STRESS

by Richard H. Hall, 1998

The Stress Response

The relationship between stress and health have become a very popular topic in recent years, and for good reason. There is more and more evidence accumulating that environmental stress and a person's response to it can have profound and long lasting effects on health. Before discussing some of this evidence, it's important to consider the underlying physiology associated with the stress response.

The "prototypical" stress response is illustrated in Figure 1. It begins with some sort of a **stressor**, which can be an environmental stimulus such as a fire, or finals week. It can also be some sort of internally generated thought, such as the memory of a stressful event. Either way this event initiates a series of actions, one of the most important of which is the activation of the **central nucleus of the amygdala** in the limbic system. This brain area has been identified as a fundamental area in the interpretation and expression of emotions, in particular fear and anxiety. So the stress response is a perfect example of this. The central nucleus then carries the signal via pathways to the brain stem. In particular, another brain area is affected, the **locus coeruleus**. The locus coeruleus, in turn, releases norepinephrine, which effects, among other areas, the **hypothalamus**.

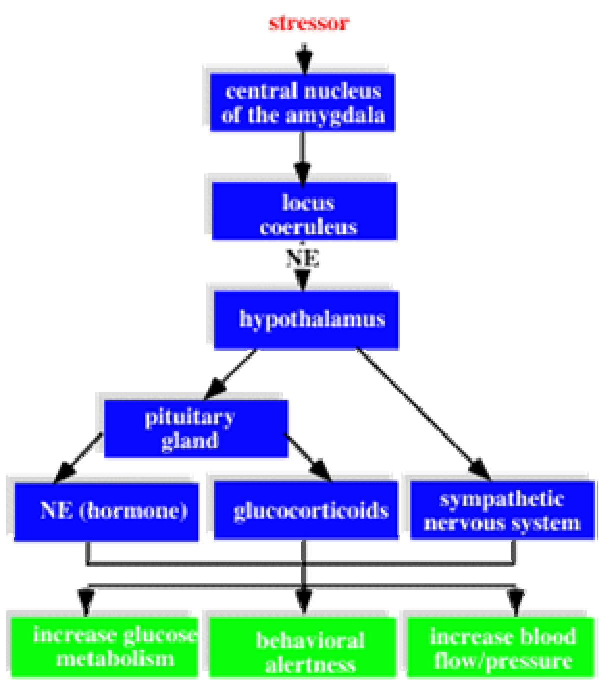

Figure 1. Prototypical Stress Response

The hypothalamus initiates two basic effects. First, the hypothalamus activates the sympathetic branch of the peripheral nervous system via the spinal cord, which has a general arousing effect on target muscles and glands. Second, the hypothalamus initiates the release of two hormones,

norepinephrine and **glucocorticoids**, by effecting the pituitary gland, which, in turn, stimulates the adrenal gland to release these hormones. Norepinephrine, which is a neurotransmitter that we know well, also serves as a hormone in the endocrine system. The best known glucocorticoid is **cortisol**. Cortisol is in some sense the "stress hormone" in that cortisol levels are often used as an index of stress levels in research on stress.

The general effect of sympathetic activity and the release of these hormones is to prepare the body for fight or flight, a very important, in fact crucial, adaptive response. Among other things, glucose metabolism is increased, so that there is more energy available for the muscles; blood flow/blood pressure increases, in order that there is more blood available for skeletal muscles; while at the same time blood supplies for digestion and other non-emergency activities is decreased; and behavioral "alertness" is increased through the activities of this system. Obviously, in terms of natural selection, these activities are essential, since, the ability to react quickly in an emergency situation is crucial for survival. In fact, the importance is even more direct, in that if this hormone system is not in tact, an organism's ability to tolerate stress greatly decreases. If the adrenal gland is removed from laboratory animals they will die from stressful situations that they would normally be able to survive easily.

On the other hand, as mentioned above, evidence is accumulating, which indicates that the long term activation of the stress response can have negative effects on behavior. Some have suggested that our body's evolutionary tendency to respond quickly and dramatically is often not very functional in today's society, since much of the stress stimuli we encounter do not require a "fight or flight" response (for example final exams). In a very general sense, the frequent and/or continued activation of this system designed to utilize as much energy as possible quickly, can over the long run, interfere with the very important energy storage and "bodily repair" process provided by the sympathetic nervous system. The consequences of this, as we will see, can have a significant detrimental impact on health.

The Effect of Environmental Stress on Health

There is a great deal of research evidence, both experimental and quasi experimental involving human, and non-human populations that indicates that the continuous exposure to a stressful environment can cause physical illness. For example, drivers of subway trains that injure or kill people are more likely to suffer from illness several months later. Air traffic controllers show a greater incidence of high blood pressure and are more likely to suffer from ulcers or diabetes. And people who give long term care to Alzheimer's patients took longer to heal from physical wounds than a control group in one experiment. There is even relatively new evidence that prolonged stress, in the form of the release of glucocorticoids in the brain, can negatively effect the hippocampus, which, in turn can impair memory function. Presumably, the glucocorticoids make the neurons less protected against things like the decreased blood flow associated with aging. In one experiment, elderly people with elevated blood levels of glucocorticoids learned a maze more slowly than those of the same age group with normal glucocorticoid levels. Also, in a study of a monkey troop, those who were the lowest in the social order were harassed and controlled more by their peers, thus exposing them to prolonged stress. Autopsies of these "low ranking" monkeys when they died indicated that they showed peripheral signs of prolonged stress such as an enlarged adrenal gland. More interestingly they also showed signs of hippocampal damage in areas found to be important in memory.

The Effect of Personality and Perception of Stress on Health

Some of the most interesting research on the stress-health relationship is aimed at exploring the role of individual personality and perception on response to stress and health. This research indicates that any model which attempts to explain the impact of stress on health must take into account the individual, because his or her response to a potential stressful stimulus will ultimately determine it's effects on bodily health (see Figure 2). In terms of predisposition, there is even evidence for a genetic component. In a study of Vietnam combat veterans who had been exposed to battle stress, 61.5 percent of those who were found to have a "stress predisposition allele" were later diagnosed with post traumatic stress syndrome, compared to 5.3 percent of such veterans in whom the allele was not found. One of the most interesting examples of the role of personality in the stress response and health was an experiment in which researchers compared childhood responses to the cold pressor test with blood pressure in adulthood. The **cold pressor test** is a test aimed at assessing predisposition towards a stress response in which participants are required to place their hands in cold water for one minute and their blood pressure is recorded. In this experiment it was found that of people who, as children in 1934, had hyperreactive presser responses, seventy percent developed high blood pressure as adults, as compared to only nineteen percent of those who had a normal response to the pressor test when they were children. Maybe the most dramatic example of predisposition comes from brain tissue transplant experiments in which the brain tissue from hyperreactive rats was transplanted into the brains of "normal" rats. The blood pressure of the recipients of the hyperreactive rat tissue increased thirty one percent more than rats that received brain transplants from a group of rats that were not hyperreactive.

In terms of perception of the stress stimuli, it has been known for some time now that the **perception of control** is a crucial mediating factor in determining the effects of a stressful situation on subsequent health. Rats who have been trained to feel a lack of control are more likely to "give up" in subsequent tasks in which they must swim to save their lives. This research is often cited as model of the phenomenon "learned helplessness", which often manifests itself in the form of dysfunctional behavior in humans. The classic study of the effects of perception of control on the stress response and consequential health deficits is an experiment in which rats received an electrical shock. Some rats were allowed to partly control the shock, while others were not, though all rats received the same amount of actual shock. Those rats who were not allowed to control the shock were significantly more likely to develop stomach ulcers.

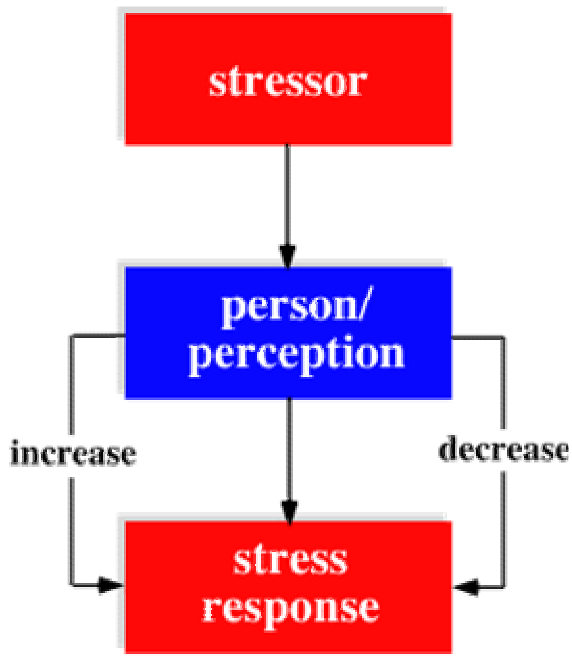

Figure 2. Interaction of Perception and Stress Response