Biological Psychology

An Illustrated Survival Guide

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and
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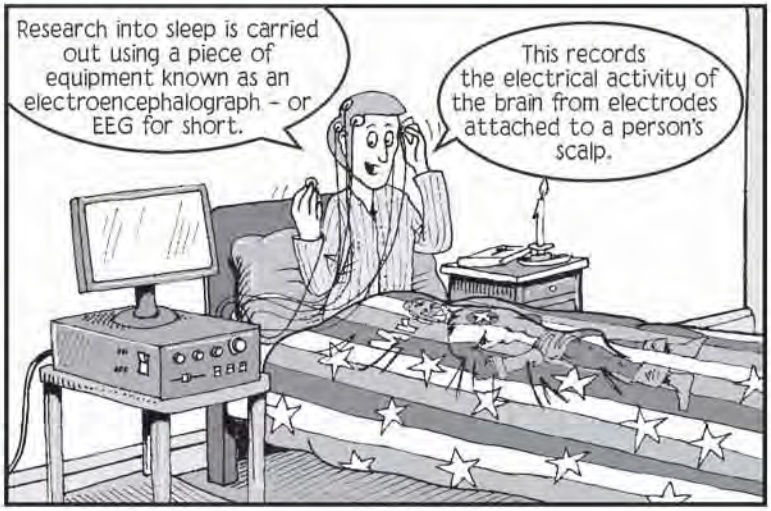
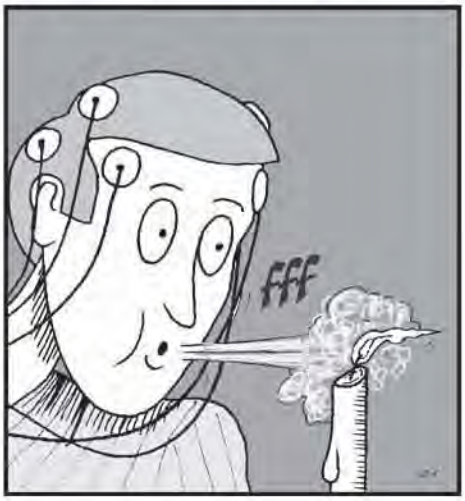
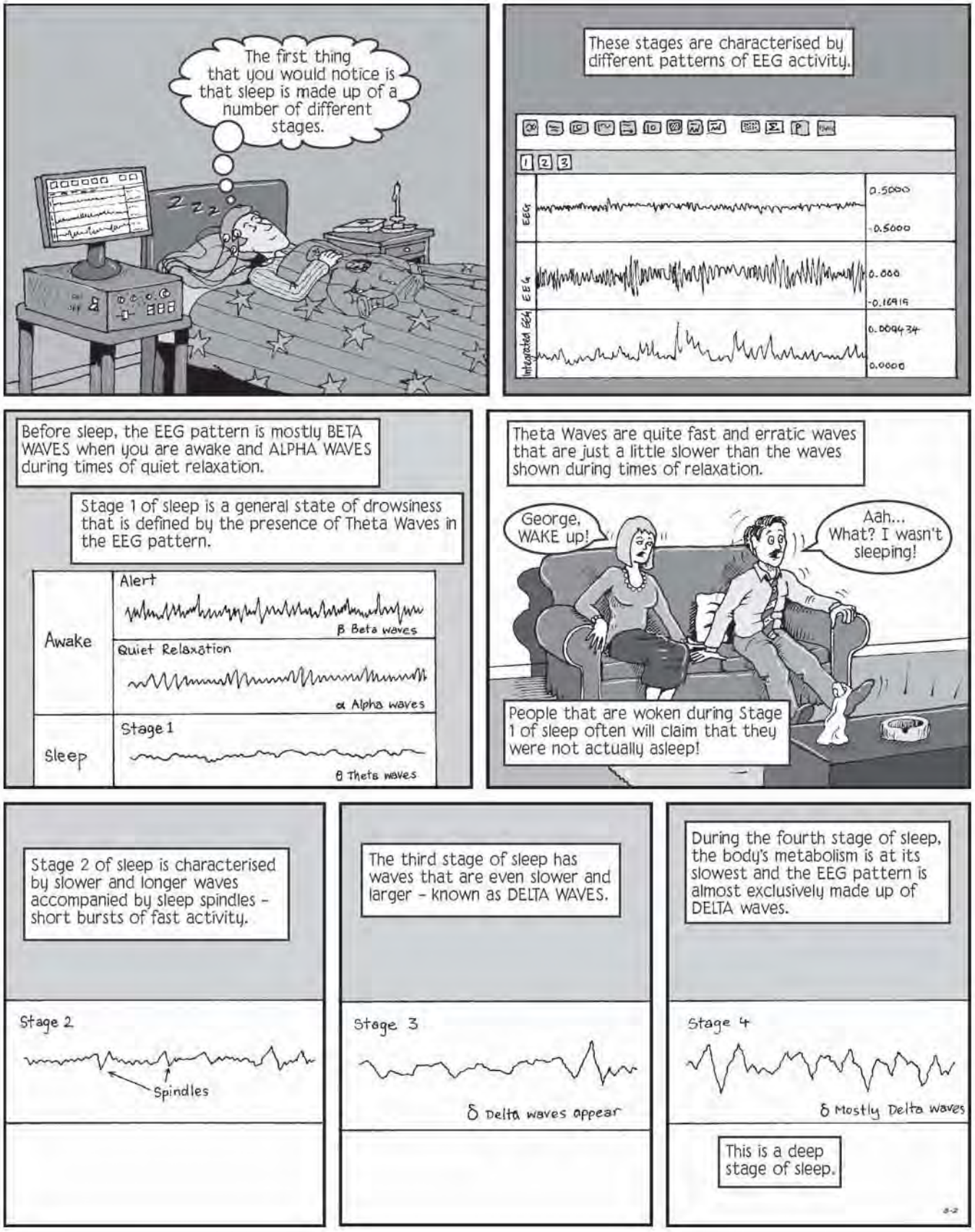
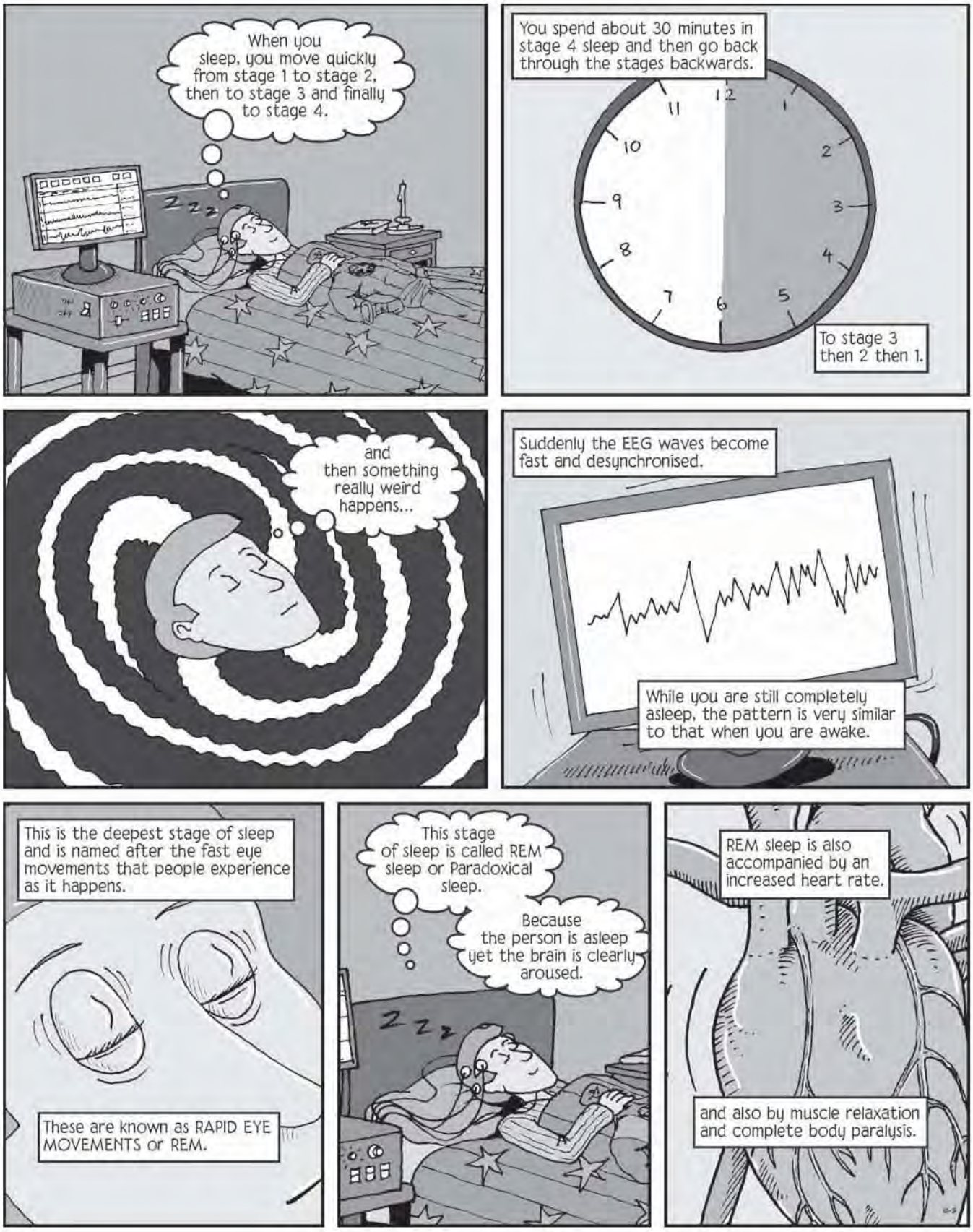
WILEY

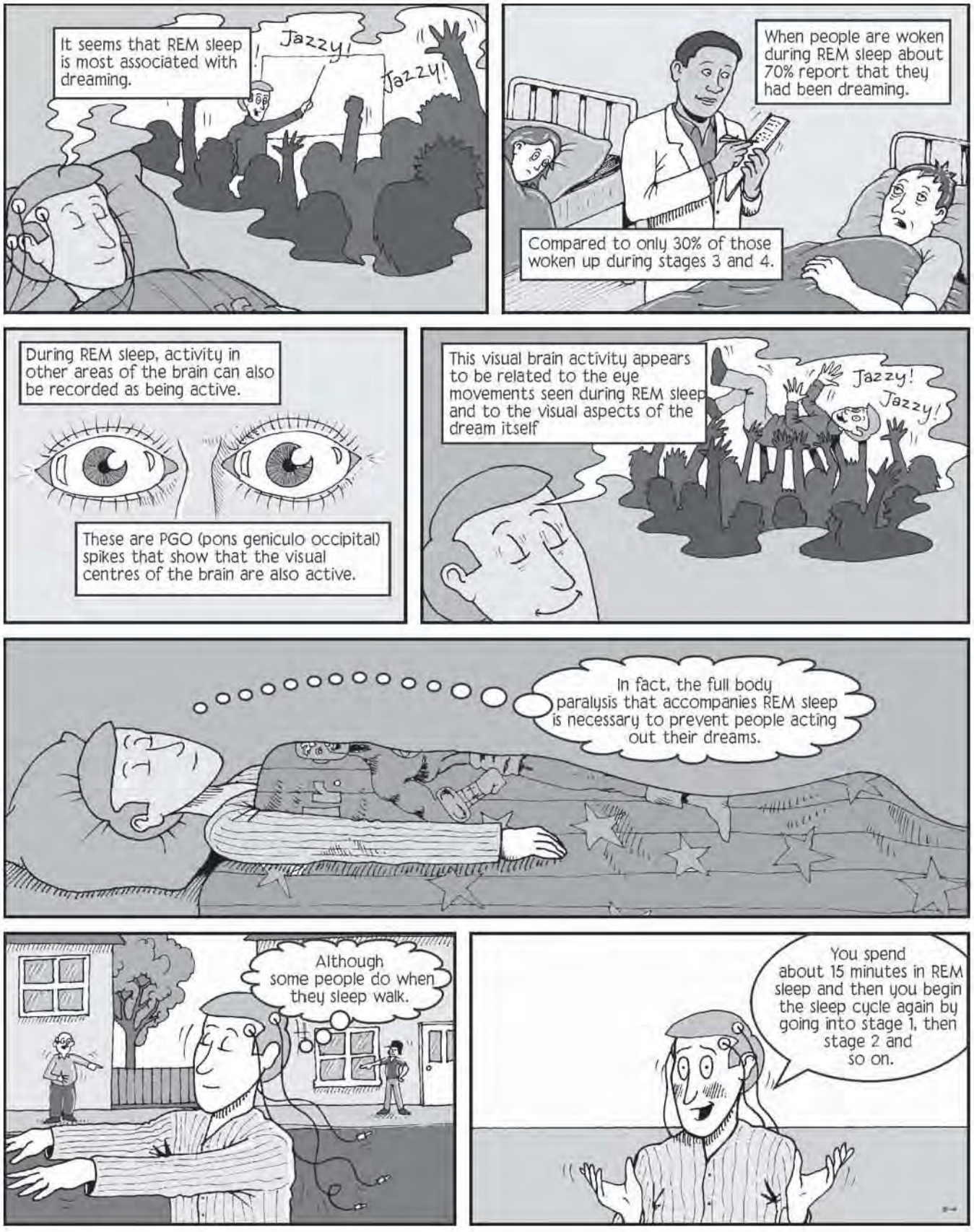
CHAPTER 8
SLEEP AND BIOLOGICAL RHYTHMS

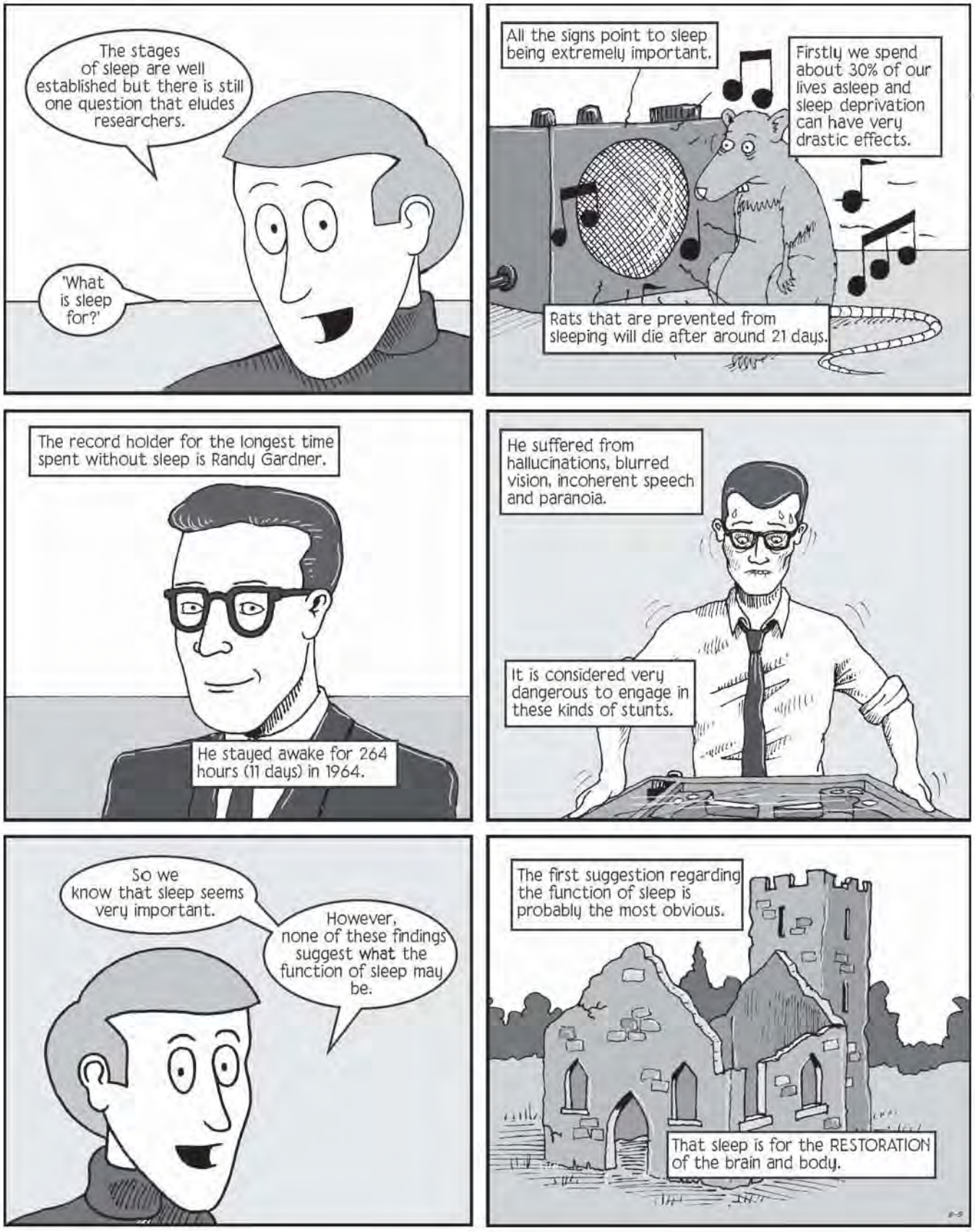


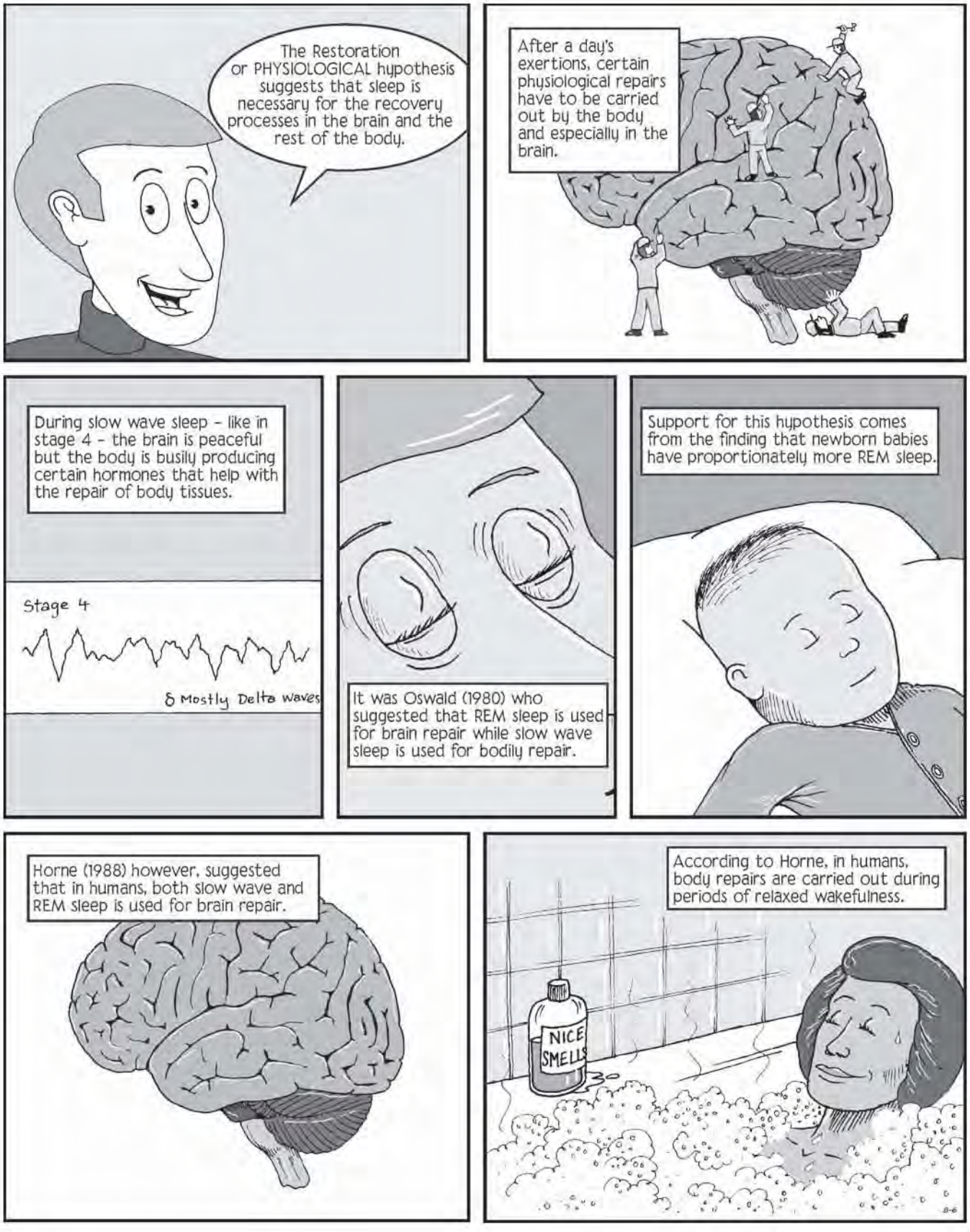



The first thing that you would notice is that sleep is made up of a number of different stages.
These stages are characterised by different patterns of EEG activity.
EEG
EEG
Integrated EEG
0.5000
-0.5000
0.000
-0.1691
0.009434
0.0000
Before sleep, the EEG pattern is mostly BETA WAVES when you are awake and ALPHA WAVES during times of quiet relaxation.
Stage 1 of sleep is a general state of drowsiness that is defined by the presence of Theta Waves in the EEG pattern.
Awake
Alert
β Beta waves
Quiet Relaxation
α Alpha waves
Sleep
Stage 1
θ Theta waves
Theta Waves are quite fast and erratic waves that are just a little slower than the waves shown during times of relaxation.
George, WAKE up!
Aah... What? I wasn't sleeping!
People that are woken during Stage 1 of sleep often will claim that they were not actually asleep!
Stage 2 of sleep is characterised by slower and longer waves accompanied by sleep spindles - short bursts of fast activity.
Stage 2
Spindles
The third stage of sleep has waves that are even slower and larger - known as DELTA WAVES.
Stage 3
δ Delta waves appear
During the fourth stage of sleep, the body's metabolism is at its slowest and the EEG pattern is almost exclusively made up of DELTA waves.
Stage 4
δ Mostly Delta waves
This is a deep stage of sleep.

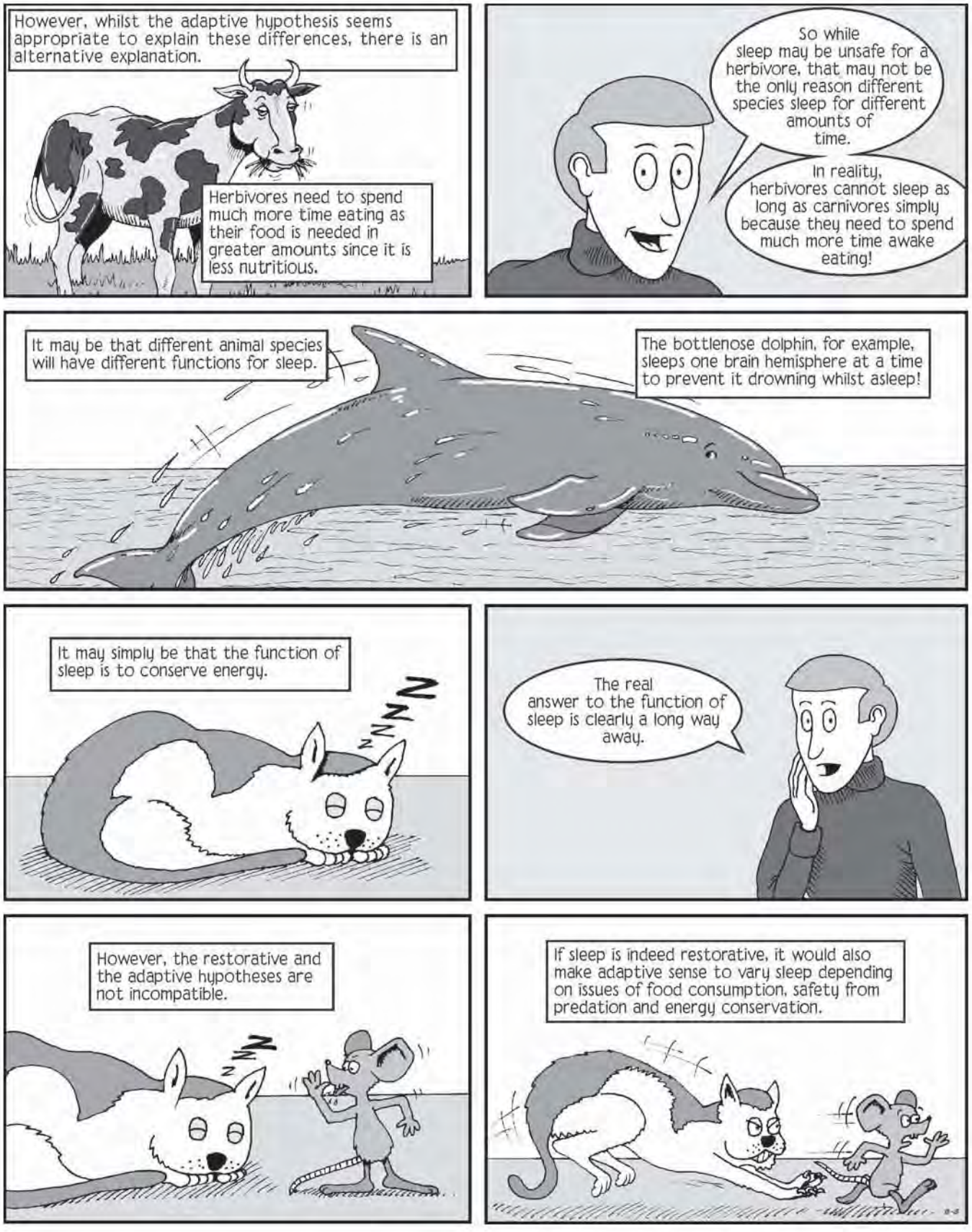

When you sleep, you move quickly from stage 1 to stage 2, then to stage 3 and finally to stage 4.
Z z z
You spend about 30 minutes in stage 4 sleep and then go back through the stages backwards.
12
1
2
3
4
5
6
7
8
9
10
11
To stage 3 then 2 then 1.
and then something really weird happens...
Suddenly the EEG waves become fast and desynchronised.
While you are still completely asleep, the pattern is very similar to that when you are awake.
This is the deepest stage of sleep and is named after the fast eye movements that people experience as it happens.
These are known as RAPID EYE MOVEMENTS or REM.
This stage of sleep is called REM sleep or Paradoxical sleep.
Because the person is asleep yet the brain is clearly aroused.
Z z z
REM sleep is also accompanied by an increased heart rate.
and also by muscle relaxation and complete body paralysis.

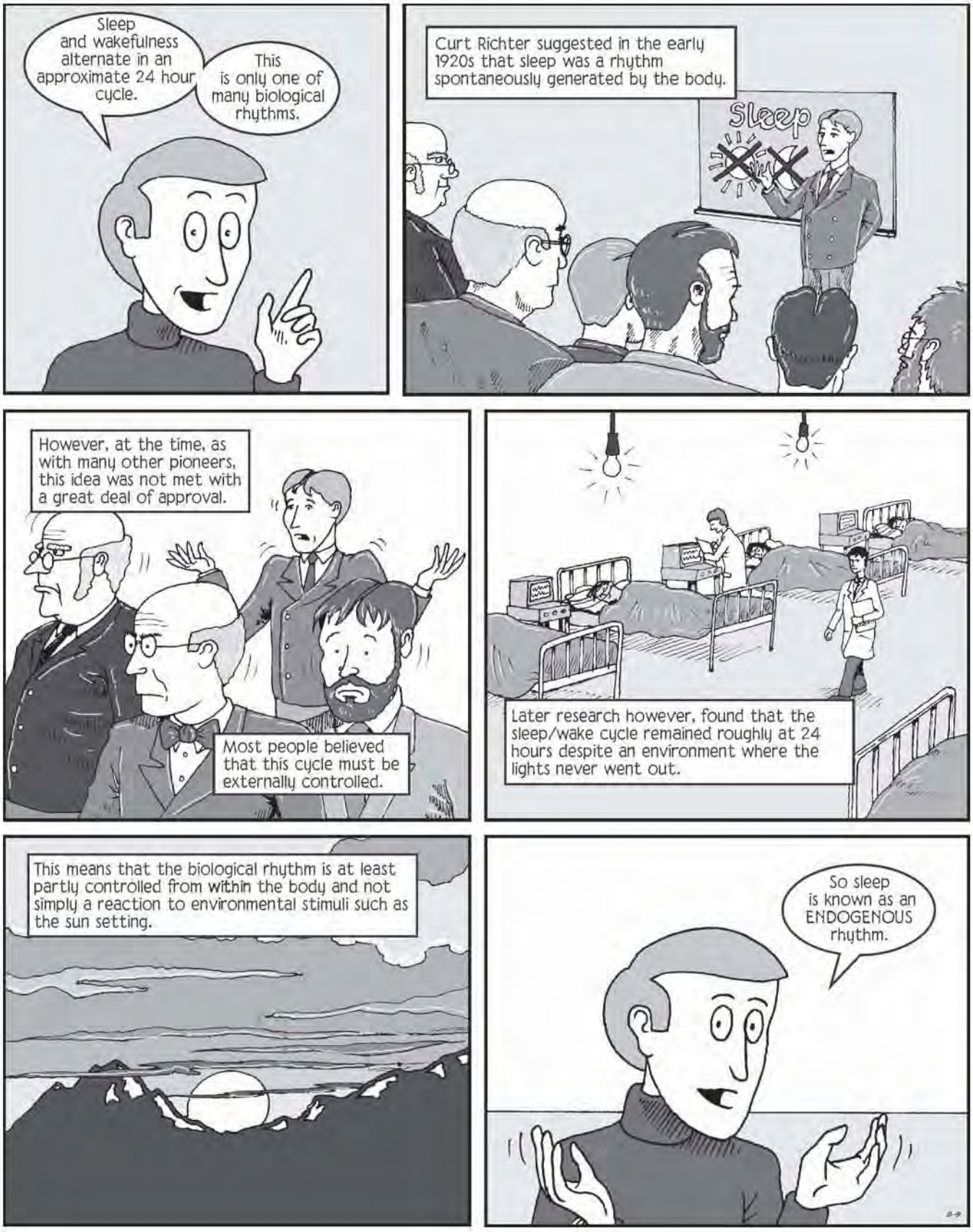

It seems that REM sleep is most associated with dreaming.
Jazzy!
Jazzy!
When people are woken during REM sleep about 70% report that they had been dreaming.
Compared to only 30% of those woken up during stages 3 and 4.
During REM sleep, activity in other areas of the brain can also be recorded as being active.
These are PGO (pons geniculo occipital) spikes that show that the visual centres of the brain are also active.
This visual brain activity appears to be related to the eye movements seen during REM sleep and to the visual aspects of the dream itself
Jazzy!
Jazzy!
In fact, the full body paralysis that accompanies REM sleep is necessary to prevent people acting out their dreams.
Although some people do when they sleep walk.
You spend about 15 minutes in REM sleep and then you begin the sleep cycle again by going into stage 1, then stage 2 and so on.


The stages of sleep are well established but there is still one question that eludes researchers.
'What is sleep for?'
All the signs point to sleep being extremely important.
Firstly we spend about 30% of our lives asleep and sleep deprivation can have very drastic effects.
Rats that are prevented from sleeping will die after around 21 days.
The record holder for the longest time spent without sleep is Randy Gardner.
He stayed awake for 264 hours (11 days) in 1964.
He suffered from hallucinations, blurred vision, incoherent speech and paranoia.
It is considered very dangerous to engage in these kinds of stunts.
So we know that sleep seems very important.
However, none of these findings suggest what the function of sleep may be.
The first suggestion regarding the function of sleep is probably the most obvious.
That sleep is for the RESTORATION of the brain and body.


The Restoration or PHYSIOLOGICAL hypothesis suggests that sleep is necessary for the recovery processes in the brain and the rest of the body.
After a day's exertions, certain physiological repairs have to be carried out by the body and especially in the brain.
During slow wave sleep – like in stage 4 – the brain is peaceful but the body is busily producing certain hormones that help with the repair of body tissues.
Stage 4
δ Mostly Delta waves
It was Oswald (1980) who suggested that REM sleep is used for brain repair while slow wave sleep is used for bodily repair.
Support for this hypothesis comes from the finding that newborn babies have proportionately more REM sleep.
Horne (1988) however, suggested that in humans, both slow wave and REM sleep is used for brain repair.
According to Horne, in humans, body repairs are carried out during periods of relaxed wakefulness.
NICE SMELLS


The support for this idea comes from the less drastic effects of human sleep deprivation compared to that in other animal species.
RIP
Ratty
Awoken to Forever Sleep
Additionally, when sleep deprived humans eventually do sleep, they only recover about 25% of the lost sleep and spend most of that time in stages 3, 4 and REM sleep.
In fact, Horne called these stages CORE sleep whilst stage 1 and 2 he considered OPTIONAL stages.
The alternative suggestion for the function of sleep is called the ECOLOGICAL or ADAPTIVE hypothesis.
This hypothesis comes from the observation that different species of mammals sleep for different amounts of time over a twenty four hour period.
Animals that eat other animals -carnivores- tend to sleep for the longest times over a 24 hour period.
BAT
= 19.9 hrs
CAT
= 14.5 hrs
Herbivores, that are predated on, tend to sleep for much shorter amounts of time.
COW
= 3.9 hrs
HORSE
= 2.9 hrs
SHEEP
= 3.8 hrs
This suggests that vulnerable animals sleep less in order to protect themselves from being eaten.
Whilst the less vulnerable animals can afford to sleep for much longer.

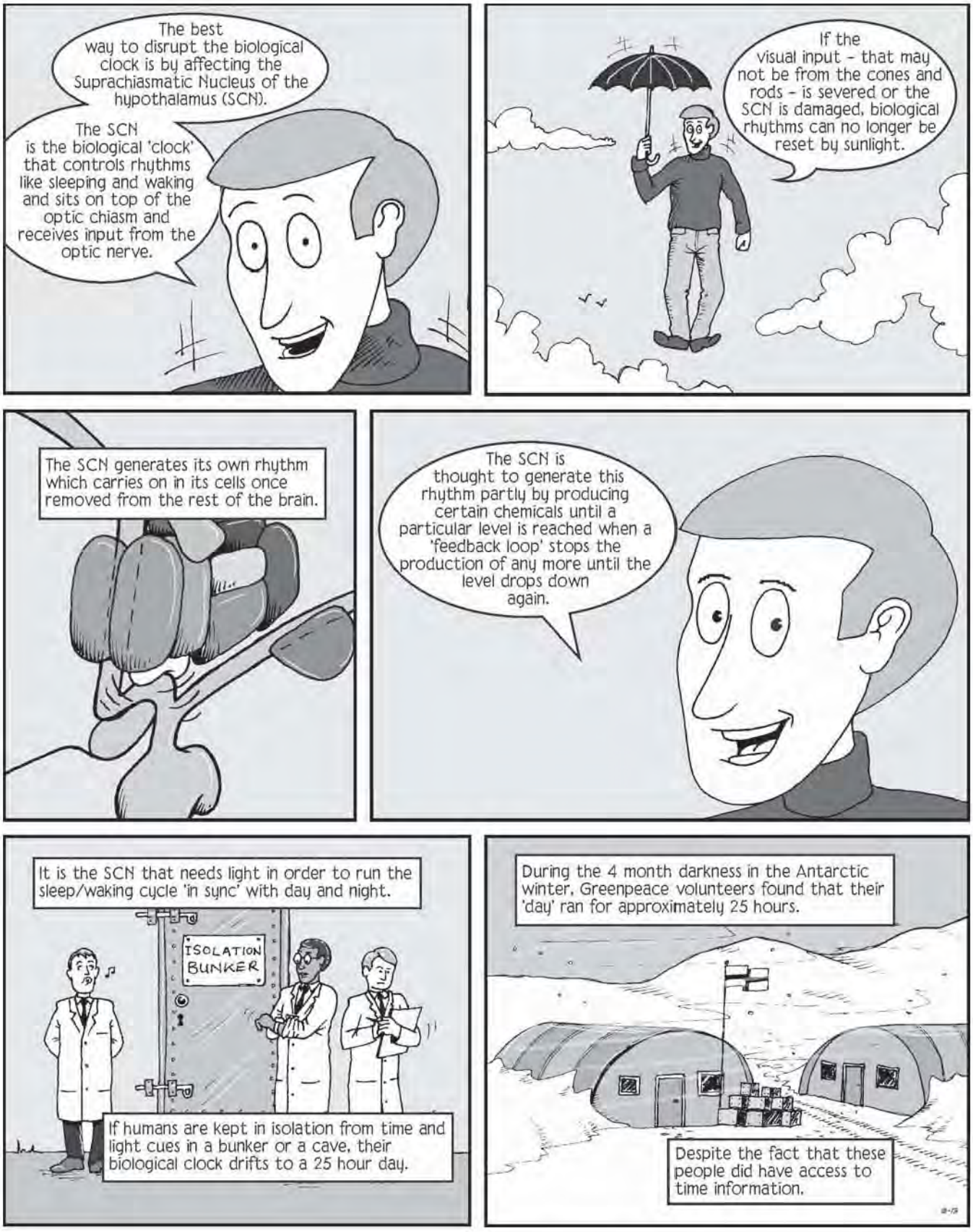

However, whilst the adaptive hypothesis seems appropriate to explain these differences, there is an alternative explanation.
Herbivores need to spend much more time eating as their food is needed in greater amounts since it is less nutritious.
So while sleep may be unsafe for a herbivore, that may not be the only reason different species sleep for different amounts of time.
In reality, herbivores cannot sleep as long as carnivores simply because they need to spend much more time awake eating!
It may be that different animal species will have different functions for sleep.
The bottlenose dolphin, for example, sleeps one brain hemisphere at a time to prevent it drowning whilst asleep!
It may simply be that the function of sleep is to conserve energy.
Z Z Z Z
The real answer to the function of sleep is clearly a long way away.
However, the restorative and the adaptive hypotheses are not incompatible.
Z Z Z
If sleep is indeed restorative, it would also make adaptive sense to vary sleep depending on issues of food consumption, safety from predation and energy conservation.

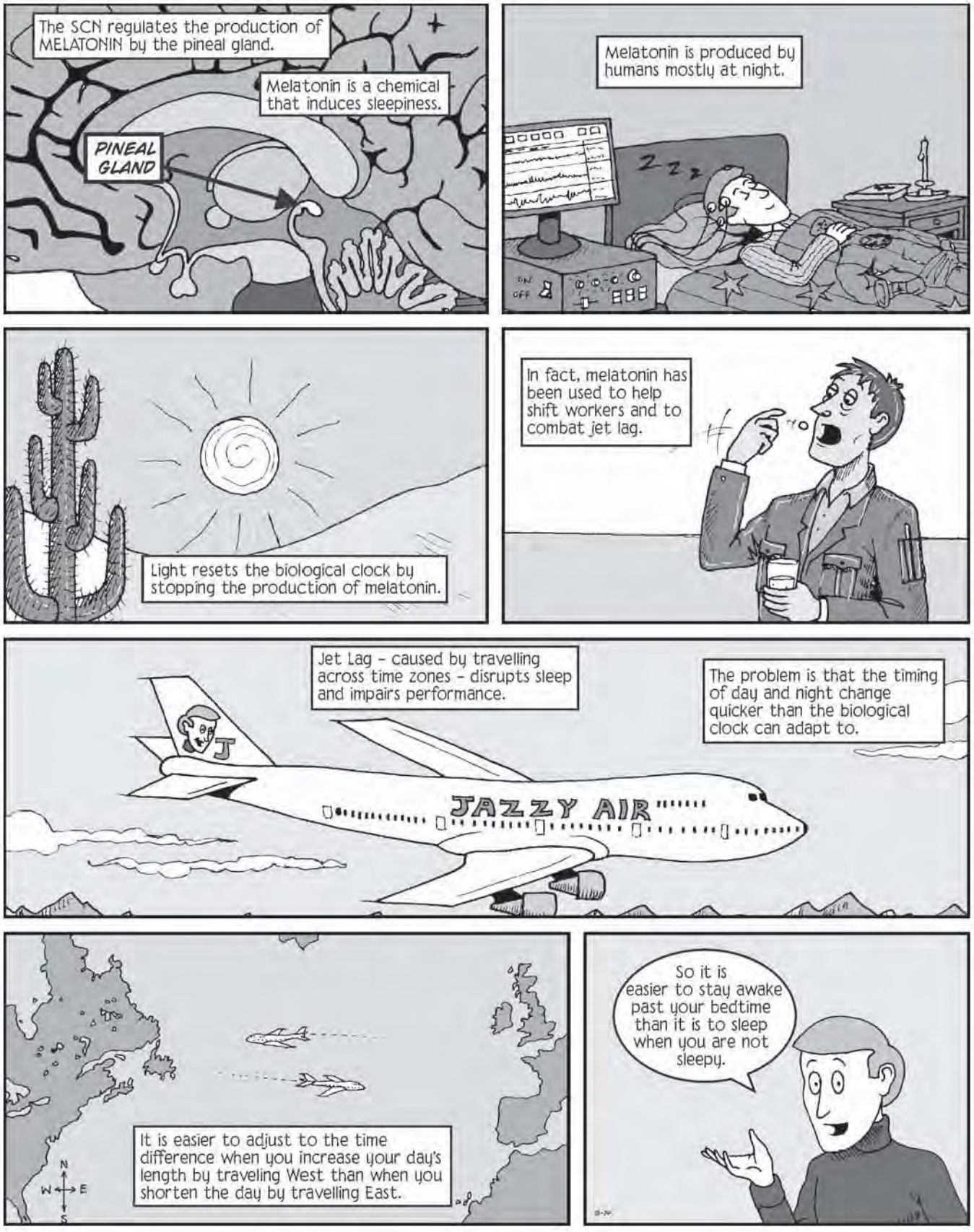

Sleep and wakefulness alternate in an approximate 24 hour cycle.
This is only one of many biological rhythms.
Curt Richter suggested in the early 1920s that sleep was a rhythm spontaneously generated by the body.
Sleep
However, at the time, as with many other pioneers, this idea was not met with a great deal of approval.
Most people believed that this cycle must be externally controlled.
Later research however, found that the sleep/wake cycle remained roughly at 24 hours despite an environment where the lights never went out.
This means that the biological rhythm is at least partly controlled from within the body and not simply a reaction to environmental stimuli such as the sun setting.
So sleep is known as an ENDOGENOUS rhythm.

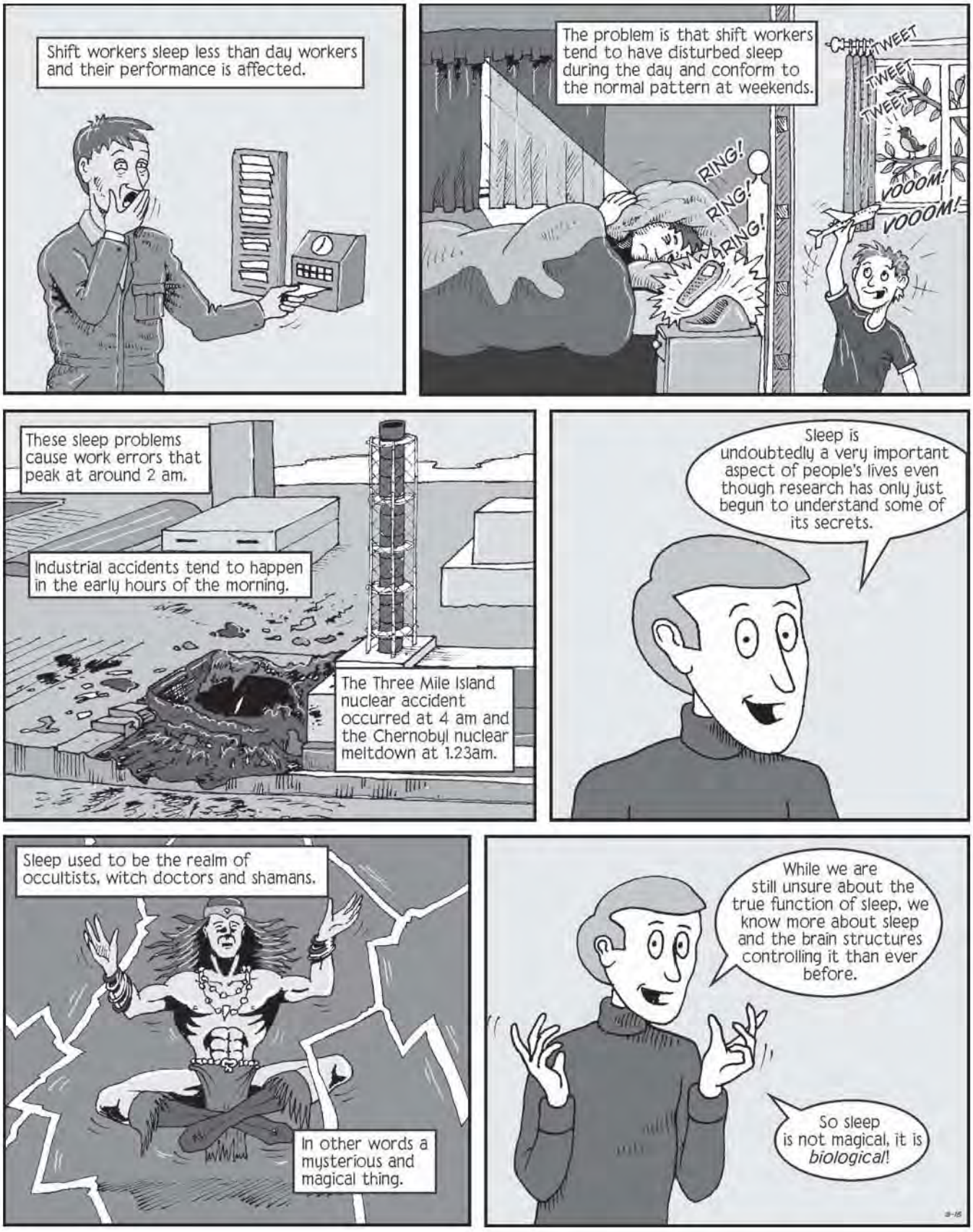

The advantages of having an endogenous cycle is that an animal can anticipate changes in the environment before they happen.
A good example of this is in migration in birds, who must leave the country before winter sets in.
Migrating birds mainly respond to changes in the amount of sunlight, so as the days become shorter, the birds begin to migrate.
Migratory birds show 'migratory' restlessness if they are caged (and hence prevented from migrating) during the Autumn and Spring.
Let me out! I HAVE to go to Africa!
Migration is also an endogenous cycle.
Migration in birds is known as a CIRCANNUAL rhythm because it has a cycle of roughly one year.
The sleep/wake cycle is known as a CIRCADIAN rhythm as it lasts approximately one day.
Other rhythms are ULTRADIAN rhythms that vary within a day.
Z z z
There a number of different circadian and ultradian rhythms in mammals.


Frequency of eating and drinking.
W.C.
Volume of urination.
and Body temperature.
These variables change according to the time of day.
Body temperature, for example, is thought to be a constant 37°, but in fact, varies throughout the day.
From around 36.5° at 4 am to 37.4° in the early evening.
While these rhythms do occur in the absence of light cues, light is necessary for their correct functioning.
It is as though there is a 'biological clock' underlying these rhythms and it is like a watch that runs a little slow.


The environmental stimulus that resets the biological clock is called a *zeitgeber* ('Time-giver' in German).
The zeitgeber for circadian rhythms in land mammals is usually sunlight and for marine mammals it is usually the tide.
When sunlight is not available – as with astronauts –then other variables act as zeitgebers.
Things like meals, noise, and temperature fluctuations.
These alternatives are not as good at setting the biological clock however, and their effectiveness varies from person to person.
Actually, the biological clock is very resistant to interference.
And people have tried with a number of different things...
Food and water deprivation.
X-Rays.
Tranquilisers
and even LSD!


The best way to disrupt the biological clock is by affecting the Suprachiasmatic Nucleus of the hypothalamus (SCN).
The SCN is the biological 'clock' that controls rhythms like sleeping and waking and sits on top of the optic chiasm and receives input from the optic nerve.
If the visual input – that may not be from the cones and rods – is severed or the SCN is damaged, biological rhythms can no longer be reset by sunlight.
The SCN generates its own rhythm which carries on in its cells once removed from the rest of the brain.
The SCN is thought to generate this rhythm partly by producing certain chemicals until a particular level is reached when a 'feedback loop' stops the production of any more until the level drops down again.
It is the SCN that needs light in order to run the sleep/waking cycle 'in sync' with day and night.
ISOLATION BUNKER
If humans are kept in isolation from time and light cues in a bunker or a cave, their biological clock drifts to a 25 hour day.
During the 4 month darkness in the Antarctic winter, Greenpeace volunteers found that their 'day' ran for approximately 25 hours.
Despite the fact that these people did have access to time information.


The SCN regulates the production of MELATONIN by the pineal gland.
Melatonin is a chemical that induces sleepiness.
PINEAL GLAND
Melatonin is produced by humans mostly at night.
Light resets the biological clock by stopping the production of melatonin.
In fact, melatonin has been used to help shift workers and to combat jet lag.
Jet Lag - caused by travelling across time zones - disrupts sleep and impairs performance.
The problem is that the timing of day and night change quicker than the biological clock can adapt to.
JAZZY AIR
It is easier to adjust to the time difference when you increase your day's length by traveling West than when you shorten the day by travelling East.
So it is easier to stay awake past your bedtime than it is to sleep when you are not sleepy.


Shift workers sleep less than day workers and their performance is affected.
The problem is that shift workers tend to have disturbed sleep during the day and conform to the normal pattern at weekends.
TWEET
TWEET
TWEET
RING!
RING!
RING!
VOOOM!
VOOOM!
These sleep problems cause work errors that peak at around 2 am.
Industrial accidents tend to happen in the early hours of the morning.
The Three Mile Island nuclear accident occurred at 4 am and the Chernobyl nuclear meltdown at 1.23am.
Sleep is undoubtedly a very important aspect of people's lives even though research has only just begun to understand some of its secrets.
Sleep used to be the realm of occultists, witch doctors and shamans.
In other words a mysterious and magical thing.
While we are still unsure about the true function of sleep, we know more about sleep and the brain structures controlling it than ever before.
So sleep is not magical, it is *biological*!