EFFECTS OF WEATHER ON MAN

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Man lives in an ever-changing environment which is partly beyond and partly under his control. He cannot wholly escape the variations in heat and cold, air movement, barometric pressure, humidity, dryness, light intensity, and electric potential of the atmosphere in which he lives; but he can modify the effects of some of them by clothing, shelter, regulation of humidity and temperature and other artificial measures. What he cannot change he must adjust to; or, failing this, he must suffer the consequences of malfunction, ill health.

The house in which he lives; the location in which it is placed; the food that he eats; his economic, social and cultural status; and his happiness and psychical states are all subject to modification and, in part, to direction by his own will. These factors modify his reaction to meteorologic and cosmic forces.

The atmospheric forces which surround him are subject to rhythmic changes such as those of day and night, and those which accompany the seasons, which are evident to any one who gives the matter the slightest thought. Aside from these, however, there are rhythmic changes which show cycles of years, such as the sun spot cycle which averages about eleven to twelve years from maximum to maximum but which has varied from about nine to seventeen years in the past century. The factor which is predominant in determining the length of this cycle is believed to be the time required for the revolution of Jupiter around the sun. This occupies an average of 12.86 years. Other planets and forces acting in conjunction with Jupiter tend to lengthen or shorten the cycle. Other cycles of still longer intervals are also recognized by scientists. These various cycles produce cumulative effects which influence man in an extraordinary manner at these particular times. In recent years we have begun to appreciate the steadily increasing effects which are produced on man by polar and tropical storms which represent an exaggeration of the regular forces in atmospheric environment. When these are severe they put an unusual strain upon the adaptive mechanism of the individual.

The human body is a receptor mechanism upon which all such forces play. The effect which they produce varies with their intensity and with the stability of the individual. As they are received by the organism they may be transformed into useful stimuli which improve function, or harmful stimuli which cause dysfunction and illness. The intensity of these forces is not perceived by us. They are always present so we consider them as a part of our natural environment and give little thought to the manner in which they influence our lives. Aside from the heat, cold, humidity, dryness and wind movement, we scarcely perceive their effects at all, yet they exert mighty influences and are capable of stimulating the organism to a degree of maximum efficiency; or, of doing vast harm, especially to the unstable individual whose physiologic balance is such that it fails to maintain equilibrium.

These forces, as they impinge upon the body, are picked up by sensory nerves which are distributed throughout the superficial tissues. They are

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transmitted centralward, then conveyed throughout the body over the network of the vegetative nervous system; and, through its integrative effects and through its action upon the endocrine glands, the cells and the body electrolytes they modify metabolic activity either to man's benefit or to his detriment. Meteorologic forces which are of sufficient strength to produce effects upon the individual do so by changing the body's oxidation rate, either increasing or decreasing it. The effect produced differs with the nature and strength of the force, and the condition of the individual at the time he is influenced by it. For example, in the temperate zone, cold is a strong stimulus which often overtaxes the reacting powers of the weak. Cold is absent from the tropics, where a monotony of temperature exists, which is accompanied by a slowness of oxidation and sluggishness of function on the part of the people. An individual who has a hyperactive thyroid gland may be stimulated to such an extent by severe weather changes that his hyperthyroid state assumes disease proportions. The mild psychoneurotic may become truly pathologic as a result of the extra demands made upon him by a severe storm or the severity of seasons. The tuberculous patient may suffer hemoptysis or pleural pain or metastatic spread of his disease in consequence of the effects of these atmospheric forces.

In studying man we must always consider him as a mechanism composed of myriads of cells, which are bathed by a fluid medium from which they derive their sustenance and into which they discharge products which result from their activity; some useful, others harmful. The former nourish the cells and produce beneficial effects; the latter are carried to the proper outlet and are discharged from the body; or, remaining in the tissues, cause injurious effects. Cells live and are able to function because of various regulatory mechanisms possessed by higher organisms which preserve the fluid matrix in which they are bathed in a state of almost unvarying equilibrium as to such factors as circulating cells, proteins, electrolytes, sugar, cholesterol, hormones, enzymes, and so on. Body temperature is also maintained within narrow variations regardless of the amount of heat produced or the temperature of the atmosphere. These regulatory mechanisms are wonders of scientific efficiency; by them the body can adapt itself to rapid changes of many degrees in the external temperature and preserve a condition of equilibrium. It can adapt itself to an atmosphere of low or saturated humidity; to rapid changes in barometric pressure; to strong wind movement or calm; to strong sunlight or clouds; and to an atmosphere carrying varying charges of electricity. It can do without food for many days; and maintain its water balance when several liters of fluid are consumed within a short space of time, or when water is withheld for two or three days. Thus man, when in a state of health, is fairly successfully cushioned and buffered against harm from these natural forces found in his environment. This does not mean that all individuals are equally protected, or that the same individual is protected equally well at all times. Some individuals are possessed of a labile physiologic stability and at no time are able to adapt as readily as others. When we remember that a failure to adapt may mean dysfunction, with a lowering of physiologic resistance, then we may understand how different individuals resist disease-producing factors with different degrees of effectiveness.

If we inquire more minutely into the effects produced upon the body by some of the atmospheric forces, we shall better understand our problem of man in his relationship to disease. Any force which impinges upon man's sensory system and is adequate to cause stimulation is transmitted central-

ward, where it joins with the efferent neurons to produce action which is accompanied by changes in function, hence oxygen consumption. Some forces increase it greatly, others slightly. Sometimes, on the other hand, atmospheric forces may be inadequate to cause reaction. We may illustrate by variation in temperature. Man is obliged to maintain a temperature equilibrium in atmospheres which are both colder and warmer than his average maximum body heat. This he does by slowing heat production and increasing heat dissipation when the atmospheric temperature is above that of body temperature and by increasing heat production and slowing heat dissipation when the temperature of the atmosphere is below that of the body. Normally there is a nicety of adjustment between heat production and heat dissipation. When unusually large quantities of heat are produced by the organism, whether physiologically or pathologically, it is carried by the blood to the surface of the body where the vessels are dilated so as to facilitate its dissipation; and, in case the amount to be thrown off is unusually large, and particularly if the atmospheric heat approaches or is higher than that of the body, the sweat glands are called into action so that evaporation may also aid in the process. These effects are instituted by a central heat-regulating mechanism in the base of the brain which is so efficient that only that amount of heat is given off which is necessary to maintain the body temperature within normal limits. The mechanism by which this is accomplished is automatic and primarily nervous.

Suppose, on the other hand, a person in health is suddenly exposed to extreme cold. What will be his response? Two conditions are necessary: the body must produce extra heat and it must conserve that which it produces. The cold impulses which impinge on the surface of the body stimulate the sensory nerves in the skin and are carried centralward to the heat-regulating center which sends stimuli over the sympathetic nervous system throughout the body, calling for aid in maintaining an equilibrium. The effect of this sympathetic stimulation is to increase metabolism so as to increase heat production and to constrict superficial blood vessels so as to slow heat dissipation. Not relying on the nervous system alone, however, the emergency action of the adrenals is also called into play to fortify the action of the nerves. Not even relying on these measures when cold is severe, muscle twitching or shivering is instituted, which further increases heat production.

In conditions of health, so soon as normal temperature has been reached, the mechanism adjusts to normal heat production and dissipation; in conditions of ill health, on the other hand, heat production may not cease immediately and furthermore the mechanisms for dissipation may be irresponsive and the body temperature may remain elevated. This is well illustrated in diseases accompanied by toxemia where a chill may be followed by overcompensation and temperature elevation. If the atmospheric temperature is hot, the superficial vessels dilate, metabolic activity is slowed down, sweating takes place, the pulse rate increases so as to hasten the flow of blood through the superficial vessels where it is cooled by the atmosphere as long as it is below the body temperature. When the external temperature equals or is higher than the body temperature sweating and evaporation is the chief process upon which the body relies for losing heat.

Blood-pressure falls with increase in atmospheric temperature and rises with cooling. Complex physiologic adjustment is necessary to keep the individual in a state of equilibrium in the presence of the changes from hot to cold and cold to hot, so are they necessary for adjustment to every atmos-

pheric and cosmic force. That adjustment is not always made, and that the individual sometimes suffers harm from a failure to adjust is quite evident. Epidemic disease often accompanies atmospheric changes. Deaths also are known to be precipitated by meteorologic causes. Storminess is especially prone to increase deaths. Deaths, in general, are most prevalent in the winter and spring. Huntington has analyzed the deaths in metropolitan centers and shown their seasonal relationship. Petersen has not only confirmed this but shown how deaths are precipitated by storms. Tuberculosis has always been known to be most severe in late winter and early spring. The disease is most active at this season, has more complications on the part of other organs such as the meninges, bowels, and larynx; and shows more miliary spread. A second seasonal crest is found in the late fall. The old saying that "if the consumptive lives through the falling of the leaves, he will live till the budding of the trees," has been shown to have a statistical basis now that we have accurate records. We have long recognized this seasonal response in our own clinical experience. We have also noted how storms precipitate deaths in the tuberculous.

What is it that causes these variations in the severity of disease? The most plausible answer is changes in the patient's physiologic protective functions. Inflamed cells are hyperactive cells. Their electric potential is changed, their permeability is increased, and they function abnormally. They are hyperactive to stimuli, consequently they are not able to defend themselves against injury. We can understand this if we look upon defense as depending upon the degree of stability of physiologic reaction that the patient is able to maintain. Sudden and severe changes in meteorologic forces exert marked stimulation upon the body and require marked effort at adjustment, whether they be the changes that are found in the diurnal variation of extremely changeable climates, particularly in the Northern storm tracks, or in the summation of stresses such as are shown particularly at the end of the winter months. Such demands test the individual's physiologic powers of adjustment, so, in the spring months throughout the more stimulating climates of the world, the adjusting powers lag and people are more prone to become ill from infections, also to break down as a result of metabolic disease. Those who are ill and those who are physiologically most unstable from any cause suffer the most. The most plausible cause is the difference in the individual's reaction on the part of his vegetative systems which receive the atmospheric and cosmic stimuli, and respond or fail to respond to the demands which they make upon him. It must not be forgotten that the nerves, the hormones and the electrolytes of the blood are altered by atmospheric forces and change seasonally. Any change in electrolytic balance affects cell activity and influences the action which a stimulus will call forth.

Tuberculous patients may be aided or injured according to the physiologic responses which they make to the metabolic demands made by meteorologic and cosmic forces. A polar storm pours out great masses of cold air over the earth, which alters atmospheric pressure, temperature, humidity, electric reaction and light content. All individuals react to these, but not with equal efficiency. Some will be scarcely affected by the most intense stimulation; others will be completely thrown off balance by insignificant forces. In case of tuberculosis these forces must be met by an organism which is injured structurally and often handicapped in its vegetative mechanism. The weak and unstable suffer from physiologic dysfunction, which may easily lead to a more or less continuous pathologic state.