MAN AND HIS ENVIRONMENT

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Man has both an internal and an external environment. The internal environment is the environment within his own body and this is kept constant by complicated and elaborate means; the external environment on the other hand is that which is found outside and around his body. The human body is continuously being played upon by a multitude of external environmental factors but it resists the impact of these external forces and maintains its internal environment in a steady state with the external. The ability to survive in varying environments is the central physiological characteristic of living things.

Man is the main purpose of architecture. This talk will deal with the physiological factors that influence architectural expression (Fig. 1) — with the relation of man to chemical, physical and biotic factors in his external environment, his adaptation to atmospheric temperature, pressure, oxygen concentration, light, radiation as well as contamination of the atmosphere.

Man and his environment is a fascinating topic which has attracted the attention of biologists for centuries. The Greek physician Hippocrates and his associates appreciated the role of the environment in relation to health and disease in man, emphasising the importance of "Airs, Places and Waters" in regard to well-being. This tradition was consolidated throughout the medieval period, first by the Arabs and later by Western European scholars, but it began to be questioned during the Renaissance. Santorio gave a tentative background for systematic studies of the cyclic relations of humans with the environment. John Hunter (Fig. 2) made observations on living organisms in relation to their surroundings and disease. It is however to Claude Bernard (Fig. 3) that we owe our greatest knowledge of the adjustment of living things to environmental conditions. He developed the concept of the "milieu interieur" in which internal regulating mechanisms are related to feedback systems from the various parts of the living material itself and from its environment — preservation of internal stability and constancy in an organism, despite any external change, is the central characteristic of life. We are now becoming aware of the importance of the environment at social and ecological levels, in such matters as over-population, air and water pollution, and the destruction of nature's eco-

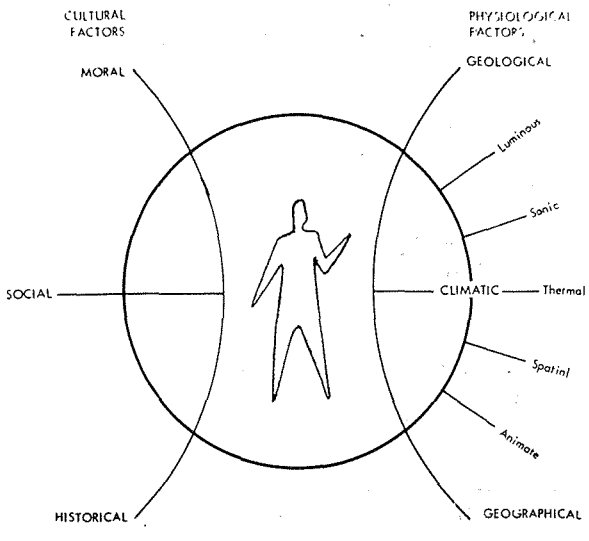
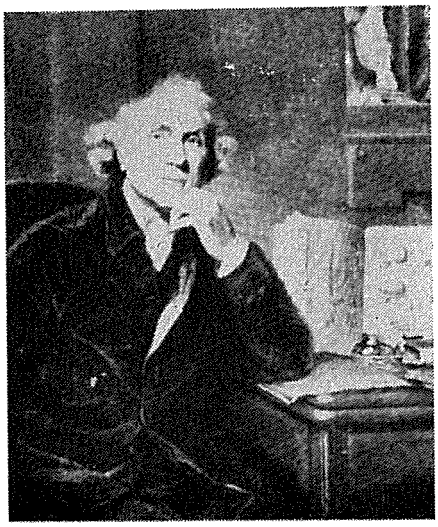


Fig. 1



John Hunter.

logical areas. Indeed so blind are we in what we do that we are in danger of destroying for ever the environment in which we took so long to evolve.

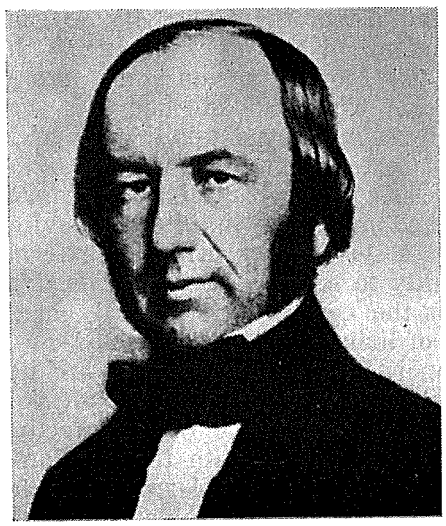
Man is throughout life being subjected to the effects of the external environment; this is evident from his very existence in utero where he is subjected to the external environment of the amniotic fluid, right up to old age when the effects of the external environment may be very manifestly evident. Throughout life, multiple physiological processes act as adaptive mechanisms by which the equilibrium between the external and internal environment is achieved. These mechanisms consist of a series of interrelated, integrated and dynamic changes which affect the various organ systems of the body.

In the nervous system, adaptation by habituation is apparent; in other words if sensory stimuli are repeatedly applied, the response to them gradually diminishes or disappears. Arctic man has adapted himself to cold by setting his temperature thermostat at a lower level so that he responds to cold with less shivering.

Muscular tissue, which forms a large proportion of the human body, can adjust its strength and endurance to increased mechanical requirements. Muscular work also contributes to temperature regulation by heat production, as in shivering and increased muscular tone, or by actual contraction. In birds, shivering, especially of the chest muscles, is the most important adaptive mechanism in cold exposure.

On the heart, heat and exercise produce an increase in the rate. Training is said to produce a slower heart rate — this, in fact, is the only difference between trained and untrained subjects at rest.

The lungs are the means by which man can obtain his most urgent molecular requirement from the environment: oxygen. Lung ventilation has many functions — it is related to surface water loss by evaporation and it regulates temperature by producing heat dissipation, as is well seen in the panting of dogs and other mammals.



Claude Bernard.

The digestive system is in direct contact with the external environment at both its oral and anal ends, and, though its contents are part of the external environment, they are separated from the internal environment for the most part only by a single layer of cells. Thirst controls water intake hence water balance; hunger, appetite and satiety adjust the food intake to body needs; while the intestine regulates and limits absorption and rejects most noxious substances.

The kidneys are of importance in conserving water, as well as excreting salt and

nitrogenous products. Completely terresterial forms must conserve water at all times. Indeed, some of the most successful terrestrial animals, mammals and insects, have kidneys capable of producing highly concentrated urine, and these animals can survive in deserts with no access to drinking water.

The skin protects man from mechanical injuries and invasion by organisms; it serves as a sense organ; it helps in the regulation of body temperature; it participates in metabolism as, for example, by forming a fat depot; and it also takes part in water and salt metabolism by perspiration.

Mechanical protection of the skin results from its thickness, the hardness of its outermost keratin layer, and its pigmentation. The importance of keratin is evident when repeated mechanical stimuli in one area cause callosities, as often appear on the palm of a farmer's hand. Normal skin colour is due to the black pigment melanin, to the red pigment of blood, and to the yellow carotene stored in skin. Racial differences in skin colour depend largely on the amount of melanin and this pigment may possibly account for the well known greater resistance of black skin to external irritants.

Temperature regulation is contributed to by heat loss through the skin. Below 31°C, heat loss depends on the dilatation of the blood vessels of the skin — this leads to the shifting of blood from the interior to the surface so that the skin temperature is raised and heat is lost. Above 31°C, heat loss is mainly from sweating. Man is foremost in the animal kingdom with respect to the development of the sweat apparatus and it is in fact this that has allowed the human race to inhabit the whole earth including the most torrid zones. Frequent and continuous exposure to high temperature causes an increase in sweating; the excessive sweating of newcomers to the tropics is well known. The total number of sweat glands is the same in all races, but the number of active ones differ; for example, Ainos have the fewest, Russians have slightly more, Japanese still more and Filippinos living in the tropics have the most.

The skin has important functions in relation to water and salt metabolism. Insensible water loss through the skin proceeds continuously and unconsciously throughout the day and night and is associated with heat loss. In dehydration this insensible water loss is diminished.

We shall see now, how man reacts to weather and climate. Weather and climate conditions in the atmosphere are continuously interacting with the internal physiological processes of man. The weather affects the human body in five ways: it stimulates the skin by changes in temperature; it may stimulate the eyes and head by solar radiation; the internal mucous lining of the nose may be stimulated by olfactory substances, changes in the humidity of the air or possibly allergic reactions to allergens in the air; the lungs may be stimulated by changes in the ion content of the air, by trace substances such as ozone, by air pollutants, by reduced pressure of oxygen, especially at high altitudes, and by thermal stresses. Weather may stimulate directly the peripheral nerves possibly by electro-static and electro-magnetic fields, by diastic changes in atmospheric pressure, and by microvibration of the earth and of its buildings.

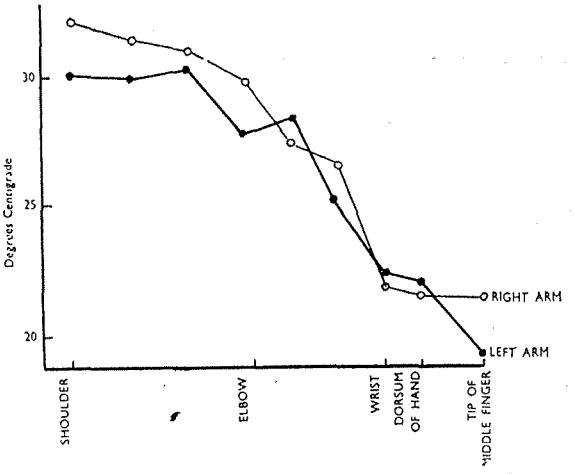


Fig. 4

The temperature of a healthy human being is kept relatively constant at 37°C, but this is the temperature in the mouth

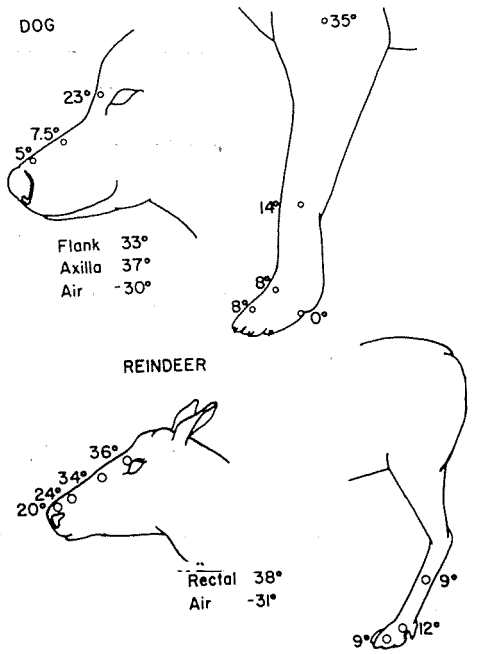


Fig. 5

or rectum. There are variations in temperature in the different parts of the human body and even in different parts of the same limb (Fig. 4). The same holds for animals, such as the dog and reindeer (Fig. 5). The body temperature of a healthy human being varies at different times of the day, and it also varies in relation to external temperature and body activities (Fig. 6).

One may ask, how does the body manage to keep its temperature relatively constant at 37°C? The temperature regulation in the body depends on the balance of heat production and heat loss. The balance of these factors is illustrated in Fig. 7. The factors which affect tehe heat exchange of the clothed body are shown in Fig. 8.

Human beings are known to live in climates where the extreme cold winter may reach —50°C, as in the interior of Siberia and North America. Although it is known that man has lived in Arctic Alaska for the last 5,000 years or so, physiological adaptation to cold accounts for only a small part of Man's conquest of cold; his adaptation is in fact mostly cultural.

Man responds to cold by increasing his metabolism and altering his peripheral insulation, at the same time improving his muscular activity through shivering. Continuous exposure makes man more tolerant to cold; for example, young Norwegian males and Eskimos develop a marked re-

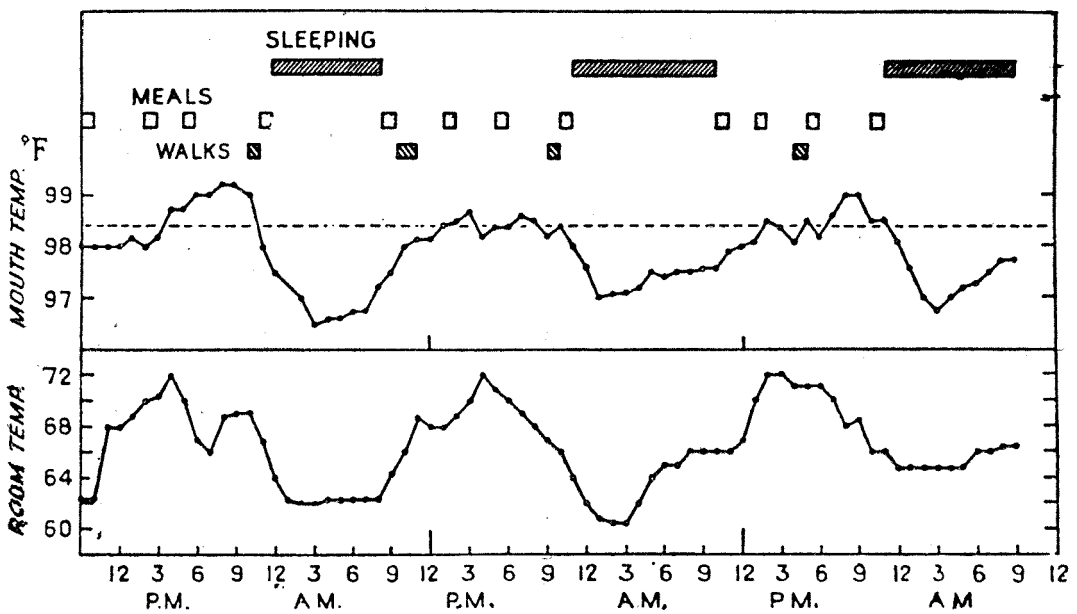


Fig. 6

sistance to cooling of their limbs.

Another interesting adaptive function of man to cold is that cold feet fail to melt the snow under them; the people of a religious sect who go about barefooted can, in steady cold a few degrees below zero, walk on snow with bare feet without trouble from icing. Sir Cedric Hicks investigated a group of Australian aborigines who live naked in areas of marked variation in temperature and who sleep naked in extreme cold near small fires. He found the skin temperature of these aborigines to be far below that of Europeans; it seems that these people control their heat loss at night by reduction in the blood supply going to the colder areas of exposed skin.

What about man's adaptation to heat? Over a fifth of the world surface, an area equal to that of Africa, is occupied by desert or semi-desert. Man living in hot dry climates is mainly concerned with preventing dessication and keeping cool. Re liance has to be placed on the evaportive cooling of the skin rather than on an increase in skin blood flow. Evaporation takes place mostly through sweating; respiratory ventilation is of minimal importance in man; increased surface area is not useful under desert conditions as heat would be added to the skin by solar radiation; decreased activity and work is impractical, while reduction in the metabolic rate seems to be minimal.

Heat produces an increase in the heart rate and swelling of the feet which may reach disabling proportions in inactive people, as is often seen in ship passengers passing through the Red Sea. There is a reduced motility and tonicity of the digestive system which accounts for the reduced appetite we all experience in hot conditions. Failure in adaptation to heat may result in heat stroke, heat exhaustion, heat cramps, and dehydration.

We in Malta have a particular interest in the effects of radiation from the sun on the human body. Sunbathing is said to be a route to health and, though no doubt giving subjective pleasure, its true relation to health is still unknown. Solar radiation directly affects body heating, vision and the general sensitivity of the body surface; it is concerned with vitamin D synthesis, with the ultra-violet radiation damages of sun burn and pigmentation, as well as with changes in skin colour.

Sunburn produces dilatation of the skin blood vessels and deposition of the pigment melanin. The relationship of hair, skin and eye colour to solar radiation is well known; light skinned, blonde and red-headed, blue-eyed frecklers are known to be more sensitive to sunlight. A dark skin protects from sunburn but not from heat gain, for infrared radiation absorption is the same for both white and black skin.

What is the effect of high altitude on the human mody? With increasing altitude, the pressure of atmospheric oxygen falls. Above 10,000 feet most persons require the addition of oxygen to the air they breathe, and at 35,000 feet 100% oxygen must be

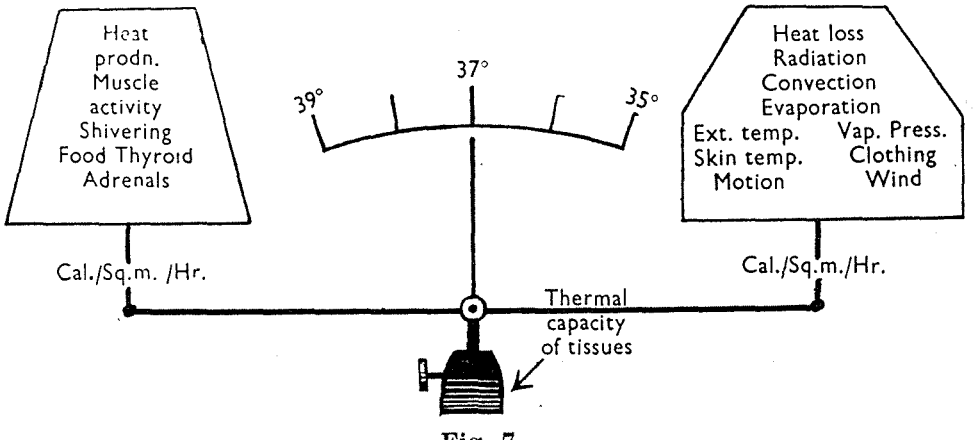


Fig. 7

Primary factors	Secondary factors
Metabolic rate	Clothing temperatures
Air temperature	Air motion beneath clothing
Mean radiant temperature	Skin temperature
Air motion	Sweat rate
Vapour pressure	Wetness of skin and clothing
Clothing type and materials fit	Cooling efficiency of sweating

Fig. 8 *Factors affecting the heat exchange of the clothed body*

breathed. It is surprising to learn that both Hilary and Tensing in 1953, when on the summit of Mount Everest, removed their mask and spent ten minutes breathing atmospheric air, though Hilary reported that he soon felt clumsiness of movement and impairment of thought.

Man can become partially but never fully acclimatized to high altitudes and those who acquire acclimatization never reach a high degree of physical and mental activity, though this is not the case in native high altitude residents. The low oxygen tension at high altitudes causes hyperventilation in man as well as increase in the number of red cells in his blood. Loss of natural acclimatization to high altitudes may cause chronic mountain sickness or Monge's disease.

Early balloon flights and more recently space flights have provided more information on the effects of altitude on man. In space, man depends for his existence on an artificial environment based on bio-

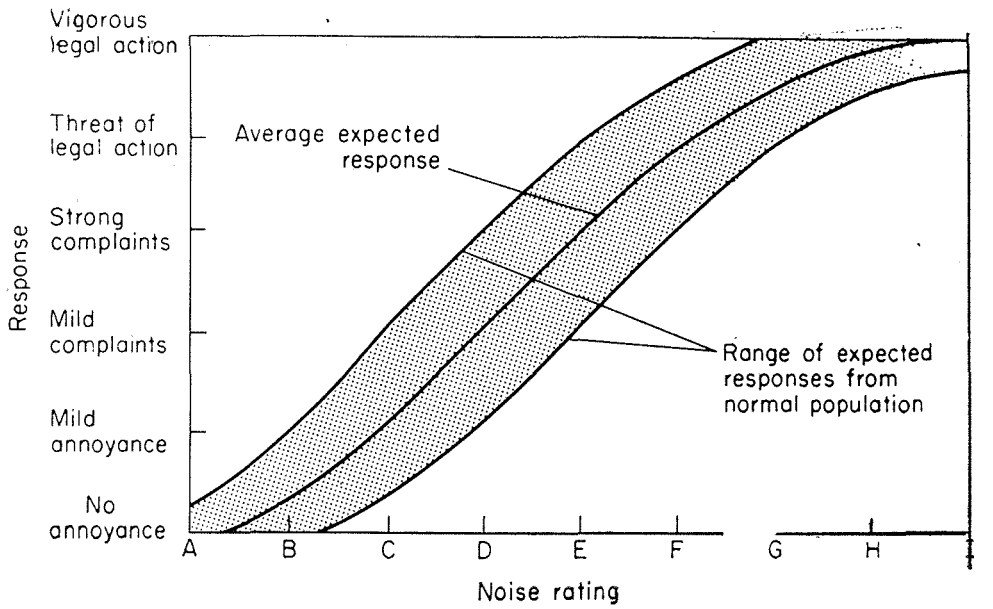


Fig. 9

instrumentation. Manned orbital space flights have brought us in relation to our ultimate environment, the universe.

How does pollution affect the human body? Man is influenced by the contaminants found in the atmosphere of industrial and urban environments. These consist of gases, mineral dusts, combustion products, radio-active fall-out, vegetable poisons and micro-organisms. Tobacco smoke and the exhaust of automobiles in congested urban areas are specialized types of local pollution.

Ionizing radiation can occur naturally in minimal amounts, but it is mostly man-made, as from X-Rays used in medical diagnosis and therapy and from the atomic fall-out from the testing of nuclear weapons in air. Radiation causes changes in the structure, bio-chemistry and genetic constitution of cells, as was well evident in the Hiroshima survivors of the atomic bomb.

The human eye is a complex structure. The eye can adapt to darkness — the so-called day and night vision — as well as to visual acuity, depth perception, binocular vision and colour perception. Dark adaptation depends on the regeneration of photo-pigments, but recently the photo-chemistry of the fluids of the eye such as the vitreous humor have come into prominence. The form and texture of an object seen by the eye depends on the direction of light. It is known that the sensitivity of the eye varies to different wave-lenghts both for day and night vision.

The ear is also a complex organ. Sound waves are propagated either by air borne means or by impact. In man the external ear has little importance as a megaphone and the intensity of a sound can be increased by cupping the hand over the ear; but it has some importance in that it renders sounds coming from the front more audible that those coming from behind.

The more intense the sound the greater the fatigue effect, though it has been found that industrial and engine noise with high frequencies is more easily damped than the human voice containing many low frequencies, so that speech intelligibility may actually be increased in noisy environments by the use of ear plugs! It is also known that loudness declines during the continual presentation of a sound. During sleep, certain sounds become more audible and can produce arousal, independently of their intensity. The behaviour of man exposed to noise varies in different individuals and in the same individual at different times (Fig. 9). Higher and intermittent noises tend to be more annoying than continuous and lower ones. On the other hand man can adapt psychologically so that an individual can "put-up" with even very loud noise.

In normal life there is a continuous flow of impulses from the sensory organs to the brain. If these are completely eliminated, as by suspending a person in water for long periods in total silence and darkness, a remarkably disagreeable reaction producing oppression and even alarm may result, for this would constitute a situation which man rarely encounters and to which he is not adapted.

In conclusion then we may say that man is indeed dependent on his environment and must respect it for the sake of his own survival and happiness. From this arises his urge to control, manipulate, and understand the environment around and within him which ultimately determines his success or failure.