CRYONICS

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Contents:

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Editorial Matters

ERRATA

The paper "Case Report: Two Consecutive Suspensions, A Comparative Study In Experimental Human Suspended Animation" in the November CRYONICS, contains two serious errors. Figure 4 (page 22) is supposed to be based on Table 3 (page 21), and Figure 7 (page 28) is supposed to be based on Table 5 (page 28). In fact, several points in each of the Figures were omitted from the appropriate Tables. The correct Tables 3 and 5 are as follows:

Table 3. SP1 - Glycerol Concentration.

Time (min)	15	113	200	500
Arterial				
Brix No. (1)	11.0	16.2	19.4	23.1
Moles (2)	0.68	1.13	1.71	2.85
Percent (3)	5.8	10.1	15.0	24.8

Time (min)	15	213	288	504	535
Venous					
Brix No. (1)	7.48	11.5	13.8	20.9	22.0
Moles (2)	0.296	0.712	1.26	2.32	2.67
Percent (3)	2.5	6.1	11.0	20.1	22.2

Table 5. SP2 - Glycerol Concentration.

Time (min)	5	34	65	108	133	237
Arterial						
Brix No. (1)	11.7	10.3	14.5	16.2	20.0	—
Moles (2)	0.608	0.610	1.08	1.39	1.95	2.95
Percent (3)	5.2	5.2	9.4	12.0	17.0	25.5

Time (min)	5	38	67	108	133	235
Venous						
Brix No. (1)	9.0	10.6	13.2	14.3	17.2	26.0
Moles (2)	0.432	0.616	0.944	1.14	1.62	2.87
Percent (3)	4.0	5.5	8.4	8.9	14.1	25.0

DREXLER PAPER

This month we begin the publication (in two parts) of **Molecular Technology and Cell Repair Machines,** Eric Drexler's presentation at the Lake Tahoe Life Extension Conference in May of this year. This piece is a reprint from the August, September, and October, 1985 issues of CLAUSTROPHOBIA magazine, and we would like to thank Eric Geislinger and Jane Talisman of CLAUSTROPHOBIA for the difficult task of transcribing it, and Eric Drexler for editing it, and all of them for allowing us to reprint it.

Gold Bracelets--A Class Act

We have taken delivery on our first order of gold-filled (gold-plated stainless steel) bracelets, and we were pleasantly surprized at how "classy" they look. They are quite stunning compared to the unplated stainless steel tags. Gold necktags—NOT including a gold neckchain—are also available.

Probably the least attractive aspect of the gold-filled bracelets and necktags is the complex pricing structure we must impose to offer them practically and affordably. The electroplating service has a per-piece charge and/or a minimum order charge, depending on the quantity of the order ALCOR can submit to them. Sparing you the tedious details, you may either 1) order the item with a guaranteed prompt delivery and pay the expensive minimum order charge, or 2) order the item at an economical cost, but wait until we accumulate other orders to make up a cost efficient order. The resulting pricing structure is as follows:

Stainless Steel bracelet or necktag, each . . . $ 7.00

Plating charge, 1 to 6 items with
guaranteed prompt delivery $80.00

Plating charge, each additional item over
6 with guaranteed prompt delivery $20.00

Plating charge, each if you wait $20.00

WARNING: If you elect to wait, **we have no idea of how long you might wait!**

If you have a credit card (VISA, Master Charge or American Express) you can phone in your order at (714) 738-5569.

ALCOR Coordinators: More Progress

The ALCOR COORDINATOR PROGRAM is picking up steam and progress is being made at a rate well in excess of what we expected. Last month we announced our plan to deploy life-support and stabilization equipment in Northern California. We are pleased to announce that the equipment is now completely ready and we expect to have it deployed by the time you receive the next issue of CRYONICS.

We are even more pleased to announce that **two more complete sets of life support equipment will soon be in the field with coordinators!**

This unprecedented progress was made possible in no small part due to the generosity and support of our Coordinators. Fred and Linda Chamberlain of South Lake Tahoe provided funds for purchase of a set of equipment for their area, as did Steve Bridge and Bob Abernathy. And what a set of equipment they're going to get!

We are putting a complete "state of the art" capability for rescue and stabilization in the hands of people who have had substantial experience and training in cryonics operations. Basically, the kits consist of an intravenous (IV) medications box (which also contains supplies necessary to start IV's with) with over $1,000 worth of drugs, instruments, and other disposables, a suitcase containing support supplies such as oxygen regulators, isolation gowns, gloves and supplies (for infectious cases), remote sensing thermometer, esophageal airway, external cooling supplies, scrub clothes, paramedic kit (clamps, flashlight, surgical tools), as well as a general tool kit. Also included is a $3,400 Brunswick 50-90 Heart-Lung Resuscitator (HLR) and its oxygen powerpack (consisting of two **E** cylinders and regulator yoke). Altogether each kit represents about $5,000 worth of equipment. Also included is an instruction manual telling how to use it and detailing ALCOR's policies and procedures for initial stabilization and transport of its suspension patients.

It's this last item that's held up deployment of the kits. Formulating a complex set of instructions and policies has taken **time.** But, we're happy to announce that the work on the manual—at least the hardest part, writing it—is done. We are now in the process of editing the manuals and preparing them for issue, along with the new rescue kits. Almost as bad as **writing** the manuals was doing an inventory on the life support kits! There are 99 different kinds of items and nearly 300 separate pieces in each kit.

It will take us a little more time to deploy the other kits. Fred and Linda should be taking theirs back with them from the Turkey Roast and a training session has been scheduled for the Northeast Coast for December or February. If you are interested in participating in an East Coast training session you should contact us at (714) 738-5569. We have not yet decided whether to hold the training session in the Washington DC area or in the New York area (Long Island). Our decision on this matter will probably be governed by the kind of response we get. If there are more New Yorkers or "Northeasterners" than there are Washingtonians or "Southeasterners" that will probably move the session up to Long Island.

We are anxious to establish a base of operations in the New York area. We have had two close calls on the East coast in the last two months, and we urgently need skilled people in the field in that area.

We now have a large Hammond map of the United States on our wall in the ALCOR office marked with colored pins and flags for suspension members and Coordinators. Once we get the four sets of equipment which we have already acquired into the field, we will have tremendously improved our responsiveness and coverage for our members not living in Southern California or Florida.

ALCOR COORDINATORS AND FACILITIES

ALCOR CALIFORNIA, 4030 N. Palm #304, Fullerton, CA 92635. Phone: (714) 738-5569.

ALCOR FLORIDA, c/o Glen Tupler, 6570 S.W. 47th Court, Davie, FL 33314. Phone: (305) 583-0801

Bob Abernathy, P.O. Box 3757, Gaithersburg, MD 20078

Steve Bridge, 1720 N. Layman, Indianapolis, IN 46218

Fred and Linda Chamberlain, P.O. Box 16220, South Lake Tahoe, CA 95706

Mike Perry, 1035 Adams Circle #222, Boulder, CO 80303

Dave Pizer, 1355 E. Peoria Ave., Phoenix, AZ 85020

Key to Map

⊡ Facilities and personnel for life support, perfusion and long term cryogenic storage.

■ Facilities for life support, perfusion and initial cooling to -79°C. Local team trained in life support and patient stabilization (induction of hypothermia by external cooling and administration of appropriate medications) only.

▲ Coordinator scheduled to receive life support and patient stabilization equipment and training.

x Information Coordinator.

ALCOR MEDIA BLITZ

Some months ago the ALCOR Board of Directors made a decision to increase public awareness of ALCOR and cryonics by allowing and even selectively encouraging media exposure. Over the last six months or so we have done over thirty national and local radio shows and half a dozen television shows. We have also appeared in literally hundreds of articles in print media ranging in class from the ORANGE COUNTY REGISTER to the GLOBE tabloid.

The two editors of CRYONICS (who also staff the ALCOR office/facilities) have done, given, been put through and anguished over enough interviews to last a lifetime. We've met all kinds of people. And we have a few interesting experiences to share with you.

The story we "worked" on hardest and longest was the REGISTER story. In terms of sheer volume, there's probably never been anything like it. Steve Eddy, the REGISTER reporter who wrote the story, spent in excess of 1Ø hours consulting with us on every aspect of our operations. The newspaper supplied a graphic artist who spent a day with us working up color drawings for the articles and a staff photographer set up a ministudio in the patient care area and spent the better part of the day taking pictures. Our many hours of conversation with Steve Eddy made us hopeful that we had achieved some kind of rapport and that he might actually reliably capture some part of what we are doing.

Well, we were wrong. The REGISTER story was about 4000 words long and it was "pretty" since the four color graphics and photographs consumed about 1/2 of the first page. But it was empty of anything but the barest idea of what we're all about. The article was titled "The Big Chill: Weird Science is a matter of faith for cryonics group." It went downhill from there. We might as well have handed them our literature and refused to talk to them--the results would probably have been the same (and we'd be ahead 20 hours or so of productive time). Another, more worrisome aspect to the REGISTER article was a quote from John Gill, Executive Director of the California State Cemetery Board, which called for a ban on cryonics. Gill is quoted as saying that cryonics is consumer fraud and that "The technology isn't proven to work. It's never been done before...I think it should be prohibited. Just them saying what they want to do is possible isn't enough...the industry should be banned until it's proven to work."

The only mitigating things we can say about this article is that it probably told at least a few of the REGISTER's 600,000 or so readers that we were still in business (the Cemetery Board notwithstanding) and acquainted a few people (albeit in a less than reassuring way) with the outline of the cryonics "central dogma." The REGISTER also ran a letter from Mike Darwin pointing out what we felt was wrong with the article (see below).

E section The Orange County Register Wednesday, October 28, 1987

SCITECH

Accent

Cooling down

Immediately after death (deanimation) the patient/member is placed on a heart-lung resuscitator to continue circulation until the body can be packed in ice and shipped to the lab in Fullerton. The blood is then pumped out as a glycerol containing perfusate is pumped in. The body temperature gradually drops to 54°F. A hole is drilled in the skull to shock the brain. At the first sign of swelling the perfusion is stopped, usually after two to four hours. The head is then severed from the body and, through a series of steps, is gradually dropped to a temperature of -320°F.

Temperature monitor
Protective plastic bag
Thermocouples (to monitor temperature)
Plastic tank
Silicone cooling fluid
Patient's head
Dry ice
Smaller cryogenic Dewar
Aluminum can
Temperature monitor
Dual patient Dewar
Plastic tank
Styrofoam wool
Patient's head
Dry ice
Liquid Nitrogen
Double-walled stainless steel Dewar
-320°
Storage
The head, placed within a bag, is surrounded by cushioning Dacron wool insulation inside a single-wall aluminum can. This can is

THE BIG CHILL

They're freezing heads in liquid nitrogen to satisfy age-old quest for immortality

Weird science is a matter of faith for cryonics group

"We are the radicals, the outer fringe of the scientific world. We are the ultimate revolutionaries."
From the Alcor Life Extension Foundation's creed

Stories by Steve Siddy
Graphic by Craig Pursley
The Register

Despite bright lights, squeaky-clean walls and gleaming aluminum fixtures in his laboratory, there is just a hint of Frankenstein when Mike Federowicz raises the lid of a round metal container.

Vapor wafts out, temporarily obscuring the view.

Soon, five containers grow visible through a misty cloud.

SCIENCE

Inside them, frozen in liquid nitrogen at minus 320 degrees Fahrenheit, are human heads, the mortal remains of five people whom Federowicz's Fullerton-based Alcor Life Extension Foundation hopes to resurrect someday.

"I genuinely think this is going to work," said Federowicz, 38, president of Alcor. "At least, it has the technical possibility of working. I expect to see these people again."

Federowicz believes -- spends his life on -- cryonics.

Please see CRYONICS

CLEARINGHOUSE The ORANGE COUNTY REGISTER, November 5, 1985

Your readers missed the real story of cryonics

I am writing to comment on Steve Eddy's Oct. 23 article on Alcor and cryonics, "The Big Chill — Weird science is a matter of faith for cryonics group" (Accent). Eddy spent a great deal of time and effort preparing the article and demonstrated a concern for fact and detail that we have rarely observed in journalism anywhere.

And yet, there's something seriously wrong with his piece — a missing dimension. Imagine, if you will, an article discussing organ transplants that described the procedure as "slicing a vital organ from the young, vulnerable body of a still-breathing corpse in a Frankensteinish attempt to buy more time for a dying life-hungry middle-aged businessman." A factual description? Technically, yes. A representative one? No.

Such is the case with the *Register's* article on cryonics. Perhaps it was our fault, but somehow, somewhere, the essence of what we are doing and what we are trying to do was lost. We are not involved in "weird science" as your headline writer so cleverly describes it. We are in a struggle for our lives and the lives of those we love and care about.

We feel strongly that contemporary medical and scientific authorities have made a terrible error in judgment about cryonics. They continue to evaluate life only in terms of their ability to deliver service now. We firmly believe that as long as sufficient biological structure remains to infer the functional state from the nonfunctional state, there is a very real, very solid chance that eventual restoration to life and health will be possible. But this will be accomplished by authorities not yet born, using skills that the present authorities will only develop in years to come.

We are not involved in 'weird science' as your headline writer so cleverly describes it. We are in a struggle for our lives and the lives of those we love and care about.

The coming decades will see the development of an engineering technology capable of action on a molecular level. When that technology is developed (and it will be, because there are tremendous economic, humanitarian and military incentives to do so), our world and lives will undergo a series of changes so profound and awesome that they can only be likened in scope of effect to the development of language or our first use of tools.

Look around you at the world of living things, at the incredible "magic" of their abilities, and you have the vaguest taste of the kind of capabilities molecular technology will give us. Think of a world where we can engineer cell- and tissue-repair devices like those in a human cell, only better. Then imagine the immense possibilities that open up to us: control and reversal of the aging process, reversal of freezing injury, the end of human disease and human hunger.

All this as the side effect of a more general technology. In short, a world where mankind has complete control over living systems and is no longer at the mercy of an uncaring and indifferent world.

The real story, the one Eddy missed, is the story of the incredible change and impact molecular technology will have on the world and the desperate, loving struggle of cryonicists to bring ourselves and our families and friends to that safe haven.

I fiercely love and deeply care about all the people now waiting in suspension. I cannot know that I will see them again. What I do know is that I have done something. I have not carelessly wrapped up and thrown away, like so much garbage, those whom I value most in life. I have not given up simply because contemporary authorities tell me their technology is inadequate to the task of healing them. That's the real story about Alcor. I'm sorry that Eddy and your readers missed it.

Mike Federowicz
Fullerton

Federowicz is president of Alcor Life Extension Foundation.

A brief article mentioning us in USA TODAY resulted in a television booking in Chicago for Mike Darwin to appear on the "Ophra Winfrey Show". Winfrey has the most popular talk show in Chicago—she even beats out Phil Donahue (Winfrey goes into national syndication in January). After seeing her in action it's easy to see why. She's earthy (kicks off her shoes when things heat up) and has an energy level gigahertz above Donahue's. The show was a lot of fun, and it also solved a mystery of sorts...

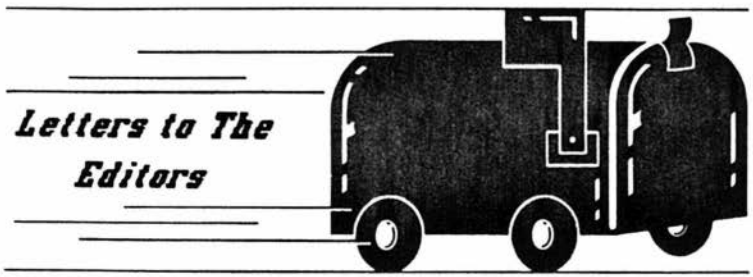
When the editors of CRYONICS travelled to San Francisco recently, we made a trip to Trans Time's facility in Emeryville. We were refused entry to the patient storage area and were told that there was "a suspension in progress", but that we couldn't be told any of the details. The American Cryonics Society (ACS) and Trans Time meetings we attended that weekend consisted almost as much of closed "executive sessions" (which we were excluded from) as it did open

meetings. The mysterious "suspension" was in part the reason why.

Well, the Winfrey show let the cat out of the bag...literally. It seems Trans Time froze the deceased (deanimated?) cat of a Chicago woman for the sum of $5,000. The lady in question called in during the course of the show with questions about ALCOR (and cryonics) and to let Winfrey and the 1 million or so people listening know that she had frozen her cat for $5,000. Apparently her cat died and was shipped on ice via airfreight to Trans Time where it was perfused by Paul Segall and Harry Waitz of Biophysical Research and Development (the details of the perfusion are being handled with Manhattan Project-style security). That revelation made the interview a little tougher (Winfrey is not brain-dead and knows when to go for the blood) but still tolerable. We think the tape would show that Mike didn't miss a step, but he confesses that's one he wasn't expecting.

Of course, the question of the hour is: Will all this media hype do us any good? One of us (Mike Darwin) has long been opposed to media exposure of this kind and has been keeping a close eye on the benefits as well as the liabilities of our PR campaign. So far the media work has netted us two suspension members (fully signed up with funding) and put several strong candidates for suspension membership in the pipe. Frankly, this isn't bad for starts. We know that it will take "repeated hits" with our message before anyone seriously considers signing up. We also are beginning to believe that there may be some advantages to "consciousness raising" among members of the public as a result of these stories. Nevertheless, it **is** hard to do these things. It is hard to be treated like a circus animal and to invest the tremendous amounts of **time** required--with so little to show for it in the way of immediate benefits.

And still the media campaign marches on. Hugh Hixon is scheduled to do a live TV show in Philadelphia ("People Are Talking") and print and TV reporters keep showing up here at ALCOR in waves, like so many whales beaching themselves on the shores of immortality. We've become convinced that it is futile to try to **really** explain to them what we're doing. We can only bang on our pipes and herd them around with the songs they want to hear and hope, that like poor Humphrey the Lost Whale, they'll eventually find their way out of the narrow river of ignorance and into the wide ocean of truth.



Dear Editors and Readers:

I am responding to Mr. Drexler's letter concerning my paper on "Prospects and Applications for the Genesis and Ultra Mass Production of Sub-Millimeter

Machines, Devices, and Replicating Systems."

The probable reason Mr. Drexler has to "confine" himself "to a few points" is that he was given earlier versions of the "Prospects . . ." article to review and had few critical comments, especially concerning the references. Indeed, to quote Mr. Drexler himself from a letter dated 12 April 1983 and titled "Comments on `Prospects and Applications . . .' 31 March 1983 draft" (after the bulk of the "Prospects . . ." paper was written): "Those are some references! Thanks." A possible reason for his radical change in opinion will be noted later on. In the meantime I will consider his complaints at face value.

If Mr. Drexler was as expert in "biology, engineering, and computer science" as his critique indicates, he would know from the literature on stochastic automata, analog associative memory, and randomly connected neural networks that "being thrown together haphazardly" does not mean not designed at some level, nor inability to perform computationally useful functions. I did not propose a "REGULAR cellular automaton" (emphasis added) in the first place, and indeed indicated the contrary. And the requirement for a vascular system to support such a device seemed obvious. Likewise for scaling — as anyone with a passing familiarity with computer science should know, the key word is modularization. Given that cells are grown in industrial quantities for microbial production of fuels, Mr. Drexler's comment on cell culture is amusing. In developing supercomputers, the idea of building a "complex" device to design a "simpler" one is no more absurd than building a "complex" computer to designing a "simple" component which permits the building of even faster computers. Of course, if the "simple" component is such that extensive computational quantum chemistry is involved, one immediately sees how "this illustrates a characteristic sloppiness" wherein Mr. Drexler confuses a relatively simple form of numerical complexity with a very challenging form of logical and structural complexity, thus failing in the "evaluation of levels of engineering difficulty." Perhaps Mr. Drexler neglected to read the introduction, since he seems to expect detailed hardware designs, and evidently failed to look up any of the relevant references that were supplied in that section and previous sections for those readers who might be interested in attempting such a task.

Mr. Drexler's dismissal of nanometer scale antennas as "wholly implausible on a variety of grounds" fails, since you don't need amplifying circuits to drive antennas. Even if his physics is a bit weak, a cursory examination of the history of radio would have spared him of this blunder. Further, it might have drawn his attention to the fact that the upper frequencies of such circuits are still advancing rapidly, making their present capabilities irrelevant in ascertaining ultimate capabilities. Finally, on that basis, consistency would require Mr. Drexler to likewise conclude that Feynman's proposed light frequency dipoles are "wholly implausible" as well.

Since I indicate (in the introduction) that many of the ideas I discuss are not new, and from the outset note that much of "Prospects . . ." is based on Feynman's work and enthusiastically promote it, it seems unnecessary to cite every instance of it. Else it would be necessary to cite it almost every time I cite any of Mr. Drexler's work. In any case, I cite Feynman's work in several places and argue extensively for the utility of Feynman's work. It is interesting to note that Mr. Drexler's quotes of Feynman used here and elsewhere in his letter are a subset of the ones I used in my other paper "Nanotechnology." His use of quotes from Feynman elsewhere in his letter

indicate that he is not familiar with their context; it seems that he is more familiar with the quotations in "Nanotechnology" than he is with Feynman's original paper, contrary to his claim.

In writing of "technical absurdities," Mr. Drexler confuses natural, existing (and inadequate) repair mechanisms with artificial ones that perform functions that the natural ones fail to do (else there would be no aging as we know it) and further confuses experimentally confirmed mechanisms with unspecified and undesigned systems that hopefully will work much better. How much better really isn't known, and that is the question at issue. Doing better than nature doesn't necessarily guarantee that nanotechnology alone is sufficient to extend life indefinitely (although I certainly hope and expect so). Given that the previous paragraph in "Prospects . . ." explicitly gave a case of possible repair, and that the next paragraph dealt with life extension, Mr. Drexler's interpretation of the passage he cites is clearly not the one intended.

As the viability of cryonics currently depends on the viability of a very small number of dedicated individuals and a reasonably viable economy, and since the possibilities of a major epidemic, an extended depression or very high inflation rate, etc., are not insignificant, the desirability of rapidly developing nanotechnology to remedy this situation is obvious. Further, suspension and revival is an extremely serious medical procedure that, while certainly far better than nothing, has not in fact been shown to be free from major negative side effects. It should be regarded as an emergency procedure, to be used as a last resort, and not taken for granted. In addition, the majority of the world's population, for reasons of poverty and politics, simply do not, and most probably will not, have access to any form of viable suspension technology in the near to medium term future. It is callous in the extreme for Mr. Drexler to claim that nanotechnology is a matter of "life or death" after writing off these people. Many other people who could have access to suspension technology will probably not believe in it until nanotechnology is substantially more advanced and proven and would likewise be condemned if his cavalier attitude prevailed.

A refereed journal doesn't guarantee soundness. Indeed, it doesn't even guarantee that the most qualified referees participate. Dr. Kantrowitz (who communicated the PNAS paper on Mr. Drexler's behalf) informed me that Dr. Feynman (who has done work in molecular biology) did not respond when the PNAS paper was sent to him for review. Further, when Dr. Feynman gave a talk this spring on quantum mechanical computers and was asked how such things might be constructed, he described scanning tunneling microscopes, not protein engineering. Note that if Mr. Drexler's proposed policy ". . . to publish chiefly summaries of work that has appeared in refereed journals . . ." were followed rigorously then Feynman's seminal papers on nanotechnology and quantum mechanical computers could be excluded, as well as cell repair proposals by other authors that predate Mr. Drexler's.

Coincidentally, it was at the last Space Development Conference this spring in Washington, D.C. where I met Dr. Kantrowitz and where Mr. Drexler, Ms. Peterson, and Mr. Miller tried to dissuade me from distributing an earlier version of my Nanotechnology paper because it referenced scanning tunneling microscopes! Incidentally, Dr. Kantrowitz was there to give a talk on "The Weapon of Openness," and indeed, vigorously argued for public discussion of scanning tunneling microscopes and related technologies. He felt that to

attempt evaluation of nanotechnology without knowledge of the various means by which it could be implemented was folly and prone to fallacious conclusions. Keith Henson, co-founder of the L-5 Society, has informed me that Mr. Drexler was upset about the STM and its inclusion in my paper because it forced him to revise his forthcoming book. The tone of Mr. Drexler's letter suggests he is still upset about it.

In mentioning Feynman's paper, Mr. Drexler fails to note that he proposed manipulating atoms as the LIMITING CASE of working from the top down; surely Mr. Drexler doesn't think that the operations at other levels that Feynman describes would not make use of some of the functions of the biomolecules he cites as examples of miniature machinery nor involve the formation of chemical bonds? Has Mr. Drexler really read the rest of the paper in question?

As in the case of Mr. Drexler, Mr. Miller was also given copies of a previous version of the paper from which the "Prospects . . ." article was edited. Thus I don't see how he can be "surprised" about its contents. Since I first heard of "Micro-robo-cops" from Mr. Miller, and he did not to my knowledge attribute it previously to Mr. Drexler, the citation seemed perfectly appropriate. In any event, I thank Mr. Miller for his correction. On the issue of priority in proposing cell repair machines, let me quote from pages 3 and 4 of the February 1981 issue of "The Immortalist." It reads: "The notion of robotic micro-surgery is not new . . ." and ". . . Jerome White and Michael Darwin have contributed somewhat more detailed versions of repair techniques [than Ettinger], involving designed viruses or other programmed micro-organisms. . ." and "Mr. Drexler's contribution appears to be the presentation of many specifics . . ." In the next issue, Thomas Donaldson mentions the possibility of ". . . micro-miniature biological-mechanical machines the size of viruses, bacteria, and the cells themselves to do repair." And Feynman, in 1959, mentions the idea of small machines that might be permanently incorporated into the body.

Regarding Mr. Drexler's statement that I incorrectly attributed protein based robots and computers to his **Smithsonian** and **PNAS** papers, this is correct in an exact sense. He did not discuss protein based computers. He did however regard sophisticated protein based tools as a step to molecular computers, and in the paragraph of "Prospects . . ." he says is in error, this is correctly represented, although with my own emphasis. He has also spoken to me personally about protein based robots and computers, and the **Smithsonian** article does refer to protein based robot arms.

Not only do I appreciate the importance of cell repair machines, but in addition I appreciate the fact that for the majority of the world's population, suspension is simply not an available option. The reasons are of course obvious and well known: poverty, politics, ideology, etc. And for many people who could be suspended, nanotechnology is not sufficiently advanced enough to be convincing. In dismissing the moral priority of developing nanotechnology quickly, Mr. Drexler forgets that the technology he is talking about does not yet exist and that its future development is by no means guaranteed. The possibilities have been known for over two decades; what is needed is much more research and experimental demonstrations. That is one reason my current job is building nanoresearch machines, including scanning tunneling microscopes, for a medical college.

Given that both the "Prospects . . ." and the Nanotechnology papers were

motivated in part by attempts to find references that Mr. Drexler failed to provide, I find Mr. Drexler's claims that "we chiefly need to understand molecular technology," which he claims "will speed its development," to be especially contradictory. Considering his letter, his talks, and his attempts to prevent distribution of technological information he would rather have suppressed, it is clearly Mr. Drexler who has muddied the water of public discussion with a heap of misinformation. I hope in the future he will practice what he preaches and consider using the "weapon of openness" more vigorously.

Eternally Yours,

Conrad Schneiker
Tucson, Arizona

Jesus Was An Immortalist

by Thomas Donaldson

"Not every one that saith unto me, Lord, Lord shall enter into the Kingdom of Heaven."

Matthew 7:21

This article is one more in a series on the historical precursors of immortalism. Let me begin it by saying straight out that I am an atheist and place no moral or factual credence upon the stories in the Bible, either Old or New Testament. It's not even clear to me that a living Christ, as a historical figure, ever existed, nor that the sayings attributed to him were ever said by him if he did exist.

However, in common with most immortalists, and even more with cryonicists, I've had to consistently meet with Christians, or people who claim to be Christians, who insist adamantly that immortality just isn't God's will, and so forth and so on.

Finally, I decided to **ACTUALLY READ** the New Testament. This was an interesting experience. I thought I would share it with other cryonicists.

The books of the New Testament are very badly written, and in places quite incoherent. Jesus does not always show up as a very admirable character, doing things such as petulantly blasting a fig tree because it had no figs and he was hungry (Matthew 21:18-19). I cannot agree with the morality of Jesus, which seems to me brutal, unkind, and primitive (cf. for example Luke 16:18 on divorce). His constant admonitions that we must follow HIS word seem quite egotistical. This guy is not really a very admirable character.

However, after reading the New Testament, I find many severe problems with

the standard interpretation of Jesus's teachings. Just what did Jesus believe (according to these stories) about physical immortality?

The very first thing we notice on reading the New Testament seriously is that very many of the miracles performed by Jesus consisted of: (guess what?) REVIVING THE DEAD. He doesn't do this just once. He does it all over the place, and it seems that this constant resurrecting of people was THE major reason why he achieved such a following. Lazarus is only the most famous example; you might care to look other places in the Bible too, such as Matthew 9:23-25. Sure, Jesus also gave sight to the blind, healed those with the palsy, etc, but his major starring miracles consisted of reviving the dead.

Not only did Jesus revive the dead, but he gave his apostles the same power, and urged them to go out into the world doing the same (Matthew 10:8). I will quote:

> Heal the sick, cleanse the lepers, RAISE THE DEAD, cast out devils; freely have ye received, freely give."

The ability to do these miracles depends on belief. Matthew 17:20,

> "...verily I say unto you, if ye have faith as a grain of mustard seed, ye shall say unto this mountain, 'Remove hence to yonder place;' and it shall remove; and nothing shall be impossible to you."

Jesus is saying that if we believe in him, we too will acquire his powers.

Furthermore, if we read the Bible in the sense of ordinary language, we discover that Jesus was claiming that belief in him would result in eternal EARTHLY life. The story of Lazarus in John brings all this out very clearly. I will quote it at length, particularly because much of its meaning depends on its context. It is John 11:21-44,

> "21. Then Martha said unto Jesus, Lord, if thou hadst been here, my brother had not died.
>
> 23. Jesus saith unto her, Thy brother shall rise again.
>
> 24. Martha saith unto him, I know that he shall rise again in the resurrection at the last day.
>
> 25. Jesus said unto her, I am the resurrection, and the life; he that believeth in me, though he were dead, yet shall he live:
>
> 26. AND WHOSOEVER LIVETH AND BELIEVETH IN ME SHALL NEVER DIE. Believest thou this?"

What is happening here is that Jesus is telling Martha that he is NOT referring to Lazarus rising from the dead "at the last day", but instead he is saying that Lazarus will rise NOW. He is drawing a clear distinction between the immortality HE offers and the standard religious interpretation of resurrection on the last day.

We can find plenty of support for this interpretation in other books of the

New Testament. If we want some really good passages we can look, for instance, in Revelations 20: and 21:1-4.

As an atheist, I will say here that copyists and religious charlatans have obviously rewritten the New Testament books many times. The first four books, in particular, read transparently as a pastiche. They could only read the way they do if they had been edited, fixed, and stuffed about to support one or the other religious view (**1984** has existed throughout human history!). However, the quotations I've given are still there.

Friend Stuart, a Christian who has argued that Jesus was proposing physical immortality, has pointed out the quotation from John 11:26. Especially when read in context, it is definitely NOT talking about a spiritual resurrection in the last days.

Anyone who consider these passages is faced with THREE possible interpretations:

1. The entire story is a load of bull.

2. These statements are meant to be interpreted allegorically or metaphorically.

3. These statements are meant to be interpreted literally. They therefore mean that NO ONE since Jesus Christ has truly believed Christ's teachings.

I believe that it is very hard to support interpretation 2. If the point of Jesus' message is simply that we will achieve a spiritual resurrection in the "last days", then WHY DOES JESUS RESURRECT LAZARUS IN THE FIRST PLACE? If death only means we go to heaven, and particularly if it means going to heaven for BELIEVERS, then what is achieved by resurrection? What could be the POINT of the Lazarus story in the first place?

Clearly, physical resurrection must have some very real value for believers in Jesus' teachings. Not only that, but Jesus himself in his answer to Martha is specifically DENYING the metaphorical interpretation.

As for the THIRD interpretation, it has the embarrassing consequence that no one has yet learned how to "believe" Jesus. What, after all, is belief to consist of? Clearly, it cannot consist simply of mindless repetition of the sayings of Jesus, since there is a lot of that going on and we notice that all those that do it have died.

Furthermore, just to shake up the Christians a bit, NOWHERE in this book do we find any strictures on the MEANS that believers in Jesus are to employ in order to live forever. It does not say that we are to achieve this goal by singing and dancing about lighted candles and a pentagram, or by attending a church, or by standing on street corners reading the Bible. It just says that if we believe in Him, we shall never die.

If someone dies, that shows that they cannot have believed. Whatever they were doing, it wasn't the right thing. We note that the world is littered with the bodies of revivalists, prelates, and preachers of all kinds.

It does seem that prayer and fasting are required to achieve these powers. Just after he says that all things are possible to those who believe, Jesus says (Matthew 17:21): "Howbeit this kind goeth not out but by prayer and fasting". For what it is worth (just to pursue this line of thought further), if in 1985 we want to find people TRYING to cure palsy and raise the dead, and have some success in that endeavor, we'd look towards scientific medicine. Perhaps all those who say that it would be impious to do all these things badly misapprehend the meaning of "belief", or "prayer", or even "fasting". Perhaps more atheists than prelates believe in Christ.

We all know of millenarian and charismatic versions of Christianity. The Watchtower Society, when we read their literature, claim an interpretation which comes hauntingly close to out and out immortalism. Unfortunately, they seem to equate belief in Jesus with some kind of psychotic fugue. Moreover, its members also aren't noted for fantastic longevity. The interesting point, though, is that their interpretation of the Bible is actually better founded in what the Bible SAYS than the standard interpretation! This observation, of course, only bears as much weight as we wish to put upon the Bible itself.

Actually, of course, as read by immortalists the one thing which comes out very strongly in these old Bible stories is exactly how desperately people did want immortality in those days. Two thousand years ago, before even the English language existed, people felt as we do about grief, death, and immortality, and clutched at every preacher for some hope that the death they saw falling upon everyone around them would never fall upon them.

Molecular Technology And Cell Repair Machines

by Eric Drexler

The following paper was presented at the 1985 Lake Tahoe Life Extension Festival on May 25, 1985.

My talk this afternoon is on cell repair machines, life extension, cryonics and the relationship among them. In the course of this I will be describing a technology that seems to be clearly able to make it possible for people to live indefinitely in perfect health. In doing this, I didn't begin by thinking: "Gee, wouldn't it be nice if we had a technology that would allow people to live indefinitely in perfect health? Now, how would we do that?" Instead, I was thinking as an engineering-oriented person at MIT looking at the future of technology, trying to see what it would be possible to build with tools we do not have yet, but tools that we understand, that we will have economic incentives to develop, and that we will therefore eventually be using.

One area that I examined for a good number of years was space industrialization, the field I did my graduate work in. There, I looked at what we could build with spacecraft and systems of hardware easy to understand, but located in space. I also kept track of molecular biology, thinking "This looks interesting--it's a cutting-edge field--I'd better keep track of what's happening in it." Being an engineer, I increasingly thought in terms of, "Well, gee, they're describing molecular machines here. What can we do with these molecular machines?" And that is what eventually led to the conclusions that I stated earlier.

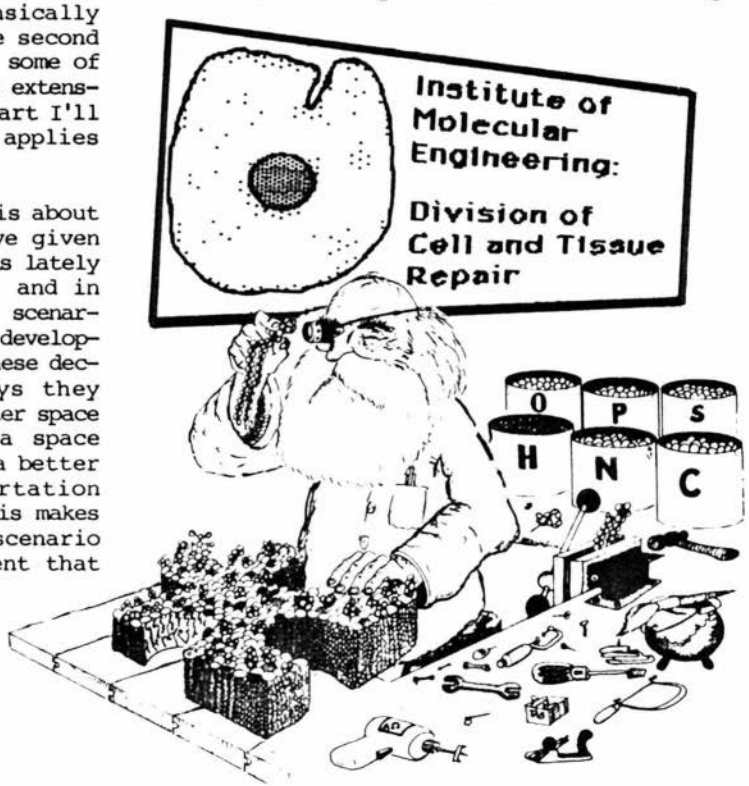
Part of what this means is that nanotechnology, or molecular technology (since we speak of micro-technology or micro-circuits when we have micron wide lines on silicon chips, it's reasonable to speak of nanotechnology when we're talking about things on the nanometer scale), is a field in itself. And, I think this will turn out to be a very important from the point of view of selling life extension and specifically, of selling the idea of cryonics. Now, the reason for this: at present we're in a position (or have been in a position) of taking a direct approach. "You want to avoid death, **don't** you?" is, in effect, what you say to someone. And, with respect to cryonics, you say, "Well we've got an approach that **just might work.**"

You're asking people to risk getting their hopes up about something of fundamental emotional concern to them. This is something which much of human culture revolves around and is adapted to—this idea of the inevitability (and historically, it **has** been inevitable) of personal death. People have adapted for good evolutionary reasons. People in the past who said, "I'm going to try to find some way to avoiding dying" were wasting their time. They didn't do as well economically. They didn't do as well in any competing activity. Evolution selected against people who had brains that tended to think that way. It selected against cultural patterns that would encourage people to do what, at that time, was useless. So the real reason for what earlier speakers have described as "deathism" is actually an "evolutionary adaptation" that was appropriate from an evolutionary standpoint. Of course, evolution is not

necessarily good, so we needn't like all of its products.

So, I think this goes some distance toward explaining the well-known phenomenon of massive resistance when we approach people with the idea of radical life extension. Well, what I'm going to be outlining will make possible another approach, an indirect approach, for selling the idea of cryonics, because the conclusions that make cryonics seem reasonable fall out of the broader field of nanotechnology. The field of nanotechnology turns out to raise more **conventional** sorts of life-and-death issues, such as avoiding getting killed as opposed to avoiding aging and death. Since it raises these issues, it's full of hooks that grab people, interest people, and that don't **directly** have anything to do with cryonics or life extension. But it turns out that the set of ideas they've become interested in involves radical life extension as a natural consequence. So, we have an indirect approach to the idea. Military strategists will tell you that indirect approaches are a marvelous thing and some military strategists will also tell you that they apply to the world of the mind.

I've decided to structure my talk in a way that illustrates this. The first segment will be on nanotechnology in general and I'll say nothing about life extension. In the course of this, if you imagine that you didn't come to a life extension conference and instead were interested in space, computers, the future, technology, science, and so forth, I think you'll find a bunch of things that are just intrinsically interesting. In the second section, I'll discuss some of consequences for life extension. In the third part I'll talk about how this applies to cryonics.

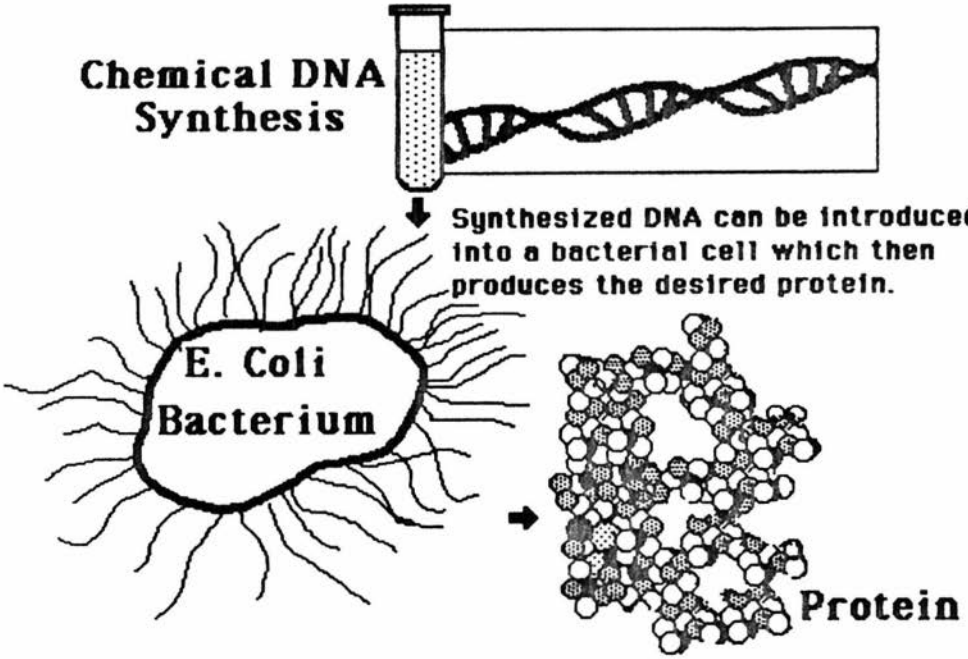


The first part is about nanotechnology. I've given several of these talks lately to space audiences, and in them I'll say, "Well, scenarios for future space development spread across these decades, and NASA says they might give you a better space shuttle here, and a space station there, and a better deep-space transportation system here." And this makes up the conventional scenario for space development that doodles off into the middle decades of the next century with us just beginning to get a real toehold for civilization in space.

And then I proceed to say to them, "Ah! But there are things that we can foresee right now that will change that scenario." (I talk about this to soften them up a little bit, and because it turns out to have relevance to nanotechnology and how fast it will advance.) Then I say a few things about computer-aided design and robotics and computer-aided manufacturing and automated engineering. I discuss how efforts like the Strategic Computing Initiative (which is having almost a billion dollars poured into it) and the Japanese Fifth Generation Project will combine with industrial computer-aided design to give us machines which will help us design things more swiftly. And robotics will give us machines which will help us build the things we design. I then say, "Well, this takes this future scenario (trailing off across the decades) and shortens the design cycle times and smashes the whole thing down to a fraction of the time." And then I argue that probably out around 20 years, plus or minus 10, is when this "crunching factor" will start.

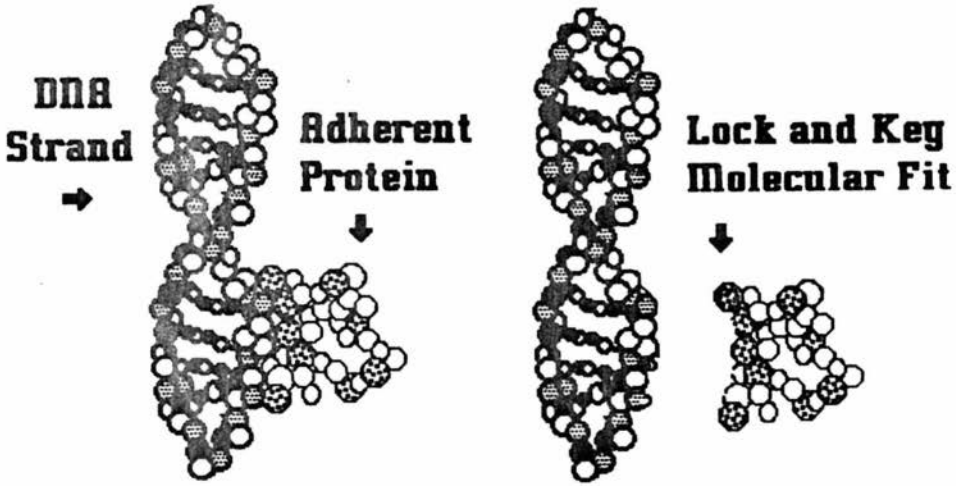
And then I say to them, "But this all relies on very conventional technology. It's just putting together widgets and materials we already know about in new ways, using no fundamentally new **kinds** of hardware. But there's another revolution brewing, which **is** going to lead to new kinds of hardware. Computer-aided design is going to speed **this** revolution as well, and that revolution lies in the area of molecular technology."

I then ask them to put on the first slide [DNA slime being pulled out of a beaker]. This rather disgusting looking substance is DNA. People now know how to make DNA molecules of any sort you want. You type out the sequence of nucleotides you want in your DNA molecule, you go to the gene synthesis machine, make little segments that correspond to the parts you want, patch them together, and (with sufficient time and money), make any kind of DNA you want. But why



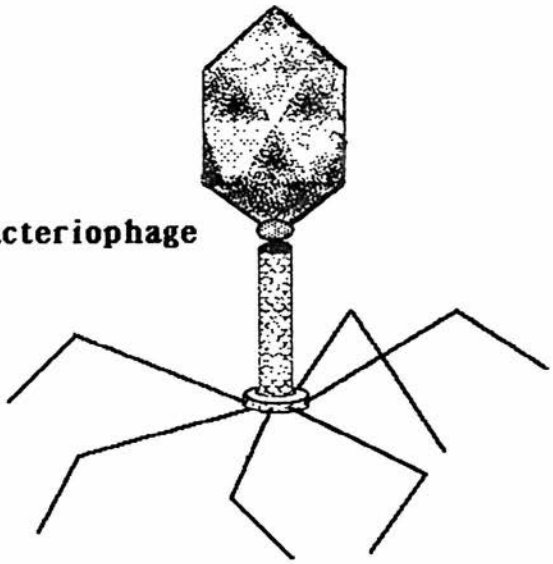
bother? DNA isn't good for anything directly. But what you can do with it is to put it into this appetizing-looking substance here [slide of tan paste on a spatula] which is a solid mass of **E. coli** bacteria, the result of running a whole bunch of culture media through a centrifuge. You can program bacteria with your DNA. The DNA gets transcribed to RNA, the RNA gets fed through molecular machines called ribosomes, and then a molecular matching process leads to synthesis of ever-longer protein chains, a bunch of amino acids stuck together to make a unique protein sequence. This sequence acts like a numerically-controlled machine tool, where you feed in a "tape" (DNA) which directs the manufacture of a "thing" (protein), a chain of amino acids which in fact folds up to form an object of a particular size and shape, with particular mechanical and other properties.

This picture represents a small protein adhering to a DNA molecule at a specific location, and in a very specific way. Their bumps and hollows match and the pattern of their electrostatic charges match—where there's a positive charge on the DNA there tends to be a negative charge on the protein. "Lock and key" is one analogy often used to describe this kind of molecular fit. What this illustrates is that if you can make these molecular objects, you can also get them to stick together in specific, controlled ways. If you make them right, they will stick together right.

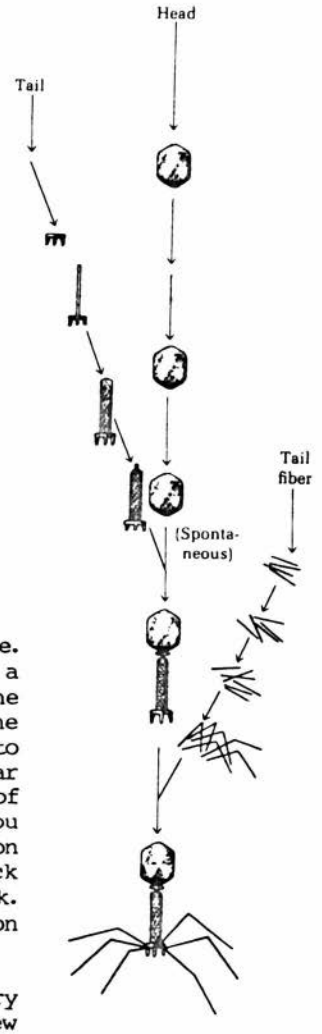


This is illustrated even more dramatically by this, which looks like something out of an industrial small parts catalog, but which is, in fact, a virus. This is a T4 bacteriophage. All of the structure that you see here is made up of protein molecules. The head contains DNA. It turns out that you can take these things apart into subunits and the subunits will reassemble. In fact, you can take them apart into their constituent protein molecules, and these proteins will self-assemble in solution. You put them together in a test tube under the right conditions, shake them up, and you get assembled subunits. You take these subunits and put them together in the right sequence, shake them up, and you find the pieces of molecular hardware self-assembling out of solution. The pieces go together to form a **working** infectious virus particle.

The virus is a piece of molecular machinery. The tail fibers can recognize



T4 Bacteriophage

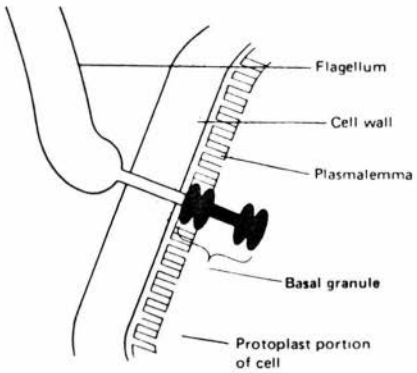


Self Assembly of T4 Phage

the surface of a bacterium and grab onto its surface. This "end-plate" comes down to the surface, it cuts a hole through the cell wall of the bacterium, the sheath collapses, this part gets jammed into the bacterial wall, and the DNA molecule is injected into the cell where it proceeds to take over the molecular machinery of the cell, directing it to produce more of these damn viruses, and then the cell bursts and you have more of these viruses around, and pretty soon they're all over the place. (Since they attack bacteria, this illustrates that even germs get sick. This is, perhaps, somewhat heartening, depending on your perspective.)

What this next slide illustrates, in a very simple and direct way--just by pointing to a few things in nature and then picking up a few other examples here and there--is that there are a wide range of molecular devices which are found in nature. Molecules have a size, a shape, a fairly well-defined surface, mechanical properties, and a distribution of mass. They can act as moving parts. The connection between two segments of a molecule, if made with the right kind of bond, lets them rotate quite freely; it turns out that a sigma bond can make a good rotary bearing. If you examine how bacteria manage to swim through water despite the fact that they're basically just little rigid boxes, it turn out that the little rigid box has, coming out of it, a little rigid corkscrew. And at the base of the corkscrew, where it meets the box, there is a device that turns out to be a reversible, variable-speed motor that drives the corkscrew as a propeller. Enzyme systems, which pass molecules from one enzyme to another by diffusion, act as production lines;

a sequence of operations by machines takes thing apart and puts things together and ends up with a molecular product. What all this shows is that there is a path that leads to molecular machinery, a path that involves learning to design protein molecules. Other paths seem possible. But this one is easiest to explain. And, because of the wealth of natural examples, it leads to a solid case for the feasibility of molecular machines.



Bacterial Flagellar Motor

If you look at the genetic system--including the ribosomes at the far end of it which actually produce the proteins according to the instructions that ultimately come from the DNA--it can be described as a numerical control system much like the early numerically-controlled machine tools developed in the 1950s. So, on a molecular scale, we find all sorts of machines. What this shows is that there is a path that leads to molecular machinery in which we learn how to design protein molecules.

In fact, we can make any protein molecule that we want right now, it's just that we don't know which ones to want. If you ask for a specific amino acid chain, a genetic engineer will say, "Okay, we know how DNA directs the construction of proteins; we'll just synthesize a DNA molecule that will direct the synthesis of this amino acid chain. We'll make that DNA and stick it in a bacterium, and we'll get what we want." The only problem is that, unless we design it properly, it'll fold up into some shape that isn't what we want. Getting these things to fold up in a very specific way is something that has not been tried much until recently, partly because biochemists were confusing science with engineering—confusing the problem of predicting natural folding with that of designing something that will fold predictably.

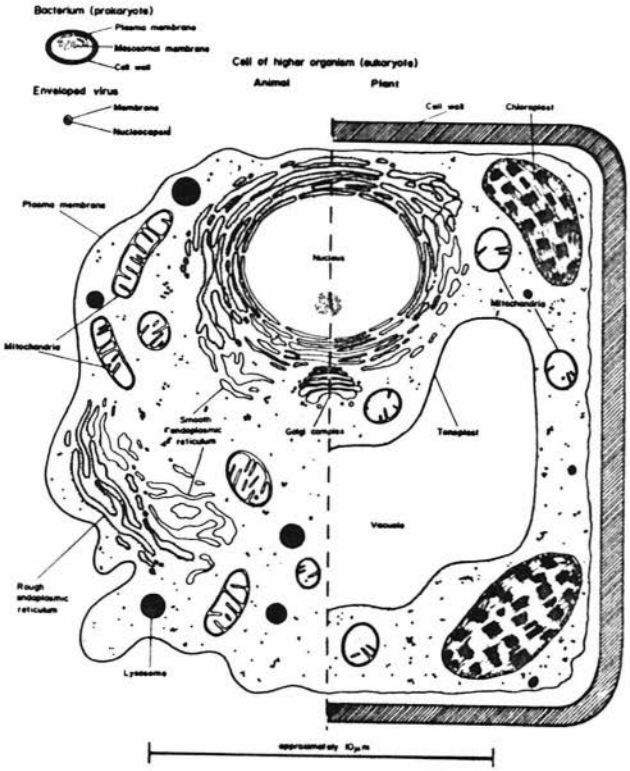
But progress is being made and there have been a number of review articles lately that talk about enzyme engineering, the steps that have been taken in that direction, and what the prospects are. The people in the field are saying, "How long will it be before we're able to design protein molecules from scratch—10, 15 years? Perhaps not that long." That's a close paraphrase from a review article that appeared in Applied Biochemistry and Biotechnology a couple of years ago, authored by a researcher at Genentech.

So people are learning protein design. When we get good at it, this will enable us to build protein machinery. We'll be able to make the sorts of things we see in the cell, including complex machines. But instead of relying on an evolutionary mechanism based on random mutations to produce things, we'll be using an evolutionary mechanism in which engineers vary and select ideas in their heads, come up with plans to design pieces that fit into the overall concept, then get everything together, debug it, and make it work. So we can build kinds of molecular machines that won't happen in nature—say, a miniature player piano, for example. (It won't sound like a piano, but it could go through all the motions!) Charles Babbage, in the middle of the last century, came up with an apparently workable design for an entirely mechanical computer--

a programmable computer, all out of brass and gears. Well, you can also make mechanical computers on a molecular scale, though you probably won't want to make them out of proteins.

Once you have any kind of molecular machine that does a half-decent job at taking reactive molecules and bringing them up to a surface in a controlled position and orientation, then you're in a position to make reactions happen just where you want them. Today, chemists must shake a bunch of stuff together in a liquid. The molecules diffuse around and bump every which way, making it difficult for chemists to get reactive molecules to stick together in complex patterns. But with molecular machines, we can avoid these problems by just putting reactive molecules in the right place and thereby getting control over the three-dimensional structure. All the unit operations required are demonstrated by enzymes, and by organic chemists; we're just controlling where they happen by positioning the molecules better.

In this way, we can use these protein machines to make other machines, better than protein machines, that don't burn easily, or that don't have to operate in water, or that are as hard as diamond. These machines, in turn, will be able to assemble **almost** anything. That is, if you design a pattern of atoms such that all atoms look like they're pretty happy locally--so that a chemist would say, "These atoms are bonded in a reasonable way"--then (with some exceptions that don't seem to be important for engineering purposes) you should be able to make molecular machines manipulate molecules and assemble that pattern of atoms. And **this** will be a fundamental breakthrough.



Some relative sizes of naturally occurring molecular machines. A T4 bacteriophage is approximately 100 times smaller than the bacterium shown here.

In the past, we have either used materials built by the molecular machinery in nature (things like wood, leather, and so forth), or we have taken a bunch of rocks or other materials, and pounded them, mixed them, cooked them, or stretched them, and ended up with things like metals and plastics. But when you look at the typical plastic do-hicky, it's not a particularly clever object when you consider how many atoms it has in it and how

little it does. When we eliminate the constraints of traditional manufacturing methods, we'll be able to do much better.

Some steps have been taken on this path--here is a book [slide] that was published as the proceedings of the First International Workshop on Molecular Electronic Devices, sponsored by the U.S. Naval Research Lab. There was a second such conference where I presented a paper—the proceedings on that will be published this fall. There is good reason to believe that you can make pieces of matter patterned on a molecular scale, to make molecular electronic devices. That will bring circuits to their ultimate limits--and you can make them fast and with low power dissipation.

The British magazine The Economist a couple of weeks ago reported that the Japanese have put $30 million into a molecular electronics program. This is the same technology base that is needed for molecular machines. A company called VLSI Research, Inc. also reports that about half a dozen other Japanese companies have "a full-scale research program in the area." So, interest is serious, progress is being made, people are designing proteins, they are working on molecular electronics, and it all leads to molecular machines.

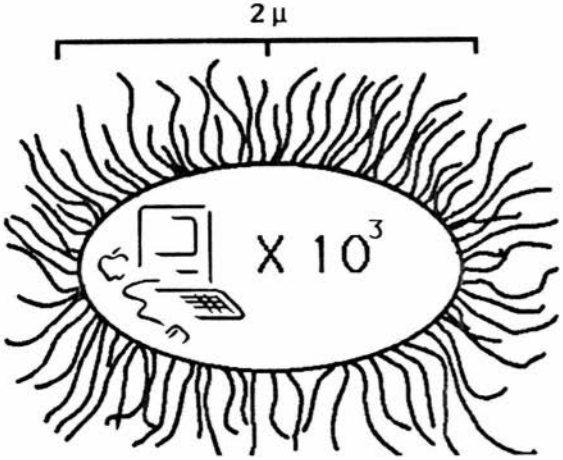
So we face a really fundamental breakthrough in technology—to be able to build things on a molecular scale and structure things to atomic precision. What are some of the consequences of this? Well, off hand, you'd expect there'd be a **whole lot** of consequences because everything around us is made up of matter, and because the way atoms are arranged makes a big difference. The difference between a chunk of coal and a diamond is in how the carbon atoms are arranged. The difference between a healthy cell and a cancer cell lies in the way a very modest number of atoms are arranged.

These machines that are able to build almost anything need a name--call them **assemblers**. One of the things they can build, since they themselves are patterns of atoms, will be copies of themselves. So assemblers lead directly to **replicators**. In evolutionary terms, creating assemblers is like reinventing the ribosome. It will give us a new programmable molecular device that can make much more general sorts of structures than were possible before. We will have molecular machines that can copy themselves—much as bacteria can, but without the ecological constraints faced by bacteria. That is, **potentially** without those constraints. You can give them different constraints. You can have them do useful things, like replicate a ton of them—starting with one—which takes a matter of a day or so. Then, if each one of them incorporates a nanocomputer (I'll get to nanocomputers shortly), you can program them to team up and build something else for you. Such as a rocket engine whose structure, instead of being made out of metal, is made of a diamond-fiber composite with tens of times the strength-to-weight ratio of metals, and therefore, much higher performance. Such as a lot of other things also--super-strong materials, lightweight refractories, miniature components, all sorts of materials and devices with space applications.

Regarding nanocomputers (which will turn out to be very relevant to what I'm **not** discussing right now, but will shortly), it's easy to find a lower bound to what you can do with molecular machines to improve our ability to do a lot of computation in a tiny volume. A chip today can be seen as a slab that has a certain thickness of active material and an area about a centimeter on a side. If you look at chips (of a few years ago, at least), they had typical line widths of about three microns (three millionths of a meter). If you look at

molecular mechanical computers, instead of transmitting signals down thin wires, you're transmitting them down even thinner rods. You push and pull them, or send vibrations down them. It's a tin-can telephone approach to signal transmission. The best rod material consists of chains of carbon atoms, alternating triple and single bonds, called carbyne. The rods are about three **angstroms** in diameter, compared to three **microns** for wires on chips. The ratio of angstroms to microns is ten to the fourth in linear dimension; in volume, you have to cube that, giving us a factor of ten to the twelfth (a trillion).

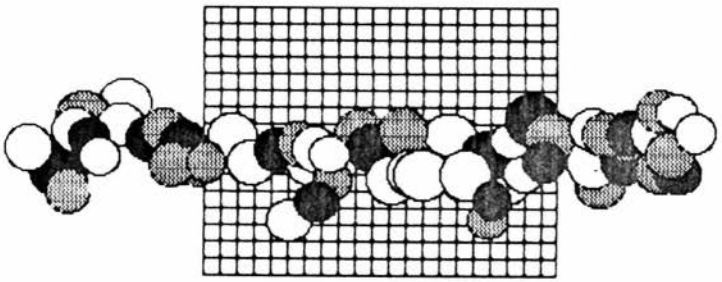
This seems to be a reasonable approximation. Even more detailed examinations give ratios within 50% of this figure. So you'll be able to shrink the active volume of a chip-equivalent device by a factor of a trillion. And, because you're not limited to "spraying" features onto surfaces, you can make this device in the shape of a little block. It turns out, if you run through the numbers, that you can make something that's about the equivalent of the processor in the Apple Macintosh and put it in a volume that is somewhat less than one-thousandth of a cubic micron. So you're talking about being able to put on the order of 1000 Motorola 68000 CPU's in the volume of a bacterial cell. And a bacterial cell, in turn, is about a factor of one thousand smaller than a human cell. So we're talking about being able to put roughly a million microprocessors in the volume of a cell (if you leave no room for anything else).



"So you're talking about being able to put on the order of 1,000 Motorola 68 000 CPU's (the processor in the Apple Macintosh) in the volume of a bacterial cell."

END OF PART I

Science Updates by Thomas Donaldson



HOW TO ENGINEER MOLECULES

A few months ago, I reported in CRYONICS some of the clever methods biochemists have worked out to insert genes into living people. So far, these methods are only experimental, but they're still both clever and fascinating, particularly for cryonicists.

If we intend to manipulate matter in bulk on a molecular scale, we'll need many more tools than those we now have. The scale on which we would operate is much smaller than that which electronics companies use with microelectronics. Enzymes work like machines, but they're so small that even a microscope is far too crude to see an enzyme. Genetic engineering is most important not because of its immediate benefits (practically speaking, not nearly so tremendous as public puffery claims) as because it's a very important new tool to manipulate molecules.

A recent paper in NATURE (314, 642-644 (1985)), far less spectacular than genetic surgery on man, gives us some more thoughts on how we can modify molecules. An international team headed by D.A. Hopwood from Norwich, England, with others from Ohio State, in the US, and in Tokyo, Japan, has just presented an account of **molecular engineering of drugs.** The problem is that genes don't make most biochemicals directly. Instead, these chemicals result from a process of synthesis using **enzymes** made by these genes. Most forms of genetic engineering to date operate not by designing new reactions with new enzymes, but simply by inserting a single gene in a foreign cell, where it makes the same old enzyme as before.

These scientists obviously worked on antibiotics because of their possible immediate use. Most antibiotics aren't made directly by genes, but rather result from **metabolic pathways** created by many genes interacting. The team used techniques using plasmids to insert new genes into the host cells. This time, they managed to insert the entire sequence of genes involved in the synthesis of one antibiotic, **actinorhodin,** into another strain of bacteria.

If a bacterium already produces an antibiotic of one kind, and receives in addition the genes necessary to make another different antibiotic, the processes MAY interact to make something totally new. These scientists transferred the machinery to make actinorhodin from Streptomyces coelicolor to another bacterium, Streptomyces violaceobuber.

This hybrid bacterium did make a new antibiotic. The authors name this chemical **dihydrogranatirhodin.** They could show that this molecule had a structure melded together from that of granaticin and actinorhodin, the two separate molecules made by the original parent strains.

Genes are one thing, but transferring and redesigning entire metabolic pathways is a far deeper innovation than gene transfer. Genes are important only because they produce the enzymes which guide and regulate the workings of our cells. We want the **results** of this guiding and regulating. We have a long way to go before we reach the stage in which we can design the metabolism of an entire creature. This recent article in NATURE is interesting because it begins to study means for such redesign.

Guides For Growing Nerve Cell Fibers

When any mammal grows from a single egg, it develops a whole complex nervous system to a quite precise design. The problems of knowing how to repeat this design for repair, and knowing how it arose in the first place, are very close. In fact, the entire process of development is one of the major commonplace mysteries. The fact that it's so common can blind us to the fact

that we almost totally lack understanding of the process!

Recently, several papers have appeared exploring the different factors which may guide nerve cell growth. In NATURE (315, 409 (1985)) Friedrich Bonhoeffer and Julita Huf study whether or not nerve cells can have an inborn "preference" in how they grow. They studied growing optic nerves in culture. They set up an experimental system in which a growing nerve fiber could choose to grow either towards nerve cells of one type (in one arm of a Y-shaped chamber) or towards nerve cells of another type (in the other arm). The two different types of nerve cells were cells from the temple half of the chick retina and those from the nose area.

It turns out that optic nerves from the temple area will try to grow towards the arm containing similar cells. Optic nerves from the nose area didn't distinguish.

This experiment tells us that at least one of the factors guiding growth of nerve cells is a preference coded in their own genetic structure.

In a second paper in NATURE (315, 406 (1985)) Seth Blair and others at the University of Washington report work on another system in which they could piece out different factors guiding growth. This system is the wing of the fruit fly. Previously, at least two different cues were thought to guide directions of nerve cell growth. The first of these is mechanical. The wing forms channels which may guide growth. Blair and his colleagues split these channels, but the nerve cells could still send fibers to the right locations anyway. Secondly, the nerve fibers may grow toward particular nerve cells, using others as guides. Destroying these guide cells also does not destroy the ability of the nerve cells to send their fibers to the right location. That's not the whole story, however. The growing nerve fibers use more than one nerve cell as a guidepost. If one is missing, they follow the other farther ones. Destruction of all guideposts leads to disoriented growth.

As yet, our understanding of how our bodies guide nerve cell growth remains very primitive. We haven't even got chemical characterizations of the different growth factors. Beyond that, we need to know how they influence the cells. It is still all a great mystery. The practical effects of understanding these processes would be profound, making possible cures for many injuries and control over all growth and development.

Neural Transplants: Their Prospects

Several years ago, scientists began looking seriously at transplants of brain tissue as a way to repair injuries and aging damage in the brain. Since the leading source of transplant tissue (at the time) would be aborted human fetuses, even LOOKING at transplants caused a lot of unease. Many scientists denied any practical possibility of brain transplants in human beings (a transparent manuever!).

Quite recently, in **NEUROBIOLOGY OF AGING** (6, 131-150 (1985)) three neurologists from the University of Rochester, D.M. Gash, T.J. Collier, and J.R. Sladek, have presented a review of neural transplant experiments with explicit discussion of the prospects for applying them to man. Their review is 19 pages

long, followed by at least two times that number of pages of commentary from all their "peers" about their paper. It's clear that even raising the possibility causes a lot of anxiety. While many of these commentators couched their papers in the form of scientific and medical objections, I personally believe that those objections weren't the real concern at all.

This work would interest cryonicists for two different reasons. First, it's evidence that eventually we WILL repair brain damage. Even in the worst case, with no cells harvested from fetuses, we should **eventually** be able to make brain tissue in vitro for transplant. Secondly, a need for nerve tissue transplants must mean a need for nerve tissue storage, hence freezing, hence a great increase in our ability to freeze and store brains.

The authors make several points that are relevant to us. First, they claim that practical difficulties may prevent transplants from fetuses. (Coming from proponents of transplants, this point has a lot of weight.) The reason for this is that a nerve tissue graft must come from an embryo at certain precise times in order to survive and grow in the recipient. We couldn't just harvest random fetuses for their brains. Right now, we don't know these critical times for human tissues. The time constraints COULD (not necessarily WOULD) make fetal transplants impracticable.

Second, we have alternate sources. Nerve tissue from the **peripheral** nervous system (nerve cells from outside the head and the spinal cord) will survive transplant. This need not come from fetal donors. It's then possible to get consent from the donors or their legal guardians. The political problems of fetal donors wouldn't cause trouble. Furthermore, it's also possible to produce transplantable tissue from cultures of cancerous nerve tissue. Since these cells are cancerous, they will divide without limit and harvesting them is easy. Apparently it's also known how to **reliably** fix these cells so that they'll stop dividing and won't induce cancer in the host. Cultured cells have lots of advantages for transplants since they avoid all the cumbersome logistics involved in transplants. On the other hand, as cryonicists we would LIKE doctors to deal with this cumbersome logistics problem as much as possible, since that means so much more effort for freezing research.

An interesting side issue, which shows how science REALLY proceeds, is the historical review included in the article. The authors found references on nerve tissue transplants as far back as 1890. In 1917, E.H. Dunn reported well documented success with brain cortex grafts in newborn rats! (J. COMP. NEUROL, 27, 565-582 (1917))

In any case, the subject of nerve tissue transplants in aged and brain injured subjects has come out of the closet. This is a real forward step in repairing brain injury and may be a forward step for brain freezing too.

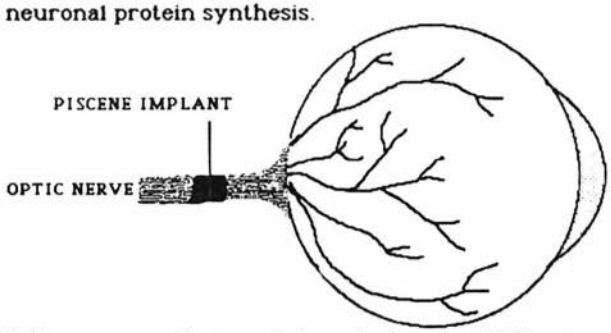
Nerve Cell Generation and Regeneration

Many scientists all over the world are now actively studying nerve cell regeneration and repair. Behind this study, of course, we need to understand the factors which guide neurons in their normal growth. Scientific activity on these questions has become very heavy, and observers can feel that some breakthrough is imminent, not just in understanding but in actual treatment.

Unfortunately, as yet no such breakthrough has happened. However, several significant papers have recently appeared. Our understanding of this problem is certainly growing.

Two recent papers have presented data which helps to specify some exact chemical factors which promote and guide growth of nerve cells. In SCIENCE (228, 600-603 (1985)) a team of researchers headed by M. Schwartz at the Weizmann Institute in Israel present their work showing that the nervous systems of fish produce a chemical factor which promotes nerve cell repair even in mammalian nerve tissue.

Transplanting segments of regenerating fish optic nerves into injured rabbit optic nerves resulted in an increase in neuronal protein synthesis.



Unlike mammals, fish can repair brain damage. These experimenters cut the optic nerve of rabbits. They then transplanted segments from regenerating fish optic nerves into the cut optic nerves of their rabbits. This treatment didn't cause repair of the severed optic nerves, but the transplant did cause an increase in protein synthesis in the injured rabbit nerves. Compared to uninjured rabbit nerves, cut nerves usually show a **decrease** in protein synthesis. Nerves so treated also showed increases in specific proteins, some with molecular weights similar to proteins made by a fish nervous system during repair.

Schwartz and his coworkers also looked at rabbit retinas in culture. The same kind of transplant from regenerating fish nerves would cause rabbit retinas to grow new branches.

Other work has shown that it's not the nerve cells which make these chemicals, but other cells in the fishes' nervous system (M. Schwartz et al, BRAIN RES, 272, 237 (1983)). It would be very useful to characterize these substances. Schwartz and his colleagues feel that their experiment shows that failure of regeneration in mammalian nervous systems happens not because the cells lack ability to regenerate, but because their **environment** fails to promote it.

A second paper by A.R. Schonfield and others, in BRAIN RESEARCH (336, 297-301 (1985)), also studies chemical factors which may promote nerve cell regeneration in mammalian cells. After several years of work, neurologists have identified several different chemical factors which promote survival and growth of nerve cells in culture. Schonfield and his coworkers did experiments to see if any of these chemical factors might also promote growth in injured nervous tissue in a living animal.

They invented a simple system to test for this ability to promote repair. They implanted the iris of an eye into the hippocampus of rats, together with a small tube through which they could inject these chemical factors. They then treated groups of their rats with the different cellular factors.

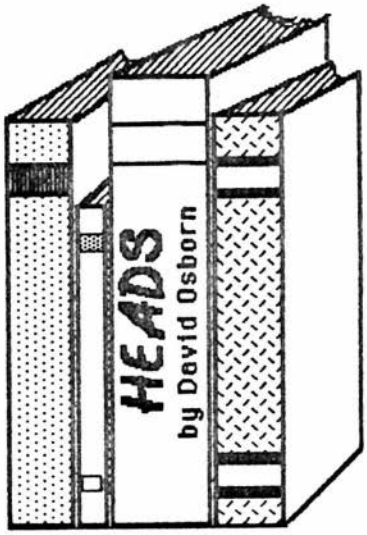
None of their growth factors has any chemical characterization. Basically, they are obtained from fluids in which various types of cells had grown.

Previously, Schonfield et al reported an experiment of this sort (A.R. Schonfield et al, BRAIN RESEARCH, 229, 541-546 (1985)) with medium in which chick embryo hearts had grown (HCM: heart conditioned medium). This medium contains two different chemical factors which promote neuron survival in culture and outgrowth of nerve fibers in chick nerve cells. Giving this medium to their rats for one week would stimulate growth of nerve fibers onto the iris.

They have now tried similar experiments with two new media. One is "ciliary neurotropic factor" (CNTF), a mixture of proteins from chick eye tissues. This factor promotes the survival of chick embryo neurons in culture. The second is "polyornithine-binding neurite promoting factor" (PNPF) from media in which rat cancer cells have grown. This mixture promotes nerve fiber growth from cultured neurons.

These two factors had different effects. CNTF stimulated the sprouting of nerves into the injured hippocampus tissue. PNPF had no effect.

Schonfield and his coworkers suggest that the different effects of these two factors may tell us something about nerve cell repair in general. CNTF promotes survival of neurons, while PNPF promotes their growth. The failure of PNPF to help regeneration may tell us that cell death after injury happens because injury removes a chemical which normally supports cell survival. By now they report considerable progress in purifying these factors. We may expect a lot more on this subject in the near future.



Book Review: Heads

(David Osborn, Bantam Books, 1985)

Review by Bob Abernathy

From the prologue (with editing for brevity):

The dying man had an IQ of 138, a master's degree in

social anthropology, a doctorate in political science. He was going to leave behind a wife of twenty years and two daughters in their teens. He fitted perfectly their research needs.

"What would you say if I offered you a better-than-even chance to live at least another two or three years? Do you understand me? We are quite certain we can keep you alive. If you agree to this, you won't be able to see your family again. Or current friends. Ever. You will have donated your 'remains' to science and they'll be told you died and will be given a sealed coffin."

"When would it happen?" he asked. "Is it surgery? or what?"

"Some of it is surgery," she replied. "And if we do it at all it's got to be immediately, tonight."

Something hard like iron grabbed at his heart. Tonight? No! It was impossible. He tried to think. Death was right there. A dark presence just by his bed, the awful terror of not being anymore, the black non-knowing forever. No words could describe it. Every dawn now he poured sweat and stifled screams. And prayed for a coma. He didn't want to know the final moment.

He said, "Whenever you want."

Michael rose. "We'll be back in an hour."

The warm pressure of his hand, his quiet smile. The door closed behind him and Katherine Blair.

It was done. Minutes ago there'd been nothing but the black despair of inexorable injustice, the inevitability of death. Why? Why him? Now, suddenly, there was hope. He stared at the dark rectangle that was the night window of his room. It was as though death had been sent to wait outside. He ceased thinking about others, then. He began to think only of himself. He didn't have to die. He might live. He just might. He felt as though a miracle had happened.

Pretty soon, some nurses came with a stretcher to take him away.

So starts the novel Heads, a curious mixture of contradictory sentiments about a number of issues relevant to life extension in general and cryonics in particular. As most readers may be able to guess (and the cover and book title certainly provide ample clues to the uninitiated), Heads is about the "Platt option" (if ALCOR East member Doug Platt will allow us to use his name to coin a phrase): the detachment of one's head shortly before the otherwise inevitable onset of death and the indefinite maintenance of the head on a "console" (as it

is called in the book) which supplies all of its biological needs.

Obviously, this is a great idea in principle and we, like the character in the prologue, would snap it up in a second given his circumstances, all other things being equal. Interestingly, as the above example of writing suggests, the author of this book seems also to be aware of the positive aspects of this option. But in writing a novel which would have a broad appeal to the average member of the reading public, Osborn gives his audience what it likely wants by twisting plot circumstances in such a way as to maintain as sinister an atmosphere as possible, enticing the reader to associate a kind of faint, undefined terror with this option in order to provide a cheap thrill. The conflict between the good aspects of what might be called "neuro-maintenance" and its supposed macabre aspects is resolved in the end only by resorting to unlikely and even outrageous literary devices. With such tools, Osborn brings the story to the kind of a conclusion which would please the angry villagers from a Frankenstein movie. It probably **won't** please many cryonicists.

The book is set in Washington, DC, an area Osborn obviously knows intimately. The main character is Susan McCullough, the live-in girlfriend of tall, lanky genius John Flemming. Flemming is the youngest person ever to direct the University Hospital Brain Research Laboratory and a man already mentioned as a possible Nobel prize candidate for his work on neurometrics, a computer-based system for diagnosing brain diseases. The two have a model relationship which, ironically, contributes to their discovery of the secret project run by John's brilliant colleague, Michael Burgess, at the Borg-Harrison Foundation.

On the way home from a neurobiology meeting in Baltimore, John's concentration is dulled by a combination of fatigue and distracting thoughts about Susan, and the result is a terrible car accident which burns up most of his body but spares his head. Against his will, his head is removed and transferred to a console, thereby saving his life but also allowing Burgess to make use of John's considerable talents. It seems that Mike Burgess' work with his "experimental cerebrals", or "EC"s, as they are referred to, involves accelerated learning and improved abstract thinking. Already remarkable results have been obtained, but the results are not good enough to satisfy the high-level powers that be within the Foundation or their various contacts within the federal government. Mike needs John's genius to force more performance out of the ECs to please the board members and save his project.

It turns out that John, meanwhile, is secretly using his computer to find a way of blowing the whistle on the whole, highly classified project. When Susan joins the Foundation and discovers John's condition, the rapidly building tension in the story leads to the decision to make her into an EC to keep her quiet. We won't reveal how the story ends, but lovers of poetic justice will not be disappointed.

Technically, the book is good but not perfect. Osborn obviously has considerable knowledge of operating room paraphernalia and medical terminology, but there are some notable flaws. He never makes any reference to the work of Robert J. White or other real-world researchers who would have logically had a major role in making the head project technically possible. He consistently uses the word "profusion" when he means "perfusion"; he refers to the use of an "operating electron microscope" (give us a break!) during the decapitation operation; he refers to the "arterial and venal (!)" systems at one point; pH is

for some reason changed to p with a superscripted small h, with the notations for blood gasses similarly flawed; pain centers are referred to as pain "receptors".

Literarily, the book is reasonable and readable, but not perfect. Michael's character and that of his "right hand woman" and occasional lover, Katherine Blair, are not well developed, but perhaps this is natural considering that they were the heavies in this tale. Several other characters seem similarly shallow and placed in the story either to move it in the appointed direction or to entertain the reader with various sexual encounters. (Although the sex was often gratuitous and was not always very realistic, it was indeed entertaining.)

Near the end of the book, the following passage appears:

"The EC's pathetic and frightening madness served to snap Susan forcefully back to reality. The research program was an obscenity. John and the other ECs lived an existence of horror. And Michael had suddenly become a man who reduced human beings to howling things. The Dr. Frankenstein who had, in his quest after science, sacrificed his own humanity."

And yet, for all this nay-saying, this book may be a good example of the kind of disguised drive to immortality postulated by Alan Harrington to explain much of human action, just as most Frankenstein movies seem to be. That is, the downfall of the quest for life extension (whether this quest is consciously defined as life extension or not) is brought about not by any inherent problems with the quest per se but by a series of unfavorable circumstances or tragic flaws. In this case, it is in fact interesting to notice just how hard Osborn had to work to make his book into a horror story: he had to contrive the head project as an unlikely, nonhumanitarian research venture, and what little "horror" there was in the book was overwhelmingly due to the way the heads were treated or the way Susan was treated, rather than being due to the existence and nature of the heads themselves. As in Frankenstein movies, the unfortunate situations contrived in Osborn's book in the end allow the deathists to have their way in practical terms in the short run, but fail to invalidate the quest for life extension in principle; thereby they leave the reader with enough food for thought to encourage those of us who want to live.

If you need some reasonably entertaining light reading, Heads would not be the worst choice you could make.

Kudos For Laura Branigan

Every great, great once in a while you hear or see a piece of artistry that touches something so deep inside you it sends waves of chills over you and leaves you shaken and covered in gooseflesh. The last time this happened to me was around 1974 when a song called "Air Disaster" by Albert Hammond and M. Hazel Wood hit the charts and made it into the top 10. "Air Disaster" was the first, and until recently the only, openly immortalist song I'd ever heard. After discussing the myriad ways people die, including the the so-called natural aging process it concluded with the refrain "I don't want to die for no good reason—I just want to go on and on."

Music Review: Laura Branigan's "FOREVER YOUNG"

Reviewed by Mike Darwin

Now Laura Branigan has added another work to the slim folio of immortalist song and verse. Her latest album, "Hold Me," includes a song entitled "Forever Young" which begins--I first thought—as a protest against the nuclear stalemate. It is not. Branigan cleverly uses the apprehension and uncertainty created by our awareness that life could end arbitrarily at any moment due to nuclear annihilation to set the mood, and then builds on that to introduce us to the real problem:

"Let us stay younger
Let us live forever
We don't have the power
But we never say never.

Sitting in the sandpit
Life is a short trip
The music's for the sad man...

Forever young
I want to be forever young
Do you really want to live forever
Forever and ever?

Some are like water
Some are like the heat
Some are a melody
And some are the beat
Sooner or later they all will be gone
Why don't we stay young?

It's hard to get old without a cause
I don't want to perish like a fading waltz
Youth like diamonds in the sun
And diamonds are forever.

So many adventures wouldn't happen today
So many songs we forgot to play
So many dreams waiting out in the blue
Will never come true.

Forever Young.....

Branigan dissolves this poetry in the strong spirits of a plaintive melody that is both deeply sad and deeply hopeful. The music has a haunting edge reminiscent of the cry of a caged wild animal filled with longing, filled with sorrow.

In "Forever Young" and her skillfully crafted previous hit "Self Control", Laura Branigan has told us a little of the cages that have held, and hold her. Unfortunately, the rest of "Hold Me" fails to communicate as effectively as "Forever Young". Branigan needs more variety of sound and to pace herself better--"Hold Me" is just too monotonous as it stands.. Still, even leaving immortalism aside, one could do far worse on today's pop music market than purchasing a copy of "Hold Me".

DECEMBER, 1985 - JANUARY, 1986 MEETING CALENDAR

ALCOR meetings are usually held on the first Sunday of the month. Guests are welcome. Unless otherwise noted, meetings start at 1:ØØ PM. For meeting directions, or if you get lost, call ALCOR at (714) 738-5569 and page the technician on call.

ALCOR

ALCOR LIFE EXTENSION FOUNDATION

4030 NORTH PALM #304
FULLERTON, CALIFORNIA 92635
(714) 738-5569

The DECEMBER meeting (Annual Turkey Roast) will be held at the home of:

(SAT, 7 DEC, 1985) **(FIRST SATURDAY)**

Brenda Peters
8150 Rhea
Reseda, CA

DIRECTIONS: Take the San Diego Freeway (Interstate 405) north into the San Fernando Valley, to Roscoe Blvd. Go west (left) on Roscoe 3-4 miles. Rhea is 2 blocks past Reseda Blvd. Turn south (left) on Rhea, which has a geodesic dome church on the corner. 8150 is the second house in the second block, on the left.

The JANUARY meeting will be at the home of:

(SUN, 5 JAN 1986)

Hugh Hixon
289 Cerritos Avenue
Long Beach, CA

DIRECTIONS: Take the Long Beach Freeway (State 7) to Long Beach, and get off downtown at the Broadway exit (goes east). Continue on Broadway to Alamitos, where Broadway turns into a 2-way street. Bearing to the right, continue two blocks on Broadway to Cerritos and turn north (left). 289 is in the old apartments on the SE corner of 3rd and Cerritos.

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