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GLOBAL WARMING, PHYSIOLOGY, HEALTH AND FOOD SUPPLIES*

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It has been determined that the Earth's near surface temperatures have increased on average by about 0.6^0C in the last 100 years. Estimates vary as to what the rate of increase may be in the future but it has been suggested that the rate may be as much as 1 to 5^0C per 100 years.

It has been postulated that the fundamental cause behind the rise in average temperature is principally the build-up in the atmosphere of certain gases These gases have been termed "greenhouse gases" since they allow solar radiation to pass through and reach the Earth but absorb and thus "trap" the heat (i.e. energy of a different wavelength) which radiates from the Earth's surface. Thus (as in the "greenhouses" or hothouses" used in temperate countries for growing green plants even in cold weather) the Earth's average temperature is raised to an average + 15^0C from the around - 18^0C it would be at in the absence of any greenhouse effect.

Since the commencement of the industrial age, Man has been quantitatively and qualitatively adding to greenhouse gases in the atmosphere. The percentage contributions of the various greenhouse gases to the additional warming are, at present, as follows: carbon dioxide (50%), methane (19%), chlorofluorocarbons or CFCs (17%), tropospheric ozone (8%), nitrous oxide (4%) and stratospheric watervapour (2%).

The increase in carbon dioxide levels is largely due to the combustion of fossil fuels (coal, oil and gas) and biomass (firewood etc.) and the clearing of forests (which trap and "fib' carbon dioxide during photosynthesis). Important sources of methane include escapes of natural gas, coal mining, oil production,

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paddy cultivation, livestock production, termite activity and waste dumps. Chlorofluorocarbons (CFCs) are generally of anthropogenic origin, while nitrous oxide chiefly arises by microorganisms breaking down mineral nitrogenous fertilizers. Tropospheric ozone arises by complex reactions for which the presence of carbon monoxide, hydrocarbons and nitrogen oxides are necessary.

It is expected that with time a variety of serious consequences may arise as a result of global warming. We will attempt to examine some health and food aspects of global warming, although much of the available information is fragmentary and speculative. The discussion will focus on global warming and not the possible repercussions of the postulated damage to the ozone layer. However, the increased flow of ultraviolet radiation due to the latter phenomenon may lead to greater incidence of skin cancers and cataract of the eyes and weakening of the immune system during global warming, since some gases (such as the CFCs) may contribute to both effects.

It must also be recognized that many aspects relevant to climate change are multi-factorial and cannot be examined in isolation (as is possible in laboratory experiment).

For instance, an important greenhouse gas is water vapour. Generalised global warming would cause more water to evaporate, thus causing the addition of more water vapour to ths atmosphere and leading to an increased "greenhouse effect". Again, a reduction in snow and ice, which reflect solar radiation back to space, may result in further absorption of solar energy. The influence of cloud formation on greenhouse warming is also extremely difficult to assess and depends on a complex of factors including the extent, height. and liquid water content of the cloud cover.

The immensity of the number and variety of factors influencing global warming are exemplified by the above and the number and variety of anthropogenic and natural sources and "sinks" of greenhouse gases as described elsewhere.

Physiology

The "climate" is composed of a number of elements including temperature, wind, humidity and rainfall and the time components of the above and the extreme ranges and normal deviations of the above factors.

Of the above factors, the temperature is very important and, generally speaking, life processes can continue only when the temperature of the body stays within certain limits. Thus, while populations of certain trees can become acclimatized to survive winter temperatures of -50^{0}C (-58^{0}F) provided the summers are sufficient for growth and reproduction, animals can usually cope with or acclimatize themselves to climate change only if the temperature rise or fall or its rate of change is not excessive.

Animals have developed a variety of mechanisms to reduce heat loss or to acclimatize themselves to conditions in their surroundings., These include developinga layer of subcutaneous fat

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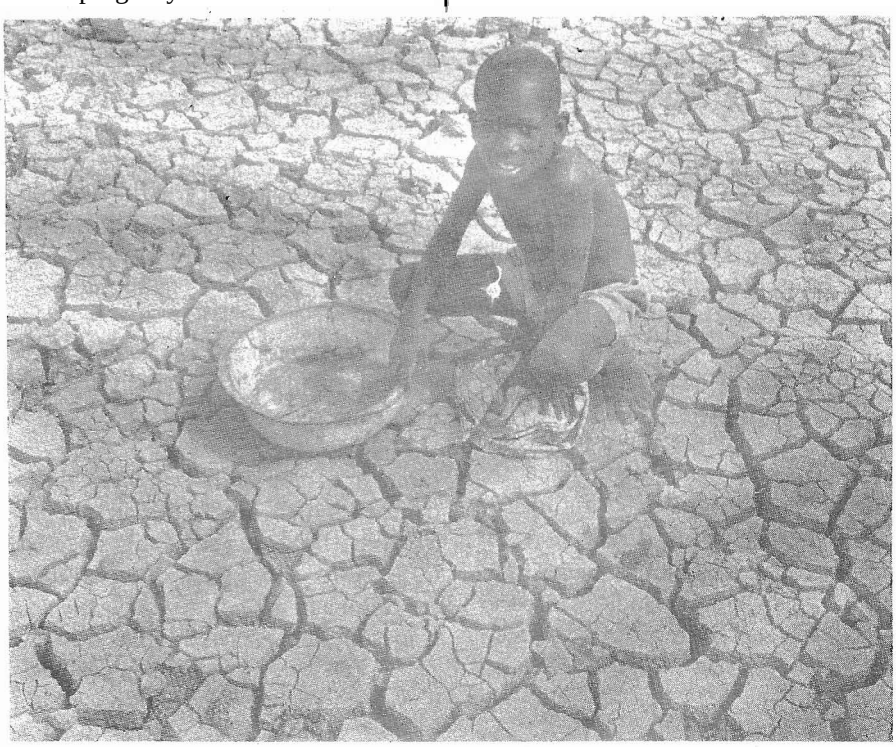

Drought in Mali. Human activity has ondoubtedly contributed to environmental degradation in the Sahel, but some scientists believe the deteriorating conditions may also be attributable to global warming.

and the use of fur or feathers for thermal insulation.

Excessive heat may be more damaging to living organisms and more difficult to guard against than cold. The term "thermal pollution" has usually been associated with waste heat emitted, for example, with cooling water from a thermal power plant. A rise of even a few degrees in the receiving waters can (and does) cause severe mortality in eggs and larvae of fish and invertebrates and other life forms which form parts of marine and freshwater food chains. This could be of importance in the event of generalized global or regional warming.

A better appreciation of the Importance to organisms of guarding against excess heat may be gained by surveying a few of the mechanisms available for thermoregulation. One mechanism of guarding against excessive heat may be behaviourial methods. Honeybees, for instance, maintain a constant colony temperature of around 34^0C and can survive mammal outside temperatures of up to about 49^0C by adjusting the rate at which they circulate air and evaporate water within the hive.

Mammals may lose considerable excess heat from their body surfaces Thus, those animals with a thick coat of fur may experience problems in losing heat in the event of elevated environmental temperatures. The large ears of rabbits assist in getting around this problem by providing an extensive surface for heat loss. Such loss can be reduced during cold weather by constricting the blood vessels which carry heat to the surface.

A different problem confronts the camel which lives in an environment which can become quite warm and where a shortage of water limits the use of mechanisms of losing heat in urine or by sweating. In this case, the animal's thick coat blocks the passage of heat from the surroundings into the body, whose temperature can also vary according to that of the surroundings.

Animals like the dog, on the other hand, lose heat by panting in which the flow of air causes cooling by evaporative loss.

The above examples indicate something of the diversity of the ways in which animals protect themselves against fluctuations of temperature in the world around them. This is, of course, in addition to crawling into burrows in the earth or holes in trees and going into a state of hibernation during the winter season.

ditions have acquired a low skin surface to body ratio by factors such as reducing the length of arms and legs With a reduced surface area to body size ratio, heat loss can be reduced. Conversely, people of tropical regions have been shown to have more sweat glands per square unit of skin surface to help in heat loss by evaporative cooling The darker skin colour of tropical people also facilitates heat loss by radiation, in addition to giving some protection against ultraviolet radiation. (White skin, fur or feather coloration also provides a camouflage effect when viewed against a background of snow and ice).

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Thermal regulation is of prime importance in homoeostasis or the maintenance of the "internal environment", described by the French scientist, Claude Bernard. Over a century ago, Bernard proposed that the "internal environment" must remain approximately constant for the body to function normally and that adequate mechanisms operate to ensure that the necessary balances are maintained.

Several mechanisms may be operative in the human to ensure heat balance and temperature control.

First, one may mention physical attributes which are found in people who have become genetically selected to be better fitted to the temperature conditions in which they live. For instance, people exposed to Arctic con-

Generally, however, thermoregulation in an individual is performed *via* the heat regulatory centre located in the hypothalamus of the brain. This performs much like a thermostat acting on feedback information received from other parts of the body. Heat loss and (or) temperature regulation is effected by a variety of mechanisms of which the activity of the sweat glands is under the control of the nervous system, which is in turn controlled by the temperature-regulating centre. Other methods by which heat is lost include that lost in the urine and by evaporation of water from the lungs. Thermoregulatory mechanisms can also effect changes of the breathing rate, level of blood sugar and the metabolic rate. The regulatory mechanisms may, however, be inadequate to maintain the body tempera-

ture at its normal value of around 98.6°F under factors such as disease, exposure, metabolic rate and hormones.

Further compensatory adjustments are necessary in acclimatization to hot weather above about 30°C (86°F). After a few days, this could result in more sweat glands becoming active, less water being eliminated through the kidneys and less salt being excreted through the kidneys and sweat glands as well. Acclimatization processes may also eventually influence the signals which trigger changes in sweating and peripheral (cutaneous) blood circulation.

Human Health

Insufficient information is available to be able to predict with any assurance the full extent of the effects global warming may have on human health. However, some general observations may be noted.

Firstly, one study on urban populations in the U.S. suggested that an increased temperature of 3.9°C caused an approximately four-fold increase in the number of deaths due to heat stress in a summer under conditions of partial acclimatization, while the figurewas further doubled in the absence of acclimatization. Elderlypeople are particularly afflicted by hot weather.

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Some studies in urban areas noted the increase in heart disease and stroke at temperatures over 25°C.

Climate change (e.g. temperature and humidity) could influence the spread and life cycles of organisms such as insects, bacteria and viruses, which may cause or transmit diseases. Mosquito-borne diseases, such as malaria, dengue, (arbovirus-induced) encephalitis, yellow fever and Rift valley fever may cause problems in the United States if climate change takes place. Another risk could be the movement to the U.S. from Central and South America of parasites which cause health problems, such as ascariasis and Chagas disease.

Scenarios have been calculated where global warming may take place at anything from 0.06 to 0.80C per decade. It has been suggested that by the year 2050, semi-arid tropical areas will increase in temperature by 0.3 to 5.0°C accompanied by a decrease in precipitation, while the humid tropics will, also, experience a rise of 0.3 to 5.0°C, but with an increase in rainfall. In high latitude regions, the average winter temperatures may increase by 0.8 to 5°C.

It is feared that elevated temperatures may lead to an increased incidence of premature births and mortalities around the time of delivery.

Among the other effects of warm weather may be those on the psychology of the individual leading to an increasing incidence of crimes of violence.

Other and complex effects will also occurwhich cannot be evaluated as yet in the absence of sufficient reliable data.

Agriculture

Possible effects on crops are more difficult to assess, partly due to inherent differences in heat tolerance. Global warming will not be uniform but will differ in extent and consequences from region to region. Freshwater resources will be affected.

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In addition to the probable geographical shifts of crop growing areas, a host of other factors will need to be considered in relation to global warming. These would include the possibility that increased atmospheric carbon dioxide (CO_2) will result in the more rapid growth of certain crops and that climate change will have effects on not only crops but also livestock, soils, pests and weeds.

Rice is the world's principal food crop as far as direct consumption is con-

cerned. A number of effects of temperature and CO_2 have been described on rice plants and on the rice cultivation ecosystem. These include 1) changes in grain production, 2) changes in photosynthetic rates, 3) altered water use efficiency, 4) altered competitiveness with weeds, 5) changes in nitrogen fixation by symbiotic organisms and 6) changes in problems caused by insects and diseases.

The above are only an indication of the lines of research that have been performed on the possible effects of global warming on rice production.

Fishedes

Global warming could affect manne fisheries in various ways It could affect the plankton, which is the starting point of the food chains on which the higher forms of marine life depend. It could change ocean currants and, thus, fish distribution, by changing nutrient and temperature patterns in the waters. Another way in which global warming could affect fisheries is by disturbing fish breeding grounds (e.g. estuaries, mangroves) following sea level rise or the alteration of freshwater inputs in these coastal regions.

The above discussion only briefly notes some of the ways in which climate change could affect some of out food supplies Among the other factors which have been discussed is, for example, whether we should reduce our consumption of meat since that would permit us to reduce our herds of cattle (a significant contributor, as noted above, to emissions of the greenhouse gas, methane). While this wili reduce overgrazing of the world s pasture lands, many other changes or shifts in our traditional food production and consumption

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patterns will be needed to meet the challenges of global warming.

Migrations

Shift will also be necessary for a large proportion of the world's population. About 50 per cent of the world's population lives in coastal regions. The global warming is expected to result in the melting of ice in the polar regions and the expansion of sea water. This may lead to a rise in sea level by 30 cm to 1.5 meters by around 2050 thus leading to the submergence of coastal and low-lying areas, This will lead to severe overcrowding and attendant public health and social problems. Similar problems are also attendant on disasters caused by violent storms (cyclones), whose frequency would increase under conditions of global warming and cause injuries and death in addition to damage to crops and fisheries. Global warming may also affect the availability of fuelwood to cook the available food.

The above account has attempted to sketch in a few of the health and food-related challenges which may be experienced due to the phenomenon of global warming. These challenges are not to be lightly taken. It is possible that entire nations such as the Maldives and some islands in the Caribbean risk being submerged in the event of a marked rise in sea level. We need to recognize that should this happen the people of these countries will need to be accommodated and provided for in other countries, which themselves will be experiencing population pressures. These adjustments will result in fresh political problems arising.

Finally, and in conclusion, it must be noted that many unusual problems are likely to lie ahead. For example, one may refer to the turtles, where the sex of the hatchlings of the clutch is greatly influenced' by the temperature at which the eggs are incubated. While the incubation temperature should lie between 28 and 33^{0}C, hatching at the higher end of the scale results in more males being produced and at the lower end in more females The influence of man's activities on global temperatures may well affect the survival of these and other species of living organisms in fairly bizarre ways.