

# **Sleep, body clocks and the 24 hour society.**

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As implied by my title I elected to try to achieve three objectives in my talk to the society. The first is to give some insight into our understanding of sleep as sleep science progresses; the second is to explain the interaction between sleep and the clocks that run our body and the implications for human performance and finally to speculate on the impossible dilemmas we impose on our biology in seeking a 24 hour society.

World consumption of coffee, a powerful stimulant, has doubled in the last 35 years which is not all due to slick marketing by Starbucks. I would propose and will try to convince you that the inexorable increase in consumption of this and many other stimulants such as "V" is due to our increasing abuse of our sleep as we try to adapt to rapidly changing lifestyles.

Most of us consider that life happens whilst we are awake and that sleep is a regrettable thing that we have to do in-between times. We almost believe that time spent sleeping is lost opportunity and diminishes our lives. This attitude is summarised by the slogan for an American brand of coffee, "Life is short, stay awake". I will try to persuade you that our increasing understanding of sleep would suggest the opposite.

Our society regards sleep as a period of unconsciousness punctuated by periods of dreaming. This reinforces the attitude that sleep is passive and thus can be sacrificed.

Scientific study of sleep stretches back only 50 years and our tools for studying sleep remain largely crude and limited. Nonetheless we are gaining a rapidly increasing amount of knowledge about sleep.

Currently our knowledge is fragmentary. However it is clear that the nervous system is not inactive in sleep. In sleep we are monitoring our environment continuously though our degree of interaction with the world is reduced. We are never truly unconscious.

It is important to understand that humans have 3 distinct and separate states of existence: wakefulness, non-rapid eye movement sleep (N-REM) and rapid eye movement sleep (REM). REM sleep, often mistakenly called dream sleep as in fact we dream in all sleep states, is as different from N-REM sleep as is wakefulness. The best analogy I can use is to think of your brain like your PC with 3 different operating systems constantly fighting to be the dominant operating system. In the morning when well rested the wakefulness system is

the most powerful and dominates, yet in the afternoon we all see increasing sleepiness and if physical circumstances are conducive, e.g a warm day and a monotonous sedentary task such as driving on a straight country road, then NREM sleep may succeed in becoming dominant

In REM sleep our brain's consumption of oxygen is higher than in wakefulness though compared to wakefulness different areas of the brain are consuming that oxygen. In NREM oxygen consumption varies between stages and in slow wave sleep (Stage III & IV of N-REM) oxygen consumption is lower but by no stretch of the imagination can the brain be described as inactive or switched off.

### *The Function of Sleep?*

The function of sleep is unknown. However birds and mammals separated during evolution hundreds of millions of years ago and yet both species have similar sleep suggesting a very profound importance and that it is an essential to life for both species.

Theories regarding the purpose of sleep range from a mechanism to save energy by limiting movement through to a restorative function for the hugely complex structure of the brain. The latter theory almost certainly holds some truth but the amount of sleep needed by any single mammalian species does not correlate with the size of the animals brain!

What is the brain up to in sleep? The short answer is we do not know but there are many hints that sleep, both REM and NREM are crucial for our brain to function adequately and for us to survive. Total sleep deprivation leads to death in all mammals over a period of weeks yet at post mortem no clearcut cause of death will be found.

Some evidence points towards us re-living the events of the day in sleep, almost as if we replay the video, as a learning experience to hone our performance skills. There is also evidence that sleep is essential to memory and organisation of memory though the evidence is indirect.

### *How much sleep does a human require?*

Assessing any individual's sleep is complicated by the huge amount of personal and cultural beliefs that abound around sleep. We are all full of preconceptions about our sleep based on a mixture of personal experience and folklore. One of the commonest myths is that we all need 8 hours sleep.

In fact like everything about our physiology there is a range, just as we range from short to tall, some of us need less than 8 hours (probably around 20% of the population) but the majority of us need at least 8 hours and a significant proportion need more than 9 hours. This fact is not so surprising if you remember that until the invention of the electric light bulb most human's

lifestyles were dominated by natural light/dark cycles. A hundred and twenty years ago the average Briton slept over 9 hours per night.

All the current evidence is that sleep deprivation is endemic in our society with at least 30% of adults carrying a significant sleep "debt". Amongst adolescents, who as part of their developmental physiology tend to be night owls, the evidence is that they are sleeping less and less with each successive decade. We are breeding a generation of adults who will have never known what it is like to be fully and consistently well slept. Our knowledge of evolution suggests that it will take hundreds of generations to adapt and breed humans that can function optimally with significantly less sleep.

### *The structure of sleep.*

Not only is sleep essential but it is a highly organised activity with a clear architecture based on a series of sleep cycles through the night with set portions of each sleep stage present in each successive cycle. Thanks to this highly structured state our brain is "restored" and we are capable of performing at our maximal cognitive ability the following day.

Another poorly appreciated fact is that sleep is for the brain and only for the brain. Other tissues, eg muscles, may need rest but they do not benefit directly from sleep.

Sleep is not negotiable it is essential for you to achieve your maximal intellectual and functional capacity. Partial sleep deprivation, as so many of us increasingly practice, does not kill us but leads to underperformance in terms of both mental function and physical reactions such as reaction times. We cope by concentrating harder and taking more stimulants. However those stimulants do not conveniently switch off at bedtime and they impact on the quality of our sleep leading to a vicious circle of increasingly damaged and inadequate sleep periods and reliance on stimulants to keep us functional during the day.

### *Body clocks and sleep.*

Our body's have a built in clock or circadian rhythm. This branch of science, known as chronobiology, has exploded in recent years and is producing many fascinating and thought provoking discoveries. Every cell in our body has a built in clock but in humans a dedicated area in our brains, the pineal gland is the dominant clock which, by reading light/dark signals, very accurately alters our body's biology throughout our 24 hour day. Using these signals a wide variety of functions and particularly many hormonal functions are linked with time of day. In the night a variety of hormones are produced, women will not be surprised to hear that testosterone is almost exclusively produced at night!

No matter how well slept you are the mixture of hormones present in the middle of the night are less stimulant than the mixture during the days. Thus

your reaction times and mental abilities can never be as good in the middle of the night no matter how much sleep you have had, as you would achieve with the same amount of sleep at 10 am.

This fact alone has major implications for those of us called to do complex tasks in the middle of the night whether as surgeons or stock market traders, not to mention pilots.

### *Shift work.*

Regular night shifts can move the body clock provided the worker is in a very bright environment at night and takes care to reduce exposure to daylight at home whilst sleeping. However night shift workers are human and have families and neighbours so their sleep is disrupted during the day and on their days off they, not unreasonably, revert to a normal day/night schedule and thus "confuse" the system. There is overwhelming evidence that night shift workers as a group are considerably more sleep deprived than workers doing "nine to five" schedules.

### *Feasibility of a 24 hour society?*

It is noteworthy that many of the worst industrial accidents in the last 30 years have been the result of bad decisions made by sleep deprived workers in the middle of the night. Such accidents range from marine accidents such as the Exxon Valdez oil spill through Three Mile Island nuclear accident to the Challenger space shuttle disaster. In reality the hidden mountain of tragedy from sleep deprivation is the relentless toll on our roads and in industry of avoidable accidents caused by sleepy workers who are often the ones that perish. The highest number of road traffic accidents are not in the rush hour but in the early hours when roads are the quietest.

It has taken millions of years for our biology to adapt to the natural conditions of our environment, a 24 hour light dark cycle. There is no reason to believe that if mankind profoundly alters that environment that in the space of a few generations our body's have an ability or capacity to adapt to alterations that lead to loss of the natural light dark cycle, resultant perturbation of our natural diurnal rhythms from disruption of our body clocks and interference with our evolutionary programmed "normal" sleep periods.

Society is forcing profound changes on us, some from apparent necessity, such as the need to participate in the 24 hour market for stock brokers and others out of lifestyle choices. We are persuaded that regular all night raves or computer games on the net lasting into the early hours are sustainable life style choices with no significant downside.

Without an understanding of our biology we may as a society go down a blind alley of increasingly fighting our biology and paying a huge price in terms of

poorer emotional and cognitive functioning combined with an addiction to stimulants to help us try to lead an unsustainable lifestyle.

### *Legal implications?*

Our increased understanding of sleep and the steady accumulation of evidence that sleepiness inhibits performance and leads to accidents has implications for many industries including the insurance industry who have an increasing awareness of these risks. To their credit, the insurance industry is one of the few organisations willing to address the implications of this knowledge.

No Board of Directors has yet been successfully prosecuted for their company's practices leading to accidents due to sleepy workers but there have been several attempts such as following the "Herald of Free Enterprise" ferry disaster. Individual workers have, however, been prosecuted for such accidents and jailed.

Courts have taken differing views across the world whether falling asleep and causing an accident is the individual's fault or whether it is an involuntary act and thus not negligent. Humans can get sleepy very quickly given the right set of circumstances, e.g. heat, sedentary activity, time from last sleep etc. Nonetheless the evidence would suggest that we always get some warning of impending sleep though such warning maybe very short. The situation is further confounded by the fact we are poor at detecting short periods of sleep and can be totally unaware we have slept for a few minutes. This fact confounds the ability to determine the frequency of accidents due to sleepiness for authorities.

### *The pinnacle of sleep evolution: the bottle nosed dolphin?*

Ideally we need to copy the bottle nosed dolphin which has spent thousand of generations evolving the ability to never sleep and thus ensure its survival from its natural predator – the shark. How has it achieved this ability not to sleep? In fact its brain like all mammals brains needs to sleep but in the dolphin one hemisphere of the brain is asleep whilst the other is awake and vice versa thus ensuring it is for ever alert to the presence of predators.

Sadly we will not achieve this degree of evolutionary fine tuning to meet the demands of the 24 hour society in the foreseeable future and society needs to address these issues now for all of our sakes.