SURVIVAL

life in extreme conditions
Volunteer roadworkers

In Lesotho, a small land-locked country in southern Africa, the land is subject to extensive erosion caused by severe drought followed by intensive rainfall, by heavy over-grazing, and fuel-wood cutting. To combat erosion, increase agricultural production, improve the road network and encourage the development of village woodlots, the Government of Lesotho, assisted by the United Nations World Food Programme, organized a food-for-work project with voluntary labourers. Women constituted 90 per cent of the work-force. Above, labourers shovel earth while widening a track into a road.
Editorial

Man has always lived dangerously, ever since his most distant ancestor, a hominid who probably lived on the African continent, took the first steps along the path of human evolution and discovered that a stone held in the hand could be used as a tool or a weapon.

From the dawn of history onwards, human beings continually courted danger as the struggle for survival schooled them in resourcefulness and impelled them to the limits of endurance. This determination to perform seemingly impossible feats is a thread which runs through the pattern of human destiny and helps to explain the extraordinary efforts made by human communities in various parts of the world to adapt to extremely rigorous environmental conditions. From the primitive hunters who confronted their prey armed only with a stone axe, to the space travellers of the late twentieth century who must reach peak physical and mental condition in order to spend long periods in a state of weightlessness, human beings have always shown capacities for adaptation both to the natural environment and to their self-imposed challenges. Man is by nature an inventive, forward-looking being whose relentless drive to master himself and the world around him is so strong that today some fear that it may even lead him along the road to destruction.

This issue of the Unesco Courier looks at the processes of human adaptation and endurance as they are revealed in a number of extreme and potentially dangerous situations. A medical doctor describes his gruelling experiences during a solo expedition to the North Pole on skis, while another scientist presents some of the findings of his extraordinary experiments in long-term confinement underground, cut off from the rhythms of the solar day. Other articles examine the ways in which space voyagers deal with weightlessness; the mechanisms of adjustment to high altitudes; adaptation to conditions in deserts and tropical forests, to life on and under the sea, and to the wear and tear of everyday existence in the modern world. Finally we evoke the phenomenal exploits of a Norwegian long-distance runner who a century and a half ago ran across Europe and parts of Asia and Africa at a rate of around 150 km a day.

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The Courier
A window open on the world

Published monthly in 33 languages by Unesco
The United Nations Educational, Scientific and Cultural Organization
7, Place de Fontenoy, 75700 Paris.

English  Italian  Turkish  Macedonian  Finnish
French  Hindi  Urdu  Serbo-Croat  published A selection in Braille is
Spanish  Tamil  Catalan  Slovene  published quarterly in English,
Russian  Hebrew  Malaysian  Chinese  French, Spanish and Korean
German  Persian  Korean  Bulgarian  Greek
Arabic  Dutch  Swahili  Sinhala
Japanese  Portuguese  Croato-Serb

June 1987
40th year

4
Survival
Human adaptation to extreme conditions
by Felix Z. Meerzon

8
It's tough at the top
Life at high altitude
by Gerardo Antesena, Mario Paz-Zamora and Enrique Vargas

12
Travelling light
Coping with weightlessness in space
by Oleg G. Gazenko

14
The time of our lives
Subterranean experiments on the rhythms imposed by the solar day
by Michel Siffre

16
The desert as a way of life
by Hamidou A. Sidikou

20
Hunter-gatherers of the tropical forest
by Laurentia Palade

23
The sea within us
by Dan Behman

27
Stress in the modern world
by Lennart Levi

30
Solo to the Pole
Interview with Jean-Louis Etienne

33
Marathon Man
by Bredo Berntsen

2
A time to live...
LESOTHO: Volunteer roadworkers

Cover; Caravan in the Sahara (Mauritania).
Photo @Maximilien Bruggmann, Yverdon, Switzerland
ADAPTATION, in human beings and in animals, is a process whereby the organism gradually acquires resistance to certain factors in its environment and consequently the capacity to live in conditions previously incompatible with life, and to solve previously unsolved problems.

To live in conditions previously incompatible with life" can mean complete adaptation, allowing a wide range of physical and intellectual activity as well as the perpetuation of the species in conditions of polar cold, desert heat or shortage of oxygen at high altitudes, just as it can mean a far from complete adaptation which permits only survival for a more or less extended period.

Likewise, "to solve previously unsolved problems" includes resolution of elementary problems, such as how to avoid attacks by predators by standing stock still—a passive defence reflex—or of more complex ones, such as travelling in space or controlling the life processes of the organism.

All these adaptive mechanisms have one feature in common: although in the initial phase of adaptation to any new factor the organism is close to the limits of its capacities, the manner in which it solves the problem is far from perfect. However, if the person or animal concerned survives, and the causal agent of adaptation continues to be active, the possibilities open to the organism increase and the extreme or urgent stage is replaced by one of effective, stable adaptation.

This transformation is the crucial moment in the whole process, and it often has remarkable consequences, as in the case of the experiments carried out by a Peruvian scientist who “lifted” in a pressurized chamber a group of people, some of whom were already adapted to high altitudes while others were not. When the pressure was equivalent to that at an altitude of 7,000 metres the novices lost consciousness, while the others continued playing chess.

Similarly, a healthy but untrained person can run a few hundred metres at the most without stopping to rest, whereas a trained runner can cover more than 40 kilometres. The cold weather which hit Western Europe in the winter of 1986-87 had catastrophic effects in some countries and caused a number of deaths. During the same period in Verkhoyansk, a town in eastern Siberia and one of the coldest places on Earth, eight- to nine-year-old children continued going to school in temperatures of -57 °C and herds of thoroughbred horses grazed as usual, watched over by their herdsmen.

In the field of intellectual activity, where adaptive reactions are qualitatively more complex, the transition from the stage of extreme tension to that of stable adaptation is manifested in an
In 1984 a group of walkers crossed a part of the Kara-Kum desert in the Turkmen S.S.R. during a Soviet experiment on life in desert regions. The walkers were not allowed to drink water during this endurance test, which was closely monitored by doctors. Right, a doctor examines two walkers during a rest period.

In 1979, a seven-man Soviet expedition reached the North Pole after a 1,500 km trek on skis across drifting ice. The expedition, which took two and a half months, made a notable contribution to knowledge about life in Arctic regions (see the Unesco Courier, January 1980). A ceremony (below) was organized at the Pole to celebrate the achievement.

Equally striking manner. This transformation of an unadapted organism into an adapted one is well known, and has been described in detail.

Two interrelated series of phenomena develop in the organism faced with a new situation. In the first series there is a rapid development in the function of the system most directly concerned in the adaptation process, for example the organs of movement, blood circulation or respiration when a physical effort is involved, or specialized parts of the brain during training and acquisition of new skills. The cells react by increasing the synthesis of nucleic acids and proteins, and a selective development of the structures limiting the function occurs. Thus, during adaptation to altitude or physical effort, the coronary arteries expand and there is a two to threefold increase in the number of "power stations" (mitochondria) in the skeletal muscles. As a result, a series of changes takes place in the cells of the dominant system, that on which adaptation depends, which increases the physiological capacity of the system and forms the material basis for the transition from an extreme stage to genuine adaptation.

The second series of phenomena is the well-known stress reaction discovered by the Canadian biologist Hans Selye, which he called "general adaptation syndrome". It is now known that the stress reaction manifested by the secretion of adrenal hormones into the blood not only mobilizes the organism's energy and structural resources, but also ensures their transfer from inactive systems to the dominant system. In other words, the reaction allows the vitally important problem created by the environment to
be solved. When adaptation has been achieved and the individual has become accustomed to the cold, or learned to solve mathematical problems or to play the piano, the stress reaction disappears. Adaptation to other physical or chemical factors in the environment takes place in the same way (e.g., gradual habituation to increasing doses of poison).

Afterwards the organism can no longer be damaged by the external factor to which it has become adapted. It is remarkable that the multiple reactions set off by the process of adaptation to one environmental factor frequently contain components which heighten resistance to other factors. Thus adaptation to an insufficiency of oxygen strengthens the organism's resistance to physical effort, hallucinogens, epileptogens, factors producing high blood pressure, stress damage to the heart, ischaemia (interruption of the blood supply to an organ or tissue), and even to ionizing radiation.

This opens up vast possibilities for the utilization of adaptation in the prevention and treatment of diseases. Nowadays, when extensive use—and in some cases abuse—of medicines creates a real possibility of dependence on them, it would be useful to have doctors prescribe, not only medicines, but adaptation to a complex of individually selected factors.

It is now known that external stress can provoke or speed up the development of gastric and duodenal ulcers, high blood pressure, arteriosclerosis, ischaemic heart ailments, diabetes, mental disorders, skin troubles and—as has been shown recently—tumours.

Below, Soviet divers study the diffusion of light underwater, during research in the Indian Ocean conducted by the Marine Biology Institute of the USSR Academy of Sciences Centre for the Far East.

However, the role of stress in certain pathological conditions is now so well known that it may obscure the important fact that most human beings and animals, placed in extreme conditions from which there is no escape, do not die but acquire some degree of resistance which allows them to survive until better times. Such situations—prolonged periods of hunger, cold, natural catastrophes, interspecific and intraspecific conflicts—still occur widely among animals in their natural habitat.

More complex stress situations occur just as frequently in human society. During a relatively short historical era man has survived periods of slavery, serfdom and world war in such a way as to prove the efficiency of his powers of adaptation. Of course, the price of this adaptation has been unjustifiably high, but these indisputable facts inevitably lead to the conclusion that the human organism must be
endowed with efficient specialized mechanisms that limit the reaction to stress and prevent stress damage.

Research carried out in the last decade has confirmed the existence of these stress-inhibiting mechanisms. It has been shown that under pressure from extreme tensions, the stress reaction is accompanied by intensified activity of the central stress-inhibiting systems. One example is the increased production in the brain of morphine-like opiate peptides and other substances which limit the stress reaction. These substances accumulate in the brain and neutralize the stress-inducing excitation of the nerve-centres.

The activity of the stress inhibitors also intensifies in the other organs, where substances accumulate that limit the action of stress hormones on the cells and prevent stress damage. The dual activity of central and local stress inhibitors protects the organism from gastric ulcers, heart damage, impairment of immune systems, arrhythmia, and injury caused by chemical factors.

These facts generally correspond to what can be observed in everyday life. People who have experienced terrible ordeals acquire a certain resistance to the wear and tear of life. Moreover, the possibility can now be envisaged of employing substances produced by stress-inhibiting centres, equivalent substances produced by synthesis, and the chemical activators of such inhibiting systems, as substitutes for the natural mechanisms of adaptation, in order to protect the organism from stress and other forms of damage. This theory, now largely confirmed by experiment, opens up highly promising prospects for the prevention and treatment of non-infectious diseases.

The little town of Verkhoyansk in eastern Siberia (Yakut Autonomous S.S.R.) is one of the coldest places on Earth. Common winter temperatures of -60°C do not disturb the tenor of life. A hardy local breed of horses is raised on a Verkhoyansk farm, above.
The overwhelming majority of the world's population live between sea level and an altitude of 3,000 metres. Only some 15 million persons live in permanent settlements between that level and 4,800 metres, mainly on the high plateaux of the Andes in South America, and of Tibet in Central Asia.

Altitude inevitably imposes constraints on people who live in these regions. In the first century AD, Pan Kou, a Chinese historian, described in these terms the Karakoram mountain range in Central Asia: "It is necessary to cross two mountains, one large and one small, which make the head ache. The earth lies naked there, on the scorching slopes, and the human body loses its colour because of the heat; the torrid sun causes headaches and nausea, and it has the same effect on animals ..."

Father José de Acosta, a Jesuit missionary to the New World, describes acute mountain sickness in his treatise Historia natural y moral de las Indias (1590; Natural and Moral History of the Indies, 1604), and relates it to the fact that at such altitudes "the air is so subtle and so refined that it is unsuited to human respiration, which needs air that is thicker and more temperate ..."

What exactly is meant by the term altitude? Altitude in the sense of environment consists of a number of physical factors, principally the lowering of barometric pressure1 and therefore of the partial pressures2 of respiratory gases, the wide range of variation in day and night temperatures, increased solar radiation and a greater incidence of high-energy heavy particles in the atmosphere.

The lowering of barometric pressure is by far the most important factor as far as man is concerned, and it is an unavoidable constraint to which technology has found no practical long-term solution. Consequently, the values of the partial

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1. Atmospheric pressure as indicated by a barometer, usually of mercury, and expressed in several different systems of units, such as pounds per square inch, or millimetres of mercury.
2. The pressure that a gas, in a mixture of gases, would exert if it alone occupied the whole volume occupied by the mixture.
pressure of respiratory gases, especially that of oxygen in the arterial blood, are usually taken as the basis for determining the physiological limits of altitude. "Physiological" altitude therefore does not correspond to physical altitude. On the one hand, the fall in atmospheric pressure is not directly proportional to height above sea level; on the other, the oxygen content of the blood is not a simple function of the partial pressure of oxygen in the air. Three levels can be distinguished, according to the value of the partial pressure of oxygen in arterial blood:

- above 70 millimetres of mercury, changes in the partial pressure of oxygen (i.e. in altitude) have little effect on the amount of oxygen contained in the blood. (The normal arterial blood pressure at sea level is 90 millimetres of mercury);
- between 70 and 40 millimetres of mercury, the effect of the fall in the partial pressure of oxygen becomes more noticeable;
- below 40 millimetres of mercury, the oxygen content of the blood falls considerably and more or less constantly with small changes in the partial pressure of oxygen.

Altitudes of less than 3,300 metres correspond to the first level; there are no significant effects on the oxygen transporting function of the blood.

The Ourou Indians live in floating settlements on Lake Titicaca, one of the world's biggest mountain lakes (8,340 km², altitude 3,812 m), on the border of Peru and Bolivia. Above, a group of Ourou Indians in their boats made of bundled reeds.
Harvest scene in the Dolpo Valley (Nepal), 4,000 m up in the Himalayas. Barley is the only cereal grown in the valley.

It is impossible for man to live permanently at the third level—above 5,500 metres.

Altitude, in the physiological sense of the term, thus corresponds to a level of between 3,500 and 5,500 metres (a barometric pressure of between 500 and 370 millimetres of mercury).

The main problem for the human organism in such an environment consequently lies in transferring oxygen from the atmosphere to the cells.

Like the higher animals, man has two active transfer mechanisms: the respiratory system, and the circulatory system which distributes to the various tissues the oxygen bonded to the haemoglobin in the blood. At an altitude of over 3,500 metres the partial pressure of oxygen in the air is insufficient to saturate the haemoglobin. Respiration and circulation rates are therefore the most affected.

People living at high altitudes have more red corpuscles and more haemoglobin circulating in their blood, and this makes up for the fall in the partial pressure of oxygen. This increase in red corpuscles at high altitudes allows the cardiac output to return to, or sustain, its sea level value. These two responses, greater cardiac output and an increase in the number of red corpuscles, have the same purpose: to convey to the tissues the oxygen they need, despite its rarefaction in the atmosphere. The first is an immediate functional response; the second is more adaptive and takes over from the first.

Reduced barometric pressure is not the only constraint due to altitude; cold is usually an associated factor. Some physiological responses to cold, such as decreased circulation to the skin, are also among the responses to altitude hypoxia.3

Man is thus not naturally suited to life at high altitudes; all the regulatory and control mechanisms of the human organism work in accordance with sea level conditions. However, in temperate and tropical regions people live at heights where the barometric pressure is close to half that of sea level, and most of the body's functions have adjusted accordingly.

People have travelled through and lived in high altitude regions since ancient times. They have served as places of refuge or as extensions of land used for stock-rearing, for example. The inhabitants have adapted physiologically to these exceptional living conditions, but they depend for subsistence on the poor pasture land which feeds the animals they raise, and they are always at the mercy of a severe winter which could decimate their beasts. They also rely on the water supply from glaciers to irrigate their fields.

The people who live in the high plateaus of South America or Central Asia lead an active life as farmers and herdsmen. Their extensive empirical knowledge of the soil and climatic conditions has enabled them to create a highly efficient system of terraced irrigation and cultivation. They follow a sowing timetable which ensures that crops can be harvested in the minimum of time, and they know how to cross-breed animals to increase their resistance and how to store food as a precaution against irregular harvests. The growing of cereals and the raising of animals are closely interdependent, for intensive agriculture is only possible if manure is available.

The Andean peoples grow potatoes, maize (corn), fava beans and quinoa (a plant of the Chenopodium family) and raise llamas and vicunas. They use the wool and meat of another camelid, the alpaca, as well as its skin and its fat, which is thought to have therapeutic powers. The breeding of these animals and of oxen and sheep, which were introduced in the sixteenth century, is their main livelihood: a herd of 200 animals is needed to maintain a family of six.

3. Deficiency in the amount of oxygen delivered to the body tissues.
Several centuries of exploitation of mineral resources have led some peoples to settle at altitudes of around 4,800 metres—at the Chorolque mine in Bolivia, for example. In Central Asia, the farmers who live in the southernmost and easternmost valleys of Tibet grow barley, peas and, more recently, potatoes on irrigated land. They also raise oxen and sheep.

Nomadic tent-dwelling herdsmen in these regions live entirely by stock-rearing. In the main they breed animals such as yaks, sheep, goats and horses, which are well suited to the conditions. The yak provides them with milk, from which they make butter and cheese, as well as meat, skins and hair; it is also used as a beast of burden. These nomads control the greater part of the transport and trade in salt, bartered for grain from the lower-lying valleys.

In order to obtain food and survive at high altitudes, the inhabitants of the Andean and the Central Asian mountain ranges have developed production systems designed to subjugate nature, reduce risk, and make the most of available resources (in the case of the Andes, by making the maximum use of the ecological zones at different altitudes). Their aim is to take from the environment all that is necessary to meet their needs, at the same time eliminating or reducing climatic risks. This is a basic feature of the relationship between high mountain societies and their environment, and it is to be seen not only in agriculture and stock-rearing, but in all the other activities of their life—the procurement of food, shelter and a dwelling-place.

The very wide range of individual reactions suggests that altitude may have had a selection pressure on peoples living permanently in high-altitude regions, and that throughout the generations such selection may have favoured people who were better suited to develop favourable responses and, even more, to reduce those responses likely to prove unfavourable.

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Entrance shaft of the “Siglo XX” tin mine, part of Bolivia’s most important mining complex. The Bolivian writer Sergio Almaraz Paz has written of this mining region, over 4,000 m up in the Bolivian Highlands or Altiplano, “There is no colour; nature is clad in grey. Contaminating the belly of the earth, the ore has transformed it into a desert.”
Coping with weightlessness in space

by Oleg G. Gazenko

It is just over a quarter of a century since man first ventured into space. An assessment of the achievements of astronautics so far indicates that man now has a firm foothold in the realm of space travel and that the human factor will be decisive in the conquest of outer space.

Today systematic study is being made of all aspects of the Universe, with priority being given to the exploration of the Earth from space and to the use of space technology to solve many of the problems of our planet.

Every space flight makes an important contribution to this enterprise, furthering the study of the Earth's natural resources and of the world ocean, the application of new technologies and the development of new products (especially pharmaceutical compounds and biological substances which are difficult or impossible to obtain on Earth because of the effects of gravity) and the monitoring of the environment.

Cosmonauts are remaining in space for longer and longer periods and are required to perform increasingly numerous and complex tasks, including manoeuvres outside their spacecraft, which call for continual progress in medical research to ensure that space travellers remain healthy and capable of working at full capacity.

Already, the findings of such research have opened up new perspectives on the workings of the human organism, leading notably to a greater understanding of the general laws governing adaptation to the environment, and above all adaptation to such an unusual condition as weightlessness, which man does not experience on Earth.

Throughout its long evolution the human body has never had occasion to make use of mechanisms capable of compensating for absence of gravity. On the contrary, the whole evolutionary process has been to fight against the force of gravity, in order to survive in the continual heaviness imposed by the Earth's gravitational pull. Gravity influenced the development of the structures and functions of the cardio-vascular system, the motor system and the central nervous system.

The degree of adjustment that we have attained, which makes us human, is thus a logical development, and the individual in the course of his life is capable of refining and improving that adaptation, just as he can lose it, at least in part, usually through ageing or illness. However it has been observed that this can also happen to young, healthy subjects when they travel in space and experience weightlessness.

Before the first manned space flight, some scientists claimed that man would be incapable of working in a state of weightlessness. They even went so far as to declare that a normal human being would be psychologically unable to cope with the state of weightlessness and the cosmic void. The space flight of Yury Gagarin resoundingly disproved these pessimistic predictions and, by showing that human beings can indeed journey through space, flung open the gateway to the stars.

How does weightlessness influence the human organism? What changes does it produce, and what shocks can it cause against which preventive measures should be taken?

Weightlessness first of all produces a sensation of disequilibrium and of floating, due to a disruption in the normal functioning of sense organs such as the vestibular apparatus of the inner ear, sight, touch and muscle awareness. The cosmonaut has the impression of flying upside down or falling. Sometimes this is accompanied by disagreeable and very uncomfortable sensations of giddiness, weakness or nausea. The form and duration of these symptoms vary greatly from one individual to another. On more than 200 space flights, two-thirds of the subjects experienced them to some extent, lasting for periods ranging from a few hours to several days. Subsequently the symptoms wear off, only to reappear, as a rule, for the first few hours or days after returning to the Earth's gravitational field.

The absence of gravity subjects the car-
dio-vascular system to a redistribution of the total amount of blood in the body: instead of accumulating in the lower part of the body, the blood tends to rise into the thoracic and cephalic regions. This modifies the regulation of the heart and the metabolism of the cardiac muscle, which gradually weakens, and also causes a loss of tone and elasticity in the veins of the legs. If this state is prolonged, the absence of blood pressure causes a deterioration in the reactions of the cardio-vascular system to physical effort or to movement, and it starts to "run down".

As the influence of weightlessness continues, other forms of reaction emerge, owing to the lack of demands made on the bones and muscles. Indeed, without gravity, no effort is required to move around inside the space station or to shift objects from one place to another. A gradual functional atrophy of the muscles occurs, starting with those which are used to combat gravity, hold certain positions and compensate for the Earth's gravitational pull during movement. This leads to a partial wastage of the muscle mass, especially the muscles of the legs and back.

Decalcification of bone tissue occurs through loss of calcium salts and phosphorus, but this has never reached alarming levels, even on the longest space flights. However, if effective measures are not taken, decalcification could become a serious obstacle to longer manned space flights.

These phenomena and other physiological reactions to weightlessness are primarily functional and do not constitute a threat to cosmonauts' health. Furthermore, it is abundantly clear that human adaptation to the state of weightlessness signifies, to some extent, a loss of adaptation to the conditions of life on Earth. A rather singular situation then arises: the more complete the adaptation to weightlessness, the more difficult is the process of readaptation after re-entry. All cosmonauts who have spent time in orbit are familiar with this experience. How far this process can be a threat to their health is difficult to determine. Adequate scientific evidence is lacking to enable a valid judgement to be made, since for all space flights lasting more than three weeks various methods have been used to protect the cosmonauts from the negative influence of weightlessness.

In view of the increasing duration of space flights, doctors have been obliged to devise ways and means of countering too great an adaptation to weightlessness, in order to ensure that the mechanisms indispensable to life governed by the Earth's gravitational field continue to function effectively. It has been necessary to prevent the body's systems from "forgetting" their terrestrial vocation and to "remind" them of their role on Earth.

These measures include, first and foremost, physical training on bicycles and moving running-tracks to tone up the muscles. During long space flights, cosmonauts walk approximately 3 kilometres a day, and cycle for some 10 kilometres. The amount of exercise depends on the day in the training cycle, the duration of the flight and the individual characteristics of the body. Additional exercises using extensors and other apparatus can also be carried out if necessary.

To prevent circulatory disorders, the cosmonauts have to exercise while negative pressure is applied to the lower part of the body. They put on a special gar-

Above, two cosmonauts take a shower on board the orbiting Soviet space station Salyut 7.

Left, a cosmonaut (foreground) works out on an ergometric bicycle in the Soviet space station Salyut 7. This type of exercise is vital to enable the body to readapt to Earth's gravity after a time spent in space.

Much is now known about the body's reactions to weightlessness, and how these reactions come about is largely understood. The general impression is that man is capable of adapting satisfactorily to a prolonged state of weightlessness, then of re-adapting to gravity and smoothly returning to a normal and useful life on Earth.

However, since human health and safety are at stake, it is important to assess each new step in space exploration with meticulous accuracy, and to pay the closest possible attention to the smallest details in the growing store of experience. Nothing must be overlooked, from the remote consequences of space flights already undertaken to the difficulties and complications likely to be faced on future flights. Science, especially biological and medical research in space, has a long way to go in order to perfect knowledge of Man and the Universe and penetrate the complexities of the interaction between the two, thereby helping to achieve a harmonious relationship.

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Subterranean experiments on the rhythms imposed by the solar day

PHYSIOLOGISTS since the time of Hippocrates and probably even earlier have demonstrated the important ways in which man is conditioned by environmental rhythms, especially the twenty-four-hour alternation of night and day.

In man, as in other animals and plants, rhythmic variations in a whole range of physiological functions—alternation between sleep and waking activity, formation of glycogen (animal starch) in the liver, temperature change, metabolism, for example—occur regularly every twenty-four hours.

Known as "circadian rhythms" (from the Latin circa: "about", and dies: "day"), these more or less independent or interdependent rhythmic variations, operating throughout the day/night cycle, constitute the mechanism that is termed man's "biological clock".

These circadian rhythms are of considerable importance. If they are interrupted or too rapidly or abruptly thrown out of phase, serious physical and psychological troubles can result. It is common knowledge that total deprivation of sleep over a period of several days is certain to entail marked deterioration in mental and physical performance. After an east/west or west/east flight of only a few hours it may take a passenger's rectal temperature rhythm as long as fifteen days to adapt to the appropriate rhythm of the new local time.

It is generally held that, under normal conditions on earth, environmental factors, and especially the alternation of night and day, act as phase-setters or synchronizers which maintain the coincidence between human circadian rhythms and the local twenty-four-hour time scale. What, however, would happen to our biological rhythms, to the bundle of nerve cells whose precise location in the brain is now being established and which register the periodic signals of the environment, were those signals to be suppressed?

Botanists and biologists have known for a long time that cycles of about twenty-four hours continue in many plants and animals even when they are kept either in total obscurity or in continuous light. However, concentrated research on the adaptation of the human organism to an aperiodic environment, that is to say to an environment in which the normal phase setters or synchronizers are lacking, only began in earnest in 1962.

The three main situations in which these conditions apply are those in which people find themselves living for long periods in space, underground or under water. Would the human organism continue to show evidence of regulation by circadian rhythms once deprived of the environmental synchronizers it had known throughout the millions of years of human evolution? Are there, in fact, other rhythms specific to the human organism?

This was the crux of my long-term experiments, deep in an underground cave, which have added to our knowledge of how man adapts to a timeless, aperiodic environment. These experiments have shown how
complex that adaptation is and how much it varies from individual to individual, and how fundamental is our understanding of the mechanism of human circadian rhythms. Without synchronizers, without time “landmarks”, whether natural (alternation of day and night) or artificial (clocks or watches), each individual’s internal rhythms appear to be, but in fact are not, synchronized with the rhythms of local time. The change from a circadian to a forty-eight-hour cycle is that for just a few days from twenty-four to forty-eight hours (thirty-six to forty-eight hours of continuous waking activity and fourteen to twelve hours of sleep), for others this may not happen for several months. A comparison between my 1962 experiment (when I was isolated on the underground glacier at Scarasson in France from 16 July to 17 September) and my second experiment in 1972 (205 days alone in Midnight Cave, Texas) shows clearly the unreproducibility of the sleeping/waking cycle.

A significant outcome of this spontaneous change from a twenty-four-hour to a forty-eight-hour cycle is that for just a third more sleep than is normal under ordinary conditions of life it is possible to double the period of waking activity, a very considerable potential increase in creative activity, entirely naturally and without having recourse to any form of drug, for a period of several weeks.

Desynchronization of the circadian rhythm of sleep and waking activity is paralleled in most of the other physiological rhythms examined, such as the cardiac rhythm, the rhythm of the rectal temperature, of potassium and of the hydroxycorticosteroid hormones.

I believe that this desynchronization is an adaptive response by the organism to the aperiodicity of the environment. This brings me to the second group of important findings concerning the structure of sleep in a timeless situation. We were the first to undertake such studies which were carried out in 1966. Under a forty-eight-hour sleeping/waking cycle the human organism theoretically builds up a sleep deficiency or debt. The question then arises as to which of the major stages of sleep (see below) is reduced to compensate for the abnormal (thirty-six-hour) period of waking activity. Progress in this field of research was only made possible by underground, atemporal experiments. Previous experiments on sleep had been carried out within the context of local time and of a circadian (twenty-four-hour) sleeping/waking cycle. Consequently, the natural variations in the various stages of which sleep consists could only be very limited. The relative proportions of what is known as REM (Rapid Eye Movement) sleep and the four other stages of sleep could only vary minimally around the mean average, which itself varied according to the individual concerned and the time of the year.

However, the spontaneous changes in periodicity of the sleeping/waking cycle (cycles of 12, 24, 26, 28, 36, 48, 60 and even 72 hours) occurring within the framework of my “out of time”, aperiodic experiments revealed the natural evolution of the time devoted to each stage of sleep, especially to REM sleep and to what is known as Stage 4 sleep (deep sleep), as a function of total sleep and in relation to the biological cycles and the waking period.

In short, the neurophysiological adaptation of the human organism in an “out of time” setting is marked by profound modifications in the internal structure of sleep, which vary from individual to individual, and which can be summarized as follows:

- Whatever the duration of the sleeping/waking cycle, the proportion of REM sleep can be accurately forecast since there is a precise linear correlation between REM sleep and total sleep, of which it is a function. This phenomenon was observed for the first time in man during my experiments underground.

- When the period of continuous waking activity doubles (rising from 16 to 36 hours), total sleeping time does not double. However, REM sleep increases in a ratio of about one to ten to the length of waking activity.

- The change from a circadian to a forty-eight-hour sleeping/waking rhythm does not affect the period (some 90 minutes) of REM sleep, which remains stable.

To conclude this brief survey of the time factor in human adaptation, it should be recognized that it is an imperative necessity for ever more penetrating studies to be carried out on the desynchronization of circadian rhythms in order to increase man’s vigilance and operational capacities. The study of the desynchronization of the biological clock is all the more essential in that unavoidable desynchronization creates fatigue in many situations in modern life—night work (total inversion of the cycle), work in revolving shifts (continuous and prolonged desynchronization), east/west and west/east travel (involving almost continuous desynchronization for certain personnel). Life around airports and other sites with high sound levels, work in exceptional surroundings (missile silos, tanks, submarine-spotting aircraft, nuclear submarines, spacecraft and space laboratories).

Finally, when the organism is synchronized (that is to say, when it is subject to the normal circadian rhythm of twenty-four hours), the effect of many medicines varies according to the time of day that they are taken. Consequently, any change in the periodicity of the sleeping/waking cycle (resulting, for example, from an east/west or west/east jet flight) or of the organism’s other rhythms, could have repercussions on the action of the medicine, altering or even reversing its therapeutic effect.

— Michel Siffre, French speleologist, devised and carried out the first major experiments in voluntary human confinement. These experiments, effected in caves in France and the United States, produced new information relating to biological rhythms, psychological time, sleep and dreams. He is the author of some 50 scientific papers, 8 books and 5 films.
To survive in a harsh world man has no option but to adapt to the physical and climatic conditions of his environment. In doing so he must develop strategies which are often reflected in salient features of his culture and society.

The peoples of Niger, and especially the Tuareg, the Tubu, the Kanuri, the Guézébida and the Arabs who live in the difficult conditions that prevail in the arid and semi-arid regions of the country, are no exception to this universal rule. Individually and collectively, their way of life is influenced, if not determined, by the need to adapt to the rigours of a climate in which the dominant factors are wide temperature variations, their duration, occurrence and intensity.

Over two-thirds of Niger’s total area of 1,267,000 square kilometres consists of desert and semi-desert zones situated between latitudes 15° and 23° North. Of this vast expanse, the Ténéré Desert, bounded to the west and north-west by the Air massif and to the north and north-east by high plateaux whose southern limits are marked by impressive cliffs, itself covers more than 350,000 square kilometres.

In these climatic zones, a combination of factors related to rainfall, atmospheric humidity and seasonal temperature variations normally gives rise to four distinct seasons of varying length.

The rainy season, which lasts from July-August to September, is short and irregular. When it does rain, the precipitation is often slight, but sudden violent storms are a threat to those whose houses are made of low-quality earth containing a large proportion of salts which dissolve rapidly in the wet.

From the end of September to the end of October there is a short intermediate season characterized by both high atmospheric humidity and very high temperatures. This is followed by a dry, cold season lasting from November to March when an east wind, the Harmatan, brings dry mists which are liable to be transformed into violent sandstorms, and temperatures fall below zero at night.

Finally, there is a hot dry season which extends from March to June or July. This is the season of very great heat, with temperatures reaching 45°C or more. The maximum daily temperature range which is generally experienced at the beginning and end of the dry season may be as great as 20°C, while the range between the absolute minimum and maximum temperatures may even reach 40°C, if not more. An extraordinary capacity for adaptation is required of
peoples subject to such rigorous climatic conditions. This adaptation is reflected in every aspect of their lives. The strategies they adopt are in many cases indissociable from the organization of society and from housing, clothing and diet.

In this setting, human activity is strictly ruled by the existence of watering places. Because they are so rare, they have great economic value and are decisive factors in the determination of social status. Three branches of human activity—stock-raising, agriculture and manual labour—appear to be directly determined by the harsh climatic conditions.

Stock-raising activities not only fulfil economic requirements but also meet the need to adapt to the climate with its great variations of temperature. Camels and cattle are the main species raised, primarily for the production of milk which is the basic element of the diet. Since camels are more hardy than cattle, they can be raised in wide open rangelands and are able to adapt more easily to variations in soil composition and grazing vegetation.

The available quantity of milk, which serves as both food and drink, varies from season to season, and this is why two complementary species are chosen for its production. Thus camel's milk, which is available in adequate quantities during the hot, dry season, is appreciated both for its very rich vitamin content and for its low fat content, characteristics which are thought to increase endurance and resistance to hunger. It is also said to have remarkably beneficial effects on eyesight. The absence or very low proportion of visually handicapped people among populations whose diet is based on camel's milk may be partly due to its high mineral content.

Camel-herders also engage in trans-Saharan trading. One reason for this is the need to reconcile the differing demands of life in complementary ecological zones. Until it declined following successive droughts which decimated the herds and destroyed the vegetation on which they depended for grazing, the caravan trade, in which tens of thousands of camels were still involved only a few years ago, was of more than just economic significance. It was one of many responses to the particular environmental conditions and perpetuated a whole way of life through a wide-ranging network of social relationships.

Knowledge of the location of watering places is a key factor in this way of life in areas where the water supply is a matter of fundamental and permanent concern. Agricultural activity is thus limited to the area around oases where a permanent supply of water is available. Date-growing is the mainstay of this irrigation agriculture adapted to the seasons. Dates,

An Inhabitant of Bilma, a large town in Niger, carries loaves of household salt for family consumption.
which are an important item of trade with the regions to the south, are a source of food, according to their quality, for both man and beast.

Manual labour is primarily concerned with the exploitation of salt and natron. The latter, a hydrous sodium carbonate, is an essential element in animal feed since it meets the animals' salt requirements and also rids them of intestinal parasites, thus boosting their milk production.

The concern to adapt diet to environmental conditions, which always underlies human behaviour, is also apparent in the unusual, some would say immoderate, consumption of tea. A beverage that both quenches thirst and staves off hunger, tea is served ceremonially. It plays a part in creating physiological mechanisms for adapting to the variations in temperature.

Dress is another important indication of adaptation to the environment. The wearing of the veil and the turban are not only of social significance (attainment of adult status, for example), they also serve to protect the head, and in particular the eyes, nose and ears against the effects of low temperatures, the stinging blast of hot or cold winds and sandstorms. The wearing of voluminous clothing, usually made of cotton, is a form of adaptation to high temperatures.

Finally, housing, its conception, the materials used in its construction, and the use made of it in relation to the seasons, is another important element in adaptation to climatic conditions. In the Kawar region of Niger, for example, where, in past centuries, fortified villages were constructed for security reasons, four main types of dwellings are found.

Stone houses, the last relics of those troubled times, are used during the dry, cold season because they offer better protection against sharp drops in temperature.

Salt pans at Tegguidan-n'Tessoum, Niger. Salt is produced by solar evaporation of the brine in each pan. Workers' legs are covered with ulcers caused by walking knee deep in the brine.

Finding, transporting and storing water is a major preoccupation for Saharan nomads. Right, women of Niger carry water in gourds, an indication that they belong to a semi-sedentary village (since caravanners use water containers made of goatskin).

During the hot, dry season, houses constructed of date-palm leaves come into their own. Cool, airy and well ventilated, they are divided into rooms designated for different functions. A room reserved for the head of the household adjoins the entrance; there is a room for the women and children, a store-room for food or for animal fodder, a kitchen, and a living-room in which meals are taken.

Tents, which are made of skins or of rush matting, vary in size according to the means of the occupants. They are always put up on a north-south axis with one or two openings on the east and west sides to allow air to circulate and the rays of the sun to enter. Tents are all-the-year-round dwellings which can easily be dismantled.
They are set up on top of dunes during the hot season and in spots protected by vegetation among the dunes in the cold season. The tent is the perfect example of a dwelling fully adapted to the climate.

Straw huts, whose dimensions vary according to economic considerations and to the availability of straw, itself dependent upon rainfall, are used both as temporary shelters and permanent dwellings. In the latter case they are used mainly during the rainy season and in the hot season since they offer the best protection against rain and great heat.

These are some of the strategies developed by the peoples of Niger who live in very hot desert areas. Their purpose is to provide a minimum of comfort by adaptation to temperature conditions which remain, throughout the year, a matter of primordial concern.

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Loading a camel with its cargo of salt in the sandy plain of Tenéré. Salt is a vital commodity for man and animal in the desert, where it is still transported by camel caravans and serves as a form of currency.
Between 100,000 and 200,000 Pygmies live in equatorial Africa, scattered through the forest which extends from the Atlantic Ocean to the great lakes of the east. Remarkably well adapted to conditions in the tropical forest, they live by hunting and gathering. Below, a Uganda Pygmy hunter with animal hides for use as drumskins. Beating drums is a form of communication between isolated groups in the forest.

Tropical forests form a green band around the Equator, extending roughly 10° North and South. This means that they account for only a small proportion, about 8 per cent, of the Earth’s land surface. Yet they comprise almost half of all growing wood on the face of the planet, and harbour at least two-fifths of Earth’s plant and animal species, a genetic resource of increasing importance to humanity through agriculture, medicine and industry. They also comprise the most complex and diverse ecosystems on Earth, which fulfil regulatory and productive functions that are essential to man and to his natural environment.

The question of human adaptation to conditions in tropical rain forests has been examined in a number of scientific studies on groups of hunter-gatherers such as the Pygmies. The existence of such peoples is recorded in ancient times. Representations of them dating back over 4,000 years are found on ancient Egyptian bas-reliefs from the tombs of pharaohs of the Vth Dynasty. They are mentioned by Homer in the Iliad as well
Moist, dense, broad-leaf evergreen forests with many epiphytes (*air plants* growing non-parasitically on trees and other plants and deriving their nutrients from the air).

Drier, more open, partially deciduous forests with relatively few epiphytes.

World distribution of tropical forests

Pygmies are to be found in most of the world's tropical forests. They are fairly numerous; the Ituri Pygmies of Africa, for example, number some tens of thousands. Operating in small groups of from five to thirty-four individuals, they live a semi-nomadic life adapted to conditions in the rain forest which are as extreme and pitiless as those of the cold and inhospitable Polar regions.

Light penetration of the forest canopy is minimal. Virtually all ultraviolet rays are screened out. The accumulated heat and humidity is so intense that the atmosphere is like that of a greenhouse. The average temperature is 28°C, with variations no greater than from 3°C to 9°C. Average relative humidity is 95 per cent at night and 60 to 70 per cent during the day, with only slight seasonal variations. Winds are also very light, except when there is a tornado, and the air is extremely rich in carbon dioxide and is laden with scent elements, formic vapour and microscopic particles of hair, scales and fibres. Rapid breakdown and transformation of organic matter is ensured by micro-organisms, which teem in the heat and humidity.

The level of evapotranspiration is very high—three times the average for the planet as a whole. The forest floor is permanently moist and a protective layer of branches and leaves is essential should you wish to lie on it. Ants and termites abound. Like the flora, the fauna of the forest is rich and varied. Animal life is "stratified", with different species living at different levels. Monkeys and birds live in the higher levels of the canopy where conditions are easier and food is more abundant.

The tropical forest is not very generous to the people and the larger animals who live at ground level. Food is difficult to find and they sometimes have to be content with fruit that has been dropped by monkeys. At night, the large predators venture out to the open savannah at the edge of the forest and to river banks and abandoned cultivated plots. Game consists mainly of small antelope. At the same time, the inhabitants of the forest are under constant threat from insects, parasites and arboviruses, a group of viruses that develop in anthropods such as mosquitoes and are then transmitted by bites to vertebrate hosts.

One indication of adaptation to forest life is to be seen in the fact that forest-dwelling elephant and buffalo are, in general, half the size of their counterparts living in the savannah. The forest people, too, weigh less and are shorter than those who live in open country. A comparative study undertaken in Africa has shown that forest-dwellers weigh, on average, 39.8 kilograms and are 1.44 metres tall, as compared with 62.5 kilograms and 1.69 metres for inhabitants of the savannah. In comparison with other population groups, their oxygen consumption during effort, their pulmonary capacity and their cardiac rhythm are above average. They show no signs of protein deficiency or malnutrition.

Their small stature gives the hunter-gatherers of the tropical forest a definite advantage in the form of a relatively high work capacity under difficult climatic conditions. A well organized routine, with major activities carried out early in the morning or late in the evening, helps them to avoid excessive perspiration. In fact, despite the dampness of the atmosphere, they sweat very little. In general, they maintain a satisfactory state of health and, among those who live in a...
Below, a Yanomamo Indian. The Yanomamo, with a population of over 15,000, live in the luxuriant tropical forests of Venezuela and Brazil.

In order to adapt to the constraints of a life of hunting and gathering in the forest, the Pygmies, like nomads, have had to reduce their material possessions to a minimum. Those they do have are easily replaced. All they need is a stick to dig with and a leaf to drink from; a hollow stem provides a pipe for them to smoke. As a general rule they manage without anything that is too heavy to carry, such as pots and pans and looms. The forest provides them with liana, bark and branches with which to build their huts, make their beds and clothe themselves. They make strings for their bows and padding for their shields from raffia fibre. From the hide of the game they kill they make belts. They carve traps from roots and make wicker griddles which, placed over a fire, enable them to smoke the flesh of big game. Food is cooked in large leaves.

Hunting, upon which the survival of the group depends, is traditionally a male preserve. It has had a profound effect on both the individual and the collective mentality and has forged family and social structures. The forest is a foster-mother who must be respected. It is tacitly accepted that no animal should be killed or tree felled unnecessarily. Game is usually caught with a net made of interwoven liana and its meat is shared out in accordance with a strict ritual. Gathering, which is left to the women, is a complementary source of food. The produce of the forest—fruit, roots, leaves, mushrooms—is abundant. Certain insects, such as caterpillars and termites, are gathered, as is honey. The forest also provides products for bodily care and the treatment of wounds, sickness and infirmities.

These forest people know their environment to perfection. Far from being overwhelmed by their natural surroundings, they are well organized and lead an active social life—festivities, palavers, dancing—and have a culture rich in tradition, myth and legend.

The uncontrolled clearing of tropical forests for agriculture presents the forest-dwellers with problems of adaptation to their changing environment and may expose them to health and other risks. The pathogenic agents found in a forest environment attack man more readily in a cleared area than in an intact forest, where they concentrate on the primate and rodent population. An increase in the incidence of malaria, cardio-vascular troubles, physiological ailments and nutritional imbalances has in fact been noted.

The exploitation of forest regions constitutes an indispensable economic development resource in many tropical countries. In order to achieve a judicious strategy which respects the natural balance, Unesco’s Man and the Biosphere Programme (MAB) is currently engaged on a project to study the ecological effects of increasing human activity on tropical and subtropical forest ecosystems. It is hoped that this project will help to answer the many scientific questions raised by land use planning in the tropics.

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The sea within us

by Dan Behrman

Traditional method of tuna fishing off the coast of southern Spain. As the shoals of fish move from the warm Mediterranean waters towards the Atlantic the fishermen trap them in large nets stretched between their small wooden boats. The giant fish are then hooked and pulled aboard.

The sea flows inside us—literally. In our blood as in seawater, the proportion of dissolved salts is the same: 3.5 per cent. Like all other forms of life, we emerged from the sea, yet despite such links, our attitude towards it is ambivalent. The sea inspires awe and fear, it is so unlike the landmasses that we inhabit. The vastness and solitude we now associate with outer space have always been present at sea. Even close to land, the surf waits to take its toll.

With the ending of the Ice Age 10,000 years ago and the subsequent rise in sea level, peoples everywhere found themselves driven back by the invading waters. Peninsulas became islands, the land bridge between Asia and North America was swamped and early coastal settlements drowned on what is today’s continental shelf. The story of the Flood is found in cultures worldwide; perhaps dim memories of the encroaching sea gave birth to the legend of Atlantis sinking beneath the waters.

But the ocean gave life as well as taking life away. Fish were plentiful and easy game; archaeological finds along the western coast of Europe include Stone Age bone fish hooks big enough to catch deep sea fish. The seine nets, the trolling gear and the traps devised by the Inuit
mittens, for if he slipped, he was a gone man. All the boats were hoisted in on deck and there was nothing to be lowered for him. We had need of every finger God had given us. ... Frequently we were obliged to leave off altogether and take to beating our hands upon the sail, to keep them from freezing.” Such Olympic exploits were part of the daily business of moving passengers and cargo.

Until the end of sail, a seaman’s life was a constant flirtation with death. And now? Kipling’s “call of the off-shore wind and the voice of the deep-sea rain” can still be heard, but can it be answered? Hardly, on the automated tankers and cargo carriers of today. Noel Mostert, author of Supership, describes such a vessel: “One felt the arid metal acreage spreading invisibly all around, and its impact was one of menace: a mechanical desert of indefinable purpose imposed upon the sea’s own emptiness, and with forms and shapes that had no reassuring familiarity; it was filled with wind signs, not those of masts and rigging but of abandoned structures upon a plain, and there was no comfort even from the sea.” Mostert perhaps saw his vessel as a precursor of unmanned ships of the future, sailing under remote control.

There are still those who must seek the sea—fishermen, oceanographers, divers—and they are of a different breed. The attitudes of small-scale fishermen have not changed over time. They still live in small egalitarian communities where growth is not a goal and information is shared in co-operative networks.

Above, the “Triton”, an early breathing apparatus for divers, named after the son of the sea god Poseidon. In Greek mythology, Triton lived with his parents in a golden palace in the depths of the sea.
Right, two women aquanauts, a botanist and a zoologist, carry out an experiment on fish behaviour as part of a U.S. marine research programme on the sea bed. The scientists lived for two weeks in a 4-room habitat at a depth of 15 m in the Caribbean near St. John Island (Virgin Islands).

Left, a diver about to take the plunge from HMS Tedworth, protected by the cumbersome type of diving suit used in the 1930s.

Sociologists observe that fishermen tend to defer their pleasures and ritualize their risk-taking behaviour. Risks there are: the death rate of fishermen is seven times higher than the average. And they are a vanishing species, as booming leisure activities encroach on their beaches and shellfish beds.

Not all fishing fits these descriptions. Big trawlers are more like factories, as William W. Warner points out in Distant Water: "Not since the great age of whaling have men stayed at sea for such protracted periods ... and no whaler ever suffered the continuous and exhausting work schedules of the modern distant water fisherman." Despite their size, these ships fell victim to storms, especially in winter when they were top-heavy with ice. Adoption of 200-mile economic zones shut them out of rich shelf waters and rendered them obsolete. Warner sees a future with smaller medium-range ships such as "autoliners" that can handle 15,000-hook lines entirely by machine.

Oceanographers are another variant of the human species found only at sea: not only must they survive aboard small ships but they must do scientific work as well, collecting data with precision. I once went out on an Icelandic research ship and took my turn taking Nansen bottles' off a wire as they were winched in. All waste motion had been eliminated from this series of movements that had to be repeated tens of times a day, hundreds of times a voyage. The captain, his big tousled head stuck out of the port window of the bridge, made a special effort to keep the wire within my easy reach. With the help of propellers and rudder, he could move his 800 tons of ship literally by the inch in the empty grey water.

I thought of the oceanographer on this voyage, Svend Malmberg, reading the thermometers on his Nansen bottles to an accuracy of a hundredth of a degree, when I came across an account of the contrasting life on board an oil rig 200 kilometres out in the Gulf of Mexico with four 2,000-horsepower generators roaring night and day. Crew members worked seven 12-hour shifts on this platform, then hoped that bad weather would not hold up their relief. Drilling for oil is probably the least nautical of all occupations pursued at sea, but it is not necessarily the safest. Oil rigs cannot run from a Gulf hurricane or a North Sea storm.

Divers, too, are essential to these cities on the sea when it comes to finishing up a wellhead or troubleshooting on the bottom. One of the oldest of the maritime trades is here put to good use by one of the newest. Divers were going down for pearls in the Babylonia of 4,500 years ago, using the breathhold technique that now allows them to stay under for 4 minutes at depths of up to 45 metres (the record for such diving is 90 metres).

In the nineteenth century, diving suits fed by compressed air from the surface were invented, allowing divers to spend more time on the bottom but bringing in the danger of the bends, that painful and potentially fatal condition engendered by nitrogen bubbles forming in the blood. Now that man was moving in this totally alien environment he had to adapt to it, to the lack of oxygen, to the cold, to the distortion of vision by water pressure on the eyes.

He did this with the hard-hat diver's suit invented in 1819 by a German engineer, Augustus Siebe, that still left the diver attached to the surface. Then in 1942, the Frenchmen Jacques Cousteau and Emile Gagnan came up with their independent breathing device, the Aquaplu, and the scuba diver was born. Here was a new animal, free-swimming into the depths.

It was soon apparent that many psychological and physiological adjustments had to be made. Nitrogen under pressure in the divers' air led to "rapture of the deep" or the so-called "martini effect" (each 15 metres of depth equals one dry martini). An oxygen-helium breathing mixture took care of this but created new problems: a high-pitched "Donald Duck" voice and extreme cold.

Diving tables were developed to show

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1. Metal water-sampling bottle equipped with closing valves and a mercury thermometer to record temperature at specified depths.
2. Scuba = self-contained underwater breathing apparatus
how much time was needed in decompression for a stay at a given depth. Once a diver is “saturated” at his depth, the decompression time is the same no matter how long he stays there. Understanding of this principle led to the first attempts to colonize the sea floor, the underwater habitats of the 1960s and the 1970s. Unlike man-in-space missions that demand rockery within the capability of only a few nations, man-in-the-sea experiments could be carried out by a number of countries. Among them were France, the United States, the Soviet Union, the German Democratic Republic, the Federal Republic of Germany, Israel, Poland, Czechoslovakia and Canada (which set some kind of a record with an “underwater Volkswagen” costing only $15,000).

The French were first to develop a manned underwater station, with Cousteau’s Conshelf, then the U.S. Sealab was constructed. All sorts of problems arose in the habitats. Humidity gave rise to infections, particularly in the ear, and wounds were slow to heal. Cooking could be tricky—dough just will not rise in a high pressure environment and if a can of fizzy drink is opened the bubbles go inward. (Some habitats solved all this by having their meals sent down from the surface in containers.) Cuisine may not be all that important, since many aquanauts reported a loss of their sense of smell and taste.

It has been found that during the first five days of habitat living, people show signs of stress which then go away only to reappear after fifteen days. Life under the sea is shipboard or submarine life carried to an extreme. Like space travellers, aquanauts occasionally resented “ground control” at the surface with its constant monitoring of their behaviour. The telephone could be a hated intruder, constantly interrupting their routine.

And people had to get on well together. In one habitat, scientists at first found themselves at odds with seamen doing simulated salvage work, but they ironed out their differences. Everyone would probably agree with the Soviets aboard Chernomor, who in 1971 reported in the newspaper Izvestiya: “The psychological problems caused by the confinement of several men together for long periods of time was of great concern before the start of the programme. Under these conditions it is well-known that men may tend to find fault with each other, that a man’s silence may be taken for sullenness, a very neat man may be accused of being fussy. ... There were some problems aboard the Chernomor during the first few weeks but soon the crew came to appreciate the abilities of the other members and no new problems arose.”

There have been no recent experiments in underwater living. Instead of remaining on the bottom, divers can now be brought to the surface in personnel transfer capsules and live in pressurized deck chambers until they go down again. But there will always be underwater explorers, just as there were navigators on the surface. Perhaps they will benefit from that ultimate transformation, the invention of an artificial gill through which the diver’s blood will flow and take up oxygen from the water, as fish do.

Then the age of the sea people will have truly begun.

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An engineer makes a tour of inspection inside one of the legs of a natural gas drilling rig in the North Sea.
Stress in the modern world

by Lennart Levi

According to United Nations statistics, the world’s urban population has doubled since 1950 and may double again by the end of this century, by which time three-quarters of the population of developed countries and one-third to one half of the population in developing countries will be living in cities. Current estimates suggest that as a result of both population growth and migration, the number of poor people clustered in slums and shanty-towns is increasing annually by 10 to 15 per cent. Conditions in these places are appalling. The result is tension, depression and violence superimposed on physical hardship and a constant threat of disease.

According to the Athenian statesman Pericles (495-429 BC), “health is that state of moral, mental and physical well-being which enables man to face any crisis in life with the utmost facility and grace”. This ancient definition highlights two critically important points: firstly that health concerns man’s interaction with his living conditions, and secondly that he may lose his capacity to adapt if the life crisis is severe enough.

Much more recently, this insight has been echoed in the terms of a Swedish measure, the Public Health Service Bill (1984-1985), which declares that “Our health is determined in large measure by our living conditions and lifestyle. ...” The Bill goes on to state that “The health risks in contemporary society take the form of, for instance, work, traffic and living environments that are physically and socially deficient, unemployment and the threat of unemployment, abuse of alcohol and narcotics, consumption of tobacco and unsuitable dietary habits, as well as psychological and social strains associated with our relationships—and lack of relationships—with our fellow beings.”

The Bill strongly advocates what is called a “holistic approach” to such problems and attempts to solve them, meaning that “people’s symptoms and illnesses, their causes and consequences, are appraised in both a medical and a psychological and social perspective”. Bearing this in mind, let us look at some of these possible “causes” in the human environment, including some of those in the world’s major cities in developing and developed countries.

According to recent United Nations and World Bank statistics, half of the countries of Africa and southeast Asia, including four of the five largest, with a combined population of almost 2,000 million, have an annual median per capita income of less than $300. This mass poverty leads to hunger, undernourishment and malnutrition for vast legions of children in the developing world.

In the worst of cases, children die. In the “best” of cases, they grow up with physical and mental disabilities. When they reach sexual maturity, therefore, it is even more difficult for them to plan their families and care for their children, who then become even more malnourished, even more disabled, and even less competent to care for the following generation of children. Thus a descending spiral is created causing morbidity, death and suffering for hundreds of millions more in the poor countries of the world.

According to recent UNICEF reports, in the developing countries 15 million children die annually before the age of five, most of them because of lack of potable water, adequate nutrition and basic hygiene. In many African and some Latin American countries, plagued by hunger and shortage of water, this means almost every other child.

The Food and Agriculture Organization of the United Nations (FAO) and the World Bank report that at least 430 million human beings are malnourished or undernourished. In the developing countries about 60 per cent of the population has no access to safe potable water; 75 per
cent has no access to basic hygiene—simple latrines, ways to dispose of household rubbish, and personal and food hygiene.

Only 19 per cent of the population of these countries has access to housing of acceptable quality. Four out of every five households live in miserable huts in the countryside or in shacks made of burlap, cardboard and sheet metal in the slums of the large cities. Public health services are available to less than 15 per cent of the rural and urban poor.

Such conditions cause acute physical and psychological and social stress by creating threats to survival, health and well-being, to self-esteem, to close attachment to others, to the sense of belonging to a valued group. These threats can in turn provoke potentially pathogenic reactions leading to further increases in sickness and mortality rates.

But causes of psychological and social stress are also extremely common in developed countries, in all types of social and economic systems. In the United States, for example, 13.7 million children have unemployed or absent fathers. One out of three white and three out of five black children will experience marital disruption before reaching the age of sixteen. Most of them will grow up in women-headed families, which are six times as likely to be below the poverty level. In 1978, 17 per cent of all children in the United States under eighteen (11 per cent white, 27 per cent Hispanic, 41 per cent black) lived in poverty, i.e. in conditions of run-down housing, heavy traffic, overcrowding, risk of contagion, accidents, injuries, pollution, violence, abuse and neglect.

When people are exposed to stress-inducing conditions of this kind—whether it is a question of lack of control over their lives, combined with excessive demands, unsatisfied needs, expectations that cannot be fulfilled, overstimulation, or role conflicts—most of them experience “dysphoric” reactions such as feel-

Above left, an oral health clinic in Thailand. In the developing countries the provision of medical treatment, vaccination and safe drinking water is an essential part of a global approach to environmental health risks which also takes into account other aspects of the “human ecosystem” such as malnutrition resulting from mass poverty. The Rheumatic Heart Centre, established at the foot of the Great Pyramids at Giza, above right, came into being thanks to the initiative of a Cairo voluntary association.

In the developing world some 15 million children die annually before the age of 5, mostly because of lack of safe drinking water, adequate nutrition and basic hygiene. Left, Niger has launched a community-oriented nursing programme to improve child health care. Below, monitoring the growth of a toddler at an open-air clinic in Nicaragua.
ings of anxiety, depression, uneasiness, apathy, alienation and hypochondria.

In Sweden, statistics produced by the National Board of Health and Welfare (1978) show that every third four-year-old has mental problems (with symptoms such as bed-wetting, aggressivity, nocturnal fears). Every third adult suffers from malaise, sleep disorders, fatigue, dejection or anxiety. Every seventh working person is mentally exhausted at the end of the working day. Every other man and three women out of four will suffer from pronounced mental decompensation some time in his or her life up to the age of sixty. Every tenth man has an alcohol problem. Two thousand people commit suicide every year, and 20,000 attempt to do so (in a population of 8.3 million).

Taken together, these figures mean that approximately every third or fourth Swede lives a life in which malaise, anxiety, fatigue or dejection is a common component. Moreover, the situation did not improve from 1968 to 1974, in spite of a considerable increase over this period in material wealth and social security. This rather alarming picture assumes a further dimension when related to the ambitious goals and very considerable material means of the Swedish welfare state.

According to studies recently summarized by the World Health Organization (WHO), there are at least 48 million drug abusers in the world. But this is only one example of stress-related pathogenic behaviour. Others include tobacco dependence, quoted as the primary cause of one-third of all cases of cancer, 75 per cent of chronic bronchitis and 25 per cent of myocardial infarction in the United States.

As well as reacting emotionally to the stresses and strains of modern life and behaving in potentially disease-provoking ways, we also react physiologically—with our internal organs. Coping with stress influences basic physiological reactions in our central nervous system as well as our ductless (endocrine) glands. The biologically active agents of the glands,
the hormones, together with nervous impulses, influence virtually every cell in the organism. If prolonged, pronounced, or recurrent, such reactions can eventually lead to physical ill health.

A WHO report (1986) also mentions the high prevalence of somatic symptoms resulting from psychological and social distress, i.e. in cases with no ascertainable organ pathology, or with complaints of discomfort disproportionate to the physical problem. This accounts for from 30 to 50 per cent of all consultations in developed countries and for from 15 to 25 per cent of those coming to the attention of health care personnel in developing countries—the largest single complaint category in primary care.

Altogether, the resulting conditions make for an extreme and ever greater suffering for over one-quarter of mankind. It is true that people can adapt even to extreme environmental influences. Yet, as indicated above, this adaptation takes its toll in terms of emotional, behavioural and/or physiological deformation. Although a cause-effect relationship is difficult to prove in specific cases, circumstantial evidence supports the existence of such a relationship.

In developed and developing countries alike, governmental action against such problems is often of a troubleshooting nature; it addresses only one or a few specific problems. It may include the provision of medical treatment, vaccination, food shipments, or wells of potable water. Not infrequently, it takes the form of acute disaster aid in situations where disasters are usually chronic. In such cases, intervention is usually administered by one of many specialized agencies, with no or insufficient co-operation with other specialized agencies. One health problem—say, ill-health caused by pollution—may therefore be attacked, while another, such as poverty-induced undernourishment, is neglected, or vice versa.

This brief, oversimplified account illustrates the existence of many interacting and pathogenic factors in the human ecosystem. If one of its components is influenced, effects will occur in many of the others. Consequently, it will probably be impossible to cope successfully with current and future urban and health problems by considering—in research, therapy and/or prevention—just one or two of the components of the total ecosystem. Success will be more likely if as many as possible of the critical ones can be taken into account.

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Solo to the Pole
An interview with Jean-Louis Etienne

On 11 May 1986, forty-year-old Jean-Louis Etienne, a French nutritionist and doctor specializing in the care of athletes, reached the North Pole after a solitary hike lasting sixty-three days. Wearing cross-country skis and pulling an ultralight sledge, he had covered 750 kilometres in temperatures as low as -52°C and in winds of up to 100 kilometres an hour. The Unesco Courier talked to him about his exploit.

What motivated you to undertake your solitary walk to the North Pole? Was it the challenge of a great sporting achievement, or was it the scientific interest of an experiment designed to measure the limits of human resistance in an extreme environment?

It was neither. The fact is that such motives are often advanced to give respectability to a taste for adventure, a love of open spaces and the pleasures of discovery. There is really no need to go such a long way just to carry out a scientific experiment. It would be perfectly possible to set up a cold chamber right here in Paris and live in it for three weeks, or two months, at a temperature of -47°C. For me, to go to the North Pole was a dream, just as earlier I had dreamed of climbing Mount Everest, rounding Cape Horn, or sailing round the world. It was also a human and, above all, a technological challenge.

What exactly do you mean by that? What equipment did you take with you?

The North Pole is located in the centre of an ocean of ice, the Arctic, but it is no skating rink! The terrain is very uneven. The ice is cracked, sheets are superimposed on sheets or collide and compress to form ridges. You can never see the horizon, and your progress is constantly hampered by the ice which can be completely churned up for kilometres on end. It is rather as if you decided to cross Paris in a straight line by walking across the rooftops. What is more, this extremely difficult terrain is only accessible for about two months of the year, between the beginning of March, when the Polar day dawns, and mid-May, when the ice-pack begins to break up as summer approaches. It is a real race against time, and to travel fast you have to travel light. To equip myself for this undertaking I made use of materials that have the best low-temperature performance. With the aid of an
engineer friend of mine, I perfected a sledge made of Kevlar, a light but very tough polymer which is being increasingly used in aeronautics. The sledge was 2.20 metres long by 60 centimetres wide and weighed 3 kilograms. I managed to get the load down to 30 kilograms. To keep my bearings on the ice-pack I carried with me a small Kevlar-encased safety-beacon-cum-radio-emitter, the signal from which was picked up by satellite and transmitted to a computer at the Centre National d'Etudes Spatiales (National Space Studies Centre) in Toulouse, France. Michel Franco, who was acting as my back-up at our base camp at Resolute Bay on Cornwallis Island in the far north of Canada, questioned the computer by telephone every evening and then informed me of my position. The beacon-emitter was powered by lithium batteries which are capable of withstanding extremely low temperatures.

Did you also use a compass?

No. The magnetic pole, to which compass needles point, is some 1,500 kilometres from the geographical pole through which passes the axis of rotation of the Earth, and it was to this “true” North Pole that I was heading. Furthermore, compasses are disoriented by the magnetic fields in this region. Here the sun is the only guide. I therefore had a watch made on which the hour hand made only one complete revolution in twenty-four hours. Knowing that the sun is in the east at 0600 hours, in the south at 1200 hours, in the west at 1800 hours and in the north at 2400 hours, all I had to do to find my bearings was to point the hour hand in the direction of the sun.

Why did you travel on skis?

Skis are indispensable. The ice-pack is fractured and there are crevasses everywhere, into which it is easy to fall unless you take great care. Skis enable you to cross them. In most places the ice-pack is from 2 to 3 metres thick, but where it breaks the water freezes again forming a very thin skin of ice. Skis spread your weight over a larger surface and enable you to walk over very recently-formed ice. I used nordic cross-country skis to the undersides of which I had stuck synthetic anti-slip skins. In the past, people used sealskins for this purpose because of the rigidity of the seal's body-hair which enables it to climb on ice without slipping. When, once a fortnight, Michel Franco brought me fresh supplies by airplane, he would also fit me out with new skins.

What did you have to eat?

Drawing on the recorded experience of previous polar expeditions, I had concocted some special food rations. At the beginning I allowed myself a daily ration of 4,000 calories. However, this proved to be insufficient and I was somewhat hungry, so I stepped up my daily ration to 5,000 calories. My meals for a day were vacuum-packed in bags of about 1 kilogram. As this was dried food I would melt some ice to go with it (only newly-formed ice is salty; old surface ice loses its salt by gravity). I would heat up the water on a petrol cooker (at those temperatures gas is unusable) and pour it on the dried food to produce a kind of porridge. In the evenings my supper consisted of soup and a freeze-dried pre-cooked dish.

On his expedition to the North Pole Jean-Louis Etienne took specially designed lightweight equipment weighing 50 kg, left. His sledge weighed only 3 kg.

The surface of the ice-floe is rugged. The blocks of ice fracture, collide against each other and impact to form walls extending over several km.

Did you also draw on the cold weather survival techniques of the inhabitants of the far north? Did you, for example, dress in their fashion?

Not at all. These people are hunters who live in encampments, do not travel far and do not go in for comparable, long-lasting physical or sporting activities. They are not interested in the North Pole, where there is nothing and where life is not possible, and they have never been there. In this they are similar to the Nepalese who would not dream of climbing Everest. As far as dress is concerned, clothes are now made that are much warmer and much lighter than traditional Eskimo clothing. The clothes I wore were made of Qualofil, a synthetic fibre with very good insulating qualities.

Your journey lasted sixty-three days. Can you describe a typical day?

I used to get up at four in the morning and set off at six. I would walk for eight to ten hours a day, until about three or four in the afternoon. Then I would stop, switch on my beacon-emitter and put up my tent. After that I would have a snack and rest until seven, when I would contact Michel Franco by radio. After that I would write up my log book, have my evening meal and go to bed.

Weren't you ever afraid that you might go to sleep in the cold and never wake up again?

No. When you are in good physical shape, as I was, you are always first woken up by
Nutritionist and medical doctor, Jean-Louis Etienne devised the contents of compact rations to provide him with 5,000 calories a day. The food was freeze-dried and vacuum-packed in numbered packets each weighing 1 kg. Supplies were flown to him every two weeks.

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LONG-DISTANCE running has enjoyed a popular revival in recent years, and runners such as Paavo Nurmi, Emil Zatopek, Abebe Bikila and Grethe Waitz are household names. But it was 150 years ago that the greatest runner of all time was at the peak of his career. He was a Norwegian named Mensen Ernst.

His real name was Mons Monsen Oyri. He was the son of a poor tenant farmer from Leikanger on the Sognefjord where he was born in 1795. He lived there until he was about fifteen years old, when he moved to the town of Bergen. He went to sea, and won his first competitive run in Cape Province in 1813.

As a seaman and adventurer he visited the American, African, Asian and Australian continents, acquiring along the way survival skills that were later to help him navigate, wheedle and bluff his way through his extraordinary journeys. The only surviving contemporary portrait of the “Running King”, as he was known in Norwegian, shows him cradling a sextant.

In 1818 he arrived in London. It is here that he officially became a “pedestrian”, a runner or walker who covered long distances in return for money. Here he also took his professional name, Mensen Ernst. His subsequent career was to last for twenty-five years.

His first important run was in the spring of 1819, from London to Portsmouth (116 kilometres) in nine hours. His popularity was assured when he then covered the 240 kilometres from London to Liverpool in thirty-two hours.

After a time he began to long for the Continent, however, and in 1820 crossed the Channel again, travelling on foot to Annenrode manor in Mühlhausen (in what is now the German Democratic Republic), where he made a number of life-long friends. From then on he lived as a professional runner, and his fame as the greatest runner of all time spread quickly as he ran from city to city—Berlin, Prague, Rome—across the Continent. In 1826 he put on a demonstration in Copenhagen, where the high fees he earned included 100 “daler” from the Danish King Frederick VI. Ironically, his native Norway was one of the few countries through which he never ran.

After some years Mensen Ernst came to see himself as something of an internationalist. He became a genuine traveller, curious about foreign cultures and customs; he learned to speak French, English and German well, and knew some Italian and Turkish.

How did Ernst adapt to the extreme conditions encountered on his journeys, the burning sun, cold winds, pouring rain? We know that he had a strict set of rules that he followed all his life. He stuck to a simple diet, for example: mostly bread and cheese, a few vegetables, less frequently cold meat; but he never ate warm food. He also preferred to sleep outdoors, believing that lying on hard ground kept the body supple. If he did sleep indoors it was always on a hard bench, never a soft bed. His only weakness was for wine, which he used to drink by the bottle even on his runs, but with no apparent ill effects.

By the time he returned to Paris from his Moscow run, Mensen Ernst was a hero. He had become a living legend who attracted rapturous audiences of thousands.

In 1833, he set out from Munich for
Nauplion, then the capital of the newly founded state of Greece. He suggested to King Ludwig I and Queen Therese that he carry documents for their son, Otto I of Greece, and after a delay of some months his offer was accepted. His departure on 6 June was cheered by a crowd of 20,000 outside Nymphenburg Palace.

This was a particularly dramatic journey, partly because of the rugged landscape, partly because of some unusually severe problems Ernst encountered along the way. In Montenegro he was set upon by five robbers wielding pistols and swords; as well as his money, they took his maps, compass and quadrant, but fortunately not the letters. He managed to find his way to the town of Cattaro, where he got food and drink, new maps and compass, and started out again—only to be arrested as a spy. He spent three days in jail before he was freed by the Pasha of Janina, who “looked more like a Western general than an Oriental Pasha”, as Ernst later said.

On 1 July he stood outside the King's residence in Nauplion to receive his award of 1,000 guilders. He had covered 2,700 kilometres in just over twenty-four days. Allowing about four days' delay for various mishaps, he had done the run in twenty days, or about 135 kilometres daily. These statistics are so extraordinary that we are lucky to have contemporary sources to verify them.

Ernst’s third and most dramatic project began with an offer by British merchants of the East India Company in Constantinople: £150 to carry important documents to Calcutta. He left on 28 July 1836. The vigorous Norwegian had the thought the journey would take perhaps six weeks; in fact he did it in four, on a route that took him through Anatolia, and finally across the Indian sub-continent.

On his twenty-eight-day return journey he took a more northerly route: Lahore, across Persia to the Caspian Sea, Teheran, Tabriz, and up to the Black Sea. He covered about 8,300 kilometres in fifty-nine days, 150 kilometres daily allowing for a three-day rest in Calcutta.

The newspapers of his day praised his achievement in completing the Asiatic tour. The Times on 24 March stressed “the unquestionable certificates” held by Ernst.

His fourth epic run was to be his last. It began when the German author, proprietor and adventurer, Count Hermann von Pückler-Muskau, thirty years before Stanley and Livingstone, asked him to find the source of the White Nile. Count Hermann had a keen interest in running stemming from a visit to Greece in 1837, when he had watched the Marathon and heard about the Norwegian’s exploits four years previously.

Ernst left the Count’s estate in Prussian Silesia on 11 May, 1842. He passed Constantinople and reached Jerusalem in thirty days, and then ran the 500 kilometres to Cairo. After some months in Cairo he headed south along the Nile.

But now his luck had run out. He succumbed to dysentery on 22 January 1843, ending his legendary career in the desert near Syene, now Aswan. Ten years later a Norwegian newspaper declared: “The world will never see his like again.” Nor has it!

BREDO BERNTSEN, of Norway, is deputy librarian at the University of Oslo. He is the author of a book about the life and times of Men¬sen Ernst, Loperkongen (“The Running King”, Oslo, 1986), and of many other articles and books including Naturværnets historie i Norge (1977, “The History of Nature Conservation in Norway”).

The desert near Theben, north of Syene (now Aswan) in southeast Egypt, where the great runner died from dysentery in 1843.
The Courier

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Different walks of life

Above, at an altitude of some 4,000 metres, a traveller and his pack-animals wend their way above the valley of Dolpo in the Himalayas (Nepal); below, a woman aquanaut carries out an experiment near an underwater habitat in the Caribbean (see page 25).