

## Circadian Rhythms

In the 19th Century, the French physiologist Claude Bernard first proposed the concept of *milieu intérieur* or homeostasis. He wrote that “the stability of the internal environment is the condition for the free and independent life”. This idea of homeostasis, of a constant internal environment in the body has therefore become deeply ingrained in our way of thinking. Consequently, it is believed that alterations in lifestyle, for example shift work or shifting sleeping patterns will simply be accommodated by the body as it returns to homeostasis.

The reality is completely different. Many fundamental processes of the body are governed by rhythmic behaviours rather than constancy. This is not at all surprising since humans have evolved, like other animals, in a world that is profoundly rhythmical over the period of a 24 hour daily cycle. From an evolutionary perspective therefore, an organism that is able to predict the constantly changing external environment by changing their internal environment will be much better placed to survive than one that simply has a constant response. To be properly adapted to the rhythmic environment therefore, organisms have to rhythmically regulate their behaviour, physiology and gene expression. Fundamental biochemical processes such as insulin action, glucose and lipid metabolism are controlled via an internal timekeeping system that has evolved to be in step with and accommodate the external rhythmic environment.

A ***circadian rhythm*** is a biological process that shows a cycle of around 24 hours (from the Latin *circa diem* or approximately a day). Such rhythms are driven by a rhythmic process within the cells of the body known as the *circadian clock*. These clock processes are seen not only in animals but also in plants, fungi and cyanobacteria. Circadian rhythms are built-in but adjust to the local environment by cues such as daylight. They are therefore said to show sustainment (the ability to maintain the necessary oscillations even in the absence of external information about the time of day) and entrainment (the process of synchronization to external cues such as daylight).



Mammals have developed an internal circadian clock which is located in the brain in an area known as the hypothalamus (specifically an area of the anterior hypothalamus known as the hypothalamic suprachiasmatic nucleus, or SCN). This responds to the light-dark cycle and controls 24 hour behavioural and physiological rhythms. Similar clocks are also found in the cells of many different organs outside of the brain (e.g. liver, muscle, adipose and pancreas) each of which have their own clocks and which regulate cellular and physiological functions. Energy balance and metabolism of nutrients are controlled by the circadian clock,

which alters our biochemistry and certain metabolic proteins throughout the day. In turn, these affect the core clock mechanism in a feedback system. Circadian and metabolic processes are therefore linked throughout the whole body and changes to this can lead to metabolic dysfunction and diseases such as Type 2 diabetes (see the information sheet on *Chronodisruption*).