Theories of Sleep

A theory of sleep is an attempt to explain why animals sleep. A good theory of sleep must fulfil a number of criteria including:

- *It should provide a plausible explanation as to why sleep is found in such a variety of different animals.*
- *It should explain the findings of research studies into sleep deprivation.*
- *It should be able to explain the differences that exist in sleep patterns between different species.*

There are two general approaches taken by theories of sleep. On the one hand, *restoration theories* suggest that sleep exists in order to repair and restore the body. On the other hand, there are *evolutionary theories* that relate sleep to the ability to survive in a hostile environment.

Restoration Theory (Oswald, 1966)

According to **Oswald (1966)**, the function of sleep is to restore the body during periods of inactivity so that adequate biological functioning is ensured. The tissues of the brain and body are repaired and the chemicals needed for proper functioning are replenished. Specifically, Oswald claims that:

- NREM sleep restores biological processes that have deteriorate during the day;
- REM sleep replenishes and renews brain processes through the process of protein synthesis.

Evidence for Restoration Theory

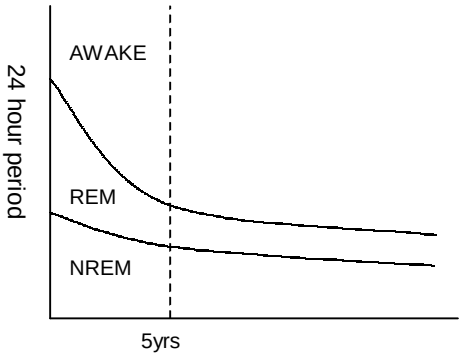
Sleep Deprivation Studies
(see previous handout)

Many animal studies of sleep deprivation support the ideas of the restoration theory because they show that biological functioning deteriorates if an animal is deprived of sleep. However, the results of human studies are not as clear cut and do not seem to support the idea that biological functioning is upset if a human is deprived of sleep.

Changes in Sleep Patterns over the Lifespan

Better support for Oswald comes from studies of sleep patterns as a child grows older. Babies sleep far more than older children and adults, and they spend much more of their sleep time in REM (see fig. 1).

Fig. 1 – Changes in sleep pattern over the lifespan



Babies spend about 18 hours in every 24 asleep, and about half of this in REM. By the age of five, this has fallen to about 8 hours in every 24, only a quarter in REM, which remains basically the same for the rest of their life. Since the first five years are very important for brain development, where a great deal of protein synthesis is necessary for cell growth and manufacture, it makes sense that a younger child would require far more REM sleep than an adult.

Sleep Patterns Following Brain Insult

If REM sleep is necessary for proper brain functioning, then we would expect increases in REM sleep in people whose brains had been adversely affected by something. This is exactly what is found. People recovering from brain injury, electro-convulsive therapy and drug withdrawal tned to spend more time in REM during their recovery period.

Sleep Patterns and Illness

If sleep is required for immune functioning, then we might expect total sleep time to increase during periods of illness. Again, this is observed in humans and other animals.

Hormonal Fluctuations During Sleep

There is evidence that secretion of growth hormone by the pituitary gland increases during stage 4 sleep. Growth hormone is necessary for normal functioning of the body, and a deficiency can result in muscular disorders. People with a condition called fibrositis (which results in inflammation of the muscles) tend to have abnormal sleep patterns, with very little uninterrupted stage 4 sleep. **Gross (1996)** points out that prolonged deprivation of stage 4 sleep induces fibrositis symptoms in healthy volunteers.

Evaluation

All of this evidence is consistent with the idea that sleep serves the purposes of restoring and replenishing biological processes and functions. However, there are a couple of objections that are worth noting:

- Studies of sleep deprivation in humans do not so far indicate that it results in serious biological malfunctions.
- Cell repair has been shown to carry on for 24 hours a day and is therefore not confined to sleep periods (although it does increase during sleep periods).

- During REM sleep the brain is very active, and this would actually prevent protein synthesis from taking place.

The final objection does not mean that sleep is not for restoration, but makes it unlikely that REM sleep is specifically for the restoration of the brain, as Oswald claims.

Hibernation Theory

Hibernation theory (**Webb, 1974**) is one of a number of evolutionary theories of sleep. Evolutionary theories in general suggest that sleep evolved because it allows an organism a greater chance of survival in a hostile environment.

Specifically, Webb suggests that sleep has evolved because it forces the animal to conserve energy. In general, animals that conserve energy are more likely to survive than animals that do not. Therefore, the characteristic that helps them conserve energy is more likely to be passed on to the next generation. Sleep helps an animal conserve energy in a number of ways. For example:

- During sleep, behavioural activity stops, meaning less energy is spent on movement.
- Body temperature and metabolic rate slow down, again, saving energy.

According to Webb, an animal's sleep patterns will be determined by the rate at which it loses heat, what it eats and the availability of food. By comparing the sleep patterns of different species at different times, it is possible to see whether these factors appear to have an effect.

Evidence for Hibernation Theory

Rate of Heat Loss

The smaller an animal is, the faster it loses heat. Since heat loss is a major waste of energy, we might expect that smaller animals will sleep more than larger ones. This seems to be true. Bats, voles and other small mammals sleep for as many as 20 hours in every 24, whilst giraffes sleep for as little as 1 hour.

Diet

An animal's diet determines its rate of energy intake and this in turn determines how long it must spend each day searching for food. Carnivores eat large, nutritious meals and therefore don't have to spend much of each day eating. Lions, for example, sleep for as many as 18 hours a day, possible more if they have just made a large kill. One the other hand, horses eat grass, which contains very little nutrition. For this reason, they must eat a massive amount just to stay alive. This takes a great deal of time and they sleep for only 3 hours in every 24.

Food Availability

Hibernation theory would predict that sleep time should increase when food is scarce, because the animal has a greater need to conserve energy. According to **Berger & Phillips (1995)** this is indeed the case.

Evaluation

The main problem with hibernation theory is that there are a whole host of evolutionary factors that could potentially affect sleep patterns. For example, prey animals are at greater risk of attack than predators. Therefore, we might expect buffalo (4 hours per day) to sleep less than lions, as a buffalo must be on the lookout for predators, whereas a lion does not. There are in fact two problems here:

- Which factors are actually important? Does a bat get lots of sleep because it is small, or because it has few predators?
- Similarly, why do animals with very different lifestyles get similar amounts of sleep? For example, both humans and rabbits get about 8 hours in every 24 but have very different body sizes, diets and relationships with predators.

Ultimately, there is no variation is sleep pattern that cannot be 'explained' by using evolutionary ideas. But at the same time, there is no way of deciding which evolutionary factors are important. This means that Webb's evolutionary theory of sleep is *unfalsifiable*. A theory that is unfalsifiable is not a scientific theory.

Another major problem with the hibernation theory is that it does not explain why sleep is universal. Surely it would be possible to find evidence of animals that do not sleep, because there is no evolutionary advantage in doing so?

- However, *all* mammals sleep. Dolphins sleep with half of the brain at a time – surely if the only function of sleep was energy conservation it would be easier to get rid of it entirely.
- Similarly, hibernation theory cannot explain why sleep deprivation can be fatal.

Conclusions

Both the restoration and the evolutionary approaches have their advantages. However, the evidence does seem to favour the restoration approach. That does not mean that evolution has had no impact on different species' sleep patterns. The example of the dolphin makes this clear – because it lives in the water but breathes air and needs sleep it has evolved a special way of accommodating all these conflicting demands.