Stress and Health[1]

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Relational trauma or maltreatment in infancy and early childhood affects physiological as well as psychological structures in the human bodymind. Among the physiological structures affected are those related to our ability to deal with stress and challenges. Therefore, in pursuing the question, "How do individuals who have been severely traumatized in early life, turn in a direction of positive health," it is important to understand the mechanisms of stress and how they relate to health. In the human organism those mechanisms represent an elegant interweaving of the brain, endocrine system, immune system, autonomic nervous system, and neuromuscular systems. When compromised, the physiological soil is set for the growth of emotional and physical difficulties.

There is mounting evidence that stress is an influential factor in a wide variety of physical and emotional disorders. It has been estimated that the cost of stress related disease is 200 billion per year (McEwen, 2002). This astronomical figure includes the cost of a wide range of physical illness such as heart disease, hypertension, asthma, diabetes, allergies and other immune disorders. It includes syndromes such as migraine headaches, fibromyalgia, chronic fatigue syndrome and numerous digestive disorders. As recently as 1999, the Surgeon General indicated that for persons ages 18-54, anxiety and stress-related diseases are the major contributors to mental illness in the United States, with more than twice the prevalence of mood disorders (Everly and Lating, 2002). And there is also evidence that stress is implicated in mood disorders. "Clearly, trauma and stress are at epidemic proportions in the United States. It seems clear that such conditions represent a clear and present danger to the psychological health of the American society" (Everly and Lating, 2002, p.5). The numbers indicate a clear and present danger existing at both the psychological *and* physical levels.

There is a condition that has been described as *limbic hypersensitivity phenomenon* which is a generic, common dominator condition that gives rise to what has been called “arousal disorders” (Everly and Lating, 2002). The possibility of a single common denominator condition that has a wide variety of etiological factors and an even wider display of symptom manifestations, including both physical and emotional conditions, opens the possibility of focusing treatment on a root cause. Further, it has implications for preventive education at many different levels.

In this chapter, we will look what the stress response is, including a new understanding of the autonomic nervous system and its role in stress. We will include a brief look at stress and the immune system, stress and the brain, and stress and the cardiovascular system. We will then address limbic hypersensitivity phenomenon, and the question of how the phenomenon becomes self-perpetuating and plays a major role in *both* physical and psychological disorders. We will conclude this chapter by examining additional psychological factors affecting the human stress response.

Definitions of Stress

Stress may rank among the most commonly used words in the English language, yet from the very beginning of its usage, its definition suffered from vagueness and ambiguity. In its original sense from physics, stress refers to a strain that is exerted on an object that can alter the shape of that object. In this definition stress is a stimulus, an external force that affects an object or organism. Stress can also be defined in terms of a response or what goes on inside an organism as a result of the perception of that stimulus. The understanding of the relationship of stress to health and illness has been evolving over many years. The grandfather of that understanding was Hans Selye.

Selye was a Hungarian researcher who was responsible for putting the word stress on the map. He was attempting to determine the effects of a particular hormone on the body. The lore has it that he was particularly clumsy in handling and injecting the hormone into his experimental rats and would drop and chase them. Whether true or not, when he conducted his examinations, he discovered his experimental rats to have peptic ulcers, shrunken immune tissues and enlarged adrenal cortexes (a part of the adrenal gland). Being a good scientist, he of course gave a neutral stimulus to a control group, so that he would not erroneously conclude the results he observed were a function of the hormone he had injected. To his chagrin he found that the control group, the one where the rats were injected with perhaps a water solution, displayed the same responses. They also had ulcers, shrunken immune tissues and enlarged adrenal glands.

Daunted but not defeated, he wrestled with the problem, until arriving at the conclusion that there exists a nonspecific response to external demands. In other words, in response to any demand, the body has a general stress response. This is normal, natural, and adaptive. The organism's resources mobilize to meet demand. However, if the situation is prolonged, problems occur. Selye developed what he termed the "general adaptation syndrome," which states that the first response to threat is an *alarm reaction*, followed by a mobilization of resources, which he called the *resistance phase*. If the mobilization continues, resources become depleted and illness results. Selye termed this the *exhaustion phase* (Sapolsky, 1994; McEwen, 2002). From a physiological perspective, a general, nonspecific response to a wide variety of stimuli did not make sense. Specific responses were always believed to have specific stimuli. Certainly, specific illnesses were believed to have specific causes. The nineteenth century German physician Robert Koch, in fact, won a Nobel Prize for the discovery of a specific agent (the tubercle bacillus) as the cause of a specific illness (tuberculosis), greatly advancing medical research based on the theory of disease specificity (Ornish, 1997). Yet, Selye's theories were the major take off point for years of research on stress, leading to the radical concept of a common denominator cause for a variety of illnesses.

In their 2002 revision of their book a *Clinical Guide to Treatment of the Human Stress Response*, George Everly and Jeffrey Lating define stress as what occurs physiologically when a situation or event is perceived as stressful and the ensuing effects on internal or "target" organs. Target organs include the heart, the brain, lungs, kidneys, adrenal, pancreas and other internal organs. The mind can also be a target organ. That is, stress can affect our perceptions, judgments, cognitive functioning, and even our personalities. Everly and Lating offer highly detailed physiological descriptions of the mechanisms involved in the stress response.

In an effort to avoid the ambiguity that has accumulated over the word stress, Bruce McEwen (2002) suggests that we drop the term stress response and replace it with the word *allostasis.* Allostasis has at its root the Greek word *allo,* which means variable. Allostasis, then, refers to the systems that keep the body constant by themselves changing. These systems are designed to enhance the individual's ability to meet environmental challenges. McEwen refers to allostatic load for the condition of when the stress response does damage. He describes how the allostatic process is positive; even the immune system is strengthened by its activation. However, when these mechanisms turn against themselves, the condition he calls allostatic load, trouble begins. Whether or not McEwen's terminology replaces the word stress still remains to be seen. What we can conclude, however, is that organisms have mechanisms designed to enable them to meet challenges and threat. In humans those mechanisms are very complex and involve an interweaving of brain, the endocrine system, the autonomic nervous system, the immune system and the neuromuscular system. It is time to take a closer look at the human stress response.

The Stress Response

When the stress response is initiated, there is a shift in the organism's attention from long term-needs to short-term needs. For example, reproductive activity can be placed on hold, but the neuromuscular systems will require an increase of energy. In general, stressors are stimulus events that precipitate a stress response, and can be classified into two categories, psychosocial and biogenic. Biogenic stimuli require no appraisal or cognitive dimension and include such substances as caffeine, nicotine and amphetamines, among many others. Psychosocial stimuli are individually determined; a situation terrifying for one individual may be enjoyable for another.

For conceptual clarity, the stress response or allostatic systems can be conceived as occurring along three axes: the neurological axis, the neuroendocrine axis and the endocrine axes (Everly and Lating, 2002). The neurological axis is the swiftest of the three and consists of the autonomic nervous system with its sympathetic and parasympathetic divisions.

The Autonomic Nervous System

Let's put in the ANS in context by beginning with our nervous system as a whole. The human nervous system is conceptualized in terms of the central and peripheral systems. Our central nervous system consists of our brain and spinal cord; obviously, their called central because they are in the center of the body. The peripheral system consists of all the nerves going to and from the central system to everywhere else in the body. Like the central nervous system, the peripheral also has two parts: the somatic and the autonomic. The Somatic nervous system controls our skeletal muscles. Any voluntary movement is made using the somatic nervous system.

The autonomic nervous system is the system most responsible for maintaining internal stability in our bodies. It is somewhat of a bridge between conscious knowledge of our actions, and control over them on one hand; and the activity of our cells, tissues and organs on the other. The movements it mediates are involuntary, such as our skin temperature or the rate of our heart beat.[2]

The two main divisions of the autonomic nervous system are the sympathetic and parasympathetic. Both are controlled by a structure in the brain called the hypothalamus. Although about the size of a peanut, it controls the autonomic nervous system and plays a key role in our endocrine systems. Leaving the hypothalamus, the sympathetic fibers run primarily along either side of the spine, and from there out to the many organs and muscles of the body. Some of its effects are to dilate the pupils of the eyes, thicken saliva, dilate the bronchial tubes of the lungs, stimulate the secretion of adrenaline and noradrenalin at the adrenal glands, increase heart rate and contractility, and decrease output of urine and decrease digestion. The sympathetic system is associated with the "fight-flight" response because at its extreme those are the emergency measures for which it prepares us. It is responsible for many of the feelings we associate with stress, for example, the pounding of the heart, sweating, our hairs standing on end. More generally, it can be thought of as the system that mediates mobilization and the expansion of energy. A skier challenging a particularly difficult slope, a speaker about to address a large and important audience, or a child screaming on a roller coaster, all have their sympathetic system activated.

The parasympathetic system insures that the body's priorities shift back to internal needs when the external demands have been met. At the bottom of the slope or at the end of the roller coaster ride, the parasympathetic returns the organism to a state of equipoise. The fibers of the parasympathetic are found mainly among the cranial nerves, which are a set of twelve nerves that send fibers to all the facial structures, the throat structures, and the heart and digestive organs. The vagus complex is the principle nerve complex of the parasympathetic system. This system constricts the pupils, stimulates a water secretion of saliva, increases digestion and peristalsis and decreases heart rate. All but a couple of organs receive impulses from both sympathetic and parasympathetic systems. The nerves of the ANS affect the organs they reach by way of a chemical they secrete, a neurotransmitter. The sympathetic system secretes noradrenalin, and the parasympathetic secretes acetylcholine.

The two divisions, sympathetic and parasympathetic, are designed to work in what is known as a coupled-reciprocal relationship. When one side goes up, the other is down, and then in response to changing conditions, the reverse occurs. Picture two individuals of equal weight on a seesaw, and that is what is meant by coupled-reciprocal. As we shall see later, this is not always the case. Trauma will alter the relationship between those two parts of the autonomic nervous system.

Most texts describe the sympathetic as the first to activate in response to an external demand. When it is activated, the organism is prepared to mobilize; energy is leaving the digestive area, for example, and heading for the extremities. Adrenaline is starting to be pumped, and so forth. It is not a response that is, ideally, initiated frequently throughout the day; nor is it a response to be maintained for long periods of time. Then why would it be the first response to environmental demand as we have thought it to be for so long? As it turns out, it is not. Scientists are developing a new model of the ANS, which places the first response towards mobilization in the parasympathetic side of the system.[3] Because this understanding is very new and contradicts prevailing thought, we will examine this new model in some detail.

The primary nerve of the parasympathetic division is called the vagus nerve. It is cranial nerve number X, and exits from the medulla, a structure that can be considered part of the brain stem. The brain stem is the lowest area of the brain. It is where the spinal cord transitions to the brain. However, the vagus nerve in mammals has two distinct parts, which exit from different places in the medulla. One part is myelinated, which means the nerves are covered with a kind of tissue that acts as insulation and allows for a much faster transmission of the impulse along its fibers. This part is referred to as the *ventral vagal complex*[1], and exits from a part of the medulla called the nucleus ambiguous. It travels to the facial area, the larynx, the esophagus, the lungs and the heart. The other part is unmyelinated, and thus its transmission of impulses is slower. It is called the *dorsal vagal complex,* and exits from a place in the medulla called the dorsal motor nucleus of the vagus. It travels primarily to the area below the diaphragm, the visceral region. It also sends some fibers to the heart, but does not exert a major influence on the heart[4]

Observing the ANS in an evolutionary context, we can see three stages of development. The oldest or most primitive is the dorsal vagal complex, which can be found in certain fish. The fibers of the dorsal vagal complex are not myelinated, and its primary function is to foster digestion and reduce cardiac output to protect metabolic resources). Behaviorally, the dorsal vagal is associated with immobilization behaviors. Reptiles, for example, do not have a ventral vagal nerve. When a reptile is confronted with a novel stimulus or threat, its first response is to freeze. The action of freezing is mediated by the dorsal vagal. This is the first phylogenetic level of the ANS.

The second phylogenetic stage is the development of the sympathetic division of the autonomic nervous system. This system first appears in bony fishes and amphibians. Its engagement *inhibits* the activity of the dorsal vagal's effect on the digestion process as it prepares the organism to mobilize its resources in response to a strong environmental demand or threat. This is an important point. The sympathetic system keeps the dorsal vagal in check. In others words, if the dorsal vagal becomes over-regulated, that is too strong, it will immobilize the system. It will "freeze." Traumatized human beings freeze as well.

The third and most recent system to develop is the ventral vagal complex. It makes its appearance among the higher mammals. Its myelinated fibers allow for a rapid regulation of cardiac output, which in turn allows for engagement and disengagement with the environment, ***without the activation of the sympathetic system***. In other words, as it disengages the output of the heart increases to provide more oxygen to the body. Its activation also inhibits the activity of the sympathetic system, and modulates sympathetic activity to allow for a return to equipoise after sympathetic arousal. The ventral vagal functions, metaphorically, as a brake that when released, allows for increased cardiac output, without the necessity of engaging the more intense sympathetic system. In humans the brake is on most of the time, or should be. *It is the slow releasing of this vagal brake that permits modulated responses to psychosocial demands*.

If that brake is functioning poorly, the individual will feel at the mercy of internal and external forces, which others seem to negotiate without great difficulty. Why? Because then, the sympathetic does become the first level of response to engagement. Further, s/he will be less interpersonally available and responsive. Why? Because it is through our facial muscles, vocal chords that so much interpersonal communication occurs. Think of someone you know you is typically expressionless. Think of someone who doesn't show any or little expression on his face and I will bet you that he is not someone you consider a very available and responsive individual. As we shall see later, the experience of being loved, and socially connected are primary antidotes to stress and outstanding predictors of health. A compromised ventral vagal system may be one of the physiological substrates impeding the experience of being loved and connected.

Let us say it another way. There is a phylogenetic hierarchical response to stress and trauma. The first response is a deregulation of the ventral vagal system, a sophisticated and minute biological adjustment that allows the organism to respond to low level psychosocial demands in a modulated and "stress free" fashion. A good example of a psychosocial demand is meeting people at a party. Another is responding to a distressed child. Another may be giving a presentation to one's colleagues. For some individual's these events of life can be quite stressful. For others, they are all part of good day.

Now, if for whatever reason, the ventral vagal system is compromised, the next system "up" becomes the sympathetic. In that case it would take less time for the sympathetic to be engaged, and longer for it to shut down. The implications begin to become obvious. Simply stated what is just an increase of energy for some people is fight or flight for others.

One example of how that vagal brake can be damaged is that perinatal hypoxia is known to prevent the myelination of nerve tissue. That is, if in the birthing process, the baby suffers any type of temporary suffocation, it is possible that the tissues would not myelinate or would poorly myelinate. The individual would be living without the benefits of a “vagal brake.” He will respond to minor psychosocial demands as if they were threats. His sympathetic system, with its adrenalin, will be overly engaged and the behaviors associated with the sympathetic are “fight-flight.” Examples of fight behaviors in humans include hostility, resentment, anger, and aggression. Flight behaviors include withdrawal, passivity and avoiding. As we will see later, chronic maltreatment in infancy or severe trauma at any age, can compromise the ventral vagal. The importance of a well functioning ventral vagal system should now be very clear.

What happens if the sympathetic division is overwhelmed? This is what can happen in a severe trauma such as serious car accident, mugging or rape. The individual is not capable of either successfully fighting or avoiding the danger. He is overwhelmed and cannot mobilize resources. Then, the dorsal vagal ascends; it becomes over regulated, and the result is a shutdown, freeze or immobilization. There is profound helplessness, coupled with frozen terror or rage. This is an example of the sympathetic division being overwhelmed. It remains highly charged, but it is overshadowed by the dorsal vagal. Like a startled reptile, there is no movement. However, it is not an all-or-nothing. There are gradations in the strength of the ventral vagal. One important construct used to measure those gradations is vagal tone.

Vagal tone is the scientific name for the vagal brake. Our heart rate is controlled by the vagus nerve, particularly the ventral vagal. A well-known physiological reflex of the heart is known as *respiratory sinus arrhythmia* or *heart period variability,* which refers to spontaneous heart rate changes associated with respiration (Porges, 1991). With inhalation, our hearts beat ever so slightly faster, as the effects of the vagus nerve on our heart are lessened. With exhalation, our heart rate decreases, as the vagal effects are reinstated*. The higher the magnitude of the heart period variability, the stronger the vagal tone*. Many studies have supported this relationship (Porges, S.W. and Doussard-Roosevelt, 1997). In addition to baseline strength, another significant quality of vagal tone is the organism’s ability to modulate that strength in response to either external or internal conditions. For example in response to a mild external stressor, vagal tone should decrease appropriately. In other words, the mechanism should be flexible. These two qualities–strength and flexibility– correlate with a significant number of behaviors, and are central to our understanding of stress and health.

Here are some results observed in a number of different studies with infants (Porter, Porges, and Marshall, 1988). In general, infants with strong vagal tone showed greater soothability, better visual attention, more approach behaviors, greater emotional expressivity, and fewer emotional problems. Children with poor vagal flexibility demonstrated problems related to the regulation of sleep, arousal, emotion, attention and digestion. Thus, flexibility of the vagal tone relates to one's ability to regulate arousal and emotion. This capacity to regulate arousal is central to healthy functioning. A simple example of such regulation is how we respond when we unexpectedly encounter a traffic jam. All things being equal, a well regulated individual can take the unexpected frustration in stride whereas a poorly regulated individual might be angry for the rest of the morning and take even longer to return to equanimity.

In addition, the flexibility of the vagal tone correlated inversely with social withdrawal, depressed behavior and aggressive behavior in children (Porges, S. W, Doussard-Roosevelt, J.A. Portales, A.L., and Greenspan, S.I., 1996). That is, the less flexible the tone, the greater the problems. In one especially interesting study (Porter, F.L., Porges, S.W., and Marshall, R. E., 1988), investigators measured the vagal tone before and after circumcision. In healthy full-term infants, they found a precipitous drop in vagal tone immediately after circumcision, indicating the intensely stressful nature of the experience. However, in these healthy babies, the vagal tone was quickly restored, indicating that the babies were able to handle the stress. However, in infants who were either premature or had perinatal difficulties, the vagal tone did not return to baseline in a short amount of time. Their vagal brake was inadequate to the challenge. We can only guess what the long-term effects would be.

It is be important to keep in mind the image of "gradations of effects." It is obvious that powerful environmental effects can influence the developing nervous system, but "we propose that more subtle environmental factors also may restructure physiological organization. For example, chronic stress via poor social interactions or inadequate emotional support by the parent might change the underlying state of neurotransmitters and produce different 'set points' or 'thresholds' for the regulation of autonomic function and behavior. In shifting the set point, the activity and reactivity of the child might shift from being calm to being highly active and reactive" (Porges, S.W. and Doussard-Roosevelt, J.A, 1991). We can conjecture that countless individuals endured the stress of poor social interactions and inadequate emotional support throughout childhood. We can further conjecture that many of those never considered themselves to have been maltreated. Can this be a factor in the dismal health statistics cited above? We will return to this question again.

Neuroendocrine and Endocrine Axes

Once again, anatomically and physiologically the human stress response is a very complex multi-system process. We will continue our overview of this process with a look at the neuroendocrine and endocrine axes. The neuroendocrine axis begins in an area of the brain called the limbic system. French surgeon and neuroanatomist Paul Broca first identified a group of organs in the brain that he called the limbic brain (Lewis, Amini, and Lannon, 2000). The word comes from the Latin limbus meaning "edge, margin or border," and refers to an area above the reptilian brain that is common to all mammals. This area of the brain is at the center of activities dealing with stress, emotion, love and trauma. We shall return to it again and discuss several of its components. One component, the amygdala, named after the Greek word for almond because of its shape, initiates the neuroendocrine axis.

From the amygdala, impulses travel to the hypothalamus, and then to the sympathetic fibers, which link to the part of the adrenal glands called the adrenal medulla. From here adrenaline is secreted. Adrenaline is one of the two major stress hormones; cortisol is the other. Adrenaline steps up the heart rate, sends more oxygen to the lungs, brain and muscles. It stimulates the secretion of a substance called fibrinogen, which aids in the clotting of blood. It mobilizes the release of glucose and fatty acids from their storage as glycogen and fats, respectively. It increases blood pressure, heart rate and cardiac output, decreases blood flow to the kidneys, skin and the gastrointestinal systems. Action requires energy, and these physiological activities are mobilizing energy in preparation for action. As is obvious, this is not a condition that one would wish for except in the very short term to meet whatever emergency is at hand. That is exactly the design. However, when some of these effects become chronic, then the very systems designed to empower begin to have unwanted consequences.

The neural stimulation of the adrenals occurs very rapidly. A slower, more prolonged set of effects occur along the endocrine axes of which there are several such as the HPA axis, the somatotropic axis and the thyroid axis. It will suffice for our purposes to discuss only the primary endocrine axis, the HPA or hypothalamus-pituitary-adrenal axis (McEwen, 2002). There is evidence that the highest point of origin of this axis is again in the limbic system, where two structures, the septum and the hippocampus, are involved (Everly and Lating, 2002). From the septal-hippocampal complex, neural impulses descend to the hypothalamus, which secretes a substance called corticotropin-releasing factor (CRF). CRF descends to the pituitary gland, and stimulates the secretion of adrenocorticotropic hormone (ACTH) into the blood stream. ACTH's primary target organ is the part of the adrenal gland called the adrenal cortex. Here a class of hormones, called glucocorticoid hormones, is secreted. Cortisol is the primary glucocorticoid hormone and like adrenaline, the effects of cortisol are both complex and double-edged. One of its first functions is to replenish the energy supply depleted by the effects of adrenaline. It does this by converting a variety of food sources into glycogen and fat storage. Cortisol also has a double-edged effect on the immune system, which we will see later. It promotes the loss of minerals from bone and takes proteins from muscles and converts it into fat. Both cortisol and adrenaline can tip the HPA axis out of balance (McEwen, 2002). Too much or too little of either and problems ensue.

One reason that it is important to understand the link between stress and disease is that many individuals, who suffered moderate to severe neglect, abuse or misattunement, can appear on the surface to not be suffering any effects as adults. They may go to work, marry and raise children. On closer examination, however, those effects are revealed in their medical histories, and probably in their family dynamics as well. For example, let us take a maltreated individual who relies primarily on the defense mechanisms of dissociation and somatization. This means he characteristically disconnects from his body and emotions, and expresses conflict and pain through physical symptoms. He can appear to the world as perfectly integrated psychologically. However, his hypertension and heart disease are the very expression of that maltreatment, mediated through the mechanisms we described above and will continue to describe below. Further, this individual's marital and family relationships may be characterized by emotional distance and chronic strain if some deep primary needs are chronically unmet. I would conjecture this type of situation is extremely common. As we will see, the stress response can mediate between interpersonal events and disease, contribute enormously to disease, and exacerbate conditions that it does not cause. Before examining the link between stress arousal and disease, we will round out our understanding of allostasis by looking—again briefly and cursorily– at the effects of stress on the immune system, the brain and the cardiovascular system.

Stress and the Immune System

For almost forty years scientists have posed questions concerning the relationship of the brain, behavior and the immune system. This field came to be known as psychoneuroimmunology, and over the years, it has generated a vast amount of research. The basic question that we are concerned with here is this: does stress affect the immune system? If stress can be shown to influence the immune system, then that means it must be considered in relationship to infectious and degenerative diseases as well as psychosomatic diseases (Everly and Lating, 2002). In addition, if early trauma seriously compromises the allostatic process, and if that suppresses the immune system, the link from early trauma to the susceptibility of infectious, degenerative and psychosomatic disease has been established.

The immune system is an active participant in the allostatic process. Immune cells are generated in the bone marrow, are carried in the blood, and destroy whatever does not "belong" to the body. When the "fight-flight" mechanisms are engaged, there is an increased chance of injury resulting from those activities. Therefore, the immune system must prepare to deal with infection if there is a wound as a result of injury. Cortisol initially boosts the immune system by sending white blood cells to their battle stations, and then turns off the immune response after an appropriate level is reached (McEwen, 2002.) Cortisol also shuts off its own production to keep the stress response from getting out of hand. "In conditions of acute stress, cortisol promotes the trafficking of immune cells out of the blood and onto 'lookout' positions such as skin and lymph nodes. If the cells don't spot any signs of infection, they eventually return to the circulating blood. Then, once the stressful stimulus goes away or is satisfactorily dealt with, cortisol helps to send the all clear to the immune system. Finally cortisol acts directly on receptors in the hypothalamus in the built-in negative feedback loop, which the hormone uses to halt its own production" (McEwen, 2002, p.99).

If these protective functions of cortisol are not effective, the immune system can go on overdrive. Inflammatory disorders and autoimmune disorders are conditions of the immune system getting out of hand. In the former, the immune system goes on the attack in response to stimuli that do not bother most people, such as pollen or dust. These are allergies, and as we mentioned in chapter one, allergies are on the increase in children today. In autoimmune conditions, immune cells fail to distinguish self from nonself. It is the same idea as in inflammatory processes, but it is carried one step further. The system begins attacking healthy tissues. Some examples are rheumatoid arthritis and type I diabetes. In type I or juvenile diabetes, the immune systems destroys insulin-producing cells in the pancreas. The result is dependency on insulin injections. Not only has stress been shown to aggravate these conditions, there is a body of evidence suggesting that it determines whether they develop in the first place (McEwen, 2000). We can begin to see how crucial it is to develop healthy stress responses or allostatic systems. We can also begin to see how early maltreatment may play havoc with those systems setting the stage for a wide range of physical or emotional problems.

When the immune system is depressed, we are more likely to become ill. Confirming an experience that most of us have probably had, Sheldon Cohen (1997) found that individuals were more likely to catch colds during periods of prolonged stress. There have been numerous studies demonstrating emotional effects on the immune system. Glaser and his colleagues (1984), in studying a group of medical students, found that loneliness could suppress the immune system. They also found that people with little social support who were caring for spouses with Alzheimer's disease fared worse in tests of immune system activity than did those with stronger social support (Dura, J.R. Speicher, C.E. Trask, O.J. and Glaser, R., 1994).

In the early 1950's 126 healthy men were randomly chosen from their Harvard graduating class. They were asked to describe the closeness and warmth of their relationship with their mother and father. They were asked to choose among four answers: very close, warm and friendly, tolerant, strained and cold. Thirty-five years later, 100% of the men who rated both parents low in warmth and closeness had diagnosed diseases compared with 47 percent of those who rated both parents high in warmth and closeness. The researchers said, "The perception of love itself…may turn out to be a core biopsychosocial-spiritual buffer, reducing the negative impact of stressors and pathogens and promoting immune function and healing" (Russek, L. G. and Schwartz, G.E., 1996).

Stress and the Brain

The development of highly sophisticated imaging techniques has opened the doors to a new frontier of brain research. What happens in the brain when we are learning something new? What happens when we love? What happens when we have been neglected or abused as infants? These and many other questions are now being approached with the aid of techniques such as the positron emission tomography, and functional magnetic resonance imaging. These techniques allow researchers to watch the living brain in action. In the next chapter we will look at some of the specific effects of childhood trauma on the developing brain. To set the ground for that discussion we will describe some pertinent brain structures and make some general comments about the effects of stress.

The human brain is an extremely complex network of billions of neurons or brain cells. To simplify our understanding, we will divide the brain into three main parts, the neocortex, the limbic brain and the brain stem or reptilian brain. The neocortex is, in humans, the largest of the three brains. It is also the most recent arrival. It has two asymmetrical sides, the left and right. In the first three years of life the right side is dominant in its growth. The right side of the brain processes in a more holistic, spatial-visual manner, and focuses more on nonverbal aspects of language such as tone of voice and facial expression than does the left. Self-soothing, body awareness and affect regulation are also more a function of the right hemisphere than the left. The left hemisphere is the more linear, logical and linguistic. Its growth spurt begins somewhere around age three. Cause and effect thinking is also more a function of the left hemisphere (Siegel, 2003).

The part of the cortex of greatest interest to our topic is the *prefrontal cortex.* If we wish to have a visual impression of the location of these structures, we can fold our thumb into our palm, and turn our palm so we are facing our fingernails. Thus, our wrist, hand and fingers will symbolize our brain. Our fingers folded over our thumbs will represent the cortex. The area from our last knuckles, closest to our fingernails, down to our fingernails, will represent the prefrontal cortex. The middle part of the prefrontal cortex is called the *orbital frontal cortex*. Located behind the orbit of the eyes, it is an extremely important area in that it sends and receives signals from all the other major areas of the brain and controls the autonomic nervous system as well. Thus, it has a special role in integrating the complex system of the brain, and in dealing with arousal, regulation and stress.

If we lift our fingers exposing our thumb, we see the area symbolizing the limbic system. The evolution of the limbic system corresponds to the evolution of mammals. Generally, mammals give birth to babies, while reptiles hatch eggs. Mammals and reptiles also have very different orientations towards their offspring. Reptiles are detached and disinterested in their progeny while mammals are capable of engaging in subtle and elaborate interactions. The limbic system is one of the prime mediators of those interactions. It is the neurological center of emotion and motivational states.[2] Some of the structures included within its boundaries are the *hippocampus, amygdala, septum, anterior cingulate,* and others. Some authors include the hypothalamus as part of the limbic system, which we have already described.

The hippocampus is a small, layered folded structure that is necessary in the formation of explicit, factual or autobiographical memory. It is concerned with the context and sequence of events. The amygdala is a rounded ball shaped structure lying deep under the cortex close to the hippocampus. It assigns emotional significance to an event and is important in the processing of highly charged events. It has face recognition cells, which become active in response to emotionally expressive faces (Siegel, 2003). It is also involved in implicit memory. Implicit memory means we can remember the emotional experience and even formulate deep convictions about others, the world and ourselves, *before* we develop any factual memory. It is central to our understanding of trauma, stress and health. We

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[2] Of course emotion and motivation involve neurological connections from the limbic center to every other major area of the brain.

will clarify it further in chapter three. Interestingly, the amygdala is well formed at birth, while the hippocampus is not fully developed until the third year of life (Rothschild, 2002). The septum is a structure very similar to the hypothalamus in both anatomic connection and function (Lindlsey and Holmes, 1984). The anterior cingulate helps coordinate what we do with our thoughts and our bodies (Siegel, 2003).

The *brain stem* or reptilian brain is the oldest part of our triune brains. In essence, it is a bulbous elaboration of the spinal cord, located just as the cord enters the foramen magnum, the large hole at the base of the skull. Physiologically this is the area of survival. Vital centers such as the control of respiration, heartbeat, and the startle control center are located here. It receives information from perceptions, from our bodies and the outside world. Here the *raphe nucleus* manufactures *serotonin* and the *locus ceruleus* makes noradrenalin. Rudimentary interactions are mediated via this center, such as displays of aggression, territorial and mating behavior.

Having laid out a simplified sketch of the relevant brain structures, we can turn to our question of what effects does stress have on the brain. The hippocampus is very rich in cortisol receptors, and cortisol is a major stress hormone. In emotional memories the hippocampus mediates context and sequence. Cortisol participates in that process. However**, when stress levels are severe or exceptionally prolonged, the hippocampus itself and its role in memory formation are at risk**. Stress hormones assist in engraving experiences into our memory; that is the adaptive utility of the allostatic system. But excessive or chronically elevated levels of these same hormones can damage the structure of the brain responsible for turning them off. McEwen (2002) reviewed a number of studies from which he arrived at the following conclusions concerning stress and the brain. In response to stress, the brain puts two key processes on hold. They are *neurogenesis* and *plasticity*. As we will see later neurogenesis and plasticity may be central processes in healing from early maltreatment.

Neurogenesis refers to the brain's ability to grow new cells throughout its lifetime. Scientist did not accept that this was possible until the end of the 20th Century, when Elizabeth Gould (1998) demonstrated that the adult rat hippocampus continues to produce new cells in an area of the brain called the dentate gyrus. She also found that increased levels of cortisol and stress could suppress the production of these new cells, putting the process on hold.

Plasticity refers to the brains malleable, responsive and resilient nature. It actually remodels and reconfigures its very structure in the process of learning. Both neurogenesis and plasticity are central to learning and memory processes, and both are put on hold in times of stress. This is a protective feature and another example of allostasis or the adaptive nature of those stress mechanisms. If the stress is terminated, then both neurogenesis and plasticity resume and there is no permanent damage to the brain. However, once again when allostasis becomes allostatic load, protection becomes damage. What was a temporary restructuring now becomes diminished connection or shrunken tissue (McEwen, 2002).

Stress and Cardiovascular Disease

The statistics on cardiovascular disease in America are daunting. According to the American Heart Association, it is the number one cause of death in the United States, claiming the lives of 40.6 percent of the more than 2.3 million people who die each year. Almost 61 million Americans have some form of cardiovascular disease, ranging from congenital heart defects to high blood pressure and hardening of the arteries (The American Heart Association, 1998). In 1999 about 530,000 Americans died from heart attacks. Of these, 739 were aged 25 to 34 and 5,970 people were aged 35 to 44 (The New York Times, 2002). According to Dr. Stempien-Otero, a transplant cardiologist at the University of Washington, "the prevalence of largely avoidable risk factors for heart disease—smoking, obesity, diabetes, high cholesterol, and high blood pressure—is rising at an alarming clip nationally" (Seattle Magazine, 2002, p.61). As with so many contemporary diseases, modern medicine has been brilliant in developing pharmaceuticals and surgical procedures to deal with the symptoms, but not so great in recognizing and preventing its root causes. Nevertheless, stress has now become accepted as a risk factor for cardiovascular disease.

Whenever we are aroused, whether that arousal is pleasurable or stressful, the heart beats faster to provide the body with more oxygen and fuel, such as glucose. Our hearts are extremely sensitive to our need for increased responsiveness. Elevations in blood pressure help us deal with environmental challenges, even if those challenges are not emergencies. As we have seen, the stress hormones adrenalin and cortisol in proper balance provide and restore energy. But if they are out of balance, they can become problematic. However, it is the autonomic nervous system, that bridge between conscious knowledge of our actions and control over them on one hand, and the activity of our cells, tissues and organs on the other, that is the key. "The status of the autonomic nervous system, although often ignored by clinicians, is a major determinant of cardiovascular health and prognosis" (Curtis and O'Keefe, Jr. 2002, p. 45). Remember, in the absence of a *strong and responsive* vagal brake, the individual is at the mercy of an overactive sympathetic system. "Excessive sympathetic stimulation and diminished vagal tone not only are markers of an unhealthy cardiovascular system but also in part *cause* the adverse events. Chronic sympathetic hyperactivity increases the cardiovascular workload and hemodynamic stresses and predisposes to endothelial dysfunction, coronary spasm, left ventricular hypertrophy, and serious dysrhythmias" (Curtis and O'Keefe, Jr. 2002, p.46.). So what does 'chronic sympathetic hyperactivity look like?

Let us picture an individual with a weak or rigid vagal brake, the ventral vagal system we have spoken about above. Since it is likely that a healthy ventral vagal facilitates satisfying, contactful, engaging, warm, loving interpersonal relationships, it is also likely that an individual with a weak ventral vagal would present with interpersonal challenges. Given further that a weak or rigid ventral vagal is likely to indicate a hypersensitive sympathetic system, our hypothetical individual would display more fight-flight behaviors. Hostility, resentment, impatience, poor impulse control or self-regulation, and interpersonal withdrawal will likely be found. What we are describing here is, more or less, the notorious type A personality. And, although an analysis of the type A studies has cast some doubts on whether the global construct is a good predictor of heart disease, the research has shown that chronic hostility and cynicism are risk factors for coronary disease. Some studies have implicated depression and anxiety as risk factors as well. Research has also shown that type A individuals tend to be extremely reactive when confronted with psychosocial challenges (Everly and Lating, 2002). This is very consistent with poor vagal tone or flexibility; they are displaying "sympathetic hyperactivity." In a later chapter, we will elaborate on how predisposed individuals can turn in a healthier direction. But we have seen how prolonged stress with its chronic sympathetic hyperactivity affects the immune system, the brain, and the cardiovascular system.

Limbic Hypersensitivity Phenomena and Disorders of Arousal

Stress plays a crucial role in health and disease, but there have been impediments to the general acceptance of that notion. The major impediment has been a hundred and fifty years of medical success based on the 'one cause for one disease' theory. Another major impediment has been the uncertainty about how stress translates into disease. Although it may be intuitively obvious, the mechanisms of that translation have been anything but obvious. Hans Selye's general adaptation syndrome described an "exhaustion" phase where structures were eventually worn down. This was a beginning but not nearly a sufficient explanation.

Several different theories attempted to explain how stress translates into disease. For example, one states that specific psychic conflicts, such as repressed hostility results in specific conditions, such as migraine headaches (Alexander, 1950). Another theory states that individuals are predisposed to respond to stressful stimuli with a particular pattern of psychophysical reactivity. This results in frequent activation of specific organs and the failure of homeostatic mechanisms, which eventually leads to disease (Sternbach, 1966). Another model suggests that disease is not the result of direct stress physiology, but of insufficient motor expression. "The system that has been put all but out of commission (by our sedentary lifestyles), the striated musculature…has an important role which exceeds the mere function of locomotion. Action of the striated muscles influences directly and indirectly circulation, metabolism, and endocrine balance….Last but not least the striated muscles serve as an outlet for our emotions and nervous responses….Obliteration of this important safety valve…might well upset the original balance to which the bodies of primitive man have been adapted" (Kraus and Raab, 1961, p.4). We will revisit the importance of "movement" in a later chapter.

Synthesizing decades of theory and research, Harvard Psychophysiologists arrived at a model to elegantly explain the pathogenic mechanisms in diseases considered "psychosomatic." A consistent observation that provided the basis for that model was that a variety of "technologies," such as meditation, biofeedback, and yoga, which resulted in hypoarousal (or relaxation), ameliorated or at least lessened the severity of a wide variety of diseases (Everly and Lating, 2002). If learning to relax can improve a wide variety of psychosomatic conditions, then it follows that there is a common denominator of those conditions. Reviewing the experimental and theoretical literature, they conclude that there is a common denominator condition, which they call ***limbic hypersensitivity phenomena***, a state in which the limbic system is either chronically 'aroused' or has a very low threshold so that it is easily aroused (We also refer to this condition as a **Compromised Nervous System Disorder**). This condition then gives rise to a wide variety of physiological and emotional disorders. The uncovering of an underlying latent condition that can appear clinically in a plethora of physical and psychological disorders has obvious and profound implications for prevention and treatment.

This model accepts what is common to all previous attempts to explain the linkage from stress to illness. Simply stated the commonality is that organs that have been over stimulated for long enough periods will eventually manifest disease. The dysfunction may be a result of "wear and tear", biochemically induced trauma or toxicity, or visceromotor fatigue or exhaustion. However, *it places its emphasis on the limbic system itself. It states that a wide variety of etiological factors– including emotional, cognitive, environmental, social, and biochemical—can result in a limbic system based neurological hypersensitivity. In turn, this state activates a variety of stress axes, such as the neurological, neuroendocrine, and endocrine axes, that can, through their effects on target organs, manifest as disease. Limbic hypersensitivity phenomenon is a common denominator of a wide range of conditions that can be called arousal disorders.* Included in this classification would be all anxiety-related and stress-related conditions, both physical and psychological. Physical illnesses include gastrointestinal disorders such as peptic ulcers, ulcerative colitis, irritable bowel syndrome and esophageal reflux. They include cardiovascular disorders, such as essential hypertension and coronary artery disease. They include respiratory disorders such as asthma and allergies; and many others such as migraine headaches, fibromyalgia, chronic fatigue, and chronic pain (Everly and Lating, 2002). Anxiety related disorders would include panic syndromes, generalized anxiety, and posttraumatic stress. Some forms of depression are also likely to involve limbic hypersensitivity phenomenon. The implication of this understanding cannot be overstated.

We can reasonably assume that one major consequence of early childhood trauma is limbic hypersensitivity that could potentially be expressed in later life as physical and/or emotional disorders. As we will see in our next chapter, the neurological mechanisms involved in the regulation of stress require a nurturing environment for optimal growth. Also, we have seen that intense stress can diminish the functioning of the immune system. It is not a huge leap to conclude that early child maltreatment renders an individual vulnerable to both physical and psychological conditions. Let us take a look at how maltreatment or trauma can result in a hyper limbic sensitivity by way of a compromised autonomic nervous system.

Connection—the Antidote to Stress and the Way to a Happy Heart

Connection is the single most important factor in health and well being. (See our **Principles of Heart Connection**) What a powerful statement! It goes right to the core of our humanity, our human beingness. Study after study is demonstrating the importance of connection, social connection, interpersonal connection, self connection to our health and well being.

References

McEwen, The End Of Stress As We Know It.

Everly and Lating, A Clinical Guide to the Treatment of the Human Stress Response

St John, Maltreatment in Early Childhood: Consequences, Recovery and Beyond, Doctoral Dissertation.

[1] Please ignore all below references as this paper is a composite of several. All references furnished on final page

[2] **Comment on how with biofeedback we can control…**

[3] **See Porges…**

[4] See Porges for all this work on the ventral vagal and dorsal vagal