DISRUPTION OF BIOLOGICAL RHYTHMS

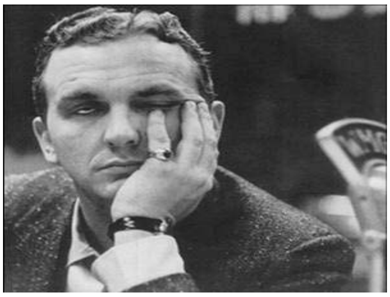
Note: The AQA specification gives 'shift work' and 'jet lag' as *examples* of the ways in which biological rhythms can be disrupted. Because they are examples, this means that we do *not* have to study them, and we are free to other ways of disrupting biological rhythms. Because of their relevance to research into the nature and functions of sleep, we will look at the consequences of depriving people of all of their sleep, and some of their sleep.

One way in which **circadian rhythms** can be disrupted is by depriving people of all their sleep. This, of course, completely disrupts the sleep-/waking cycle, and is called a **total sleep deprivation** study. One way in which **ultradian rhythms** can be disrupted is by depriving people of one stage of sleep (such as REM sleep or Stage 4 sleep). This disrupts the cycles of sleep, and is called a **partial sleep deprivation** study.

Disrupting the sleep/waking circadian rhythm

The earliest study into the effects of total sleep deprivation (TSD) was conducted by **Patrick & Gilbert (1898)**. They deprived 'three healthy young men' of sleep for a total of 90 hours. Although they experienced some difficulties (e.g. perceptual disorders), after they had been allowed to sleep normally they returned to perfect health.

In 1959, a New York disc jockey called Peter Tripp held a 'charity wakeathon' in which he attempted to go without sleep for 200 hours. He achieved this, but at some psychological cost to himself. By the end of his stunt, Tripp was in a very strange altered state of consciousness, and suffered from hallucinations and paranoid delusions. When allowed to sleep normally, Tripp spent 24 hours sleeping continually. After this, he *appeared* to have recovered from the hallucinations and delusions.



Peter Tripp

In 1965, **William Dement** studied a 17-year-old student called Randy Gardner who attempted to break the world record for staying awake. Gardner managed 264 hours and 12 minutes, and like Patrick and Gilbert's participants, his health returned after he had been allowed to sleep normally.

Randy Gardner

When allowed to sleep normally, Gardner also spent longer sleeping than usual (14 hours and 40 minutes), suggesting that after depriving ourselves of sleep we need to make up for lost sleeping time. Interestingly, Gardner spent most of his time in REM sleep and Stage 4 sleep, suggesting that these may be particularly important.

Subsequent to Gardner's world record, the 200+ hours barrier has been broken many times. In 1986, for example, a new world record of 453 hours and 40 minutes was set by an R. MacDonald from California. This beat Maureen Waters' time of 449 hours set in 1983.

One problem with these *case studies* is that they lack control. However, studies conducted in sleep laboratories are carefully controlled. The effects of being deprived of sleep on successive nights has been summarised by **Huber-Weidman (1976)**:

- Night 1: No problems
- Night 2: Some problems – 3a.m. to 5a.m. most difficulties
- Night 3: More problems; Activities necessary; 'Microsleep'; Perceptual disturbances (hallucinations/illusions)
- Night 4: As above + auditory hallucinations and 'hat phenomenon'
- Night 5: As above + paranoid delusions and depersonalisation

The consequences of these effects are, of course, all likely to be negative. Although Huber-Weidman's findings also indicate that physical functions (such as heart rate and blood pressure) are typically unimpaired, at least if you are deprived of sleep for five nights, other research suggests that *a lack of sleep is eventually fatal.*

However, it is not a lack of sleep *per se* that is fatal. Rather it is the effect that a lack of sleep has on physiological functions. For example, rats can last around **33 days** without sleep, before they eventually die (possibly as a result of a failure to regulate their own heat).

The notorious 'flowerpot' technique for studying sleep deprivation in rats

We cannot do TSD experiments with humans (for obvious reasons). However, interesting case studies occasionally occur. In one of these a 52-year-old man suddenly stopped sleeping. Eventually (after a year or so) he died from a lung infection. In a condition called **fatal familial insomnia**, people sleep normally until middle age, and then stop sleeping. Death occurs within two years.

All of these studies of TSD suggest that sleep has a very important function: *it stops you from dying.* Even if you are only deprived of a night's sleep, you will still sleep longer the following night, as though you need to make up for 'missing time'. Because of this, the question that has mainly interested psychologists is whether the different stages of sleep have important functions, and we will look at this in the topic on the functions of sleep

Disrupting the cycles of sleep ultradian rhythm

In studies of partial sleep deprivation (PSD), participants sleeping under laboratory conditions are woken whenever they enter a particular stage of sleep. They are then told to go back to sleep, until they enter that stage again, when they are woken again. This continues throughout the night, and deprives them of a single stage of sleep. The stage of sleep that has been most extensively investigated in this way is **REM**, and there are two important findings. First, following REM sleep deprivation a 'rebound effect' is commonly observed (suggesting that the brain needs to catch up on lost REM sleep time for some reason). Second, continued deprivation of REM sleep (i.e. going several nights without REM sleep) leads to 'REM starvation', in which the brain makes increasingly more attempts to have the REM sleep it is being deprived of.

One way in which we can deprive ourselves of REM without being in a sleep laboratory is through drinking *alcohol*. Alcohol suppresses REM without affecting NREM sleep. When people abstain from alcohol, they also experience a rebound effect. REM deprivation also affects our anxiety levels.

Researchers argue that if REM sleep didn't serve any function, then we wouldn't see rebound and starvation effects when people are deprived of it. We will look at what these functions might be in the topic on the functions of sleep. What is important here is that research also suggests that the consequences of being deprived of REM sleep are negative, at least as far as learning and memory is concerned. Complex learning tasks are associated with longer time spent in REM sleep in both non-humans and humans. Therefore, being deprived of REM sleep might impair learning. Support for this comes from studies which show impaired memory following REM sleep deprivation (with studies showing an average deficit of 15%).

This suggests that REM sleep is vital to consolidate learning and memory. A lot of people disrupt their own REM sleep by using alcohol excessively, and the consequence of this is impaired long-term memory in chronic alcoholics. Being deprived of REM sleep also affects anxiety levels, which is another negative consequence.

Research suggests that deep sleep (Stages 3 and 4) also has important functions. These are to restore depleted energy resources, eliminate waste products from muscles, and recover physical abilities. Therefore, deep sleep is needed to repair the damage done to the body during the waking day. If people are deprived of deep sleep (Stages 3 and 4), they suffer physical problems. One of these is very similar to a condition called fibrositis, and it is well known that people with fibrositis do lack stage 3 and 4 sleep.

Research also shows that the pituitary gland releases growth hormone at night, but only during deep sleep. This hormone is important in tissue growth and red blood cell formation (i.e. the growth process). Therefore, if people are deprived of deep sleep, the negative consequence is lack of growth. It has also been found that cell repair occurs during deep sleep through a process called 'protein synthesis'. When people are deprived of deep sleep, another consequence is that the skin takes on a yellow appearance and bags appear under the eyes, reflecting the fact that cell repair has not taken place.

Overall, then, the consequences of disrupting the circadian rhythm of sleeping and waking, and the infradian rhythms that occur during sleep are always negative and never positive.