Temperature Dominance over Human Life

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TEMPERATURE bears an importance to man far beyond the mere matter of his hour-to-hour comfort. In some places it lays a heavy, stagnating hand over his life and holds him to a vegetative existence; in others, it generates an energy and progressiveness which drives him forward with irresistible impetus. Its effects begin even before he is conceived, for the metabolic vigor of parental germ cells at the time of their union exerts a potent influence over the entire course of the new life. Without favorable temperatures, neither individual nor nation can develop innate potentialities to the full.

The hand of temperature is being felt over the world today, much as Ellsworth Huntington so ably pictured its course through past centuries. We are now caught in one of the long cycles of climatic change that alter the courses of nations and of world trends. Man thus has urgent need to understand the mechanism of this temperature dominance over him as an individual and over mankind as a whole. The answer lies in a close study of human dynamics.

The human body is essentially a combustion machine that functions only as its cells release energy by burning the foodstuffs taken in. True, this combustion in the cells is a very complicated affair, carried on at low temperatures and in numerous independent steps through the aid of special catalysts. Although it is far less violent than the gasoline explosions in an automobile motor, its over-all efficiency is no greater, and it is even more dependent upon rapid dissipation of its waste heat. The working efficiency of men, horses, and dogs ranges between 20 and 25 percent, but the Diesel engine designed by present-day engineers performs at over 40 percent efficiency.

For every unit of combustion energy transformed into work-output by our bodies, three or four similar units must be dissipated as waste heat. Failure of such dissipation to keep pace with heat production in the body may mean heat stroke and death within a few hours. The waste heat of combustion thus becomes one of the body's most important excretory products.

Sudden changes in external temperatures, or in the rate of heat production within the body, are quickly countered by the movement of more blood into, or away from, the skin and by the activity of the sweat glands. The body can thus meet short-term emergencies with only slight changes in its internal temperature or behavior characteristics. External heat or cold, prolonged through many weeks or months, however, induces basic and important changes in the body economy.

Following several weeks of difficulty in dissipating waste heat, physical and mental activity declines, and there is is a drop in the combustion rate. Some of the glands of internal secretion, which so largely influence combustion rate, go into a less active, or resting, state. This is particularly true with the thyroid, adrenal, and sex glands, probably also with the pituitary. A lowered total combustion rate means less energy for thought and action, as well as less waste heat to be dissipated. Physical and mental characteristics thus change, from the dynamic and pushing, to a more passive, "let-George-do-it" type. Personal initiative gives way to a desire for security.

That these are basic changes in the individual's metabolic make-up is evidenced by equally profound alterations in such body functions as growth, rate of development, resistance to infection, and thought capacity. When difficult heat-loss induces a lowered combustion rate in the cells, growth slows down and may be completely halted, even though an ample food supply be available; onset of puberty and maturity is progressively delayed, and ability to reproduce is reduced or completely obliterated, although matings go on freely; resistance to bacterial invasion is impaired, especially for those respiratory infections in which the white blood cells (phagocytes) provide the first and main line of the body's defense-system; and, finally, ability to solve problems is greatly impaired.

Proper ease of body heat-loss means just the opposite—a fast growing, early maturing, highly fertile individual, with a keen mentality and good ability to fight infectious disease. These statements are by no means hypothetical but are based upon well authenticated statistical findings on man and on experimental animals under controlled conditions. They show up in the laboratory, under natural climatic differences, and during the wide seasonal swings in middle temperate latitudes.

Half of the earth's population lives year after year under a depressive blanket of moist heat that makes

impossible an active life or high vitality. There children grow slowly, mature late, and are, in the main, of inferior stature. Although the birth rate is high because of lack of restraint, high stillbirth and infant mortality rates cut heavily into the ranks of those who might live on to adulthood. Infectious diseases are the chief causes of death at all ages. The menses come on 1½–2 years later than among girls of cooler climates, and reproductive fertility shows an even greater lag. The age-old fallacy of early tropical maturity should be abandoned—it probably represents a carry-over from the Ice Age of 20,000 years ago, when optimal temperatures for man were to be found only in what are now the tropical regions. Even two millenniums ago. Hippocrates was stressing the fallacy of early tropical maturity, although the girls of ancient Greece were beginning their menses at the same early age as in middle American latitudes today. With the subsequent rise in earth temperatures, the girls of Greece today begin their menses two years later than in Hippocrates' day.

Domestic livestock show a comparable retardation where heat-loss is difficult. To bring a steer to the choice 1000-pound slaughter-size takes 12–15 months in Iowa or Illinois, 2½–3 years in Louisiana, and 4–5 years in Cuba, Panama, or Colombia. This represents maximum adult size in the tropical heat, whereas in Iowa or Illinois the steer will grow to almost double this weight. Hogs show the same contrast, taking 15 months in Panama to reach the 200-pound slaughter size achieved by Iowa shoats in 6–7 months.

In spite of the lack of sexual restraint and our "Mother India" ideas of early tropical maturity, evidence indicates that functional fertility is attained several years later, on the average, among tropical girls than among the more lusty progeny of cooler climates. Laboratory findings under controlled temperature conditions provide complete confirmation of the human statistics. Difficulty in heat-loss can so reduce animal fertility that conceptions become impossible, even with oft-repeated matings. Human conceptions resulting in live births are also sharply reduced during prolonged periods of severe heat among people of the temperate regions. The whole state of Florida suffers a 30 ± percent decline in conceptions during the long summer heat, whereas in Maine conception rates then are highest.

The body's ability to resist or survive infectious attacks goes down with all other vital indices in tropical heat or in long subtropical summers. The number of deaths per 100 acute appendicitis cases hospitalized in the Gulf states is twice as high as in the Upper Plains states; and at Cincinnati, migrants from the South last just half as long with tuberculosis as do the Northern-born, considering only those who die, from first symptoms to death. Those adapted to heat also succumb more readily to pneumonia—a Dakota winter would produce a holocaust of pneumonia deaths in Panama or the Philippines!

Loss of mental acuity constitutes perhaps the most disturbing phase of heat effects, when viewed from the standpoint of the general welfare of mankind. Some years ago Ellsworth Huntington collected statistics showing best mental function at 38–40° F, whereas 64° F seemed optimal for physical performance. Today we know that college students, given the standard aptitude or intelligence tests at Cincinnati latitudes across the country, achieve ratings only 60 percent as high in summer heat as in winter cold. No such seasonal contrast in ratings occurs in the northern tier of states, where there is no prolonged depressive summer heat.

White rats have further confirmed the folly of summer sessions in colleges at lower latitudes unless the students be air-conditioned. With three groups of male rats from divided litters, kept on uniform diet and at three different environmental temperatures, it was found that ability to solve maze-tests was sharply retarded with increasing difficulty of heat-loss. The rats kept for four months at 55° F required only 12 trials before finding the correct maze pathway to the food dish; and, once they found the proper turns, no further errors were made on later testings. Those kept at 75° F made, on the average, 28 wrong turns before discovering the proper pathway, and even then their learning was far from complete. For the rats kept at 90° F, food seemed not worth the effort; those that did get through to the food took an average of 51 wrong turns and still could not repeat on successive days.

The rats' memory, or retention of learning, was tested by bringing them back to the maze after a month's absence. Those from the 55° F room showed perfect retention of their previous learning, those from the 75° F warmth had to relearn about half, but those from the 90° F heat seemed to retain no memory of their former efforts.

These basic observations on temperature dominance over mental ability and physical development are indeed of great significance to mankind as it faces existence problems in many regions of the earth. Should the more favored portions of our country give aid to those peoples whose living conditions are more adverse? Should such aid take the form of educational funds or of nutritional upbuilding? Fortunately, nutritional studies on animals have demonstrated that most of the depressive heat effects can be overcome by proper attention to vitamin and protein

intake. Certain of the B vitamins are needed in extra amounts, and hot-weather diets should be richer—not poorer—in protein, if we would avoid metabolic letdown. Actually, our protein requirement remains the same (in grams per pound of body weight) in heat and cold, but a lowered calorie intake in hot weather makes it necessary that the smaller amount of food eaten be richer in protein.

Difficulty in body heat-loss begins its dominance over any person's life even before he is conceived. The metabolic vigor of parental germ cells at the time of their union exerts a considerable influence over the whole life course of the new individual. Those children at Cincinnati latitudes whose parents have been depressed by July and August heat before conception have just half the likelihood of entering college that is enjoyed by those conceived in winter cold. Those conceived in summer heat also grow more slowly, develop later, and live a shorter life span (over four years less, according to Huntington's findings).

Further handicaps of hot-weather conception include a low likelihood of inclusion in *Who's Who* volumes and of being president of the United States of America. Eleven of our presidents were conceived in the first quarter of the year, ten in the second, *four* in the third, and seven in the fourth. Until the present incumbent entered the White House, there had never been an August conception at the head of our government. In any field of accomplishment one investigates, the advantages of cold-weather conception stand forth in bold relief. Perhaps these facts will find expression in high school or college eugenics courses and in planned parenthood through coming years. If so, the country's obstetricians will be able to plan a long vacation for each year!

Climatic temperature differences, whether brought about by latitude or altitude, are potent factors in human life, and so also are the wide seasonal temperature swings of the earth's middle latitudes. The fortunate nations of the earth are those located where the body's waste heat can be lost readily. Many other factors of life are also of great importance, of course, but this article is devoted to the basic role of temperature. Due recognition must be given to the part that improved nutrition may play in minimizing the depressive effects of external heat. Natural resources may thus exert a marked and beneficial effect on a given population group by making possible a better dietary intake, but dietary improvement will still be conditioned on the exercise of mass intelligence in food selection and on the willingness to work for the better food, no matter how great the natural resources. We thus come back to energy as the mainspring of life, with all its potentialities and handicaps.

Proper ease of body heat-loss may be essential to progressiveness and accomplishment, but its advantages are by no means free of hazards. Evidences of mental and physical breakdown are today most alarming in those regions of the earth where temperatures are most energizing. Arteriosclerosis and heart failure, diabetes, cancer, and many other breakdown diseases are there claiming far more victims than in tropical warmth, where infectious diseases run rampant. Northern rates of mental instability and breakdown, for instance, more than offset the decrease in tuberculosis deaths. Perhaps some day artificial conditioning will provide us with the Golden Mean.

Up through the millenniums since the last Ice Age, the crest of human civilization has shifted farther and farther poleward, with irregularly rising earth temperatures and melting ice caps. Improved housing and greater protection against winter cold have been considerable factors in this poleward shift, but probably of greater importance has been the expanding region of tropical heat. Volumes of argument pro and con would add little to that statement about the distant past, so let us move to more recent times.

Through the last 10,000 years of the earth's history, cyclic changes in temperatures have left fairly clear records. A millennium of rapidly receding glaciers and polar ice caps was succeeded by one of stability or advance. Five such cycles are in evidence over the last 10,000 years of rapid Ice Age regression. The next-to-last cold millennium fell in the days of early Greek and Roman glory and was followed by the thousand years of Dark Age warmth, when cereal grains could be ripened in Iceland and grapes in England.

The peak of Dark Age warmth occurred about A.D. 850, when optimal temperatures in far northern Scandinavia activated the Norsemen and Vikings into a century of exploration and settlement. The gradual return of benumbing cold to their homeland and to the Greenland and Iceland settlements from the tenth to the fourteenth centuries dimmed their glory. Central Europe was at the same time relieved of her enervating warmth and entered the Renaissance and the period of industrialization. The miracles of this Western mechanistic civilization have reached a peak in America during the century just passed.

Once again earth temperatures are surging irregularly upward, reaching levels in 1930 about as high as prevailed a thousand years earlier. During the warmth of the early thirties soil thawing in Greenland allowed excavation of Viking bodies that had lain in solidly frozen earth for a thousand years. All records available indicate that earth temperatures have been rising for a full century, bringing definitely milder

winters and the long summers of depressive heat that sap human energy and change the course of nations.

The same semitropical lethargy which earlier engulfed the Mediterranean countries of Europe is today creeping northward over the United States and Central Europe. Later onset of the menses in girls and smaller adult stature in American college youth have replaced the trend of recent centuries toward earlier maturity and ever-better physique. In the Carolinas the reversal came with children born in 1918, at Cincinnati latitudes a little later, and in Wisconsin it still remains only an indefinite hint. It is especially significant that this physical downturn should have occurred at a time when the production and distribution of foodstuffs were at all-time peaks and when greatest emphasis was being laid on child care and nutrition. Children now have fewer illnesses and grow faster in their early years than ever before; yet the adult stature is showing definite evidence of decline.

The northward shift of world power was emphasized by Germany's bid for a "place-in-the-sun" in World War I. Only the superior ingenuity and resources of Britain and America kept her from her goal, for Russia was then only in the early throes of her awakening, and France was quite incapable of coping with her more vigorous neighbor. When World War II came a quarter-century later, America was pushed to new peaks of industrial productivity and scientific advances that contributed substantially to victory, but the war's most significant outcome was the bid for world power by a new far-northern nation—Russia.

Retarded by the benumbing winter cold of past centuries, much of Russia today enjoys temperatures which are near the optimal for human endeavor. Freer flow of her energies and the heady successes of war and postwar years have given her a self-confidence that considers nothing impossible. Hers is now the early American frontier reaction of bubbling enthusiasm and nigh irresistible impetuosity. In the warm centuries ahead she may gain the sought-for place-in-the-sun, along with the lesser northern nations of Scandinavia and Canada. To appreciate that Russia is really a far-northern nation, one should bear in mind that the city of Stalingrad lies close to the latitude of Winnipeg.

The effects of temperature will go far beyond their present influence over individual life and national trends. The present millennium of warmth may witness complete melting of the polar ice caps and consequent profound changes in the climates of present polar and temperate zones. The earth has experienced long eons of freedom from polar cold during past periods of interglacial warmth, and Brooks, in his book, *Climate through the ages,* pictures the present ice caps as being down to the critically small diameter that makes them susceptible to rapid disappearance. Anyone desiring to make use of this information for long-term investment in northern real estate should buy high land, however, for the ocean level will rise roughly 150 feet as the ice caps disappear.

Present-day international interest in the mineral and fuel deposits of Antarctica may prove to be well based, in view of these temperature trends. Also, the broad, fertile, but still frozen reaches of northern Siberia and Canada may someday support the earth's most energetic populations, if the present outward expansion of semitropical lethargy continues. It takes only a few degrees of change in mean annual temperature to produce striking climatic alterations. Dark Age temperatures of Scandinavia, Britain, Iceland, and Greenland, for instance, were probably only 4–5 degrees higher than those prevailing through the colder centuries since the time of the Renaissance.

Much study and speculation have centered around the possible causes of these shifts in earth temperatures. The regular seasonal cycles are, of course, known to be based upon the changing inclination of the earth's axis with respect to the sun. Variations in sunspot activity and in the intensity of solar radiation to the earth have also been correlated with periods of unseasonal cold or warmth. Sudden outbursts of sunspot activity are accompanied by increased heat and magnetic radiation to the earth but are soon followed by greater storminess and low temperatures in temperate latitudes. During the declining or low phases of sunspot activity in the major 11-year cycles of the last two centuries, two thirds of the months have shown unseasonal warmth, while unseasonal cold has accompanied rising or high sunspot activity two thirds of the remaining time. We may tentatively accept the sunspots and the changes in solar radiation as a direct cause of weather shifts and of periods of unseasonable warmth and cold through the years. Whether the same influence lies behind the 2000-year cycles, and the Ice Ages and alternating Inter-Glacial Stages, still remains a matter of conjecture.

Sunspots are thus a matter of profound concern and have prompted investigations into the causes lying behind climatic fluctuations. As a result, we now know that each of the major planets of the solar system tends to depress sunspot activity on that part of the sun's surface exposed to a given planet. Observations have shown that sunspot activity decreases on any segment of the sun's face exposed to the earth during half of the sun's 28-day rotational period and increases on the opposite side during the other two weeks. Tides in the sun's gaseous mass have been

believed to result from the varying planetary pulls, but there is also a possibility that other heavenly bodies may also exert potent influences.

Our personal fortunes through the years, as well as our health and energy, are thus linked to the sun and, through it, to the planets of our solar system—and perhaps to the nearer stars!

Today we pride ourselves upon our scientific achievements and the conquest of disease by men of medicine; yet months or years of unseasonable warmth bring devastating economic downturns against which we have found no defense, and at such times sickness and death rates decline, even while our physicians are least busy. Statistically, one might say that people are better off the less they see of a doctor, but in reality, it is the lessened storminess and reduction in bodily stress that account for the health betterment in hard times.

Man is in reality a pawn of the environmental forces encompassing him, being pushed forward to a vantage point at one time or held in lethargic bondage at another. Here is a challenge of the first magnitude —can human intelligence find an effective answer? If not an answer, then it should at least comprehend the forces at work and the major significance of their effects.

Evidences of Associative Interference in Psychomotor Performance[1]

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UNEQUIVOCAL EXPERIMENTAL EVIDENCE of associative interference in the performance of a task predominantly motor in character was presented by Lewis (*4*) in a paper read at the 1947 meeting of the Midwestern Psychological Association. Lewis' subjects performed on a special model of the Mashburn apparatus built at Iowa. They first practised with the three controls in their usual setting. After attaining proficiency in the required task, they were given practice with all controls reversed. Following this reversed practice, they relearned the original task. Reliable decrements in performance appeared during the initial stages of relearning.

Buxton, in collaboration with Henry and Grant (*1, 2, 3*), had previously studied the effects of three different varieties of motor activity on acquired ability to perform on a Koerth-type pursuit rotor, but had found only *relative retroaction* and not actual decrements in ability to perform—decrements such as those easily demonstrated in verbal learning. In contrast to the decrements obtained by Lewis, Buxton could point only to amounts of gain in pursuit rotor performance following the interpolated activities which were different from the amount following a period of rest.

[1] Studies of associative interference in psychomotor performance are being conducted at the State University of Iowa under Contract N5ori-57 with the Special Devices Center, Office of Naval Research.

The Mashburn apparatus[2] in modified form seemed ideally suited to the studies of associative interference undertaken by Lewis. Basically, the unit consists of three double banks of small pilot lights and of a control stick and rudder bar. Each bank has a row of 13 red stimulus lights and a parallel row of 13 green response lights. Various combinations of stimulus lights come on automatically in random order, to provide patterns of red lights that must be matched by corresponding green lights. The three rows of green response lights are separately controlled by means of commutators and brushes associated with the stick and rudder bar. The green lights in any row come on and go off in succession as the corresponding control is moved in a given direction.

When a subject performs on the apparatus, he is presented with three randomly selected red lights, one in each of the three double banks. His task is to manipulate the stick and rudder bar until a green light is shining opposite each of the three red lights. When this condition prevails, a stepping relay oper-

[2] The apparatus was originally devised by Mashburn (*6*) for use in detecting flying aptitude. The Iowa model was constructed by Lewis for an investigation of the effects of noise and vibration on psychomotor responses (*5*). During the recent war, a somewhat improved form of Mashburn's original instrument was used extensively in the selection of air cadets and came to be known as the S. A. M. Complex Coordinator, a general description of which has been provided by Melton (*7*).