Throwing new light on sleep

Mark Greener

Most people don’t realise the benefits that sleep brings until they can’t sleep well any more,’ Lockley and Foster comment in Sleep: A Very Short Introduction. It’s a lesson millions of people learn the hard way.

About 10% of us report chronic insomnia, for example. Many more – about a third – suffer from one or more of the 75 or so clinical sleep disorders at some time in our lives. At least 80% of people with depression or schizophrenia and many of those with Alzheimer’s or Parkinson’s disease experience sleep disturbances. Indeed, hypersomnia and excessive daytime sleepiness can be one of the first signs of parkinsonism. (This probably reflects dysfunctions in neural networks and neurotransmitters common to sleep and parkinsonism.)

Sleep disordered breathing independently predicts stroke risk and worsens the outcomes of stroke and epilepsy. Yet while the health implications of disrupted sleep are increasingly clear, sleep remains, arguably, the most enigmatic of our basic biological drives.

Changing patterns of sleep

Almost every life form shows cycles of activity and rest that help the organism tailor activity to environmental changes over a day. This circadian variation allows, for example, animals to live in a ‘temporal niche’ when they can best exploit the environment. In response to the demands and opportunities in the niche, the time spent asleep varies widely between species. The brown bat, for example, spends 19.9 hours a day asleep, a giraffe in the wild just 1.9 hours. In pre-industrial times, humans probably ‘naturally’ slept for up to 10 hours in the winter. Indeed, we probably sleep less today than at any time in the recent past.

Over the last 50 years, long work hours, shift work, commuting, global communication and so on have eaten into the time we spend asleep and detached us from the natural cycles of light and dark. According to a 2013 survey, 70% of people sleep for seven hours or less. One-in-14 gets less than five hours sleep each night.

Electric light, of course, made these dramatic changes in lifestyle possible. Electric lighting, however, results in inadequate illumination during the day inside buildings and too much light at night to drive ‘normal’ circadian patterns. As Stevens and Zhu remark, electric illumination ‘results in circadian disruption and alters sleep / wake cycle, core body temperature, hormone regulation and release, and patterns of gene expression throughout the body’. Such connections are biologically plausible. Circadian disruption and disturbed sleep result in several potentially pathogenic changes including:

- Alterations in the regulation of the cell cycle and the effectiveness of DNA damage responses (both linked to cancer).
- Melatonin, for instance, is a powerful free radical scavenger.
- Changes in leptin and ghrelin, which are implicated in obesity.
- Sleep deprivation reduces levels of leptin (which inhibits feeding and reduces appetite) and increases ghrelin concentrations, which has the opposite effects.
- Loss of glycaemic control and an increased risk of diabetes.

A meta-analysis of 11 reports encompassing 18 443 cases among 482 502 participants reported a U-shaped relationship between sleep duration and the risk of developing type 2 diabetes. People who slept for seven to eight hours a day were at the lowest risk. Compared with those who slept for seven hours; each hour less sleep increased the relative risk of type 2 diabetes by 9%. Each additional hour asleep increased the risk by 14%.

‘However, the direct evidence is circumstantial, as it must be
because experiments in humans (randomised clinical trials) are unethical for any agent suspected of causing harm,’ Stevens and Zhu comment.4

Some experimental studies are, however, beginning to confirm these links. Numerous studies link poor sleep quality and short duration with an increased risk of contracting acute infections. Most studies used subjective sleep measures. Now new, more robust, research confirms that short sleep duration increases the risk of contracting a common cold by around four fold.6

Researchers enrolled 164 healthy men and women aged between 18 and 55 years. Wrist actigraphy and diaries captured sleep duration and continuity for seven consecutive days. The researchers then administered nasal drops containing rhinovirus and monitored volunteers for signs of a clinical cold for five days.6

Volunteers who slept for less than five hours or for between five and six hours were 4.50 and 4.24 times, respectively, more likely to develop a cold than those sleeping more than seven hours a night. The 66% increase in those sleeping 6.01–7 hours was not statistically significant. This association was independent of antibody levels before challenge with rhinovirus, demographics, season, body mass index, psychological variables (including perceived stress), and lifestyle, such as smoking, alcohol consumption and activity.6

‘Short sleep was more important than any other factor in predicting subjects’ likelihood of catching [a] cold. It didn’t matter how old people were, their stress levels, their race, education or income. It didn’t matter if they were a smoker. With all those things taken into account, statistically sleep still carried the day,’ said lead author Aric Prather, assistant professor of Psychiatry at University of California, San Francisco. ‘Not getting [enough] sleep fundamentally affects your physical health.’6

Against this background, further studies need to ascertain whether the early treatment of insomnia prevents adverse health outcomes, including cardiovascular disease, depression, suicidality and cognitive dysfunction.2 On the other hand, targeting circadian dysfunction – for example, using sleep deprivation and light therapy – can ameliorate symptoms of mood disorders and Alzheimer’s disease. Even ‘simple behavioural circadian reinforcement’ can improve mild dementia and enhance wellbeing in elderly people.2

**Why we sleep**

While we have an unprecedented understanding of the consequences of deprivation, Lockley and Foster comment, ‘the reasons why we sleep remain frustratingly unresolved’. There are many theories. We lack, however, an overarching hypothesis that explains this ‘major aspect of our behaviour’. Nevertheless, the high cost – not eating, drinking or reproducing while being vulnerable to predators – suggests that sleep must be a critical adaptation.1

Broadly, researchers devised three theories to explain why sleep is critical. One of the longest established theories – it’s been suggested, in some form, since at least since the time of Aristotle (384–322 BCE) – is that sleep allows the body to repair and recuperate. The theory’s current iteration focuses on the cell noting, for example, that expression of certain genes – especially those modulating major metabolic pathways and replenishment of transmitter vesicles – changes during sleep.

Another theory is that sleep evolved to conserve energy. The saving seems quite low, however, roughly ‘the equivalent of a hot dog bun’ in humans each night. Meanwhile, a growing body of evidence suggests that, in part at least, sleep allows information processing and consolidation of memory.1

In 1924, John Jenkins and Karl Dallenbach reported results of a study during which they asked two colleagues to learn lists of nonsense syllables in the morning or late evening. They tested recall between one and eight hours later. Recollection was better after the volunteers slept between exposure and recollection than when the person remained awake.7,8

Numerous subsequent studies confirmed that sleep influences memory. Sleep deprivation, for example, can impair learning.1 Conversely, the sooner the learner sleeps, the better the retention.8 Furthermore, insight – mental restructuring that yields a sudden gain in understanding or explicit knowledge – is almost three times more common after sleep.1

The component of sleep needed for consolidation depends on the type of knowledge. For instance, ‘declarative’ memory – conscious recall of facts or experience – almost exclusively benefits from slow-wave sleep. Rapid-eye movement (REM) and non-REM sleep, possibly synergistically, seem to consolidate procedural memory (perceptual or motor skills).8

Recent research, from Nicolas Dumay at Exeter University, suggests that sleep also makes memories easier to access. Dumay tracked memories for novel, made-up words learnt before a night’s sleep or an equivalent period of wakefulness. Subjects were asked to recall words immediately after exposure, and again after sleep or wakefulness. Compared with
daytime wakefulness, sleep helped rescue unrecalled memories more than it prevented memory loss. 8

‘Sleep almost doubles our chances of remembering previously unrecalled material,’ Dr Dumay says. ‘The post-sleep boost in memory accessibility may indicate that some memories are sharpened overnight. This supports the notion that, while asleep, we actively rehearse information flagged as important. More research is needed into the functional significance of this rehearsal and whether, for instance, it allows memories to be accessible in a wider range of contexts, hence making them more useful.’ Dr Dumay believes that the hippocampus may ‘replay’ recently encoded episodes to brain regions involved in their capture. So, the person would effectively re-experience the event.

Incidentally, dreams may be, at least partly, a by-product of information processing and memory consolidation. 1 On the other hand, interventions that help adequate sleep may promote neuroplasticity and cognitive processes during rehabilitation following brain damage and during cognitive behavioural therapy. 2

Sleep has fascinated physicians, researchers and philosophers for millennia. Today, it seems that sleep is beginning to yield some of its secrets – although sleeps seems more complex than those early researchers could have dreamed. Meanwhile, we increasingly recognise the harm association with sleep deprivation and circadian disruption.

As a recent consensus document remarked: ‘promoting adequate sleep is crucial to cognitive function and learning, especially in a society that values “work around the clock”’. 2 Whether society, politicians and employers will take note remains a moot point. It seems diseases and other problems linked to circadian disruption will continue to give clinicians a few sleepless nights for some time to come.

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References
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