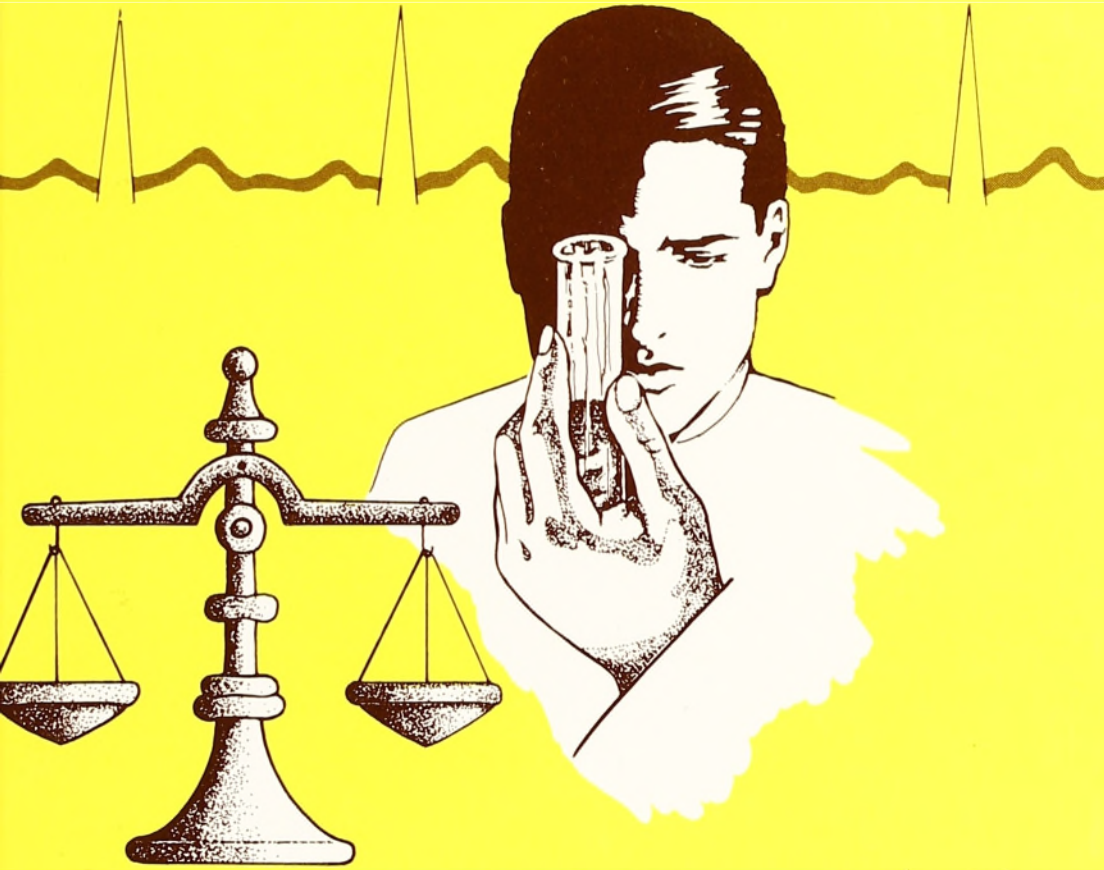
The right to LIFE

Issues in bioethics



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THE RIGHT TO LIFE

ISSUES IN BIOETHICS

A collection of papers presented at the
twelfth symposium of the Institute for Theological Research
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Preface

The concept of life has fascinated mankind through the ages. Theories on the origins of the human race, the nature, origin and end of life, whether there is life after death, and how these different aspects interrelate, have been widely discussed over many centuries. In addition to what we learn in the Bible about the views of life of the Jews and early Christians, similar and different ideas about life — all valuable — are found in other religions. Philosophers have grappled with the complexities of the phenomenon and have given many answers to the various questions concerning life. Biologists have come up with the most interesting ideas and theories; so have medical scientists and many others to whom the concept of life presents tantalising secrets. These different views have given rise to a wide range of bioethical issues, which need to be addressed in terms of our current understanding of life.

The emergence of industry and the development of technology have opened up new challenges to humankind, and have changed our concept of life. Because of the discovery of the structure of DNA (deoxyribonucleic acid), modern genetic engineering, for example, has enabled scientists to modify genetic material, which has major implications for humankind and its environment. Developments in reproductive technologies, such as in vitro fertilisation, embryo freezing and oocyte donation, have necessitated serious thought by medical scientists, philosophers, ethicists, theologians, jurists and others. These developments are part of our daily experience. At the same time we are reminded daily of other realities influencing our concept of life and raising questions about the right to life.

Malnutrition, poverty, power struggles, oppression, warfare, terrorism, the emergence of new and horrifying diseases such as AIDS, and many other things we experience, influence the way in which we construct reality and how we conceive of life. It is only by considering the challenging complexity of life that we can really start thinking about the right to life.

The concern of the organising committee of the twelfth annual seminar of the Institute for Theological Research at Unisa was to offer a forum for those who are interested in the complexities of bioethics from a theological point of view. To this end we invited a number of speakers to prepare papers on a variety of topics about the right to life. To talk meaningfully about bioethics, one has to consider the question 'What is life?'. The answers to this question lead to ideas about the right to life. Being aware of the many possible answers to that question, we decided to invite speakers to tackle the question of the right to life from different angles. This book contains a selection of the papers delivered at the seminar. It addresses a small, but nevertheless important aspect of the problem and clearly indicates the complexity of the right to life and quality of life in our own time. The views expressed are those of the authors of the essays and not necessarily those of the Institute or the University.

I am indebted to many individuals who helped me with the preparation of the seminar and the book. The organising committee, consisting of Jansie Kilian, Hilda Steyn, Klippies Kritzinger and Willie Wessels, was responsible for finding a topical issue, appropriate topics and knowledgeable speakers, and for organising the seminar. In this connection it gives me great pleasure to thank Professor J V van der Merwe, Dean of the Medical Faculty of the University of Pretoria, who has made it possible for us to have Dr Quigley of Cleveland, Ohio in the USA as one of our speakers.

I am also indebted to the authors of the essays contained in the book and to the referees who had to ensure academic quality. Deep appreciation is extended to Jansie Kilian, Hilda Steyn and Beverley van Reenen for their help in editing the book, and to those who assisted in proofreading the manuscript: Almarie Blaauw, Adrian Blom and Ernst Horn. The manuscript was typed by Nonnie Fouché. My sincere thanks to all of you, including my secretary, Linda Bedingfield.

THE EDITOR

A P DU TOIT

What is life?

As a way of presenting possible answers to the question 'What is life?' I shall begin with two parables.

FIRST PARABLE

Scientists first produced life in the laboratory by physico-chemical experimentation in the year 2010. A form of life had spontaneously come about. This breakthrough made it possible for the scientists to produce and cultivate a human being by physico-chemical processes. They made a male human being and, by the time the boy was seven years old, scientific tests had shown that he was in all respects similar to any other human male. During this time scientists had also produced a substance which stopped the ageing process. If humans took it at the age of thirty years, for the sake of argument, they would to all outward appearances stay that age and not show any physical deterioration. Scientists claimed that, by taking the substance regularly, humans could live indefinitely.

Then the philosophers came along and said, 'Look, the boy created by the scientists may have to be distinguished from human beings born in the usual way. We could have a new mutation of the human species which also calls for new descriptions. For the time being we shall label this mutation a Category B human being. The human beings who take the substance that gives everlasting life may also be of a different category. We shall call them Category C humans, and by observation and argumentation we shall decide how to describe them and where they fit in. Clearly our concept of life will also change.' The philosophers went away to work on new descriptions, new theories and alter their concept of life.

The theologians came along and said, 'Look, the first thing we shall have to decide is whether the human male produced by the scientists has a soul, or not. And what does "soul" mean in this context? We may find that the soul has never existed, and that human beings born in the usual manner do not have souls, after all. It may even be necessary to drop the concept "soul" from the theological vocabulary. On the other hand, perhaps God has had a change of mind and now allows man to produce both life and souls.' The theologians went away to think about these matters and to contemplate the kind of contribution they could make in this changed world.

And the scientists and the philosophers and the theologians all started taking the substance that makes humans live indefinitely.

SECOND PARABLE

In the year 2010 mutations of the AIDS virus had become so prolific and contagious that 95% of the world's human population had been wiped out. Estimates showed that it would take three years for man to become extinct. The latest reports said that scientists were frantically preparing space ships to travel to the earth's moon and other planets, thus hoping to escape the deadly viruses. At that point in time there were no indications that conditions elsewhere in space could sustain human life and thus save the species.

The few remaining philosophers and theologians had become strangely silent. It was rumoured that they now agreed that they may have been mistaken about what life was really all about ....

-oOo-

Why should we interest ourselves in the question 'What is life?' Because we regard life as something vital, deep and of great importance, surely. Theories on how human beings first came into existence, and on the phenomena of birth, life and death, are bound to interest us; they also shape our views of what we are and wish to be, and thus profoundly affect our lives. Through the ages the concept of life has always been a central topic in theoretical contexts and if we go back in history we find numerous great thinkers who had important ideas about life, existence and being.

'Life' is a multifaceted concept. It has various meanings, depending on the context in which it is used. The question 'What is life?' could relate to the origins of cosmic life, to problems concerning the period from birth to death, to the actions or fortunes of individuals, to various forms of life, to the distinction between conscious and unconscious life, transcendental life, to the meaning of our lives, to the survival of the human species, and so forth.

For present purposes I shall investigate some of the more important issues raised by the question, 'What is life?' and the theories which form the basis of the various answers. I shall argue that questions about life posed within the context of empirical science are dependent for their answers on available scientific evidence - that is all we have to go by - and questions on the non-empirical level are by their nature of a different order and thus require different answers.

1 THE QUESTION 'WHAT IS LIFE?' IN A SCIENTIFIC CONTEXT

The world in which we exist gives us the living and the nonliving (Thürkauf 1980:351), and in the course of ordinary daily life we have no difficulty in distinguishing between the living and the nonliving. It is only in very extraordinary circumstances that we would be uncertain as to whether something was alive or dead. We have a 'natural' ability to observe the difference between the living and the nonliving. This ability can also be extended and aided by scientific instruments which make it possible to observe the living and the nonliving on macro and micro levels to which we do not have access through our ordinary senses. Since the advent of the Natural Sciences, every age has had an explanation of the origin of life. These explanations have always carried weight and have usually become the point of departure for reflection on the concept of life. Current scientific progress has heightened expectations of finding answers to important questions on life, its origin, its various forms, evolutionary processes, and so forth.

1.1 The origin of life

Contemporary science generally explains the origin of life as follows:

Living beings are composed largely of molecules, called proteins, the complex organic compounds formed by the combination of amino acids. The amino acids arrange themselves in long chains in different orders, giving rise to an enormous number of proteins which have functions of support for the organism, as well as controlling and guiding its internal activities. Enzymes are an important class of proteins with catalytic properties that allow the development of the chemical reactions needed within the organism. The cellular construction of living organisms, achieved through the manufacture of proteins, is undertaken by a code - a communication system within the organism - which transmits the messages indicating how to construct amino acids. In the living cell, cytoplasm and the nucleus can be distinguished, the latter containing chromosomes which in turn contain genes - substructures that carry hereditary characteristics. A gene again is composed of a long, linear molecule of deoxyribonucleic acid (DNA), made up of a chain of elementary units. DNA chains, appearing in pairs, form a double helix structure. A unit of the chain contains a character of a code and the characters, composed of the DNA bases, are guanine, adenine, cytosine and thymine and their order in the genetic chain determines genetic information. The mechanism of writing and reading a certain message involves other large molecular structures, known as ribonucleic acid (RNA) of different types. Without getting involved in intricate molecular biology, suffice it to say that the essential problem for those who study the origin of life is that of knowing if these molecular chains and this code have been put together according to a preordained plan, or if the process could have developed by itself under suitable environmental conditions. This is a much debated point, but today a considerable number of scholars are convinced that in a certain environment (like that of the earth billions of years ago), the phenomenon could have started by itself. An essential condition is that processes that free sufficient energy to break molecular bonds should exist in nature (Di Francia 1976:370). How such energy could have been released, and certain processes set in motion, has been explained by simulating earth's primitive atmosphere, thus attempting to show that certain natural processes give rise to complex molecules, among them DNA bases (Di Francia 1976:371). Although the precise, detailed origins of cosmic life are still largely a matter of conjecture, most natural scientists accept the hypothesis that life is nothing more than especially complex physics and chemistry.

Herbert Spencer wrote in 1862:

> Life in its simplest form is the correspondence of certain inner physicochemical actions with certain outer physicochemical actions; each advance to a higher form of life consists in a better preservation of this primary correspondence by the establishment of

> other correspondences. So that, over its nominal nature of which we know nothing, life is definable as the continuous adjustment of internal relations to external relations.
>
> (Spencer 1928:70)

The same sentiment was echoed by Pierre Teilhard de Chardin (1966:39), who claimed that the beginnings of life are lost to us. Life, in scientific experience, is none other than a specific effect of complex matter, 'a property in itself coextensive with the whole stuff of the cosmos, but perceptible to us only where ... complexity exceeds a certain critical value - below that value we cannot perceive it at all' (Teilhard de Chardin 1966:24).

It seems to me that the statements of natural scientists on the origin of life are descriptions of primitive forms of life, or life in action as encountered for example on the microbiological level. These statements should not be taken as explanatory statements of the *origin* of the complex molecules, DNA bases, and so forth.

1.2 Life as a force versus life as physicochemical processes

Another option would, of course, be to conceive of life as a synthetic force of a higher order than that of physicochemical forces, a force which would influence the physicochemical causes without disturbing their functions. Most scientists reject this idea on the grounds that should such an intelligible causality or power bring about life or influence the steps in evolution, then it should be empirically verifiable. If that were possible, this force would be on the same empirical level as the physicochemical forces, which would of course rob it of a higher status:

> Many scientists ... argue as follows: either this intelligible causality to which you appeal has some influence upon each step of evolution, or it does not. If it does, then it should be empirically verifiable. In that case, it is an empirical causality, on the same level as the others. If it does not, how can it have any influence upon life or evolution as a whole?
>
> (Donceel 1967:52)

Those who argue for a higher-level force claim that its working has the character of becoming, being, vanishing and returning. It is difficult to conceive of a force which cannot be identified in the usual manner and the workings of which cannot be checked.

We can legitimately claim that the practice of chemistry and physics is something other than nature itself. Chemistry and physics are the results of our reflection on nature; they embody our thinking on, and our descriptions of, nature. The practice of chemistry and physics, it is argued, is in itself nothing chemical or physical. Rather, chemistry and physics are objects of inquiry; they come about through human thinking on nature according to a very definite hypothesis. Chemistry and physics cannot be understood physicochemically! To understand physics and chemistry one needs to reflect *on* chemistry and physics and this act is more than just a physicochemical process (Thürkauf 1980:352-353).

1.3 Experimentation, mechanism and hypotheses

Clearly, then, natural scientists depend greatly on experimentation and *factual evidence* for their theories about the possible origin of life. The empirical criteria for life would roughly be its cellular constitution, that is, the build-up of cells, metabolism of some kind, unstable equilibrium, some sort of organisation, and eventual death.

Scientists are often accused by philosophers of having a mechanistic world view:

> Mechanism holds that life is some kind of material energy, or the result of a combination of material energies; that it can be explained, or will eventually be explained, by the laws of physics and chemistry; that a living being is only a complicated machine.
>
> (Donceel 1967:44)

There are many variations of the mechanistic model, one such recent attempt to integrate mankind with nature being the so-called Gaia hypothesis put forward by J E Lovelock. The Gaia hypothesis states that life is not governed by physical events, but that life itself is the guiding principle which makes and remakes its own environment.

> Life reacts to global and cosmic crises, such as increasing radiation from the sun or the appearance for the first time of oxygen in the atmosphere, and dynamically responds to insure its own preservation such that the crises are endured or negated.
>
> (Sagan & Margulis 1984:61)

According to this theory no unknown external forces need be invoked to account for the origin or the continuance of life; temperature regulation, for example, becomes a consequence of the well-known properties of life's responsiveness and growth, whereas other theories wrongly state temperature regulation as a prerequisite for life. The Gaia hypothesis thus reverses the whole process - it is not that something invokes life, but rather that life itself invokes; for example, life continually synthesises and removes the gases necessary for its own survival. 'Life controls the composition of the reactive atmospheric gases' (Sagan & Margulis 1984:67). Sagan & Margulis (1984:66) also claim that 'The Gaia hypothesis says in essence that the entire earth functions as a massive machine or responsive organism'.

In science, 'mechanism' covers a great deal. The concept is used to describe almost any system, some of whose elements act upon the others. Mechanism has today more defenders than ever before among physicists, biologists and philosophers - especially in the form of the thesis that man is a computer. Suffice it to say that the doctrine that man is a machine or computer is unsatisfactory, because it regards man and the world as a closed physical system '... whether a strictly deterministic system or a system in which whatever is not strictly determined is simply due to chance: according to such a world view human creativeness and human freedom can only be illusions' (Popper 1972:254). Popper (1972:219) explicitly states:

> By a physically closed system I mean a set or system of physical entities, such as atoms or elementary particles or physical forces or field of forces, which interact with each other - and *only* with each other - in accordance with definite laws of interaction that do not leave any room for interaction with, or interference by, anything outside that closed set or system of physical entities. It is this 'closure' of the system that creates the deterministic nightmare.

It is especially by using certain scientific methods that biology has been able to examine the lower forms of life, working from the higher forms of life to the lower. It is at the level of an elementary form of life that experimentation often becomes controversial, because much of the work is hypothetical. Hypotheses are proposed and thought experiments become the *modus operandi*. The empirical situation usually forces on us the hypothesis that we eventually accept. How do we choose between hypothesis A and hypothesis B? Both may initially have strong evidence to support them. However, as we gain more knowledge about nature and more and more observations begin to favour hypothesis B, it will become increasingly difficult to maintain hypothesis A and we may reach a stage where we are prepared to abandon it. This is practice, but the problem arises when our experimentation prompts us to hypothesise about the probability of one thing happening rather than the other on the level where we do not (and for a long time yet may not) have sufficient knowledge or adequate grounds for accepting one hypothesis in preference to another. By this I mean that our experimentation on this 'uncertain level' could lead us to the hypothesis that things happened in that particular way, and not in any other, or our reasoning could even lead to a prediction that things are going to happen in a certain way in future, excluding other possibilities. In view of the foregoing I want to claim that although experimentation has shown that physicochemical processes are necessary for *sustaining life*, it does of course not mean that they are *sufficient*, or that there is enough evidence for accepting that life, as we know it, *is* only a physicochemical process.

2 THE QUESTION 'WHAT IS LIFE?' IN A PHILOSOPHICAL CONTEXT

2.1 World-views and empiricism

Science is not so pure or so exclusive that it is practised in complete isolation. Nothing is ever done in isolation. Where science is practised, it is always done within a specific context. 'Facts are not gathered in a vacuum, but to fill gaps in a world-picture which already exists. And the shape of this world-picture depends deeply on the motives for forming it in the first place' (Midgley 1985:2). Personal opinions, distortion of facts, indiscriminately collected information, strong preferences and so forth often distort our theories and lead to unbalanced world-views. Philosophers, scientists and theologians are all to blame, because they do not always have the background, insight or flexibility to detect possible alternatives or errors.

The fear of distortion has compelled certain philosophers to adhere to a strict form of empiricism, even advocating that the place of philosophy is within the realm of the natural sciences. One such philosopher is W van Orman Quine (cf Quine 1984) who argues that we should accept the external world as it is given. In his philosophy of natural realism Quine is not interested in ontology, but in structure. The truth about nature is to be discovered by looking to the stimulatory input of sense data through the triggering of our nerve endings and our subsequent output - that is, our claims to knowledge - which he labels as the descriptions of faraway things and the theories of the inner workings of nature. All we can really do is analyse the descriptive use of language. He then proceeds to distinguish various types of sentences - observation sentences and standing sentences.

> Science ... is about regular occurrence, or what Quine calls 'standing sentences'. The connection comes in observation categoricals in which one finds a *whenever* or *wherever* construction, as in 'Where there's smoke there's fire'. Here is the beginning of rudimentary science. Scientific theory is the distinction between true and false observation categoricals .... All evidence stems from sensory stimulation and enters language through observation sentences ....
>
> (Rouner 1984:2)

This type of approach is favoured by many contemporary philosophers who prefer to stay away from ontological questions and rather focus on the network of the logical implications of our observation sentences which in turn result from sensory stimulation.

2.2 An existential interpretation

A different philosophical approach is for example that of Hans Jonas (1982) who offers an 'existential' interpretation of biological facts. He claims:

> ... scientific biology, by its rules confined to the physical outward facts, must ignore the dimension of inwardness that belongs to life: in so doing, it submerges the distinction of 'animate' and 'inanimate'. A new reading of the biological record may recover the inner dimension - that which we know best - for the understanding of things organic and so reclaim for the psychophysical unity of life that place in the theoretical scheme which it had lost through the divorce of the material and mental since Descartes.
>
> (Jonas 1966:IX)

Jonas seeks to break through the anthropocentric confines of idealist and existentialist philosophy, as well as through the materialist confines of natural science.

> Although my tools are, for the most part, critical analysis and phenomenological description, I have not shied away, toward the end, from metaphysical speculation where conjecture on ultimate and undemonstrable (but by no means, therefore, meaningless) matters seem called for.
>
> (Jonas 1966:X)

Philosophers such as Jonas vehemently attack dualistic world-views which regard humans as consisting of the interrelation of two different entities, body and soul, thus splitting reality into self and the world, mind and body, inner and outer existence, and so forth. The notion of separate spheres of spirit and matter entrenches on the one hand the view that matter can be without spirit and on the other hand the opposing viewpoint that spirit can be without matter.

Suffice it to say that philosophers who concern themselves with the origin of life and the question of what human life consists of, how it is to be explained, and what comprises man, usually end up in one of the two mainstreams of thought on these matters - psychophysical monism or psychophysical dualism.

2.3 Life, death and the soul

I believe that, in posing the question of what life is, the very fact of death is brought to mind. In the Homeric age it was held that man passes away as leaves fall from a branch, that there is no life to come. The doctrine of the soul had not yet been developed and if some afterlife existed, it was at best shadowy and unconscious. The cycle of the seasons, night following day, and death following life, were all seen as the natural order of things - so we should eat, drink and be merry. The Orphic religion taught that the body is the tomb of the soul (soma-sema), thus offering a dualistic answer to the problem of death. Life (the soul) is alien to the body and needs eventually to be liberated from its tomb. Plato was the first to offer a scientific justification for the belief in the soul. According to Plato, souls - like common-sense people - are substances, and the soul, for various reasons - such as the fact that it is the principle of life - is also immortal. Aristotle, on the other hand, regarded a soul simply as the form of the organisation of the body and in view of this it would be unacceptable to suggest that it might survive death. The Christian religion extended and entrenched the dualist notion of body and soul, the emphasis on present life (being alive, existing) as such. Although the Christian religion and other religions did have laws against killing, the preservation of life or the extension of life for the sake of life itself, was something of minor importance.

> At the peak of the dualistic movement, in Gnosticism, the *soma-sema* simile, in its origin purely human, had come to extend to the physical universe. The whole world is tomb (prison house, place of exile, etc) to the soul or spirit, that alien injection of what is otherwise unrelated to life. There, one might be tempted to say, the matter rests to this day - with the difference that the tomb has meanwhile become empty.
>
> (Jonas 1966:14)

Dualism was finally elevated to a dogma by Cartesianism. The world was regarded as a vast machine, the Creator being the clockmaker. The universe functioned according to the general laws of mechanics. During the seventeenth and eighteenth century this view was generally accepted and history had to wait for evolutionism to rediscover the concept of life.

> Evolutionism, however, regards this given type of structure, the condition for a specific performance of life, as itself a product of life, the outcome and temporary stopping-place of a continuous dynamism which itself must be termed 'life'. Thus life appears in its very means, that is, in its structural equipment for living, as its own achievement, or at least result, instead of being simply endowed with its means and faculties. This is one of the most far-reaching discoveries ever made with regard to the nature of life.
>
> (Jonas 1966:45)

2.4 Philosophies of life

The deterministic outlook on life prevailing in science before the twentieth century provoked protest from a number of thinkers who, in their writings, propagated the right to life, the worth of the human person, and spiritual values. There were three prominent movements in philosophy which generated new interest in the phenomenon of life and related matters:

(a) *The philosophy of life*

These philosophers were actualists who emphasised movement becoming life. Their conception of reality was an organic one. Biology was given high priority and their method was strictly empirical. Pluralism and personalism were strong trends within the movement. Important exponents of this trend were Henri Bergson, Wilhelm Dilthey and William James.

(b) *The philosophy of existence*

Philosophies of existence also contributed greatly to a renewed interest in the phenomenon of life (Kierkegaard, Heidegger, Jaspers, Marcel, Sartre, etc). Although it is extremely difficult to exactly define philosophies of existence, for present purposes suffice it to say that these philosophers attempted to see man in his totality and they reflected on problems such as the possibility of human life, subjectivity, the meaning of life and death, and other particular human experiences.

The following extracts from José Ortega y Gasset's *Some lessons in metaphysics* captures the mood of the age of the philosophies of existence: 'Life is what we do and what happens to us ...' (Ortega y Gasset 1969:36), 'Our life is what we are doing now ...' (1969:37), 'all living is one's own living ...' (1969:38), '... all living is a living with, a finding oneself, in the midst of a circumstance, a surrounding ...' (1969:40). 'Life is thrown at us, or we are thrown into it - but the life we are given is a problem which we ourselves must resolve' (1969:41). 'To live is to be continually deciding what we are going to do' (1969:43). 'Life is decision' (1969:57). '... our life is most of all a colliding with the future .... Life is an activity pointed toward the future; we find the present as the past afterward, in relation to the future' (1969:45).

(c) *The philosophy of being*

These philosophers confined themselves mostly to the analysis of being. They offered philosophies of nature, a philosophy of man and so forth. Of the more important figures in this movement were Alfred North Whitehead, George Santayana, Nicolai Hartmann and the Thomists.

One should of course also not underrate the influence of new movements in sociology and psychology which overcame mechanistic materialism in favour of a more humanistic approach.

2.5 The ethical life

Clearly, then, there is also the other type of philosopher who does not concern himself with the origins of man, the body-mind problem, the status of the mind, the possibility of introspection and so forth, but is interested in the question of *ends*. The concept of life is studied in its broader context - and themes such as the following come into play: forms of life, living responsibly, interpretations or views of life, the value of life, and the quality of life. The concept of life is studied in its broader application, for example in ethical systems, where the 'value of life' principle is of great importance. A prerequisite for any ethical system is the existence of living human beings. 'It is perhaps the most basic and necessary principle of ethics, since empirically speaking, there can be no ethics whatsoever without living human beings. This principle can be stated in several ways, but I prefer to state it as follows: "Human beings should revere life and accept death"' (Thiroux 1986:124). The principle stated by Thiroux has two components. Firstly, there is the reverence for life. The foregoing analysis - whatever one's point of view about the origin of life and of how different forms of life (including the life of man) are to be explained - clearly shows modern man's concern and interest in the phenomenon of life.

Today most cultures revere life and have strict rules prohibiting killing, although some allow killing under special circumstances. Prohibitions against killing are found in Judaeo-Christian ethics, Buddhism, Hinduism, Islam and in the ethical codes of humanism. Although some systems do allow killing under special circumstances, it can safely be suggested that in contemporary cultures, with the possible exception of a few small primitive groups, preserving and extending human life is a common goal. In most contemporary cultures the preservation and protraction of life are desirable under normal circumstances. It is argued that life is a basic possession, the one thing that all humans have in common, although of course each human life is unique and can never be exactly duplicated. That a living human being has life is an empirical fact which is universally accepted. What is to be done with that life, how it is to be used, whether in certain circumstances it can or should be terminated, are all matters of a different kind. How we argue about these issues would also reflect the worth or value we place on our lives and the lives of others.

The ethical dimensions of our beliefs, attitudes, actions and policies regarding the begetting, sustenance, protection, manipulation and improvement of life are especially the concern of bioethics, which means 'life ethics'. This includes the ethics of sexuality, population and birth control, fertilisation, abortion, sterilisation, genetics, birth, health care, human experimentation and informed consent, organ transplantation, the treatment of dying patients, mercy killing, truth-telling and confidentiality in medicine, and related matters such as the right to live and the right to die. Ethical problems arising in areas such as medicine, business, law and ecology have caused renewed interest in ethics, not only on the theoretical level, but also as something which should be applied to human affairs in a very practical way. I believe that the ethical issues that have arisen have served as a great stimulus in our time and have generated new interest in the implementation of applied ethics.

3 THE QUESTION 'WHAT IS LIFE?' IN A THEOLOGICAL CONTEXT

3.1 Scientific facts and theological theories

Philosophers and theologians cannot ignore the information which the natural sciences offer regarding the origin of the cosmos, the origin of forms of life and especially that of human beings. Discoveries in the natural sciences and theories put forward by natural scientists have important implications for philosophy and theology alike.

Wolfhart Pannenberg (1981:4) expresses the following opinion:

> If the God of the Bible is creator of the universe, then it is not possible to understand fully or even appropriately the processes of nature without any reference to that God. If, on the contrary, nature can be appropriately understood without reference to the God of the Bible, then that God cannot be the creator of the universe, and consequently he could not be truly God and could not be trusted as a source of moral teaching either.

I do not think that theologians can ignore *indisputable* evidence concerning man and his origin, whatever the content of this evidence may be. It is often argued that scientific evidence which in the past was offered as indisputable has often turned out to be questionable or false. There are writers who warn against accepting everything science offers at face value. Mary Midgley (1985:11) contends that:

> The point I am currently making about the idea of 'the universe' as a whole is that, if one means by it not much more than is already described in scientific books, one is less likely to be deeply impressed with its vastness and mystery than if one regards those books as small mirrors reflecting only parts of its more superficial aspects.

The ideal would, of course, be for scientific, philosophical and theological theories of life to coincide. The fact is that they do often clash, but this is because of the confusion created by each attempting to understand the other from its own point of view. The foregoing analysis has clearly shown that the concept of life is not only to be considered on the factual level, but it also concerns the meaning we attach to these facts. We order our experiences of life in a certain way, and their meanings are consistent with a certain system which we usually describe as our world-view. Facts, our interpretation of them and the meaning we attach to them, all form an interconnected whole. Facts about the origin of human life are at one end of the scale, whereas the meaning we attach to our lives is at the other end, where faith operates - the sense of our life having a plan within a whole greater than ourselves. And these two ends of the scale are on different levels - facts and values are of a different order.

John Hick (1976:46-47) wrote:

> This emphasis upon human potentiality completes an important shift of emphasis in theological anthropology from the question of origins to the question of ends. It is not what man has come from but what he is going to that is important. We must assume that the picture being built up by the natural sciences of the origin of man, both individually and as a species, is basically correct and is progressively becoming more adequate and accurate as research continues. According to this picture, life on this planet began with natural chemical reactions occurring under the influence of radiations falling upon the earth's surface. Thus began the long, slow evolution of the forms of life, a process which has eventually produced man. And each human individual comes about through the partially random selection of a specific genetic code out of the virtually infinite range of possibilities contained even in the portion of genetic material lodged in his parents. This is, in broadest outline, the picture of man's beginning as it emerges from the physicists', chemists' and biologists' researches. And Christianity

> does not offer a different or rival account of our human origins. It says, in its hebraic myth of man's genesis, that he has been created out of the dust of the earth; but the details of the creative process, from dust to the immensely complex religious and valuing human animal, are for the relevant sciences to trace.

3.2 The rediscovery of the present self

Man's quest for meaningfulness is what Hick describes as 'what he is going to'. Philosophies of being, of existence and of life have also influenced theology where the emphasis has shifted away from the preoccupation with man's eternal soul (as life hereafter) to the existing human self, man in his concrete existence here and now.

It has for many years been fashionable amongst theologians, influenced by the life philosophies, to describe life as a mystery. They claimed human life to be totally different from any other form of life. Man was regarded as an exception in the world of living creatures. They argued as follows: Man is aware of and awaits his own death. But no other organism dies as man dies, because in life man is aware of his own approaching death and what he loses by dying. He can understand and explain the death of an organism, the disintegration of living structures or his relations into what remains after death has set in, but man cannot explain what it is for the 'I', the 'person', to die. In this sense death is a mystery. Of one thing we are certain - our own death - but it has been argued that 'personhood' sets humans apart from other living creatures, thus making human life and death unique. Knowing about death is also simultaneously a non-knowing - death, like life, is also a mystery (cf Brunner 1965:107f).

Much of contemporary thinking on life centres on the meaningfulness of man in an everyday context.

> To say that human beings have a soul is to say that they can do various things. ... I [have] enumerated their ability to think, hope, love, speak, perceive, etc. These are all things which human beings do. The category of action is, in this way, internal to that of having a soul. To say that human beings have a soul is to say that they have a capacity or ability to perform actions. The soul simply is this capacity for action which human beings have.
>
> (Cooke 1986:270)

This type of argument leads to the following claim:

> When the human being dies, his body decays and ceases to be the foundation for spatial and temporal predications of the human being. Can the human being still exist and be the subject of activities attributable to him because of the capacity for activity which is the soul? I do not see any metaphysical or logical reason why this should be impossible ....
>
> (Cooke 1986:274)

The emphasis is on the quest for a *meaningful life*. Human life as such has come to be regarded as extremely important; it is to be respected and even prolonged, if possible. The individual and society should both work toward the goal of making every human life a meaningful one. The idea of the life of the eternal soul has now become the idea of the moral life as responsible and meaningful. The life of the self has been rediscovered. Life for the contemporary religious individual means to be the responsible, the understanding self living as a social in-response-relationship-to-other-selves (cf Niebuhr 1963).

Some of the important issues in religious life at this point in time are: In terms of which symbols should we interpret religious life? What is the correct form and character of Christian life? How does it differ from other styles of human existence and action? To what other life styles is it closely related? Which is the best possible way to make sense of life? How can I give meaning to my own life and that of others?

4 THE FUTURE?

Spectacular progress in the natural sciences has confronted philosophers and theologians with new challenges. On the other hand it must be stated that the metaphysical controversies are still very much the same. Although new arguments have been put forward, none of the major metaphysical questions has an answer yet that is agreed upon. Philosophical contributions (other than metaphysical) to the general question 'What is life?' - with all its subsidiary offshoots and problems - lies on the level of the conceptual. Progress in this area means new ways of thinking about perennial problems, new descriptions and the development of alternative philosophical vocabularies. It is especially in this last area where much work needs to be done. The existing vocabularies have become outdated.

And what about the contribution of theology? Recently theologians have been under strong pressure to demonstrate the credibility and contribution of theology to areas of research such as bioethics. The burning question is: Can theology make a significant contribution to bioethics in general? (cf Shelp 1985). The question reaches even further: Can theologians offer a significant contribution towards the question 'What is life?', with its many ramifications? I think that ongoing discoveries in science and the application of new techniques in various fields, together with the development of innovative philosophical theories and vocabularies, will in future generate controversial and radically new thinking in theology as well.

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D I FERREIRA

Genetic engineering in life

The scope of modern genetic engineering is discussed in sufficient detail to allow the reader to gain a perception of the 'creative activities' it entails. Examples of genetic engineering (mainly in agriculture) are presented, as well as the dangers and fears which accompany such activities. Finally, reference is made to the ethical dilemmas relating to genetic engineering in living organisms.

1 INTRODUCTION

Genetic engineering - alteration of the genetic components of organisms - has been practised in an elementary form in agriculture for millennia, as plants and animals are selected to favour desired qualities. The fundamental laws of inheritance formulated by Mendel (1866) form the basis of modern plant and animal breeding. Traditional breeding involves the introduction of desirable traits and the elimination of undesirable genetic traits through natural mating and selection of suitable offspring (Council for Agricultural Science and Technology 1986 = CAST 1986). The new genetic engineering was triggered by Watson and Crick's discovery in 1953 of the double helix structure of deoxyribonucleic acid (DNA).

2 MODERN GENETIC ENGINEERING

Modern genetic engineering allows scientists to make precise changes in genetic material, that is, DNA (deoxyribonucleic acid). Like a magnetic tape, DNA stores information in the cell which directs each phase of development of the individual. The information in DNA is stored in the form of long strings of sequences of four small molecules, in which the order of occurrence of the basic molecular units may differ from one sequence to the next (CAST 1986). The term 'gene' is given to the region in a DNA molecule that gives rise to a particular genetic character. It is now possible to exploit particular enzymes to cut DNA and isolate genes or other segments of DNA which are of interest; this DNA can then be introduced into another organism or it can be modified before reintroducing it into the same or a different organism (Davies 1987). All this has already been done and a few examples will be given later on. This technology is also called recombinant DNA (rDNA) and, in addition to other advantages, it makes it possible to introduce desired genes from exotic sources which would otherwise be impossible.

Thus genes can be transferred between different plants such as tobacco and maize, or different animals like rats and pigs; genes from microorganisms can also be introduced into plants and animals. It is this fact, especially if the transfer and elimination of human genes, or both are considered, which poses the first ethical question. To answer this question the objectives of genetic engineering will have to be stated and evaluated.

3 THE OBJECTIVES OF GENETIC ENGINEERING

The ultimate aim of scientists employing the technology of genetic engineering is to create a 'product' to improve the quality of life of all people, directly or indirectly. It is, however, debatable whether this statement is always valid. If not, genetic engineering becomes a question of morality.

How can this technology indeed improve the quality of life of all people? The umbrella goals of genetic engineering can be summarised as follows:

* The improvement of crop production.
* The improvement of animal production.
* The improvement of health care for humans.

It may occur to the reader that these goals are defined in very general terms, but each entails a large number of diverse activities and secondary goals. In the African context genetic engineering means increasing food production to feed the starving population through plants and animals that have become better adapted. Between six and seven million children under the age of five probably died in Africa during 1985, many of them in the areas of greatest food scarcity (Joseph 1985). In any given year, some four to five million children die in Africa from the combination of causes that is responsible for death associated with famine (Joseph 1985). In many cases they die from the synergetic effect of malnutrition and infectious disease, and genetic engineering can therefore make an important contribution to health care.

Genetic engineering can therefore be regarded simply as a 'tool' to achieve specific aims. The moral and ethical dilemmas relate to the means of achieving these aims. A greater understanding of the principles involved in genetic engineering can be reached if specific examples are studied.

4 GENETIC ENGINEERING IN LIVING ORGANISMS

4.1 Genetic engineering in crop improvement

According to Goodman (1985),

> Improvement in world agriculture ultimately depends on a combination of improved farming practices, the availability of supplies to allow farmers to grow their crops, the accessibility of markets and the means to move produce to the market. Plant breeding continues to be the applied scientific discipline that delivers improved genetic traits for use by farmers. Genetic engineering will make its contribution in the near- to medium-term in improvements that will reduce input costs, reduce risks, reduce losses after planting or harvest, increase quality, and increase market value.

The application of genetic engineering to plants is possible because of the ability to regenerate whole plants from plant parts, to use *Agrobacterium*, nature's own genetic engineer, to transfer selected genes into the plant genome (the genetic library of an organism); other techniques are also used for direct gene transfer. With the rapid development of the technology for genetic engineering in plants, it is worthwhile examining some of the possibilities for its implementation.

4.1.1 Herbicide resistance

Weeds cause a serious reduction in the yield of crop plants and herbicides are therefore commonly applied to control weeds. Apart from the high costs involved, some herbicides may damage crops. The first useful gene transferred to plants was a gene which imparted tolerance to glyphosate (a potent broad-spectrum herbicide which inhibits the growth of both weed and crop species). This gene was isolated from a bacterium *(Salmonella typhimurium)* and transferred to plants such as the petunia, tobacco and the tomato (Shah et al 1986; Fillatti et al 1987). Resistance to Atrazine (another herbicide) has also been incorporated into plants by analogous procedures (Davies 1987). Incorporation of these genes into crop plants therefore allows farmers to use these herbicides in the control of weeds without damaging the plants. Useful genes have thus been transferred from microorganisms to plants!

4.1.2 Disease resistance

Improving plants' resistance to disease is one of the more lucrative areas of genetic engineering. Plant disease is disruptive and, at times, catastrophic. For instance, late blight (a disease resulting from an infection by a fungal pathogen) caused the starvation of one million people and forced the emigration of another two million to North America, owing to its decimation of the potato crop in the Irish potato famine of 1845-1860 (Jaynes, Xanthopoulos, Destefano-Beltran & Dodds 1987). Attempts are being made to isolate genes for coding disease resistance from some plants and transferring them to other crop plants. The most novel approaches, however, are those in which genes for resistance to disease are isolated from insects and transferred to plants.

Certain insects have the ability to produce bactericidal proteins. One of these insects is the silk moth *Hyalophora cecropia)* in which the pupae respond to bacterial infection by the synthesis of from 15-20 antibacterial proteins (Dodds & Jaynes 1987). Some of these proteins like lysozyme, the antibacterial protein also found in egg white and human tears, were purified. Genes which code for the production of these proteins were very recently transferred to potatoes to combat diseases such as *Erwinia* and *Pseudomonas* (Dodds 1987).

4.1.3 Pest resistance

Like diseases, pests can also impair agricultural productivity. Biological control of insects is an increasingly attractive alternative to chemical insecticides which are believed to be extremely hazardous to the environment and humans, owing to their toxicity and even carcinogenicity (Carlton & Gonzales 1986).

The best known example of biological control is the use of a bacterium, *Bacillus thuringiensis*, which has been marketed as a biological insecticide for more than twenty years (National Research Council 1987 = NRC 1987). It produces an endotoxin which is a potent insecticide for certain pests. Initially, the gene which codes for the production of this toxin was transferred to another bacterium *(Pseudomonas fluorescens)* which colonises corn roots. This genetically engineered organism is freeze-dried and coated on seeds before planting, and it is therefore able to kill certain pests including the black cutworm - an important maize pest (NRC 1987). An even more novel approach is to transfer this ability to plants. The gene was successfully transferred to tobacco (Vaeck et al 1987). Larvae that were feeding on the genetically altered plants became paralysed after forty-eight hours and died within three days. The gene has also been transferred to tomatoes (Fischhoff et al 1987) while attempts are being made to transfer it to potatoes.

4.1.4 The use of microorganisms

Microorganisms in the environment affect the growth of plants in a variety of ways and can be either beneficial or harmful. The problem of disease has already been discussed. However, while some microorganisms protect plants from bacterial and fungal infection, others protect them from environmental stresses such as acidity, salinity, or high concentrations of toxic metals. Still others attack weeds that compete with crops. The best known association between microorganisms and plants is the symbiotic relationship between nitrogen-fixing bacteria of the genus *Rhizobium* and members of the legume family, such as soya beans (NRC 1987).

The first development which has progressed to the point of field testing involves genetically altered bacteria designed to prevent frost damage. *Pseudomonas syringae* is a bacterial species with many members that are normally harmless and commonly inhabit the outer surface of plant cells. However, some of these bacteria contain a protein that initiates the formation of ice crystals at temperatures below freezing. The growing ice crystals can rupture and damage plant cells. If the bacteria are not present plants can withstand colder temperatures without damage (NRC 1987). The gene that makes the protein was identified and removed from the organism (Lindow et al 1982). The so-called 'ice-minus' strain was thereby developed. In laboratory and field tests, plants sprayed with this strain could withstand frost conditions. The ice-minus strain replaces the wild strain and provides the crop with some measure of frost protection. Due to public apprehension, based on a lack of understanding and confusion over the types of precautions needed to regulate its release into the environment, it took approximately five years before approval was granted to conduct field trials. This was the first case in which a genetically engineered microorganism was tested outside the laboratory.

Another novel but quite different approach involves the common firefly *(Photinus pyralis)*. When scientists transfer genes from one organism to another it is very difficult to tell whether the gene is actually transferred. In most cases this can only be tested in the mature plant. Scientists therefore make use of 'marker' genes. These genes code for a product, such as resistance to an antibiotic, and their transfer can be detected at a very early stage if the cells are cultured on a medium containing the antibiotic. These 'marker' genes are transferred together with the other wanted gene. Ow and his co-workers (1986) isolated the luciferase gene in fireflies, which encodes an enzyme that catalyses light-producing luciferin. This gene was transferred to carrots and tobacco and the light emitted by luciferase was detected in the plants!

4.2 Genetic engineering in animals

For centuries, people have sought to improve animal productivity by selecting and breeding only the best animals. Breeders have sought to develop animals that grow bigger, produce more, provide leaner products of a better quality, use resources more efficiently, or show increased fecundity or resistance to disease and stress (NRC 1987). Techniques such as artificial insemination and embryo transfer date back to 1782 and 1890 respectively (Steane 1985). These techniques have revolutionised animal breeding in this century while the next important advance in animal husbandry will result from combining conventional breeding methods with genetic engineering. Although the technology of gene transfer in animals is still in its infancy, a number of notable successes have already been achieved. Some of these achievements will be described briefly.

4.2.1 Animal breeding

Gene transfer between mammalian cells by somatic cell hybridisation was achieved in the 1960s. Owing to the fact that an animal can only result from the development of a fertilised egg, the transfer of genes to single cells is of use only in gene mapping. The transfer of genes to fertilised egg cells has been achieved both in a number of laboratory species and in cattle (NRC 1987).

Rat growth hormone genes were transferred to mice resulting in larger body size and this characteristic was also transmitted to their progeny (Palmitter et al 1982). Hammer and others (1985) reported the production of transgenic rabbits, sheep and pigs. The isolation and transfer of the so-called Booroola gene is being attempted. This gene is found in Australian merino sheep and it boosts the incidence of twinning and triplets, giving an overall 20-40% increase in the number of lambs weaned (NRC 1987). Scientists may attempt to transfer this gene to other valuable livestock species once it can be isolated and transferred.

Although the science of pisciculture (fish farming) is relatively young, genetic engineering has already been applied to fish production. The fertilised eggs can easily be manipulated to change the chromosome numbers, leading to bigger fish. The sex of the fish can also be regulated, which is an advantage because female fish are preferred for commercial markets (NRC 1987). Attempts are being made to isolate an 'antifreeze' gene from Antartic fish and transfer it to other fish species, which will allow more species to tolerate low temperatures.

4.2.2 Vaccines against disease

The development of vaccines through genetic engineering holds great potential. The first of these vaccines was Omnivac, which immunises pigs against pseudorabies. This disease infects about 10% of the four million pigs in the United States and is costing the pork industry in that country as much as $60 million a year (NRC 1987). Another vaccine (for colibacillosis) was approved for use in Europe in 1982 (Marketing International 1984). These vaccines depend on cloned genes of the disease agent which are used to produce large quantities of certain proteins in cell culture. When injected into an animal as a vaccine, these proteins stimulate the animal's own immune system to protect it from infection (NRC 1987). Such vaccines can be effective, safe, easy to manufacture and economical to produce. Genes have been cloned for the surface proteins of viruses that cause fowl plague, influenza, vesicular stomatitis, herpes simplex, foot-and-mouth disease, feline leukaemia, rinderpest and rabies; vaccines have either been developed or experiments are leading to their development against these animal diseases (Van Brunt 1987).

4.2.3 Microorganisms in animal husbandry

The production of growth hormones and the modification of intestinal organisms are the two fields of interest which will be briefly presented.

The low cost production of large quantities of animal growth hormones is an exciting prospect. Bovine growth hormone (BGH) is a naturally occurring hormone that increases milk production in cows (Gagliardi 1985). Bacteria have been genetically engineered to produce the hormone, which when administered to lactating cows daily, can increase milk production by up to 40%. The animal's milk composition does not change, although it does require greater amounts of, and more nutritious, feed (NRC 1987). Studies are being conducted to transfer the BGH gene to animals. Another example is that of porcine growth hormone (PGH). This hormone greatly stimulates pigs' growth, elevates the growth rate, feed efficiency, and ratio of muscle to fat (NRC 1987). The PGH gene has also been cloned into bacteria, purified and administered to pigs by injection.

A more speculative area of interst to genetic engineers lies within the agricultural animals themselves. Attempts are being made to improve the microorganisms inside an animal to create a more effective, natural bioprocessing system. This research is still in its infancy but provides a glimpse of the far-reaching possibilities that lie ahead for agriculture.

4.3 Genetic engineering in humans

Genetic engineering in humans is the most controversial field of genetic engineering, or it has at least the potential to become controversial. Reports of such results as the fusion of cells from mouse and man (Harris & Watkins 1965) create public unease. The major application of genetic engineering in humans lies in the field of health care and this will be outlined in the following sections.

4.3.1 Genetic engineering as a tool in diagnostics

The diagnosis of diseases is an important aspect of human health care. New approaches have been developed through genetic engineering using DNA probe technology. A DNA probe is basically a piece of DNA which complements the DNA or RNA of the disease-causing organism. In the case of Legionnaire's disease, for instance, the DNA probe test can be performed on a patient's serum, blood, sputum, faeces or liver cells (Van Brunt 1985). The complementary DNA probe hybridises to a complementary nucleic acid sequence in the sample, which confirms the presence of the disease. This technology holds great potential for the rapid and precise diagnosis of diseases, including cancer.

4.3.2 Genetic engineering as a tool in therapeutics

Developments in this field are finally aimed at the treatment of serious diseases by physicians in a hospital environment. Several products have already been developed and are being marketed. These include the human growth hormone, interferons, human insulin (the first genetically engineered therapeutic, which has been on the market since 1982) and tissue plasminogen activator (t-PA) (Klausner 1985; Ratafia 1987).

The genes that code for the various therapeutics were cloned into bacteria *(Escherichia coli)*, or mammalian cell cultures. Large amounts of the product can then be produced in these cultures. Genetically engineered *E. coli* is for instance used to produce interferons (used in cancer therapy and several other diseases), tumour necrosis factor (TNF, which kills some tumour cells), human growth hormone (for treatment of hypopituitary dwarfism) and interleukin-2 (IL-2, used in the treatment of cancer and possibly AIDS) (Klausner 1985). Mammalian cell cultures can also be used to produce hormones, enzymes and proteins. The best example is the production of t-PA, which is a revolutionary blood-clot dissolver used for treating heart attacks. It has been tested successfully and one company is working on a system of automatic injectors, whereby a person with a heart condition might be able to self-inject t-PA (Klausner 1985). Many more examples can be added but these should suffice to explain the therapeutic principles involved.

4.3.3 Gene therapy

Gene therapy which transforms human cells to treat genetical defects is a high-risk field of research, and strict control measures therefore exist (Beers & Bassett 1977). The ultimate goal of gene therapy is to prevent disease, not just to cure it. Research is still, however, focused on the genetic manipulation of the germ line to produce heritable changes (McCormick 1985a). Marrow culture and transplantation have proved successful in the more conventional (not genetically engineered) treatments of some diseases such as adenosine deaminiase (ADA) deficiency, a disease that produces a severe combined immune deficiency syndrome. Scientists are therefore attempting genetic manipulation of bone marrow cells. According to McCormick (1985a) '... researchers won't yet inject foreign DNA into a human subject. Far better to transfer genetic material in culture and reimplant it.'

There are certain preconditions to experimentation in human gene therapy (McCormick 1985a), all of which ensure the safety of the patient and others. The more controversial possibilities still lie in the future. These include germ-line modifications, where defective genes - in dominant diseases - are replaced, or in which parents homozygous for a recessive trait are determined to have children free of that trait. The problems associated with system-wide genetic change (i e a change that effects the whole body) are enormous and no reputable researcher is willing to take the responsibility for unknown effects on what might be generations of offspring (McCormick 1985a).

A final possibility of genetic engineering in humans is not to correct defects, but to add desirable characteristics. The debate on this potential has already started and it can only be hoped that it will never be exploited.

5 FEARS AND DANGERS

Public concern about genetic engineering has focused on two nightmarish scenarios. One is of genetically engineered organisms such as bacteria to which we have no resistance, escaping from the laboratory into the environment and causing a new plague. The other features arrogant scientists, always on the look-out for a chance to 'play God', redesigning humans in accordance with their own visions of excellence. None of these are part of the reality of our time, but there are related topics which should be addressed. The fears of genetic engineering in microorganisms, plants, animals and humans and the associated dangers will be dealt with briefly.

5.1 The release of genetically engineered microorganisms

When a 'new organism' is released into the environment the question of safety or possible danger immediately arises. The release of genetically engineered microorganisms into the environment is controlled by statutory bodies in countries all over the world. The current approach to determine if the release of such an organism constitutes a hazard focuses on five questions (Marx 1987):

* Will the released organism survive?
* Will the organism multiply?
* Will it spread beyond its original area of application?
* Can it transfer its genetic material to other organisms?
* Will the original organism or any of those that might pick up its genes prove harmful?

The risk of releasing genetically engineered microorganisms will therefore be assessed, case by case. As a result of uncertainty and the actions of environmental activists it took Steven Lindow and his co-workers five years to obtain approval for the field testing of the 'ice-minus' bacteria (McCormick 1985b; Marx 1987). It may be concluded that the risks involved in the release of genetically engineered microorganisms are minimised by strict control measures.

5.2 Genetically engineered plants

The cultivation of genetically engineered crop plants might pose two environmental risks: the negative environmental effects of a modified genotype (genetic constitution of an individual) itself and the possible movement of that unique DNA to other organisms (Hauptli, Newell & Goodman 1985).

Weedlike tendencies are the only real environmental nuisance posed by a new crop variety. Careful assessment of a new plant in natural and agricultural environments, before introduction is permitted, should reveal the weedlike nature of the plant. The transfer of the transformed DNA from a crop species to a weed species may be at best impossible or, at worst, result in an overly persistent weed (Hauptli, Newell & Goodman 1985), especially if the transferred gene codes for herbicide tolerance. However, the mechanisms involved and the reproductive barriers separating most crop species from weeds, make such an event highly unlikely. These risks must nevertheless be assessed before permission for release is granted.

5.3 Genetically engineered animals

The environmental impact of genetically engineered vaccines is probably the only aspect of such vaccines that needs to be considered. This should not cause any ethical problems, provided that assessment procedures are sound enough. The transfer of a genetic trait from one mammalian species to the germ line of an unrelated mammalian species may, however, raise certain ethical questions. If proper attention is given to animal welfare, modification of the germ line of domestic animals raised for food, with the intention of improving their properties, may become ethically acceptable (Danforth & Roblin 1986).

5.4 Genetically engineered humans

The development of therapeutics and diagnostics for human health care through genetic engineering causes no serious ethical problems, provided that strict testing for unwanted side effects is maintained. Even gene therapy in humans is not a controversial subject if it is done through somatic cells such as bone marrow. The first ethical problem arises when germ line modifications are considered. There can be no objection if this action can lead to the cure or the prevention of the disease. The problem is that the side effects of such an action are unknown. This is of great importance because once the gene is inserted the trait becomes inheritable. The side effects will only become visible once the gene is inserted but the gene cannot be inserted before scientists are sure that it is safe. This is therefore a catch-22 situation.

Another ethical question involves the transfer of genetic traits from human beings into the germ line of another mammalian species or the transfer of a genetic trait from any mammalian species into the germ line of a human being. A lawsuit seeking to prohibit experiments of this type was filed in the USA (Danforth & Roblin 1986). Do these experiments violate ethical and moral standards? The debate will undoubtedly continue for many years. However, the insertion of genes with the aim of adding desirable characteristics (not to correct defects) cannot be defended on any ethical or moral basis.

6 CONCLUSIONS

The ultimate aim of life scientists is to improve the standard of living of all people. Genetic engineering can be regarded as a tool to achieve certain goals which could not be achieved through conventional approaches. The long-term possibilities created by genetic engineering for the production of food and the improvement of human health care, make it a moral imperative that such research should be done, although society must be involved in its demarcation and application. Society's involvement should be based on moral and ethical principles.

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