MAN IN SPACE

A new dimension in Health Care

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OPSOMMING

Nuwe wetenskappe, ruimtebiologie en ruimtemedisyne, wat ontstaan het uit die mens se eksplorasie van die buitenste ruimte, het vêrreikende implikasies vir gesondheidspersoneel op aarde.

Ruimtetegnologie en die gevolge daarvan, wat hul voordoen in die vorm van nuwe, miniatuur — en meer effektiewe instrumente wat gebruik word vir diagnose, behandeling en rehabilitasie, is besig om 'n rewolusie in medisyne en verpleging te ontketen. Biologiese eksperimente wat in die ruimte uitgevoer word lei tot die ontwikkeling van nuwe medikasies en vooruitgang in die genetika; nuwe velde in kliniese navorsing word ontbloot; en hierdie kennisontploffing het ernstige etiese en morele implikasies vir die praktyk van gesondheidsorg.

INTRODUCTION

Unprecedented advances in technology and science in the 20th Century have enabled man to take himself and his inventions on voyages of space exploration. It has been man's dream for centuries, not only to fly, but also to explore the vast outer reaches of space. Modern space exploration, the new frontier, is a triumph for the new sciences of space biology and space medicine.

Space medicine would appear to be a very new science, but the beginnings of this specialisation goes back a hundred years with the first biological experiments done on animals in rarified atmospheres. The rocket was known long before other means of mechanical transportation appeared, but its practical use as a means for making possible the penetration of a human being into outer space, has become possible only recently.

Before manned flights could take place, certain fundamental principles in space biology had to be established. As far back as 1908, a Russian scientist, K Tsiolkovsky, put forward the idea that space scientists will confront biological problems in manned space flights. Space medicine as a science was necessarily preceded by space biology, but the boundaries of the two disciplines today merge to the extent that they are almost inseparable.

DEVELOPMENT OF SPACE BIOLOGY

There were three stages in the development of space biology:

Stage 1 — Preliminary investigations in laboratories

Achievements in applied physiology, aviation medicine, radio-biology and other related sciences had established sufficient theoretical premises to permit first biological experiments in rockets. Aviation medicine, in particular, promoted the development of space medicine.

Stage 2 — The conduct of biological experiments during animal flights in rockets

Stage 3 — Preparation of astronauts for flight.

The fundamental problems of space biology are as follows:

- the investigation of the effects of a long-term space flight on man and other living organisms
- the discovery of conditions and factors that may unfavourably affect the inhabitants of a space ship
- the development of corresponding means of protection
- medical provision for prolonged space flights, involving co-operation with engineers to develop life-support systems, ship controls, and devices for checking the hygienic parameters of the cabin and the physiological state of the crew. This included problems of health maintenance and preventive and clinical medicine
- establishing adequate medical criteria for proper selection of crew and effective methods of preparing them plus developing special training aimed at improving their endurance under unusual conditions
- providing for prolonged space flights by developing life-support systems modelled on relationships between human organisms and the terrestrial environment — achieved by biological re-cycling of matter using solar energy
- studying life conditions and extra-terrestrial life forms and taking precautions against uncontrolled contamination of space, and the reverse — the contamination of our planet with extra-terrestrial life.

The abovementioned problems have very nearly settled into routine engineering work, and research is now directed mainly towards measures for human survival at bases on the moon and planets.

MAN IN SPACE

Space medicine is involved in three distinct phases of a space programme:

- pre-flight research
- the space flight itself
- post-flight tests and research

Pre-flight research

Pre-flight research for manned space flight involves biological and physiological research into the ability of the human organism to withstand the hazards of space travel. From the biological point of view there are three groups of hazards connected with space travel. They are:

- flight dynamics factors such as acceleration, vibration, noise and weightlessness
- factors connected with outer space as a peculiar habitat such as ultraviolet, infra-red and visible radiation, ionising radiation, barometric pressure, peculiarities of temperature and control
- factors involved in the long stay of an organism under the artificial conditions of a hermetically sealed cabin of a space ship including isolation, limited room, peculiarities in feeding, the diurnal cycle and micro-climate

The selection and training of astronauts

Much of the background knowledge of aviation medicine has been applied in the selection and training of astronauts. Past experience in aviation has led to the following requirements for qualification:

- the candidate must be a university graduate with a degree in physical science or engineering. Lately doctors and geologists have been included
- he must have had training as a test pilot
- he must be in superb physical condition
- he must possess the right psychological and physical attributes for space flight
- he must not be taller than 5'11"
- he must be under 40 years of age
- he must be a volunteer!

During selection candidates are subjected to rigorous testing to determine their reactions to various stresses such as weightlessness, acceleration, heat, isolation, tumbling and fatigue.

Although prospective astronauts undergo years of training, it is still not possible to rule out the possibility of something going wrong on a flight. To give one example — vestibular or air sickness and the varied responses of individuals to weightlessness, spinning and tumbling can cause problems. Air sickness, however, has also been described as an *unsatisfactory rationalisation of fear.* Subjects, who have passed all tests successfully, might nevertheless succumb to genuine deep fear which takes hold when a man is confronted with the incessant awful threat of the cold, silent nothingness from which body and soul are separated only by a fragile sheet of metal.

Physiological hazards connected with flight dynamics

Acceleration and deceleration

The human organism can endure any velocity provided it is not accompanied by excessive acceleration. To illustrate, the earth travels around the sun at a speed of 100,000 Km per hour and at the equator the rotation on the earth's axis causes a velocity of 1675 Km per hour and yet we do not notice all this motion.

To offset the effects of excessive acceleration during lift-off, engineers have developed a technique known as *staging.* G-strain caused by acceleration motion, affects the organism as does gravity, but with more intensity. The degree of human endurance of G-strain depends therefore on the length of time it is applied and the position of the body while it is being applied. *Staging* helps to alleviate the stress caused by G-strain and acceleration rates can be kept tolerable. Furthermore, human tolerance to acceleration is determined to a significant extent by the amount of body distortion produced by the force. This distortion, particularly blood displacement, seems more important than other results of the force itself. Consequently tolerance is improved when displacement or distortion is prevented by proper body positioning, cushioning and body restriction. The semi-prone position has been found to be the best position and to this is added a countergravity suit which provides intensified pressure to the legs and lower trunk to retard the outflow of blood from the brain.

Vibration and hazards of rocket fuel

The noise and vibration caused by a rocket on lift-off are tremendous and obviously the astronaut has to be protected from these harmful effects.

Rockets and booster mechanisms require thousands of gallons of highly inflammable fuel and oxidising chemicals for propulsion. Aerospace medicine concerns itself with the safe handling of these fuels including the proper training of the handling and maintenance people, proper clothing and the understanding of fuel toxicity.

As the astronaut has to sit atop the tremendous quantities of fuel during count down a survival mechanism in the form of a small tower was divised. Should there be a fire or explosion on the launch pad, the control centre or the astronaut himself could fire retro-rockets to lift the capsule away and carry it to a safe area by parachute.

Weightlessness

Weightlessness is a new and unusual situation for man. In the past there had been considerable controversy over the maintenance of orientation in the weightless state as the sensory apparatus of the inner ear and other positions in the human body are gravity orientated. Sensitivity to a weightless state is extremely varied, not only in different people but also in the same person at different times. Nausea or vestibular sickness is one problem, a sense of *up and down* is lost in some subjects and some have breathing problems.

However, eating and drinking is not affected when gravity is absent, because the passage of food depends on muscular contractions of the oesophagus. The use of squeeze bottles to inject fluid into the back of the throat for further swallowing also furnishes a solution. Weightlessness does not seem to affect the efficiency of suitably orientated astronauts.

Avoiding physical atrophy in protracted weightlessness is also problematic, as is seen in the bedridden patient who sustains muscular atrophy from disuse and a loss of rigidity of unloaded bones. The answer has been to develop special apparatus designed to exercise muscle in spite of the loss of counter-gravity. The influence of zero-gravity depends a great deal on training and how long the weightless state lasts. Creating artificial gravity is another answer.

Tumbling and spinning

Above the atmosphere, where stabilising wings or fins are no longer possible, there is a tendency for vehicles to spin about on their long axis or to tumble end over end. The human body cannot tolerate either rapid spinning or tumbling for any appreciable length of time, neither can it adapt well to aberrant motion. This problem appears to have been solved.

Factors connected with outer space as a peculiar habitat

Low barometric pressure

This is the notable characteristic of outer space as a habitat.

Low barometric pressure leads to a reduction of oxygen pressure in inhaled air. Man is extremely sensitive to anoxia. Even small degrees of rarefication can disrupt co-ordination, weaken memory and attention and reduce working efficiency. An increase in the degree of rarefication leads to clinical convulsions, loss of conciousness and death. Besides anoxia low barometric pressure can also produce vapourising and boiling processes in the tissues.

Sealed cabins with artificially maintained pressure as well as wearing pressurised suits are thus essential. Space-ships colliding with meteorites can sustain instant depressurisation of the cabin. The result will be explosive decompression with catastrophic effects. There will be an instantaneous and momentary expansion of air and gases in hollow tissues and organs (such as lungs, ears, sinusses and alimentary canal) followed by boiling of tissue liquids and the escape of gasses in physical solution. If the hole formed by the meteorite is large enough the astronaut may be completely ejected from the ship.

Cosmic radiation

Potential exposure of man in space to radiation and its consequences cover a very wide range. A considerable choice is possible, however, on the actual levels of exposure to which a man in space shall be subjected. Space outside the atmosphere is penetrated by cosmic rays and their particles have a velocity close to the velocity of light. A square metre of the surface of a space ship would be bombarded every 10 minutes by a million or more of these particles. It becomes clear how serious the danger of exposure to cosmic rays is.

An astronaut must have some protection against radiation (special shields on the space-ship) dependent on the length of the mission and the flight profile. An extended stay in the Van Allen Belt or a long interplanetary voyage will demand more radiation protection than a flight to the moon or a low-altitude orbit around the earth which can be recalled at short notice in case of a dangerously powerful solar flare.

Nausea and vomiting and a possible decrease in sensory perception and mental efficiency are among the adverse reactions to cosmic radiation.

Temperature

Environmental temperature decreases with altitude, until an altitude of seven miles is reached when it stabilises at — 67 °F, begins to rise again through the stratosphere and then decreases when there is no longer any atmosphere through which heat may be transferred. Temperature therefore depends on the absorptive or reflective characteristics of an object. During re-entry into the earth's atmosphere temperatures may also become very high because of friction and heating.

These problems of temperature control have been solved by the development of new surface absorptive or rejective materials for the shell of the space vehicle.

Life-support systems

Currently re-supply of food, water and oxygen from earth for space flight is extremely difficult. Each and every item for man or vehicle must thus be conserved as far as possible and used over and over again, as in the case of re-cycling in closed ecological loops.

For extended space travel it is desirable to perform the functions of the earth's ecological system. There has for instance been considerable research in the use of certain algae as gas exchangers — exchanging respired CO_2 for O_2 — while these algae are fed by the body's waste products. Urine can be recycled to clean water.

On board a space-ship the principle of safety is a leading one. The most rational approach is to find physiological criteria for establishing an artificial environment. An equilibrium between the velocity of changes which man introduces into the environment, and the velocity of the recovery of changed parameters determines whether a relatively constant environment can be maintained. An astronaut must have specialised equipment and supplies in addition to food and drink in order to survive in outer space. This includes:

- a pressurised spaceship cabin, with a method of replenishing O_2, removing CO_2 odor and controlling temperature and humidity
- an acceleration couch, for the high accelerations and decelerations encountered during launch, mid-course manoeuvres, and re-entry
- a pressure suit to protect him in case of loss of pressure in the cabin, and as compulsory equipment if the mission should require the astronaut to leave the spacecraft.
- sanitary facilities in accordance with the duration of the mission
- some radiation protection.

If one studies the following list of physiological factors which are monitored during a space flight one begins to get an idea of the tremendous benefit therein for health care here on earth.

These aspects are as follows:

- neuro-physiological aspects
- tolerance to the combined effects of cold and an abnormal atmosphere
- thermal homeostasis under hypoxia
- heat loss in space
- physiological problems of weightlessness
- avoiding physical atrophy in protracted weightlessness
- observations on heart rates and cardio-dynamics during prolonged weightlessness

- influence of dynamic environment on man in space
- biological hazards of radiation
- evaluation of stress by quantitive hormone studies
- predicting the susceptibility to vestibular sickness
- monitoring and predicting nervous functions in space
- means and methods of bio-medical experiments in space flight
- bio-medical data collection
- the effects of isolation and fatigue.

Because of the almost unlimited funds available for space research medical technological research has been speeded up to an unbelievable rate. This involves research and advances which in the normal course of events, and with the limited funds available, would have taken many more years to come to fruition.

It is estimated that one thousand new technical products and processes, developed for space projects, are made available to civilian consumers each year. Even after this short period of its existence the space programme has become the most prolific source of technical innovations that ever existed.

Monitoring all the abovementioned physiological parameters in a space capsule requires sophisticated computers as well as the development of other equipment which can be monitored by ground staff.

One such parameter is cardiac output, and a method using the so-called *re-breathing* technique, has been developed . . . without the need for drawing blood or invading the circulation. Another example is a specially designed chair containing sensitive light cells which can measure blood volume, pressure temperature and so on, do ECGs and EEGs — all without the complicated and bulky apparatus usually needed for these measurements.

The apparatus in a space capsule has to be light and compact because of the weight problem. This requirement has speeded up the development of, for instance, miniaturised computers containing postage stamp size silicone chips, new alloys and the miniaturisation of many other machines and equipment.

Re-entry into the Earth's atmosphere

The problems associated with deceleration, temperature control, and vibration which arise out of rapid re-entry into the Earth's atmosphere, have been discussed under *flight dynamics* above.

Post-flight research

Aerospace medicine is involved with the processing of the physiological data obtained during flight as well as the possible after-effects of a space flight — such as the effects of cosmic radiation, which may only appear months after the flight.

Naturally this research is aimed at devising new ways of dealing with the dangers and stresses of space flight.

SIGNIFICANCE FOR THE HEALTH PROFESSIONS

Aerospace technology and manned space flights are already exercising a profound influence on many aspects of health care. The modern health care professional must have some knowledge of these implications for by the year 2000 almost every aspect of health care will in some way be influenced by the achievements of the space scientists and the men and women who dare the many hazards of space flight.

Spinoffs from space technology and their implications

The health professions are fundamentally concerned with two aspects of the spinoffs from space technology namely:

- preparation of astronauts for space flights, monitoring their state of health during and after flights, and
- the spinoffs or benefits to medicine from space technology and its implications for health practice.

The main purpose of this article is to discuss the latter aspect with particular reference to the implications for medicine and nursing practice.

New aspects in clinical research

The uniqueness of the space environment lies mainly in the access it affords to altered gravity conditions, ultra-high vacuum and particular spectrum of ionising radiation. For the first time biologists can study physiological responses and psychological behaviour of gravity-dependent organisms in a so-called zero gravity condition. A second unique feature in space is that test organisms are removed from any possible influence of the earth's twenty-four hour period of rotation.

Overall analysis of the impact of various space flight factors on the human body requires monitoring certain physiological parameters. Cardiovascular studies have yielded data on the automaticity, excitibility, conductivity and contractile function of the myocardium and on the state of the peripheral circulation. To throw light on the origin of these and other phenomena, clinical studies of patients are conducted using space cardiology techniques.

These studies promote the application in clinical practice of new, up-to-date methods for the collection and processing of medico-biological information.

Research on the inner ear is another field which could take on a new significance in the light of the results of manned space flights. Valuable data has been obtained on the effects of isolation, stress and fatigue.

The technological spinoff's of space exploration

To cross-match the space *answers* with the bio-medical *questions* a 'bio-medical applications programme' has been initiated in the United States to communicate aerospace technology to the bio-medical community.

The obviously important transfer of technology in this area is facilitated by:

- accelerating the flow of new concepts through the medical community
- bringing from the engineering and physical sciences fresh knowledge that would be unlikely to find its way into medicine by any other channel.

The following points illustrate some of the technological spinoffs of space exploration:

Deterioration of man's physical environment particularly in urbanised areas. Many of the solutions which must be considered by engineers providing a constant environment in a space capsule are in fact highly relevant to the scientist, engineers and health professionals concerned with less glamorous projects such as water purification, sewage disposal and soil microbiology.

Food shortage in developing countries, especially concerning protein supply. To try and perfect a life-support system progress has been made towards developing technology to produce a new protein-rich food source (from bacteria and water electrolysis). Work on suitable diets for manned flights has furthermore led to improved methods of preserving, processing, packaging and storing foods for human consumption.

Automation in identification of pathogens and its probable application to population growth. The urbanisation process, increased coverage of the food and dairy industries and the tendency towards the use of mono-cultures and large herds of cattle are all facts which emphasise the need for rapid identification techniques which permit quick counter-measures whenever pathogens appear.

Space research should give a powerful stimulus to new approaches in the detailed evaluation of the balance between different micro-organisms in mixed population.

The greater social impact may well be in diagnostic routines involving identification of pathogens and the determination of resistance to antibiotics.

New alloys. New alloys which result from research at NASA will be useful not only in normal bearing applications but in a wide range of wear surfaces such as artificial hip joints.

Computerisation. The development of smaller more compact computers and bio-sensors has resulted in the familiar picture of a nurse at a console monitoring the condition of a ward full of patients. From monitoring intensive care patients to sending out hospital bills, computers have swiftly become medicine's newest partners.

Computer technology may yet outstrip the expert's expectations. Computer performance in terms of capacity and operating speed continues to grow by a factor of ten every two to three years — even engineers are awed by what is already being tested. Hand in hand with the development of computer technology has gone the development of laser pictures and holograms and photography. All these techniques are becoming increasingly invaluable for medical diagnosis and surgery.

Stereo photography computers which can image a body to obtain a three dimensional picture showing the distribution of body volume. This is a valuable diagnostic tool.

Electron microscopists can freeze and split apart the four-ten-millionths-of-an inch thick membranes enwrapping our brain cells and photograph craters and vesicles within.

Development of better **X-ray techniques** and machinery is also due to space technology, as is the development of **infra-red sensors** which can measure the heat radiating from a man's face.

A computer technique to enchance television pictures of the moon and Mars has helped to clarify and sharpen medical X-ray photographs.

A computer-tomography scanner in a hospital records thousands of low dosage X-rays for a detailed picture of inner organs — a red laser beam shows the area scanned, a cross-section is produced by a computer. This scanner taking thousands of low-dosage X-ray measurements creates detailed cross-sectional pictures of a patient's brain or torso. The sections are electronically processed by a computer, which then presents the information as a three-dimensional video image for colour coding. With this device inflamations can be seen, benign and malignant tumors can be distinguished and the extent of many cancers can be determined, thus eliminating exploratory surgery. The computer-tomography scanner's clearest advantages are in diagnosing brain disorders.

Electron microscopes are another development receiving impetus from space research. The electron microscope is giving us a new view of the cell and also the atom.

The camera has been developed to such a high level of sophistication through space technology that now it is used for charting the parameters of the brain and is the tool of behavioural scientists who film gestures, fleeting facial expressions and language in order to obtain new windows into the human psyche. The camera is evolving into something more than a tool — it will soon be almost impossible to divorce the camera from the computer.

Laser beams are being used not only in brain surgery but also in chromosome surgery — or genetic engineering. A laser beam is focused through a microscope to cut so finely that just one part of a chromosome can be removed. A human blood cell can have holes drilled in it by a laser.

Chromosome sleuthing by computer. To scan chromosomes for detailed analysis, the computer is married to a microscope. Though this system, called CYDAC, is a tool of basic research it can also be used for clinical diagnosis.

Electron microscopic investigation of viruses and viral genes and genetic engineering has already revolutionised diagnostic approaches and resultant treatment modalities.

NASA experimental space suits are used for children who are born with no immunity against infections.

An eye-activated switch was designed so that an astronaut could activate electronic controls by voluntary movement of his eyes in a situation where high gravity forces might prevent him from moving his arms and legs. This switch has already been adapted for control, by partially paralysed patients, of such items as hospital telephone switchboards, wheelchairs and other devices.

Walking chair. A six-legged vehicle proposed as an instrument for unmanned exploration of the moon has been adapted by a California company as a walking chair that can carry crippled children over rough terrain and obstacles that would stop an ordinary wheelchair.

Respirometer. The astronaut helmet has been adapted as the basis of a device for paediatric respiratory studies, replacing a mouthpiece and tube that subjects found awkward to use during clinical tests. The helmet is also used for giving mild anaesthetics which are piped into the helmet making the child groggy, more pliable and less fearful.

Spray-on electrodes. At the NASA Research Centre a new technique for applying electro-cardiograph electrodes to test-pilots was developed. A liquified, conductive mixture is sprayed over the ends of lead wires and on to the patient's chest. The coating dries quickly and is thin, comfortable and flexible and can be easily removed — but will keep the electrodes in place during exercise causing perspiration.

Cryo-surgery. Micro-thermocouple probe's are used in cryo-surgery which is a technique using great cold. It is used in brain surgery, eye surgery and the repair of lesions by *welding* tissues at cryogenic temperatures.

A derivative of hydrazine, a component of rocket fuel shows promise as a drug for certain mental conditions and the treatment of tuberculosis.

Ageing and gerontology. It takes much time and effort to train an astronaut, and his experience and knowledge must be used for as long as possible. Research must determine the point at which the astronaut's experience no longer compensates for his performance because of deterioration due to ageing. This research will shed new light on the whole process of ageing.

There is therefore a prediction of an increase in the life-span as a consequence of this research.

PREDICTIONS

Innumerable such developments are possible. At the heart of this lie unprecedented advances in technology and the uses of the *micro-chip*, and an ever growing understanding of the life process and how this process can be managed through the aid of technology. The possibilities are endless. This may mean that health professionals will have to re-examine and restate their beliefs and values about man in need of health care. Such developments will touch the very core of existing ethical concepts.

The spinoffs of space development will pervade our lives and we will not be aware that they originated with space exploration. In medicine the results are already dramatic, but more is on the way. There will come a day when the family doctor will carry in his traditional black bag, devices that now occupy many cubic feet of space and demand high power — such as machinery for EEGs, ECGs, X-ray's, diathermy and metabolism devices. The doctor will have tiny analytic devices that will automatically report blood count, cholestrol level, sugar content and the presence or absence of specific antibodies in the blood.

Patients with chronic and potentially acute conditions will wear analytical devices with broadcast attachments, and by dialling the video-phone will ask the doctor *How am I* and get a precise answer. Some day (possibly) the doctor may inform his cardiac patient *You're through on Earth — move to the moon and the lesser gravity may give you a dozen more years of life!*

ETHICAL ISSUES ARISING OUT OF THE ADVANCES OF SPACE/MEDICAL TECHNOLOGY

Space medicine and technology has had a tremendous influence in the explosion of knowledge in the medical sciences in the last thirty years. This influence is likely to increase, not diminish, in the next twenty years.

The implications for man are vast. These developments in technology will lead to vast new bio-engineering industries, chains of medioelectronic repair stations, new technical professions and a reorganisation of the entire health system. They will change life expectancy and bring about important shifts in human outlook. Surgery will be less frightening to the average individual, and implantation will become routine. The human body will come to be seen as modular, that is, through application of the modular principle (preservation of the whole through systematic replacement of transient components) we may add two or three decades to the average life span. We shall no longer implant only to save life, but to enhance it — and make possible the achievement of moods, states, conditions or ecstasies that are presently beyond us.

Under these circumstances, what happened to our age-old definitions of *humaness?* How will it feel to be part proto-plasm, part transistor? Exactly what possibilities will it open? What limitations will it place on work, play, intellectual or aesthetic responses? What happens to the mind when the body changes? Questions like these cannot long be deferred for advanced fusion of man and machine are closer than we suspect.

Moral decisions

In the not too distant future, computers may act on moral values. Some knowledgeable people in data processing do not think it at all unlikely that some day computers, supplied with feelings and even moral values, will make decisions based on those feelings and values, as well as on what their sensors perceive. Does this mean that in the future doctors and nurses will not have to make decisions as to whether to save life or let die, that computerised bio-sensors will do the deciding for them? The medical and nursing professions are already facing an ethical crisis which is likely to become more acute as this century draws to a close. Can they evade responsibility by letting computers make these decisions

The new biology has opened up more questions than it has answered. Many are important social questions, and we must begin dealing with them now. Do we have the right to develop new forms of life for our own purpose? Should we try to control our own physical destiny? If so, who is to decide what man should become? Would it be ethical to try and manufacture genes to cure illness, knowing that such techniques could create the means for the weapons of a horrible biological war?

Should we try to manipulate the immune system to make all types of organ transplant commonplace — with the possibility that some lives might be extended indefinitely? How do we protect the diversity of our species from those who might want to *improve* it with clones of its ideal specimens?

Is it morally justifiable to spend billions on this kind of research straight out of the annals of science fiction, when the majority of the Earth's population still suffer from the ravages of endemic disease and malnutrition? Many ethical decisions will have to be made some day, particularly as the new biology advances our knowledge of the mind.

Fortunately, the human brain still confounds science. Even if we know all there is to know about how a cell works, we would still not have the answers. Molecular biology can still not, if ever, explain how nerve cells create emotions, thoughts, behaviour, memory, and other perceptions.

There are many and varied consequences of scientific research but few would deny that the one inescapable result of research is that it increases knowledge and that the application of this knowledge in general can improve the quality of life. This was of course true long before science as it is known today was ever practised. There is also another inescapable result of research — that scientific discoveries will not always be applied to what most people would consider to be desirable ends.

There is a great need to keep some particular sections of the community closely appraised with scientific developments. The interactions between science, the law and religion should be stressed. The lawyers, theologians and members of parliament need to be closely involved with scientists in discussions of the implications of scientific research. Preceding this, the philosophers and theologians need to go back to the drawing board.

Right to life

Finally we come to the question of what is human and the natural right to life. One view holds that the life of the human individual begins at conception and ends with biological death and that the natural right to life therefore begins at conception and ends in death. The other view takes that property to be something which is characteristically, perhaps uniquely, human and which appears only some time after conception and may disappear before death, and that the natural right to life is not, therefore *co-extensive* with human individuality. These views reflect the opposing sides in the euthanasia controversy. That it is one thing to kill someone and quite another merely to let that person die is a common assumption.

Distinguishing killing from letting die might be a task best left to the philosophers. The assumption that there is a distinction, and that the distinction has moral significance is however clearly reflected in our law, in religious discussions, and in contemporary medical writing.

Members of the medical and nursing professions, at this time, generally reject the idea of euthanasia, seeing their role as healing and prolonging life rather than ending it. However, patients cannot always be cured and there are times when the prolonging of life is of questionable value. In some cases, prolonging life might be seen as prolonging dying. At some point it may be appropriate to stop staving off death. But at what point?

It would seem therefore that medical morality is being threatened by scientific advances. It must be conceded that science and morality have conflicted throughout history.

The examination of images of man (that is free-will image as opposed to deterministic image) and the new and traditional social moralities provide an insight into the relationship between science and morality in contemporary medicine. It is apparent that science is part of a much broader movement which will change the basic moral foundations of medicine and society.

Whatever answers the philosophers and the scientists may present, the whole question is an extremely loaded one for the doctor and nurse. More than this, health workers are the ones faced with these acute moral and ethical dilemmas here and now, every day, whereas the philosopher in his ivory tower can muse, deliberate and argue for years without reaching any conclusion. It is the dilemma in health care of the last decades of this century. No health professional can escape the implications of man's immense outreach to space.