Optional background reading: Stress, Health and Cortisol

Cortisol (see Figure 1) is a glucocorticoid hormone that is naturally produced by the adrenal glands (see Figure 2) in response to stress. Although undoubtedly real and regularly experienced by people in a complex, ever-changing world, the molecular and cellular events that cause us to feel “stressed” are not very well understood by researchers.

The biological term “stress” was introduced in the 1930’s by Canadian endocrinologist Dr. Hans Seyle. Biological stress is usually conceptualized as a response to a disruption of the body’s chemical and physical balance, homeostasis. The process by which the body adapts to regain its balance is called allostasis. The measures that the body has to take to return to its natural balance exert a toll called the allostatic load. Coping with the consequences of high levels of cortisol in the human body can be thought of as part of this allostatic load. The study of the response of a system as complex as a human body to disruptions of its natural balance is no easy task. Nevertheless, scientists believe that they are developing a reasonable understanding of the events that can trigger disruptions of homeostasis, and the tolls exerted by the allostatic load in some situations.

The presence of cortisol in the body is almost always associated with some kind of biological stress (such as perception of a threat, consumption of a toxic substance or waking from sleep). The presence of cortisol in the body is so intimately associated with biological stress (in humans) that some physiologists define “stressful events” as those that result in an elevated level of cortisol in the body.

The production of cortisol by the body is not a simple one-step procedure - the biochemical reactions that take place in the human body in response to perceptions of physical or psychological threat are highly complex and only partially understood. The description of the biochemical pathway that is presented here should be regarded as a gross simplification of the actual chemical and physiological changes that take place in the human body as a response to stressful stimuli.

When a normal human perceives a threat, a hormone called corticotrophin-releasing hormone (CRH) is released throughout the brain, and in very large quantities within a

1 Image source: http://www.genome.ad.jp/kegg/catalog/cpd_ steroid_hormone.html
2 Image source: http://www.cnn.com/
3 This description is adapted from articles available from: http://wwwnlm.nih.gov/medlineplus/
structure at the base of the brain called the hypothalamus (see Figure 3\(^4\)). The CRH released by the hypothalamus travels to the nearby pituitary gland (see Figure 3) where it stimulates the release of adrenocorticotrophin hormone (ACTH).

ACTH travels from the pituitary gland to the outer layers (cortex) of the adrenal glands (see Figure 4\(^5\)) that are located on the kidneys. The presence of ACTH stimulates the kidneys to produce cortisol.

In a human being with a normally functioning endocrine system, the levels of cortisol are reduced to zero as soon as the threat is perceived to have passed. However, scientific studies have documented elevated levels of cortisol in humans who have taken certain substances (such as 3,4-methylenedioxyamphetamine and alcohol), who engage in some types of competitive activity (such as long-distance running) and who are suffer from certain medical conditions (principally Cushing’s Disease).

Although cortisol is a hormone that is naturally produced by the human body, prolonged exposure to high levels of cortisol have been linked to a number of mental and physical problems. These include:

\(^4\) Image source: [http://www.humboldt.edu/](http://www.humboldt.edu/)
\(^5\) Image source: [http://lancelot.bms.ac.edu/](http://lancelot.bms.ac.edu/)
• Possible permanent damage to the hippocampal formation in the brain. (A number of animal studies have suggested that the hippocampal formation is important in regulating the production of cortisol. If the hippocampus is damaged, then the capacity of the body to regulate subsequent cortisol production may also be impaired.)

• Impairment of memory and learning ability.

• Mood alteration.

• Depression and other psychiatric and neurological disorders.

• Psychosomatic disorders (such as chronic fatigue syndrome).

• Immune system suppression.

• Obesity (in men).

Clearly, any habit or activity that produces elevated levels of cortisol in the body for prolonged periods of time has some potential to create serious health (mental and physical), psychological and social problems for the person engaging in the behavior.

In Homework #4, you will use anti-derivatives and integrals to calculate the amount of cortisol produced by the body under various circumstances and evaluate the health risks involved with each of the situations described.

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