when required.
Pineal gland	A small, important gland, so called because it resembles a small pine cone. It is located in the back of the brain and produces melatonin.
Polysomnography	A medical examination that is used to study sleep in depth and is usually carried out in a sleep clinic.

REM stage	Stands for "Rapid Eye Movement". A sleep phase characterized by rapid movements of the eyes, it is the stage during which we dream.
Stupor	A state distinguished by the absence of consciousness, less severe than a coma, in which the individual can only be woken up for a short period of time with a painful stimulus. It often results from the use of toxic substances such as tranquilizers.
Supra-chiasmatic nucleus	A small part of the brain, located in the hypothalamus, responsible for regulating the rhythm of various periodic functions that follow the alternation of light and dark.
Synapse	A specialized nerve structure that serves as a connection point between two neurons that communicate with each other.
Synaptic pruning	A natural phenomenon that reduces the number of synapses, that is, the connections between neurons. It occurs mainly during non-REM sleep and serves to eliminate unimportant information received in the waking state.
Thalamus	A brain structure located in the center of the brain, the main function of which is to receive all sensory stimuli, such as those derived from the five senses.
Vital function	A function indispensable for life, such as breathing, heartbeat, etc.

Human beings have always needed to sleep since they first appeared on Earth and they spend about a third of their life asleep; yet the study of this mysterious and fascinating phenomenon only began less than 70 years ago.

The science of sleep is therefore a young discipline, but it has already led to great scientific discoveries that enable us to answer some fundamental questions: what is sleep? What happens during sleep? What is sleep for? And how long can you survive without sleep? How are sleep disorders diagnosed and how are they treated?

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Inside the comic:

Sharp Knife

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