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robert c. w. ettinger

the
prospect
of

immortality

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Preface

by Gerald J. Gruman, M.D., Ph.D. Lake Erie College

While reading this book, I was reminded of the Belgian businessman who in the early days of World War II heard rumors about the possibility of atomic fission. He ordered a large supply of uranium from the Congo and sent it to warehouses near New York just in time for the atomic bomb project. (On Edgar Sengier, winner of the U.S. Medal of Merit and former president of the Union Miniere du Haut Katanga, see The New York Times, 7-30-63:29) I must confess that were I interested in business speculation, I should be busily stockpiling equipment needed for Mr. Ettinger's project.

Unlike the creation of the atomic bomb, Mr. Ettinger's proposals are completely benevolent and humanitarian in their intent, so much so that readers may wonder why scientists and physicians are not already applying low-temperature techniques ("cryobiology") to extend human life. To this it must be said that too often there has occurred an unfortunate lag between the scientists' findings in the laboratory and the application of those findings for human welfare. In 1928, for example, Sir Alexander Fleming discovered that penicillin was remarkably effective in killing germs, but he lacked the capital to prepare sizable quantities of the substance, and nothing was achieved until the massive casualties of World War II stimulated a cooperative search by government and business in Britain and America. By 1944 the drug was performing medical miracles; but what about the lag between 1928 and 1944? No one can calculate the cost of those fifteen years in human suffering. It has been the same with other much-needed innovations: the first anesthetics were suggested in the early 1800's but forty more years of anguish passed before surgical operations became painless, and an even longer struggle was necessary before this benefit was extended to women in childbirth.

Many more illustrations could be given indicating what I think is the most outstanding virtue of Professor Ettinger's book: he is trying to bridge a gap between the world of the research laboratory and that of everyday practice, because he has come upon something which holds great promise for mankind. He has spent years searching the technical literature in a careful and responsible way in order to prepare himself for a vital role: the arousing of general public demand for a new service which science can offer, and the

stirring of the conscience of physicians, lawyers, businessmen and government officials so that the demand will be met. Mr. Ettinger feels that what he is calling for may happen anyway someday (to some degree, it already is happening), but what he wants to be sure of is that it will happen as soon as possible and in the best possible way. That is why he has adopted a stirring, optimistic writing style, and, in my opinion, he is justified in doing so, because he has a solid grasp of the physical, chemical and biological processes he discusses and a hard-headed appreciation of contemporary technical, economic and social realities.

What is this revolutionary development in science? In brief, it is this: if a man dies today it no longer is appropriate to bury or cremate the body. For there is hope that by keeping it at very low temperatures, physicians of the future may be able to revive him and cure him. And if someone has an "incurable" disease, it is not good practice any more to let him succumb; it is preferable to put the patient into low-temperature storage until better medical facilities become available, or until a cure is discovered. In regard to the scientific and medical bases of this concept, we are fortunate in having the excellent preface by Dr. Rostand who is world-renowned both for his laboratory research and for his understanding of the social and philosophical aspects of science. As Mr. Ettinger states, Dr. Rostand in 1946 was the first to report the protective action of glycerol in the freezing of animal cells. It also is noteworthy that the English scientist Dr. A. S. Parkes in whose laboratory the glycerol phenomenon independently was rediscovered in 1948 also has spoken favorably about the possibility of cryogenic preservation of the body for indefinite periods of time. (C. E. W. Wolstenholme and M. P. Cameron, eds.: Ciba Foundation colloquia an aging, vol. 1, Boston, 1955: 162-69.)

Mr. Ettinger represents the latest spokesman for a worthy American tradition going back as far as Benjamin Franklin. That eminently practical inventor, philosopher-scientist, and statesman predicted in 1780 that scientific progress would bring about means to lengthen the life span beyond a thousand years. Franklin was delighted with the advances of his time; the lightning rod (his own invention), inoculation for smallpox, the steam engine, flying (manned balloons), etc., and he yearned to see the developments of the future. In a letter to a French scientist, he expressed the wish that he might be awakened in a hundred years to observe America's

evolution; the great English surgeon, John Hunter, had a similar idea, hoping to arrange thawing for one year out of every hundred. Franklin also was keenly interested in experiments in resuscitating persons apparently "dead" from drowning or electrocution; in fact, the eighteenth century was fascinated by such activities.

The main pioneers in reviving the "dead" were the Humane Societies set up in Europe and the United States after 1767. (On the Humane Societies, see the article by E. H. Thomson: Bulletin of the History of Medicine, 37:43-51 (1963).) They had to overcome some scorn and ridicule, because, among ignorant and superstitious people, attempts to rescue drowning victims or trapped coal miners were considered utterly foolhardy. But many a conscientious doctor threw himself into the cause, and there were enlightened clergymen to hack them up; the Quakers of Philadelphia aided these reforms, and also the great Methodist John Wesley was called into the campaign. An Episcopalian minister concluded in a sermon in 1789 that the Humane Societies deserved his blessing, "Their sole reward is in the holy joy of doing good." As we congratulate ourselves today over the Red Cross and medical successes in artificial respiration, cardiac massage, blood hanks and other methods to revive the "dead," we should recognize that Mr Ettinger is performing the same kind of service and merits our wholehearted support.

Bringing up the question of the nature of death is a major contribution of this hook, and it is one reason why physicians should read it carefully. We tend to accept uncritically as absolute such concepts as "irrevocable damage," "biological death," etc., and we overlook the insidious nature of this "hardening of the categories," (A phrase coined by Dr. Esther Menaker to describe a common "intellectual disease" of professionals and experts) an intellectual flaw as prevalent and as hampering as hardening of the arteries. This is one of the most useful things about Mr. Ettinger's text; he challenges with admirable tenacity many of these fixed ideas, and every physician will benefit from reading his ingenious attacks on hypotheses we too often take for granted. By serving this function, Mr. Ettinger helps to open original lines of thought and to prevent any lag in the utilization of recent findings in cryobiology, both in practice and in further research.

Of course there are a few points (all peripheral) on which I might not completely agree with Mr. Ettinger; but this has not obscured for me the undeniable logic of his train of thought and the real value of his insight into some of the most difficult problems of modern man. I believe that reviewers and readers in general will find that the core of the book once grasped will never be forgotten and not only will lead to further thought but also to action. We have heard a great deal recently (to our shame) about the costly and childishly sentimental funeral practices referred to as the "American way of death." (Jessica Mitford: The American Way of Death, N.Y., 1963.) Here we have a book which proposes an American way of living on, a demand that our superb (and underemployed) technological facilities be used to implement in a realistic and mature way our avowed belief in the beauty and value of life and health and the immeasurable worth of the individual.

In conclusion, I am reminded of the story about Benjamin Franklin who on one occasion was marvelously rescued from a shipwreck. Having expressed feelings of gratefulness and thanksgiving, he was asked if he intended to build a chapel to memorialize his escape. "No, indeed not," he replied, "I'm going to build a lighthouse!" It is my considered opinion that Mr. Ettinger too has "built a lighthouse," one which throws a powerful light into the years ahead. In the first sudden brightness some persons will be startled, others will ponder curiously the strange, unexpected ways that old perspectives and landmarks have been altered. But those who have faced the pain and the loss and the maddening "absurdity" of human death, whether on a wartime battlefield or in dingy hospital wards - those persons will feel this illumination as a welcome glow of hope in a world which has been waiting so very long.

Preface

By Jean Rostand de l'Academie francaise

About a century ago, Edmond About, a fine French writer and one of the precursors of "science fiction," published a short novel called *The Man with the Broken Ear*. In this diverting tale, he tells about a professor of biology who dries out a living man and then, after a "suspension of life" lasting several decades, successfully resuscitates him.

What was, in 1861, only an amusing fantasy has in our time taken on a rather prophetic air; for, in the light of recent scientific developments, a similar method of preserving a human being no longer seems so impossible.

We have learned, from the experiments of Hahn de Becquerel and others, that some animals of the lower orders (Rotifera, Tardigrada, Anguilla), some vegetable seeds and some microbes can have all internal activity interrupted for a long time by being reduced in temperature to close to absolute zero-and then, upon being thawed, resume all normal functions again. But more than this, researchers report having observed "resurrections" of this sort even among higher order animals; though the entire animal may not have been involved, it is definitely the case that a significant amount of tissue-and even whole organs - were thus frozen and revived. In the same way, the sperm of certain mammals, when impregnated with proper preservatives, has been able to endure the temperature of liquid nitrogen for some months without losing the ability to regain normal mobility and the capacity to reproduce. Likewise, the heart of a chicken, after undergoing a similar super cooling, was able to heat again after being rewarmed.

So it is not out of the question to anticipate future successes of greater and greater complexity; indeed, we are at last even forced to concede the real possibility that the means for freezing and resuscitating human beings will one day be perfected, at however distant a time this may be. This certainly is the opinion of M. Louis Hey, one of the most competent contemporary biologists in the field. He writes:

"There are some very convincing reasons to think that, thanks to future research, one will be able to bridge the gap that now separates the superior organisms from the Tardigrada and Rotifera; the solution will then be found

to the problem of suspending the vital life force perhaps indefinitely."(Conservatism de 1a vie par le froid. Hermann, 1959.)

In *The Man with the Broken Ear*, Edmond About envisioned, with a certain amount of humor, some of the consequences for human society which could result from the preservation of human beings.

"The sick people who were declared incurable by the ignorant scientists of the nineteenth century need no longer bother their heads about it; they were dried up to wait peacefully in the bottom of a box until the doctors had found remedies for their ills."

R. C. W. Ettinger, the author of *The Prospect of Immortality*, has gone a crucial step beyond the French writer: It is not only the incurables he proposes to preserve, but the dead themselves. Indeed, as Mr. Ettinger suggests, should not the dead be considered to be only "temporary incurables" that a better informed science might one day resuscitate by repairing the ills to which they had succumbed - whether their difficulty be sickness, accident or old age? The preservation he advocates would be through refrigeration (a liquid helium or nitrogen bath); this is a method of freezing that is not harmless now, but undoubtedly the science of tomorrow will have ways of repairing freezing damage too.

So we don't have long to wait before we shall know how to freeze the human organism without injuring it. When that happens, we shall have to replace cemeteries by dormitories, so that each of us may have the chance for immortality that the present state of knowledge seems to promise. At the moment, all of this may seem like a remote chance, and no one is more aware of this than Mr. Ettinger. But he has the insight to realize that we have nothing to lose and, possibly, everything to gain by pressing the search. It is, in a sense, a Pascal's wager based on a faith in science. Certainly, a decision to let all corpses remain corpses is, in the face of Mr. Ettinger's alternative, the highest folly.

What is important to realize is that Mr. Ettinger is, in the strictly biological section of the book, carrying to its logical conclusion an argument for which he has unimpeachable premises. It is not the role of the prefacer to pronounce on the immediate practicality of the program. Indeed, Mr. Ettinger himself fully understands that the whole job cannot be done

overnight. What he is telling us is that we must begin; the job will be done some day, and for every day that we put it off untold thousands are going to an unnecessary grave.

In any case, Mr. Ettinger's book is a captivating, stimulating tonic crammed with original views-especially on the problem of the personal identity of the individual. It deserves to be read and thought about.

Translated by Sandra Danenberg

CHAPTER 1

Frozen Dead, Frozen Sleep, and Some Consequences

Most of us now living have a chance for personal, physical immortality.

This remarkable proposition - which may soon become a pivot of personal and national life - is easily understood by joining one established fact to one reasonable assumption.

The fact: At very low temperatures it is possible, *right now*, to preserve dead people with essentially no deterioration, indefinitely. (Details and references will be supplied.)

The assumption: If civilization endures, medical science should *eventually* be able to repair almost any damage to the human body, including freezing damage and senile debility or other cause of death. (Definite reasons for such optimism will be given.)

Hence we need only arrange to have our bodies, *after we die*, stored in suitable freezers against the time when science may be able to help us. No matter what kills us, whether old age or disease, and even if freezing techniques are still crude when we die, *sooner or later* our friends of the future should be equal to the task of reviving and curing us. This is the essence of the main argument.

The arrangements will no doubt be handled at first by individuals, then by private companies, and perhaps later by the Social Security system.

By preserving our bodies in as nearly life-like a condition as possible, it is clear that you and I, *right now*, have a chance to avoid permanent death. But is it a substantial chance, or only a remote one? I believe the odds are excitingly favorable, and it is the purpose of this hook to make this belief

plausible. If it is made plausible, the necessary efforts will be encouraged further to improve the odds.

It is my hope that the cumulative weight of the discussion will convince the reader that his own life is at stake, and those of his family, and that his personal efforts are urgently needed in this mighty undertaking. (The pun should be forgivable; it is impossible consistently to accord the subject the awesome dignity it deserves.)

Suspended Life and Suspended Death

It must be made very clear that our basic program is *not* one of "suspended animation," and does *not* depend on any special timetable of scientific progress, but can be instituted *immediately*. To make sure of our orientation, let us review the meaning of suspended animation and of the several kinds of death.

Suspended animation refers to a standstill in the life processes of the body. It is a stasis that can be imposed and removed at will, and the subject is regarded as alive at all times. In some simple life forms suspended animation can be produced simply by drying, and reanimation by moistening them again; in fact, certain bacteria found embedded in salt have been reported revived after hundreds of millions of years. For humans, the only likely way to induce suspended animation is by freezing, but full recovery after complete freezing has not yet been achieved with any mammal.

The subtle distinction between life and death is evident in the case of the dried bacteria, which were regarded as alive merely because they were potentially capable of displaying life processes. In fact, we recognize at least five kinds of death, which must be kept firmly in mind.

"Clinical death" is the kind we most frequently have in mind, its criteria being cessation of heartbeat and breathing.

"Biological death" has been defined by Dr. A. Parkes as the state from which resuscitation of the body as a whole is impossible by currently known means. This is very logical, but also very odd: a frozen body might lie around for years in a "dead" condition, then all at once come alive, without any physical change whatever, as soon as someone found a means of resuscitation.

"Cellular death" refers to irreversible degeneration of the individual tiny cells of our bodies.

The questions of legal death and religious death will be left for later chapters.

The important point is that a man does not go like the one-horse shay, but dies little by little usually, in imperceptible gradations, and the question of reversibility at any stage depends on the state of medical art. Clinical death is often reversible; the criteria of biological death are constantly changing; and even cellular death is a matter of degree, since it is possible for an individual cell to be made nonfunctional by minor and eventually reparable damage.

Suspended death, then, will refer to the condition of a biologically dead body which has been frozen and stored at a very low temperature, so that degeneration is arrested and not progressive. The body can be thought of as dead, but not very dead; it cannot be revived by present methods, but the condition of most of the cells may not differ too greatly from that in life.

There is also an interesting intermediate condition between suspended life and suspended death, which will be mentioned in a later chapter.

Future and Present Options

When full-fledged suspended animation becomes practicable, a wide range of options will be available. For example, the feeble aged and the incurably ill may choose to suspend life and await a day when cures are known. On the

other hand, many people may still choose to be frozen only after natural death - but the techniques of suspended animation, applied after clinical death but before biological death, should ensure that their condition is still one of suspended life. (It is not self-evident that techniques applicable to a living person are also suitable for one clinically dead, but reasons for thinking so will be produced later.)

The chief value of research on suspended animation, then, is that it will develop new freezing techniques, ways to avoid freezing damage. When this is achieved, we will be able to preserve our freshly dead bodies with only the damage of old age or disease, and without the additional insult of damage by crude freezing methods, and thus our chances of early resuscitation will be vastly improved.

(How strange that the many popular articles on suspended animation have mentioned chiefly its possible use by astronauts on long interstellar voyages! This aspect is trivial. Its importance lies not in travel to the stars, for the few, but in travel to the future, for the many. It will open a veritable "door into summer" for all of us.)

Research in freezing techniques is proceeding actively, although so far on a relatively small scale, at a number of laboratories and hospitals in the United States, France, Britain, Russia, and elsewhere. Some small animals, and some types of human tissue, have been deep-frozen and successfully restored to life. Actual full-body freezing and suspended animation of a human being is anticipated fairly soon by some workers. Dr. James F. Connell, Jr. (St. Vincent's Hospital, New York) is reported in 1962 to have said, "If all the medical personnel involved with this problem make a concerted effort, we will do it in less than five years."

Research work will be multiplied and accelerated if sufficient demand appears for freezer programs. Should this happen, most of us now living will have the benefit of freezing by advanced techniques, so that our bodies will be preserved in much better condition than is now possible.

If feasible, therefore, one should contrive to stay alive for the next few years, since the odds will improve rapidly during this time.

For the present, we must rely on the basic program of suspended death. It is simply proposed that, after one dies a natural death, his body be frozen and preserved at a very low temperature - perhaps near absolute zero, the lowest possible temperature - which will prevent further deterioration for an indefinite period. The body will be damaged by disease or old age which is the cause of death, and will be further damaged (although in some eases probably not much, as we shall see) by our current freezing methods. But it will not decay or suffer any more changes, and one assumes that at some date scientists will be able to restore life, health, and vigor - and these, in fact, in greater measure than was ever enjoyed in the first life. (This is a tall order, of course, and one of the chief aims of this book is to make it seem reasonable.)

After a Moment of Sleep

The tired old man, then, will close his eyes, and he can think of his impending temporary death as another period under anesthesia in the hospital. Centuries may pass, but to him there will be only a moment of sleep without dreams.

After awakening, he may already be again young and virile, having been rejuvenated while unconscious; or he may be gradually renovated through treatment after awakening. In any case, he will have the physique of a Charles Atlas if he wants it, and his weary and faded wife, if she chooses, may rival Miss Universe. Much more important, they will be gradually improved in mentality and personality. They will not find themselves idiot strangers in a lonely and baffling world, but will be made fully educable and integrated.

If civilization endures, if the Golden Age materializes, the future will reveal a wonderful world indeed, a vista to excite the mind and thrill the heart. It will be bigger and better than the present - but not only that. It will not be just the present, king-sized and chocolate covered; it will be different. The key difference will be in people; we will remold, nearer to the heart's desire, not just the world, but ourselves as well. And "ourselves" refers to people, not

just posterity. You and I, the frozen, the resuscitated, will be not merely revived and cured, but enlarged and improved, made fit to work, play, and perhaps fight, on a grand scale and in a grand style. Specific reasons for such expectations will be presented.

Clearly, the freezer is more attractive than the grave, even if one has doubts about the future capabilities of science. With bad luck, the frozen people will simply remain dead, as they would have in the grave. But with good luck, the manifest destiny of science will be realized, and the resuscitated will drink the wine of centuries unborn. The likely prize is so enormous that even slender odds would be worth embracing.

Problems and Side Effects

In order to remove the prospect of immortality from the realm of thin, hazy speculation or daydreams and secure it in the domain of emotional conviction and work-a-day policy, it is essential that the discussion assume some scope and provide some background detail. The gist of the main argument has already been given, but it needs to be filled out and buttressed. Many obvious objections must be met, a host of troublesome questions answered.

How much progress in freezing techniques has actually been made? How much is known about freezing damage? How severe is the damage produced by current methods of freezing, and what reasons, other than vague optimism, are there for thinking the damage may be reversible? Can frostbite be cured?

Since the brain usually begins to deteriorate within a few minutes after breathing stops, how will it be possible to freeze the body soon enough? Considering the varied circumstances of death, how can one cope with the diverse practical problems that will be faced by the pioneers in treating and storing bodies?

Do you have a legal right to freeze a relative? Will failure-to freeze be considered murder or negligent homicide? Will there be an increase in mercy killings and suicides? Can a corpse have legal rights and obligations? Can a corpse vote?

Can families be kept together? Will widowers and widows be allowed to marry again in the first life? What will happen to the resuscitated person confronted with two or more ex-husbands or wives? Is there a conflict between the freezer program and religion, or should the freezers be considered merely the latest in a long series of medical efforts to save and prolong life? If a Christian refuses a chance at extended life through freezing, does this amount to suicide?

Will the cost of dying become so high that we cannot afford it? If we freeze every American, the current population alone will produce something like fifteen million tons of bodies; where's all the money come from, and where can we stack them all?

What about the population problem? When the frozen are revived, where will the throngs of ancestors find lebensraum? Do we have a right to impose ourselves on our descendants, like a mob of poor relations come to dinner? Who needs us? Will it be only the selfish and cowardly who are frozen?

Even if the future welcomes us and makes room for us, will we like it? Even if we like it at first, will we not become bored? How can a mere human endure, let alone enjoy, thousands of years of life? And if we cease being human and become superhuman, will we still be ourselves? How much can a man change without losing his essence?

In fact, some of the most profound questions of philosophy are forced to the level of practical affairs. What is a man? What is death? What is the purpose of life?

How will the answers to these questions affect existing problems? Will a freezer program cause sharper competition or more cooperation among individuals and nations? Will a nuclear war become more likely or less? Will a man looking forward to thousands of years be less inclined to rock the boat and more inclined to practice the Golden Rule?

An attempt will be made to throw some light into all these dark corners.

CHAPTER II

The Effects of Freezing and Cooling

If you are about forty years old now, then probably when you die, in another thirty or forty years, physicians or technicians paid by your insurance company will bank your blood, perfuse your parts, and lay you to rest - not eternal rest, but temporary, and not in the cold ground, but in a much colder freezer. A few years later, perhaps they will slide your wife in beside you.

At first thought, many people find this notion both implausible and a little repellent. They may find it repellent because their minds associate a freezer with dead meat. They find it implausible, because they know a lamb chop looks pretty inert to begin with, and furthermore begins to spoil after a very few years in a freezer at 0 degrees Fahrenheit.

It is also recalled that we sometimes have to chop off a severely frostbitten toe; we cannot revive it, even though the rest of the body is alive. How, then, can we hope to revive a man frozen throughout his very vitals? How can we have any confidence that it will ever be possible?

A mere, generalized optimism is certainly not convincing. It is all very well to say that future science will surpass imagination; but will it be able to take a tub of frozen corned beef hash, and from this reconstitute a steer - the same steer that went into the hash? We are interested in something that is probable, and not just barely conceivable. If our chances were no better than those of the hypothetical steer, we would not want to be bothered.

To provide a basis for reasonable confidence, let us examine carefully some of the salient facts and estimates concerning the effects on living animals of cooling and freezing.

Long-term Storage

Our basic argument was based on one fact and one assumption. The fact - that it is possible, right now, to preserve dead people with essentially no deterioration, indefinitely - is easily established.

It is a well-known principle of chemistry that at temperatures near absolute zero (about -273C or -459F) reaction rates generally become negligibly small. The molecules are nearly motionless. The life processes of any organism cooled near this extreme should become immeasurably slow, and also any processes of decay. Actual observation confirms this theoretical principle.

Dr. Harold T. Meryman (Naval Medical Research Institute, National Naval Medical Center, Bethesda, Maryland), a leading authority in the field, says, "Under any circumstances, storage in liquid nitrogen, at - 197C can be considered as essentially indefinite." (68)

Dr. Humberto Fernandez-Moran (University of Chicago), a prominent expert in biophysics, notes that ". . . no detectable metabolic activity has been reported at liquid nitrogen temperatures . . ." He points out, however, that activity involving short-lived molecular fragments called "free radicals" can occur at - 197C and that long-term storage should perhaps be at liquid helium temperatures, namely within a few degrees of absolute zero. The reaction rates at liquid helium temperatures are calculated to be slower than at liquid nitrogen temperatures by a factor of about ten trillion! (30)

Many other investigators have written to the same effect. The consensus of the best-informed opinion, based on long observation as well as theory, indicates that a body cooled by liquid nitrogen can be stored without significant changes or deterioration for a period measured at least in years and probably in centuries. A body cooled by liquid helium will keep, for all practical purposes, forever.

Clearly, then, the storage problem is not the main difficulty. Whatever condition the body is in when it reaches the storage temperature, that is the condition in which it will remain for as long as it is necessary to keep it. If it

is alive, it will remain alive; if it is somewhat damaged, it will remain somewhat damaged.

The principal hazards pertain to the freezing and thawing processes. Let us next inquire what progress has been made in actually freezing specimens and restoring them to active life.

Successes in Freezing Animals and Tissues

Among smaller and lower organisms, there are many which can survive actual hard freezing at temperatures far below the freezing point, even without any special protection, and others which can be assisted to do so.

Becquerel has found that certain minute, primitive animals, which can tolerate dehydration, can be cooled, after drying, to within a fraction of a degree of absolute zero, and after rewarming and remoistening revive fully. (5) Since the water had been removed before freezing, there had been no damage from ice crystals.

Two Japanese scientists, Asahina and Aoki, worked with larvae of a certain insect, Cnidocampa flavescens. The larvae were removed from their cocoons, kept for one day at -30C, and then immersed in liquid oxygen at -180C. After thawing, their hearts resumed beating, and some of them lived to their next developmental stage, that of "imago," but none completed metamorphosis to the adult stage. (2) It was thought that the pre-freezing period of one day at -30C allowed growth of ice crystals outside, rather than inside, the cells; that is, the ice crystals formed in the intercellular spaces.

Many protective agents have been tried to reduce damage to animal tissues in freezing; perhaps the most successful of these has been glycerol. Professor Jean Rostand, working with frog spermatozoa, provided the first evidence; motility of the sperm was preserved for several days at -4C to -6C. (94) (The freezing point of pure water at standard pressure is 0C.) Subsequently it has been found that certain cold-hardy insects naturally contain glycerol in their bodies! (110)

Another protective agent sometimes used successfully is ethylene glycol, a solution of which was used by Dr. B. J. Luyet and Dr. M. C. Hartring in freezing vinegar eels, anguillula aceti. The eels survived immersion in liquid air at about - 190C, provided both cooling and rewarming were rapid. (110) It was thought that the ethylene glycol caused dehydration, and induced a vitreous rather than a crystalline condition of the water in the cells.

Clams on certain northern shores, exposed to temperatures far below 0 degrees celsius when the tide runs out, apparently become solidly frozen and thawed twice daily for weeks on end, yet survive. It is suspected that these organisms also may secrete a natural protective agent of some kind, and investigation is continuing. (110)

When we turn our attention to larger and more highly developed forms of life, we find there have been many successes in freezing and reviving cells, tissues, and even organs. Usually protective agents have been required, but not in all cases.

Bull semen has been treated with glycerol, stored at -79C (the temperature of solid carbon dioxide or "dry ice") for periods up to seven years, and thawed with a high survival rate. But it is interesting to note that a little deterioration occurs even at this temperature; lower temperatures improve the results. (110) It is also observed, contrary to the experience with vinegar eels, that too rapid freezing can be harmful. (110)

Human spermatozoa, without protection, show resistance to extreme cold which varies from cell to cell, and also from donor to donor. In one study, up to 10 per cent of the sperm cells survived five-minute exposure; hardihood varied from donor to donor, but for a single donor survival was the same at -79C, -196C, and -269C. (110)

Dramatic evidence of the viability of deep-frozen human sperm is furnished in a New York Times Service article (Detroit Free Press) of September 6, 1963. Two babies were born to women who had been artificially inseminated with sperm stored for two months at liquid nitrogen temperature. Dr. Jerome K. Sherman, of the University of Arkansas, is said to have stored semen at this temperature for three and a half years without loss.

Dr. S. W. Jacob and co-workers have reported cooling human conjunctival cells (from the membrane lining the eyelid) as well as sperm to within less than one degree of absolute zero, with viability maintained. (50)

Embryo chicken hearts, after treatment with glycerol solution, have been cooled to -190C, and heating resumed after thawing. This was one of the developments which led Dr. D. K. C. MacDonald of Ottawa University, an expert in low-temperature physics, to write, ". . . perhaps the day will come when, if you want it, you can arrange to 'hibernate' for a thousand years or so in liquid air, and then be 'wakened up' again to see how the world has changed in the meantime." (65)

In the case of the mammals, attempts to freeze, store, thaw, and revive specimens have not yet been completely successful. But there have been many partial successes, and much has been learned.

The best-known experiments may be those of Dr. Audrey U. Smith, of the National Institute for Medical Research, Mill Hill, London, working with golden hamsters. These animals have been successfully revived after being about half frozen. In particular, more than half the water in the brain had changed to ice, and the bodies were rigid; yet these mammals recovered to apparently normal activity. (110) This is very important, since it seems to provide some evidence that mental faculties can survive freezing and thawing.

It is to be noted that Dr. Smith's results were achieved by crude means: the cooling was with cold baths and cold packs, and the aids to resuscitation were simply artificial respiration and microwave diathermy. The tissues were not given any local protection in the form of special infusions, although it is known that such protection can be very important.

Similar work includes that of Andjus and Lovelock, who have reported recovery and long-term survival of 80 per cent to 100 per cent of ice-cold rats. (110) Dr. J. R. Kenyon and his co-workers have chilled dogs approximately to the freezing point, with heartbeat and circulation completely stopped, and obtained sufficiently complete recovery so that they survived many weeks after the experiment. Chemical infusions were used to counter-act accumulation of certain harmful metabolic products. (55)

The mechanism of freezing damage is still poorly understood. There is much variation in hardihood among different types of cells, and even among individual cells of the same type. Different temperature ranges also have their own distinctive problems.

Experimental work directed toward testing new theories and new protective agents and techniques proceeds vigorously, but on a relatively small scale. When the public becomes interested in freezers, progress should become much swifter. It is not always possible to hasten scientific progress simply by spending more money, but in this instance the possibility seems to exist. Many avenues apparently are not being explored, for lack of workers.

Among other things, a massive, systematic search for new protective agents seems called for.

Even with work at the present relatively slow pace, there is much optimism. Dr. A. S. Parkes, F.R.S., in the foreword to Dr. Smith's hook, says that in the next decade (1961-71), "The preservation [in deep freeze] of whole organs for transplantation may become possible . . ." (110)

Dr. Juan Negrin, Jr. (Lenox Hill Hospital, New York) is reported in 1961 as saying, "We are working now to develop a method for using full body freezing to suspend life. We have already succeeded in bringing about this state in various animals." (117) Some new successes will no doubt be on a cut-and-try, empirical basis. But in order to get a better idea of future prospects and present possibilities, let us briefly review current ideas about freezing damage.

The Mechanism of Freezing Damage

There are several suspected reasons for the frequent failure of animal cells and tissues to survive after being cooled to very low temperatures, stored, and thawed.

Before listing these possible causes of freezing damage, it should be pointed out that "failure to survive" is a very vague and possibly misleading expression. The usual criterion for survival is resumption of function, if an entire organ is involved, or growth in culture or successful transplant or autoreplant if a piece of tissue is in question. (Autoreplant refers to grafting the tissue back into the donor animal.) A tissue just below the borderline of resumed function is called "dead," and an experiment in which only a small percentage of the cells survive may be considered a failure. But in fact, near successes and partial successes afford substantial grounds for optimism, since they suggest that a comparatively small amount of damage has been done.

It is convenient to list several separate types of possible freezing injury, even though they are not all mutually exclusive, as follows:

1. There may be mechanical damage by ice crystals.

The most obvious opportunity for injury would be a stabbing, crushing, or bursting action against the cell membranes and cell bodies by the ice crystals formed as water freezes. Yet oddly enough, this kind of event seems rarely to have been observed, although it may sometimes occur. (In the case of plant tissues, with their more rigid membranes, this kind of damage occurs much more easily.)

In slow freezing - involving a typical cooling rate of, say, one Centigrade degree per minute - pure ice gradually separates out from the solution in the cell, the ice crystals forming beyond the membrane in the intercellular spaces. Slower freezing produces crystals that are larger in size, and of course fewer in number; faster freezing, the reverse. When the so-called eutectic temperature is reached, the remaining solution freezes out in a close mixture of crystals of ice and of the various salts or their hydrates.

There is ample evidence that ice crystal formation as such is not necessarily fatal, even though water expands when it freezes. Meryman says: "Experimental frostbite research produces evidence that a dog's leg can survive after the deep tissues have been at a temperature well below freezing for as much as fifteen to thirty minutes . . . There is no question but that ice crystals are formed, and yet the tissue survives . . . there appears to be little question but that in the soft tissues encountered in the animal kingdom it is

possible for an ice crystal to intrude itself between the cells and to collapse the cells completely without impairing their capacity for survival." (70)

In fast freezing, the crystals formed are much smaller, and possibly for that reason less dangerous mechanically, even though the total volume of ice is the same. But fast freezing does not allow the water to leave the cell, and small intracellular or even intranuclear ice crystals may form, with poorly known but probably dangerous potentialities. For example, a membrane surrounding the cell nucleus may be violated.

2. There may be a dangerous concentration of electrolytes.

Since freezing involves a separation of ice from solution, it is a process of dehydration. The fluid left behind in the cell has an unnaturally high concentration of salts and similar substances, called "electrolytes," which have special electrical and chemical properties. This drastically changed internal environment may be fatal to the cell. (69)

Damage to the cell from this cause is thought to be dependent on the degree of electrolyte concentration, the time of exposure to it, and the temperature; a lower temperature means a slower reaction. The electrolyte concentration may be dangerously high, depending on the type of cell and other factors, roughly between 0C and -25C. Hence cooling in this range should be relatively rapid, if possible, in the absence of protective infusions.

Dr. J. E. Lovelock thinks the lipoproteins are especially sensitive to denaturation, or loss of chemical characteristics, from this cause. "A frequent if not invariable component of the many membranes of a complex living cell is the lipid-protein complex . . . held together not by the relatively strong covalent bonds which link the atoms of a simple protein, but by weak association forces similar to those supporting a soap bubble, these complexes are inherently unstable and probably maintained in living cells by continuous synthesis . . . Freezing [can easily] denature the more sensitive lipid-protein complexes of the cell.

"The high sensitivity of lipid-protein complexes to the adverse effects of freezing suggests that not only the principal cell membrane, but also the lesser membranes of the cell . . . may suffer irreversible damage during freezing. The profound change in the environment of the cell which occurs

during freezing is also capable of causing harm to the more stable molecular constituents of the cell." (62)

Not to put too fearful a face on it, we should note also that he goes on to say, ". . . many living cells and tissues have now been stored successfully in the frozen state ... in spite of these formidable hazards."

We should also remind ourselves once more that the phrase, "irreversible damage" is used much too cavalierly, and really means only "incapable of being reversed by methods so far employed."

3. There may be metabolic imbalance.

Dr. L. R. Rey, a prominent investigator of the Ecole Normale Superieure, Paris, believes the cells may be thrown out of kilter by the unequal effect of cold on delicately balanced life processes. "Various enzymes are not inhibited in the same manner ... there may be an abnormal accumulation of intermediate metabolites which normally have a transitory existence and which may either prove to be toxic or to orient the metabolism in a different direction." (90)

This sounds rather hopeful, since it seems to leave open the possibility of redressing the balance, once we have both the understanding and the means.

A similar comment has been made by Dr. L. Kreyherg. "It is evident that in areas of organized tissue in situ [on site] the limits for survival of some of the cells after freezing . . . is not decided by the tolerance of the individual cells, but by the local reactions to the disorganization of the social life of the cells." (56) One suspects a like remark might apply to conditions within an individual cell and between its parts.

4. There may be thermal shock and osmotic shock.

Rapid freezing is fatal to many cells, for reasons not well understood. One hypothesis about "thermal shock" is that various materials in the cells and their membranes shrink at different rates as the temperature is lowered, setting up destructive mechanical stresses. "Osmotic shock" refers to the unfavorable effects of sudden changes in solute concentrations in contact with certain membranes.

5. There may be damage during storage.

The cell encounters various vicissitudes as it is cooled, depending on many factors in each of several ranges of temperature; and when it finally arrives at storage temperature, its troubles may not be over. As already pointed out, there is evidence that at all but the very lowest temperatures, near absolute zero, eventually appreciable changes do take place, although they may be very slow.

Although Fernandez-Moran has pointed out that free radical activity can occur at -196C, and suggested that perhaps long-term storage ought to be at liquid helium temperatures, nevertheless most writers seem to agree that storage at the temperature of boiling nitrogen is probably safe.

In any case, the word "decay" is probably ill-chosen to describe the deterioration that may take place at low temperatures. It is probably not a case of general rot or putrefaction, or even normal metabolism, proceeding at a reduced rate, but rather a case of a few sensitive processes going essentially to completion, with ensuing stability for an indefinite period. If this is true, cooling with dry ice for long periods may be just about as safe as cooling with liquid helium, except for some initial minor damage. On this, however, I cannot quote authority, and many questions remain unanswered.

6. There may be thawing damage.

There is ample evidence that more damage may occur during thawing than during freezing, especially if thawing is slow and protective infusions are lacking. The mechanisms of damage appear to include migratory recrystallization of ice (small crystals may merge into larger crystals, causing mechanical disruption) and gas bubble formation, as well as others. These effects may occur at temperatures as low as -40C.

For a time, the difficulty of obtaining fast thawing was thought to be extremely serious for any but the smallest specimens, for which heat exchange is not a problem. It now appears, however, that microwave diathermy and induction methods will allow rapid thawing, at a more or less uniform rate throughout the body, even of large specimens. These methods involve the use of high frequency radio waves, alternating magnetic fields, or alternating electric fields; the former are analogous to an ordinary heating

lamp, the latter to so-called electronic ovens. Apparatus has been described by Lovelock. (61) Using this, rabbits can be thawed in just a few seconds. (110)

7.There may be miscellaneous deleterious effects.

Various bits of evidence and speculation point to additional possibilities in the complex question of freezing injury. Drugs and antibiotics, as well as normal body solutes, may become concentrated to lethal levels. At dry ice temperature, if glycerol is used, there may be incomplete freezing, and a slight solubility of salts in glycerol may allow slow damage. At extremely low temperatures, complete removal of water as ice might include water molecules necessary for the structural integrity of proteins. And so it goes; much is known, but much more needs to be learned.

In summary, if we seek the main danger to humans frozen without perfusion by protective chemicals, expert consensus seems to point to denaturation of protein molecules, a consequence of overexposure to concentrated salt solutions, which in turn is a consequence of too-slow freezing. As to the possibility of avoiding this danger by using protective agents, or by increasing the speed of freezing, more will be said later.

Frostbite

We are now in a position to answer the skeptics who say that, because a frostbitten toe may be incurable today, they doubt it will ever be possible to freeze and revive a complete man; and it may be worthwhile to make the answer explicit.

To begin with, frostbite often is cured, as shown by both clinical and laboratory experience. When we investigate which cases are cured and which are not, we find some neat tie-ins with the earlier discussion of the mechanism of freezing damage.

It has been shown, both in man and other animals, that freezing may actually occur, with formation of ice crystals in the tissues, without any irreversible harm. (110) The damage occurs if the temperature is too low, so that too much ice separates out, producing too high a concentration of solutes in the tissue fluids; or if freezing is too protracted, resulting in exposure of the cells to concentrated solutes for too long a time; or if thawing is too slow, resulting in dangerous high-temperature exposure to somewhat concentrated solutes; or if there has been bending or rubbing of the member while frozen, damaging non-resilient tissues; or if unfrozen but chilled and malfunctioning blood vessels fail to supply the thawed parts.

Medical texts recognize that thawing should be rapid, and rubbing (with snow or anything else) avoided. (12)

In a word, the presently incurable cases of frostbite are simply those cases in which the conditions were unfavorable. In other cases, frostbite can be cured. In fact, human skin has been rapidly frozen to dry ice temperature, and then used in grafts with some success. (110) Rabbit skin has been stored at dry ice temperature for four years without deterioration, after being pre-treated with glycerol. (110)

It is not obvious how a whole man could be rapidly frozen, or treated with glycerol, but these matters will be discussed later. The point here is simply that much is known about frostbite, it is preventable, and it is often curable. In addition, of course, some of the cases now thought incurable will be curable in the future.

The Action of Protective Agents

A brief review of the substances which have been found useful as protective infusions to prevent or reduce freezing damage, and of the theory of their action, shows that a good beginning has been made in the research, and that we are not without resources even now.

An ideal protective agent is one to which the cells are readily permeable, which prevents all kinds of freezing damage but is not itself toxic, and which can be easily removed after thawing. Nothing is known which completely fills this bill for all kinds of tissues. The substances which seem to be most nearly and most widely satisfactory are glycerol and dimethylsulfoxide.

Glycerol, in particular, has been extensively tested. Its use has been markedly successful, although not always completely successful, with a wide variety of organisms and tissues, including mammalian kidneys, bone, lungs, sperm, skin, hearts, ovarian and testicular tissue, and - most important - nervous tissue. (110)

In most cases, glycerol is thought to exert its beneficial action mainly by buffering the solution of electrolytes, that is by somehow preventing or reducing the chemical action of the dissolved substances. This action may be linked to the capacity of glycerol to bind water, and itself to dissolve some of the salts. Glycerol also suppresses the occurrence of a sharp eutectic point in physiological media; if there is no sudden crystallization, the cells may be saved from osmotic shock. (110) Other modes of protection may also occur, and the relative importance of the various modes depends on the nature of the tissue.

Other substances, especially various sugars and alcohols, have been used with varying degrees of success.

Many fascinating experiments have been reported whereby tissues have been induced to tolerate glycerol as a result in adjustments of other components of the solution used for perfusion, such as calcium and potassium; and whereby ingenious methods of removing the glycerol have been devised. It is encouraging to note that in a great many cases where unsolved problems remain, it is the thawing phase and the removal of glycerol which seem to present the difficulty. This suggests that our bodies might be frozen and stored in reasonably good condition, so that future technicians would only have to perfect methods of thawing and removing the protective agents, and would not have to perform excessive wonders in reversing freezing damage.

The Persistence of Memory after Freezing

Some scientists not so long ago feared that even if we could freeze a body, store it at low temperatures and then restore it to active life, the brain would be wiped clean of memories, resulting in a kind of grown infant or idiot. It is obviously of the utmost importance to assure ourselves that this will not be the case.

Everything hinges on whether memory is dynamic or static. In computing machines, there are two general ways to store information: there are dynamic methods, involving oscillations which will die out if the power is turned off, and there are static methods, such as the use of magnetic tape, in which the information remains even though the machine is not turned on. These two possibilities exist for the brain as well.

As recently as 1960, Professor William Feindel of McGill University wrote: ". . . nerve cells have some of their numerous branches turning back to end on the body of the parent cell, so that they actually receive samplings of their own outgoing messages . . . these self-re-exciting nerve loops may keep up a perpetual circular impulse which is the 'memory' of that particular cell ...." (29) But he also pointed out that memories might be related to physical, chemical, or electrical changes at the hundreds of tiny button-like endings covering each nerve cell in the brain.

More recently, however, Professor I. S. Roy John, director of the University of Rochester Center for Brain Research, has written: "Ample evidence exists for a two stage process of memory . . . (1) an early consolidation period approximately 0.5-1.0 hour long, in which reverberatory electrical activity probably maintains a representation of the experience, and (1) a long-lasting stable phase, in which experience is stored as a structural modification of some sort." (51)

In other words, very recent memories are dynamic, and this helps to explain the retrograde amnesias sometimes observed after certain kinds of shock or trauma. But most of the memories, the long-term memories, are static. In fact, they are believed to consist of changes in protein molecules in the brain cells. (46)

Many experimental tests have been made. For example, Dr. Smith reports, "We found, in collaboration with animal psychologists, that rats which had been trained to solve problems of finding food in mazes showed no appreciable loss of memory after cooling to a body temperature just above freezing. Activity of the cerebral cortex, as judged by electroencephalograms, ceases at about + 18C in the rat, so that cerebral activity most have been arrested for 1-2 hr. in all the animals tested. After reanimation they were, nevertheless, capable of acting on previous experience. This result was not consistent with the theory that memory depends upon a continuous passage of nerve impulses through actively metabolizing neurons in the brain." (110)

There are two other points of great significance concerning memories: each one seems to be stored in many separate locations in the brain, and therefore may withstand widespread damage; and they consist of chemical coding similar to the traces which record genetic and immunological information, and possibly therefore they may be hardy and resistant to damage.

Professor Hans-Lukas Teuber of the M.I.T. writes, "Experiments employing massive cerebral ablations [removal of parts] or multiple transections [cross sections] of cortex . . . show remarkable resiliency of established 'engrams.' . . . The survival of old established traces following hibernation, general anesthesia, or convulsions suggests a mechanism protected against loss in a manner analogous to immune reactions, i.e., by virtue of multiplication of the trace, relatively small size, and considerable dispersal throughout the cerebrum. . . . [Certain experiments may reveal] that biological trace processes are of essentially the same type, whether we are dealing with genetic processes, embryonic induction, with learning, or immunological.(116)

We shall see the importance of this view when we ask how much freezing damage may be tolerable.

The Extent of Freezing Damage

It must be emphasized that freezing damage, especially to the brain, may not be excessive, even though no mammal has yet made a complete recovery after full-body freezing by the rather crude methods so far employed.

There are several difficulties in freezing large animals. Perfusion with protective agents is not easy, and fast freezing of deep tissues has been regarded as hopeless. It follows that there may be denaturation of protein molecules in the brain by concentrated salts, and this thought has produced much gloom. In the next section it will be suggested that the major part of the freezing damage can, in fact, be avoided. In this section it will be argued that, even if the freezing injury is as severe as it usually seems to be, reasonable grounds for optimism remain.

First, while it may be hard to conceive of a generalized method for reversing protein denaturation, this is by no means the end of the story. For one thing, such a method may very well be devised, despite our inability to conceive it, by the ingenious men and redoubtable machines of the future. After all, in the last century engineers considered a heavier-than-air flying machine impossible; and before 1926, when Sumner isolated urease, it was not even known for sure that enzymes were proteins. (3) Further, as we shall see, the nature and extent of the denaturation is not uniform, and may in some cases be trivial; and the attack need not necessarily be "generalized."

It must be stressed that even crude freezing frequently fails to kill all cells, and that those "killed" suffer varying degrees of damage; this is true even if we fix our attention on a single type of tissue. Also, the most important parts of the cells may be the hardiest.

That some cells survive freezing even when most "die" we note, e.g., from the work of Rey, who rapidly cooled embryo chicken heart tissue: " . . . there is no growth in the cultures without glycerol except sometimes in two or three migrating cells . . . some peculiar cells do survive after the exposure to liquid nitrogen. . . . Why is the main part of the tissue killed by rapid cooling in liquid nitrogen? . . . we think [these alterations] occur during the thawing process." (90)

Even though chickens are not people and hearts are not brains, it is important that some cells survive; we can logically conclude that probably many others almost survived, and could have been rescued by future scientists either before or after thawing by improved methods.

By way of analogy, imagine viewing (from the air) a strafing attack on a column of troops. If none gets up afterwards, perhaps they are all dead. But if even one or two get up, it is highly probable that many others are merely wounded and not killed.

Again, Kreyberg says: "It is evident that through severe exposures to cold, many cells, sometimes most of the cells, succumb. Sometimes single cells, sometimes smaller groups of cells survive and are able to repopulate cultures and even form rather complex transplants, as demonstrated through the experiments with ovarian tissues." (56)

There is somewhat similar experience with mammalian nervous tissue, which is the most vital concern. Pascoe, working with rat ganglia, found that although one experiment was mainly negative, "One preparation [without glycerol] was stored overnight at - 150C and on warming the post-ganglionic nerve gave a small action potential when it was stimulated directly." (86)

Not only does experiment indicate that some cells survive unfavorable freezing methods, but theory also. The act of freezing will catch various cells in many different environmental situations and at different phases of the metabolic cycle. Some of these are almost sure to be lucky ones.

Further evidence that freezing damage to the brain may be only moderate, even in the absence of protective infusions, seems to be provided by the work of Dr. H. L. Rosomoff, of The Neurological Institute, New York. He produced lesions in dogs' brains by contact of the dura mater (brain integument) with a brass tube containing liquid nitrogen for eight minutes. If the dogs were kept at normal temperature afterwards, they invariably died, and microscopic examination showed "wide-spread destruction of cellular elements, especially the neurons, complete loss of cytoarchitectural markings, . . ." But of seven dogs kept at 25C or less (after the lesions were produced) for eighteen hours before rewarming, two survived, and the others lived five times longer than those not kept hypothermic; furthermore, examination of the lesions showed that: "The cortical architecture was better

preserved, cellular elements showed less evidence of injury, albeit definite degenerative changes were found which may or may not have been reversible in nature." (93)

This experiment was not intended to study freezing damage as such, but was meant to investigate the benefit of hypothermia (reduced temperature) in the aftercare of any kind of brain lesion. Nevertheless, the damage to the cells in the lesion region presumably was produced by freezing. This seems to indicate rather clearly that the most serious damage following such freezing may be the result of anatomical and physiological events during and after thawing, and that while frozen the cells were in relatively good shape. As already pointed out, this is very important, since our task need only be to preserve the bodies with as little damage as may be; if necessary, we can leave to the future the problem of proper treatment during and after thawing.

Again, in the case of nervous tissue pre-treated with glycerol, there is evidence that the major difficulty may lie not in freezing and storage, but in the removal of glycerol. Dr. Smith, commenting on the work of Pascoe, who studied rat nervous tissue after perfusing whole rats with glycerol solution, says, ". . . damage to nervous tissue might not be a limiting factor in attempts to resuscitate a whole animal which had been perfused with glycerol and cooled to and thawed from a very low temperature. " (110)

Having gone to considerable pains to show that even crude freezing methods may not kill all cells, and that even many of the "nonsurvivors" may be only slightly damaged, we are now ready to make our conclusions more explicit.

It will be helpful if the reader will tentatively accept two propositions which will be given support in later chapters:

(1) Mastery is beginning to be obtained, and will eventually be thorough, over the growth, development, and differentiation or specialization of both genetic and somatic (body) cells. It will become possible to grow replacement parts, large or small, in culture, or alternatively to make the body repair itself by regenerating missing parts. (In the case of the brain, of course, there cannot be complete replacement or regeneration, since this would be equivalent to growing a new individual.)

(2) Wealth and resources will grow in the future at an ever increasing rate, qualitatively as well as quantitatively. In particular, there will be available fabulous machines, capable not only of action on a titanic scale but also of "thought" on extremely high levels and manipulation on microscopic levels. Now, we recall that memories are stored probably as changes in protein molecules in the brain cells, with multiple locations for each trace in many regions of the brain. (And since the memory recordings are thought to be chemically similar to the codings of genetic information, and since the latter is known to withstand liquid helium temperatures, it may be that memories are equally hardy, but we are not depending on this.) Other elements of personality may be represented in a similar way, or they may inhere in larger-scale circuitry, as in the fiber connections among the nerve cells.

There seems a good chance that the supra-molecular circuitry can be read well enough after freezing. Hence it may well be that only a small percentage of the brain cells need escape with little damage; this may be enough for reasonably faithful reconstruction of the brain with freshly generated tissue.

The robot surgeons of the future will have powers now only faintly foreshadowed, but beginnings have already been made in cell surgery. Individual cells have been successfully operated upon, e.g., transplanting nuclei into enucleated amoebae, even cross-species! (27) Thus, if brute-force methods are necessary, it is not inconceivable that huge surgeon-machines, working twenty-four hours a day for decades or even centuries, will tenderly restore the frozen brains, cell by cell, or even molecule by molecule in critical areas.

We hasten to add that in all likelihood the methods used will be much more elegant and yet unforeseen. The great chemist, Linus Pauling, speaking in a general sense not so long ago, said, "The great discoveries of the future - those that will make the world different from the present world - are the discoveries that no one has yet thought about. . . . I know . . . that . . . discoveries will be made that I have not the imagination to describe - and I am awaiting them full of curiosity and enthusiasm." (88)

We must also bear prominently in mind that only those frozen in the very near future may be severely damaged; there will soon be accelerated research, and before many years non-damaging techniques should be

available. Indeed, a man can probably be frozen right now with comparatively little injury, as we shall see in the next section.

Rapid Freezing and Perfusion Possibilities

Is a high freezing rate, with cooling of many degrees per minute, really out of the question for an animal as massive as man? And what are the chances of giving a complete large organism the protection of perfusion with a protective agent like glycerol?

It seems that in the absence of a protective agent, the brain (and body) should be frozen quickly. This will not prevent all damage, but might reduce the major risk of protein denaturation. How may quick freezing be accomplished?

Merely immersing the head or body, or even the naked brain in a cold bath such as liquid nitrogen will not do it, except for the outer layers. And while methods of heat transfer other than simple conduction do exist, they do not now seem applicable to cooling the body. The only means that seem presently feasible require more brain surface in contact with the refrigerant.

The most obvious method would be to circulate cold fluids through the brain's blood vessels. This in fact is done in open-heart surgery, but at temperatures above freezing. Whether anything could be done in the subzero range is, so far as I know, one of the open questions requiring investigation. It would certainly be difficult, with vessels tending to be brittle and clogged as well as constricted, but it is not obviously impossible.

Certain heroic measures also suggest themselves. For example, the brain might be "teased" apart into smaller segments which could be cooled more quickly. Or hollow needles carrying refrigerant might be inserted, as into a pincushion; care would be taken to penetrate different regions in the two hemispheres, to avoid destroying the homologous tissues on each side. Or the brain, after cooling, might even be sliced into sections for quick freezing, on the theory that this mechanical damage, although massive by present

criteria, might yet be small compared with the damage done by slow freezing, and more easily repaired.

But the method of choice at the present time would seem to be moderately slow freezing after perfusion with glycerol solution.

Apparently there have been relatively few attempts at full-body perfusion. Dr. Smith says, "So far no technique has been evolved for perfusing individual organs or the whole mammal with glycerol and removing it without damage. If this could be done it might be possible to cool the intact mammal to and resuscitate it from temperatures as low as -70C. Long-term storage of frozen mammals might then be considered. It must be emphasized that there is no prospect of accomplishing this in the near future." (110)

The great thing, however, is that we do not need the fullness of this accomplishment in the near future! Whole rats have been perfused, as previously noted, and probably men could be also. The problem of removing the glycerol without damage can be left to the more distant future, along with the problem of repair of those parts not reached or incompletely protected by the glycerol. The people who are dying right now cannot, and need not, wait for 100 per cent mastery of the problem.

The Limits of Delay in Treatment

If you have a dying relative, you can probably give him his best chance by obtaining skilled medical help, planned in advance, to prepare, perfuse, and freeze the body. If this kind of help is not available, and you nevertheless want to give him some chance, more desperate measures are required. In any case, it is important to know how soon after death treatment must be started, and this question will now be considered.

Many laymen, and even many physicians, have the impression that the body must be frozen within a few minutes after clinical death in order to have a chance of revival. This is an error.

It is quite true that if the oxygen supply is cut off, the brain ordinarily seems to suffer damage within three to eight minutes. But this seemingly simple statement is very deceptive: the words "ordinarily" and "damage" beth require clarification.

If death comes unexpectedly or without preparation, the brain may certainly suffer "irreversible" damage. When the blood circulation stops, there is no more delivery of oxygen and dextrose, and no more removal of waste products. The immediate causes of damage, according to Wolfe, include increase in inter- and/or intracellular fluid, loss of tone in the capillaries, increased permeability of tissues lining the blood vessels, disturbance of fluid balance, and concentration of lactic acid. (129)

How quickly the damage begins to occur is not entirely clear. Total circulatory interruption is considered dangerous after three minutes, and the most commonly mentioned limit of tolerance of the brain to lack of oxygen is perhaps five minutes. But Brockman and Jude have conducted experiments with dogs indicating that ten minutes of oxygen deprivation causes no harmful effects, although fourteen minutes at normal body temperature is fatal. They believe the shorter estimates result from use of methods which leave circulation depressed after the period of anoxia, producing added damage and causing the experiments to be misinterpreted. (10)

Of course much depends on temperature and individual variation, as well as other factors. In a later chapter we shall recount the story of a boy who made a nearly complete recovery after twenty-two minutes under water and 2 1/2 hours of clinical death.

While the brain cells do indeed "die" more quickly than cells of other kinds, we must not therefore come to a hasty pessimistic conclusion. As already indicated, it may well be that the most important parts and functions of these cells are not so delicate as the cell as a whole.

By way of crude analogy -- which of course must not be stretched too far -- consider a bicycle and a huge snowball rolling down a slope. The bicycle is much more complex, and it can be stopped by merely thrusting a stick through the spokes, while much more effort is needed to stop the snowball.

Just the same, a bicycle is on the whole much sturdier than a snowball, and when the stick is removed it will be ready to roll again.

It is possible, then, that hope should not be given up so long as any of the body cells show life. If the skin, for example, is still alive, then there is some chance that the brain cells are also alive, albeit damaged. Removal of excess lactic acid, adjustment of the fluid balance, and so on, by techniques at the disposal of future science, may find them good as new.

The period of grace before all of the body cells die is measured at least in hours, and perhaps in days. According to Lillehei et al., the stomach remains alive and healthy outside the body, even without cooling, for at least two hours. (59) Gresham, referring to an unpublished study by V. P. Perry, says, "Tissues removed from cadavers as late as 48 hours postmortem have, in most instances, shown cellular outgrowth in tissue culture. Although this does not eliminate the possibility of cellular alteration, it suggests that many tissues may remain functional for relatively long periods after death, and that postmortem tissues may be satisfactory for viable grafting." (36)

Boiling all this down to a rule of thumb, what perhaps emerges is that in a self-reliance situation, if you want to give the deceased the benefit of even a relatively slim chance, a body should be frozen if it is found on the day of death. If the body has been exposed to cold weather, perhaps the chances are not too remote after two days. It seems entirely possible that the delay damage will still be no greater than the damage of the crude freezing method you may have to use.

In a hospital situation, with medical cooperation, the story is different and much more hopeful, and further remarks are called for.

The Limits of Delay in Cooling and Freezing

Three separate phases of postmortem care of the body may be distinguished: measures in advance of cooling, cooling down to the freezing range, and cooling down to storage temperature.

For various reasons, death may come before cooling equipment is ready. Looking for means to prevent deterioration meanwhile, we find interesting possibilities. Some of them are relevant only if specialized equipment and personnel are at hand, while other measures can be employed by almost anyone.

Methods are already being applied to keep freshly dead bodies in good condition, for the purpose of maintaining organs in good health, when a transplant is contemplated but cannot be performed immediately. Heart-lung machines have been used to keep the body supplied with oxygenated blood for up to eighteen hours after death, and then livers taken from the bodies and used for grafts. (Detroit Free Press, October 31, 1963.)

An obvious resort in emergency is to use artificial respiration and external heart massage. (At the same time, the body could be cooled with ice packs, or by exposure to cold air.) Anyone can learn the techniques, and tubes are available so that mouth-to-mouth artificial respiration can be given without actual contact. Effectiveness would depend strongly on the cause of death and the condition of the body, but in some cases these simple measures might keep a body in reasonably good condition for hours. In other cases supporting measures might be needed, possibly including injection of anticoagulants.

In certain types of chest injury, possibly help might be obtained from a technique developed by Neely and coworkers. They perfused dogs with a buffered glucose solution instead of blood, and found that ". . . animals can survive 30 min of asanguineous perfusion with no oxygen, and that the survivors exhibited no gross brain damage." (80)

Another intriguing possibility, if the equipment were available, is suggested by the work of Dr. I. Boerema of the University of Amsterdam, The Netherlands. He has obtained some remarkable results treating patients inside a pressure caisson; the surgeons and attendants breathe air at three atmospheres pressure, while the patient breathes pure oxygen at the same pressure. It has been found that the blood circulation can be arrested without harm for about twice as long as normal; at 14.5 deg C dogs can be kept a half hour or longer without extracorporeal circulation. Animals can actually live without blood; with pigs, the hemoglobin could be reduced virtually to

zero for at least fifteen minutes, dissolved oxygen taking the place of oxygen carried by red corpuscles.

"... when an animal or patient breathes pure oxygen at 3 atmospheres (absolute) there is a greatly increased physical solution of oxygen in all tissues of the body, both fluid and semi- fluid. . . . [There is] extreme saturation of the whole body with physically dissolved oxygen, so that the cells have a much higher reserve of oxygen than they normally have. . . . We may assume, then, that the increased amount of oxygen in solution provides a true reserve for the tissues and, consequently, that the tissue cells can withstand a circulatory arrest of longer duration." (7)

If a terminal patient could be kept in such a chamber, there would be a wider margin of safety when he died. Or if a newly dead patient were put in such a chamber, artificial respiration and heart massage might work more effectively.

With fully adequate preparation, equipment, and personnel, the cooling phase seems to present little problem in most cases. Heartlung machines and heat exchangers are available at many hospitals. The cardiopulmonary bypass technique is commonly used for open-heart surgery, with cooling of the blood and body from the normal of about 38C down to 20C, and sometimes lower; this technique has been described, for example, by Sealy and co-workers. (104) Apparently it could also be used, depending on the cause of death and opportunity for preparation, to cool freshly dead bodies quickly and safely, with no damage to the brain.

Finally, we ask how long it is safe to keep the body, after it has been cooled and before it has been frozen.

If a heart-lung machine has been used, and continues to be used, this time may be more or less indefinite.

If the brain has reached the vicinity of 10C without damage, for example by use of a heart-lung machine which then has to be disconnected, it can survive up to an hour without blood circulation, although there may be some relatively minor damage, if use is made of carotid arterial infusion of low molecular weight dextran; this is on the basis of experiments of Edmunds and co-workers with living dogs. (25)

Likewise the experience of Egerton and coworkers with patients undergoing hypothermic open-heart surgery showed that temperatures below 12C for more than forty-five minutes produced some brain damage, although most of them made complete recovery within four months. (26) Other work also shows that there is some brain damage, even if the blood still circulates, when the temperature reaches the vicinity of 0C, the freezing point of water.

Hence probably the body should not be cooled below about 10C before the freezing equipment is made ready, if this can be done within an hour or so later, as ought to be possible in a hospital.

Maximum and Optimum Storage Temperature

There seem to be four main possibilities for choice of storage temperature, and we must consider the theoretical and practical advantages and disadvantages of each. These are naturally occurring low temperatures in the arctic and antarctic, and the temperatures respectively of solid carbon dioxide, liquid nitro gen, and liquid helium.

By way of general introduction, Dr. Audrey U. Smith says: "The basic principle in storing living cells is to arrest the processes of aging and degeneration. When living cells are cooled there is a slowing down of the biochemical processes involved in respiration, metabolism and all the other interactions between the cytoplasm of the cells and their environment. If they are cooled to temperatures in the range below -79C in which carbon dioxide and other gases are solidified or liquefied, all chemical changes must either be slowed to a minute fraction of the normal rate or else completely halted. Aging should not occur and it should be possible to preserve them for infinitely long periods in this temperature range." (110)

Of course, "infinitely long" is a slight exaggeration, and in fact we know that some kinds of cells stored at dry ice temperature, -79C, do show slow changes, with the percentage of living (revivable) cells decreasing week by week or even day by day, even though other kinds of cells have shown no appreciable deterioration after several years. For example, Meryman says:

"In the case of blood frozen without glycerol significant decay is measured in days of storage at -70C, weeks at -80C, months at -90 C, and years at -100C (70)

This does not necessarily mean that the relatively high temperatures are altogether hopeless. Some changes may take place, but little can yet be said about their extent and their reversibility. It may be that the changes, even though "fatal" by present tests, are minor, limited, and eventually reversible. It is not a case of general rot proceeding inexorably, although slowly; rather, it may be a case of some kinds of action not being completely inhibited, and stability may be reached after only some changes which, seen in perspective, are trivial.

Thus we cannot dismiss out of hand the suggestion sometimes heard that bodies be submitted to natural cold storage in arctic regions below the frost line. It has the obvious advantages of requiring no expensive investment and servicing, and of reduced vulnerability in event of war. However, the coldest natural temperature is well above that of dry ice, and probably too high. The odds would seem heavily adverse.

For extremely long-term storage, there seems to be nearly - but not quite - universal agreement that liquid helium temperatures, in the neighborhood of -270C, are safest . One of the dissenters is Dr. R. B. Gresham, who says: "It has been shown that after materials are frozen, there occurs a continuous thermodynamic activity down to -196C (-321F) or liquid nitrogen temperature, where movement ceases only to be noted again at -269C (-449F) or liquid helium temperatures. . . . Although the effects of this thermodynamic activity on long-term storage of living cells is not known, when storage time is to be measured in years, it is theoretically desirable to maintain a temperature of - 196C." (36)

This argument does not really seem very impressive. The "thermodynamic activity" and "movement" refer merely to certain irregularities in the rate of heat loss as the temperature is lowered, and accompanying shifts in the molecular structure or physical state of materials, mainly water. As far as I can see, there is no particular reason to think this implies any instability at a fixed temperature, in general. Most writers do not seem to be worried by this question.

A more serious objection to use of the lowest temperatures is that while nothing will happen after storage temperature is reached, changes may take place en route. In other words, we should not use a temperature any lower than necessary, because we may be letting ourselves in for gratuitous trouble. In every range, more cooling means more change, and unnecessary changes are to be avoided.

On a practical level, liquid helium is relatively expensive, and tricky to handle.

What would seem to emerge, then, is the following. At the present time, the temperature of choice is that of liquid nitrogen. When permanent installations are built, probably liquid helium will be used. As an emergency or austerity measure, one might use dry ice, which is cheap and easy to handle.

Radiation Hazard

Would a body in cold storage, although preserved against decay, be gradually "cooked" by the slow but inexorable attack of natural radiations?

We know these are all around us: cosmic rays bombard us from the skies; uranium, thorium, and radium in rocks and soil, in concrete and brick, spray penetrating emanations similar to X rays; and certain radioactive atoms (radioisotopes) in our own bodies dribble slow poison. (In addition to this natural "background" radiation, there is fallout radiation from testing of nuclear weapons, but this so far is more or less negligible.)

Since these radiations are of low intensity, they produce only a "chronic dose" which is scarcely noticed, since a functioning body can repair most of the damage as fast as it occurs. But all doses absorbed by a body in cold storage must be regarded as acute; we must consider the possibility that the cumulative damage to a frozen body might become serious as the centuries passed.

Examining the data, we find there may indeed be a problem, but not one too formidable. (The pertinent information can be found, for example, in The Effects of Nuclear Weapons, U. S. Atomic Energy Commission, 1962.)

The unit usually used to measure dosage of radiation is the "rem" (roentgen equivalent, mammal, or man); we do not need its technical definition, but may note that an acute dose of 100 rems or less is unlikely to produce noticeable illness, a dose of 600 rems results in severe radiation sickness requiring hospitalization and the most competent care, and a dose of 1000 rems or more is almost certainly fatal with the present resources of medicine.

Background radiation varies considerably with locale, but as a rough average we might expect everyone to receive a dose of about 10 rems in 50 years. A stored body, then, might take 500 years to accumulate a "clinical" or symptom-producing dose of 100 rems, and 3,000 years to soak up a currently dangerous dose of 600 rems. These times, to be sure, might be reduced if nuclear war or excessive weapons testing produced heavy fallout; but they could also be much lengthened by precautions available at moderate expense.

If the bodies were stored underground, in vaults made of low-radioactivity materials, then they would be shielded from most of the external background radiation, leaving only the internal radiators to worry about. These consist mainly of one of the forms of the element potassium (the radioisotope potassium-40) found especially in the soft tissues of the body.

The dose rate due to potassium-40 is about 20 millirems (0.020 rem) yearly. This will continue essentially indefinitely, since the "half life," or time required for the dose rate to halve as the decaying potassium-40 is used up, is over a billion years. But to accumulate a dose of 100 rems would take 5,000 years, and for 600 rems the wait would be 30,000 years.

Even then, the radiation damage would no doubt be substantially less than the injury done (to the earliest frozen bodies) by crude freezing methods, so one might guess that at least 100,000 years must elapse before radiation damage becomes critical. I can think of certain heroic measures to extend this time to a million years or more, but it is hardly worth the trouble.

Most of us will be frozen by advanced methods developed in the next decade or two, and will be waiting in cold storage mainly for the solution of the aging problem. In light of the explosive acceleration of scientific progress, it would be astonishing if this were to take as long as 5,000 years. In this view, we can ignore the effects of bodily radiation damage.

However, a postscript may be worth while to reassure those worried about the genetic effects of radiation. It is true that a dose of 100-300 rems inflicted on everyone in every generation might eventually produce so many mutations or freaks of inheritance as to threaten the race, if nothing were done about it. But we expect eventually to control and tailor our genes, the physical blueprints of inheritance carried by our cells, and in any event the resurrected frozen will not constitute the entire populace. Individually, there is no cause for concern: a man exposed to 500 rems has only a negligible chance of observing deformities in his children or grandchildren. (See, for example, the article by Professor Muller in Radiation Biology, ed. Alexander Hollaender, McGraw-Hill, 1954.)

CHAPTER III

Repair and Rejuvenation

We have investigated the proposition that a freshly dead body can be frozen, stored for a long time at low temperature, and thawed again without excessive damage. But after this has been done, it is still just a freshly dead body (although it may be hundreds of years old) and much more is required. We need assurance that we can be revived, and not only that; if we die sick, we want to be made well; if we die broken, we want to be made whole; and if we die old, we want to be made young.

(Indeed, we want yet more. We hope to be made not only good as new, but eventually much better than new. This part of the discussion, however, will be mostly reserved for later chapters.)

Absolute, rigorous proof of the future capabilities of science cannot, of course, be offered. For example, no engineer today could prove that it will ever be possible to manufacture a cheap, safe, reliable family helicopter. He cannot prove it can be done, because he does not know exactly how to do it. Nevertheless many engineers, and probably most, would make such a prediction with confidence; there are favorable hints in current research, and the whole march of history is obviously in this direction

That future technicians will be able to repair and rejuvenate us cannot be proven, but it can be made convincing all the same. Let us review briefly, and with no strenuous effort to be orderly, some of the striking accomplishments and prospects of modern medicine and biology, especially those relevant to repair and rejuvenation

Revival after Clinical Death

It is well known that hundreds of people have been revived after being clinically dead for many minutes, i.e. after heartbeat and breathing stopped. Most of these died of such things as heart trouble, shock, asphyxiation, and drowning. They were revived by rather simple measures including artificial respiration, blood transfusions, heart massage, and stimulation by drugs or electricity. (97)

A remarkable example of what can be done even in these primitive times is offered by the case of Professor Lev Landau, a famous Russian physicist who suffered an auto accident in 1962. He is reported to have sustained a fractured skull, brain contusions, severe shock, nine broken ribs, a punctured chest, a fractured pelvis, a ruptured bladder, paralysis of the left arm, partial paralysis of the right arm and both legs, and failing respiration and circulation. During the next fourteen months he died four times, and was four times resuscitated. In the spring of 1963 he was still alive and apparently improving. (180

The people in the freezers -- you and I -- will have died mostly of disease or old age. The immediate cause of death will usually be the failure of some vital organ. The future medicos, then, will perhaps proceed somewhat as follows: first, either restore or provide respiration and circulation; next, repair or replace the defective organ that was the proximate cause of death; then cure any acute disease and make any other urgent repairs; lastly, and at leisure, make a general overhaul and rejuvenation.

The first stage, the restoration and support of life while biological repairs are being made, will demand the use of mechanical devices, some of which are already well known.

Mechanical Aids and Prostheses

There exists right now a rather imposing list of inventions to perform biological functions. To assist breathing, we have respirators of various kinds, oxygen masks, pressure chambers, and iron lungs. To help a faulty heart keep proper time we have electronic "pacemakers," some of which can be implanted in the body. There are pumps which can be connected to the circulatory system and do the work of the heart. There are even machines which can take the place of both heart and lungs, aerating the blood as well as pumping it. These are all matters of common knowledge.

Slightly less familiar is the use of a machine to perform the function of a missing or diseased kidney. Dr. B. H. Scribner of the University of Washington, for example, has been reported treating patients once or twice a week by running their blood (out an artery and back into a vein) through the device, which removes the wastes ordinarily handled by the kidney. Just a very few years ago these patients would have been doomed, unless they were lucky enough to get a successful kidney transplant, but now they can apparently live indefinitely without kidneys. (21)

Pacemakers or electronic stimulators have been used not only for the heart, but also in cases (as after abdominal surgery) when the intestine is paralyzed, and in the case of dogs when the bladder is paralyzed. (82)

The future outlook for prosthetics is even more impressive. Dr. Lee B. Lusted (professor of biochemical engineering, University of Rochester) thinks that within fifty years it will be possible to replace nearly all of the body organs by compact artificial organs with built-in electronic control system -- including, for example, the heart, kidneys, stomach, and even the liver. (64) (Imagine an artificial stomach, which would tolerate unlimited insult in the way of greasy and spicy foods, and never dream of growing an ulcer! Imagine a gin-resistant liver! Like most blessings, these would no doubt be mixed.)

Artificial limbs are less important than vital organs, but tremendously advanced arms and legs will be available from the shop if needed. Russians at the Central Scientific Research Institute for Prosthetics in Moscow

already claim they have an artificial hand device operated by thought control! A metal bracket strapped to the arm is supposed to pick up biopotentials (electrical nerve impulses) generated by an effort of will; in other words, they claim the nerves of the body are used to control metal instead of muscle. Furthermore, they say they are working on a way to produce artificial hands with a sense of touch! (11)

Since there have been many sensational announcements from Russia which turned out to be exaggerated or premature, a healthy skepticism is proper in this instance. Nevertheless, the principle is sound, and sooner or later the hardware will be ready. Mechanical limbs and their controls are so far crude, bulky, and inefficient, but steady strides are being made toward miniaturization of both controls and motors, with only power sources still lagging behind from the point of view of compactness. To get an idea of how compact computing machinery used for controls may become, we need only note what Dr. Fernandez-Moran has said: "At the present time . . . advanced techniques of ultraminiaturization . . . are bringing us ever closer to practical realization of information storage and integrated electronic circuits at the molecular level ..." (31) A computing machine which functioned at the molecular level might rival the human brain for compactness! And to get an idea of how small machinery may be, we may note that in 1961 a young engineer collected a $1,000 prize by constructing an electric motor .oo6 inch in diameter. (126)

Artificial organs and limbs will be used if natural repairs or replacements cannot be had; and they will probably be used again in the more distant future when they become so efficient that they are to be preferred over the biological. But our ability to repair or replace natural organs and limbs is growing rapidly, and probably for a long time this will be the dominant theme.

Transplants

The routine transplanting or grafting of any organ of the body (obtained for example from a fresh corpse or from a cold-storage bank) is not yet possible,

because the "immune reaction causes the body of the host to reject the "foreign matter." But leading biologists such as Dr. Jean Rostand are confident this barrier will be overcome. (119) In fact, it has been partly overcome already, and very impressive advances have also been made in the surgical techniques needed for these operations.

One of the very difficult but very active fields is that of lung transplants. Apparently the first successful reimplantation (into the same animal) of a lung taken from a dog occurred in 1951. In 1963 Dr. S. L. Nigro and coworkers reported this technique so far perfected that dogs are surviving after 1 1/2 years on the replanted lung alone. (83) Dr. J. D. Hardy of the University of Mississippi, a leading worker in the field, in 1963 reported temporarily successful transplants of lungs from one dog to another; in some cases he kept the lungs in cold storage for two to six hours before using them. The immune reaction, however, was not sufficiently suppressed, and the transplanted lungs eventually died. (38)

Dr. Hardy was also reported in 1963 to have performed the first human lung transplant. A fifty-six-year old man, a heavy cigarette smoker, had cancer of the left lung as well as impairment of the right lung. The donor lung was taken from a man of about the same age immediately following death. After the operation, the patient was reported as doing well. (24) It is not clear from this report, however, whether new methods were used to suppress the immune reaction or whether only temporary success is expected.

Another major organ, the kidney, has often been successfully transplanted. In earlier years there was usually very limited success unless the donor was a twin of the host; in this case, since they share the same genetic heritage, the new kidney knows the password, so to speak, and is not shot down as an intruder. Recently, however, the use of certain drugs and of X-ray treatment to suppress the immune reaction has led to more success with transplants from more distant relatives or strangers.

Many other examples could be cited. A recent one, rather interesting if not tremendously important, concerns tooth transplants reportedly made by Dr. Miklos Cserepfalvi of Washington, D.C. Of 146 tooth transplants made since 1956, 140 resulted in permanent, live teeth; by contrast, earlier attempts had usually resulted in rejection of the new tooth as foreign matter within a year or so. The teeth had been extracted from children eight to

twelve during orthodontic work; they had not yet erupted through the gum, and the tooth was removed complete with the sac surrounding it. Dr. Cserepfalvi is quoted as saying, "There is no reason for anyone in this country today to have a false or missing tooth in his head." (15)

The general outlook is entirely favorable. In 1963 Dr. Robert Brittain (University of Colorado) and Dr. Richard Lillehei (University of Minnesota) are reported to have said at a convention of the American College of Physicians that within only five years it will be possible successfully to transplant all human organs, except those of the central nervous system! (40)

But even the central nervous system is not inaccessible to these techniques, although mastery will take longer, and of course we are only interested in repair of the brain, and not its replacement. A Yugoslav researcher, Dr. Mira Pavlovic, has successfully grafted a large part of the brain of one embryo chick to that of another; some of these subjects hatched and lived as long as two months. (119)

As already suggested, the organs for transplant will often be obtained from cold storage banks. Dr. Lillehei, together with Drs. Bloch and Longerbeam, expect surgical deep freezes of the near future to store kidneys, spleens, and lungs, as well as other organs. They have already quick frozen organs, kept them up to two weeks at dry ice temperature, then thawed them rapidly by microwave diathermy, treated them with a substance called LMD (low molecular weight dextran) and replanted them. (102)

But now a question arises: if everybody is frozen, there will be no cadavers to scavenge; where will the spare parts come from? Fortunately, answers are in sight.

In the relatively near future, and for a certain period in history, we may use organs from lower animals. There has been some success in suppressing the "immune reaction" even in the case of "heterografts," or transplants between different species.

On December 22, 1963, many newspapers throughout the country featured the remarkable story of Jefferson Davis, a New Orleans dock worker, whose diseased kidneys were replaced by those of a ninety-pound chimpanzee. The historic operation was reported performed by a team of Tulane University

surgeons headed by Dr. Keith Reemtsma. A few days after the operation, the grafted kidneys seemed to be functioning satisfactorily, although the prognosis, of course, was uncertain. It seems unlikely that this pioneering effort will be completely successful. The measures now used to induce the host body to tolerate the foreign tissue are usually inadequate, unless applied in such massive doses that the side effects become critical. Radiation and/or presently known drugs have poisonous effects themselves; furthermore, along with suppressing the immune reaction, they depress the body's ability to fight off infections, opening the way to complications. But the research is being vigorously pressed, and it may not be many years before lower animals can supply us with replacements for such organs as the lungs, kidneys, heart, liver, spleen, stomach, or pancreas.

Organ Culture and Regeneration

To the question of where the spare parts will come from in the more distant future, there is a beautifully simple answer: they will come from ourselves!

We know that germ cells - sperm or egg - produced by our reproductive organs contain chromosomes carrying our genetic information or blueprints, and that these germ cells, after combining with one from the opposite sex, are capable of developing into complete human beings. It is less widely known among laymen that either the sperm or the egg alone is considered capable of developing into a person, although so far this has seldom if ever happened. (119) Still less is it realized that ordinary body or somatic cells, which also carry the chromosomes, may retain potential "totipotence"; even though they are differentiated and specialized, it may be possible to reverse and then generalize their development, and in fact such cases have actually occurred, where an ordinary body cell (in certain lower forms of life) has taken the place of a germ cell and led to growth of a complete individual. (79)

The possibilities, then, are obvious. As soon as enough is known about guiding growth and development, a germ cell or an ordinary somatic cell, perhaps even from the skin, can be taken from the resuscitee's body, and

from this will be grown, not a complete individual, but just the organ or organs needed for repair. It will not even be necessary to suppress the immune reaction when making the implant, because it will be his own tissue; it will be an autograft and not a homograft. You may get a new heart, for example - your very own, exactly like the original, but young and strong and ready for another three-score-ten of faithful pumping service.

Can we really be sure this will come about? Is not the guidance of growth and development an exceedingly intricate and difficult business? The answer, as usual, is that the problem is indeed complex, but there is ample optimism among the experts and there are already successful beginnings.

Tissue culture, the growth of cells in a test tube or other artificial environment, is of course old hat. The famous Dr. Carrel "maintained a strain of chick embryonic cells in this way for more than thirty years (much longer than the lifetime of the hen which would have grown from the embryo). . . ." For obvious reasons this strain of cells was called Carrel's 'immortal' strain. It died (of neglect) during the Second World War... (87) Complete organs have also been maintained outside the body of the animal for varying lengths of time, and test-tube grown organs require no great stretch of the imagination.

Speaking in a somewhat different but nevertheless appropriate sense, Dr. Philip Siekevitz (Rockefeller Institute of Medical Research) has said, "I shall not be surprised if in our lifetime we know in general, often in specific, terms how the body regulates its growth. And to know is to influence." (105)

We can wait in our timeless freezers for many lifetimes, if need be, but a sufficient degree of control may come fairly early. It need not be based on complete theoretical understanding, but can be to a considerable extent empirical. Experiments based on clever guesses have shown, for example, that embryonic skin treated at a certain stage with vitamin A will develop into the kind of epithelial tissue which lines the intestines, whereas in the absence of vitamin A it forms a normal-appearing skin. (8 7) Another fascinating news item, bearing on the way in which simple environmental changes can affect reproduction and development, concerns chinchilla breeding. Those bred under ordinary incandescent light produce all-male offspring; under a bluish daylight incandescent light, nearly all progeny are

female; in natural daylight, there are equal numbers of each! (99) This particular item invites skepticism, but who knows?

So far we have been talking about growing an organ in the laboratory, starting with a scrap of tissue or a single cell, and then grafting it into the body; but this is not the only possibility. Some parts of the body might be re-grown *in situ*.

In lower animals, promising beginnings in organ regeneration have been made. Professor Marcus Singer at Cornell University, by manipulating nerve tissue, has caused adult frogs to re-grow amputated limbs, although normally they cannot. As Dr. Singer says, "Obviously, there is some practical interest in the possibility that human beings might some day be able to re-grow tissues and organs which they presently cannot."(98)

Adult humans can regenerate many tissues (although virtually no organs). Skin is one; another, surprisingly and hopefully, is nervous tissue, at least of certain kinds. In the famous case of the boy whose right arm was severed below the shoulder in a freight train accident in 1961 and sewed back on by Dr. Ronald Malt and co-workers at Massachusetts General Hospital, nerve cells grew back in the arm. In the spring of 1963 healing was not complete, but the cells showed growth at the rate of about one inch per month. (81)

Other pioneering experiments include those at New York University in repairing gaps in human nerves. Frozen nerve grafts from dead donors were used; these were also irradiated to minimize the immune reaction. The grafts themselves are said to work for as long as three years, allowing restoration of muscle function and sensation; eventually the grafts die, but meanwhile there is regeneration of new nerve fibers, which gradually replace the graft. (22)

With such sparkling beginnings, with the quickening pace of research, and with the optimistic outlook of experts, it seems not too much to expect that the brain itself will eventually prove amenable to repair, although enough of the original must remain to preserve memory and personality.

What will no doubt happen, then, is that the more urgent repairs will be made while the resuscitee is still unconscious, with new organs or tissues either grown in the lab and implanted or else gradually regenerated in the

body. After this has been done he will be alive, and in much better health than just before he died - but he will still be old.

Curing Old Age

In the discussion heretofore, we have been extrapolating from a solid basis of known achievement. But when we claim that old age will be curable, that senile debility in its varied manifestations will be reversible, we might seem to be on shakier ground. After all, there seem to have been no successes whatever so far in extending human life, except statistical successes based on reduction of infant mortality and conquest of disease.

Nevertheless, theory and expert opinion again provide ample reason for optimism. By way of analogy, one might compare the prediction of a family helicopter with the prediction of an interstellar space ship. The helicopter prediction is conservative; helicopters already exist, and not much daring is required to prophesy that they will eventually become safer, cheaper, and more reliable. On the other hand, no star ship has ever been built or even planned. Even so, interstellar travel is in the cards; if necessary, it can be achieved with chemical fuels and known technology, if we have endless patience and a bottomless purse, but in practice we know we can count on new discoveries as well as the polishing of the old. Interstellar travel is entirely possible in principle, and the practical difficulties will without doubt be overcome; just so with biological immortality.

It is conceivable, although far-fetched, that extended life or even permanent life might result from some kind of "youth serum" such as crops up in the news from time to time. In 1963 a Swiss, Dr. Paul Niehans, is reported treating wealthy old patients with a serum made from the cells of stillborn lambs at $13,000 a shot. (20)

There have been many other reports of possible "youth serums," some of which are still being investigated. For example, in 1963 the National Medical Association heard about extraordinary results in reinvigoration of old people by thyroxine, a hormone of the thyroid gland. Every system of

the body is said to be favorably affected, including the circulatory system, nervous system, and digestive system. This research seems to be carried on mainly by Dr. Charles A. Brusch, of Cambridge, Massachusetts, and Dr. Murray Israel of the Vascular Research Foundation, New York, who have treated many patients. They insist that there are no harmful side effects, even with relatively massive doses, and that the metabolism needs this extra spark in old age even when the usual tests ("basal metabolism" and "protein-bound iodine") show normal thyroid function. (See, for example, The Detroit Free Press, August 20, 1963.)

Another sensational report is that attributed in September of 1963 to Dr. Robert A. Wilson, gynecologist of the Methodist Hospital of Brooklyn, New York. He is said to claim, after treating hundreds of patients, that two female sex hormones (estrogen and progesterone), when properly augmented and supplemented with special diets, vitamins, minerals, and exercises, can benefit older women immensely. The secondary effects of menopause are eliminated; heart disease and atherosclerosis are reduced; cancer of the breast or genitals becomes unlikely; the skin improves in texture and color; the bones do not tend nearly as much to become porous and brittle.

There is said to be a specific "juvenile hormone" in certain insects, injection of which will keep them young indefinitely. Although nothing of the kind has been found in mammals, conceivably it might be.

Vastly more likely, progress will come slowly on a mixed theoretical and empirical basis. The theory is just beginning tentatively to be laid, since it is based on obscure, small-scale phenomena which have heretofore been almost inaccessible both theoretically and experimentally.

The electron microscope, the digital computer, the formulas of quantum chemistry, and other experimental and theoretical tools now allow studies on the subcellular level, investigations of the inner workings of the life processes. Biochemistry and biophysics are making violent thrusts in all directions (including, I suppose, backwards).

Drs. B. L. Vallee and E. C. Wacker recently wrote, "Molecular biology, suddenly exploding on cellular biology - as did nuclear physics on atomic physics a generation ago has brought far-reaching challenges and hopes for

the solution of questions of normal and diseased life processes thought to be experimentally inaccessible a decade ago." (123)

To get an idea of the ultra-fine work being done, we may quote a fragment from a fairly recent paper by Fernandez-Moran: ". . . the electron microscope can now be used as a powerful tool both for the controlled production and the direct observation of radiation damage in preselected macromolecular regions of hydrated biological systems. Enhanced contrast and high resolution of the order of 6 to 8 A have been achieved in direct studies of the macromolecular organization of virus particles, ribosomes, and of isolated cell constituents." (32) An Angstrom unit, abbreviated A, is a hundred millionth of a centimeter, and there are 1.54 centimeters to the inch! Using such techniques, and others, Dr. Fernandez-Moran has found an "elementary particle," only 80 to 100 A in diameter, which he regards as the ultimate unit of the function of the mitochondria, which are tiny granules or rods located in the cytoplasm or outer portion of cells. (31)

Concerning the specific problem of aging, there have been many suggestive studies. Enough has been learned to encourage Dr. F. M. Sinex, chairman of the biochemistry department of the Boston University School of Medicine, to say, "The present development of biochemistry and biology suggests the question, 'Why do we get old?' may be answered in the foreseeable future. [Certain hypotheses about aging suggest that] preventative therapy . . . is a possibility." (108)

After prevention, the next step is cure. We may also note that even the prevention of further aging in an old brain might be good enough; most of us die with our strictly mental (as opposed to muscular and glandular) faculties still in reasonably good condition. But in all likelihood the aging process in brain and body will prove reversible.

There are many ideas regarding the cause or causes of biological aging, and a few of these will now be briefly reviewed, with no attempt to be systematic, let alone exhaustive.

One of the major primary or secondary causes of death usually associated with old age is atherosclerosis, often thought of as "hardening of the arteries" and roughly analogous to scaling or rusting of pipes in plumbing. In recent years, much attention has been given to the suspicion that its

development is related to intake in the diet of saturated fats leading to the presence of cholesterol in the blood. However, this view does not seem to be held any longer by a majority of scientists. (113)

In fact, it is amusing to note that the unsaturated fats may be the dangerous ones. According to a Dr. Bernard L. Strehler of the National Heart Institute, ". . . the unsaturated fats are particularly liable to cross-reaction and linkage, a fact that makes them extremely useful in the paint and varnish industry but which may be highly detrimental to biological systems over the long run. The gradual accumulation of a layer of varnish over various intracellular structures is an unpleasant prospect. The observation that the rate of accumulation of cardiac lipofuscin [fatty pigment] is higher in the Japanese, who incidentally consume a diet richer in unsaturated fats, is suggestive. " (113)

Another relatively ancient theory is that aging may be the result of somatic mutations brought on by radiation or other cause. That is, changes in the genetic structure of the body cells may occur haphazardly, from time to time, caused by cosmic rays or other natural radiation (or by fallout from nuclear bombs); since the mutations or changes are almost always for the worse, the percentage of defective cells mounts. This theory has some attractions, not the least of which is the fact that animals subjected to heavy doses of radiation exhibit symptoms resembling those of accelerated aging. Nevertheless, this theory has been fairly well demolished by Muller (79) and others.

One of the currently respectable theories seems to be that of Dr. Sinex, who thinks aging may be related to changes or breakdowns in irreplaceable molecules of protein in collagen, which is the main organic constituent of connective tissue. Contrary to a popularly held notion, it is not true that all of the material of our bodies is continually replaced and renewed; it is not true of cells and it is not true of molecules. The same brain cells last us throughout life, and in collagen, at least in rats, the same molecules persist throughout life, or enjoy only limited replacement. If these are damaged by chemical, mechanical, or thermal accidents, the road is downhill.(107)

Another idea is that an "autoimmune reaction" occurs with age; roughly, that is, we can't stand ourselves any more. Still another is that the various subsystems of the body from time to time are taxed beyond their ability fully

to recuperate, so that each such part is like a ball which on successive bounces doesn't reach quite as high, and eventually doesn't bounce at all. And so on.

The point is that much has been learned, many promising lines of inquiry are being followed, and as Dr. Joseph W. Still has said, "Medical experience has taught us that when we fully understand a chemical event, we are able to manipulate and alter or modify it. For this reason, we can be skeptical about the assumption that "we can't live forever!" (111)

Dr. Strehler, a gerontology specialist, although pessimistic about the practical possibility of abolishing aging (in the comparatively near future, presumably), affirms that: "It appears to me that there is no inherent contradiction, no inherent property of cells or of Metazoa [many celled animals, including man] which precludes their organization into perpetually functioning and self-replenishing individuals." (113)

If nothing better were known, brute-force methods of rejuvenation could be employed. That is, brain cells could be grown in the lab, the appropriate information "read in" to them, and then used surgically to replace the senescent cells. Of course, this would have to be done gradually, over a period of time, and even then some tricky philosophical questions might arise; but these questions will be reserved for a later chapter, since they deserve extended treatment.

But again, in all probability brute-force methods will not be required; more elegant methods are nearly certain to be discovered - provided we do not dawdle too much along the way.

In a recent article in the New England Journal of Medicine was the following remark, intended to be humorous: "If age alone were publicized as an eventually mortal cause of degeneration, associations would undoubtedly be organized to seek its abolishment, under huge federal grants." (47) Many a true word is spoken in jest, and precisely this is going to happen, although one cannot be sure whether the funds will be mainly public or private. Dr. Strehler has already made a plea for sponsorship of a long-term program of research into the biological problems of aging, with something like a National Institute of Gerontology at the helm. (113)

There can be no serious question about the trend of events. You and I, as resuscitees, may awaken still old, but before long we will gambol with the spring lambs -- not to mention the young chicks, our wives.

CHAPTER IV

Today's Choices

Overall, three great questions concerning the freezer program are being treated: Is it technically sound, so that the frozen will have a good chance of being resuscitated and rejuvenated? Is it feasible on a practical level, raising no insuperable new problems? Is it desirable, both for the individual and for society?

These questions are to some extent inextricable. In fact, they are so intertwined that there is no completely logical order of presentation, since at almost every stage the argument depends not only on what has gone before but also on what is yet to come, and the picture may not come into clearest focus until a second reading. But in order to finish, one must start, and words have to be set down one after another. In a later age, you and I will no doubt learn better methods of communication.

So far we have dealt chiefly with the first question, and in subsequent chapters shall consider mainly the last two. At the present juncture, the reader is asked tentatively to assume more or less affirmative answers to all three questions, and on this basis to consider the immediate opportunities and obligations presented to him as an individual.

What can we do, today, to improve our own chances? How can we give a dying relative his best chance? If a relative dies when we have made no advance preparation and have limited resources, what can be done? How far, in good conscience, must we carry our efforts?

The Outer Limits of Optimism

Before going into detail, if we stand back and look at the problem in its broadest outlines, we note that the extreme limits of optimism depend on two questions: (1) Under what circumstances, if any, is the essence or identity of an individual absolutely and forever lost? (2) What limits, if any, will the human race encounter in its technical development, in its ability to manipulate the universe?

As to the first, the answer of the completely dauntless optimist is that in a deterministic universe no information is ever irretrievably lost, since every detail of history is implicit in the present. Thus, just as the past and future positions of the planets can be calculated from present observations, it is always possible, in principle, to find out every minutest detail of a man's life, memories and personality, given a sufficiently fabulous degree of technical competence. (At least, this seems to be true if we ignore the possibility of the universe being finite in extent, and also ignore limits imposed by expanding-universe theories with their "disappearing galaxies".)

Thus the determinist believes it possible, in principle at least, for a sufficiently advanced civilization to infer as much as necessary about any man who ever lived, and either reconstruct him or replicate him, after gathering together either his original atoms or substitutes. As an intermediate case, an Egyptian mummy could be resurrected; as an extreme case, Ug of Ur. (Some of the "philosophical" problems involved will be discussed in a later chapter.)

Of course, the present consensus (but not the unanimous opinion) of physicists is that the universe is not completely deterministic, and that the outlines of events, whether past, present, or future, must in general always remain somewhat blurred, and that individual atoms have no permanent identity. In this view, there is a theoretical as well as a practical limit to the accuracy with which we can draw inferences about a man and reconstruct or replicate him. But what this limit may in fact be at present unknown, mainly because we do not yet know enough about microbiology.

As to the second question, no one can be sure how much of what is possible in principle will ever become feasible in practice. If a corpse can lie in a freezer for an essentially unlimited time with no strain on its patience, we can hardly set arbitrary limits on future capabilities. But it is better to limit our guesses to the next few centuries, and to those areas where definite technical developments already point the way.

Preserving Samples of Ourselves

There is one obvious way of helping our chances, in case we die in the early years before non-damaging methods are known for full-body freezing. This is to have little snippets of ourselves surgically removed, while we are in good health, and stored at low temperatures with the benefits of protective chemical infusions. These better-preserved samples can be enlarged in culture by the future technicians for use in repairing our damaged bodies.

In the last chapter something was said about growing cultures, if necessary, from the frozen body itself, and this will doubtless be possible, since a certain percentage of the cells are likely to be in reasonably good condition. At the same time, a margin of safety will be added if samplings of the healthy body are frozen separately ahead of time.

In future eras it will certainly be possible to develop any needed tissues or organs from a germ cell, and it should soon become customary for all adults to make deposits of these cells in cold storage banks. Such banks already exist for the male (sperm) cells, and according to Professor Muller a relatively small amount of research might make a similar procedure possible for women. (77)

Advanced biological art should in fact be able to generate any kind of tissue or organ from a somatic cell; a single scrap of skin might suffice. On the other hand, it is conceivable that at a certain stage in history it might be helpful to have samples of many kinds of tissue from many organs of the body.

It might also be desirable to take tiny samples from many regions of the brain, of course recording the location of the source as accurately as possible. As mentioned earlier, a memory trace is thought to be multiply duplicated in various regions of the brain, so that each of many memories can be both left in the brain and stored in a separate sample vault. Whether a significant number of memories can be protected in this way is an open question.

The procedure seems harmless, since in general tiny specimens taken from various regions of the brain apparently leave it undamaged. Haldane, for example, referring to the work of Lashley says, ". . . while removal of a large fraction of a rat's cerebral cortex abolished the learnt capacity to traverse a maze, local injury to any small part of this volume had little or no effect. The facts on human cerebral injuries lead to a similar conclusion." (37) (In other words, we are brainier than we need to be, in spite of the daily news headlines.)

Manifestly, this kind of procedure will not soon, if ever, lend itself in full to large-scale application; there are not enough brain surgeons, nor people anxious for brain surgery.

In the near future, as a compromise, perhaps it will become routine during any surgical procedure to take a few extra snips here and there for the bank. In a different but roughly similar way, it is already becoming useful for people with rare blood types to freeze-bank it for use in case of emergency.

Preserving the Information

We normally think of information about the body as being preserved in the body - but this is not the only possibility. It is conceivable that ordinary written records, photographs, tapes, etc. may give future technicians enough clues to fill in missing or damaged areas in the brain of the frozen.

The time will certainly come when the brain's method of coding memories is thoroughly understood, and messages can be "read" directly from nervous

tissue, and also "read" into it. It is not likely that the relation will be a simple one, nor will it necessarily even be exactly the same for every brain; nevertheless, by knowing that the frozen had a certain item of information, it may be possible to infer helpful conclusions about the character of certain regions in his brain and its cells and molecules.

Similarly, a mass of detailed information about what he did may allow advanced physiological psychologists to deduce important conclusions about what he was, once more providing opportunity to fill in gaps in brain structure.

It follows that we should all make reasonable efforts to obtain and preserve a substantial body of data concerning what we have seen, heard, felt, thought, said, written, and done in the course of our lives. These should probably include a battery of psychological tests. Encephalograms might also be useful.

Like anything else, this notion can be carried too far. Pushing this kind of reasoning to the extreme, one might say that one need only preserve a single cell of his body, for its genetic content; from this he could be regrown, and the original personality and memories, at least in coarse outline, implanted from the records. But this sort of connection is both too difficult and too tenuous and unsatisfying for most people. Yet we can be sure that before long "record mania" will be added to our list of tics, and swindlers will peddle all kinds of bizarre recording devices and services. No advance is without its price.

Organization and Organizations

What practical steps can one take to ensure that he will be frozen at death? A number of obvious courses suggest themselves.

One of the simplest steps is to specify in your will that you insist on being frozen. (A number of people have already done so, as of this writing, I am told, including persons in Michigan, District of Columbia, New York, New

Jersey, California, and Japan.) To make sure this demand is effective, of course, a number of precautions should be observed.

First, the will should certainly be drawn with competent legal counsel. Second, the details should be made as explicit as possible, and therefore the will should be periodically updated. Third, promise of cooperation should be obtained from your expected surviving next of kin, preferably in writing. Fourth, you should choose an executor both sympathetic to your desire and capable of vigorous and decisive action, not necessarily a close relative. Fifth, you should provide funds for the purpose, possibly in the form of direct or indirect proceeds of a special insurance policy.

Pursuant to the question of money, it is clear that if you are living up to your income or slightly beyond it, as most of us are, you must mend your ways and practice thrift. Your estate, including insurance policies, must provide for any dependents in addition to purchasing freezer accommodations and a trust fund for yourself. A wise and moderate balance must be struck in all things; however, the more money you save, the more you will be able to take with you, and the more influence you will wield in the meantime.

Another obvious step is to obtain the promise of cooperation from your physician in case of death. This is not meant to imply that you should deliver an ultimatum tomorrow that unless he promises to help freeze you, you will change doctors. Most physicians, in the immediate future, will be very skittish on the subject. But you should discuss it with him, make your views clear, make sure he informs himself on the subject, and maintain a judicious pressure. This kind of action, together with other developments, will assure that before too long there will be an ample choice of cooperative physicians. (It is not suggested that physicians are reactionary and ignorant and have to be led by the nose; but they naturally tend to be conservative, and they need to be informed both of specialized technical developments and of patient opinion.)

A whole crop of organizations will undoubtedly sprout in the fairly near future, offering various services, or a whole range of services, in connection with the freezer program. Perhaps some of them will be formed by morticians, or will be adapted from existing mortuary companies. But until commercial organizations are on the scene, people will have to hand together to form their own.

In union there is strength, and existing organizations, for example fraternal societies, could form committees and sub-organizations, possibly somewhat on the order of burial societies, to serve their members. The pool would provide moral, financial, and administrative support. All preparations would be made in advance, making the most and best of local conditions, and on the death or impending death of a member the organization would swing into action.

If in some cases it turns out to be awkward to work within existing organizations, then mutual aid societies can be formed with this specific purpose, the usual legal precautions being observed.

Finally, another way the individual can help the general impetus is to write his life insurance company, inquiring about freezer insurance. Many companies already sell special-purpose policies, for example, with the proceeds ear-marked to pay off a mortgage. In logic, of course, this seems a little silly, since the beneficiary might as well simply have the additional funds, to apply as seems fit; but psychologically the companies find this device useful. Also, it is not clear that the life insurance companies would want, or would be legally able, to have a direct hand in physical freezer facilities. But the point is that there is an immense new market for life insurance, and when this is realized the life insurance companies are sure to exert heavy influence, directly or indirectly.

Emergency and Austerity Freezing

Many circumstances of death, in the near future, will pose a painful and nearly intractable problem for the next of kin. Substantial funds may be lacking; medical cooperation and hospital facilities may be lacking; death may come unexpectedly and the body may not be found immediately. What can be done in such cases, and how much hope do the possibilities afford?

The second question has already been discussed. In the worst cases, most scientists would doubtless characterize the chance of revival as remote or

even vanishingly small; but this estimate is based on a feeling and not on a calculation.

The estimate can perhaps be regarded as depending on three factors. First, is the degeneration really irreversible in principle. Second, how nearly will technical feasibility approach theoretical possibility, looking into the indefinite future? Third, how likely is it that historical developments will deny to the frozen the treatment technology could provide them?

It seems to me that at present we cannot make even a reasonable guess about the first two, while the third, based on discussion in later chapters, has a most hopeful answer. If this reasoning is correct, then estimating the chance as "remote" or "vanishingly small" represents nothing more than a vague and generalized pessimism, arising because many scientists are overawed by the apparent difficulties.

Even so, in the immediate future it would take an unusually strong and resourceful person, with nerves of steel, to undertake freezing single-handed. If a mutual aid society, or even a coherent family, can work together, however, probably something can be done, and a few practical suggestions will now be offered.

It is understood that these suggestions do not constitute medical advice, carry no guarantee of any kind, and are not even claimed to represent a consensus of current opinion. They represent only the author's impressions, as of this writing, for whatever they may be worth. The reader is expected to seek other opinions, as recent and as authoritative as may be.

First, whoever is present at time of death, or soon after, should probably try to reduce the rate of deterioration by applying artificial respiration and external heart massage. (Tubes are available for mouth-to-mouth artificial respiration without actual contact; sources of information on these techniques can be obtained from physicians, druggists, and libraries.)

A physician should be called as quickly as possible to certify death. Then cooling and freezing should be accomplished by the best available means. Ice might be used at first if nothing else is at hand, or the body might be placed in a cold room in winter. Dry ice might be used next, being readily available in all cities during business hours, at a price currently of around 6

cents a pound or less. The body might be packed in dry ice chips, with blankets to maintain contact and keep out the heat; or faster cooling might be accomplished by using one of various slushes of liquid chemicals mixed with dry ice.

A few words of caution should be inserted. Communicable diseases, of course, require special precautions. Water should not be allowed to get into the body cavities. Dry ice should be handled gingerly, or with gloves; and while carbon dioxide is not poisonous, if too much is used in too confined a space a lack of oxygen may result.

If the body is not discovered until it has begun to stiffen, the artificial respiration and heart massage are probably useless, since the blood vessels are clogged, and this part of the procedure would be omitted.

The problem of where to store the body is one the individual, family, or mutual aid society will have to solve. The question of a container and its cost and servicing will be touched upon in Chapter VII.

Freezing with Medical Cooperation

If medical help and hospital facilities can be obtained, the outlook is much brighter. Various possibilities have been alluded to in Chapter III, particularly that of perfusing the whole body with glycerol solution, along with supportive measures, before freezing the body with liquid nitrogen; this may afford the best chance at present to minimize - although by no means to eliminate - injury.

With a cooperative physician and careful advance preparation, obviously the odds will improve immensely. If the physician hesitates to work on the body himself, he might at least be willing to supervise preparation, have himself or an associate available in the hospital for a very quick finding of death, and train a mortician to do the actual work after death. The mortician, of course, would also have to be quickly available - how quickly, would depend on the methods used; again refer to Chapter III. The state of the art is constantly

improving, and new and better methods may be known by the time this book is in print.

Physicians may often be reluctant to cooperate in freezing for several reasons - generalized fear of criticism, fear that they lack competence in the techniques, and fear that all their dying patients will demand freezing. None the less, some physicians are willing to try desperate or experimental measures in otherwise hopeless circumstances, and it is possible to put the case in this light. That is, if the patient is in a hospital and known to be near death, the physician might be persuaded to give medical help on the basis of treatment.

We recall that "suspended animation" is ordinarily taken to mean freezing without damage, so the person is regarded as still alive, and capable of being revived at any time without waiting for new developments; this technique is not yet perfected. But we also recall the experiments with whole-body perfusion of rats, and other evidence suggesting that people could be cooled by passing cold glycerol solution through their circulatory systems, and then stored at low temperatures in relatively good condition, although at present we have no means safely to thaw them and remove the protective agents. It is possible, although not certain, that the greater part of the damage occurs in thawing and not in freezing; hence these patients, after freezing, need not definitely be considered dead, and their condition could be called "suspended animation".

Thus some courageous physicians, if persuaded by patient and family, might agree to freeze the subject before natural death, with all the advantages of deliberate preparation and a body in better condition; the purpose would be to reduce metabolism and preserve life while a cure was sought. No death certificate would be issued, and the freezee would remain a patient and not a corpse, with various legal and practical advantages - and also, of course, some disadvantages.

A variation of this idea might be to have one physician certify death, after the patient expires, and a second physician immediately treat the body to prepare it for freezing, later certifying that in his opinion the patient may not be dead. The major biological advantage, of treating a fully living body, would be lost, to be sure, but this might be necessary to induce the physician to cooperate. The death certificate would help protect the second physician,

while his doubt about the patient's death might be translated into legal life, although the earliest cases would involve protracted litigation.

Individual Responsibility: Dying Children

Many Americans and Europeans, as well as others, will very soon be called upon to make life or death decisions. Perhaps some are facing such decisions this very day, as you read these words.

Let us consider first the most tender and least exculpable example; the impending death of a child.

Every year in the United States, over 150,000 children under nineteen are taken by death, often signaled well in advance as a result of incurable disease. In 1959, cancer alone claimed over 10,000. (124)

Until now, parents could only seek religious comfort, or compose their minds according to their resources. Now it is better, and of course worse. Better, because there is hope. Worse, because hope implies also trouble, turmoil, and the possibility of failure.

If an adult is dying, it can be argued that he should be allowed to make his own decision about freezing; and if he is of advanced age, the rationalization of a "full life already lived" can be used to justify inaction. But in the case of a dying child, the parent cannot easily find shelter from his responsibility.

I realize very well the cruelty of adding to the burden of grief a further torment of difficult decision and a potential load of guilt. Many people will have no clear idea of what is right. On the one hand, it will seem to them, if they freeze the child their hopes may prove unfounded and they will have engaged in gruesome, bootless, agonizing and expensive sacrilege. On the other hand, they may find it hard to forgive themselves if they bury the child and the freezer program nevertheless gains acceptance. It is my view, of course, that the freezer program will become general and will prove

successful, and that the price in money and temporary emotional upset is not too high.

The decision will necessarily be on an individual basis. Entering into it will be such considerations as estimate of the chances, advice by physicians and clergymen, the status of the freezer program in general, and the financial and emotional situation of the family.

Assuming parents find the strength and resources to freeze a child, and eventually see him safely in a permanent Dormantory, they will then have time to ponder some very disturbing questions. When will I see my child again? If I die at an advanced age, will my revival be more difficult than his, and hence later, and will he therefore be older and wiser than I when I awaken? Will the relation of parent and child be effectively reversed? Or will I be frozen by more advanced methods, and therefore revived first, as a physically young adult, and him later, still as a child?

One can only assume that society will gradually evolve a standard operating procedure for dealing with such matters wisely, taking into account both the wishes of the individuals involved and the welfare of the community.

Husbands and Wives, Aged Parents and Grandparents

If your husband or wife is dying, the problem is in some respects different. If the dying spouse wants to be frozen, clearly you should comply, even at substantial financial sacrifice. (One hopes there may eventually be tax relief or subsidy for the families of the early frozen, who have not had the opportunity to buy freezer insurance policies.)

If your husband or wife is mentally competent but opposes freezing, a difficult moral problem arises. The easy way out is compliance and burial, but you will have to live with your conscience a long time. The key consideration, it seems to me, is that burial is final, whereas freezing commits one to nothing except a second chance; there is always time to bow

out, if one should insist. You can change your mind after freezing, but not after burial.

In the case of an aged parent or grandparent, lacking in vigor and perhaps limited in understanding, there may again be an unwelcome responsibility. Should his decision prevail, or your judgment? Many circumstances will enter, as in the case of children. In addition, the responsibility may be split among several children who may not concur, and one must decide for himself how much effort conscience demands. But the rationalization of "a full life already lived" will not hold water: in the long view, eighty or ninety years is not a full life, but only a beginning.

Even before custom gives sanction, I believe a sufficient number of people will prefer beginnings to endings.

CHAPTER V

Freezers and Religion

At first thought, one might expect that many religious people will be repelled by the freezer program, refusing to share in it and even denouncing it as immoral. After all, there are several obvious ways in which the program may seem incompatible with religion, if one thinks hastily and superficially.

First, the idea that death is not absolute and final, but a matter of degree and reversible, seems to do violence to the notion of "soul," to the duality of body and spirit which plays an important part in most religions. Might it not be claimed that a freezee, after revival, would be a soulless monster or zombie? Or that to revive a corpse, and thereby recall a soul from its resting place, would be an act of blasphemy?

Second, there is implicit in the freezer program the view that modern man is not the acme of development, but represents only a rung on the evolutionary ladder; that we not only evolved from lower forms of life, but will continue to ascend, through manifold biological and bioengineering techniques, both racially and individually, changing profoundly in both outward and inward nature. Does this not put a severe strain on the idea that man was created in God's image? In particular, can a Christian accept the notion that Jesus, in His human form, did not represent the pinnacle of development?

Third, some churchmen will see looming larger the specter of creeping secularism. With unlimited physical life in prospect, will the flocks forget about spiritual immortality? Will they turn en masse to materialism? Will they worship only the Golden Calf?

Several subsidiary and related questions also present themselves.

Forbidding as these questions may appear, 1 believe they will evaporate rather quickly, leaving behind only a few patches of fog which will continue to swirl for a long time.

Revival of the Dead: Not a New Problem

Hundreds of people have already been resurrected from the dead, with no fuss or question as to the abode of the soul during and after death. These were the victims of drowning, asphyxiation, heart failure, and the like, who suffered clinical death but were revived by the use of artificial respiration, heart massage, chemical stimulation, electrical stimulation, and other methods of modern medicine. An especially interesting case is that of Roger Arnsten, a Norwegian boy who drowned in 1962 and was dead for about 2.5 hours, including an estimated twenty-two minutes under water.

Roger, five, fell into an icy river on a cold winter's day. After drowning, his body temperature continued to fall, probably getting below 75F, and of course this hypothermia prevented swift deterioration of his brain. Dr. Tone Dahi Kvittingen applied artificial respiration with a tube down the windpipe, and rhythmic pressure on the chest to force blood circulation. At the hospital, an electrode needle pushed through the chest wall into the heart revealed no beat; but the attempt at resuscitation was continued, including exchange blood transfusions, and about 2 1/2 hours after drowning a natural heartbeat resumed. In the sequel, Roger remained unconscious for about six weeks, and even went temporarily blind, and at times appeared demented, but finally made a nearly complete recovery, with slight impairment of some muscular coordination and peripheral vision. (58)

The point here is that nobody worried about little Roger's soul. Did God, knowing he would be revived, rule that this was not really death and simply leave the soul in the body? Or did He keep the soul in escrow, as it were, and return it to the body at the moment of resuscitation? If the boy did leave his body temporarily, was he conscious or unconscious? No one knows, and no one seems inclined to make an issue of it.

Why, then, should anyone be concerned about the souls of the frozen? The mere length of the hiatus can hardly be critical: in God's view, 300 years is only the blink of an eyelash, and presents no more difficulty than 2 and 1/2 hours.

Except quantitatively, then, the problem is not new, and the religious communities have already made their decision. They have implicitly recognized that resuscitation, even if heroic measures are employed, is just a means of prolonging life, and that the apparent death was spurious.

The Question of God's Intentions

The cry will certainly be raised in far right religious quarters that freezing is "unnatural" and that it was not "intended" for cadavers to be revived. The answers to this should be quite obvious, but we may as well indicate them anyway.

Part of the answer lies in a recent version of a very old joke. A querulous lady objects to astronauts attempting to leave God's green earth for outer space. "It's against the will of God," she says, "for man to try to live in the sky, going to the moon and Mars and such. Why can't those people just stay quietly at home and watch TV, like God intended?"

A somewhat earlier version concerns objections to Henry Ford's Model T. "If God had intended man to go forty miles an hour, He would have provided him with wheels instead of legs."

This attitude is less amusing in the case of certain sects said to oppose the "interference" of physicians in the course of nature, even forbidding the use of silver nitrate in the eyes of the newborn, on the ground that God "intended" the child of a gonorrheal mother to be blinded.

It is exactly man's nature to "go against nature." Beasts live, even though miserably, in "harmony" with nature; but man must strive to improve both himself and his environment. It is a little dangerous to say simply, "God gave man a brain to use," because this kind of argument might pose a problem with respect to, say, the appendix, and also because the question is not just whether to use it but how to use it. Nevertheless, modern clergymen of most denominations are now thoroughly committed to the view that the advance of science does not imply a retreat from God.

Dr. G. Ernest Thomas, Director of Spiritual Life for the General Board of Evangelism of the Methodist Church, has written: "Religion needs science . . . The purposes of God are brought into clearer focus by every new discovery of truth which the scientist makes. . . Because religion interprets God as interested no less in the fulfillment of man's greatest possibilities as in the orderly functioning of the planets and the stars, religion honors Pasteur, Lister, Koch, Einstein, and other men of science. It recognizes the scientist as one who shares in the fulfillment of God's purposes for His world . . . I recognize that science holds the secret of a more abundant life than man has ever known." (115) (The italics are mine)

However, this does not mean that every activity of science, much less every activity of a scientist, is necessarily good, and some additional discussion of the "soul" puzzle may be useful to convince the doubtful that freezing is not sinful.

The Riddle of Soul

Besides being interesting in itself, especially in light of our later treatment of the problem of identity, a brief look at this very obscure question will serve an important purpose: without denying that the soul may exist, we shall show that its definition is so vague that no one, however religious, can claim to know much about it, much less lay down moral directives about it.

In modern times, intelligent religious people apparently make little attempt to characterize the soul. It is just another Divine Mystery, rooted in faith, revelation, and especially in a kind of misty tradition. People have them; lower animals do not. (or perhaps we should say, souls clothe themselves in the bodies of Homo Sapiens, but never in those of other species.)

When are matter and spirit joined? Dr. George W. Corner says, " . . . most Roman Catholic theologians, Orthodox rabbis, and some Protestants hold that the soul is infused into the body at the moment of fertilization. To the Roman Catholic, the loss of an embryo, even if too small to be seen without

a microscope, of whose existence its own mother is not yet aware, means its soul must dwell forever in limbo, outside the gates of heaven." (14)

When medical knowledge was more primitive, ideas about the soul were correspondingly different. St. Augustine and St. Thomas Aquinas are said to have written that the fetus receives its soul in the seventh or eighth week of embryonic life, which is about the time it becomes an obviously recognizable human being. (14)

In 1677 Anthony van Leeuwenhoek of Delft is supposed to have regarded each sperm cell as a rudimentary embryo. His followers thought each sperm a little mannequin, itself having testes carrying tinier sperm, ad infinitum. On this basis, the German philosopher Leibniz reasoned that the first man must have carried all his descendants in his genitals, including all their myriad souls, awaiting each his turn to develop. (14)

Our main lesson from this little bit of history is that notions of soul have followed and not preceded science, and doubtless will again.

Even professional theologians have the utmost difficulty in struggling with the problem of soul. Consider the following well-meaning but pitiful effort:

" ... those who oppose the materialists insist on another kind of reality, which is not accessible to the senses . . . but only to the mind . . . a nonmaterial or spiritual world, accessible only to the reason and not to the senses . . . as when you think of numbers and geometrical figures and other abstract ideas, such as unity and freedom and love, none of which can ever be seen or touched or smelled. [To this realm] belongs man's soul . . . as well as God and whatever other spiritual beings there are." (41) (The quotations are slightly out of order.)

That writer cannot possibly mean that God, for example, is only an abstract idea; if He were, He would be incapable of acting except through the agency of another mind. The quotation undoubtedly represents a thought, and possibly a significant one; but if so, there has been a failure of communication.

As to what the soul may be from a scientific standpoint, it is again most difficult to say. So far as I know, no one has ever devised a way to detect its

existence. Since beasts, and also postulated extra-terrestrial humanoids, seem to have intelligence, personality, character, feelings, conscience, and indeed every other physical and behavioral attribute capable of detection, and yet have no souls according to religious belief, the soul seems detectable only to God.

It is also hard to see how the soul can determine identity, unless one is prepared to claim that beasts lack individuality, or that identity has a different repository in beast and man.

Perhaps, in some unclear way, the soul is not the man, but is nevertheless his most important part, somewhat as your head is not exactly you but is still the main part of you. Possibly the body can be amputated from the soul without destroying the essence, more or less as the feet can be amputated from the body without mortal damage.

It is also conceivable that the soul is physically detectable after all, but only with extreme difficulty, like the neutrino. The crudeness of our observations may be at fault. There exists, of course, a substantial quasi-religious body, the Spiritualists (séances and all that), who seem to believe in a quasi-physical soul.

Some Christians, especially those literate in science, have been so impressed with the difficulties of "soul" that they advise abandoning the word altogether. Dr. Arthur F. Smethhurst, Examining Chaplain to the Bishop of Salisbury, has written: "The word 'soul' is another term, the use of which might well be abandoned in view of the ambiguities which surround it . . . If we are to reject the use of the word 'soul,' what we should substitute in place of it is probably the word 'self.' By this we must mean a self-conscious, rational human personality." (109) One suspects that the substitute word retains considerable ambiguity; but if this suggestion were widely adopted, there could be little question as to the soulfulness of the resuscitees.

Since the concept of soul in the Judaic and Christian traditions is so vague and changeable, it may not be out of order to mention the ideas of other religions and peoples. In the Shinto religion, for example, there seems to be the idea not of a soul, but simply of soul (kami). Kami refers to anything of the spirit, and it comes in variable quantities. (9)

In the Indian religions - Hinduism, Jainism, Buddhism, and Sikhism - there is belief in samsara, transmigration or reincarnation; a single soul tenants a succession of bodies. (9)

Speaking of multiple bodies brings to mind the converse idea of multiple souls. Can there be more than one to a customer? Is it possible that on clinical death the soul goes to its reward, and that if the body is revived another soul, a sort of twin-soul, occupies it? After all, we know that in the case of identical twins being born, the fertilized ovum was split into two individuals with two souls; hence either there were two souls present before the split, or else an extra one was inserted when it became necessary. A similar device might handle the death-and-resurrection difficulty, if it is deemed necessary. But we hasten to repeat that the simplest solution is to regard revival as the extension of life and not its renewal, to assume that death was not real.

The theologians in good time will decide all such questions. Or rather, several schools of theologians will each evolve a whole series of accommodations to the developing insights of science and the developing pressures of society, in the usual way.

Suicide Is a Sin

Elusive as the soul may be, Christians seem pretty much agreed that it is sinful prematurely to separate it from the body. Both murder and suicide are regarded as sinful under most circumstances, and this whether by act of commission or omission.

Physicians are generally required, by religious morality as well as civil law, to take all available measures to save life and to prolong it, even if the measures are not certain of success. Temporary death, or clinical death with a recognized chance of resuscitation, can hardly be deemed death at all in this connection, and hence the freezers must be recognized as a probable means of saving or prolonging life.

It will then follow that failure to use the freezers is tantamount to suicide, if the decision is made for oneself, or to murder, if the decision is made for a member of your family.

Although this argument seems to me a very powerful one, not everyone will recognize it as compelling. There will be clerics on both sides of the fence.

Bishop Fulton J. Sheen, while in no way condoning mercy killings, is reported to believe that "extraordinary" medical measures should not be taken to prolong the lives of "hopelessly" ill patients. (23) Undoubtedly many other clergymen would vehemently disagree, since the line between "ordinary" and "extraordinary" measures is an arbitrary one, and the epithet "hopeless" always represents a guess. Some would say that the withholding of medical assistance. whether "ordinary" or not, does indeed constitute mercy killing.

What emerges, then, is that some few of the clergy will insist that the freezers represent an improbable means of saving life, and a disagreeable one besides, and a presumptuous and profane one as well, and will roundly condemn it. But I think the majority will take an initially cautious view, and before long will agree that failure-to-freeze represents a denial of life, and therefore of God.

God's Image and Religious Adaptability

The freezer program represents for us now living a bridge to an anticipated Golden Age, when we shall be reanimated to become supermen with indefinite life spans. Indeed, even the term "superman" may eventually become inappropriate, just as a man is not aptly described as a "super-amoeba" even though we evolved from a one-celled organism.

At first thought, this cannot be other than a most disturbing prospect to the Christian, Moslem, and Jew, since it seems to promise to leave Jesus, Mohammed, and Moses behind in the mists of the pre-dawn. And yet one must not underrate the adaptability of modern religions, and in fact I believe

they will succeed in reinterpreting holy writ and tradition to keep pace with science and society, as they have done so often in the past.

In earlier days, there was raw conflict between science and religion. As a prominent Lutheran theologian, Dr. M. J. Heinecken, reminds us, "Whenever there was a new discovery which went counter to the traditional beliefs, the church and its leaders were quick to protest . . . Giordano Bruno was burned at the stake in 1600 because he no longer believed in a finite, enclosed universe . . . In 1632, Galileo was forced to recant his conviction that the earth revolved and not the sun. . Martin Luther did not think well of Copernicus for contradicting the cosmology of the bible . . . [and] . . . the church opposed . . . inoculation, anesthesia, birth control, and above all, the theory of evolution." (41)

Happily, those days are long gone, and modern Christianity and Judaism are in the main admirably humane and forward-looking. The humanity and adaptability is wittily exemplified in two anecdotes, which came my way through Catholic friends.

The first concerns a priest who was asked by his friend, a rabbi, to contribute money to a project of the Jewish congregation, the building of a new synagogue on the site of the old. "I'm afraid," said the priest, "the bishop would not approve my helping build a new synagogue." He thought a bit, and continued. "However, there must be some expense involved in tearing down the old Synagogue, and to that I can contribute."

The second concerns a priest in a French village, in the aftermath of a battle in which invaders were successfully repulsed and one of the defenders, a Protestant soldier, died. The rules forbade burying the Protestant within the churchyard fence, and he was seemingly doomed to a lonely grave. But the good Father was equal to the occasion: he buried the soldier just outside the fence, and then labored all night until he had moved the fence, so that in the morning the new grave was in the churchyard after all. This story is not quite so funny as the first, but strikes closer to home, since it concerns adaptability with respect to customs in the disposal of bodies.

Most Christian denominations have accommodated themselves to Darwin's theory of past evolution. Dr. E. C. Messenger has written, " . . . many think there is good reason to suppose that the 'dust of the earth' of the Scriptural

text need not and should not be taken to signify that the immediate source of the first human body was in fact inanimate matter. They see no reason why, on the contrary, the first human body may not have been fashioned by God from some animal organism, and this hypothesis has now been officially recognized by the supreme authority in the Catholic Church as open to discussion." (71)

Accommodation to the doctrine of future evolution, of individuals as well as the species, may be in some ways more difficult. But the same writer quotes St. Augustine as saying, "Whatever men can really demonstrate to be true of physical nature, we must show to be capable of reconciliation with our Scriptures ..." (71) This sums it up, it seems to me, rather nicely, even though it is scarcely more than a truism and leaves open the question of "should" as opposed to "could."

The problem of "God's image" in its narrower aspect should not pose too much difficulty. To be sure, man may have originally "created" God in his own image - in particular, the ancient Hebrews, I suppose, pictured God as a kind of super-goatherd but educated moderns do not seem to insist on any special physical attributes for the deity. Jesus was physically a Hebrew, but no one will assert that a Negro or an Oriental bears a more distant resemblance to God than does a Jew; or that God has any physical likeness to some of the monstrous bodies that clothe human souls. The "image" of which we speak is unquestionably a spiritual image in some sense. Maurice R. Holloway, a Jesuit writer, has said, " . . . the soul . . . is made to the image and likeness of God." (44)

Added Time for Growth and Redemption

When we say that the human soul is made in God's image, we have only broached a topic and not capped it. Much remains to be investigated.

Clearly, the soul is capable of growth and change. Just as clearly, while it may be an image of God, it is an imperfect image. Billy Graham, Billy the Kid, and Billy-down-the-block have souls differing markedly in texture from

each other and from God. Every man has the duty to seek growth and betterment, both for himself and for others.

Here, then, is another chance for the religious community to view the freezer program as a challenge and an opportunity, rather than a threat. With an extended life span, the soul has a chance to grow nearer perfection. Three score and ten simply is not enough time for respectable accomplishment, in most cases; too many jobs remain undone, too many duties undischarged, too many visions too dimly seen.

In early Christian days, the apostles expected Jesus to return in their lifetimes; later, Judgment Day was anticipated at the end of the first millennium. Now, some few sects preach an imminent Second Coming, but most Christians seem willing to agree that our earthly human history may lie mostly in the future. Likewise, in Jesus' day the average life span may have been around forty; in America now, owing to improved medical arts, including the freezer program, the average man may live for thousands of years.

In the case of the unconverted soul, surely the pious must welcome a chance to preserve his life and thereby extend the opportunity to save him. Letting him rot would seem to condemn his soul to Hell, whereas freezing him would allow future missionaries (or the same missionaries after their reanimation) another chance at him. I am convinced that conscientious Christians will take this argument very seriously.

Dr. Edwin T. Dahlberg, a former president of the National Council of Churches, has written something which seems relevant here: " . . . the present-day leaders of religion are beginning to appreciate the fact that science is not an enemy to be denounced but rather an ally to be welcomed as one of the *redeeming forces* in the life of mankind." (16) (The italics are mine.)

Further, we must again emphasize that the religious problems associated with increased longevity will inevitably appear whether or not the freezer program is shared by the religious. Sooner or later medical science will succeed in increasing the human life span. This has already been explicitly recognized by Christian writers.

Dr. Gene Lund, professor of religion at Concordia College, is one. "Who knows but what a decade or two hence the average man will comfortably reach an age of one hundred years - at least." (63) He goes on to say, "But science does not have, and never will have, the power to eliminate death."

In other words, the Christian can expect, and welcome, the prospect of increased longevity, and cannot set any limits on it. At the same time, permanent death will surely come some day, however long deferred; science can give us indefinite life, but not literal immortality, not mathematical eternity. Hence the freezer program, if we take a sufficiently long view, is not so radical after all, but merely another incident in the cosmic drama. The freezer program is merely a medical means which will allow the present generation to share the longevity which our descendants will have in any case.

Conflict with Revelation

Some Protestant denominations, in particular, make much of Revelations in the New Testament, and can be expected to oppose a program that does not seem to fit their view of God's plan for history. But Christianity as a whole is unlikely to make a stand on this issue, because the pertinent passages are so obscure and there is so much disagreement about their meaning.

For example, Dr. Merrill C. Tenney, writing about the Millennial Kingdom, tells us: "There are three main interpretations of this passage. (20: 1-6) The post-millennial view looks upon the Millennium as a period closing the conquest of the world by the preaching of the Gospel . . . His Kingdom comes. At the end of an indefinite period of peace and righteousness, He will return to judge the living and the dead, and the ages of eternity will begin.

"The amillennial view treats the thousand years as wholly figurative . . . There will be no outward and visible reign of Christ on earth until after the judgment.

"The premillennarian view holds that Christ will return to earth to abolish all outward opposition, that He will establish here an outward visible Kingdom lasting one thousand years more or less ..."(115)

There is certainly ample room here for the view that the freezer program is part of God's plan.

It is interesting to remark the accommodation that has been made by certain modern Jews in Israel with respect to the prophecies of Messiah. Christians, of course, believe Jesus was the Jewish Messiah, although He did not seem to fill the bill well enough to convince many Jews; some modern Jews still expect Messiah to appear; but a substantial body of modern Jewish opinion, if I understand correctly, holds that the State of Israel embodies the concept of Messiah, with no haloed individual to be expected.

In a vaguely similar way, then, perhaps it is even conceivable that the freezer era -- if it develops into an age of brotherly love and a living Golden Rule, as I believe it will -- may be accepted by some as the embodiment of the Millennium.

The Threat Of Materialism

The pious have long been afraid of the know-it-all attitude sometimes engendered by science; they decry the loss of the sense of wonder at the mysterious universe. In this connection, Dr. Gene Lund has quoted a verse attributed to Peter Marshall:

Twinkle, twinkle, little star -
I know exactly what you are:
An incandescent ball of gas,
Condensing to a solid mass.

Twinkle, twinkle, giant star -
I need not wonder what you are,
For seen through spectroscopic ken
You're helium and hydrogen.

But whatever the effect of scientific advancement on the man in the street, the scientists themselves usually have a very lively sense of wonder, if not of awe. Many of them, including some of the greatest, have also been deeply religious - e.g., Copernicus, Galileo, Kepler, Boyle, Newton, Priestley, Faraday, Eddington, and Pasteur, as well as a host of moderns.

Does the freezer program, then, really threaten the existence of the mass of the people in that it will become hopelessly secular and materialistic?

The answers are fairly obvious, but let us display them anyway, after devoting a few words to the always bothersome question of definitions.

A "materialist," as the word is often used in a derogatory sense, is someone who is blind to things of the "spirit"; in extreme cases it means someone who is obsessed with wealth and sensuality and does not appreciate the values in art and in human relations. As I prefer to use it, however, it merely means someone who is not a dualist, someone who conceives of the universe as unitary, without any dichotomy between "matter" and "spirit."

"Religion" is much harder to define. According to the Rev. M. R. Holloway, "Religion. . . consists in that act by which man worships God, subjecting himself to Him." (44) But this definition seems much too narrow.

One of the organized religions, Buddhism (at least in some of its forms), does not even concern itself with a deity! Millions of Buddhists have religion but no God. Furthermore, many writers have acknowledged that Soviet communism has essentially the character of a religion. Seeking the common elements, we can probably say that the essence of religion lies primarily in extreme dedication, and secondarily in fellowship.

It is plain enough that man can get along without religion in the narrow sense - or at any rate some men can. Many men get along without it in America today, just as many got along without it in classic Athens, including

great and good individuals. But whether many people could get along indefinitely without some kind of dedication and fellowship is another question, and the answer is probably negative.

It follows that the church as an institution is in no danger. It offers a formal dedication which fills a deep-felt want. It offers - even without Bingo - a warmth of fellowship hard to find elsewhere. Like everything else pertaining to man, the churches will change, but they will not die.

Perspective

The religions are willingly and foresightedly undergoing a continuing process of reexamination and adaptation in light of new discoveries and new capabilities, of which the freezer is only one. Precedent already exists for regarding preservation and reanimation of seemingly dead people as routine medical procedure, aimed simply at prolonging life. The religious problems, if any (as well as the economic and social problems) related to extended life have long existed, and will continue to grow, with or without a freezer program. When the freezer program gains momentum, religious people, except in scattered instances, are not likely to be left behind.

CHAPTER VI

Freezers and The Law

Even though our Supreme Court is sometimes accused of radicalism, jurisprudence in general is very conservative. In fact, some jurists face rigidly backward; they don't care where they're going, but only want to know where they've been. They are perpetually astonished that tomorrow always arrives. But they, like their more progressive colleagues, may as well face up to the fact that there really is a future, and that it is more comfortable as well as more dignified to walk into it than to be dragged in.

Not only the bodies of the frozen must be protected, but also their property; and not only their property, but also their rights. Remember Ralph Waldo Emerson: "For what avail the plough or sail or land or life, if freedom fail?" The defender of the status of the frozen, as of us all, must be the law.

The law indeed, but what law? Why, the law that will be shaped in the usual way, in the legislatures and more especially in the courts, by test, re-test, compromise, and evolution. While its outlines are still dim, we can look at some of the obvious problems, and conjecture about solutions.

Freezers and Public Decency

To begin with, there will be an attempt to fit the freezers into the structure of laws governing the disposal of bodies and the operation of cemeteries, mausoleums, and home crypts. Conceivably, this attempt might cause some localities to try to outlaw freezers altogether; but the advantage would seem to be with those backing the freezers.

Present laws in general seem to give priority to the wishes of the deceased and of the next of kin, subject to the community interest with respect to health hazards, property values, and common decency. Courts of equity have power to settle controversies as to the burial of the dead, the care of their remains after burial, and the preservation of the place of interment from wanton violation or unnecessary disturbance. (73)

There is legal precedent to allow unusual treatment of bodies. In Seaton v. Commonwealth, 149 Ky. 498, the defendant buried his child in a wood in a paper box, without religious ceremony, yet the court held that no criminal action would lie. (73) Michigan law states that the next of kin ". . . can bury the corpse in any manner he sees fit, so long as it does not outrage public decency or amount to a public nuisance." (73) But a disposition permit is required.

Further, the burden of proof will apparently rest on those opposing the freezers: "An unlawful, improper or dangerous establishment . . . may be enjoined, but not at the suit of one . . . who cannot show the likelihood of positive and substantial damage." (72)

If some locality decides a freezer is an outrage or a nuisance and orders burial, the relatives of the frozen will no doubt be able to obtain a temporary restraining order against enforcement, since time would be vital only to the frozen. If lower court decisions should be adverse (which is not easy to imagine), then probably the issue could be taken to the United States Supreme Court on the question of "equal protection," granted in the Fourteenth Amendment.

If, for a time, freezing in some localities is legally too difficult, then many people will leave those localities.

Definitions of Death; Rights and Obligations of the Frozen

The only definition of death acceptable to a biologist is that of Dr. A. S. Parkes: "Death is the state from which resuscitation of the body as a whole is

impossible by currently known means." (110) Implicit in Dr. Parkes' definition is nearly the main thesis of this book: that if we use extreme freezing to prevent deterioration, sooner or later "currently known means" will be adequate, and the body will no longer be regarded as dead. The present legal definition of death, effectively, is simply any condition discouraging enough to induce the attending physician to sign a death certificate. Usually this means "clinical death" - cessation of breathing and heartbeat - but not necessarily, since artificial respiration, heart massage, or other measures may be indicated.

When we quick-freeze a freshly dead corpse, we have someone who is thoroughly dead by current criteria, but who has potential life in almost the same way as a drowning victim who may be helped by a respirator. This is something new in the world of jurisprudence, and account must be taken of it.

When suspended animation becomes feasible, some will choose to be frozen alive, making their journey to the future first-class, perhaps with stop-overs along the way to check on conditions. While in the freezer, such a person will not be dead by Dr. Parkes' definition. Yet his active life will be only potential; he will be thoroughly inert and will require a special kind of legal status and protection, just like an actual cadaver.

Heretofore a corpse has had in itself neither rights nor obligations; now it will have both. His rights will include protection of his body and of his property, governmental supervision of the freezer and of his trust funds. His obligations will include the duty to pay taxes out of his funds and property and to submit his estate to regulation. Furthermore, the manner of his previous life and of his death may affect the nature of his privileges and duties after resuscitation.

Perhaps the law will come to recognize three classes of people in addition to the active nuisances: those in suspended animation, those frozen after death, and those who are thoroughly dead because they were burned up, well rotted, lost at sea, or otherwise considered poor bets. We can anticipate some sticky lawsuits questioning the categories assigned in particular cases.

Life Insurance and Suicide

Will a frozen individual be dead enough for the beneficiaries to collect his life insurance? There will usually be two beneficiaries, the next of kin and the corporation handling his freezer and trust funds.) At first thought, the answer seems obvious: since he died in the ordinary course of events, the actuarial basis of his insurance is unchanged, hence the insurance company has suffered no unusual loss and should pay off. But on second thought, things are not quite so simple.

Will not the suicide rate increase? It seems likely that some people not desperate enough to face permanent death might reach the point of choosing premature death followed by freezing, hoping to awaken to find vanished problems and a new life.

This particular problem seems easy to solve. At present, the insurance companies typically pay off on suicide if it is not within two years of the date of issuance of the policy. In the freezer era, the insurance companies will either insert a straight-ban suicide clause or use some kind of sliding scale based on experience. A few enterprising characters may try to camouflage suicide as accident, but this will not be an easy trick, remembering that the body must not be badly damaged and must be quickly available for freezing. Falling out of windows or under subway trains won't do.

Suicide has always been illegal. The Earl of Birkenhead tells us that in eighteenth century England, on at least one occasion, attempted suicide was punished by hanging the wretch! (6) Served him right, no doubt. Now actual suicide will become punishable as well, perhaps by imposing fines on the estate of the frozen, who will then awaken poorer than he had hoped. We can't have people just sneaking off, shirking their responsibilities.

But the illegality of suicide will have to be carefully reviewed, for clearly there can be extenuating circumstances. If some poor devil is wasting away with an excruciating cancer, he may decide to kill himself and be frozen -

both to spare himself the terminal agony and to freeze his body in better condition, as well as to save further hospital bills. Similar remarks could be made about various kinds of unfortunates with crippling deformities. The legislatures will no doubt set up standards, and the courts will issue suicide permits.

We may also note the need for a new word to distinguish destructive suicide from self-inflicted temporary death. Maybe we could call it "sui-term" or "sui-kaput," to indicate that one has not merely killed himself, but ended himself.

Mercy Killings

Closely related to the problem of suicide is that of mercy killing. Under what circumstances, if any, will the next of kin be allowed to decide whether a blighted life should drag on or be mercifully frozen? Under what circumstances will the courts make this decision?

If an aged parent is in an institution with his mental faculties largely gone, is it right to keep him there? Would he not be better off frozen before his brain deteriorates further? And cannot the family's financial resources be better used to provide him a trust fund than to support him in a sanatorium?

What about a hideously deformed and defective child, as in a severe case of cretinism? Must his life drag on, in the usual way, at bitter emotional expense? Would not early freezing be a true mercy? Some will say that if we freeze all the cretins, there will be no way to study cretinism. Others will go further and say that if we freeze all corpses, the medical students will have no one to slice up in the freshman course in Gross Anatomy. However, there will probably be enough such objectors to save the situation, for surely they will volunteer their carcasses to the medical schools!

The painful problem of deformed and defective children is not one of negligible proportions. According to Jane Gould, "In all, roughly three newborn infants out of a hundred are seriously abnormal." (35) Most of

these, of course, will not be considered for early freezing; they will either die early natural deaths, or will be cured, or can be helped to lead lives not too pitifully far from the norm. But consider, for example, the worst cases of cerebral palsy. According to Jessie S. West, in the United States in 1954 there were around a half million victims of this disease. Many had normal intelligence, although the affliction produced symptoms such as facial grimacing, drooling, and unintelligible speech which might make them seem subnormal to an uninformed observer. But many had serious mental deficiencies, and in fact 13 per cent were considered uneducable. (127)

At present, we properly do not countenance euthanasia for this 23 per cent, even though they may be suffering and even though there is a heavy emotional and financial burden on the other members of the family. But will not the situation be different when freezers are available?

Some will insist that we cannot end life for any reason, let alone for reasons of cost and convenience. But in fact we have always sold lives, and sometimes rather cheaply, in peace as well as in war. Consider, for example, the annual American traffic death toll - around thirty thousand, I think. We could certainly save several thousand of these, merely by doubling the police traffic detail in every city, or by making all vehicles carry speed governors, etc. But we do not want the expense or inconvenience of saving these lives; we make a cold-blooded calculation, and let them die.

Certainly there is an extremely important difference between traffic deaths and mercy killings. In the former case the victims are not known in advance, and we all take our chances. Nevertheless, life does have its price, and the freezers introduce a profoundly important new element.

One cannot evade his responsibility by speaking of "God's will." The failure to act also constitutes a decision. When the judge is pondering the case and searching his soul for right, let him ask himself this question: if the child were already frozen, and it were within my power to return him to deformed life, would I do so? If the answer is negative, then probably the freezer is where he belongs.

Murder

In the new era, the heinousness of the manslayer's crime may depend not only on the motives and circumstances, but also on the degree of damage to the body.

My grandfather used to say there are two kinds of lazy -- "lazy" and "stinking lazy." Society may now distinguish between plain murder and sloppy murder. If the victim is doused with gasoline and ignited, or ground up in the garbage disposal, or hidden in a swamp and left for the alligators, this is sloppy murder. But if he is merely shot through the heart and quickly found and frozen, then this is a more civilized kind of murder.

The punishment of murder will have to be reviewed. Should it fit the crime? Should one who destroys his victim be himself scattered to the winds? Should one whose victim can be frozen be himself frozen? In those states which do not use capital punishment, can freezing be substituted for life imprisonment in some cases?

Further, a new kind of manslaughter will appear, namely, failure-to-freeze. (As civilization continues its majestic advance, the categories of crime inevitably multiply.) Failure to get a body into a freezer, and failure to service a freezer, will probably count at least as negligent homicide.

In this connection, it is interesting to consider our attitude toward abortion, which is also a kind of cutting off of potential life. Abortion is a crime, but it isn't murder, and no funerals are held. Failure-to-freeze will not be taken as lightly, since the victim is more clearly a person, one who had a name and an identity and leaves a more definite sense of loss.

Freezing also offers an alternative to the abortion dilemma. If there are strong indications favoring abortion, but the people involved have strong feelings against it, possibly they might decide to remove the fetus by a careful operation and freeze it rather than destroy it, so that the potentiality of life remains.

Making freezing at death compulsory will at first be successfully opposed in the name of individual and religious freedom, somewhat analogously to the claims of certain Christian Scientists and snake-handling cults. But the courts have overridden the religious objections of parents to ensure proper medical care for dangerously ill children, and have allowed the police to interfere with the snake-handlers. Similarly, the relatives of the deceased will be compelled to freeze him.

Suppose an adult of sound mind leaves explicit instructions that his remains not be frozen? This case will soon become more hypothetical than real. Before long nearly everyone will see the Golden Age shimmering enchantingly in the distance, and will not dream of relinquishing his ticket. Those that may remain stubbornly skeptical will realize they have nothing to lose: if by some chance they don't like what they see on awakening, they can then destroy themselves, or else climb back into the freezer. In practice, before long the objectors will include only a handful of eccentrics.

Widows, Widowers, and Multiple Marriages

In the Kingdom of Heaven, it is said, there is "neither marriage nor giving in marriage," and of course angels all love one another with indiscriminate determination, so that all the ex-wives and multiple husbands will simply sing in chorus. But on earth the resuscitees may have narrower views, and provision must be made for reunions which may not be entirely blissful.

A common form of the marriage vow says something about "until death do us part." If this be interpreted to mean permanent death, some brides and grooms will surely have second thoughts before promising to spend perhaps thousands of years with the same person. On the other hand, if temporary death is allowed to dissolve a marriage, as at present, and remarriages occur as usual, then many a widow will find herself, after resuscitation, facing two ex-husbands, of whom the less recent, the lover of her youth, is likely to be the dearer.

In a few score years these questions may be meaningless. Who can be sure the institution of monogamy will persist? At present we are thoroughly committed to it, and yet one remembers wryly the moment in Shaw's Caesar and Cleopatra when a Briton expresses shock at a Roman custom. Caesar, speaking to another Roman, says: "Pardon him, Theodotus: he is a barbarian, and thinks that the customs of his tribe and island are the laws of nature." Just so; our tribal custom of monogamy is not a law of nature, and may eventually be replaced by . . . what? Perhaps group marriage, or no marriage at all, or marriage determined on a strictly individual basis by contract. With the biological functions and the nature of reproduction itself subject to scrutiny and deliberate change, no one can make a long-range guess with confidence.

A momentary digression here may be useful to point out that the religious notion of "natural law" is by no means so rigid a concept as many Catholic laymen, for instance, seem to believe. George W. Constable, writing in the Natural Law Forum of the Notre Dame Law School, has said: ". . . natural law consensus is not and cannot be static. . . If the conclusion of one qualified member of society is in conflict with the conclusion of another as to what the natural law is in any given case, then, ex definitione, each is justified in following his own lights. . . All are subject to correction, whether priest, king, or democrat." (13)

In the immediate future, some of the problems and their likely remedies are fairly clear.

The first marriage partner to die will leave demands on the survivor not formerly known, demands both emotional and financial. The freezee will want to awaken neither deserted nor impoverished, but to reclaim both his wife and his estate. The wife, on the other hand, may want to inherit everything, and may want to be free to console herself. What to do?

If we are talking about an average couple in the near future, so that the man dies at a moderately advanced age leaving a very modest estate, the result seems clear enough. The widow will be faithful. A decade or so of separation, at an advanced age, is not a high price to pay for emotional security. For the peace of mind of the first to die, this may even be formalized in law; under these circumstances, the widow of a freezee may be

legally still married, and no more able to obtain a divorce than the wife of someone in an insane asylum.

Some may object that all this concern is unrealistic. After all, the resuscitees will not be the same people; they will be rejuvenated and overhauled, changed and improved (although not necessarily immediately) in physique and personality. The life will be new in a very drastic sense, and there may be no interest at all in the former spouse.

The answer is that there must be a reasonable amount of continuity, or at the very least the anticipation of a reasonable amount of continuity (in personal relations), for otherwise the future would be too frightening altogether, and motivation would tend to evaporate.

Consider next a more difficult case, say where the survivor, even though aged, breathes a sigh of relief, thinking, "Good riddance to the bum! Thank heavens I don't have to put up with him any more." Or consider the case of a husband or wife dying in middle life, leaving dependent children. Notice I say, "consider," not "let us consider," because I have already considered them and find myself fresh out of answers. They will just have to be worked out - somehow.

Before leaving this topic, we might mention one possible solution to the problem of the young widow - one not put forward very seriously, but intended to remind the reader of the vast scope of the possibilities.

It is suggested by a news item relating that, in 1963, it is possible in Japan for a girl to go to a plastic surgeon, pay a fee of $50 to $100, and get herself a new maidenhead. (48) Her groom is thus spared the embarrassment of learning of her previous indiscretions. The next logical step, one presumes, is for the girl to go to a psychiatrist and have him hypnotically erase the memories associated with the original maidenhead!

Then she would be a maiden pure in every sense except that of history -- and history, as everyone knows since H. Ford I, is bunk.

Our widow, then, makes the following arrangements. On revival, she lives with the second husband until they can separate by mutual consent - perhaps even until they are tired of each other. Only then is the first husband

revived, and the wife meanwhile has her brain washed clean of the second husband by psychiatric or biopsychiatric techniques. Admittedly, the scheme in this simple form raises more problems than it solves, but it is only intended to be vaguely suggestive.

Cadavers as Citizens

Rumor has it that in certain political wards on Chicago's South Side, for example, it is possible by hallowed tradition for a recumbent corpse to be yet an upright citizen, since he retains his place on the roll of eligible voters. Perhaps, in some degree and sense, this custom will come to be fixed by law.

Two well established principles are involved: ". . . nor shall any State . . . deny to any person within its jurisdiction the equal protection of the laws" (U. S. Constitution) and "no taxation without representation" (Boston Tea Party et seq.). The frozen will be potentially alive; they will be property owners and tax payers. How must the law be modified for proper recognizance of these facts?

At present, our voting laws are for the most part extremely simple - and simple-minded. One competent adult, one vote. Administratively, this is nice and tidy, but logically it is a ghastly mess. The whole area of voting rights and voting weights needs to be reexamined - not merely the question of lowering franchise age to eighteen, as has often been suggested, but the entire philosophy and rationale of representative government.

Should the vote of a man with four children count only as much as that of a father of two? The children are people, they have interests which can be furthered or damaged, and they are entitled to representation. Should a well-informed voter swing only as much weight as the emptiest ignoramus? The very purpose of our republican government is to avoid this. Should not voting eligibility and voting weight depend on the specific issue and the degree to which the voter's interests are affected? It is already customary in certain areas for some issues to be voted upon only by property owners.

Perhaps another layer ought to be sandwiched in between the citizens and the legislatures. That is, any group of citizens might be permitted to delegate their votes to a chosen elector, who would be authorized to cast these votes in an election.

In any event, such an overhaul will surely, among other things, recognize the right of incompetents to certain kinds of representation. Incompetents now form a small group, which is ignored in this respect; but the frozen will constitute an enormous body of influence which must be duly recognized and represented.

Potter's Freezer and Umbrellas

For failure to pay the premiums on one's freezer insurance, the death penalty seems a trifle severe. Hence society will be obliged to freeze the indigent. How fine, that the ne'er-do-wells will in the future escape both death and taxes! They will live on The Welfare and, dying, remain on The Welfare. To add insult to injury, on resuscitation they will be just as bright and shiny as the people who paid taxes. Is this justice? Ask me again in a thousand years.

For the further protection of the weak, the lazy, and the unlucky, the inheritance and bankruptcy laws will need working over. I shall not delve into this, except to remark that the quality of mercy may be displayed by ruling debts subject to simple interest only, while assets may accumulate compound interest.

Countless other legal problems remain to be first revealed and then handled. And while it is true that the freezer era will be the era of the Golden Rule, the fraternal outlook will become general only gradually, and even then there will be honest differences of interest and opinion. For a considerable period we will have to bear in mind the immortal words of Ferguson Bowen: "The rain it raineth on the just / And also on the unjust fella / But chiefly on the just, because / The unjust steals the just's umbrella."

CHAPTER VII

The Economics of Immortality

Even though Professor John K. Galbraith and many others have described our society as "affluent," most people know in their bones this is balderdash. The fact that many people are much poorer does not make us rich. In 1958 the median American family income was only $5,050 (66), which might look good to a Hottentot but is scarcely tolerable by our own present standards, and which seems entirely intolerable if we dare lift our faces from the dust long enough to catch a glimpse of what may be and ought to be. Our wants - our realizable wants, in many cases pertaining to basic physical requirements of health and safety - greatly exceed our wealth.

This view - that our country by even modest standards is not rich but poor - is supported, for example, by Professor Edward C. Banfield of Harvard, who has written: "No one can possibly maintain that our economy is able to produce all of the goods and services that people want. We could not do that, or begin to do it, even if we all worked an 80 hour week . . . The fact is that much of our population is very poor. In 1957, one of every seven families or unattached individuals earned less than $2,000, and the average of those who earned less was only $1,100. . . We are so far from suffering from Abundance that we cannot afford, for example, to rid our cities of slums and blight. A recent study . . . showed that to bring all our cities up to what professional planners consider an adequate standard would cost over $100 billion a year for 12 years. . . My own income is a comfortable one, but I wish it were 10 times what it is. I think I could make very good use of that much more. Most people, I expect, feel the same way." (4)

This being the case, one may tend to be daunted by the likely costs of a freezer program, direct and indirect, and still more by the prospect of immortality with its population problems. But on closer inspection these tough, new problems turn out to be not so new after all, and perhaps not so tough either.

Before coming to grips with specifics, we shall want to view the questions of wealth and population from Olympus. in preparation for this, it is most important to gain some appreciation of the infinite potential inherent in problem-solving machines.

The Solid Gold Computer

Everyone who reads the papers or watches TV knows by now that, whereas the first industrial revolution involved the replacement of human and animal muscle by machines, the second industrial revolution, now barely beginning, rests on the replacement of human brains by machines. The computers already have remarkable problem-solving capacities, and it appears to be only a matter of time until they can "really think."

The invention of thinking machines, of automata with genuine intelligence, will of course have an importance difficult to exaggerate, quite aside from the prospect of immortality. This invention will obviously be in one sense the most important ever made, since it is equivalent to the invention of a magic lamp from which will stem other wonders without limit. There are many "philosophical" implications, some of which will be touched upon in later chapters, but at the moment our concern is with the economic impact.

Specifically, we want to lay the groundwork for the concept of unlimited productive and inventive capacity, through the agency of intelligent, self-reproducing and self-improving machines. The first aim is to convince the reader that such machines will indeed appear.

It is acknowledged in advance that anyone has the right, if he chooses, to reserve to humanity such words as "think," "imagine," "feel," and "live." When referring to machines, one may substitute the phrases "seem to think," "appear to display imagination," etc. With this understanding, then, the simpler terminology will be used in the discussion.

Let us at once attempt to shatter the notion held by most laymen, and fostered by some scientists, that, while machines can calculate, they will

never be able to show the higher qualities of thought, will never display originality, and will never transcend the limitations of their inventors. We shall first quote some expert opinion and then discuss some specifics.

Dr. J. L. Kelly, Jr. (Bell Telephone Laboratories) and Dr. O. G. Selfridge (Lincoln Laboratories, M.I.T.) say: "Now we believe that it is certainly logically and physically possible for a digital computer to do any sort of information processing that a man can. This includes thinking or invention, regardless of how broadly they are defined." (53) (One of these scientists is optimistic, the other pessimistic, about the length of time such developments might take, but this is of no great importance.)

Dr. Jerome B. Wiesner (former Special Assistant to the President for Science and Technology) has pointed out that machines may eventually rival the human mind in compactness of information storage and that they greatly exceed it in speed. Neurons cannot respond oftener than about 100 times per second, whereas electronic switching exceeds a rate of a billion per second. Nervous signals travel no faster than about 300 meters per second, whereas electric signals travel essentially with the speed of light, namely about 1,560,000,000,000,000 furlongs per fortnight, or a million times the nerve speed. From these and other considerations he concludes that ". . . one should ultimately be able to create thinking machines much brighter than the smartest human being, if presently unforeseen limitations . . . do not appear." (128)

Dr. Marcel J. E. Golay (Extraordinary Professor at the Technische Hogeschool, Eindhoven, The Netherlands) also believes that "mere size, complexity and speed may play the main part in transforming the 'stupid' computers of today into thinking machines which will teach us basically new concepts." (33)

A similar note is struck by Dr. W. Grey Walter, director of the Burden Neurological Institute, London, who believes that mere complexity may largely span the gulf between crude machines and sentient beings. {125)

Those who deprecate "mere" complexity forget that quantitative differences can mount up until they become qualitative differences. A very simple computer may only be able to add and subtract; but if we enlarge the computer sufficiently, although it is still only capable of addition and

subtraction, it can now combine these operations in such diverse and complex ways that the result is multiplication and division, and even differentiation and integration, and more! A difference in degree may become a difference in kind.

Professor Norbert Wiener, the famous originator of cybernetics, believes that machines can and do transcend some of the limitations of their makers, and can be capable of originality. (101)

Dr. Marvin Minsky (Lincoln Laboratories, M.I.T.) says, "I believe . . . that we are on the threshold of an era that will be strongly influenced, and quite possibly dominated, by intelligent problem-solving machines." (74)

The list of optimists could be extended indefinitely. Looking for pessimists, there seem to be very few among experts actually working in the field. A semi-skeptic is Dr. Mortimer Taube, who has devoted a whole hook (114) to scolding those scientists who (a) are "over-optimistic" regarding rapidity of progress, (b) exaggerate the closeness of analogy between brain and computer, and (c) assume a materialistic, mechanistic universe and a lack of fundamental distinction between man and machine. Perhaps his nagging injects a healthy note of caution, especially with respect to time tables. But (b) and (c) need not worry us; we may not care very much what methods the machines employ, or whether they have "really" any awareness. Dr. Taube does not place any limits on the objective capabilities of the machines.

Looking now at some actual accomplishments to date, we note that Dr. Arthur Samuel (I.B.M. scientist) is reported to have designed a checker-playing machine which regularly beats him at checkers. (101) Already we see a machine which in one narrow way transcends the intellectual powers of its maker. It is true, as we are so often reminded, that this machine can only do what its program tells it to do, and that the programmer could do the same thing himself (more slowly) if he wished. But while its moves are predictable in principle, in practice they are unexpected.

Dr. S. Corn has discussed some of the ways to endow a machine with learning ability. (34) And it is well known that machines can be programmed to learn very easily, if elegance is no object. For example, a machine with a large enough memory could be easily programmed to learn chess. It would start out playing poorly, but would not repeat mistakes, so its game would

slowly improve. If it played enough games against the best players, it would eventually surpass all of them. (In fact, it could even learn by playing against itself.) Many ways are being studied to improve economy, elegance, or subtlety.

Dr. Herbert A. Simon and Dr. Allen Newell (Carnegie Institute of Technology and The Rand Corporation) have described other recent computer achievements:

"[There is a program that can] discover proofs for mathematical theorems-not to verify proofs, it should be noted, for a simple algorithm [procedure] could be devised for that, but to perform the 'creative' and 'intuitive' activities of a scientist seeking the proof of a theorem.

"At least one computer now designs small standard electric motors (from customer specifications to the final design) for a manufacturing concern.

"The ILLIAC, at the University of Illinois, composes music and I am told by a competent judge that the resulting product is aesthetically interesting." (106)

Let us now turn to evidence that machines can exhibit life-like behavior, including reproduction, "purposive" activity, and homeostasis (maintenance of internal conditions within permissible limits, in spite of changes in the outer environment).

The latter two are exemplified, in a crude and elementary way, by the "mechanical tortoises" of Grey Walter. (125) These are little electrical-mechanical devices which propel themselves on wheels, and wander around, in a manner suggestive of "curiosity," until their batteries get low; then they seek an electrical outlet and plug themselves in for a recharge. In seeking the outlet, one will look for ways around obstacles, and will probe and try in unpredictable ways until it either succeeds or "dies." This is not a bad imitation of one of the main features of life, say on the level of microorganisms.

Professor Kemeny has discussed a "reproducing" or self-duplicating machine proposed by von Neumann. This is a device which is extremely simple compared to any biological organism, with a "body" of about 32,000

simple parts and a "tail" of about 150,000 simple information units, analogous to the units of heredity in a living plant or animal. The tail serves as a blueprint describing the machine. In a suitable environment, the machine can make a copy of itself by reading the blueprint in the tail; after making a daughter machine, it also copies the tail and attaches the new tail to the daughter, which is then in business for itself. (Sex plays no part, and the daughter is exactly like the mother, except for possible "mutations" by accidental interference or malfunction.) (54)

British geneticist L. S. Penrose has also described self-reproducing machines. (89) He has designed mechanical models to have many analogies to chemical and biological properties of living things. The machines possess only a few parts, analogous to molecules in living matter. A mechanical scheme governs logic and programming, controlling correct assembling of parts. The scheme uses only hooks and latches, depending on gravity for their action. Parts are arranged at random on a flat surface, which vibrates to provide the necessary energy, producing motions analogous to the thermal agitation of molecules in nature. Each part has different states or conditions, with different potential energies. If a complete machine (called a "seed") is present, it causes the parts to rearrange themselves into copies of the first machine; if the seed is absent, there is no "spontaneous generation." In some models, a seed can contain indefinitely long chains of information-storing units, which can be likened to the chains of molecules in the chromosomes of living organisms. Some models have actually been built and successfully operated. (54)

It is true that von Neumann's machines and Penrose's machines are at once too simple and too dependent on special environments to have more than theoretical interest, although this theoretical interest of course is extremely important. But Dr. Edward F. Moore (Bell Telephone Laboratories) thinks that in only ten to fifteen years, with an effort that might cost as much as a half billion dollars, economically useful self-reproducing machines might be made. These would be self-contained sea-going mining or harvesting machines, which would bring back minerals or processed ocean crops. While on the job, they would power themselves by sunlight or by the food and fuel they find, and they would also build others of their kind. When they had produced enough new machines and collected enough of a harvest, they

would swim dutifully home. They would be mechanical slaves which would enrich us not only by working, but also by breeding. (75)

For most uses, it will not be necessary for machines literally to reproduce themselves. They will, however, be required to design new and smarter machines, or to design improvements in themselves. And computers have already been used to assist in designing new computers. (101) The implications are obvious, and stupendous.

And now at last, having taken this long but interesting detour, we are ready to climb Mt. Olympus and appreciate the view.

The View from Olympus: How Rich Can We Get?

If we only assume progress continues more or less as it has done in this century, we shall grow richer rather rapidly. In 1958 the median U.S. income for a "consumer unit" (family or unattached individual) was $5,050. (66) Since about 1890 the yearly increase in productivity per capita has averaged around 2.3 per cent. (28) If we assume an average rate of increase of income of 2.5 per cent annually for the next 300 years, and if we assume no inflation or other disturbing influence (remembering that the statistics we used referred to real productivity and not flexible-dollar productivity) then in the year 2258 the median income will be over $8,000,000 a year! This is no fantasy, but a conservative projection; you will actually receive that much money every year, in terms of today's prices. The average woman then will have much more spending money than any movie star does today - and still more important, will have much more to spend it on.

(It may be objected that this picture is oversimplified, since, for example, it neglects the questions of relative land prices and of taxes. But unless there is a monopolistic landlord class, and unless the taxes are wasted, these considerations will make little difference.)

In any case, all this is merely preliminary. If we take a really long view, if we strip away all the nonessentials and disregard all the immediate

problems, the production of wealth depends simply on the availability of matter, energy, and organization.

The kind of matter doesn't matter: with the right techniques and enough energy, any kind of atom can be transmuted to any other kind, in principle if not yet in practice; and the right kinds of molecules and higher complexes can be produced or reproduced. From our seat on Olympus, these are mere details.

Matter, of course, is in practically inexhaustible supply in the earth, the planets and satellites, and, if need he, the sun and even other star systems.

Energy will also be available virtually without limit. Nuclear fission energy is becoming cheaper, and John E. Ullman of Columbia University has predicted that by 1968 it will become as cheap as energy from conventional sources, and rapidly thereafter much cheaper. (122) It is well known that all our foreseeable needs for many centuries could be met (at prices not yet competitive) either from the sunshine reaching the earth's surface or from fission of low concentration uranium in granite. When the fusion problem (controlled thermonuclear reaction) is solved, there will be another nearly boundless supply of fuel in the deuterium of seawater. There is also the possibility, if a combination of circumstances should make it useful as a stop-gap, of setting up solar power stations on Mercury, where there is no atmosphere, a permanent day side, and a radiation intensity more than six times that on earth.

Our trump card, finally, is that unlimited organizing capacity is also in sight, in the shape of intelligent, self-propagating machines. Such a machine need only show a small profit: that is, it must be able to reproduce itself from scratch and also do some directly useful work before it wears out. This is enough to ensure, on the compound-interest principle, that starting with only one machine we can in sufficient time have as many machines and as much wealth as we please. One expects, of course, that in practice the profit margin will be ample and the machines can produce any desired amount of wealth with little time lag.

In a simplified, representational sense, then, one may picture the Golden Age society in which every citizen owns a tremendous, intelligent machine which will scoop up earth, or air, or water, and spew forth whatever is

desired in any required amounts - whether caviar, gold bricks, hernia operations, psychiatric advice, impressionist paintings, space ships, or pastel mink toilet rolls. It will keep itself in repair, and in fact continuously improve itself, and will build others like itself whenever required by an increase in the owner's family.

It is clear that in the long run, as long as the machines reproduce themselves faster than the people, there can be no economic problem - unless we run short of space. Let us next size up the ogre of "population explosion."

The View from Olympus: How Fast Can We Spawn?

First of all, we must recognize that population problems and all the attendant difficulties will inevitably arise, with or without a freezer program. The freezers may exacerbate these problems, but will not create them. With or without freezers, there will soon be increased longevity. With or without freezers, there will eventually be an indefinite life span. Since solutions must be found anyhow, we may as well make them good enough so that our own generation and those immediately succeeding can share the Golden Age.

In fact, the population problem already exists, without freezers and even without extended longevity, simply as a result of natural increase. In many parts of the world it constitutes a serious economic and political problem right now.

In the United States the population increased from 132 million in 1940 to 151 million in 1959 and 179 million in 1960, with an estimated total of 375 million in the year 2,000, based on moderate assumptions. (8) But the Malthusian doctrine of population always outrunning food supply has here long been proven false: the record shows that our birth rate is responsive to economic conditions and the general outlook. (8) Similar remarks apply to Europe.

The prospect in other parts of the world might seem grimmer. China had about 654 million people in 1960, and if present trends continue will have

894 million in 1975. (8) But the government of China, despite its greed for cannon fodder, seems to have realized the folly of unrestrained growth and is promoting birth control, according to many reports. And the Japanese, once extremely fecund, have exercised their admirable intelligence and cut their birth rate to about that of the United States. (8)

In India, the population has grown from 361 million in 1951 to 461 million in 1963 an increase of 100 million in twelve years! But the government sponsored birth control program is reported to be making headway, with the birth rate in Bombay down from forty per year per thousand to twenty-seven, and with the beginnings of success in the countryside. (19)

There is some evidence that Roman Catholic opposition to birth control will recede. A prominent Catholic gynecologist, Dr. John Rock, has received wide publicity for his views favoring birth control. In 1963 he is reported as saying, "The Catholic Church is in no way an obstructive agent to what is good for humans. The church does not sidestep responsibility . . . Not all of the church is done up in red petticoats and Roman collars. A large part is the lay church, which does not intend to be misled in obstructing its own welfare." Of those lay members, he said that 95 per cent of those who have expressed an opinion on his birth control plan have given their approval. (92)

All in all, there is good reason to believe that population will not run far beyond desirable limits, although some countries, especially in Africa and Latin America, may lag in progress. Human stupidity is formidable but not invincible.

It should also be noted that the freezer program itself will help speed the adoption of a reasonable birth control program, and perhaps of a general eugenic program. The long view will tend to make everybody more foresighted and aware of responsibility in all areas, including this one.

Granted that population can be controlled and that the actual course of events will be the sensible course, what is the freezer population likely to be when the Penultimate Trump is sounded?

One might guess that everyone would be satisfied with two children at about age thirty. Having fewer might tend to annihilate the family; having them

earlier might build the frozen population too rapidly. Increasing the average child-bearing age to thirty would reduce the population for a while, but it would then stabilize.

If we consider the whole world, with a base population of, say, four billion, then the frozen population would increase by four billion every thirty years. If it takes 300 years for civilization to reach the immortality level, there would then be some forty billion people to revive and relocate - if we assume, for simplicity, that it all happens at once. The figure of 300 years is more or less picked out of a hat, of course, since we have no clear idea either of the extent of the problem or of our rate of progress; but the outlook with respect to thinking machines is so encouraging, and the rate of progress will be so steeply exponential once thinking machines exist, that it is difficult to suppose that any problem we are now capable of posing could take much longer.

There is ample room on our planet for forty billion people. Most of the land surface is thinly populated, with vast areas of the antarctic, the arctic, the jungles of South America and Africa, and the deserts of Australia, Asia, Africa, and the United States virtually empty, waiting to be made habitable and productive.

Agricultural and industrial techniques already known or in early prospect can probably handle a population of fifty billion, according to Professor Richard L. Meier of the University of Chicago. (67) Hence conditions at the opening of the era of immortality, based on our assumptions, would not be too bad, even without unforeseen breakthroughs - but what about the long ages following?

Retaining our seat on Olympus and assuming all problems of dissension will be solved and a reasonable course navigated, there seems very little cause for concern. First of all, if no other solution were in sight for a certain period of history, the people could simply agree to share the available space in shifts, going into suspended animation from time to time to make room for others.

But the main point is that we can regard the available space as unlimited, remembering that we will sooner or later have unlimited wealth. For example, we could honeycomb the earth to a great depth, multiplying the

usable surface. We could colonize other planets and satellites of the solar system, if appropriate at a certain stage in history. Beyond that, when our machines become numerous enough and big enough and small enough, we can simply use the mass of other planets, and even mass from the sun, actually to create thousands of new planets just like earth! Nobody would have to live underground.

Beyond that still, if we choose to breed fast enough and long enough to make it necessary, we can go to the stars. Strange and even wild as these possibilities may seem, they are nothing more than simple consequences of the concept of unlimited productive capacity, which in turn is a simple consequence of the concept of self-propagating, intelligent machines.

In the long run, then, neither costs nor population pressure need worry us. But now it is time to come down off Olympus and consider some of the very real and possibly dangerous intermediate problems.

The Cost of Commercial Freezers

One might expect a freezer program to multiply mortuary costs by a sizable factor. However, let us investigate this question a little.

In Detroit, in 1962, according to several leading morticians, funeral costs ranged from about $200 to about $6,000, with an average of perhaps $800. In 1961 the California Funeral Directors Association "suggested" a minimum of $450, and funerals over $1,000 were common. (120)

In Detroit in 1963 a single cemetery plot seemed to cost $80 at least, including perpetual care. (The funds are invested, the interest supplying the maintenance costs.)

In rough figures, then, the total cost of death at present is typically in the neighborhood of $1,000. Now let us try to guess the cost of freezing in the near future, when commercial facilities become available.

The preparation of the body may correspond roughly to a major operation by a team of surgeons using expensive cryogenic equipment, and can therefore perhaps be expected to cost several hundred dollars at least. This might be reduced if mortuary technicians can be trained to replace surgeons.

Even more difficult to assess is the cost of the 'Dormantory' and its maintenance. But there are some suggestive known costs.

In Detroit, in 1963, a mausoleum crypt could reportedly be had for $1,250. The mausoleum itself cost about $3,000,000 to build and holds 6,500 bodies.

Can we make a first crude estimate of the cost of a Dormantory by regarding it as a refrigerated mausoleum? Perhaps we can, at least as regards first cost and not maintenance. In fact, since the freezer need not be as fancy nor as spacious as a mausoleum, and need not provide for routine access once it is filled up, possibly its initial cost will be no greater than that of the mausoleum, especially if the refrigeration scheme is the very simple one now to be considered.

To fix a rough upper limit on the cost of maintaining the refrigerating equipment, let us think of the simplest scheme possible; besides being the simplest, it will probably be the cheapest to install and the most expensive to maintain.

This involves merely surrounding the storage space with liquid helium and insulating layers, and replacing the liquid helium as it evaporates.

Now, liquid helium in a 4,000 liter spherical container 2 meters in diameter, shielded by liquid nitrogen, evaporates at about 0.2 percent per day. (103) If we consider a cubical storage space 30 meters on an edge, this will hold 18,000 bodies at 1.5 cubic meters per body. If we assume the evaporation rate is about proportional to the area of the exposed surface, as it ought to be, then the liquid helium evaporating per day would be roughly 3,400 liters.

Liquid helium was quoted in Detroit in 1962 at $7 per liter in 100-litre lots. If we use this figure, the evaporation loss cost comes to about $1.32 per day per body, or roughly $480 per body per year. Actually, the price for large amounts will surely be lower. Helium is available in large quantities, occurring as 1 per cent to 8 per cent of natural gas at various wells. (103) On

the other hand, we have ignored the cost of replenishing the liquid nitrogen shield; but liquid nitrogen is quoted at only 50 cents per liter in 100 liter lots, and its latent heat of vaporization per dollar's worth is much larger than that of helium, and sufficient insulation could make the heat leak very small, minimizing this cost.

In fact, with very thick insulation, the liquid nitrogen shield could be dispensed with altogether, and the evaporation rate of the helium still reduced, no doubt. In any case, the cost of cooling and recycling the helium will surely be much lower than the cost of simply replacing it, especially after large-scale study and investment. Also, the allotment of 1.5 cubic meters per body may be much too liberal; this is more than 51 cubic feet. All in all, perhaps it is not unreasonable to guess at a figure of $200 per body per year for maintenance as a first approximation.

To produce $200 a year would require capital of $6,667 invested at 3 per cent. (There are always plenty of good bonds for sale which yield this much.) Then adding together the $1,250 storage space cost, the $6,667 capital investment for refrigerating cost, and a few hundred dollars for preparation of the body yields a rough total of $88,500 per body. This is the tentative cost of a private freezer program on a group basis.

It is also interesting to note, for whatever it may be worth, that a 6 cubic foot frozen food locker, holding 150 pounds of meat at a temperature Below 0 F, and of course providing routine access, rents for $10 to $15 per year. (52)

Needless to say, countless refinements and improved safety factors could increase the cost. For example, it might be possible to construct a fully automatic unit with no moving parts, if the Peltier effect can be brought to engineering feasibility. (If an electric current is passed through a circuit containing two different metals, one of the junctions may be cooled and the other warmed; this is the opposite of the thermocouple phenomenon.) Thermoelectric cooling is already receiving considerable attention. (130) The source of power could be thermoelectric as well. Such a sophisticated installation would demand heavy investment, but maintenance might be virtually nil, except for taxes and occasional inspection.

On the other hand, any of many possible developments might reduce the total cost, and tax subsidy might reduce the direct cost.

The Cost of Emergency Storage

If a mutual aid society wanted to store a frozen member in the absence of commercial facilities of any kind, in the immediate future, what might the expenses be?

Presumably a building would have to be obtained, and caretakers hired, and so on; but what is of interest here is the refrigerating expense.

A rough estimate might be made as follows. Let us assume a container with average dimensions (that is, neither inside nor outside, but in the middle of the insulation) of 7 feet by 3 feet by 3 feet. Let it be metal, with cork board insulation six inches thick. The inside might be divided into a lower compartment, for the body, and an upper compartment, for the refrigerant.

If dry ice is used, other figures entering into the calculation are as follows. The latent heat of vaporization is 246 BTU per pound, the temperature of the dry ice is -109 F, the conductivity of cork board is 0.22 BTU in. per hour per square foot per degree Fahrenheit. (52) The cost of the dry ice is probably less than 6 cents a pound.

If room temperature is taken as 70F, then combining these figures in a simplified calculation gives a refrigeration cost of roughly $4 a day for replacement of dry ice. But this figure can be bettered in many ways.

Even if the crudest methods are used, as sketched above, there will be certain factors working in our favor which are hard to calculate theoretically. For example, the average room temperature will be well below 70F, because it will be unheated in winter, and will be cooled by the carbon dioxide vapor. This effect will be accentuated if there are a number of bodies, in which case there would also be a greater effective average insulation thickness. Further, if the storage room is in a basement, the earth below and around may provide additional insulation. Also, the previous calculation ignored the heat absorbing power of the carbon dioxide as it warms up, after sublimating, from - 109 F to whatever temperature it reaches before escaping, although this consideration partly overlaps that of room temperature.

If several feet of additional insulation were used, and especially if there were several bodies, it seems to me the cost could easily be reduced by a factor of ten, making it 40 cents per body per day. (The added insulation might be straw or glass wool, the latter being preferable both from the standpoint of insulating quality and of fire hazard. Glass wool is about as good an insulator as cork board.) If there were a sizable number of bodies, and if a specially designed or modified building were used, and if still more insulation were added, the cost might even be brought down to 10 cents daily per body, without the project becoming too unwieldy. We would expect, of course, that in a very few years more economical commercial installations would be come available.

If liquid nitrogen were used, the replacement cost might be over twenty-five times as great. Handling would also be more difficult; but it is not necessary to use gas-tight or pressure-tight containers, except in transport; in fact, an evaporation vent must be provided, as for dry ice.

Trust Funds and Security

Before submitting to freezing, people will make strenuous attempts to safeguard their dormant bodies, and to ensure firm positions in society on revival. It may be expected, for example, that elaborate trust funds will be set up.

Those who try to "take it with them" will want reliable supervision of the freezers, and will hope, through the magic of compound interest, to awaken wealthy. Yet at first thought one is apt to doubt that everybody can awaken rich, because this is somehow "against nature," or would represent "something for nothing." We also realize that future governments could confiscate any property and outlaw any trust arrangements at will.

While the considerations involved are very complex, both economically and psychologically, and predictions can be only half educated guesses, still there are some pertinent remarks to be made.

Interest rates depend, of course, on two broad factors, one physical and the other psychological. The first concerns the productivity of a dollar, that is, the rate of production of wealth by a dollar's worth of capital goods. The second relates the supply and demand situation. The physical productivity factor, of course, one expects to increase continuously, but the psychological factor almost defies analysis, let alone prediction. If this is correct, one can do little except to take experience as a rough guide, without trying to estimate the effect on the money market of the supply represented by the trust funds.

Let us ignore taxes, and assume we can hedge against inflation by always having part of the money in equity investments. Then, if the return on conservative investments is something like 3 per cent yearly during the freezer era, $1,000 untouched would grow to roughly $19,000 in 100 years, $370,000 in 200 years, or $7,000,000 in 300 years. This money is real; it represents initially the diversion of buying power from consumer goods to capital goods, followed by continuous reinvestment. If such wealth seems awesomely huge, we must remember that the productivity par capita of the nation is now increasing by almost 2.5 per cent yearly, and the rate of increase will probably improve greatly. The annual Gross Product per capita in the year 2264 of what is now the United States, even if the rate of growth does not improve, will be about $4,500,000! In 1960 it was only about $2,800. (49)

I see no reason to expect future generations to be jealous of the bank accounts and financial influence of the frozen. Those breathing will get later starts in saving, but will be able to save from much larger incomes, and would not have to be second class citizens financially, even without discriminatory or confiscatory laws aimed at the frozen.

The people in the freezers should also be protected by family loyalties, and by a tradition which recognizes that each in his turn (until the generation that achieves immortality) must become frozen and helpless, dependent on the good will and law-abiding character of his successors.

It must also be remembered that before long the option of suspended animation will be available. Some individuals will choose cold sleep before they become senile, and will therefore be able to arrange for periodic awakenings to look the situation over and check up on Junior.

It is not easy to anticipate the legal and sociological consequences of these visits by great-grandpa. Some of us might feel a little queasy at the notion, so to speak, of a zombie climbing the cellar steps every few years, with the frost in his beard, to cast a fishy eye on the family and perhaps vote his shares at the election of directors of an important corporation. But one grows accustomed to everything, and it rather seems the net result could be a beneficial tradition of permanence of the family and institutions, a strengthened feeling of the unity of mankind, an ingrained sense of our endless responsibility for each other.

World Relations

Very little has been said so far about the prospect of immortality as seen from elsewhere than the United States, Europe, and similar regions. How will it affect the internal and external policies of the retarded nations? Of the communists? At this juncture perhaps little can be said of what will actually develop, if something can be said about what could happen and ought happen.

The first reaction on the part of leaders of backward or totalitarian states might be unfavorable, since a freezer program could put heavy extra demands on already inadequate resources and could weaken discipline by substituting materialistic goals for the quasi-religious ideals of the self-styled revolutionaries. To help clarify the problem, a few remarks about the nature the "emerging" nations and the "communist" nations may be in order, representing common knowledge which is not always made explicit.

Economically, they most often stand for a kind of socialist state capitalism, and in this respect differ little from some Western countries. Politically, they usually represent bureaucracy enthroned, or, to use an older word meaning almost the same thing, oligarchy, and in this respect also represent nothing new in the world, and differ little from many established and rightist countries. Even their usual totalitarian character, the enshrining of the state high above the individual, shows no radical departure either from earlier history or from various established states of the political right. The driving

force, in the case of the undeveloped countries, is largely just racist or nationalist patriotism or chauvinism, distilled into a foggy ideal. In the case of the Reds there is an additional unifying mystic element based on the Word of the Prophets, Marx and Lenin. From the standpoint of the leaders, the goal may be personal and national aggrandizement, and the "ideologies" may be only tools to pry obedience and self-sacrifice out of the people.

Words have an amusing way of becoming twisted in usage, and while it is commonplace to regard ourselves as idealists and the Reds as materialists, in fact the reverse is nearer the truth. We are mature enough to be materialistic in the sense of wanting freedom and wealth for ourselves, and not just for some dim posterity, and in the sense that we try to remember the state is only an instrument of the people, only a means to an end. The Reds, on the other hand, are childish idealists to the extent that they are willing to sacrifice themselves for slogans and embrace a kind of mysticism in imbuing their state and ideology with intrinsic worth and permanent meaning. It is we who are generally godless and not the Reds: we may acknowledge the ascendancy of Jehovah, but seldom consult Him in practical affairs, whereas they pay a more sincere homage to their god-in-overalls, through his prophets, Marx and Lenin, looking to them for day-to-day guidance. Soviet workers are so pious that they have sacrificed their right to strike on the altar of Marxism-Leninism.

Serious dangers therefore arise. Many leaders of the eastern and southern countries may feel a freezer program would threaten the very foundations of their regimes. The people themselves, who often take pride in the term "revolutionary" but in fact may notably lack intellectual flexibility and adaptability, may find it difficult to switch gears and reorient themselves. A fury of bafflement, resentment, and jealousy may even exacerbate international tensions at first. But there are hopeful factors as well.

The communists, and even their leaders, are after all not demons, but people like ourselves, struggling to live in, and make sense out of, a very difficult and mysterious universe. Desperation makes fanatics, but hope - on a practical, personal level - may be the key to cooperation.

The nationalist and leftist leaders may buzz angrily about for a while, like hornets in a bottle, but they should quiet down as they come gradually to realize two things. First, they will want immortality for themselves and their

families. Second, all problems take on a completely different perspective in the long view. When the future expands, the past shrinks; historical affronts lose their sting, and vendettas their fascination. The words of the song then make self-evident good sense, that is, to eliminate the negative and accentuate the positive.

Many compromises and makeshifts may be necessary to stretch the rupees, pesos, etc. For a time the strictest economies in freezing may have to be practiced in many countries. Perhaps bodies will be stored in pits insulated with straw and cooled with dry ice. It is even possible that after freezing with dry ice they will be shipped to Siberia for natural cold storage, if it is decided that the changes at these temperatures are limited, or that the cost of maintaining artificially low temperatures here is sufficiently less to warrant the cost of transportation. From the standpoint of civil order, it will not at first greatly matter how skillfully the bodies are preserved, so long as hope is preserved. Demands will increase with time and learning, but so, one hopes, will resources and cooperation. In particular, this jolt may abruptly shift the birth control program into high gear. One may even dare hope that before too long the poorer countries will prefer cryobiological aid to military aid. There are perils in plenty, but there is also much room for optimism.

CHAPTER VIII

The Problem of Identity

In considering the chances of reviving, curing, rejuvenating, and improving a frozen man, we have to envisage the possibility of some very extensive repairs and alteration. This leads to a number of very perplexing puzzles.

As an extreme case, imagine an elderly cancer victim who is not frozen until several hours after death, and then only by crude methods. Almost all the cells of his body have suffered severe damage and are thoroughly dead by present criteria, although some would grow in culture and we assume a small percentage of them have degenerated relatively little. But after enough centuries pass medical art at last is ready to deal with him, and for the sake of emphasis let us assume a grotesque mixture of techniques is used.

When our resuscitee emerges from the hospital he may be a crazy quilt of patchwork. His internal organs - heart, lungs, liver, kidneys, stomach, and all the rest - may be grafts, implanted after being grown in the laboratory from someone else's donor cells. His arms and legs may be bloodless artifacts of fabric, metal and plastic, directed by his own will and complete with sense of touch but extended and flexed by tiny motors. His brain cells may be mostly new, regenerated from the few which could be saved, and some of his memories and personality traits may have had to be imprinted on or into the new cells by microtechniques of chemistry and physics, after being ascertained from the written records.

Striding eagerly into the new world, he feels like a new man. Is he?

Who is this resuscitee? For that matter, who am I and who are you?

Although most resuscitees will not represent such extreme cases - we hope most of us will be frozen by non-damaging methods - nevertheless we cannot sidestep the issue. We are now face to face with one of the principal unsolved problems of philosophy and/or biology, which now becomes one

of prime importance in an exceedingly practical way, namely that concerning the nature of "self."

What characterizes an individual? What is the soul, or essence, or ego? This seemingly abstruse question will shortly be seen to have ramifications in almost every area of practical affairs; it will be the subject of countless newspaper editorials and Congressional investigations, and will reach the Supreme Court of the United States.

We can bring the problem into better focus by putting it in the form of two questions. First, how can we distinguish one man from another? Second, how can we distinguish life from death?

Later I shall offer some tentative partial answers. First we can illuminate the question, and perceive some of its difficulties and subtleties, by considering a series of experiments. Some of these experiments are imaginary, but perhaps not impossible in principle, while others have actually been performed.

Experiment 1. We allow a man to grow older

Legally, he retains his identity; and also subjectively, and also in the minds of his acquaintances (usually). Yet most of the material of his body is replaced and changed; his memories change, and some are lost; his outlook and personality change.

It is even possible that an old acquaintance, seeing him again after many years, might refuse to believe he is the same person. On first considering this experiment, we are apt to feel slightly disturbed, but to retain a vague conviction that "basically" the man is unchanged. We may feel that the physical and psychological continuity has some bearing on the question.

Experiment 2. We watch a sudden, drastic change in a man's personality and physique, brought about by physical damage, or disease, or emotional shock, or some combination of these. Such has often occurred.

Afterwards, there may be little resemblance to the previous man, mentally or physically. There may be "total" amnesia, although he may recover capability of speech.

Of course he retains, e.g., the same fingerprints, and the same genes. But it would be absurd to say the main part of a man is his skin; and identical twins have the same genes, yet are separate individuals.

Although the physical material of his body is the same stuff, he seems - and feels - like a different person. Now we are more seriously disturbed, because the main continuity is merely physical; there is a fairly sharp discontinuity in personality. One might say with some plausibility that a man was destroyed, and another man was created, inheriting the tissues of his predecessor's body.

Experiment 3. We observe an extreme case of "split personality."

It is commonly believed that sometimes two (or even more) disparate personalities seem to occupy the same body, sometimes one exercising control and sometimes the other. Partly separate sets of memories may be involved. The two "persons" in the same body may dislike each other; they may be able to communicate only by writing notes when dominant, for the other to read when his turn comes.

We may be inclined to dismiss this phenomenon by talking about psychosis or pathology. This tendency is reinforced by the fact that apparently one of the personalities is usually eventually submerged, or the two are integrated, leaving us with the impression that "really" there was only one person all along. Nevertheless, the personalities may for a time seem completely distinct by behavioral tests, and subjectively the difference is obviously real. This may leave us with a disturbing impression that possibly the essence of individuality lies after all in the personality, in the pattern of the brain's activity, and in its memory.

Experiment 4. Applying biochemical or microsurgical techniques to a newly fertilized human ovum, we force it to divide and separate, thereby producing identical twins where the undisturbed cell would have developed as a single individual. (Similar experiments have been performed, with animals.)

An ordinary individual should probably be said to originate at the moment of conception. At any rate, there does not seem to be any other suitable time - certainly not the time of birth, because a Caesarean operation would have produced a living individual as well; and choice of any other stage of development of the fetus would be quite arbitrary.

Our brief, coarse, physical interference has resulted in two lives, two individuals, where before there was one. In a sense, we have created one life. Or perhaps we have destroyed one life, and created two, since neither individual is quite the same as the original one would have been.

Although it does not by any means constitute proof, the fact that a mere, crude, mechanical or chemical manipulation can "create a soul" suggests that such portentous terms as "soul" and "individuality" may represent nothing more than clumsy attempts to abstract from, or even inject into, a system certain "qualities" which have only a limited relation to physical reality.

Experiment 5. By super-surgical techniques (which may not be far in the future) we lift the brains from the skulls of two men, and interchange them.

This experiment might seem trivial to some. Most of us, after thinking it over, will agree it is the brain which is important, and not the arms, nor the legs, nor even the face. If Joe puts on a mask resembling Jim, he is still Joe; and even if the "mask" is of living flesh and extends to the whole body, our conclusion will probably be the same. The assemblage of Joe's brain in Jim's body will probably be identified as Joe. But at least two factors make this experiment non-trivial.

First, if the experiment were actually performed and not merely discussed, the emotional impact on the parties concerned would be powerful. The wives would be severely shaken, as would the subjects. Furthermore, Joe-in-Jim's-body would rapidly change, since personality depends heavily on environment, and the body is an important part of the brain's environment. Also, we may be willing to admit that Joe's arms, legs, face, and intestines are not essential attributes of Joe - but what about his testicles? If Joe-in-Jim's-body lies with one of their wives, he can only beget Jim's child, since he is using Jim's gonads. The psychiatric and legal problems involved here are formidable indeed.

Some people might be tempted to give up on Joe and Jim altogether, and start afresh with Harry and Henry. In one sense, this is an impractical evasion, since the memories, family rights and property rights cannot be dismissed. From another view, it may be a sensible admission that characterization of an individual is to some extent arbitrary.

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Once again, the suggestion is that physical systems (i.e., real systems) must in the end be described by physical parameters (operationally) and that attempts to pin profound or abstract labels on them, or to categorize them in subjective terms, cannot be completely successful.

Experiment 6. By super-surgical techniques (not yet available) we divide a man's brain in two, separating the left and right halves, and transplant one half into another skull (whose owner has been evicted).

Similar, but less drastic, experiments have been performed. Working with split-brain monkeys, Dr. C. B. Trevarthen has reported that " . . . the surgically separated brain halves may learn side by side at the normal rate, as if they were quite independent." (121) This is most intriguing, even though the brains were not split all the way down to the brain stem, and even though monkeys are not men.

There is also other evidence in the literature which we can summarize, with certain simplifications and exaggerations, as follows. Either half of a brain can take over an individual's functions independently. Normally, one half dominates, and loss of the other half is not too serious. But even if the dominant half is removed, or killed, the other half will take over, learning the needed skills.

There is presently no conclusive evidence that so drastic an experiment as ours would necessarily succeed; but in principle, as far as I know, it might, and we are not at the moment concerned with technical difficulties.

If it did succeed, we would have created a new individual. If the left half was dominant, we might label the original individual LR; the same skull containing the left half alone after surgery we might call L, and the right half alone, in a different skull after the operation, is R. L thinks of himself as being the same as LR. R may also think of himself as LR, recuperated after a sickness, but to the outside world he may seem to be a new and different, although similar, person.

In any case, R is now an individual in his own right, and regards his life to be as precious as anyone else's. He will cling to life with the usual tenacity, and if he sees death approaching will probably not be consoled by the knowledge that L lives on.

Even more interesting is the attitude of L, the formerly dominant half, now alone in the skull. Suppose that, before the operation, we had told LR that the dominant half of his brain was diseased, and would have to be removed, but that the other half would take over, albeit with some personality changes and possibly some loss of memory. He would be worried and disturbed, certainly -- but he would probably not regard this as a death sentence. In other words, LR would be consoled well enough by the assurance that R would live on. Yet after the splitting, and transplanting operation, L would regard his own destruction as death, and it would not satisfy him that R lived on, in another body.

This experiment seems to suggest again that, psychologically if not logically, the physical continuity is an important consideration.

Experiment 7. A man is resuscitated after a short period of clinical death, with some loss of memory and some change in personality.

This experiment has actually been performed many times. (97) Death was real by the usual clinical tests (no respiration, no heartbeat) but of course most of the cells remained alive, and most people would say that he had not "really" died, and that he was certainly the same person afterward. This experiment is important only as background for the following ones.

Experiment 8. A man dies, and lies unattended for a couple of days, passing through biological death and cellular death. But now a marvel occurs; a space ship arrives from a planet of the star Arcturus, carrying a super-surgeon of an elder race, who applies his arts and cures the man of death and decay, as well as his lesser ailments.

(It is not, of course, suggested that any such elder race exists; the experiment is purely hypothetical, but as far as we know today it is not impossible in principle.)

The implications are apt to shake us. If decay is to be regarded as just another disease, with a possibility of cure, then when may the body be considered truly dead? If "truly" dead be taken to mean "permanently" dead, then we may never know when we are in the presence of death, since the criterion is not what has already happened to the man, but what is going to happen to him in the (endless?) future.

Experiment 9. A man dies, and decays, and his components are scattered. But after a long time a super-being somehow collects his atoms and reassembles them, and the man is recreated.

Once more, the difficulty or even impossibility of the experiment is not important. We also disregard the question of the possibility of identifying individual elementary particles. Is it the "same" man, in spite of the sharp physical discontinuity in time? If memory, personality, and physical substance are all the same, perhaps most of us would think so, even though we are disturbed by the black gulf of death intervening. But if we so admit, we must open the door even wider.

Experiment 10. We repeat the previous experiment, but with a less faithful reproduction, involving perhaps only some of the original atoms and only a moderately good copy. Is it still the same man?

Again, perhaps, we wonder if there is really any such thing as an individual in any clear-cut and fundamental sense.

Experiment 11. We repeat experiment 10, making a moderately good reconstruction of a man, but this time without trying to use salvaged material.

Now, according to the generally accepted interpretation of quantum theory, there is in principle as well as in practice no way to "tag" individual particles, e.g. the atoms or molecules of a man's brain; equivalent particles are completely indistinguishable, and in general it does not even make sense to ask whether the atoms of the reconstructed body are the "same" atoms that were in the original body. Those unfamiliar with the theory, who find this notion hard to stomach, may consult any of the standard texts.

If we accept this view, then a test of individuality becomes still more difficult, because the criteria of identity of material substance and continuity of material substance become difficult or impossible to apply.

Experiment 12. We discover how to grow or to construct functional replicas of the parts of the brain - possibly biological in nature, possibly mechanical, but at any rate distinguishable from natural units by special tests, although not distinguishable in function. The units might be cells, or they might be larger or smaller components. Now we operate on our subject from time to time, in each operation substituting some artificial brain parts for the natural ones. The subject notices no change in himself, yet when the experiment is finally over, we have in effect a "robot"!

Does the "robot" have the same identity as the original man?

Experiment 13. We perform the same experiment as 12, but more quickly.

In a single, long operation, we keep replacing natural brain components with artificial ones (and the rest of the body likewise) until all the original bodily material is in the garbage disposal, and a "robot" lies on the operating table, an artificial man whose memories and personality closely duplicate those of the original.

Perhaps some would feel the "robot" was indeed the man, basing the identity in the continuity, on the fact that there was never a sharp dividing line in time where one could say man ended and robot began. Others, well steeped in democracy and willing to apply political principles to biology, might think the robot was not the man, and ceased to be the man when half the material was artificial.

The subject himself, before the operation, would probably regard it as a death sentence. And yet this seems odd, since there is so little real difference between experiments 13 and 12; 13 merely speeds things up. Perhaps sufficient persuasion could convince the subject that the operation did not represent death; he might even be made to prefer a single operation to the nuisance of a series of operations.

Experiment 14. We assume, as in the previous two experiments, that we can make synthetic body and brain components. We also assume that somehow

we can make sufficiently accurate nondestructive analyses of individuals. We proceed to analyze a subject, and then build a replica or twin of him, complete with memories.

Does the identity of our subject now belong equally to the "robot" twin? It might seem absurd to say so, but compare the previous experiment. There is scarcely any difference, especially since in experiment 13 the subject was under anesthesia during the operation; experiment 13 was virtually equivalent to destroying the subject, then building a robot twin. The only real difference between experiments 13 and 14 is that in experiment 14 both the original and the duplicate survive.

Experiments 15, 16, and 17. We repeat experiments 12, 13, and 14 respectively, but instead of using artificial parts we use ordinary biological material, perhaps obtained by culturing the subject's own cells and conditioning the resultant units appropriately. Does this make any difference?

In logic, one would think perhaps not, but blood is thicker than water. Some people might make a different decision on 15 and 16 than on 12 and 13.

Experiment 18. We assume the truth of an assertion sometimes heard, viz., that in certain types of surgery a patient under certain types of anesthesia suffers pain, although he does not awaken and afterwards does not remember the pain. The experiment consists in performing such an operation.

Most of us do not fear such operations, because we remember no pain in previous experiences, and because authoritative persons assure us we need not worry. Even a warning that the pain under anesthesia is real is unlikely to disturb us much, if we are not of very nervous temperament. Still less do we fear ordinary deep anesthesia, in which there seems to be no pain on any level, even though for the conscious mind this gulf is like that of death. Yet a child, or a person of morbid imagination, might be intensely frightened by these prospects.

Thus again we note a possible discrepancy between the logical and the psychological.

Experiment 19. A Moslem warrior is persuaded to give his life joyfully in a "holy war," convinced that the moment his throat is cut he will awaken in Paradise to be entertained by houris.

We draw the obvious but useful conclusion that, from the standpoint of present serenity, it is merely the prospect of immortality that is important.

Experiment 20. We pull out all the stops, and assume we can make a synthetic chemical electronic mechanical brain which can, among other things, duplicate all the functions of a particular human brain, and possesses the same personality and memory as the human brain. We also assume that there is complete but controlled interconnection between the human brain and the machine brain: that is, we can, at will, remove any segments or functions of the human brain from the joint circuit and replace them by machine components, or vice versa.

In a schematic sense, then, we envisage each of the two brains, the biological one and the mechanical one, as an electronic circuit spread out on a huge "bread board" with complete accessibility. From the two sets of components, by plugging in suitable leads, we can patch together a single functioning unit, the bypassed elements simply lying dormant.

To make the picture simpler and more dramatic, let us also assume the connections require only something like radio communication, and not a physically cumbersome coupling.

We might begin the experiment with the man fully conscious and independent, and the machine brain disconnected and fully dormant. But now we gradually begin disconnecting nerve cells or larger units in the man's brain, simultaneously switching in the corresponding units of the machine. The subject notices no change - yet when the process is completed, we "really" have a machine brain controlling a "zombie" human body!

The machine also has its own sensory organs and effectors. If we now cut off the man's sensory nerves and motor leads and simultaneously activate those of the machine, the first subjective change will occur, namely, an eerie transportation of the senses from one body to another, from the man's to the machine's. This might be enjoyable: perhaps the machine's sense organs are more versatile than the man's, with vision in the infra-red and other

improvements, and the common personality might feel wonderful and even prefer to "live" in the machine.

At this stage, remember, the man is entirely dormant, brain and body, and the outside observer may be inclined to think he is looking at an unconscious man and a conscious machine, the machine suffering from the curious delusion that it is a man controlling a machine.

Next, we reactivate the components of the man's brain, either gradually or suddenly, simultaneously cutting off those of the machine, but leaving the machine's sensors plugged in and the sensors of the human body disconnected. The subject notices no change, but we now have a human brain using mechanical senses, by remote control. (We disregard such details as the ability of the human optical center to cope with infra-red vision, and the duplication of the new memories.)

Finally, we switch the human effectors and sensors back in, leaving the man once more in his natural state and the machine quiescent.

If we perform this sort of exchange many times, the subject may become accustomed to it, and may even prefer to "inhabit" the machine. He may even view with equanimity the prospect of remaining permanently "in" the machine and having his original body destroyed. This may not prove anything, but it suggests once more that individuality is an illusion.

Discussion and Conclusion. In discussing these hypothetical experiments we have touched on various possible criteria of individuality - identity of material substance, continuity of material substance, identity of personality and memory, continuity of personality and memory - and seen that none of these is wholly satisfactory. At any rate, none of these, nor any combination, is both necessary and sufficient to prove identity.

One cannot absolutely rule out the possibility that we have missed the nub of the matter, which may lie in some so far intangible essence or soul. However, such a notion seems inconsistent with the ease with which man can instigate, modify, and perhaps actually create life, and with several of our experiments.

The simplest conclusion is that there is really no such thing as individuality in any profound sense. The difficulty arises from our efforts first to abstract generalities from the physical world, and then to regard the abstractions, rather than the world, as the basic reality. A rough analogy will help drive home the point:

The classification "man" is useful, but not sharply definable. Is a freak a man? Is an aborted fetus a man? Is a pre-Neanderthal or other "missing link" a man? Is a corpse a man if some of the cells are still alive? And so on. A label is handy, but objects may be tagged arbitrarily. In the physical world there is no definite collection of objects which can be called "men," but only shifting assemblages of atoms organized in various ways, some of which we may choose to lump together for convenience. Let us then cut the Gordian knot by recognizing that identity, like morality, is man-made and relative, rather than natural and absolute. Identity, like beauty, is partly in the eye of the beholder. It is only partly existent, and partly invented. Instead of having identity, we have degrees of identity, measured by some criteria suitable to the purpose.

The result is wonderful: we have lost our souls, but gained heaven, in a certain sense. Perhaps few of us, even if intellectually convinced that identity is an illusion and death therefore unimportant, may be able to translate this into emotional acceptance, or will want to. But we can now persuade ourselves that death need never be regarded as absolutely final - since it is always possible, at some distance in space, time, and matter, for reasonably close duplication or resuscitation to occur - that is, for physical reincarnation, with memory or without. This possibility can dull the edge of desperation for those unable to obtain first-class freezer accommodations for themselves or their families.

CHAPTER IX

The Uses of Immortality

When people blithely assert that they "wouldn't want to live forever," it usually means only that they have not really thought about it.

The disclaimers fall perhaps into two main categories. The first concerns alleged moral considerations. "When I'm called, I'm ready to go . . . We have to step aside for our children. We shouldn't impose ourselves on posterity . . . Trying to hang on beyond our natural span is undignified and cowardly . . . Birth, growth, and death form a natural and necessary cycle. . . Fear of death is a sign of immaturity."

As far as "imposing ourselves on posterity" is concerned, some remarks have already been made, and a good deal more will be said in the last chapter. At this point it may be well just to insert a reminder that the freezer program should make everybody less desperate and the world more stable; it may even swing the balance in preventing a nuclear war. If this is true, then without the freezer program there may be no posterity. In that case, our descendants need it as much as we do.

When someone continues to insist that he would not want unlimited life, he is often wearing a mask which can be lifted by putting the question just a little differently. Let us ask first: "In case of a severe infection, would you refuse penicillin to stave off the 'natural' conclusion of death?" He can hardly claim he would. We ask next: "If a serum were to appear on the market, guaranteed to add twenty vigorous years to your life, would you refuse it?" He is not likely to say he would, nor would he refuse a perfected immortality serum.

And now we see his true face: he wants immortality, all right, but he wants it on a silver platter. It is not life he objects to, but effort and risk. Far from being stoic, or resigned, or well-adjusted, or complacent, or mature, or

philosophic, or self effacing, or altruistic, or any of the other dignified things he pretends to be, he is merely myopic and nervous.

A slightly different way to unmask such a person is simply ask him what span of life he would pick, if he could make his own choice merely by wishing. Would he pick exactly his "natural" span, neither more nor less? Would he willingly accommodate himself to whatever accident or ailment would do him in, in the ordinary course of events, seeking neither to shorten nor prolong his life? Merely to ask these questions reveals the absurdity of affirmative answers.

The notion that superior personalities accept death more readily has also been denied, for example, by Dr. C. Knight Aldrich, chairman of the department of psychiatry at the University of Chicago. He writes:

"However, my experience, both clinical and extra-clinical, suggests that it is particularly difficult for the strong, well-integrated personality to accept with equanimity the idea of his own death.

"Strength of personality may help a patient not so much to void depression in anticipation of death as to conceal depression in others. On the other hand, many patients who seem to accept death with real equanimity have depressions that antedate their fatal illnesses or they have lost interest in living as a result of pain or disability. Their apparent realistic courage indicates that they have given up life and are welcoming death. Death can be faced more readily if there is little to lose by leaving life than if there is a great deal to lose." (1)

A few of my friends have expressed fear that the cowards will embrace the freezer program most eagerly, while the brave and the dignified may spurn it. This notion seems to be negated, not only by the theoretical considerations already put forward, but also by observation. Among the many who have talked and written to me, it is by and large the weak and timid who hang back - is it not the nature of the weak and timid to hang back? - while the strong and hold spirits usually seize the concept with delight. Only those embrace death who are half dead already. The ones who surrender are those who are already in retreat.

You, Better than New

Disclaimers in the second category question whether extended life is worthwhile, even to the individual. "I've had a full life. I'm already bored and couldn't endure a second life. I wouldn't like a futuristic world. . . . There would be nothing to do . . . I wouldn't fit in." Etc.

The main difficulty is that few people have the remotest conception of what the future will he like; they think of it dimly as mid-twentieth century, plus maybe sliding sidewalks, family helicopters, and a twenty-hour work week. They fail to understand that the differences will be qualitative as well as quantitative.

In particular, they completely fail to grasp that people will be different, including themselves. Mental qualities, including both intellectual power and personality or character, will be profoundly altered, not only in our descendants but in ourselves, in you and me, the resuscitees.

That genetic science will enable us, sooner or later, to mould our children as we please seems almost taken for granted by the experts and by all laymen with a spark of imagination. We might for example quote Dr. Philip Siekevitz:

"For I think we are approaching the greatest event in human history, even in the history of life on this earth, and that is the deliberate changing by man of many of the biological processes. ... Already we can very easily produce mutants in bacterial strains; we will soon be able to control these changes; and it is not such a big jump from bacteria to plant, to animals, or to man himself . . . we will be able to plan ahead so that our children will be what we would like them to be - physically and even mentally." (105)

Some of us may suspect that from uncontrolled mutations in bacteria to controlled mutations in man really is a pretty big jump, and it may take quite a while. But time, fortunately, is what we have plenty of. Sooner or later, these achievements will be realized. Professor Hermann J. Muller, Nobel Prize winner in genetics, has said: "I am convinced that he [man] will

remake himself [genetically] . . . we may attain to modes of thought and living that today would seem inconceivably god-like." (76)

Such breath-taking predictions are readily accepted by many intelligent laymen - but only as interesting speculations of no direct concern. These notions take on entirely different colors when we realize that we, personally, may be there to witness these titanic events - and that we will have to deal with these supermen.

What will they be like, these genetically planned and engineered descendants of ours?

On the physical side, they will be strong, handsome, and healthy, but beyond this it is impossible yet to say. They may look almost exactly like people today, or they may not; certainly the current human design leaves plenty of room for improvement.

For example, Professor Muller has pointed out the absurdity a multi-purpose mouth. "[An alien] would find it most remarkable that we had an organ combining the requirements of breathing, ingesting, tasting, chewing, biting, and on occasion fighting, helping to thread needles, yelling, whistling, lecturing, and grimacing. He might well have separate organs for all these purposes, located in diverse parts of his body, and would consider as awkward and primitive our imperfect separation of these functions." (78)

While Dr. Muller may have stretched it a little -- not all of us want to separate our yelling from our lecturing, and a special organ to thread needles will find few buyers even in a ladies' sewing circle-the point is surely well taken. Imagine the incalculable benefit in teen-age happiness alone, if one could eat, chew gum, and talk on the telephone, all at the same time - without the danger of strangling!

But the great changes will be those in intellect and personality. And if our descendants are all super-duper whiz kids, even if they are kind and good, how can we compete? How can we live? The problem is real, but there are solutions.

One solution, of course, is to refuse to breed supermen. Such issues will be hotly debated in all the parliaments of earth, with unpredictable results. But probably the issue will fade, for several reasons.

In the first place, we will not necessarily be resuscitated the moment it becomes technically feasible, unless we insist. If it should happen that at this time genetic improvement is far advanced but individuals cannot yet be much improved, then resuscitation may be delayed, conceivably.

Second, even if for a time we have to live with superior descendants, a modus vivendi may be found. There will be means for reducing envy on the one hand and arrogance on the other, and for enabling the individual to enjoy what he has; more will be said about this shortly. It is also important to remember that no disadvantage need be permanent; we can no doubt summon considerable patience when we know that we only have to wait a while, and science will improve us further.

Third, we shall probably be supermen ourselves shortly after resuscitation. Somatic improvement may stay abreast of, or get ahead of, genetic improvement. Designing a new model will not necessarily be easier than overhauling the old. It should become possible to perform extensive improvement in living individuals by various biological techniques, for example, using regeneration together with somatic mutation, microsurgery, and psychosurgery.

Besides biological changes, there is also vast potential in the use of prostheses, mental as well as physical - for example, by coupling a human mind to an electronic computer. Some different suggestions, but in the same general direction, have been made by Dr. R. M. Page, Director of Research, U. S. Naval Research Laboratory, Washington; he envisages ultra-rapid communication between man and machine by a sort of electronic mind-reading, and thinks it might be achieved in fifty years. (85) Thus all the resources of a huge computer may some day be in the direct service of a man's mind; it might even be said to be part of his mind, when hooked in on either a temporary or permanent basis. The man-machine combination may well be far superior to any purely biological superman, in which case we shall be immediately equal to our descendants.

The best advice for success in life has always been to choose your parents wisely; and now, in effect, this will become possible. Collectively, if not individually, we can expect to design ourselves, selecting the desired traits and abilities. Of course, the alarmists will protest that there may be unforeseen consequences, and such presumption is dangerous. And we must agree; that it is. But we can only choose between dangers, and not escape them. Doing nothing also constitutes a choice, and often a poor one. (Stock market players often forget that every day they hold a stock they have, in effect, except for overhead, made a new decision to buy that stock in preference to all others.)

Living has always been dangerous; and now, for the first time, dying will be dangerous too. But most of us will prefer the danger of our activities after resuscitation to the safety of no activity at all.

Just what our activities may be in the world of the future is not easy to picture. At least for a considerable period, there will still be economically productive work in the form of scientific investigation, administration, education, and many kinds of artistic endeavor. There will be many activities involving human relations which, although perhaps not economically productive, will give that "needed" and "useful" feeling; for example, taking an interest in your children's or parents' troubles, or participating in politics. Certain simple pleasures are likely to wear quite well - things like exercising the muscles and glands, playing with the children or great-grandchildren, enjoying the lakes and forests.

This may seem rather thin at first. For instance, how many people can be painters, or writers, or composers, or sculptors? The answer is, maybe everybody! Nobody will be stupid - not by today's standards, and probably not by tomorrow's, since there is likely to be more homogeneity. There will simply be more artists and smaller average audiences. I'll buy your painting, and you'll buy my music; and each will enjoy doing his own work, and each will appreciate the other's.

If this still sounds unconvincing, we can help make our point with a well-known and venerable story. A communist was exhorting an audience of laborers: "Comes the Revolution, you'll eat strawberries and cream." One worker objected, "But I don't like strawberries and cream." The agitator glared at him. "Comes the Revolution, you'll like strawberries and cream!"

The skeptics must be continually reminded that not only will the world be changed, but themselves also both their ability to perform and their capacity to appreciate and enjoy. There are already many forerunners of these developments.

There is now considerable use - sometimes excessive use - of tranquilizers on the one hand and "psychic energizers" on the other. Mood is known to be related to hormone and enzyme balance. Depression and anxiety can often be relieved by such drugs as epinephrine and adrenochrome, and many other drugs are known to affect personality. Furthermore, many common mental disorders may be at least partly chemical in nature; e.g., schizophrenia seems to be related to the production of a substance called taraxein. (43)

Some of the future potentialities have been indicated by Dr. A. Hoffer and Dr. R. Humphrey Osmond, Canadian psychiatric researchers: "Psychopharmacology may help us learn how to think clearly however distracting personal and other calls may be, without however preventing us from indulging, when we need it, in the boldest imaginings. Such capacities developed in an increasing number of our species would be as effective as a beneficial mutation and we think, far more easily achieved." (43)

Elsewhere, in discussing experiments with "psychedelic" or "mind-manifesting" drugs, Dr. Hoffer writes: "Thought becomes creative, one's horizons are widened, and the world and its problems are seen with a fresh eye . . . Over half of our patients who achieve a psychedelic experience are subsequently much better people. For example, out of more than half of a series of sixty alcoholics treated in this way over one-half are now sober and good citizens and certainly much happier than they were before. Volunteers who have experienced this type of reaction find to their surprise and pleasure that they are more mature, more tolerant, and have a broader outlook on life." (42)

Some progress has been made in tracing motivation, as well as sensation, to local centers in the brain, according to Dr. James Olds, physiologist at U.C.L.A. It appears that rats can be made to gratify the drives of hunger, thirst, digestion, excretion, and sex by self-stimulation of their brains with electricity. (The rats were allowed to manipulate controls which turned on the current, the electrodes being inserted in suitable regions in the brain; the technique is called ESB, for Electronic Stimulation of the Brain.) The report

says that "Some of the animals have been seen to stimulate themselves for twenty-four hours without rest and as often as 5,000 times an hour." (84)

This is in some ways an obscene experiment, with sinister overtones. (The same may be said of many biological experiments.) But it underscores the possibility of finding "happiness" partly by working on oneself, rather than by working on the environment.

Professor Rostand has also emphasized the possibilities in improving individuals. ". . . intelligence . . . also character can be affected by chemical dosing . . . The future may bring the use of medicines that would favor social behavior, kindness and devotion . . . the possibility cannot be excluded that there may come into being a psychosurgery whose aim would be to raise the individual above himself . . ." (95)

I would go further than the cautious optimism of these scientists and say that, given enough time, these dazzling developments and many others have a high degree of probability.

But even if one grants all this, there remain the questions of long-range goals, of fundamental values and motivations, of the nature of happiness. If we dare face immortality, must we not also face the profoundest problems of man and the universe?

The Purpose of Life

It is possible we shall never be able to find "ultimate" values or "ultimate" goals. It is also possible that there are built-in conflicts or paradoxes in the human mind on the deepest level, so that in the end tragedy cannot be avoided. Not every problem has a solution.

At present, however, such speculations seem all but futile. We are too raw even to frame proper questions, let alone understand the answers. The very structure of our brains may need improvement before we can apprehend the secrets of the cosmos.

Eventually, most "philosophical" problems may turn out to be biological. Dr. Jonas Salk has written, "If we can study CNS [central nervous system] phenomena according to those biological principles that have been shown to be applicable to other systems, a basis for reconsidering behaviour in biologically meaningful terms may emerge, which then by empirical means may expand further our understanding of the CNS of man and all that flows therefrom: behavior, creative activity, motivation, values, responsibility, and the intangible qualities of personality reflected in reactions, choices, aptitudes, and attitudes." (96)

When a humane, progressive, cooperative society has been achieved, the purpose of life will be learning and growth - the disclosure and then the attainment of ever more advanced intermediate goals, until either the final goal (if any) is revealed, or some catastrophe overtakes us.

During this grand unfolding, "happiness" in private and peripheral affairs will no doubt rest on a compromise between internal and external satisfactions. Few of us would want the contentment of a narcotic stupor, or an ESB jag, on a permanent basis. Likewise, ignorance may be bliss, but who would want the "happiness" of a cow - or even of a bull? Yet, judiciously used, chemistry and surgery can exert a beneficial stabilizing influence. On the external side, there will be an ever-widening range of activities, including some we have not yet thought about.

To some, this may appear remote and gray. Actually, the canvas of the future shows blinding color and riotous excitement. Remember, once again, you and I will not be the same, but enlarged and enriched, equipped fully to appreciate these words of Thomas Huxley: "If there is anything I thank the Gods for (I am not sure there is, for as the old woman said when reminded of the goodness of Providence - 'Ah but he takes it out of me in the corns') it is a wide diversity of tastes. . . No one who has lived in the world as long as you and I have can entertain the pious delusion that it is engineered upon principles of benevolence. . . But for all that, the Cosmos remains always beautiful and profoundly interesting in every corner - and if I had as many lives as a cat I would leave no corner unexplored." (45)

CHAPTER X

Manners, Modes, and Morals of Tomorrow

Almost every commodity, however desirable or necessary, if it is not an immediate necessity, needs to be "sold," whether it is life insurance, food, medicine, or anything else. If respiration were not reflex, many people would have to be given a hard sell to draw a breath of air. Immortality itself will have to be "sold" to enough people to start the freezer programs.

Will tomorrow really be better? Is it worth the struggle? If we agree that it will become possible to mould personality, then logically this alone should assure an affirmative answer; we can all be made into jolly, as well as jolly good, fellows. Still, we would like some assurance that the external changes will be worthwhile also.

In the previous chapter we talked about the uses of immortality in the most general terms, and of course detailed prediction on a long-term basis is entirely out of the question. However, it will be amusing to spell out a few of the shorter-range possibilities, and it may help make the prospect seem more real and personal. There will be no attempt here to be systematic, let alone exhaustive.

Before beginning this sketchy catalogue, it might be well to give just a hint of the more distant future - not by indicating anything that will be in it, for this is hopeless, but by specifying something that will not.

Beyond Beowulf

A favorite bromide of writers is that "human nature doesn't change." But the manifestations of human nature vary rather widely with cultural differences,

as we know, e.g., from studies of identical twins reared separately; and soon there will be changes in its biological basis as well, with results beyond guessing.

It is true that we still read Beowulf, and the Iliad, and Hamlet, and many scholars blithely assume that these and similar works will remain in our culture forever. But in the last thirty or forty thousand years, the supposed tenure of modern man on earth, cultural changes have been relatively small, and biological changes virtually nil. In the next few centuries, the changes will be incomparably greater.

I am convinced that in a few hundred years the words of Shakespeare, for example, will interest us no more than the grunting of swine in a wallow. (Shakespearean scholars, along with censors, snuff grinders, and wig makers, will have to find new, perhaps unimaginable occupations.) Not only will his work be far too weak in intellect, and written in too vague and puny a language, but the problems which concerned him will be, in the main, no more than historical curiosities. Neither greed, nor lust, nor ambition will in that society have any recognizable similarity to the qualities we know. With the virtually unlimited resources of that era, all ordinary wants will be readily satisfied, either by supplying them or by removing them in the mind of the individual. Furthermore, if civilization will have survived that long amid the titanic forces available, it would seem that satisfactory modes of living and mutual accommodation must have been worked out. Competitive drives, in the inter-personal sense, may or may not persist; but if they do, it will be in radically modified form.

It is impossible to say whether most of us will be resuscitated before or after man has worked really drastic changes in himself. My own guess is that most of us now living will be frozen by non-damaging methods, and the reversal of aging will be easier than a complete redesigning and rebuilding of the brain and body, and we can therefore expect to awaken while people are still more or less human. Let us then cast a few glances into the middle distance, and try to perceive some of the facets of life in this period.

Stability and the Golden Rule

As already suggested, the prospect of immortality should provide a strong damper on rash and impetuous action and anti-social behavior. National leaders will want to preserve their own skins, and will be forced to take a much longer view. A temporary advantage will become unimportant. Everyone's life will depend on the steady functioning of the freezers, and hence on the reliability of economic and administrative institutions. No one will be excessively greedy, in the knowledge that soon he will be stiff and cold and at the mercy of his successors, whose good will he dare not endanger.

In the era of the freezers, and still more markedly when immortality has actually been realized, there will be very salutary effects on interpersonal behavior. Our actions will be strongly influenced by the realization that not only ourselves, but the other fellow also, will be around a long time. The people we meet in business life and in casual encounters of every kind can no longer be counted upon to fade away and disappear; instead, our paths may cross repeatedly in a long future dimly seen. All business becomes "repeat" business; there are no more one-shots.

The Golden Rule then becomes not an ideal but a necessity, and there may well occur a Golden Age of morality and ethics, with every man counting every other his friend and neighbor.

(Some wiseacre is sure to ask what happens when a masochist tries to apply the Golden Rule. But it is not claimed either that the Rule is always crystal clear, or, even if it were, that the disposition to apply it would automatically liquidate dissension, but only that the Rule is on the whole a good one, and its general application would be a large step in the right direction.)

Possibilities of Stagnation and Decadence

Speculating about the ways of immortals, some writers have worried about decadence engendered by the excessive caution and timidity of those who are potentially immortal but vulnerable to accident. It has been conjectured that society would be emasculated, that new ventures would cease, that every citizen might eschew risks of all kinds - even refusing so much as to use vehicles for fear of an eventual accident.

This kind of development seems to me highly unlikely. In the second place, medical art will necessarily be so far advanced that few kinds of accident could result in permanent death. In the first place, creative drives and competitive pressures will persist in some form, and can be depended upon to keep the yeast fermenting nicely. As always, those who refuse risks and challenges will probably sooner or later be trampled into the ground - perhaps in a humane and genteel way, but firmly. As the lyricist says, "It's not the earth the meek inherit, but the dirt."

Even exceptionally dangerous jobs are not likely to go begging. A worthy cause, high pay, and glory will find at least a few takers for a long time to come.

More serious and sinister is the threat of decadence through strange and sophisticated new forms of seduction. We already have large numbers of "TV bums" with bent spines, bloated bellies, and stupefied minds from endless hours of slouching, snacking, and staring. Will an ordinary man be able to withstand the temptation to sit in a corner all day and tickle himself with ESB? What will happen when the circuits of the brain are well understood, and hallucinations of the most convincing reality can be made to order, so that a man can rent a tape, put on his Dreamie helmet, and experience the part of the hero in a romantic adventure?

No neat and easy answer seems possible here. In China there actually are derelict souls who spend all their time in opium dens, if they can manage it. But this kind of activity would seem to be more or less self-limiting, since

no one can retire from the world altogether without having someone else to look after him and his affairs.

An Eye for an Eye

It has been speculated that in a Golden Age criminals will be "cured" rather than punished. This notion seems to me faulty, or at least dubious, in three respects.

First, we cannot yet say for sure that every criminal is actually sick. He may be a healthy man who has decided (perhaps rightly!) that his interests and those of society do not coincide.

Second, even if antisocial behavior invariably resulted from a specific, curable disease, it would still be necessary to impose punishment for its deterrent effect. It is true that in medieval England petty crime flourished in spite of cruel punishments, and that crimes of impulse and passion are difficult to deter, and that many criminals are repeaters; but without deterrence the situation would be much worse, and the proposition remains generally valid.

Third, the general psychological atmosphere, and the feelings of the victims of wrongdoing, may for a long time demand traditional ideas of "justice," including its aspect of revenge.

It will become possible, in some sense and under some kind of interpretation, at last to make the punishment fit the crime. Culprits may be made to suffer all that their victims have suffered, and to make complete restitution. Would-be adventurers, exploiters, tyrants, and rogues will be curbed by fear of society's revenge: they will have much more to fear than death. There will be no more attitude of "might as well be hanged for a sheep as a lamb." If a tyrant causes a thousand people to be half starved for a year, he might be punished by being half starved himself for a thousand years - perhaps with a couple of centuries off for good behavior, or such other modification as would not weaken the deterrent principle.

Sex Morals and Family Life

It was indicated in Chapter VII that birth control will almost certainly sooner or later become de rigeur, at least for a certain period in history, and that this would happen even without freezers and immortality, simply because of the problem of natural increase. The availability and general practice of birth control by methods less clumsy than those now in general use - e.g., pills for either man or woman - and the much smaller average size of families and much smaller fraction of children in the population, will have many effects in many areas of life. But another development, seldom yet discussed, will have even larger effects.

Research proceeds apace on techniques of "ectogenesis," or the raising of "test tube" babies in artificial wombs instead of allowing normal gestation in the body of the mother. It is also foreseen that it will be possible to produce a child with only one parent, which could be either a man or a woman. (119) Such a parthenogenetic child, since it would have the same genetic make-up as its parent, would in a sense be a twin as well as offspring.

Ordinarily, one presumes, a child will have two parents. Few of us are so vain as to desire our children to be duplicates of ourselves. But ectogenesis will certainly become the rule: when it becomes available, what woman will prefer the ordeal of "carrying" and delivering a child?

At present, of course, many women will not admit the ordeal is disgusting, and may even insist it is "beautiful." But this is obviously just a psychological trick, making a virtue of necessity. One might just as well claim our methods of waste elimination are beautiful.

There will, of course, be a transition period and a rear-guard of opposition to this practice. Its opponents will be the same kind of people as those who howled against the use of anesthesia in childbirth when this was first introduced, claiming it was "unnatural," and that it was "intended" for women to suffer as punishment for their sins, and that mother love would be reduced if the pain of childbirth were removed.

Fathers love their children as much as mothers, without carrying or delivering them, and there will be no loss in this respect when ectogenesis becomes the rule. But there will be profound social changes.

Essentially, motherhood will be abolished. A child will usually not have a father and a mother, but instead will have two "fathers," one male and one female. The word "mother" may or may not persist, but its essence - gestation and delivery - will be gone. (Nursing is already a nearly abandoned custom in many communities.)

The differences between men and women will then be at a minimum. Most of the present differences are cultural, and the difference in physical size is of little importance; there is more difference in size between certain races of man than there is between men and women of the same race. Women will obtain genuine equality in almost all spheres.

In sex relations, women may become universally the aggressors. After all, they are not as definitely limited in capacity as are men; and when women need no longer fear pregnancy, the traditional roles of "taker" and "giver" may be reversed.

On the other hand, full equality may be restored by the discovery of ways to give men unlimited virility.

These developments need not be regarded as especially alarming. Sex is only a part of life, and not the most important part. Its problems form only a part of the enormous package of problems we must wrap up.

The relaxed sexual habits that may develop do not seem likely to eliminate family life nor demolish the institution of marriage. It may become customary to experiment more or less promiscuously early in life, and marry at a later time than is usual now. But most people will still want children. Even in the absence of children, marriage serves an important purpose, as we know from the many successful childless marriages, and still more from the many successful marriages of divorced and widowed people whose children are grown and gone. Most people, sooner or later in life, want and need the stability, comfort, and security of a relationship which neither friends nor blood relatives can supply.

The Question of Non-human Intelligent Entities

Modes and standards of conduct and intercourse may have to be developed with respect to intelligent creatures other than human. The three outstanding possibilities seem to concern the dolphins, robots, and extraterrestrial life forms.

It has been ascertained that dolphins have brains larger and more complex than those of men. Some investigators believe the dolphins, despite their lack of hands and artifacts, may be truly intelligent, and can perhaps be taught to communicate. (60) If this is true, we may eventually have to share the planet with them, and perhaps with some of their cousins, the whales.

With respect to thinking machines, the problem is much thornier. To begin with, even though the philosophical notion of dualism has been singularly unproductive and the dualists in more or less steady retreat, nevertheless the mind-body problem remains unresolved. And even if we forget about dualism, it remains conceivable that a "machine" made of meat and gravy may have modes of existence not available to a machine of tubes and wires. That is, it is conceivable - although I think it farfetched - that regardless of their problem-solving, decision-making, and goal-seeking abilities, machines will never be worthy of the appellation "living." But if we can find an appropriate test for the first thinking machine, Adam MacElectrosap, and discover he really does have awareness and essential life, then we shall be faced with a tough moral problem in deciding whether to keep him enslaved. (MAChine, ELECTROnic, SAPient, of course.)

We may also face a tough practical problem in deciding whether it is safe to keep him at all, enslaved or not. The possibility, celebrated in many a gruesome story, that our creations may some day turn on us and overwhelm us, is a real one. Professor Wiener, for example, believes that machines may not inevitably remain subject to man. (101)

After all, intelligent machines will necessarily have some degree of independence, initiative, and unpredictability - this is inherent in their intelligence, and this is why they are of value. Can we hope to control such entities, which will be in many respects, and perhaps in most respects, be

superior to ourselves? The answer is not obvious. On the one hand, it is by no means unknown for the inferior intellect to dominate the superior. Greek scholars were held as slaves by Roman farmers. In certain environments, a tiger can kill a man. And it is perhaps conceivable that a mind could be massive and brilliant, yet mild and submissive. On the other hand, there must remain an element of doubt. One suspects that, sooner or later, the greater mind will have its way.

It is clear that no rules, no restraints, no restrictions can be relied upon; and of course it matters not at all that the machine has no direct physical powers or access to weapons. The machine, if it is to function, must be allowed to communicate, and if it can communicate it can probably persuade, and that is all that is necessary.

To realize just how bad the situation could be, we need only reflect that we may not even know where our interests lie! The machine will know what is best for us, and what is best for itself, and what courses of action are appropriate for these respective goals; but we may know none of these things, and be forced to rely on the machine!

The remedy, as hinted earlier, may lie in coupling a human brain to the machine, either permanently or occasionally. If the circuits can be integrated so that the machine is only an extension and enlargement of the man s mind, then the situation may be under control. This would also represent a new level of life for the man, an experience we can hardly imagine.

Finally, turning to the question of possible extraterrestrial life, we find a riddle of awesome proportions. Where is everybody? Since the known universe contains at least 100,000,000 galaxies, with each galaxy numbering from 100,000,000 to 100,000,000,000 or more stars, and since most of these are at least several billion years old, some scientists think life must have developed on a great many worlds, and that in fact intelligent life must exist right now on myriad alien worlds.

Yet it is not true that "science agrees" there must be intelligent life on many worlds; the consensus of science appears to be uncertainty. (57) There does seem to be fairly good evidence that many stars have planets, that many of these may be suitable for life as we know it, and that under suitable circumstances life will probably arise. But there seems to be a possibility

that most planets suitable for life have no land surface. More important, there seem to be no very securely based calculations to find the probability of intelligence developing from life, or civilization from intelligence. Therefore we must not be awed by the fact that the universe contains probably over 1,000,000,000,000,000,000,000 stars; the probability of civilization having developed in one of these systems could easily be much less than one in 1,000,000,000,000,000,000,000.

If civilizations are common, then civilizations in advance of ours should also be common - but in that case, why have there been no visitors? I know of no convincing explanation. The three most common suggestions are: (1) Time is too vast; all our neighbors are either far behind us or far ahead of us in development, and in either case cannot be expected to traffic with us; (2) Space is too vast, and because of the limiting velocity of light, and perhaps unknown dangers, interstellar travel is forever impractical; (3) "They" exist, and know about us, but just don't give a damn, or are watching but not interfering.

All three suggestions seem implausible in light of our own psychology and prospects. As we indicated in Chapter VII, the Golden Age will bring essentially unlimited wealth, with matter and energy freely available, and organization, in the form of thinking machines, also virtually unlimited. Then surely we will either scout the universe ourselves, or send out drone vehicles to investigate and report. If we find life, we will monitor it and take over its guidance and development, either out of charity or wariness. We will not allow fellow creatures to stumble on in misery, or develop into threats. The size of the universe means nothing: we have all the stars to tap for matter and energy, and our thinking machines can propagate themselves to any necessary number.

Certain dark suggestions have been made about the fate of man, and of those others who have failed to visit us. Perhaps civilizations that reach a high technological level always destroy themselves. Perhaps the fundamental problems of philosophy have no solution, and the final reward of progress is only the fullness of the realization that nothing matters; after the fruit ripens, the next stage may not be super-ripeness, but rot. But such pessimistic thoughts as these are premature, to say the least. For the present, let us

simply acknowledge that the mystery remains a mystery, and also that we may, in fact, be ourselves the universe's elder race.

In any case, we gaze at the night sky and see the stars like dust, and reflect: either we are all alone in this vast universe, or else somewhere out there are other thinking beings, whom we may one day meet. Either way, it gives one pause.

Some Near-term Developments

Even the richest men of earlier times lacked many of the things available to the ordinary American and European today. These include: fast communication, fast travel, relatively reliable justice, accessible information, reliable emergency services such as fire and police departments, efficient plumbing, weather forecasts, insurance policies, loans on reasonable terms, dentistry, air conditioning, out of season foods, eyeglasses, anesthesia, and many other kinds of medical services and medicines. Certainly happiness is not directly proportional to wealth, comfort, safety, and peace of mind, but there is nevertheless a correlation.

Likewise we today are virtual paupers, compared to what we will be as resuscitees. Many extremely important goods, services, and modes of living will be available that do not exist today; some of these have already been indicated.

In addition to the qualitatively new things, there will soon be much available which requires essentially no technological advances or breakthroughs whatever - which requires, in fact, nothing except more work, more production, more automation, more wealth, of a kind that already exists, and ordinary progress.

Cities may be weather-controlled, if necessary by covering the streets with retractable roofs; the air and the streets will be kept clean and sanitary. A half-inch of snow will not tie up traffic. Hay fever and other allergy victims will have relief.

Safety and law enforcement in cities may be greatly improved in several ways. Public places may be monitored by recorded television, to speed assistance and to preserve evidence. (For example, all vehicular traffic may be continuously filmed, unless the legislatures decide the infringement of privacy is an overriding consideration.) Homes and even individuals may carry small emergency signal units, which could summon ambulances, firemen, police, tow-trucks, freezer technicians, etc. This might be combined with wrist radios, in the manner of Dick Tracy.

Honesty in private and public employment may be promoted by the use of periodic routine lie detector tests, covering prescribed areas, to ensure that trust has not been violated, as a condition of employment. Nothing helps morality so much as removing temptation. Of course, the legislatures may decide that this is akin to forcing a man to testify against himself, and disallow it, especially since it might be required of the legislators as well.

Full-coverage liability insurance may be available and compulsory, so that everyone will be financially responsible, and collectible in case he commits any kind of wrong. Those whose records indicate they are poor risks will be insured by the state, but their activities may be restricted.

The Department of Health, Education and Welfare in the United States, and similar agencies elsewhere, may take increased responsibility for family life and training. At present, children are produced and raised usually by unskilled labor; little human beings are at the mercy of ignoramuses and brutes. The children will probably not, except in extreme cases, be taken from the parents, since it seems generally agreed that even a good orphan asylum is worse than even a rather bad family. But heavy pressure will be exerted to force parents to educate themselves and qualify themselves as parents, and the children will be protected through some kind of routine inspection.

Justice will be more uniform, more reliable, and cheaper. The absurd system of punishment typified by "thirty dollars or thirty days" will be discarded. Jail may be used only for people who are physically dangerous, or who may do irreparable damage, and not for those guilty of crimes strictly against property or of technical offenses such as violation of the anti-trust laws. Offenses in the latter category may be dealt with by fines linked to ability to pay, with credit given if necessary, and by supervised probation or

restriction of activities. The rules of evidence will be drastically revised and modernized to allow a more logical evaluation of probabilities. The "reasonable doubt" rule may be replaced by a formula based on percentage probabilities.

Our republic could be transformed into a democracy, or perhaps a weighted democracy, through electronics. Every home might have a voting machine attachment built into its TV set, capable of identifying citizens by their fingerprints or retinal patterns or whatnot, and able to record and transmit votes. With the awkward machinery of voting thus streamlined, it might become practical to submit every important issue to referendum. Conceivably, the machine might first test the voter, and allow him to vote only if he proves he understands the issue reasonably well. It is also possible, as previously hinted, that the one-man-one-vote rule may be modified, giving a man instead a variable number of votes, depending on such things as his knowledge and the degree to which the issue affects him. (Admittedly, such notions would raise complex problems - but so did the replacement of buggies by autos, and so do most advances. The problems must be met and solved, and not dodged.)

Transcontinental supersonic subways, with fares low relative to average income, will allow everyone holidays and vacations in the mountains, forest reserves, or on either shore. In town, similar systems will fractionate commuting time.

The dull and unpleasant jobs will either be eliminated by automation, or compensated by shorter hours or higher pay. It is even possible that before very long all citizens will be allowed a basic income just for breathing, although jobs would be available for the qualified and would provide additional income. Perhaps the one inescapable form of work, and the main duty of all citizens, will be participation in political processes.

Those who find the mid-twentieth century a little lacking may well take heart. We have hardly begun to live.

CHAPTER XI

The Freezer-Centered Society

Besides being definitely feasible, the freezer-centered society is highly desirable, and in any case nearly inevitable. This can be seen by illuminating more brightly, or from slightly different angles, a number of aspects introduced earlier.

Inevitability of a Freezer Program

It is easy to perceive that a large-scale freezer program must inexorably develop, sooner or later, whether or not my degree of optimism becomes general, and whether or not my personal efforts exert much influence.

We recall that suspended animation of humans (by freezing alive, without serious freezing damage, so that the subject can be thawed out and restored to active life at any time) is generally agreed to be in the cards. So far as I know, not a single expert doubts that this will come about, although there are wide differences of opinion as to when the technique will be mastered. Estimates vary' from about five years on up; my general impression is that a consensus might point to success within the lifetimes of a majority of people now living.

As soon as suspended animation is practicable, persons with incurable diseases will surely be frozen alive to await the time that cures are discovered. It can scarcely be doubted that this development, at the very least and latest, would provide the entering wedge for the freezer program.

It is also a common assumption of both laymen and experts that medical science will find means of extending human longevity, at least in moderate

degree. It is not likely to come in the form of a simple drug injection, although this remains conceivable and hints in this direction crop up from time to time. For example, a Royal Oak, Michigan, veterinarian, Dr. Henry Raskin, has been reported experimenting on dogs with a drug developed in Rumania, called GH-3; results in apparent revitalization of aged dogs are said to range from fair to spectacular. (17) More likely, the treatment will be complex and will only follow much longer study, but optimism is not lacking. Dr. Joseph W. Still, of George Washington University, has written: "Aging may prove to be no more fatal or inevitable than smallpox, polio, pneumonia, or tuberculosis." (111)

Now consider the outlook of an aged person in failing health, sometime late in this century, or maybe not so late. Suspended animation will be available; substantially increased longevity for those already old may not yet be at hand but research will be very promising; technology will be booming and wealth increasing by leaps and bounds. Obviously, there will be a great temptation to take the cold sleep for a few decades, or until a specified amount of progress has been made. On awakening, this man and his wife can anticipate at least some added decades of active life in a more advanced world; in addition, compound interest will put him in a better financial situation. Why not sleep a seeming moment, and wake to a longer, brighter day? Who would not trade a few declining years in the present for a larger number of more active and rewarding years in the future?

Many, perhaps, would not -- but certainly many would. Some will make this choice, and others will follow, and finally it will become customary if not universal. Whether it comes soon or whether it comes late, whether the aim is "immortality" or something more modest, a large-scale freezer program is certainly going to mount, a majestic and irresistible tide.

Whoever would play the misguided and pathetic role of Canute, let him then he warned: he can only suffer dampened dignity.

No Generation of Martyrs

Since there is going to be a freezer program anyway, and since the frozen will share the immortality of their descendants, the rationale of opposition, if there ever was any, evaporates. Both immortality itself and the preliminary freezer program will bring their weighty problems, or exacerbations of old problems, but these can only be solved and not prevented.

If by some stretch of the imagination a determined and concerted opposition to an early freezer program should cohere, its utmost effect could be to deny immortality to our own generation. A more monumental exercise in futility and sheer stupidity would be hard to conceive.

When an initially adverse reaction to the freezer idea is voiced, no matter what "reasons" may be given, it is usually based on nothing but pure funk. The idea unsettles people; it makes them nervous; it disturbs the established order; it raises questions and demands decisions. To many, especially those long beaten down by adversity, nothing is so precious as the "security" of a fixed routine and a known end; it is notorious that in the death camps of Nazi Germany many inmates refused any risk, preferring certain death to exertion.

Ostensible reasons for opposition often include various forms of asserted altruism. "We shouldn't burden later generations." "The future doesn't need us; I wouldn't want to live on unless I could do some good." "The money freezers would cost should be spent on cancer research or longevity research." "I'd rather a year were added to the life of a cancer victim than hundreds of years to my own." (The last two, of course, are non-sequiturs.)

Such self-styled altruists, who would martyr our generation, understand neither society nor themselves.

We may be largely the intellectual heirs of the Greeks, but our moral heritage is Judeo-Christian, and in this tradition no babes are exposed on hillsides nor thrown to the wolves, no grandfathers are abandoned to die on

the trail. We risk a division to rescue a battalion; we carry our wounded with us. We recognize duty downward as well as upward, from the state to the individual as well as conversely.

In fact, the worship of the State, or the Race, or Society, or Posterity, is merely a twisted and senseless sentimentality characteristic of totalitarian ideologies; it is nothing but fanaticism. In an important sense, there is no such thing as the state, no such thing as posterity: there are only individual people, and the living deserve as much consideration as the unborn. When someone who wouldn't give an extra hundred tax dollars to save a real, starving Indian claims he would sacrifice his life to make things easier for some hypothetical descendant, he is merely making an ass of himself.

In any case, of course, the direct remedy to the "burden" problem is easy: let us practice industry and thrift, so that the money for freezers is either extra money produced by extra work, or else savings diverted from fripperies. We can pay our own way, and need not be mendicants. Our estates and trust funds, through their investments and administrators, will contribute to future production and will share in control of the means of production. While we owe a moral debt to the future, the future will owe us not only a moral but a legal debt.

As to our "usefulness" in the future, it has already been pointed out that after resuscitation and rejuvenation we will be just as educable and adaptable as anyone else, young or old.

After maybe forty thousand years of struggling through the wilderness, the race has arrived at the banks of Jordan. Crossing will not be easy, nor will life in the Promised Land. But to pitch camp on the near shore for a generation would be a bootless waste.

It seems nearly certain that most of us will either see the point or will be initially in doubt. At first a few, and then mounting numbers will choose freezing, and before long only a few eccentrics will insist on their right to rot. Most people will not dare be left behind. There will be no generation of martyrs.

The Long View as Panacea

Well worth repetition, emphasis, and elaboration is the startling transformation in human relations which the freezer program will gradually work.

Not so long ago Sydney J. Harris, a syndicated columnist, remarked the effect on many people of the realization that we only live once. " 'I shall not pass this way again.' Then why does it matter what I do? Why not ruin the fields, deforest the woods, litter the roads, pollute the streams, trample the flowers, and treat people as a mere means to one's own ends?" (39)

Although Harris was making a different point, it is obvious that a man who expects to be around for centuries or millennia will tend to behave differently from one who anticipates scant decades. In the long view, the fields, woods, roads, streams and flowers are my own; I cannot waste resources because I myself will need them later. I cannot cheat or injure a stranger, I cannot disregard his rights and feelings, because there are no more strangers, but only neighbors whom I will have to look in the face, again and again.

It has been fashionable for some time to say that "complex problems do not have simple solutions"; this is a favorite excuse of lack-wit politicians. Nevertheless, the simple use of soap and water cuts a very wide swath across the complex problem of disease prevention, and the simple routine of formal courtesy does wonders in ameliorating complex problems of human relations. Likewise, I believe the freezer program will prove virtually a panacea, particularly in international relations - not because in itself it solves all problems, but because it provides time for the solution of problems.

With an unlimited future to redress the balance, everyone can put up with temporary burdens and inequities patiently, if not cheerfully, and negotiate in good will. We all have a long, long way to travel together. When tempted

to some rash action, one need only say to himself, "The end is not yet. The end is not yet. The end is not yet."

All measures of desperation, including nuclear war, will tend to be ruled out. The reckless are usually those with little to lose - and there will be no more such, everyone will have a jewel beyond price - a glittering physical hereafter on the other side of the freezer. Heaven help Mao Zedong if he tries to persuade his people to turn their backs on this treasure, wrap themselves in tattered red flags, and lie down in moldy graves.

Time to Go Sane

Human life has always been based largely on fanatic lies and self-deception, a consequence of the endless struggle to solve the unsolvable, reconcile the irreconcilable, and scrutinize the inscrutable. Most of us have always preferred make-believe to frustration. But now at last it will be safe to go sane - at least partly.

The loyalties of the past have been mainly to ideas - usually stupid ideas, like the divine-right monarchies of post-medieval Europe, and often revolting ideas, like the blood-sacrifice rituals of the Aztecs. But the loyalties of the future will be to people - not disembodied abstractions, but individual human beings - and in this direction lies sanity.

Of course, in a sense it is only possible to be loyal to one's own thoughts, and in a sense other people are only thoughts. It is also true that doublethink and compromise with honesty will retain some utility. Still, the shift in viewpoint will be very real and very significant.

We have usually thought of people as ephemeral, and ideas, especially "principles," as immortal. But now the people will persist while ideas come and go, and the results should be most salutary.

Consider again the arch-villain Mao Zedong. Would he dare risk a fabulous life of thousands of years (including personal wealth eventually exceeding

the total assets of the world today) for a moth-eaten bag of slogans and a shabby empire? Eternity, or some substantial portion of it, belongs not to Marxism-Leninism, nor to any other passing fancy in the mind of Mao, but to Mao himself and his relatives and friends -- including you and me. Once he understands this, he dare not risk war. If he cannot understand, those who do will remove him.

Fools, Madmen, and Heroes

Even after considerable thought, some people have to fight the feeling that to seek personal immortality is somehow ignoble, that the freezer-entered society is somehow distasteful and may rob us of our manliness. The reason is partly that bravery in the face of death has always been deemed a virtue, that abstract ideals are extolled above "selfish" ones, and that logic may seem to equate immortality with timidity. Even though the error of these notions has already been indicated, another remark or two will not be out of place.

Immortality is not an end in itself, nor do we reach for it in blind and breathless panic. It is an opportunity for growth and development otherwise impossible, and it is consistent with our highest current values.

The prospect of immortality will strongly color our lives, and in some ways dominate them, but it will by no means exclude other influences. We remain the products of our conditioning. I myself, for example, have been near death more than once, and would face it again without hesitation for any good reason, such as danger to my family or country.

We must ever bear in mind the gulf between the logical and the psychological. It has been noted that the long view will tend to rule out all measures of desperation; but some acts of madness or irresistible impulse will remain. On the other side, heroism will remain available not only because we are specifically trained for it, but because the subjective value of immortality, while large, cannot approach its face value. This is easily seen by remembering the behavior of Christians: in logic, nothing whatever is

worth an eternity of hellfire, yet through the quirks of psychology countless millions are willing to be damned for the sake of paltry temptations.

Further, pondering of the problem of identity may convince some that extinction is nothing to worry about.

Finally, the steady workings of the process of natural selection will assure a continuing supply of heroes. A society without a sufficient percentage of risk-takers would scarcely be viable, let alone competitive.

These considerations also tie in with the misguided proposals that the freezer program be used as a eugenic sieve.

The Fallacy of Just-Freeze-the-Elite

One sometimes hears the naive asseveration, "Maybe we ought to save Churchill, but why should we save Joe Schmoe?"

The answer is easy, and comes in four parts:

1. Joe, after the future medicos work him over (although not necessarily immediately after resuscitation), will be just about as high-type and just about as useful as Sir Winston. He will no longer be the prisoner of his genetic inheritance.

2. If we are thinking in terms of rewards, perhaps Joe deserves first consideration, since Winnie has already licked a bushel of lollipops. Joe needs to be compensated for the sorry hand he was dealt the first time around.

3. The stratification of society is resented by the people in the lower strata. Even such trifling distinctions as those between master and slave, or between commissar and worker, are only grudgingly endured, if at all. The chance of the masses holding still for the vastly greater split between mortal

and immortal is nil. The elite have a fairly simple choice: share immortality, or be torn limb from limb.

4. The benefits to all of society resulting from the long view depend on all of society sharing this view. The Golden Rule must know nothing of class or caste.

In short, the freezer program must embrace us all, with exceptions for minorities who voluntarily reject it. There will be a preliminary slipping and clashing of gears, but this must be kept to a minimum if the world's works are not to fall apart.

There is a saying: If the rich could hire people to die for them, the poor would make a good living. But our poor are not docile enough to be content with this kind of "living"; they will not build freezers for the rich, and then lie down themselves in slimy graves. Hence there must be no excessive time lag between the private, pioneer programs and public, mass programs.

Beginning of the Freezer Era 1964?

In a sense, the freezer era has already begun, since conscious, purposeful activity in this direction is under way. There already exist, in late 1963, at least three organizations dedicated to furtherance of the freezer program, at least two of them legally incorporated. Many others can be expected to spring up shortly.

The freezer program is already a plank in the political platform of a congressional candidate, who now has the distinction of promising more than any other politician in history.

The grass-roots readiness, as indicated by my conversations and correspondence, is unmistakable - and oddly enough, it seems to have little or no relation to status or education; some poorly educated people are affirmative for the wrong reasons, and some scientists are against the program for emotional reasons. (There is wry humor in the predicament of

any cryobiologists who may not favor the program; the poor devils will have to hope for their own failure!)

The first human may be frozen before the end of 1964, that is, within a few months of publication of this book. (Possibly a few wealthy people have been quietly frozen already!) Thereafter, events will gather speed, and our medical, financial, and political leaders may find themselves in the fix of Robespierre during the French Revolution. Robespierre, the story goes, was relaxing in a cafe with a friend when a howling mob went racing by. He jumped up and ran for the door. His friend called, "What's the matter? Where are they going?" Robespierre flung back: "I don't know where they're going, but I've got to get in front. I'm their leader!"

Hopefully, the freezer advocates will not have the less appetizing characteristics of a revolutionary rabble, but they will be just as determined. After all, the prize is Life - and not just more of the life we know, but a wider and deeper life of springtime growth, a grander and more glorious life unfolding in shapes, colors, and textures we can yet but dimly sense. Large numbers of Americans and Europeans will soon come not only to perceive but to feel the vastness and the grandeur of the prize, and to understand that all other prizes, all previous goals, are secondary. Their demands cannot be long ignored.

These demands will be of two general kinds, and will be aimed, among others, at physicians, biologists, morticians, insurance men, bankers, legislators, and lawyers.

First, make available routine and regularly updated procedures for freezing those now dying, making the most of current means.

Second, provide massive scientific and financial support for accelerated research in non-damaging freezing methods, as well as for a complete range of ancillary facilities.

In 1964, there will probably be little or nothing available in the form of institutional help or standardized procedures, and courageous individuals will have to take matters into their own hands. Then, for the first time in the history of the world, it will be *au revoir* but not Good-by.

The End

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