Chapter 6

Homeostasis, stress and adaptation

LEARNING OBJECTIVES

On completion of this chapter, you should be able to:

1. Relate the principles of homeostasis, stress and adaptation.
2. Identify physiological and psychosocial stressors and the significance of the body's compensatory mechanisms in promoting adaptation and maintaining homeostasis.
3. Compare the sympathetic-adrenal-medullary response to stress to the hypothalamic–pituitary response to stress.
4. Describe the general adaptation syndrome as a theory of adaptation to biological stress.
5. Describe the relationship of the process of negative feedback to the maintenance of homeostasis.
6. Compare the adaptive processes of hypertrophy, atrophy, hyperplasia, dysplasia and metaplasia.
7. Describe the inflammatory and reparative processes.
8. Assess the health patterns of an individual and determine their effects on maintenance of the homeostasis.
9. Identify ways in which maladaptive responses to stress can increase the risk of illness and cause disease.
10. Identify key concepts in stress-reduction approaches.
11. Identify individual, family, and group measures that are useful in reducing stress.

KEY TERMS

adaptation
adrenocorticotropic hormone (ACTH)
antidiuretic hormone (ADH)
catecholamines
coping
dysplasia
family
glucocorticoids
gluconeogenesis
guided imagery
homeostasis
hyperplasia
hypoxia
inflammation
metaplasia
negative feedback
positive feedback
stress
stressor

When the body is threatened or suffers an injury, its response may involve functional and structural changes; these changes may be adaptive (having a positive effect) or maladaptive (having a negative effect). The defence mechanisms that the body exhibits determine the difference between adaptation and maladaptation—health and disease. This chapter discusses homeostasis, stress, adaptation, health problems associated with maladaptation and ways nurses can intervene to reduce stress and its health-related effects.

Fundamental concepts

Each different body system performs specific functions to sustain optimal life for the organism. Mechanisms for adjusting internal conditions promote the homeostasis of the organism and ultimately its survival. These mechanisms are compensatory in nature and work to restore balance in the body. For example, rapid breathing (hyperpnoea) after intense exercise is how the body compensates for an oxygen deficit and excess lactic acid accumulated in the muscle tissue.

Pathophysiological processes (*pathos* meaning 'experience' or 'suffering'; *physis* meaning 'nature or origin'; and *logia* meaning 'study of') result when cellular injury occurs at such a rapid rate that the body's compensatory mechanisms can no longer make the adaptive changes necessary to remain healthy. An example of a pathophysiological change is the development of heart failure where the body reacts by retaining sodium and water and increasing venous pressure, which worsens the condition. These pathophysiological mechanisms give rise to signs that are observed by the patient and/or clinician and can enable the existence and the extent of the problem to be diagnosed to inform an appropriate course of action.

Homeostasis

Physiological mechanisms must be understood in the context of the body as a whole. The person, as a living system, has both an internal and an external environment, between which information and matter are continuously exchanged. Within the internal environment each organ, tissue and cell is also a system or subsystem of the whole, each with its own internal and external environment, each exchanging information and matter (see Fig. 6-1). The goal of the interaction of the body's subsystems is to produce a dynamic balance or homeostasis (even in the presence of change), so that all subsystems are in harmony with each other. Understanding the concepts of homeostasis, stress and adaptation is essential to practicing safely in the clinical environment. The body's ability to maintain homeostasis, deal with stress and adapt to different physiological threats and challenges is related to the systems external and internal to it (see Fig. 6-1).

Homeostasis refers to physical and psychological within the body. When a change or stress occurs that causes a body function to deviate from its stable range, processes are initiated to restore and maintain the balance. When these

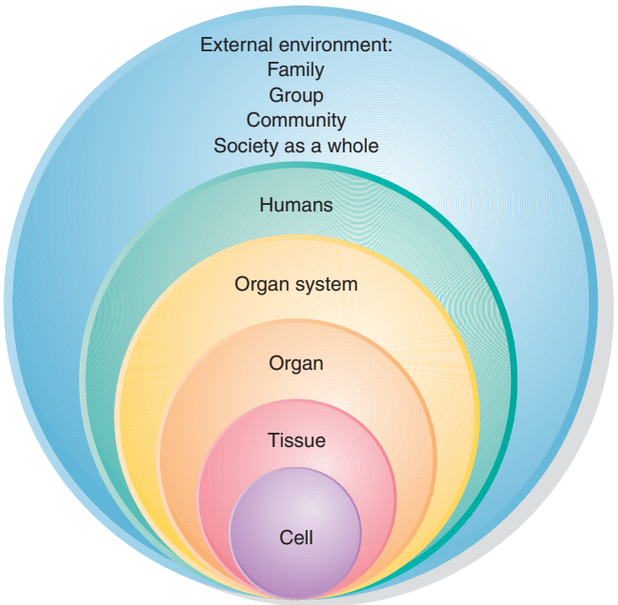

FIGURE 6-1 Constellation of systems. Each system is a subsystem of the larger system (suprasystem) of which it is a part. In this figure, the cell is the smallest system, being a subsystem of all other systems.

adjustment processes—sometimes known as compensatory mechanisms—are not adequate, homeostasis is threatened and disease or damage can occur. Disease is an abnormal variation in the structure or function of any part of the body.

Stress and adaptation

Stress is a state produced by a change in the environment that can challenge the person's dynamic balance or equilibrium. The body feels unable to meet the demands of these changes. The change or stimulus that evokes this state is the stressor. Different stressors typically affect people in different, yet not altogether dissimilar ways. The desired goal is **adaptation**, which is an adjustment to the change so that the person is again in equilibrium and has the energy and ability to meet new demands. This is the process of **coping** with the stress, a compensatory process that has physiological and psychological components.

Adaptation is a constant, ongoing process that requires a change in structure, function or behaviour to deal with changes that affect the homeostatic balance of the body. Adaptation is also an individual process as each individual has varying abilities to cope or respond. It occurs throughout the life span as the individual encounters many developmental and situational challenges, especially related to health, wellness and illness.

Because both stress and adaptation may exist at different levels of a system, it is possible to study these reactions at the cellular, tissue and organ level. Biologists are concerned mainly with subcellular components or with subsystems of the total body. Behavioural scientists study stress and adaptation in individuals, families, groups and societies; they focus on how a group's features are modified to meet the requirements of the social and physical environment in which they exist. Adaptation is a continuous process of seeking equilibrium in a constantly changing environment. The desired goals of adaptation for any system are survival, growth and reproduction.

Overview of stress

Each person operates at a certain level of adaptation and regularly encounters a certain amount of change. Such change is expected; it contributes to growth and enhances life. Stressors, however, can upset this equilibrium. A **stressor** may be defined as an internal or external event or situation that creates the potential for physiological, emotional, cognitive or behavioural changes in an individual.

Types of stressors

Stressors may be described as physical, physiological or psychosocial. Physical stressors include cold, heat and chemical agents; physiological stressors include pain and fatigue. Examples of psychosocial stressors are fear of failing an examination and losing a job. Stressors can also occur as normal life transitions that require some adjustment, such as going from childhood into puberty, getting married or giving birth.

Stressors have also been classified as day-to-day frustrations or hassles, major complex occurrences involving large groups and stressors that occur less frequently and involve fewer people. Day-to-day stressors include common occurrences as getting caught in a traffic jam, experiencing computer downtime and having an argument with a spouse or roommate. These experiences vary in effect. For example, encountering a rainstorm while you are holidaying at the beach will most likely evoke a more negative response than it might at another time. These daily hassles have been shown to have a greater health impact than major life events because of the cumulative effect they have over time. They can lead to high blood pressure, palpitations or other physiological problems (Rice, 2011).

Major stressors influence larger groups of individuals, families and sometimes even entire nations. These include events of history, such as terrorism and war, experienced either directly in the war zone or indirectly through live news coverage. The demographic, economic and technological changes occurring in society also serve as stressors. The tension produced by any stressor is sometimes a result not only of the change itself but also of the speed with which the change occurs.

Stressors concerning relatively infrequent situations that directly affect people have been studied extensively. This category includes the influence of life events such as death, birth, marriage, divorce and retirement. It also includes the psychosocial crises that occur in the life cycle stages of the human experience. More enduring chronic stressors may include having a permanent disability or coping with the need to provide long-term care to a frail older parent.

Stressors of daily life can lead to high blood pressure. Duration may also be used to categorise stressors, as in the following:

- An acute, time-limited stressor, such as studying for final examinations.
- A stressor sequence—a series of stressful events that result from an initial event such as job loss or divorce.
- A chronic intermittent stressor, such as daily hassles.
- A chronic enduring stressor that persists over time, such as chronic illness, a disability or poverty.

Stress as a stimulus for disease

Relating life events to illness (the theoretical approach that defines stress as a stimulus) has been a major focus of research. Sources of stress for patients have been well researched (Dow, 2011; Mair et al., 2011; Pierce et al., 2011). People typically experience distress related to alterations in their physical and emotional health status, changes in their level of daily functioning and decreased social support or the loss of significant others. Fear of immobilisation, isolation, loneliness, sensory changes, financial problems, death or disability increases a person's anxiety level. Loss of one's role or perceived purpose in life can cause intense discomfort. When a person endures prolonged or unrelenting suffering, the outcome is frequently the development of a stress-related illness. Clinicians should possess the awareness and skills of stress as a stimulus for disease to educate people in their care and provide evidence-informed strategies that enable them to manage their responses to stress more effectively.

Physiological responses to stress

The physiological response to a stressor, whether it is a physical stressor or a psychological stressor, is a protective and adaptive mechanism to maintain the homeostatic balance of the body. When a stress response occurs, it activates a series of neurological and hormonal processes within the brain and body systems. The duration and intensity of the stress can cause both short-term and long-term effects. A stressor can disrupt homeostasis to the point where adaptation to the stressor fails and a disease process results.

Selye's theory of adaptation

Hans Selye developed a theory of adaptation that profoundly influenced the scientific study of stress. In 1976, Selye, experimenting with animals, first described a syndrome consisting of enlargement of the adrenal cortex; shrinkage of the thymus, spleen, lymph nodes and other lymphatic structures; and the appearance of deep, bleeding ulcers in the stomach and duodenum. They identified this as a non-specific response to diverse, noxious stimuli.

General adaptation syndrome

Selye then developed a theory of adaptation to biological stress that he named the general adaptation syndrome (GAS), which has three phases: alarm, resistance and exhaustion. During the alarm phase, the sympathetic 'fight-or-flight' response is activated with release of **catecholamines** and the onset of the **adrenocorticotropic hormone (ACTH)**–adrenal cortical response. The alarm reaction is defensive and anti-inflammatory but self-limited. The person moves into the second stage, resistance, because living in a continuous state of alarm would result in death. During this stage, adaptation to the noxious stressor occurs and cortisol activity is still increased. If exposure to the stressor is prolonged, exhaustion sets in and endocrine activity increases. Exhaustion produces deleterious effects on the body systems (especially the circulatory, digestive and immune systems) that can lead to death. Stages 1 and 2 of this syndrome are repeated, in different degrees, throughout life as the person encounters stressors.

Selye compared the GAS with the life process. During childhood, there are too few encounters with stress to promote the development of adaptive functioning, and the child is vulnerable. During adulthood, the person encounters a number of life's stressful events and develops a resistance or adaptation. During the later years, the accumulation of life's stressors and wear and tear on the organism again decrease the person's ability to adapt, resistance falls and eventually death occurs.

Local adaptation syndrome

According to Selye's theory, a local adaptation syndrome also occurs. This syndrome includes the inflammatory response and repair processes that occur at the local site of tissue injury. The local adaptation syndrome occurs in small, topical injuries, such as contact dermatitis. If the local injury is severe enough, the GAS is activated as well.

Selye emphasised that stress is the non-specific response common to all stressors, regardless of whether they are physiological, psychological or social. The many conditioning factors in each person's environment account for why different demands are interpreted by different people as stressors. Conditioning factors also account for differences in the tolerance of different people for stress: some people may develop diseases of adaptation, such as hypertension and migraine headaches, while others are unaffected.

Interpretation of stressful stimuli by the brain

Physiological responses to stress are mediated by the brain through a complex network of chemical and electrical messages. The neural and hormonal actions that maintain homeostatic balance are integrated by the hypothalamus, which is located in the centre of the brain, surrounded by the limbic system and the cerebral hemispheres. The hypothalamus integrates autonomic nervous system mechanisms that maintain the chemical constancy of the internal environment of the body. Together with the limbic system, it also regulates emotions and many visceral behaviours necessary for survival (e.g. eating, drinking, temperature control, reproduction, defence, aggression). The hypothalamus is made up of a number of nuclei; the limbic system contains the amygdala, hippocampus and septal nuclei, along with other structures.

Physiology ■ ■ ■ Pathophysiology

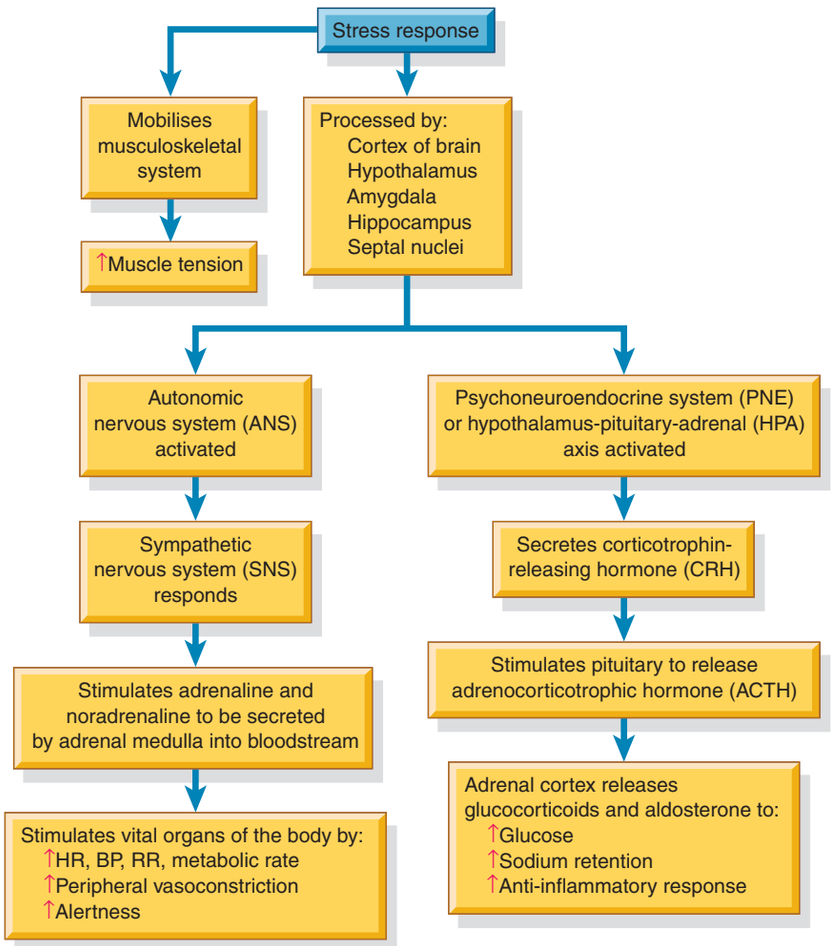

FIGURE 6-2 The physiological response to stress. The body is prepared through brain activation of the autonomic nervous system and psychoneuroendocrine system commonly referred to as the hypothalamus-pituitary-adrenal axis to cope with stress.

Each of these structures responds differently to stimuli. The cerebral hemispheres are concerned with cognitive functions: thought processes, learning and memory. The limbic system has connections with both the cerebral hemispheres and the brainstem. In addition, the reticular activating system, which is a network of cells that forms a two-way communication system, extends from the brainstem into the midbrain and limbic system. This network controls the alert or waking state of the body.

In the stress response, afferent impulses are carried from sensory organs (eye, ear, nose, skin) and internal sensors (baroreceptors, chemoreceptors) to nerve centres in the brain. The response to the perception of stress is integrated in the hypothalamus, which coordinates the adjustments necessary to return to homeostatic balance. The degree and duration of the response varies; major stress evokes both sympathetic and pituitary adrenal responses.

Neural and neuroendocrine pathways under the control of the hypothalamus are also activated in the stress response. Initially, there is a sympathetic nervous system discharge, followed by a sympathetic–adrenal–medullary discharge. If the stress persists, the hypothalamic–pituitary system is activated (see Fig. 6-2).

Sympathetic nervous system response

The sympathetic nervous system response is rapid and short-lived. Noradrenaline is released at nerve endings that are in direct contact with their respective end organs to cause an increase in function of the vital organs and a state of general body arousal (Grossman & Porth, 2014). The heart rate is increased and peripheral vasoconstriction occurs, raising the blood pressure. Blood is also shunted away from abdominal organs. The purpose of these activities is to provide better perfusion of vital organs (brain, heart, skeletal muscles). Blood glucose is increased, supplying more readily available energy. The pupils are dilated, and mental activity is increased; a greater sense of awareness exists. Constriction of the blood vessels of the skin limits bleeding in the event of trauma. The person is likely to experience cold feet, clammy skin and hands, chills, palpitations and a 'knot' in the stomach. Typically, the person appears tense, with the muscles of the neck, upper back and shoulders tightened;

TABLE 6-1 Sympathetic–adrenal–medullary response to stress

Effect	Purpose	Mechanism
Increased heart rate and blood pressure	Enhanced perfusion of vital organs	Increased cardiac output due to increased myocardial contractility and heart rate; increased venous return (peripheral vasoconstriction)
Increased blood glucose level	Increased available energy	Increased liver and muscle glycogen breakdown; increased breakdown of adipose tissue triglycerides
Mental acuity	Alert state	Increase in amount of blood shunted to the brain from the abdominal viscera and skin
Dilated pupils	Increased awareness	Contraction of radial muscle of iris
Increased tension of skeletal muscles	Preparedness for activity, decreased fatigue	Excitation of muscles; increase in amount of blood shunted to the muscles from the abdominal viscera and skin
Increased ventilation (may be rapid and shallow)	Provision of oxygen for energy	Stimulation of respiratory centre in medulla; bronchodilation
Increased coagulability of blood	Prevention of haemorrhage in event of trauma	Vasoconstriction of surface vessels

respirations may be rapid and shallow, with the diaphragm tense.

Sympathetic–adrenal–medullary response

In addition to its direct effect on major end organs, the sympathetic nervous system also stimulates the medulla of the adrenal gland to release the hormones adrenaline and noradrenaline into the bloodstream. The action of these hormones is similar to that of the sympathetic nervous system and has the effect of sustaining and prolonging its actions. Adrenaline and noradrenaline are catecholamines that stimulate the nervous system and produce metabolic effects that increase the blood glucose level and increase the metabolic rate. The effect of the sympathetic and adrenal–medullary responses is summarised in Table 6-1. This effect is called the 'fight-or-flight' reaction (Grossman & Porth, 2014).

Hypothalamic–pituitary response

The longest-acting phase of the physiological response, which is more likely to occur in persistent stress, involves the hypothalamic–pituitary pathway. The hypothalamus secretes corticotropin-releasing factor, which stimulates the anterior pituitary to produce ACTH. Adrenocorticotropic hormone in turn stimulates the adrenal cortex to produce **glucocorticoids**, primarily cortisol (Grossman & Porth, 2014). Cortisol stimulates protein catabolism, releasing amino acids; stimulates liver uptake of amino acids and their conversion to glucose (**gluconeogenesis**); and inhibits glucose uptake (anti-insulin action) by many body cells but not those of the brain and the heart (Grossman & Porth, 2014). These cortisol-induced metabolic effects provide the body with a ready source of energy during a stressful situation. This effect has some important implications. For example, a person with diabetes who is under stress, such as that caused by an infection, needs more insulin than usual. Any patient who is under stress catabolises body protein and needs supplements. Children subjected to severe stress can have delayed or abnormal development.

The actions of the catecholamines (adrenaline and noradrenaline) and cortisol are the most important in the general response to stress. Other hormones released are **antidiuretic hormone (ADH)** from the posterior pituitary and aldosterone from the adrenal cortex. ADH and aldosterone promote sodium and water retention, which is an adaptive mechanism in the event of haemorrhage or loss of fluids through excessive perspiration. ADH has also been shown to influence learning and may thus facilitate coping in new and threatening situations. Secretion of growth hormone and glucagon stimulates the uptake of amino acids by cells, helping to mobilise energy resources. Endorphins, which are endogenous opiates, increase during stress and enhance the threshold for tolerance of painful stimuli. They may also affect mood and have been implicated in the so-called 'high' that long-distance runners experience. The secretion of other hormones is also affected, but their adaptive function is less clear.

Immunological response

Research findings show that the immune system is connected to the neuroendocrine and autonomic systems. Lymphoid tissue is richly supplied by autonomic nerves capable of releasing a number of different neuropeptides that can have a direct effect on leucocyte regulation and the inflammatory response. Neuroendocrine hormones released by the central nervous system and endocrine tissues can inhibit or stimulate leucocyte function. The wide variety of stressors people experience may result in different alterations in autonomic activity and subtle variations in neurohormone and neuropeptide synthesis. All of these possible autonomic and neuroendocrine responses can interact to initiate, weaken, enhance or terminate an immune response.

The study of the relationships among the neuroendocrine system, the central and autonomic nervous systems and the immune system and the effects of these relationships on overall health outcomes is called *psychoneuroimmunology.* One's perception of events and coping styles determines whether,

and to what extent, an event activates the stress response system, and because the stress response affects immune activity, one's perceptions, ideas and thoughts can have profound neurochemical and immunological consequences. Studies have demonstrated alteration of immune function in people who are under stress (Thoma, 2011; Weston, 2010). Interestingly, some studies have even demonstrated that a stressor such as cancer in a loved one can cause poor physical and psychological health of family members too (Wells-Di Gregorio et al., 2012). Other studies have identified certain personality traits, such as optimism and active coping, as having positive effects on health or specific immune measures (Dilworth-Anderson et al., 2007; Krucoff, 2007; Verhaeghe et al., 2007). As research continues, this field of study will likely uncover to what extent and by what mechanisms people can consciously influence their immunity.

Psychological responses to stress

After the recognition of a stressor, an individual consciously or unconsciously reacts to manage the situation referred to as the 'mediating process'.

Appraisal of the stressful event

A theory developed by Lazarus (1991) emphasises cognitive appraisal and coping as important mediators of stress. Cognitive appraisal (Lazarus, 1991; Lazarus & Folkman, 1984) is a process by which an event is evaluated with respect to what is at stake (primary appraisal) and what might and can be done (secondary appraisal). What individuals see as being at stake is influenced by their personal goals, commitments or motivations. Important factors include how important or relevant the event is to them, whether the event conflicts with what they want or desire and whether the situation threatens their own sense of strength and ego identity.

Primary appraisal results in the situation being identified as either non-stressful or stressful. Secondary appraisal is an evaluation of what might and can be done about this situation. Reappraisal, which is a change of opinion based on new information, also occurs. The appraisal process is not necessarily sequential; primary and secondary appraisal and reappraisal may occur simultaneously.

The appraisal process contributes to the development of an emotion. Negative emotions such as fear and anger accompany harm/loss appraisals, and positive emotions accompany challenge. In addition to the subjective component or feeling that accompanies a particular emotion, each emotion also includes a tendency to act in a certain way. In a study on how people coped after myocardial infarction, people struggled with cognitively appraising this life event with negative outlooks linked poorer outcomes (Kroemeke, 2015). Lazarus (1991) expanded his initial ideas about stress, appraisal and coping into a more complex model relating emotion to adaptation. He called this model a 'cognitive-motivational-relational theory', with the term *relational* 'standing for a focus on negotiation with a physical and social world' (p. 13). A theory of emotion was proposed as the bridge to connect psychology, physiology and sociology: 'More than any other arena of psychological thought, emotion is an integrative, organismic concept that subsumes psychological stress and coping within itself and unites motivation, cognition, and adaptation in a complex configuration' (p. 40).

Coping with the stressful event

Coping, according to Lazarus, consists of the cognitive and behavioural efforts made to manage the specific external or internal demands that tax a person's resources and may be emotion-focused or problem-focused. Coping that is emotion-focused seeks to make the person feel better by lessening the emotional distress felt. Problem-focused coping aims to make direct changes in the environment so that the situation can be managed more effectively. Both types of coping usually occur in a stressful situation. Even if the situation is viewed as challenging or beneficial, coping efforts may be required to develop and sustain the challenge—that is, to maintain the positive benefits of the challenge and to ward off any threats. In harmful or threatening situations, successful coping reduces or eliminates the source of stress and relieves the emotion it generated.

Appraisal and coping are affected by internal characteristics such as health, energy, personal belief systems, commitments or life goals, self-esteem, control, mastery, knowledge, problem-solving skills and social skills. The characteristics that have been studied in nursing research are health-promoting lifestyles and resilience (Neenan, 2009; Reich et al., 2010). A health-promoting lifestyle buffers the effect of stressors. From a nursing practice standpoint, this outcome—buffering the effect of stressors—supports nursing's goal of promoting health. In many circumstances, promoting a healthy lifestyle is more achievable than altering the stressors.

Resilience is the name given to a general quality that comes from having rich, varied and rewarding experiences. It is a personality characteristic composed of control, commitment and challenge. Resilient people perceive stressors as something they can change and, therefore, control. To them, potentially stressful situations are interesting and meaningful; change and new situations are viewed as challenging opportunities for growth. Researchers have found positive support for resilience as a significant variable that positively influences rehabilitation and overall improvement after a challenging or traumatic experience (Chen et al., 2011; Hahn et al., 2011; Herrman et al., 2011; Pierini & Stuifbergen, 2010).

CLINICAL REASONING CHALLENGE

A 50-year-old woman is diagnosed with osteoporosis after sustaining a rib fracture. The nurse is evaluating the coping style of the woman. What indications would the nurse note in her interactions and follow-up care for this patient that demonstrate that the woman uses problem-focused coping and emotion-focused coping?

Maladaptive responses to stress

The stress response, which, as indicated earlier, facilitates adaptation to threatening situations, has been retained from our evolutionary past. The 'fight-or-flight' response, for example, is an anticipatory response that mobilised the bodily resources of our ancestors to deal with predators and other harsh factors in their environment. This same mobilisation comes into play in response to emotional stimuli unrelated to danger. For example, a person may get an 'adrenaline rush' when competing over a decisive point in a ball game or when excited about attending a party.

When the responses to stress are ineffective, they are referred to as *maladaptive*. Maladaptive responses are chronic, recurrent responses or patterns of response over time that do not promote the goals of adaptation. The goals of adaptation are somatic or physical health (optimal wellness); psychological health or having a sense of well-being (happiness, satisfaction with life, morale); and enhanced social functioning, which includes work, social life and family (positive relationships). Maladaptive responses that threaten these goals include faulty appraisals and inappropriate coping (Lazarus, 1991).

The frequency, intensity and duration of stressful situations contribute to the development of negative emotions and subsequent patterns of neurochemical discharge. By appraising situations more adequately and coping more appropriately, it is possible to anticipate and defuse some of these situations. For example, frequent potentially stressful encounters (e.g. marital discord) might be avoided with better communication and problem solving, or a pattern of procrastination (e.g. delaying work on tasks) could be corrected to reduce stress when deadlines approach.

Coping processes that include the use of alcohol or drugs to reduce stress increase the risk of illness. Other inappropriate coping patterns may increase the risk of illness less directly. For example, people who demonstrate 'type A' personality behaviours such as impatience, competitiveness and achievement orientation and have an underlying hostile approach to life are more prone than others to develop stress-related illnesses. Type A behaviours increase the output of catecholamines, the adrenal–medullary hormones, with their attendant effects on the body.

Other forms of inappropriate coping include denial, avoidance and distancing. Denial may be illustrated by the woman who feels a lump in her breast but downplays its seriousness and delays seeking medical attention. The intent of denial is to control the threat, but it may also endanger life.

Models of illness frequently cite stress and maladaptation as precursors to disease. A general model of illness, based on Selye's theory, suggests that any stressor elicits a state of disturbed physiological equilibrium. If this state is prolonged or the response is excessive, it will increase the susceptibility of the person to illness. This susceptibility, coupled with a predisposition in the person (whether from genetic traits, health or age), leads to illness. If the sympathetic adrenal medullary response is prolonged or excessive, a state of chronic arousal develops that may lead to high blood pressure, arteriosclerotic changes and cardiovascular disease. If the production of the ACTH is prolonged or excessive, behaviour patterns of withdrawal and depression are seen. In addition, the immune response is decreased and infections and tumours may develop.

Selye (1976) proposed a list of disorders that he called diseases of maladaptation: high blood pressure; diseases of the heart and blood vessels; diseases of the kidney; hypertension of pregnancy; rheumatic and rheumatoid arthritis; inflammatory diseases of the skin and eyes; infections; allergic and hypersensitivity diseases; nervous and mental diseases; sexual problems; digestive diseases; metabolic diseases; and cancer. Research continues on the complex interconnections between stress, coping (adaptive and maladaptive) and disease (Bertoni et al., 2010; Kang et al., 2009; Rousseau et al., 2011; Rzucidlo & Campbell, 2009).

Indicators of stress

Indicators of stress and the stress response include both subjective and objective measures. Chart 6-1 lists signs and symptoms that may be observed directly or reported by the person. They are psychological, physiological or behavioural and reflect social behaviours and thought processes. Some of these reactions may be coping behaviours. Over time, each person tends to develop a characteristic pattern of behaviour during stress that is a warning that the system is out of balance.

Laboratory measurements of indicators of stress have helped in understanding this complex process. Among the measures, blood and urine analyses can be used to demonstrate changes in hormonal levels and hormonal breakdown products. Reliable measures of stress include blood levels of catecholamines, corticoids, ACTH and eosinophils. The serum creatine/creatinine ratio and elevations of cholesterol and free fatty acids can also be measured. When the body experiences distress, there are changes in adrenal hormones such as cortisol and aldosterone. As the levels of these chemicals increase, there is a simultaneous release of additional cholesterol into the general circulation. Both physical and psychological distress can trigger an elevated cholesterol level. In addition, the results of immunoglobulin assays are increased when a person is exposed to a variety of stressors, especially infections and immunodeficiency conditions. With greater attention to the field of neuroimmunology, improved laboratory measures are likely to follow.

In addition to using laboratory tests, researchers have developed questionnaires to identify and assess stressors, stress and coping strategies. The work of Rice (2011), a compilation of information gained from research on stress, coping, and health, includes some of these questionnaires.

Stress at the cellular level

Pathological processes may occur at all levels of the biological organism. If the cell is considered the smallest unit or subsystem (tissues being aggregates of cells, organs aggregates of tissues and so forth), the processes of health and disease or

CHART 6-1 ASSESSMENT

Assessing for stress

Be alert for the following signs and symptoms:

Physiological

Restlessness
Dryness of the throat and mouth
Unintentional weight loss or gain
Fatigue
Strong startle response
Gastrointestinal distress
Diarrhoea
Nausea or vomiting
Change in menstrual cycle
Change in appetite
Injury prone
Palpitations
Feeling weak or dizzy
Increased body tension
Tremors
Bruxism (grinding of teeth)
Difficulty sleeping
Excessive perspiration
Urinary frequency
Headaches
Pain in back, neck or other parts of the body

Psychological/behavioural

Depression
Overpowering urge to act out
Loss of interest in life activities
Intense periods of anxiety
Impulsive behaviours
Emotional lability
Concentration difficulties

Behavioural

Increased smoking
Excessive gambling
Substance use or abuse
Nervous habits
Nervous laughter
Hyperactivity

adaptation and maladaptation can all occur at the cellular level. Indeed, pathological processes are often described by scientists at the subcellular or molecular level.

The cell exists on a continuum of function and structure, ranging from the normal cell, to the adapted cell, to the injured or diseased cell, to the dead cell (see Fig. 6-3). Changes from one state to another may occur rapidly and may not be readily detectable, because each state does not have discrete boundaries, and disease represents an extension and distortion of normal processes. The earliest changes occur at the molecular or subcellular level and are not perceptible until homeostatic functions or structures are altered. With cell injury, some changes may be reversible; in other instances, the injuries are lethal. For example, tanning of the skin is an adaptive, morphological response to exposure to the rays of the sun. If the exposure is continued, however, sunburn and injury occur, and some cells may die, as evidenced by desquamation ('peeling').

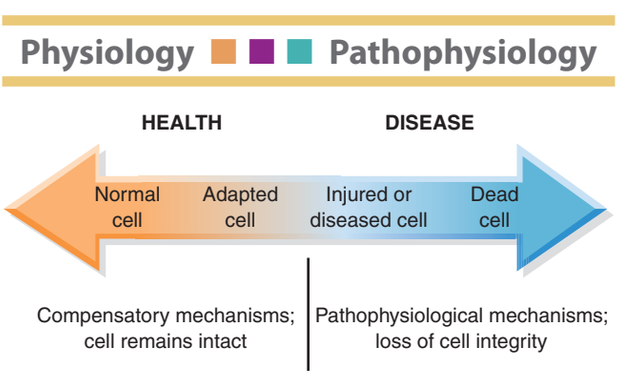

FIGURE 6-3 The cell on a continuum of function and structure. Changes in the cell are not as easily discerned as the diagram depicts. The point at which compensation subsides and pathophysiology begins is not clearly defined.

Different cells and tissues respond to stimuli with different patterns and rates of response; some cells are more vulnerable to one type of stimulus or stressor than others. The cell involved, its ability to adapt and its physiological state are determinants of the response. For example, cardiac muscle cells respond to **hypoxia** (inadequate oxygenation) more quickly than smooth muscle cells do.

Other determinants of cellular response are the type or nature of the stimulus, its duration and its severity. For example, neurons that control respiration can develop a tolerance to regular, small amounts of a barbiturate, but one large dose may result in respiratory depression and death.

Compensatory mechanisms and homeostasis

The concept of the cell as existing on a continuum of function and structure includes the relationship of the cell to compensatory mechanisms, which occur continuously in the body to maintain homeostasis. Compensatory processes are regulated primarily by the autonomic nervous system and the endocrine system, with control achieved through negative feedback.

Negative feedback

Negative feedback mechanisms throughout the body monitor the internal environment and restore homeostasis when conditions shift out of the normal range. These mechanisms work by sensing deviations from a predetermined set point or range of adaptability and triggering a response aimed at offsetting the deviation. Blood pressure, acid–base balance, blood glucose level, body temperature and fluid

and electrolyte balance are examples of functions regulated through such compensatory mechanisms.

Most of the human body's control systems are integrated by the brain and influenced by the nervous and endocrine systems. Control activities involve detecting deviations from the predetermined reference point and stimulating compensatory responses in the muscles and glands of the body. The major organs affected are the heart, lungs, kidneys, liver, gastrointestinal tract and skin. When stimulated, these organs alter their rate of activity or the amount of secretions they produce. They have been called the 'organs of homeostasis or adjustment' because of this (Grossman & Porth, 2014).

In addition to the responses controlled by the nervous and endocrine systems, local responses consisting of small feedback loops in a group of cells or tissues are possible. The cells detect a change in their immediate environment and initiate an action to counteract its effect. For example, the accumulation of lactic acid in an exercised muscle stimulates dilation of blood vessels in the area to increase blood flow and improve the delivery of oxygen and removal of waste products.

The net result of the activities of feedback loops is **homeostasis**. Homeostasis is achieved by the continuous, variable action of the organs involved in making the adjustments and by the continuous small exchanges of chemical substances among cells, interstitial fluid and blood. For example, an increase in the CO_2 concentration of the extracellular fluid leads to increased pulmonary ventilation, which decreases the CO_2 level. This change is detected by chemosensitive receptors in the respiratory control centre of the medulla of the brain. The chemoreceptors stimulate an increase in the rate of discharge of the neurons that innervate the diaphragm and intercostal muscles, which increases the rate of respiration. Excess CO_2 is exhaled, the hydrogen ion concentration returns to normal and the chemically sensitive neurons are no longer stimulated (Grossman & Porth, 2014).

Positive feedback

Another type of feedback, **positive feedback**, perpetuates the chain of events set in motion by the original disturbance instead of compensating for it. As the system becomes more unbalanced, disorder and disintegration occur. There are some exceptions to this pattern; blood clotting in humans, for example, is an important positive feedback mechanism.

Cellular adaptation

Cells are complex units that dynamically respond to the changing demands and stresses of daily life. They possess a maintenance function and a specialised function. The maintenance function refers to the activities that the cell must perform with respect to itself; specialised functions are those that the cell performs in relation to the tissues and organs of which it is a part. Individual cells may cease to function without posing a threat to the organism. As the number of dead cells increases, however, the specialised functions of the tissues are altered and the individual's health is threatened.

Cells can adapt to environmental stress through structural and functional changes. Some of these adaptations are hypertrophy, atrophy, hyperplasia, dysplasia and metaplasia (see Table 6-2).

These adaptations reflect changes in the normal cell in response to stress. If the stress is unrelenting, cellular injury and death may occur. Hypertrophy and atrophy lead to changes in the size of cells and hence the size of the organs they form. Compensatory hypertrophy is the result of an enlarged muscle mass and commonly occurs in skeletal and cardiac muscle that experiences a prolonged, increased workload. One example is the bulging muscles of the athlete who engages in bodybuilding.

Atrophy can be the consequence of a disease or of decreased use, decreased blood supply, loss of nerve supply

TABLE 6-2 Cellular adaptation to stressors

Adaptation	Stimulus	Example
Hypertrophy—increase in cell size leading to increase in organ size	Increased workload	Leg muscles of runner Arm muscles in tennis player Cardiac muscle in person with hypertension
Atrophy—shrinkage in size of cell, leading to decrease in organ size	Decrease in: Use Blood supply Nutrition Hormonal stimulation Innervation	Secondary sex organs in ageing person Extremity immobilised in plaster cast
Hyperplasia—increase in number of new cells (increase in mitosis)	Hormonal influence	Breast changes of a girl in puberty or of a pregnant woman Regeneration of liver cells New red blood cells in blood loss
Dysplasia—change in the appearance of cells after they have been subjected to chronic irritation	Reproduction of cells with resulting alteration of their size and shape	Alterations in epithelial cells of the skin or the cervix, producing irregular tissue changes that could be the precursors of a malignancy
Metaplasia—transformation of one adult cell type to another (reversible)	Stress applied to highly specialised cell	Changes in epithelial cells lining bronchi in response to smoke irritation (cells become less specialised)

or inadequate nutrition. Disuse of a body part is often associated with the ageing process. Cell size and organ size decrease; structures principally affected are the skeletal muscles, the secondary sex organs, the heart and the brain.

Hyperplasia is an increase in the number of new cells in an organ or tissue. As cells multiply and are subjected to increased stimulation, the tissue mass enlarges. It is a mitotic response (a change occurring with mitosis), but it is reversible when the stimulus is removed. This distinguishes it from neoplasia or malignant growth, which continues after the stimulus is removed. Hyperplasia may be hormonally induced. An example is the increase in the size of the thyroid gland caused by thyroid-stimulating hormone (secreted from the pituitary gland) when a deficit in thyroid hormone is detected.

Dysplasia is the change in the appearance of cells after they have been subjected to chronic irritation. Dysplastic cells have a tendency to become malignant; dysplasia is seen commonly in epithelial cells in the bronchi of smokers.

Metaplasia is a cell transformation in which a highly specialised cell changes to a less specialised cell. This serves a protective function, because the less specialised cell is more resistant to the stress that stimulated the change. For example, the ciliated columnar epithelium lining the bronchi of smokers is replaced by squamous epithelium. The squamous cells can survive; loss of the cilia and protective mucus, however, can have damaging consequences.

Cellular injury

Injury is defined as a disorder in homeostatic regulation. Any stressor that alters the ability of the cell or system to maintain optimal balance of its adjustment processes will lead to injury. Structural and functional damage then occurs, which may be reversible (permitting recovery) or irreversible (leading to disability or death). Homeostatic adjustments are concerned with the small changes within the body's systems. With adaptive changes, compensation occurs and homeostasis is achieved, although it may be at new levels. With injury, homeostatic regulation is lost and changes in functioning ensue.

Causes of disorder and injury in the system (cell, tissue, organ, body) may arise from the external or internal environment (see Fig. 6-4) and include hypoxia, nutritional imbalance, physical agents, chemical agents, infectious agents, immune mechanisms, genetic defects and psychogenic factors. The most common causes are hypoxia (oxygen deficiency), chemical injury and infectious agents. In addition, the presence of one injury makes the system more susceptible to another injury. For example, inadequate oxygenation and nutritional deficiencies make the system vulnerable to infection. These agents act at the cellular level by damaging or destroying:

- The integrity of the cell membrane, necessary for ionic balance.
- The ability of the cell to transform energy (aerobic respiration, production of adenosine triphosphate).
- The ability of the cell to synthesise enzymes and other necessary proteins.

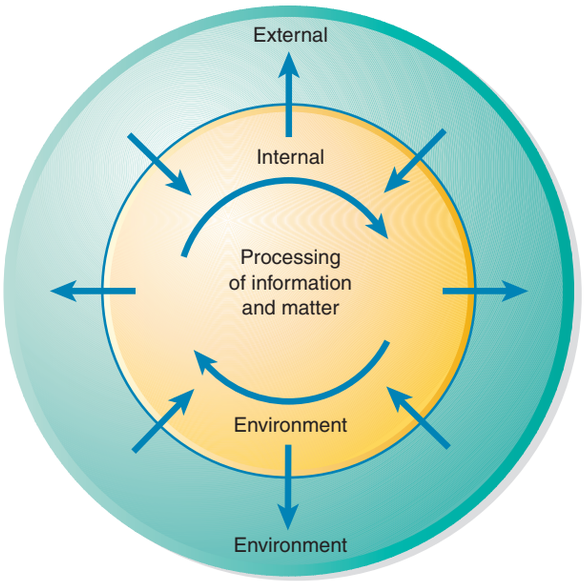

FIGURE 6-4 Influences leading to disorder may arise from the internal environment and the external environment of the system. Excesses or deficits of information and matter may occur, or there may be faulty regulation of processing.

- The ability of the cell to grow and reproduce (genetic integrity).

Hypoxia

Inadequate cellular oxygenation (hypoxia) interferes with the cell's ability to transform energy. Hypoxia may be caused by:

- A decrease in blood supply to an area.
- A decrease in the oxygen-carrying capacity of the blood (decreased haemoglobin).
- A ventilation/perfusion or respiratory problem that reduces the amount of oxygen available in the blood.
- A problem in the cell's enzyme system that makes it unable to use the oxygen delivered to it.

The usual cause is ischaemia, or deficient blood supply. Ischaemia is commonly seen in myocardial cell injury in which arterial blood flow is decreased because of atherosclerotic narrowing of blood vessels. Ischaemia also results from intravascular clots (thrombi or emboli) that may form and interfere with blood supply. Thrombi and emboli are common causes of brain attacks (strokes). The length of time different tissues can survive without oxygen varies. For example, brain cells may succumb in 3 to 6 minutes, depending on the situation. If the condition leading to hypoxia is slow and progressive, collateral circulation may develop, whereby blood is supplied by other blood vessels in the area. However, this mechanism is not highly reliable.

Nutritional imbalance

Nutritional imbalance refers to a relative or absolute deficiency or excess of one or more essential nutrients. This may be manifested as under-nutrition (inadequate intake of food)

or over-nutrition (excess food intake). Kilojoule excess to the point of obesity overloads cells in the body with lipids. Obesity places a strain on the body, as more energy is required to maintain the extra tissue. Obesity has been associated with the development of disease, especially pulmonary and cardiovascular disease.

Specific deficiencies arise when an essential nutrient is deficient or when there is an imbalance of nutrients. Protein deficiencies and avitaminosis (deficiency of vitamins) are typical examples. An energy deficit leading to cell injury can occur if there is insufficient glucose or insufficient oxygen to transform the glucose into energy. A lack of insulin, or the inability to use insulin, may also prevent glucose from entering the cell from the blood. This occurs in diabetes mellitus, a metabolic disorder that can lead to nutritional deficiency, as well as a host of short-term and long-term life-threatening complications.

Physical agents

Physical agents, including temperature extremes, radiation, electrical shock, mechanical trauma and chemical agents can cause injury to the cells or to the entire body. The duration of exposure and the intensity of the stressor determine the severity of damage.

Thermal extremes

When a person's temperature is elevated, hypermetabolism occurs and the respiratory rate, heart rate and basal metabolic rate all increase. With fever induced by infections, the hypothalamic thermostat may be reset at a higher temperature and then return to normal when the fever abates. The increase in body temperature is achieved through physiological mechanisms. Body temperatures greater than 41°C suggest hyperthermia, because the physiological function of the thermoregulatory centre breaks down and the temperature soars (Grossman & Porth, 2014). This physiological condition occurs in people with heat stroke. Eventually, the high temperature causes coagulation of cell proteins and the cells die. The body must be cooled rapidly to prevent brain damage. Extremes of low temperature, or cold, cause vasoconstriction. Blood flow becomes sluggish and clots form, leading to ischaemic damage in the involved tissues.

Radiation and electrical shock

Radiation is used for diagnosis and treatment of diseases. Ionising forms of radiation may cause injury by their destructive action. Radiation decreases the protective inflammatory response of the cell, creating a favourable environment for opportunistic infections. Electrical shock produces burns as a result of the heat generated when electrical current travels through the body. It may also abnormally stimulate nerves, leading, for example, to fibrillation of the heart.

Mechanical trauma

Mechanical trauma can result in wounds that disrupt the cells and tissues of the body. The severity of the wound, the amount of blood loss and the extent of nerve damage are significant factors in the outcome.

Chemical agents

Chemical injuries are caused by poisons, such as lye, which has a corrosive action on epithelial tissue, or by heavy metals, such as mercury, arsenic and lead, each with its own specific destructive action. Many other chemicals are toxic in specific amounts in certain people and in distinctive tissues. Excessive secretion of hydrochloric acid can damage the stomach lining; large amounts of glucose can cause osmotic shifts, affecting the fluid and electrolyte balance; and too much insulin can cause subnormal levels of glucose in the blood (hypoglycaemia) and can lead to coma.

Drugs, including prescribed medications, can also cause chemical poisoning. Some individuals are less tolerant of medications than others and manifest toxic reactions at the usual or customary dosages. Ageing tends to decrease tolerance to medications. Polypharmacy (taking many medications at one time) also occurs frequently in the ageing population and is a problem because of the unpredictable effects of the resulting medication interactions.

Alcohol (ethanol) is also a chemical irritant. In the body, alcohol is broken down into acetaldehyde, which has a direct toxic effect on liver cells that leads to a variety of liver abnormalities, including cirrhosis in susceptible individuals. Disordered liver cell function leads to complications in other organs of the body.

Infectious agents

Biological agents known to cause disease in humans are viruses, bacteria, rickettsiae, mycoplasmas, fungi, protozoa and nematodes. The severity of the infectious disease depends on the number of microorganisms entering the body, their virulence and the host's defences (e.g. health, age, immune defences).

Some bacteria, such as those that cause tetanus and diphtheria, produce exotoxins that circulate and create cell damage. Others, such as the gram-negative bacteria, produce endotoxins when they are killed. The tubercle bacillus induces an immune reaction.

Viruses, the smallest living organisms, survive as parasites of the living cells they invade. Viruses infect specific cells. Through a complex mechanism, they replicate within the cells, then invade other cells and continue to replicate. An immune response is mounted by the body to eliminate the viruses, and the cells harbouring the viruses can be injured in the process. Typically, an inflammatory response and immune reaction are the physiological responses of the body to viral infection.

Immunological diseases and disorders

The immune system is an exceedingly complex system. Its purpose is to defend the body from invasion by any foreign object or foreign cell type, such as cancerous cells. This is a homeostatic mechanism, but like other adjustment processes, it can become disordered and cell injury will occur. The immune response detects foreign bodies by distinguishing non–self-substances from self-substances, destroying the

non–self-entities. The entrance of an antigen (foreign substance) into the body evokes the production of antibodies that attack and destroy the antigen (antigen–antibody reaction).

The immune system can be hypoactive or hyperactive. When it is hypoactive, immunodeficiency diseases occur; when it is hyperactive, hypersensitivity disorders arise. A disorder of the immune system itself can result in damage to the body's own tissues. Such disorders are labelled autoimmune diseases (see Unit 11).

Genetic disorders

Genetic defects as causes of disease and their effects on genetic structure are of intense research interest. Many of these defects produce mutations that have no recognisable effect, such as lack of a single enzyme; others contribute to more obvious congenital abnormalities, such as Down syndrome. As a result of the Human Genome Project, patients can be genetically assessed for conditions such as sickle-cell disease, cystic fibrosis, haemophilia A and B, breast cancer, obesity, cardiovascular disease, phenylketonuria and Alzheimer's disease. The availability of genetic information and technology enables healthcare providers to perform screening, testing and counselling for patients with genetic concerns. Knowledge obtained from the Human Genome Project has also created opportunities for assessing a person's genetic profile and preventing or treating disease. Diagnostic genetics and gene therapy have the potential to identify and modify a gene before it begins to express traits that would lead to disease or disability. (For further information, see Chapter 5.)

Cellular response to injury: Inflammation

Cells or tissues of the body may be injured or killed by any of the agents (physical, chemical, infectious) described earlier. When this happens, an inflammatory response (or inflammation) naturally occurs in the healthy tissues adjacent to the site of injury. **Inflammation** is a defensive reaction intended to neutralise, control or eliminate the offending agent and to prepare the site for repair. It is a non-specific response (not dependent on a particular cause) that is meant to serve a protective function. For example, inflammation may be observed at the site of a bee sting, in a sore throat, in a surgical incision and at a burn site.

Inflammation also occurs in cell injury events, such as strokes and myocardial infarctions.

Inflammation is not the same as infection. An infectious agent is only one of several agents that may trigger an inflammatory response. An infection exists when the infectious agent is living, growing and multiplying in the tissues and is able to overcome the body's normal defences.

Regardless of the cause, a general sequence of events occurs in the local inflammatory response. This sequence involves changes in the microcirculation, including vasodilation, increased vascular permeability and leucocytic cellular infiltration (see Fig. 6-5). As these changes take place, five cardinal signs of inflammation are produced: redness, heat, swelling, pain and loss of function.

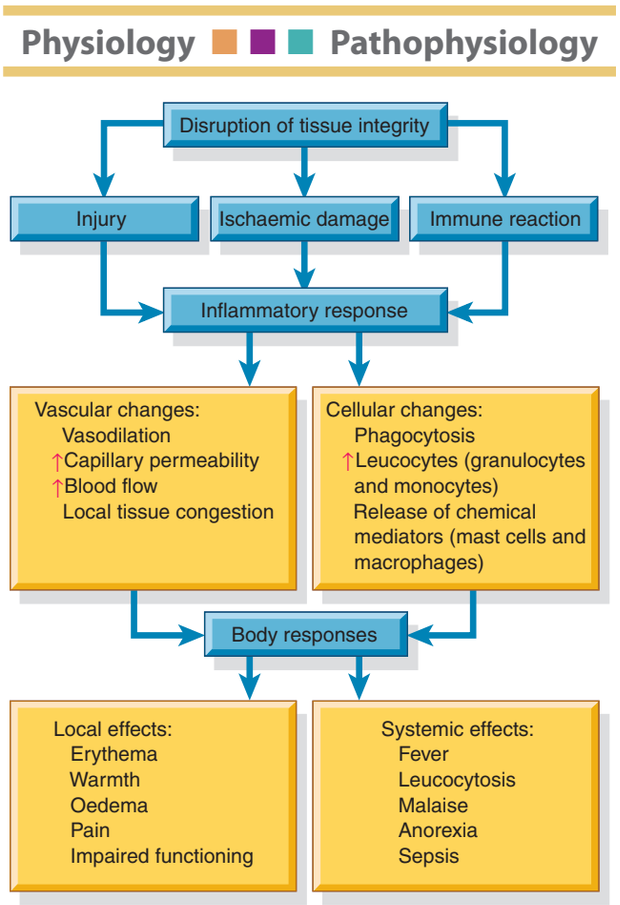

FIGURE 6-5 Inflammatory response.

The transient vasoconstriction that occurs immediately after injury is followed by vasodilation and an increased rate of blood flow through the microcirculation. Local heat and redness result. Next, vascular permeability increases, and plasma fluids (including proteins and solutes) leak into the inflamed tissues, producing swelling. The pain produced is attributed to the pressure of fluids or swelling on nerve endings and to the irritation of nerve endings by chemical mediators released at the site. Bradykinin is one of the chemical mediators suspected of causing pain. Loss of function is most likely related to the pain and swelling, but the exact mechanism is not completely known.

As blood flow increases and fluid leaks into the surrounding tissues, the formed elements (red blood cells, white blood cells and platelets) remain in the blood, causing it to become more viscous. Leucocytes (white blood cells) collect in the vessels, exit and migrate to the site of injury to engulf offending organisms and to remove cellular debris in a process called phagocytosis. Fibrinogen in the leaked plasma fluid coagulates, forming fibrin for clot formation, which serves to wall off the injured area and prevent the spread of infection.

Chemical mediators of inflammation

Injury initiates the inflammatory response, but chemical substances released at the site induce the vascular changes.

Foremost among these chemicals are histamine and the kinins. Histamine is present in many tissues of the body but is concentrated in the mast cells. It is released when injury occurs and is responsible for the early changes in vasodilation and vascular permeability. Kinins increase vasodilation and vascular permeability; they also attract neutrophils to the area. Prostaglandins, another group of chemical substances, are also suspected of causing increased permeability (Grossman & Porth, 2014).

Systemic response to inflammation

The inflammatory response is often confined to the site, causing only local signs and symptoms. However, systemic responses can also occur. Fever is the most common sign of a systemic response to injury, and it is most likely caused by endogenous pyrogens (internal substances that cause fever) released from neutrophils and macrophages (specialised forms of leucocytes). These substances reset the hypothalamic thermostat, which controls body temperature and produces fever. Leucocytosis, an increase in the synthesis and release of neutrophils from bone marrow, may occur to provide the body with greater ability to fight infection. During this process, general, non-specific symptoms develop, including malaise, loss of appetite, aching and weakness.

Types of inflammation

Inflammation, acute, subacute or chronic, is categorised primarily by its duration and the type of exudate produced. Acute inflammation is characterised by the local vascular and exudative changes described earlier and usually lasts less than 2 weeks. An acute inflammatory response is immediate and serves a protective function. After the injurious agent is removed, the inflammation subsides and healing takes place with the return of normal or near-normal structure and function.

Chronic inflammation develops if the injurious agent persists and the acute response is perpetuated. Symptoms are present for many months or years. Chronic inflammation may also begin insidiously and never have an acute phase. The chronic response does not serve a beneficial and protective function; on the contrary, it is debilitating and can produce long-lasting effects. As the inflammation becomes chronic, changes occur at the site of injury and the nature of the exudate becomes proliferative. A cycle of cellular infiltration, necrosis and fibrosis begins, with repair and breakdown occurring simultaneously. Considerable scarring may occur, resulting in permanent tissue damage.

Subacute inflammation falls between acute and chronic inflammation. It includes elements of the active exudative phase of the acute response as well as elements of repair, as in the chronic phase. The term subacute inflammation is not widely used.

Cellular healing

The reparative process begins at approximately the same time as the injury and is interwoven with inflammation. Healing proceeds after the inflammatory debris has been removed. Healing may occur by regeneration, in which gradual repair of the defect occurs by proliferation of cells of the same type as those destroyed, or by replacement, in which cells of another type, usually connective tissue, fill in the tissue defect and result in scar formation.

Regeneration

The ability of cells to regenerate depends on whether they are labile, permanent or stable. Labile cells multiply constantly to replace cells worn out by normal physiological processes; these include epithelial cells of the skin and those lining the gastrointestinal tract. Permanent cells include neurons—the nerve cell bodies, not their axons. Destruction of a neuron is a permanent loss but axons may regenerate. If normal activity is to return, tissue regeneration must occur in a functional pattern, especially in the growth of several axons. Stable cells have a latent ability to regenerate. Under normal physiological processes, they are not shed and do not need replacement, but if they are damaged or destroyed, they are able to regenerate. These cells include functional cells of the kidney, liver and pancreas. Cells in other organs, such as the brain, for example, do not regenerate.

Replacement

The condition of the host, the environment and the nature and severity of the injury affect the processes of inflammation, repair and replacement. Depending on the extent of damage, tissue healing may occur by first-, second- or third-intention healing. In first (primary)-intention healing, the wound edges are approximated, as in a surgical wound. Little scar formation occurs and the wound healing occurs without granulation. In second (secondary)-intention healing, the edges are not approximated and the wound fills with granulation tissue. The process of repair takes longer and may result in scar formation, with loss of specialised function. For example, people who have recovered from myocardial infarction have abnormal electrocardiographic tracings because the electrical signal cannot be conducted through the connective tissue that has replaced the infarcted area. In third-intention healing, the wound edges are not approximated and healing is delayed. For more information about wound healing, see Chapter 15.

Nursing management

Nursing implications

Stress or the potential for stress is ubiquitous—that is, it is both everywhere and anywhere. Anxiety, frustration, anger and feelings of inadequacy, helplessness or powerlessness are emotions often associated with stress. In the presence of these emotions, the customary activities of daily living may be disrupted—for example, a sleep disturbance may occur, eating and activity patterns may be altered and family processes or role performance may be disrupted.

It is important for the nurse to realise that the optimal point of intervention to promote health is during the stage

when the individual's own compensatory processes are still functioning. Early identification of both physiological and psychological stressors remains a major role of the nurse, and information on the interrelationships between physical and emotional health can be found in research journals. The nurses should be able to relate the presenting signs and symptoms of distress to the physiology they represent and identify the individual's position on the continuum of function, from health and compensation to pathophysiology and disease.

For example, if an anxious middle-aged woman presented for a checkup and was found to be overweight, with a blood pressure of 150/85 mmHg, the nurse would provide education on diet, stress management and activity. The nurse would also encourage weight loss and discuss the woman's intake of salt (which affects fluid balance) and caffeine (which provides a stimulant effect). The patient and the nurse would identify both individual and environmental stressors and discuss strategies to decrease the lifestyle stress, with the ultimate goal being to facilitate a healthier lifestyle prevent hypertension and its sequelae.

In the assessment of people who seek healthcare, both objective signs and subjective symptoms are the primary indicators of existing physiological processes. The following questions are addressed:

- Are the heart rate, respiratory rate and temperature normal?
- What emotional distress may be contributing to the patient's health problems?
- Are there other indicators of steady-state deviation?
- What are the patient's blood pressure, height and weight?
- Are there any problems in movement or sensation?
- Are there any problems with affect, behaviour, speech, cognitive ability, orientation or memory?
- Are there obvious impairments, lesions or deformities?

Objective evidence can be obtained from laboratory data, such as electrolytes, blood urea nitrogen, blood glucose and urinalysis results. Further signs of injury are seen in diagnostic studies such as computed tomography, magnetic resonance imaging and positron emission tomography. Further information on diagnostic evaluation can be found in assessment chapters of each unit of this book. Many nursing diagnoses are possible for patients suffering from stress. One nursing diagnosis related to stress is anxiety, which is defined as a vague, uneasy feeling, the source of which may be nonspecific or not known to the person. Stress may also be manifested as ineffective coping patterns, impaired thought processes or disrupted relationships. These human responses are reflected in the nursing diagnoses of anxiety, ineffective coping, defensive coping and ineffective denial, all of which indicate poor adaptive responses (Herdman, 2012). Other possible nursing diagnoses include social isolation, risk of spiritual distress, readiness for enhanced family processes, decisional conflict, risk of compromised resilience, impaired individual resilience, readiness for enhanced resilience and risk of powerlessness, among others. Because human responses to stress are varied, as are the sources of stress, arriving at an accurate diagnosis allows interventions and goals to be more specific and leads to improved outcomes.

Stress management is directed towards reducing and controlling stress and improving coping. The need to prevent illness, improve the quality of life and decrease the cost of healthcare makes efforts to promote health essential, and stress control is a significant health promotion goal. Stress reduction methods and coping enhancements can derive from either internal or external sources. For example, healthy eating habits and relaxation techniques are internal resources that help to reduce stress, and a broad social network is an external resource that helps to reduce stress. Goods and services that can be purchased are also external resources for stress management. It may be easier for people with adequate financial resources to cope with constraints in the environment, because their sense of vulnerability to threat is decreased compared to those without adequate financial resources.

Promoting a healthy lifestyle

A health-promoting lifestyle provides these resources and buffers or cushions the impact of stressors. Lifestyles or habits that contribute to the risk of illness can be identified through a health risk appraisal, an assessment method that is designed to promote health by examining an individual's personal habits and recommending changes when a health risk is identified.

Health risk appraisals involve the use of questionnaires to estimate the likelihood that a person with a given set of characteristics will become ill. It is hoped that if people are provided with this information, they will adopt healthy behaviours (e.g. stop smoking, have periodic screening examinations) to improve their health. Questionnaires typically address the information presented in Chart 6-2.

The personal information is compared with average population risk data, and the risk factors are identified and weighted. From this analysis, the person's risks and major health hazards are identified. Further comparisons with population data can estimate how many years will be added to the person's life span if the suggested changes are made.

CHART 6-2 HEALTH PROMOTION

Information addressed in health risk questionnaires

Demographic data: Age, gender, race, ethnic background
Personal and family history of diseases and health problems
Lifestyle choices:
- Eating, sleeping, exercise, smoking, drinking, sexual activity and driving habits
- Stressors at home and on the job
- Role relationships and associated stressors

Physical measurements:
- Blood pressure
- Height, weight, body mass index
- Laboratory analyses of blood and urine

Participation in high-risk behaviours

CHART 6-3 PATIENT EDUCATION

Coping enhancement: Nursing interventions

Definition

Assisting a patient to adapt to perceived stressors, changes or threats that interfere with meeting life's demands and roles.

Selected activities

Use a calm, reassuring approach and provide an atmosphere of acceptance for patients and families.
Assist the patient and the family in developing an objective appraisal of the event.
Provide factual information concerning diagnosis, treatment and prognosis as needed.
Encourage an attitude of realistic hope as a way of dealing with feelings of helplessness.
Acknowledge the patient's spiritual/cultural background and encourage the use of spiritual resources if desired.
Foster constructive methods of dealing with life problems for patients and families.
Assist the patient and family to identify appropriate short- and long-term goals.
Appraise the needs and desires for social support and assist the patient and family to identify available support systems.
Assist the patient to identify positive strategies to deal with limitations, manage needed lifestyle or role changes and work through the losses of chronic illness and/or disability if appropriate.

Adapted from Bulechek, G., Butcher, H., Dochterman, J., & Wagner, C. (Eds.). (2013). *Nursing interventions classification (NIC)* (6th ed.). St Louis, MO: Mosby.

However, research so far has not demonstrated that providing people with such information ensures that they will change their habits. The single most important factor for determining health status is social class, and within a social class the research suggests that the major factor influencing health is level of education (Bastable et al., 2012).

Enhancing coping strategies

Bulechek and colleagues (2013) identified 'coping enhancement' as a nursing intervention as it assists the patient to adapt to perceived stressors, changes or threats that interfere with meeting the demands and roles of day-to-day living (see Chart 6-3). The nurse can build on the patient's existing coping strategies, as identified in the health appraisal, or teach new strategies for coping if necessary.

Teaching relaxation techniques

Relaxation techniques are a major method used to relieve stress. Commonly used techniques include progressive muscle relaxation and relaxation with guided imagery. The goal of relaxation training is to produce a response that counters the stress response. When this goal is achieved, the action of the hypothalamus adjusts and decreases the activity of the sympathetic and parasympathetic nervous systems. The sequence of physiological effects and their signs and symptoms are interrupted and psychological stress is reduced. This is a learned response and requires practice to achieve.

The different relaxation techniques share four similar elements: (1) a quiet environment, (2) a comfortable position, (3) a passive attitude and (4) a mental device (something on which to focus the attention, such as a word, phrase or sound).

Progressive muscle relaxation

Progressive muscle relaxation involves tensing and releasing the muscles of the body in sequence and sensing the difference in feeling. It is best if the person lies on a soft cushion on the floor, in a quiet room, breathing easily. Someone usually reads the instructions in a low tone and with a slow and relaxed manner, or a tape of the instructions may be played. The person tenses the muscles in the whole body (one muscle group at a time), holds, senses the tension and then relaxes. As each muscle group is tensed, the person keeps the rest of the body relaxed. Each time the focus is on feeling the tension and relaxation. When the exercise is completed, the whole body should be relaxed (Benson, 1993; Benson & Stark, 1996).

Relaxation with guided imagery

Simple **guided imagery** is the mindful use of a word phrase or visual image for the purpose of distracting oneself from distressing situations or consciously taking time to relax or re-energise. The nurse helps the person to select a pleasant scene or experience, such as watching the ocean or dabbling the feet in a cool stream. This image serves as the mental device in this technique. As the person sits comfortably and quietly, the nurse guides the individual to review the scene, trying to feel and relive the imagery with all of the senses. A tape recording may be made of the description of the image, or commercial tape recordings for guided imagery and relaxation can be used.

Other relaxation techniques include meditation, breathing techniques, massage, Reiki, music therapy, biofeedback and the use of humour.

Educating about stress management

Two commonly prescribed nursing educational interventions—providing sensory information and providing procedural information (e.g. preoperative teaching)—have the goal of reducing stress and improving the patient's coping ability. This preparatory education includes giving structured content, such as a lesson in childbirth preparation to expectant parents, a review of cardiovascular anatomy to the cardiac patient or a description of sensations the patient will experience during cardiac catheterisation. These techniques may alter the person–environment relationship such that something that

might have been viewed as harmful or a threat will now be perceived more positively. Giving patients information also reduces the emotional response so that they can concentrate and solve problems more effectively (Eggenberger & Nelms, 2007; Kasper et al., 2006; Miller & Stoeckel, 2011).

Promoting family health

In addition to individual concepts of homeostasis, stress, adaptation and health problems associated with maladaptation, the concept of family is also important. Nurses can intervene with both individuals and families to reduce stress and its health-related effects. The **family** plays a central role in the life of the patient and is a major part of the context of the patient's life. It is within families that people grow, are nurtured, acquire a sense of self, develop beliefs and values about life and progress through life's developmental stages. Families are also the first source for socialisation and teaching about health and illness.

Ideally, the healthcare team conducts a careful and comprehensive family assessment (including coping style), develops interventions tailored to handle the stressors, implements the specified treatment protocols and facilitates the construction of social support systems. The use of existing family strengths, resources and education is augmented by therapeutic family interventions. The primary goals of the nurse are to maintain and improve the patient's present level of health and to prevent physical and emotional deterioration. Next, the nurse intervenes in the cycle that the illness creates: patient illness, stress for other family members, new illness in other family members and additional patient stress.

Helping the family members manage the myriad stressors that bombard them daily involves working with family members to develop coping skills. Seven traits that enhance coping of family members under stress have been identified (Burr et al., 1994). Communication skills and spirituality were frequently useful traits. Cognitive abilities, emotional strengths, relationship capabilities, willingness to use community resources and individual strengths and talents were also associated with effective coping. As nurses work with families, they must not underestimate the impact of their therapeutic interactions, educational information, positive role modelling, provision of direct care and education on promoting health. Maladaptive coping may result if healthcare team members are not perceived as actively supporting family members. Often, denial and blaming of others occur. Sometimes, physiologic illness, emotional withdrawal and physical distancing are the results of severe family conflict, violent behaviour or addiction to drugs and alcohol. Substance abuse may develop in family members who feel unable to cope or solve problems. People may engage in these dysfunctional behaviours when faced with difficult or problematic situations.

Enhancing social support

The nature of social support and its influence on coping have been studied extensively. Social support has been demonstrated to be an effective moderator of life stress. Such support has been found to provide people with several different types of emotional information (Maisel & Gable, 2010). The first type of information leads people to believe that they are cared for and loved. This emotional support appears most often in a relationship between two people in which mutual trust and attachment are expressed by helping one another meet their emotional needs. The second type of information leads people to believe that they are esteemed and valued. This is most effective when there is recognition demonstrating a person's favourable position in the group. Known as esteem support, this elevates the person's sense of self-worth. The third type of information leads people to feel that they belong to a network of communication and mutual obligation. Members of this network share information and make goods and services available to the members as needed.

Social support also facilitates a person's coping behaviours; however, this depends on the nature of the social support. People can have extensive relationships and interact frequently; however, the necessary support comes only when there is a deep level of involvement and concern, not when people merely touch the surface of each other's lives. The critical qualities within a social network are the exchange of intimate communications and the presence of solidarity and trust.

Emotional support from family and significant others provides love and a sense of sharing the burden. The emotions that accompany stress are unpleasant and often increase in a spiralling fashion if relief is not provided. Being able to talk with someone and express feelings openly may help a person gain mastery of the situation. Nurses can provide this support, but it is important to identify the person's social support system and encourage its use. People who are 'loners', who are isolated or who withdraw in times of stress have a high risk of coping failure.

Because anxiety can also distort a person's ability to process information, it helps to seek information and advice from others who can assist with analysing the threat and developing a strategy to manage it. Again, this use of others helps people to maintain mastery of a situation and self-esteem.

Thus, social networks assist with management of stress by providing people with:

- A positive social identity
- Emotional support
- Material aid and tangible services
- Access to information
- Access to new social contacts and new social roles.

Recommending support and therapy groups

Support groups exist especially for people in similar stressful situations. Groups have been formed by parents of children with leukaemia; people who had undergone ostomies; mastectomy patients; and those with other kinds of cancer or other serious diseases, chronic illnesses and disabilities. There are groups for single parents, substance abusers and their family members and victims of child abuse. Professional, civic

and religious support groups are active in many communities. There are also encounter groups, assertiveness training programs and consciousness-raising groups to help people modify their usual behaviours in their transactions with their environment. Being a member of a group with similar problems or goals has a releasing effect on a person who promotes freedom of expression and exchange of ideas.

The role of stress in health patterns

As noted previously, a person's psychological and biological health, internal and external sources of stress management and relationships with the environment are predictors of health outcomes. These factors are directly related to the person's health patterns. The nurse has a significant role and responsibility in identifying the health patterns of patients receiving care as well as those of their families. If those patterns are not achieving physiological, psychological and social balance, the nurse is obligated, with the assistance and agreement of the patient, to seek ways to promote individual and family balance.

Although this chapter has presented some physiological mechanisms and perspectives on health and disease, the way that one copes with stress, the way that one relates to others and the values and goals held are also interwoven into those physiological patterns. To evaluate a patient's health patterns and to intervene if a disorder exists require a total assessment of the person. Specific disorders and their nursing management are addressed in greater depth in other chapters.

CLINICAL REASONING EXERCISES

1. ebp A patient experiences burns to the upper extremities after being involved in a kitchen fire. Describe the manner in which homeostasis has been disrupted and the compensatory mechanisms that are evident. How does the patient's medical treatment support the body's compensatory mechanisms? Determine the evidence-based nursing interventions that are appropriate for promoting the healing process.
2. ebp A 70-year-old woman recently moved to a retirement community where she lives independently. A nurse practitioner assesses this patient's health promotion needs. The family's health history reveals that her mother had type 2 diabetes and thyroid disease and that her father had hypertension and coronary artery disease. This patient has limited resources and support networks for making necessary lifestyle changes. What evidence exists to support the nurse practitioner's initiating strategies to promote a healthy lifestyle? What is the evidence that supports intervention to limit or prevent maladaptive responses from occurring with this woman? Describe the strength of the evidence regarding the effectiveness of lifestyle changes in promoting health in older adults.
3. pg A 78-year-old man recently moved to a retirement community where he lives semi-independently. The family health history reveals that his mother had diabetes and thyroid disease, and his father had hypertension and coronary artery disease. This patient has limited resources and support networks for making necessary lifestyle changes. Identify the priorities, approach and techniques that you would use to assess this patient's health promotion needs.

ONLINE RESOURCES

For an extensive range of additional resources to enhance teaching and learning and to facilitate understanding of this chapter, please see the text's accompanying website located on thePoint® at http://thepoint.lww.com.

REFERENCES

Bastable, S., Gramet, P., Jacobs, K., & Sopczyk D. (2012). Health professional as educator: Principles of teaching and learning. Sudbury, MA: Jones & Bartlett.

Benson, H. (1993). The relaxation response. In Goleman, D., & Gurin, J. (Eds)., *Mind-body medicine: How to use your mind for better health.* Yonkers, NY: Consumer Reports Books.

Benson, H., & Stark, M. (1996). *Timeless healing*. New York, NY: Scribner.

Bertoni, A. G., Burke, G. L., Owusu, J. A., Carnethon, M. R., Vaidya, D., Barr, R. G.,… Rotter, J. I. (2010). Inflammation and the incidence of type 2 diabetes: The Multi-Ethnic Study of Atherosclerosis (MESA). *Diabetes Care, 33*(4), 804–810.

Bulechek, G., Butcher, H., Dochterman, J., & Wagner, C. (Eds.). (2013). *Nursing interventions classification (NIC)* (6th ed.). St Louis, MO: Mosby.

Burr, W. R., Klein, S. R., Burr, R. G., Doxey, C., Harker, B., & Holman, T. B. (1994). *Reexamining family stress: New theory and research.* Thousand Oaks, CA: Sage.

Chen, W. T., Shiu, C. S., Simoni, J. M., Zhao, H, Bao, M. J, & Lu, H. (2011). In sickness and in health: A qualitative study of how Chinese women with HIV navigate stigma and negotiate disclosure within their marriages/partnerships. *AIDS Care, 23*(Suppl. 1), 120–125.

Dilworth-Anderson, P., Boswell, G., & Cohen, M. (2007). Spiritual and religious coping values and beliefs among African American caregivers: A qualitative study. *Journal of Applied Gerontology, 26*(4), 355–369.

Dow, H. D. (2011). An overview of stressors faced by immigrants and refugees: A guide for mental health practitioners. *Home Health Care Management & Practice, 23*(3), 210–217.

Eggenberger, S. & Nelms, T. (2007). Being family: The family experience when an adult member is hospitalized with a critical illness. *Journal of Clinical Nursing,* 16(9), 1618–1628.

Grossman, S., & Porth, C. (2014). *Pathophysiology: Concepts of altered health states* (9th ed.). Philadelphia, PA: Lippincott Williams & Wilkins.

Hahn, E. A., Cichy, K. E., Almeida, D. M., Haley, W. E. (2011). Time use and wellbeing in older widows: Adaptation and resilience. *Journal of Women and Aging, 23*(2), 149–159.

Herdman, T. H. (2012). *NANDA International nursing diagnoses: Definitions and classification 2012–2014.* Oxford: Wiley-Blackwell.

Herrman, H., Stewart, D. E., Diaz-Granados, N., Berger, E. L., Jackson, B., & Yuen, T. (2011). What is reliance? *Canadian Journal of Psychiatry, 56*(5), 258–264.

Kang, D. H., Weaver, M. T., Park, N. J., Smith, B., McArdle, T, Carpenter, J. (2009). Significant impairment in immune recovery after cancer treatment. *Nursing Research, 58*(2), 105–114.

Kasper, J., Köpke, S., Mühlhauser, I., & Heesen, C. (2006). Evidence-based patient information about treatment of multiple sclerosis—a phase one study on comprehension and emotional responses. *Patient Education & Counselling,* 62(1), 56–63.

Kroemeke, A. (2015). Depressive symptom trajectories over a 6-year period following myocardial infarction: Predictive function of cognitive appraisal and coping. *Journal of Behavioral Medicine,* 1–11.

Krucoff, C. (2007). Mind/body. Active coping for chronic pain: Simple steps to make the shift from patient to person. *Alternative Medicine Magazine, 8*(1), 37–38.

Lazarus, R. S. (1991). *Emotion and adaptation*. New York, NY: Oxford University Press.
Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal and coping*. New York, NY: Springer Publishing Co.
Mair, C. A., Cutchin, M. P., & Kristen Peek, M. (2011). Allostatic load in an environmental riskscape: The role of stress and gender. *Health & Place, 17*(4), 978–987.
Maisel, N. C., & Gable, S. L. (2010). The paradox of received social support: The importance of responsiveness. *Psychological Science, 20*(8), 928–932.
Miller, M. A., & Stoeckel, P. R. (2011). *Client education: Theory and practice*. Sudbury, MA: Jones & Bartlett.
Neenan, M. (2009). Developing resilience: A cognitive behavioral approach. New York, NY: Routledge.
Pierce, P. F, Lewandowski-Romps, L., & Silverschanz, P. (2011). War-related stressors as predictors of post-deployment health of Air Force women. *Women's Health Issues, 21*(4), S152–S159.
Pierini, D., & Stuifbergen, A. K. (2010). Psychological resilience and depressive symptoms in older adults diagnosed with post-polio syndrome. *Rehabilitation Nursing, 35*(4), 167–175.
Reich, J. W., Zautra, A. J., & Hall, J. S. (2010). *Handbook of adult resilience*. New York, NY: Guilford Press.
Rice, V. H. (Ed.). (2011). *Handbook of stress, coping, and health: Implications for theory, research, and practice* (2nd ed.). Bern, Germany: Huber.
Rousseau, C., Hassan, G., Moreau, N., Thombs BD. (2011). Perceived discrimination and its association with psychological distress among newly arrived immigrants before and after September 11, 2001. *American Journal of Public Health, 101*(5), 909–915.
Rzucidlo, S. E., & Campbell, M. (2009). Beyond the physical injuries: Parent and child coping with medical traumatic stress after pediatric trauma. *Journal of Trauma Nursing, 16*(3), 130–135.
Selye, H. (1976). *The stress of life*. (Rev. ed.). New York, NY: McGraw-Hill.
Thoma, A. G. (2011). Immune system impairment in response to chronic anxiety. *Integrative Medicine, 10*(1), 20–24.
Verhaeghe, S., van Zuuren, F., Defloor, T., Duijnstee, M. S., & Grypdonck, M. H. (2007). How does information influence hope in family members of traumatic coma patients in intensive care unit? *Journal of Clinical Nursing, 16*(8), 1488–1497.
Wells-Di Gregorio, S., Carpenter, K. M., Dorfman, C. S., Yang, H. C., Simonelli, L. E., & Carson, W. E., 3rd. (2012). Impact of breast cancer recurrence and cancer-specific stress on spouse health and immune function. *Brain, behavior, and immunity, 26*(2), 228–233.
Weston, D. (2010). The pathogenesis of infection and immune response. *British Journal of Nursing, 19*(16), S4–S11.

RESOURCES

Australian Psychological Society -Stress and well being: www.psychology.org.au/public/topics/stress-and-wellbeing/
Beyondblue Depression, Anxiety: www.beyondblue.org.au
Centre for Stress Management: www.managingstress.com/articles/definition.htm
Inflammation—The Key to Chronic Disease: www.womentowomen.com/inflammation/default.aspx
Institute of HeartMath: www.heartmath.org
The Psychology of Stress: www.guidetopsychology.com/stress.htm
Stress: The Silent Killer: http://holisticonline.com/stress/stress_GAS.htm