Mark Your Calendars Today!

BioStasis 2000

June of the Year 2000

Asilomar Conference Center

Northern California

Artwork by Tim Hubley

Initial List of Speakers:

Eric Drexler, Ph.D.

Ralph Merkle, Ph.D.

Robert Newport, M.D.

Watch the Alcor Phoenix as details unfold!

Have you ever considered writing for publication?

If not, let me warn you that it can be a masochistic pursuit. The simultaneous advent of the word processor and the onset of the Post-Literate Era have flooded every market with manuscripts, while severely diluting the average quality of work. Most editors can't keep up with the *tsunami* of amateurish submissions washing over their desks every day. They don't have time to strain out the writers with potential, offer them personal advice, and help them to develop their talents. The typical response is to search for familiar names and check cover letters for impressive credits, but shove every other manuscript right back into its accompanying SASE.

Despite these depressing observations, please don't give up hope! There are still venues where the beginning writer can go for editorial attention and reader recognition. Look to the small press — it won't catapult you to the wealth and celebrity you wish, but it *will* give you a reason to practice, and it may even introduce you to an editor who will chat about your submissions.

Where do you find this "small press?" The latest edition of *Writers' Market* will give you several possibilities, but let me suggest a more obvious and immediate place to start sending your work: *Cryonics Magazine*!

letters to the Editor

RE: "Hamburger Helpers" by Charles Platt, "Cryonics" magazine, 4th Quarter 1998

Dear Cryonics Editor:

Charles Platt's article was one of the best essays about cryonics that I've read in a long time. Please relay my compliments on a well written, thoughtful article.

Sincerely,
Allen Alger
email: Alger@alum.MIT.edu

* * *

To The Editor:

Charles Platt, in his excellent article "Hamburger Helpers," says:

"The largest sums of money received by cryonics organizations have been postmortem bequests from people who were already members."

As an economist by training, I would like to make a modest proposal to radically restructure the way Alcor raises money. Most people or successful organizations, having encountered fortuitous circumstances, try to maximize the probability of such an event happening again. Alcor encountered fortuitous circumstances when it received a large bequest from the estate of a television writer, whose name escapes me at the moment. Alcor should logically ask itself if there is a way to make this happen again. I propose that there is.

Alcor should have a sliding fee schedule which is lower if a suspension member has an amount of life insurance above the amount required for suspension. For example, if the suspension cost is $120K, then the yearly dues would decline by, say, $100 for every $100K that the policy payoff amount is above the suspension amount. Example: Policy payoff amount of $220K. Dues of $260/year vs. $360/year (paid quarterly). Funds above the suspension amount would be immediately available for unrestricted Alcor use.

Considerations:

The larger life insurance policy will cost the suspension member more. So it will be in his/her interest to go this route if the greater cost of insurance is more than offset by lower dues. Alcor will receive less dues up front, but down the line will receive much more. One can do a simple present-value analysis (dollars today are worth more than dollars tomorrow, but enough dollars tomorrow are worth more than fewer dollars today). Here's how it works out for the above given example:

Assuming a 50-year old male will die at age 80, then that $100/year stream of money for 30 years is worth $943 in present dollars at a 10% interest rate (being conservatively biased by favoring present-day dollars), vs. getting $100,000 in thirty years, which has a present value of $5,209. Logically Alcor should forgo the income stream for the big future payoff.

At it s extreme, this would imply a dues level of zero for an insurance amount of $300,000 above the suspension amount.

Research into life-extension technologies has been accelerating lately (human stem cells, telomeres, etc.), so Alcor should count on younger members living longer than conventionally predicted. Still, this seems to be a reasonable way to proceed.

One problem might be that everyone decides to forego the dues in favor of higher life insurance. This would mean a zero revenue stream for Alcor, obviously a (temporary) drawback. One way to deal with this would be to allow this option only for new members.

Alcor has received a lot of money recently from life memberships. How does this proposal fit into that method of payment? The number of life memberships purchased indicates that there is a large range of preferences for present payments versus future payments. Thus, it is unlikely that all suspension members would elect insurance-only payment. May I suggest that it would be in Alcor's interest to think of a member's payment type as a portfolio, and that some high-risk, high-return investments would be in order.

I suggested this idea to Ralph Merkle a year or so ago, and he told me that such an idea had been proposed before but rejected. If so, why? Deciding against this idea would appear to fly in the face of both Alcor s actual experience and logic itself.

Sincerely,

James L. Rice
www.angstromtools.com
jrice@real-time.com

The editor comments:

While I wouldn't presume to second-guess the directors of Alcor or any other cryonics organization, as an Alcor staff member I can give you one very good reason why we haven't implemented some version of your plan: my paycheck! *At least to some degree, yearly membership dues pay the daily operating costs of Alcor, including salaries for its staff. Life Memberships have helped to reduce a short-term deficit, but these will not support us indefinitely. (Alcor members may have noticed that Life Memberships started at $10,000 in 1997, jumped to $12,000 in 1998, and are now at $15,000. At that rate of increase, there will be no point in maintaining the Life Membership program too many more years.) In other words, Alcor doesn't currently have enough money to* save *itself money.*

Incidentally, the money I refer to as "membership dues" has occasionally been called "Emergency Responsibility Fee." This phrase arose from a time in Alcor's past when everyone assumed that available funds would handle any emergency, including remote standby. (Then too, for the first decade of Alcor's existence there was little in the way of salaried staff members.) Eventually, experience taught us that unlimited complimentary standby could wipe out our funds within a few weeks, and Alcor began to require separate standby arrangements. As the name "Emergency Responsibility Fee" persisted, however, many potential members continued to interpret this to mean we were charging for some form of rescue and/or standby service. On numerous occasions, young people in the sign-up process with Alcor have approached us with the suggestion that we reduce or eliminate their ER Fee, since they wouldn't need rescue for many years. Because of this misunderstanding, I always use the phrase "membership dues," which evokes the programs of more familiar non-profit organizations. When you pay

membership dues to the Audubon Society or Greenpeace, you're simply making donations to these groups. Financially and legally, membership dues work the same way for Alcor; they're even 90% tax deductible!

* * *

To the Editor:

In their discussion on cryonics and Christianity (Cryonics, 4th Qtr. 1998) Mark Plus and Michel Laprade both agreed that: "Nothing in the orthodox Christian worldview implies an idea like cryonics".

I think it is not definitely so.

It is possible to interpret "an idea like cryonics" as an attempt to preserve the information describing the person in order to enable his resurrection by future technology (and cryonics itself is the best way to preserve such information).

In ancient times, advanced technology was strongly associated with gods. We may see an example of this in the myth of Prometheus, who stole fire from Olympus. Furthermore, there are indications that ancient sages believed gods (or advanced technology) would need preserved information about the dead person in order to resurrect him (see more detailes in my article "Zarathushtra's Memes," *Venturist Monthly News*, May, 1996).

A trace of this idea exists in the Bible. The description of the Last Judgement in Revelation (Chapter 20) says that all information about people is recorded in special divine books. Only those who were recorded in "The Book of Life" (usually interpreted as those who believed in Christ) will be resurrected. The following is the original text:

"Then I saw a great white throne and him who was seated on it. ... And I saw the dead, great and small, standing before the throne, and books were opened. Another book was opened, which is the Book of Life. The dead were judged according to what they had done as recorded in the books. ... If anyone's name was not found written in the Book of Life, he was thrown into the lake of fire."

St. John's visions produce mine. I see cryonics as the Book of Life. Only those who are recorded in this "book" (i.e. frozen), who believed in cryonics (Chrionics?), will be saved. If the "lake of fire" is a symbol of the final destruction of sinners, then ice (or a lake of liquid nitrogen) is the symbol of hope for the salvation of just immortalists.

Amen.

Mikhail Soloviev,
St.Petersburg, Russia

* * *

Re: Cryonics Fiction

Brian:

You might add to your list [of cryonics-related fiction] Wh*en the Sleeper Wakes*, by H.G. Wells (circa 1900) which deals with suspended animation. I think it's still in print in a Dover Wells collection, and also in Everyman paperback.

I haven't read *Love me Tomorrow* by Robert Rimmer (late 70's ?) better known for his 60's cult novel *The Harrad Experiment*, but it supposedly deals with cryonics also.

Mark Plus
Wrightwood, California

Dear Mr. Shock,

I like to review non-English cryonics-related fiction.

Some new results:

1. I looked through the novel "L'An deux mille quatre cent quarante" ("The Year 2440"), by Louis Sebastien Mercier (1771), included in the bibliography. And I found it is not a suspended animation novel — it is a dream novel and seems more like an "apology of death."

2. Why weren't the following novels included in the bibliography? I read only the novel by Wells, but as far as I know other novels are on suspended animation, too.

"Rip Van Winkle", by Washington Irving (1819).

"The Man with the Broken Ear", by Edmond About (1861) — freezing and dessication (46 years).

"When the Sleeper Wakes", by Herbert George Wells (1899) — lethargy (203 years).

3. As additions to the fiction list, I might suggest:

"Endymion" - an Ancient Greek myth. Zeus condemned Endymion to long-term sleep in order to keep him forever young. This was done at the request of Selene (Diana), who loved Endymion. In 1818 John Keats wrote a long poem after this myth.

"Argonauts of the Universe," by Alexander Yaroslavsky (1926) — a novel about travel to the moon. The travellers found that the moon was used as a suspension facility by some mighty space race.

Mikhail Soloviev

The editor replies:

I appreciate the additions and corrections to my list, Mark and Mikhail.

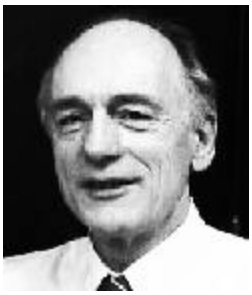
My inclusion of The Year 2440 *by Louis Sebastien Mercier was clearly an error; that's what I get for trusting Grolier's.*

I thought of including Rip Van Winkle, *by Washington Irving, but I arbitrarily decided to restrict my list to those stories where suspended animation occurred through some physical mechanism (however flawed or unrealistic). Rip Van Winkle was just an american variation on the folktales about people who spent an evening with fairies, elves, or leprechauns and then found that decades had passed by the next morning.*

The Man with the Broken Ear *and* When the Sleeper Awakes *were omitted from my list out of nothing more significant than ignorance.*

While we're at it, I'd like to add another novel myself: Larry Niven's A World Out of Time *(1976), which contains both cryonics and an immortalist theme.*

Alcor director Dave Pizer wanted me to mention his privately printed novel Ralph's Journey, *and since we're discussing novels that never reached the "real" publishers, I might as well toss in a word for my own cryonics novel,* The Tellus Recursion, *which both Charles Platt and Steve Bridge found contrived and weak on characterization. Oh well,* de gustibus non disputandum.



Parachutes and Safety Ropes

by Fred Chamberlain, III

Recent Call

In November of 1998, an Alcor Member called just after learning that his uncle had suddenly died.

"He's dead, and now his brain cells are losing ground every minute," the Member exclaimed. "How do we get his suspension started?"

I had to say that Alcor could advise, but could not become involved at the beginning. There might be provisions in the will for cremation. The uncle might have told others he did not *want* to be frozen. There were the questions of who was legally "next of kin" and could consent to a suspension. These were only the tip of the iceberg, in the way of problems.

Past Experience

"I know what you're going through!" I told the Member.

Starting in 1965, I told *my* relatives about cryonics, after reading Bob Ettinger's *Prospect of Immortality*. When a cousin or uncle of *mine* had a terminal illness, I gave them names of cryonics groups and suggested they "check them out". None were ever frozen. I felt it wasn't right for me to *push* them, to interfere with their personal life/death choices.

Four years later, in mid-December, 1969, I suddenly learned that my mother had died, in Florida, three thousand miles away.

The Specifics

"They found her in the driveway," I was told by friends living near the small apartment my parents rented for the Holiday Season. My father, a helpless stroke victim, had wondered for hours why my mother hadn't come back from checking the mailbox.

"We don't know what to do!" my parents' friends continued. "Can you fly out here right away?"

It came to me in a flash! I knew those early cryonics groups were tiny, but I'd never asked for details, had I? My mother's will would say, "cremation," wouldn't it? My Father was "next of kin." He would have to approve. Why hadn't I thought ahead?

How shallow the suggestions to my relatives now seemed! I'd asked them to consider something I didn't even have facts about, myself! Now, with many hours gone by, my mother was probably already embalmed, for the funeral. Cryonics was not a viable option for my mother, given all the factors involved. I had to face that!

The Outcome

For the next few months, I pondered what had happened. Then I joined the Cryonics Society of California (CSC). There, I found a young woman (Linda McClintock) helping to organize the Third National Cryonics Conference, to be held in May 1970. I started the signup process for my dad and myself. Within the next year, Linda and I had joined forces, formed a corporation to consolidate resources for improved cryonics technology and rescue, and had realized that deep-seated problems within CSC now necessitated a new cryonics organization (Alcor).

Back to the Recent Call

I explained this to the Alcor Member calling about the sudden death of his cousin. "I've been there!" I said. "I know what you're feeling!"

There was a sigh of relief at the other end of the phone. The Member now knew that what we want, and what we can actually do in a practical sense, may be very different. Inevitably, we *will* lose people we want to take along. There is no way around this. All we can do is to do what we can, and not mentally torture ourselves endlessly about irrecoverable losses.

Important Points

1. Without arrangements in advance, cryonic suspensions are unlikely to take place. The basic idea of cryonics is simple. Arrangements in advance are *not* simple. Those arranging to be frozen need to weigh the technical challenges and other uncertainties, as well as the costs. "Snap decisions" under great stress, on behalf of others, are not a reasonable way to deal with complex life/death options.

2. Freezing people without advance arrangements *is* possible, but only if the next of kin takes independent action or finds others to help, who rush in blindly without due regard to potential problems or liabilities. Alcor, with 35 suspendees to protect and about 450 signed up suspension members, cannot take these risks, no matter how much we want to help.

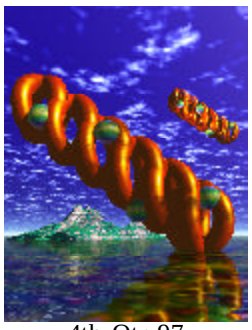
3. If you communicate with others about cryonics, as a personal option for them, you owe them an explanation of the above two points. Please do not advocate cryonics as a way of attempting to deal with death, without pointing out the essential need for arrangements in advance.

Parachutes and Safety Ropes

Cryonics arrangements are like parachutes. If life is like a flight, and there is a possibility you might fall from the sky, the parachute must be there when you need it. You cannot reach for a ripcord as you fall, and pull it, or have someone pull it for you, if you do not wear a parachute to begin with.

In another sense, we are like climbers going upward, toward the future. If someone falls, cryonic suspension is like a very long safety rope, which tugs on the rest of us as the suspended member "falls into the clouds below." Is the member alive, or not? We will not know for many decades. Still, we climb on, toward the future. If those climbing near us are not tied into the safety rope and fall, as they pass into the clouds below, they are lost to us forever, so far as we know or have any concrete reason to believe.

Parachutes and safety ropes are not for everyone. For some of us, however, the thirst for the future, the company of each other, and the enjoyment of life are one continuous whole. We rope ourselves together for safety, and wear parachutes so that we stand some chance of rejoining the others if all else should fail. Despite unknowns of many kinds, we fly and climb as if our lives were the most valuable things we possess. For indeed, they are!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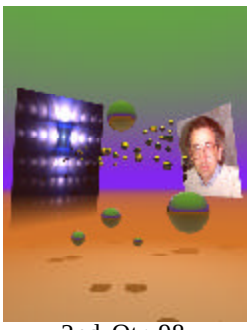
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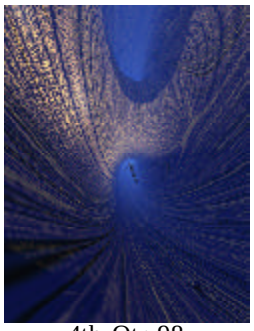
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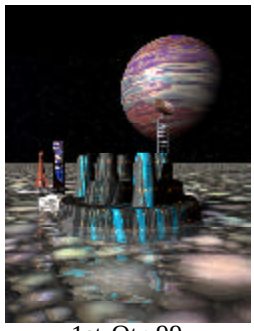
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Cover Art by Tim Hubley !

Over the last year and a half, Tim Hubley has provided *Cryonics* with some of the most beautiful and creative CGI art we've ever seen. Now Tim is selling a *limited run (only 20 copies each!)* of matted 8.5" x 11" color ink-jet prints of these images (without all the messy text added in layout) for only $15.00., plus shipping and handling.

To order your prints, contact Tim Hubley through email at:

102647.446@compuserve.com.

The 21st Century Medicine Seminar:

Amazing Breakthroughs in Cryobiology and Resuscitation

by Charles Platt

After 13 years of unsuccessful attempts to improve his own best cryoprotectant formula, cryobiologist Greg Fahy has discovered a way to develop a whole new family of compounds that should enable human organs to be vitrified in the very near future. "Vitrification" means changing a liquid to a glasslike solid as temperature falls, *without* forming ice crystals that damage cells. For twenty years, cryobiologists have questioned whether vitrification of human organs will ever be practical. The fundamental problem now seems to have been solved.

Concurrently, biophysicist Brian Wowk, a former President of CryoCare Foundation, has discovered a different family of cryoprotectant compounds which enable vitrification at lower concentrations and higher temperatures. Wowk has also developed synthetic "ice blockers" that enhance many other cryoprotectants and eliminate problems associated with rewarming vitrified organs.

Finally, Mike Darwin, a former President of Alcor, has led a highly successful initiative to minimize ischemic injury—the damage that is caused by insufficient blood flow, typically when the heart stops beating. Darwin's team now holds the unofficial world record for resuscitating dogs after up to 17 minutes of "death" at normal body temperature. (Since his research has been conducted separately from the work in cryobiology, it is summarized here in a separate sidebar.)

Photo 1: 21CM's November 8, 1998 conference; a view from the audience.

These multiple breakthroughs should enable preservation of human brains with minimal or even zero ice damage, and may lead to *reversible* brain cryopreservation within ten years. If this goal is achieved, cryonics will not have to rely on future technology to repair damage caused by freezing or toxicity, and will take a major step toward credibility in conventional science.

Long before that, however, the research has applications outside cryonics that should be highly profitable for 21st Century Medicine and its stockholders.

Biologist Christopher Rasch and surgeon Yasumitsu Okouchi collaborated with Gregory Fahy and Brian Wowk on their work, while Steven B. Harris, MD, Sandra Russell, Joan O'Farrell, and Carlotta Pengelley participated with Mike Darwin.

21st Century Medicine was founded in 1993 by Saul Kent and Bill Faloon, long-time cryonics activists who run a lucrative vitamin mail-order business and offer information on dietary supplements via their Life Extension Foundation. In 1997, after Kent and Faloon won a long legal battle with the FDA, they purchased a second building for 21st Century Medicine, hired additional personnel, and are spending currently almost $2 million a year on research.

At a seminar on November 8th, 1998 in Ontario, California, the principal researchers from 21st Century Medicine described some amazing payoffs

Photo 2: Dr. Gregory Fahy

that have resulted from the investment by Kent and Faloon, far sooner than anyone expected. The presentations were tantalizing, because key information is being withheld while patents are being filed. Still, a huge amount of information was communicated, and I can provide only a partial summary here. 21st Century Medicine is selling videotapes to anyone who wants the complete version.

New Cryoprotectants

Brian Wowk began the presentations by describing his search for cryoprotectant molecules that would bind less readily with each other, and more readily with water molecules, thus reducing viscosity and enabling faster perfusion. "The idea that we came up with was to replace hydroxyl groups on cryoprotectant molecules with methoxyl groups," he said.

For example, propylene glycol consists of a chain of carbon atoms, with two OH (hydroxyl) atomic groups attached to the first two atoms in the chain. Wowk proposed replacing one of the hydroxyl groups with an OCH_3 (methoxyl) group, creating a methoxylated version of propylene glycol. "We can make similar modifications to a variety of other standard cryoprotectants," he said. "If you do this, you get some rather dramatic results."

In the case of propylene glycol, the methoxylated version is almost 100 times less viscous than the regular version. Ethylene glycol and glycerol can be modified in the same way, though the improvements are less extreme.

The modified compounds penetrate cells much faster than conventional cryoprotectants. Ethylene glycol is probably the most penetrating cryoprotectant known, but the methoxylated version gets into red blood cells about four times faster.

Better still, the methoxylated compounds inhibit ice formation and enable vitrification far more effectively. Wowk showed a cooling curve for a 45 percent glycerol solution, and another curve for methoxylated glycerol. The former indicated significant ice formation; the latter showed virtually none.

Moreover, methoxylated compounds vitrify at higher temperatures. Wowk predicted that in the future, we won't need to use liquid nitrogen for long-term storage because a suitable cocktail of methoxylated compounds should vitrify above -79 degrees Celsius (dry-ice temperature), which will reduce storage costs and the risk of structural cracking.

One problem with the new compounds is that they are more toxic to cells. However, Wowk has found that toxicity can be mitigated by mixing appropriate compounds. In the lab, viability of cells has been measured in terms of their ability to pump potassium and sodium ions across their membranes, while they are exposed to cryoprotective agents. Ultimately Wowk found that if he replaced propylene glycol with methoxylated glycerol in VS4-1A (the previous state-of-the-art cryoprotectant developed more than ten years ago by Gregory Fahy), it enhanced the ability of cells to survive. Since VS4-1A formerly was the least toxic vitrifying agent known, Wowk felt that this was "a pretty impressive result." However, he went on, "Dr. Fahy completely destroyed these results with new results that surpassed them by almost an order of magnitude."

Another Cryoprotectant Family

At this point during the presentations, Gregory Fahy took the microphone from Brian Wowk to describe his own discovery. He began by noting the mysterious behavior of cryoprotectants. "We don't understand their toxicity, and we can't predict their toxicity," he said. He added that "there is no consensus, no common denominator, no basic grasp of what it is we are seeking and how to get to a less toxic solution."

Initially he suspected that solutions which are more liable to denature proteins would be more toxic—but found that just the opposite is true, which "makes no sense." He also thought that a less-concentrated solution would be less likely to disrupt biological systems, but found no correlation between cryoprotectant concentration needed for vitrification, and viability of cells.

In 1998, Fahy came up with a novel idea to make sense of the data. This led him to a new way to measure concentration of cryoprotectants, which does correlate properly with viability of cells. "Suddenly all the data points fall on a straight line," Fahy told his audience at

Photo 3: Dr. Brian Wowk

Treating and Minimizing Ischemic Injury

For several years, Mike Darwin has been looking for new techniques to inhibit or treat brain damage that occurs after blood circulation stops suddenly, as in a heart attack. In his presentation at the 21st Century Medicine seminar, Darwin noted that sudden cardiac arrest is the leading cause of death in the United States, afflicting 540,000 people annually. He said that despite the advent of CPR and widespread deployment of paramedic teams, fewer than 1 percent of cardiac patients survive without any brain damage if they suffer four to six minutes of cardiac arrest.

Any treatment that can improve these dismal statistics obviously would be extremely valuable in emergency medicine, and Darwin told his audience that the methods he has developed with his primary team, Steven B. Harris, MD, Sandra Russell, Joan O'Farrell, and Carlotta Pengelley, could save 300,000 lives each year.

The research is important also to cryonicists, since we are concerned with preserving the brain with minimal damage in all phases of our procedures, including the first crucial minutes after legal death is pronounced.

Darwin and his team have been remarkably successful, routinely reviving dogs after 15 to 17 minutes of cardiac arrest near normal body temperature, under anesthesia. (These results should not be confused with those of previous dog experiments where much longer survival times were achieved with deep hypothermia.)

A major factor in the success of recent resuscitation research was Steve Harris's suggestion that ischemic injury can be viewed and treated as an inflammatory response, similar in some ways to the swelling and inflammation that occur after any localized injury.

Darwin reported that in eight separate experiments with dogs, three achieved excellent recovery after six weeks (showing no neurological deficit at all), three showed good results, and two did not survive. He claimed that these results have not been matched by any other laboratory.

Unfortunately the protocol is complicated. After blood flow is restored, multiple drugs must be delivered within 5 to 15 seconds, while body temperature must be lowered by about 4 degrees Celsius within 3 to 5 minutes. How can this be achieved by paramedics working out in the field?

Darwin said that a computer-controlled system will be needed to deliver the drugs. The FDA has been reluctant to approve biomedical software, and also is generally opposed to multidrug cocktails. Consequently, the approach developed by Darwin and his team may be applied only outside of the United States, initially at least.

The challenge of rapid cooling seems severe. Darwin told the audience at the seminar that external cooling via a stirred ice-water bath typically requires about 80 minutes to lower body temperature by 5 degrees Celsius. This is far too slow, and requires about 300 pounds of ice and 200 pounds of water, making it impractical for use in the field.

However, Darwin said that the lungs can be used as a heat exchanger. Since all cardiac output flows through the lungs, which have a huge surface area of 70 square meters, they provide an excellent opportunity to draw heat out of the blood, which then cools the brain.

Cold air cannot remove heat rapidly enough, but a breathable liquid is effective and can be applied by intubating the patient, which is a standard emergency procedure. According to Darwin, experiments with dogs have proved that mixed-mode liquid ventilation using a perfluorocarbon at about 2 degrees Celsius can provide more than enough breathable oxygen while lowering body temperature by about four degrees in the first five minutes. An average cooling rate of .36 degrees Celsius per minute has been achieved, and dogs have recovered fully after their temperature has been reduced by as much as 10 degrees.

Since liquid ventilation is not only effective but could be deployed relatively easily in the field, it has a clear advantage over any other method of reducing temperature. It could be used to treat head injuries as well as ischemic injury caused by cardiac arrest, according to Darwin.

He said that inspection of lungs after liquid ventilation showed "some isolated areas of injury," particularly at the bottom part of the lungs, probably from contact with the very cold perfluorocarbon liquid. Still, the animals showed no sign of distress, and light and electron microscopy revealed no sign of structural damage in other areas of the lungs.

"If you can automate this process, any paramedic can do it," Darwin told his audience. He predicted that it could be "a potential profit center" that could save a lot of lives, and said he hopes to see clinical trials 2 to 3 years from now.

Although Darwin didn't mention the use of liquid ventilation in cryonics cases, obviously it would be extremely valuable and could be applied in the very near future.

the 21st Century Medicine seminar.

He would not reveal the exact nature of his insight, but claimed it enabled him to understand how to reduce toxicity in cryoprotectants more effectively than has ever been achieved before. He came up with a solution which he calls VX. For thirteen years he had been trying to find something less toxic than his previous achievement, VS4-1A, a 55 percent solution of DMSO, formamide, and propylene glycol. VX turned out to be the answer.

Using it as a starting point he developed four new vitrification solutions, "each of which is statistically significantly superior to the previous world champion solution, VS4-1A." One of the new VX mixes should enable 100-percent survival of perfused rabbit kidneys, according to Fahy.

Still, this did not solve the problem posed by larger organs that cannot be cooled as rapidly as rabbit kidneys, and tend to suffer from increased ice damage as a result. Fahy said he considered using "some tricks from nature" to inhibit the ice crystal growth.

The trick he tried was an antifreeze protein found in arctic fish. When he added it to conventional cryoprotectants, it achieved barely measurable results. However, when he used a new "vehicle" to deliver the cryoprotectant, and then added the antifreeze protein, he reduced the amount of ice formed in a solution of VS4-1A by a factor of 1,000.

He also tried a different vehicle designed to enhance a different antifreeze protein found in a species of beetles. This reduced ice formation even more effectively, by an additional factor of 10. The practical bottom-line result was that he could achieve vitrification with a slow cooling rate of 1 degree Celsius per minute—which is practical for human kidneys.

Also he found that the beetle protein would eliminate another intractable problem: ice crystals forming when a vitrified sample is rewarmed. Typically, a sample has to be rewarmed extremely fast to get it from its deep subzero temperature to above freezing point without ice crystals causing catastrophic damage along the way. Since raising the temperature of large organs rapidly is quite difficult, zero-damage rewarming has always been a formidable challenge. But with Fahy's new vehicle and 1 percent beetle protein, he found he could avoid ice formation at a warming rate of just 1 degree per minute.

"This is wonderful," he told the audience at his presentation, "but beetle protein is hard to come by, and is expensive. We wanted to come up with our own solution, our own ice-blocking agent, which is dirt cheap. Why not? Let's ask for the moon, maybe we'll get it. And luckily Brian found the moon for us, and now Brian will deliver it."

Ice Blockers

Brian Wowk took over from Gregory Fahy at this point and described his search for "synthetic ice blockers, hoping they could be made more inexpensively than natural antifreeze proteins." He mentioned that the beetle protein used in Fahy's experiments costs about $1,000 per milligram. Some researchers are working to synthesize a substitute, but Wowk believes even this will be relatively expensive, plus its ice-blocking action will be most effective near freezing point. He wanted a substitute that would work at the much lower temperatures required for organ storage.

"We were successful in this, almost completely successful," he said. "We were able to devise a family of synthetic ice-blocking molecules that are very inexpensive, a small fraction of the cost of even fish antifreeze proteins."

He showed a graph of vitrification enhancement that occurred when he added an ice blocker that he referred to as 21CM-X1 to a solution of dimethyl sulfoxide (DMSO). Without the ice blocker, a 50 percent concentration of DMSO is needed to avoid ice formation when cooling at 7 degrees per minute. Adding 1 percent of the ice blocker enabled the same results with 47 percent DMSO. "That doesn't sound like a lot," said Wowk, "but in terms of toxicity it is."

Also, X1 turned out to work like beetle protein in preventing ice damage during rewarming. "Even if you have a perfectly vitrified system, generally when you rewarm it ice forms in it like crazy," Wowk said. "However we found that by adding very small amounts of X1 we may in fact have got the devitrification problem under control at even very modest rewarming rates." He showed a videotape of a lab experiment in which a beaker of DMSO solution formed ice crystals when it was rewarmed, while the same solution with a tiny amount of ice blocker showed virtually no ice at all. Another video demonstrated that a vitrified solution of ethylene glycol could be rewarmed relatively slowly, without any ice forming, if the X1 ice blocker was added.

Real-World Applications

Having described his discoveries, Fahy listed some immediate, potentially lucrative applications. First, there's the transplant field. "Most kidneys are not matched to the recipient," Fahy said. "This causes rejection.... 95 percent of the time we have a bad match between the recipient and the donor in terms of tissue type. Livers and hearts are an even worse problem."

Obviously if organs can be kept "on ice," this would allow time for better matching. About 15,000 organs are transplanted each year in the United States; if a banking system enabled more efficient use of these organs by solving the problem of rejection, this would justify the expense of setting up the system and paying a royalty to 21st Century Medicine for its preservation techniques.

But according to Fahy, "The really big market is in artificial tissues and organs, because there's no limitation on supply." He estimated that the total market is for at least 100,000 implants a year.

Initially he hopes to cryopreserve kidneys, since this is the organ that has been used most extensively in experiments and is best understood. "I've had clinicians tell me that as soon as I think I'm ready, they'll go ahead and transplant a human kidney at the drop of a hat," Fahy said.

At the same time, he noted that 21st Century Medicine is "negotiating a contract with a major university which is skilled in cardiac preservation, and we will test out our new vitrification solutions in that laboratory." 21st Century Medicine will retain the commercial rights to results of the research.

"We also have some possibilities for going into liver cryopreservation," Fahy went on. "We're now negotiating a contract with a liver transplant laboratory that is interested in developing short term liver cryopreservation at relatively high subzero temperatures, and we will move forward at their expense on that, but 21st Century Medicine again will own the commercial rights."

Summing up, Fahy said, "We are now building a perfusion machine to actually do the experiments in house. The surgical facilities are ready to go.... And we're already engaged in friendly negotiations with a number of organ preservation labs, to go further."

Other Markets

Fahy said he had never paid much attention to freezing small organisms such as sperm, because the problem seemed "too trivial" compared with freezing a large, complexly structured organ such as a kidney. Still, 21st Century Medicine can acquire revenue and credibility if its research improves existing procedures such as cryopreservation of sperm or corneas.

Fahy valued the market for human sperm at $20 million, while bovine sperm is a $200 million market, and human corneas are a $400 million market. He said, however, that when he investigated these areas, he found that between 90 and 95 percent of donors are rejected because their sperm cannot survive the primitive preservation procedures, while vitrifying corneas has been considered so difficult, no one is even trying to do it anymore. "Currently there are about 50,000 cornea transplants a year," Fahy said, "but I'm told by the top people in the field that if you could bank corneas without limit, this market would expand by a minimum of 5-fold, so the corneas alone would be worth $2 billion a year, and we'd get whatever royalty we could charge on that."

He showed a video tape in which sperm died in a 1 molar glycerol solution, but survived in his new VX cryoprotectant. "We're new at this," he admitted. But, "Our result, preliminary though it may be, is better than what's out there, so it is possible we can help the sperm bankers with their problem of expanding the donor pool and saving money. That means a market for 21st Century Medicine."

He predicted similar success in vitrifying corneas, though he has not tried this yet using VX. "We're currently collaborating with a major-name medical clinic to have a venture to demonstrate that we can cryopreserve corneas by vitrification, using the new technology."

Brain Cryopreservation

For cryonicists, the most exciting aspect of the conference came at the end, where Brian Wowk and Gregory Fahy revealed results of their first two experiments applying new cryoprotectant formulas to rabbit brains. "In general," Fahy commented, "we think we have achieved complete vitrification of the brain."

A year ago, no one had any idea that this might be achieved so quickly. Moreover, the procedure does not require extremely rapid cooling, high atmospheric pressures, or other exotic techniques, and a sample brain has been not only cryopreserved but rewarmed with virtually no damage. There is some chemical damage from toxicity, which would prevent restoration of function. Additional research will be needed to address this.

Currently, under ideal circumstances (which are often unavailable), a cryonics patient is perfused with a solution of glycerol reaching a final concentration of 7 to 7.5 molar, after which the patient is cooled at approximately one-tenth of a degree per minute. This is the best we can hope for. But as Brian Wowk demonstrated at the conference, the results are extremely unsatisfactory. He showed a slide (reproduced in Photo 5) of a two-liter solution of 7.3 molar glycerol that was cooled at 0.1 to 0.3 degrees per minute, to a temperature of -100 degrees. The chalky white appearance is caused by millions of tiny ice crystals in the solution. In a human brain, each crystal is likely to cause significant damage.

Photo 4 illustrates this damage. The picture is a reproduction of an electron micrograph of a canine brain that was perfused with 7.5 molar glycerol, cooled using optimal cryonics protocol, and then rewarmed. The white, "empty" areas almost certainly were caused by ice forming and displacing or destroying tissue. After rewarming, the ice melts and debris remains. Remember, this is

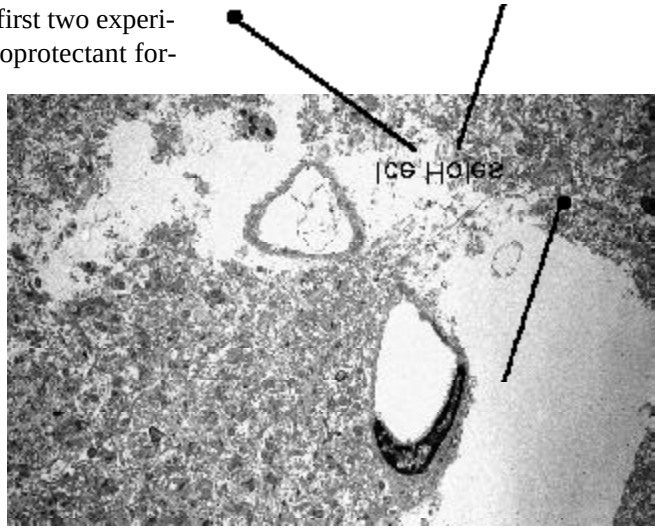


Photo 4

Photo 5

Photo 6

Photo 7

the *best* we can hope for, using current procedures.

Photo 6 shows an obvious improvement. This flask contains a 7.2 molar glycerol solution to which 1 percent of Wowk's "X1" ice blocker was added before freezing. The solution is now partially vitrified, meaning that it has turned into a uniform glasslike substance interspersed with hundreds of ice balls a few millimeters across, as opposed to millions of tiny ice crystals. The large pale object at the bottom of the flask is not ice; it is a stir bar. Wowk estimates that ice now constitutes only 10 percent of the mixture, by volume.

This is still less than ideal, but it can be achieved right now just by adding the X1 ice blocker that Wowk has discovered. No special cooling technology is required.

What if we use a 7.5 molar glycerol solution with 2 percent X1? Photo 7 shows the result. There is now virtually no ice, and almost 100-percent vitrification has occurred.

The 7.5 molar solution is so viscous, it can be used on human patients only with difficulty. Also, there's no guarantee that the insides of cells will be completely protected, because the X1 ice blocker does not penetrate cell membranes. If cooling can be done more rapidly, however, internal cell damage should be minimized, because (in very simple terms) ice has less time to form.

Until relatively recently, no one knew how to cool a human patient faster than .1 degree Celsius per minute. The new technique of perfluorocarbon perfusion, however, offers a radical improvement. First, the patient would be perfused normally with cryoprotectant. Then the vascular system would be flushed with a perfluorocarbon, which is nontoxic and remains free-flowing at temperatures as low as -130 degrees. Potentially this can produce a cooling rate of almost 10 degrees per minute—100 times the best rate for a cryonics patient using conventional methods. Because the temperature differential diminishes as cooling takes place, the cooling rate will diminish also; but 1 degree per minute is still possible at -110 degrees. This has actually been verified in dog experiments.

The procedure will require a specially insulated room where perfluorocarbon can be sprayed onto the patient and perfused through the patient under remote control. A prototype cold room has been built at 21st Century Medicine.

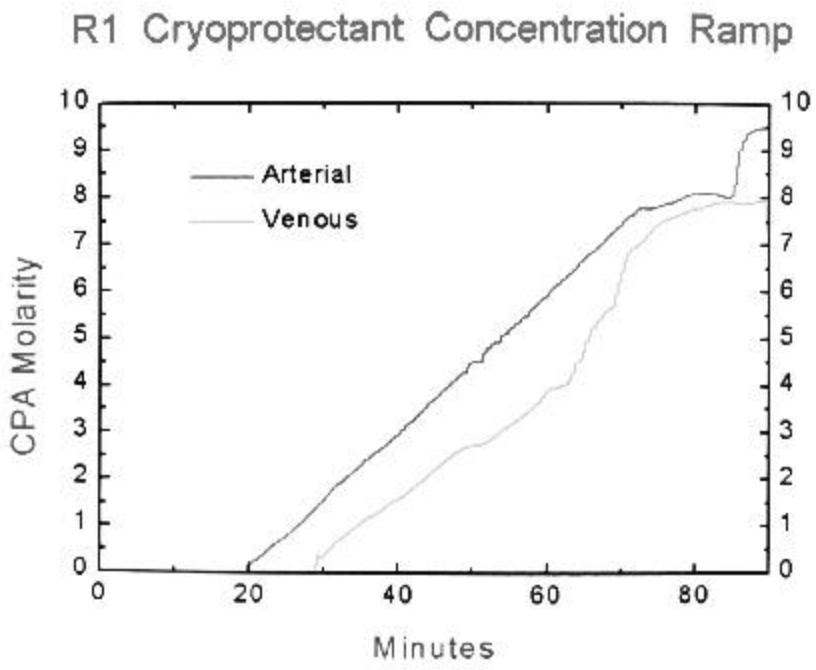
Perfluorocarbon cooling is such a powerful technique, it enables vitrification with lower concentrations of cryoprotectant. A 7 molar solution of glycerol, with X1 ice blocker added, should be sufficient.

Unfortunately, even a 7 molar glycerol solution is biochemically toxic to cells. Perhaps chemical damage will be much easier to undo in the future than structural damage, but still we would prefer, obviously, to do no damage at all.

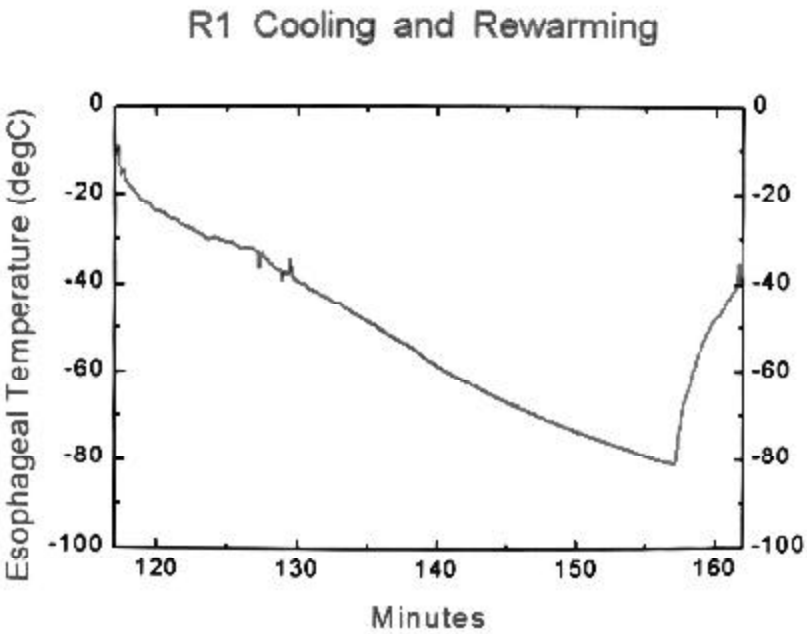
Wowk and Fahy have taken a step in that direction. Shortly before the conference, assisted by biologist Christopher Rasch and surgeon Yasumitsu Okouchi, Fahy perfused two rabbits (the first consisting of the upper body, the second consisting of the head only) using two different perfusates. The composition of the perfusates is not public information at this time, but one of them relied more on concepts developed by Brian Wowk in his research into methoxylated compounds, while the other incorporated ideas relating to the VX series of cryoprotectants formulated by Fahy.

Photo 8

Photo 9



Graph 1



Graph 2

Photo 8 shows the perfusion in progress, using an open circuit in which concentration was gradually ramped up, as shown in Graph 1. This procedure is roughly similar to that used in rabbit-kidney cryopreservation.

After perfusion, Photo 9 shows one of the specimens being cooled in the plastic bucket just in front of the stainless-steel dewar. Note the electric drill clamped over the bucket, which provided rapid stirring, promoting heat exchange.

Graph 2 shows the rate of cooling. Note the small bumps around 130 minutes and -40 degrees C. These irregularities suggest that a small amount of water froze, briefly liberating latent heat

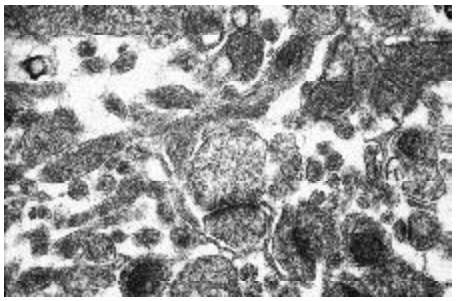


Photo 10

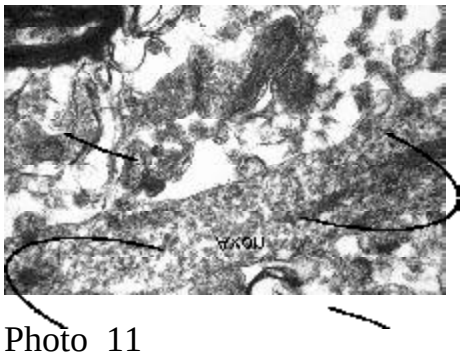


Photo 11

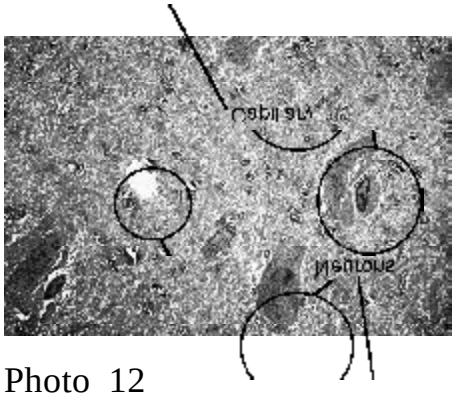


Photo 12

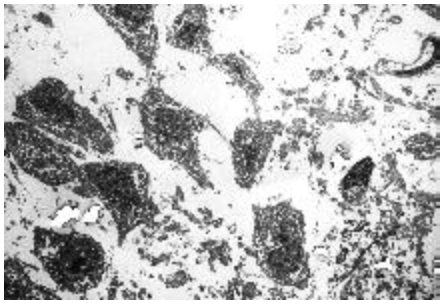
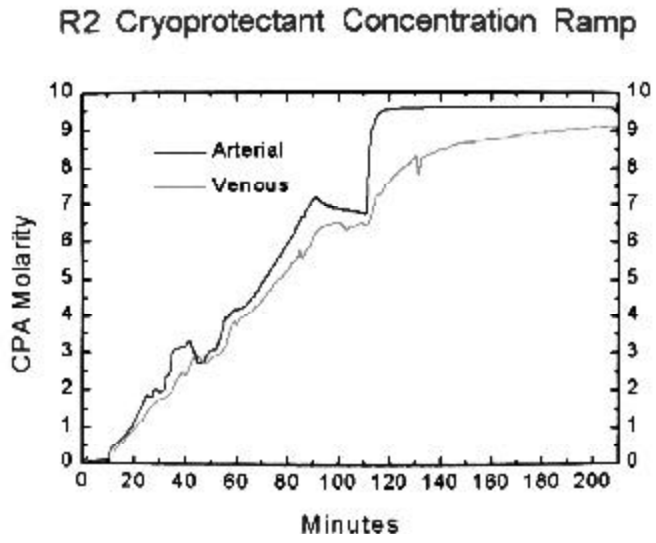
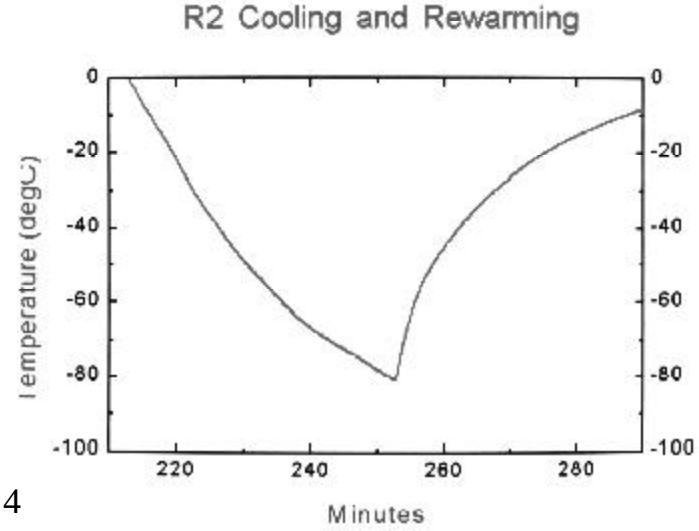


Photo 13



Graph 3



Graph 4

as it turned to ice.

Photo 10 is an electron micrograph showing the condition of the brain after rewarming. An intact synapse and presynaptic neurotransmitter vesicles are visible, with good postsynaptic density. Some shrinkage has occurred because of the high concentration of cryoprotectant, creating the small white spaces around cells. Fahy feels that this shrinkage is not very significant because the structure seems intact.

Photo 11 is at a smaller scale (the original electron micrographs range from 10,000 to 40,000 magnification) showing an intact axon with clearly defined cell membrane. "We do see some cavities on the local level," Fahy commented when he showed this picture at the conference. But these cavities are minimal compared with the damage in brain tissue perfused conventionally with glycerol.

Photo 12 provides a broader overview showing no apparent ice holes. There are some slightly shrunken neurons, but again the membranes are intact and structure is clearly visible.

Not all areas of the brain were preserved so successfully. Photo 13 shows cells that have been damaged by ice, toxicity, or inadequate osmotic pressure allowing tissue edema. "Nevertheless this seems a substantial advance over glycerol," Fahy commented.

In their second rabbit experiment, Fahy's team attempted total vitrification of the brain. "We did various things to optimize the perfusion," he told his audience at the conference, though he would not reveal specific details. Graph 3 shows the increase in concentration of perfusate over time, while Graph 4 is a remarkably smooth cooling curve, showing no kinks or bumps that would indicate ice formation as the temperature fell, and no ice forming either during the rewarming phase.

Electron micrographs of this brain revealed truly exceptional results. Photo 14 shows an axon containing neural filaments—individual conglomerations of molecules. These are clearly discernible

in the original picture but may be harder to see here because of the limits of halftone printing. "We have never seen those [filaments] in any cryopreserved brain, ever," Mike Darwin commented, as the slide was shown at the conference.

"This is a level of preservation that's really unprecedented," Fahy agreed.

A lower-magnification overview of the second brain, in photo 15, shows no pockets of cell damage of the kind seen in the first brain. There are moderately dehydrated but basically intact cells amid shrinkage spaces that are moderate and probably not a source for concern. Intact myelin sheaths are visible around axonal processes.

All the electron micrographs mentioned so far were of the cerebral cortex. Photo 16 is of the hippocampus, which is the area most sensitive to ischemic insults. Although the cells seem dehydrated and shrunken, they remain well connected to the neuropil surrounding them.

Fahy was quick to warn his audience that these two experiments are just the first that have been done using the new processes developed this year at 21st Century Medicine. "We expect that we can go farther than this fairly rapidly," he said, "now that we have a better feel for the kind of cooling and warming rates that we're dealing with."

Sitting next to Fahy, Mike Darwin added that "I've spent twenty years doing cryoprotective perfusions and subsequent evaluations of brains....my opinion is a very dismal one about the utility of current procedures, particularly in preserving the fine connections of the cells to the neuropil, which is probably where you're at, where your identity is really encoded." But he went on: "I just cannot emphasize the difference between this [new work] and the previous work that has been done. We've eliminated virtually all of these terrible tears, massive tears that occur at 10 and 30 micron intervals, and the ultrastructure is remarkably better. I think that within very short order we're going to have significant viability, 50 percent viability, in brains that are treated with techniques that yield the same kind of ultrastructural results."

Of course, we don't know how easily the work will translate and scale to human brains. Also, the researchers at 21st Century Medicine have been exploring several different approaches, in parallel, to the same basic problems of reducing damage. "We have not completely and fully combined [these ideas] to get the most powerful possible approach to cryopreservation," Fahy said, adding that the next step will involve "fine tuning all the parameters in order to get the best possible result. But it's just a straightforward process, there's nothing magical about it."

"The magic is the money and the time," Darwin commented.

Questions and Answers

After the formal presentations, Mike Darwin, Steve Harris, MD, Gregory Fahy, and Brian Wowk received questions from the audience.

Linda Chamberlain of Alcor asked about the price and availability of perfluorocarbon compounds. Mike Darwin replied that it had been difficult to obtain them, but recently he located a new supplier with a large stock. The compounds may cost between $20 and $35 per pound, but in a perfluorocarbon perfusion circuit most of the chemicals can be retained and reused.

Another questioner asked exactly how antifreeze proteins prevent ice from forming. Brian Wowk explained that they "form a kind of antibody-antigen match onto the a-axis face of ice. They coat it and prevent growth in that direction."

Fred Chamberlain of Alcor wondered what happens if you increase the concentration of ice blockers or methoxylated compounds, and whether they will be prohibitively expensive.

Brian Wowk answered that a higher concentration of methoxylated compounds will tend to dissolve cell membranes. "We're cruising on the edge of

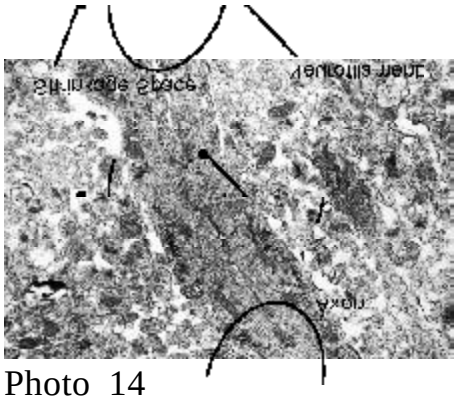


Photo 14

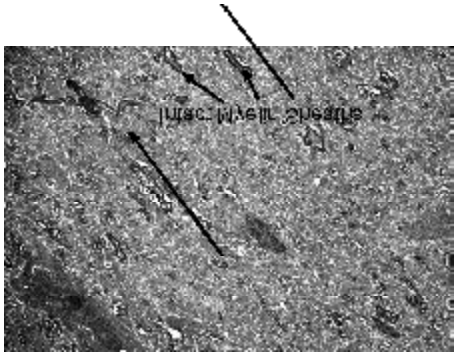


Photo 15

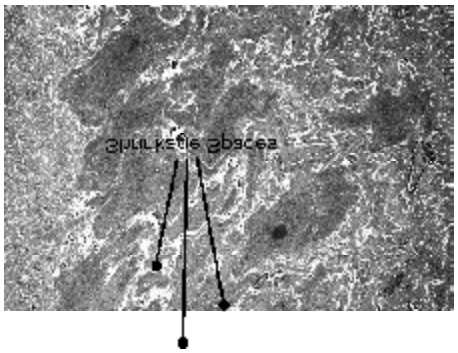


Photo 16

that," he said. A problem with X1 is that it tends to increase viscosity of cryoprotectants. Overall, Wowk said he expects that the optimum concentration of X1 will be "a few percent."

Saul Kent said it was premature to talk about pricing, but Brian Wowk pointed out that anyone with a chemical catalogue could find methoxylated compounds available off-the-shelf. "Technically the only thing to stop you from using them is infringement on our pending patent," he said.

As for ice blockers, "We could probably supply as much as you want at a reasonable price.... Chemical synthesis houses making this compound for us are

Photo 17: Question & Answer Panel
l -r: Mike Darwin, Dr. Gregory Fahy, Dr. Steven Harris

not giving us anywhere near the kind of sticker shock that antifreeze protein synthesis gives us."

Another questioner asked how long we have to wait for viable suspended animation. Brian Wowk said it should be possible within ten years for the brain, but much sooner for kidneys, because this is the major focus of research. "If sufficient funds become available from people who are interested in the [brain] problem," he went on, "we could tackle the brain just like any other organ."

Mike Darwin agreed that "somebody has to fund the work on brains, and it isn't going to be the people funding the work on hearts or kidneys or livers," because that research has an obvious financial payoff, while brain preservation interests only cryonicists. Consequently, according to Darwin, "this audience and the people they represent are going to be the ones who pay for it, else it just isn't going to get done."

"To get to the point where a brain is successfully cryopreserved in every sense of the word is an enormously complicated and resource-intensive process," Gregory Fahy commented. "We don't have the manpower to divert a lot of extra attention into those areas unless they are funded." He said he expects to discover "all kinds of adverse things that we have no clue exist right now, all kinds of things we haven't thought of, and we'll have to solve those problems. This will take a dedicated team working week in, week out, year in year out, relentlessly, until the problem is solved. We just don't have the assets for that now."

Another questioner asked how much it might cost.

"$10 million has been speculated," Brian Wowk answered, adding that this is a reasonable guess. He didn't think it would cost as much $100 million, but he was sure it would cost more than $5 million.

The panel discussion broke up shortly after this, and many of the attendees visited the two laboratories where the research has been done. Some people complained that the presentations had been overly technical, while others wondered whether the owners of the new technology will make it available on an affordable basis. Saul Kent said subsequently that he intends to offer results of the research at a reasonable price to all cryonics organizations. Obviously 21st Century Medicine hopes to reap profits from applications outside cryonics, which is a minuscule market by comparison.

Conclusion

The prospects for human cryopreservation have never looked better. Prospects, however, don't turn into realities without an infusion of money and labor.

The new brain studies at 21st Century Medicine are immensely promising, but the company must pursue research that will generate revenue, and brain research is unlikely to fulfill this need in the immediate future. Therefore, if we want zero-damage, reversible brain cryopreservation, we can't count on outside investors to pay for it. We, as cryonicists, will have to pay for it ourselves.

Six years ago, I bought $10,000 of stock in 21st Century Medicine. This represented about one-quarter of my savings at that time. Some others also purchased stock, but the wealthiest people in cryonics showed only a token interest—or no interest at all. Consequently, Bill Faloon and Saul Kent shouldered the primary burden. By my estimate, they have spent about $10 million so far.

I am constantly amazed by the reluctance of wealthy cryonicists to put money into research that could increase their own chances of survival. It seems grossly irresponsible to assume that others in the future will fix freezing damage for us, when we could address the issue ourselves.

In the past, there was some doubt that investment in research would pay off. This doubt should be dispelled, now, by the evidence presented at the 21st Century Medicine seminar. Kent and Faloon have demonstrated that money really can buy remarkable progress within a short space of time, and almost certainly reversible cryopreservation can be ours if we really want it.

Within the next year we will see whether cryonicists are willing to acknowledge this fact—or whether "Let someone else deal with the problem" will continue as the dominant motto in cryonics, as it has for the past thirty years.

Nanomedicine:

Frequently Asked Questions

by Robert A. Freitas, Jr.

Most cryonicists agree that some type of nanotechnology will be necessary to reanimate patients currently in cryonic suspension, but few of us have any concrete idea of what form such nanotechnological medicine — "nanomedicine" — might take.

"Nanomedicine" may be defined as the monitoring, repair, construction, and control of human biological systems at the molecular level, using engineered nanodevices and nanostructures. Basic nanostructured materials, engineered enzymes, and the many products of biotechnology will be enormously useful in near-term medical applications. However, the full promise of nanomedicine (including the recovery of cryonics patients) is unlikely to arrive until after the development of precisely controlled or programmable medical nanomachines and "nanorobots."

What chemical elements would medical nanorobots be made of?

The typical medical nanodevice will probably be a micron-scale robot assembled from nanoscale parts. These parts could range in size from 1-100 nm (1 nm = 10^{-9} meter), and might be fitted together to make a working machine measuring perhaps 0.5-3 microns (1 micron = 10^{-6} meter) in diameter. Three microns is about the maximum size for bloodborne medical nanorobots, due to the capillary passage requirement.

Carbon will likely be the principal element comprising the bulk of a medical nanorobot, probably in the form of diamond or diamondoid/fullerene nanocomposites largely because of the tremendous strength and chemical inertness of diamond. Many other light elements such as hydrogen, sulfur, oxygen, nitrogen, fluorine, silicon, etc. will be used for special purposes in nanoscale gears and other components.

What would a typical nanorobot look like?

It is impossible to say exactly what a generic nanorobot would look like. Nanorobots intended to travel through the bloodstream to their target will probably be 500-3000 nanometers (1 nanometer = 10^{-9} meter) in characteristic dimension. Nonbloodborne tissue-traversing nanorobots might be as large as 50-100 microns, and alimentary or bronchial-traveling nanorobots may be even larger still. Each species of medical nanorobot will be designed to accomplish a specific task, and many shapes and sizes are possible.

Finally, and perhaps most importantly, no actual working nanorobot has yet been built. Many theoretical designs have been proposed that look good on paper, but these preliminary designs could change significantly after the necessary research, development and testing has been completed.

Robert A. Freitas, Jr. is currently writing *Nanomedicine*, the first book to comprehensively address the technical issues involved in the medical applications of molecular nanotechnology and medical nanodevice design.

Nanomedicine, to be published in three volumes, represents a preliminary attempt to explore the full range of nanomedical applications, along with some details of the required foundational technical competencies. An established biomedical book publisher, Landes Bioscience, has been signed to produce all three volumes. The target publication date for Volume I is late Spring 1999.

Cryonics Magazine would like to thank both Mr. Freitas and the Foresight Institute for permission to reprint these Frequently Asked Questions. For the unabridged listing of "Frequently Asked Questions in Nanomedicine," for outlines and excerpts from Volume I of *Nanomedicine*, and for further information about this topic, please refer to the Foresight Institute's Nanomedicine Web Site, **http://www.foresight.org/Nanomedicine/index.html**.

Can you give a concrete example of a simple medical nanorobot?

One very simple nanorobot that I designed a few years ago is the artificial mechanical red cell, which I call a "respirocyte." The respirocyte measures about 1 micron in diameter and just floats along in the bloodstream. It is a spherical nanorobot made of 18 billion atoms. These atoms are mostly carbon atoms arranged as diamond in a porous lattice structure inside the spherical shell. The respirocyte is essentially a tiny pressure tank that can be pumped full of up to 9 billion oxygen (O_2) and carbon dioxide (CO_2) molecules. Later on, these gases can be released from the tiny tank in a controlled manner. The gases are stored onboard at pressures up to about 1000 atmospheres. (Respirocytes can be rendered completely nonflammable by constructing the device internally of sapphire, a flameproof material with chemical and mechanical properties otherwise similar to diamond.)

The surface of each respirocyte is 37% covered with 29,160 molecular sorting rotors (Nanosystems, page 374) that can load and unload gases into the tanks. There are also gas concentration sensors on the outside of each device. When the nanorobot passes through the lung capillaries, O_2 partial pressure is high and CO_2 partial pressure is low, so the onboard computer tells the sorting rotors to load the tanks with oxygen and to dump the CO_2. When the device later finds itself in the oxygen-starved peripheral tissues, the sensor readings are reversed. That is, CO_2 partial pressure is relatively high and O_2 partial pressure relatively low, so the onboard computer commands the sorting rotors to release O_2 and to absorb CO_2.

Respirocytes mimic the action of the natural hemoglobin-filled red blood cells. But a respirocyte can

Robert A. Freitas Jr. has degrees in physics, psychology, and law, and has written nearly 100 technical papers, book chapters, or popular articles on a diverse set of scientific, engineering, and legal topics. He co-edited the 1980 NASA feasibility analysis of self-replicating space factories and recently authored the first detailed technical design study of a medical nanorobot ever published in a refereed biomedical journal.

deliver 236 times more oxygen per unit volume than a natural red cell. This nanorobot is far more efficient than biology, mainly because its diamondoid construction permits a much higher operating pressure. (The operating pressure of the natural red blood cell is the equivalent of only about 0.51 atm, of which only about 0.13 atm is deliverable to tissues.) So the injection of a 5 cm^3 dose of 50% respirocyte aqueous suspension into the bloodstream can exactly replace the entire O_2 and CO_2 carrying capacity of the patient's entire 5,400 cm^3 of blood!

Respirocytes will have pressure sensors to receive acoustic signals from the doctor, who will use an ultrasound-like transmitter device to give the respirocytes commands to modify their behavior while they are still inside the patient's body. For example, the doctor might order all the respirocytes to just stop pumping, and become dormant. Later, the doctor might order them all to turn on again.

What if you added 1 liter of respirocytes into your bloodstream, the maximum that could possibly be safe? You could then hold your breath for nearly 4 hours if sitting quietly at the bottom of a swimming pool. Or if you were sprinting at top speed, you could run for at least 15 minutes before you had to take a breath!

It is clear that very "simple" medical nanodevices can have extremely useful abilities, even when applied in relatively small doses. Other more complex devices will have a broader range of capabilities. Some devices may have mobility, the ability to swim through the blood, or crawl through body tissue or along the walls of arteries. Others will have different shapes, colors, and surface textures, depending on the functions they must perform. They will have different types of robotic manipulators, different sensor arrays, and so forth. Each medical nanorobot will be designed to do a particular job extremely well, and will have a unique shape and behavior.

Will "old nanorobots" left in the body cause problems when they eventually fail?

Following most simple treatments, nanodoctors of the 21st century will want to remove their therapeutic nanorobots from the patient's body as soon as the nanodevices have finished the job. So there will be little danger of "old nanorobots" breaking down or malfunctioning, or causing something unpleasant to happen to the patient after the original disease or traumatic condition has been treated.

Additionally, nanorobots will be designed with a high level of redundancy to ensure fail-operational and fail-safe performance, further reducing the medical risk.

How would the nanorobots be retrieved from the body?

Some nanodevices will be able to exfuse themselves from the body via the usual human excretory channels; others will be designed to allow ready exfusion by medical personnel using apheresis-like processes or active scavenger systems. It is very design dependent. In the case of the respirocytes, the removal procedure is fairly simple:

"Once a therapeutic purpose is completed, it may be desirable to extract artificial devices from circulation. Onboard water ballast control is extremely useful during respirocyte exfusion from the blood. Blood to be cleared may be passed from the patient to a specialized centrifugation apparatus where acoustic transmitters command respirocytes to establish neutral buoyancy. No other solid blood component can maintain exact neutral buoyancy, hence those other components precipitate outward during gentle centrifugation and are drawn off and added back to filtered plasma on the other side of the apparatus. Meanwhile, after a period of centrifugation, the plasma, containing mostly suspended respirocytes but few other solids, is drawn off through a 1-micron filter, removing the respirocytes. Filtered plasma is recombined with centrifuged solid components and returned undamaged to the patient's body. The rate of separation is further enhanced either by commanding respirocytes to empty all tanks, lowering net density to 66% of blood plasma density, or by commanding respirocytes to blow a 5-micron O_2 gas bubble to which the device may adhere via surface tension, allowing it to rise at 45 mm/hour under normal gravitational acceleration."

(Quoted from Robert A. Freitas Jr., "Exploratory Design in Medical Nanotechnology: A Mechanical Artificial Red Cell," *Artificial Cells*, Volume 26, 1998, pp. 411-430. This paper is apparently the first detailed design study of a specific medical nanodevice (of the general type proposed by Drexler in *Nanosystems*) that has been published. See earlier description in: Robert A. Freitas Jr., "Respirocytes: High Performance Artificial Nanotechnology Red

Blood Cells," *Nanotechnology Magazine,* Volume 2, October 1996, pp. 1, 8-13.)

Won't medical nanorobots be attacked by the immune system, as soon as they are placed inside the human body?

Immune system response is primarily a reaction to a "foreign" surface. Nanorobot size is also an important variable, along with device mobility, surface roughness, surface mobility, and other factors. Yet the problem of nanodevice biocompatibility is in principle no more difficult than the biocompatibility of medical implants generally. In some ways it may even be an easier problem, because many medical nanorobots will have only temporary residence in the body. Even today, application of immunosuppressive agents during the treatment period would allow poorly-engineered non-bioinactive nanorobots to perform their repair work without trouble.

Passive diamond exteriors may turn out to be ideal. Several experimental studies hint that the smoother and more flawless the diamond surface, the less leukocyte activity and the less fibrinogen adsorption you will get. So it seems reasonable to hope that when diamond coatings can be laid down with almost flawless atomic precision, making nanorobot exterior surfaces with near-nanometer smoothness, that these surfaces may have very low bioactivity. Due to the extremely high surface energy of the passivated diamond surface and the strong hydrophobicity of the diamond surface, the diamond exterior is almost completely chemically inert and so opsonization should be minimized.

However, even if flawless diamond surfaces alone do not prove fully bioinactive as hoped, active surface management of the nanorobot exterior can be used to ensure complete nanodevice biocompatibility. Allergic and shock reactions are similarly easily avoided.

How fast can medical nanorobots replicate inside the human body?

This is a very common error. Medical nanorobots need not ***ever*** replicate. In fact, it is unlikely that the FDA (or its future equivalent) would ever approve for general use a medical nanodevice that was capable of in vivo replication. Except in the most unusual of circumstances, you would never want anything that could replicate itself to be turned loose inside your body. Replicating bacteria are trouble enough!

Replication is a crucial basic capability for molecular manufacturing. But aside from the most aggressive applications, there is simply no good reason to risk manufacturing "fertile" nanorobots inside the human body, when "mule" nanorobots can be manufactured so cheaply, conveniently, and in such vast numbers outside of the human body. Replicators will almost certainly be very tightly regulated by governments everywhere.

Will medical nanorobots possess a humanlike artificial intelligence?

This is another common error. Many medical nanorobots will have very simple computers on board each device. Respirocytes, for example, have only a ~1,000 operations/sec computer on board each device -- far less computing power than an old Apple II.

Most cellular repair nanorobots will not need more than 106-109 operations/sec of onboard computing capacity to do their work. This is a full 4-7 orders of magnitude below (even the potential for) true human-equivalent computing at 10 teraflops (~10^{13} operations/sec). Faster computing capacity is simply not required for most medical nanorobots.

How would a medical nanorobot be powered?

One of the earliest proposals by Drexler in *Engines of Creation* was that an in vivo medical nanodevice could metabolize local glucose and oxygen for energy. Another possibility is externally supplied acoustic power, which is probably most appropriate in a clinical setting. There are literally dozens of useful power sources that are potentially available in the human body, as described in Chapter 6 of *Nanomedicine.*

"Replication is a crucial basic capability for molecular manufacturing. But aside from the most aggressive applications, there is simply no good reason to risk manufacturing 'fertile' nanorobots inside the human body."

"Nanomedicine will eliminate virtually all common diseases of the 20th century, virtually all medical pain and suffering, and allow the extension of human capabilities, most especially our mental abilities."

How would you communicate with the machines as they do their work?

There are many different ways to do this. One of the simplest ways to send broadcast-type messages into the body, to be received by in vivo nanorobots, is acoustic messaging. A device similar to an ultrasound probe would encode messages on acoustic carrier waves at frequencies between 1-10 MHz. Thus the supervising physician can easily send new commands or parameters to nanorobots already at work inside the body. Each nanorobot has its own power supply, computer, and sensorium, thus can receive the physician's messages via acoustic sensors, then compute and implement the appropriate response.

The other half of the process is getting messages back out of the body, from the working nanodevices out to the physician. This can also be done acoustically. However, onboard power requirements for micron-scale acoustic wave generators in water dictate a maximum practical transmission range of at most a few hundred microns for each individual nanorobot. Therefore it is convenient to establish an internal communications network that can collect local messages and pass them along to a central location, which the physician can then monitor using sensitive ultrasound detectors to receive the messages. Such a network can probably be deployed inside a patient in less than an hour, may involve up to 100 billion mobile nanorobotic network nodes, and may release at most 60 watts of waste heat (less than the 100-watt human body basal rate) assuming a (worst case) full 100% network duty cycle.

There are many other techniques that may be used as well -- this one is just the easiest to describe.

If medical nanorobots are infused into the human body, intravenously, how would one track their location?

A navigational network may be installed in the body, with station-keeping navigational elements providing high positional accuracy to all passing nanorobots that interrogate them, wanting to know their location.

Physical positions can be reported continuously using an in vivo communications network. Since the typical therapeutic dose may involve billions or trillions of nanorobots (e.g. up to a few cm^3 of injection), it will usually be impractical to address nanorobots individually, though this is in principle possible for treatments involving only a few million devices, or fewer.

What form of detection system would medical nanorobots use to distinguish between differing cell types?

Each cell type has its own unique set of surface antigens. Other cell surface antigens indicate the health status of the cell, the parent organ type, the species of the animal, and even the identity of the individual: a kind of biochemical Social Security Number.

So the short answer to this question is: Use chemotactic sensors (crudely analogous to chemical force microscopy), keyed to the specific known antigens on the target cells you are looking for. Knowledge of these antigens will become extensive, soon after the completion of the Human Genome Project early in the 21st century.

How would chemical agents (e.g. an anti-cancer drug) be transported and delivered to a target cell?

Once you've identified a group of cells that needs some chemical substance delivered to it, you can simply release the agent from onboard tanks after the nanorobot arrives on the scene. A 1 cm^3 injection of 1-micron nanodevices could probably hold at least 0.5 cm^3 of chemical agent. Virtually all of these billions of nanites (in the 1 cm^3) will be smart enough to show up at the correct group of cells that are targeted for destruction, so delivery efficiency is virtually 100%. Onboard sensors can test for ambient levels of the chemical agent, to prevent overdose.

However, this question is a good example of an "anachronistic" application -- one that could be done using medical nanorobots, but in fact would probably never be done that way, because in an era of advanced

nanotechnology much more efficient and much less destructive ways would exist to get the same job done. In the above example, bulk delivery of cytotoxins to tissue cells is completely unnecessary if the means exists to reverse the carcinomatous process at the cellular and genetic level.

What could go wrong during a nanomedical procedure?

The incompetence or negligence of medical personnel is always a potential concern. However, in the nanomedical era, as today, such occurrences should be infrequent and notorious.

A true glitch will come from some direction that nobody anticipated. Biocompatibility problems are well anticipated, and multiple-redundant onboard computers should ensure safe operation, correct operation, and reprogrammability of operational parameters even after the devices have been launched on their mission -- especially to permit deactivation if anything goes wrong. Fail-stop protocols may be particularly appropriate in high-risk missions where large numbers of replacement nanorobots are readily available.

Therefore, the most serious problems may devolve from the inherent complexity of a trillion machines independently trying to cooperatively work on a very complex repair problem in a short period of time. One class of malfunction might involve some unexpected emergent machine-machine interaction -- the kind of subtle interaction that is unlikely to have been exhaustively tested in full-up systems, in advance.

As a simple example, consider two nanorobot species that are jointly repairing a given block of tissue. If the nanorobot programming allows species A to interpret the repair work of species B as a new tissue flaw that lies within species A's original repair mission parameters, and vice versa, then it would be possible for the two species to become locked in an endless recursive cycle, as each species attempted repeatedly to undo the other's work.

But even in such cases, control over the devices is not lost. The supervising physician, upon observing the fault, would simply shut down one or the other species to allow the work to proceed, or would shut down both species and reprogram them both (while they are still inside the body) to avoid the unwanted emergent behavior. The doctor must always be able to "pull the plug" on the nanomachines. This is one of the most important design constraints, one that will probably become a strict and universal regulatory requirement for all medical nanodevices.

What would be the biggest benefit to be gained for human society from nanomedicine?

Nanomedicine will eliminate virtually all common diseases of the 20th century, virtually all medical pain and suffering, and allow the extension of human capabilities, most especially our mental abilities.

Consider that a nanostructured data storage device measuring ~8,000 micron^3, a cubic volume about the size of a single human liver cell and smaller than a typical neuron, could store an amount of information equivalent to the entire Library of Congress. If implanted somewhere in the human brain, together with the appropriate interface mechanisms, such a device could allow extremely rapid access to this information.

A single nanocomputer CPU, also having the volume of just one tiny human cell, could compute at the rate of 10 teraflops (10^{13} floating-point operations per second), approximately equalling (by many estimates) the computational output of the entire human brain. Such a nanocomputer might produce only about 0.001 watt of waste heat, as compared to the ~25 watts of waste heat for the biological brain in which the nanocomputer might be embedded.

But perhaps the most important long-term benefit to human society as a whole could be the dawning of a new era of peace. We could hope that people who are independently well-fed, well-clothed, well-housed, smart, well-educated, healthy and happy will have little motivation to make war. Human beings who have a reasonable prospect of living many "normal" lifetimes will learn patience from experience, and will be extremely unlikely to risk those "many lifetimes" for any but the most compelling of reasons.

Look for more about *Nanomedicine* in *Cryonics*, 2nd Quarter 1999, when Robert Freitas will answer questions specifically about the application of nanomedicine to cryonics.

Taking Your Money With You

by William Faloon

Editor's Note:

At least once a week, Alcor members and membership prospects call me to ask about methods for preserving their money during cryonic suspension. Aside from a few very general suggestions, I have little to tell them. Although the cryonics community seems to have a serious interest in the topic of wealth preservation, so far no one has developed an inexpensive, practical method for accomplishing this.

I first heard of the Reanimation Foundation in 1990, not long after it was established. After this initial contact, I noticed little else publicized about this organization. As lately as March of 1998, I was told that all attempts at communicating with the Reanimation Foundation had failed. I assumed that it was no longer accepting contributors.

At a recent cryonics conference, Saul Kent and Bill Faloon (the men behind the Reanimation Foundation) assured me that this organization was alive, open, and still ready for business. Because of the frequent interest cryonicists express in the topic of wealth preservation, I invited Mr. Kent and Mr. Faloon to submit an article about the Reanimation Foundation.

Please note that the following is intended only for informational purposes, and should not be considered an endorsement of the Reanimation Foundation by the Alcor Life Extension Foundation, *Cryonics Magazine*, or myself. —BRS

Was Walt Disney interested in cryonics? Ever since 1966, when Disney succumbed to cancer, rumors have circulated that he was frozen. Despite the lack of evidence for this, many people are utterly convinced that Disney is resting in frozen slumber until he can rise again to reclaim dominion over Mickey, Donald, and the rest of his empire.

Walt Disney was not frozen, but even if he were, his return would not be as triumphant as we might imagine. If a hypothetical Walt Disney were brought back to life in 100 years, he would be penniless, with no control whatsoever over the billion-dollar company he created. The same is true for every patient now in cryonic suspension. If any of them are ever restored to life, they will have to start from scratch to rebuild their finances, regardless of how wealthy or powerful they once were.

Why Can't We "Take It With Us?"

As much as cryonicists might like to will their money to themselves in the future, this direct approach simply wouldn't work. No current law allows you to leave money to yourself through testamentary means. Legislators have never considered the possibility that a person "dead" by today's standards might be considered only "critically ill" according to medical science of the next century.

One possible solution is to create and endow a trust. If written properly, such a trust might possibly manage your funds and return them to you at some time in the distant fu-

ture. However, writing a legally sound trust requires the services of an attorney. Unless one of your close family members practices law, establishing this "wealth preservation" system could exhaust a significant fraction of the wealth you'd like to preserve.

Then too, Trusts must work within the Rule Against Perpetuities, which is now in effect throughout the United States (with the exception of Wisconsin, South Dakota, and perhaps a few other states) and most other countries. The Rule Against Perpetuities limits the time that the assets of a deceased person can be tied up, allowing you to leave your estate to your immediate heirs, but prohibiting your control over assets much beyond that. This time limit for trusts varies from state to state and country to country, but usually doesn't extend beyond a few decades after your legal death. The average trust probably won't survive until the reanimation of cryonics patients becomes possible.

The Reanimation Foundation

Not all countries subscribe to the Rule Against Perpetuities. Among the nations free of this restriction is Liechtenstein, a very small (about 60 square miles) mountainous principality nestled between Switzerland and Austria, with a population of about 27,000. Because of this and other factors, in 1989 Saul Kent and I chose this as the home for our Reanimation Foundation, an organization designed to maintain contributed assets for an indefinite period of time, until medical science acquires the ability to bring frozen individuals back to life and health. After reanimation, contributors to the Reanimation Foundation will be returned complete control over assets in their accounts.

Contributing financial assets to the Reanimation Foundation may provide funding for three purposes:

1. Scientific research to reanimate those contributors in cryonic suspension.

2. Attempts at reanimation for contributors.

3. Reintegration of contributors into society after reanimation (wealth preservation).

Anyone can donate money and other assets to the Reanimation Foundation. Contributions can be directed to the Foundation's General Reanimation Fund, to an Individual Reanimation Account, or the individual Reanimation Account of another person. The minimum funding level required to set up an Individual Reanimation Account is U.S. $25,000, which may take the form of cash, stocks, bonds, real estate, precious metals, insurance, or any other established method of funding. Contributors may also use a will or trust to designate which assets are to be transferred to their accounts after legal death.

Funds can be removed from an Individual Reanimation Account at any time, for any reason, prior to the contributor's cryonic suspension. As soon as suspension occurs, however, the full amount of a contributor's account is released for use by the Foundation.

The affairs of the Reanimation Foundation are governed by a Board of Directors, in strict accordance with its by-laws. The Foundation's Board is comprised of three Liechtenstein Directors who are members of a trust management team, and there are also three American cryonicists who form a "Committee of Protectors" to oversee these Directors. (While we are seeking the President of a major Swiss bank to oversee the Foundation's Directors, no such person in Switzerland is currently willing to accept the position, which includes potential responsibility of cryonics patients.) As a further precaution, the Reanimation Foundation submits to an annual independent audit.

When the first person with a Reanimation Account finally deanimates, we plan on forming a Committee of Scientific Advisors to begin studying possible reanimation techniques.

For more information about the Reanimation Foundation, call **1-800-841-LIFE**.

MOVING?

Let us know about it!
Call 1-602-905-1906
and ask for Joe Hovey.

Don't miss even *one* issue of *Cryonics*!

An Exploratory Survey Examining the Familiarity with and Attitudes toward Cryonic Perservation

by W. Scott Badger, Ph.D.

ABSTRACT

A consumer survey designed to measure familiarity with and attitudes toward the idea of cryonics was conducted over the internet. A total of 517 responses were examined in an effort to clarify the relationships between (1) the reported level of familiarity vs. the accuracy of responses, and (2) demographic variables vs. attitudes and dispositions toward cryonics. Results indicate that (1) those claiming superior familiarity do not have superior knowledge, (2) a sizable number of those surveyed have significant misconceptions regarding cryonics, and (3) important attitudinal differences exist between demographically diverse groups.

INTRODUCTION

Cryonics has been defined as "the technology for freezing a person after a terminal illness or a fatal accident, in the hope that medical science will be able to revive that person in the future, when life extension and anti-aging have become a reality".[1] Cryonic suspension is an emergency medical procedure designed to save lives (much like Cardio-Pulmonary Resuscitation), a last-ditch effort to forestall irreversible brain damage. Since the first individual was cryonically preserved in 1967, a handful of firms have sprung up offering cryopreservation and/or storage services to the general public.

It is often argued on the Cryonet[2] (an internet newsgroup for cryonics related issues) that the cryonics industry has experienced a relatively slow rate of growth over the years although some firms have grown faster than others. Between the several firms involved, it is estimated that only about 100 individuals have been frozen to date, with another 700-800 signed up for cryopreservation once they are pronounced legally dead.[3] These figures cannot be considered to be highly reliable since some firms do not divulge membership information. These are disappointing figures for many leading cryonicists who have struggled financially and worked incessantly to convince the public that cryonics is a rational and affordable alternative for those who wish to extend their lives and the lives of those they love.

The successful reanimation of those who have been frozen will depend on a number of factors. First and foremost, the technology required to repair the damaged bodies will have to be developed. The successful operation and long-term growth of the organization responsible for one's eventual reanimation will also be of significant importance.

It has been stated that despite three decades of massive publicity, the growth of the cryonics industry has been abysmal.[3] Cryonicists have appeared on talk shows, television magazines have taken tours of cryonics facilities, a number of magazine and newspaper articles have been published, marketing professionals have tried to sell cryonic services as they have successfully done with other services, and individual members have tried to persuade their friends and family. Even so, these approaches appear to have had little effect on the growth rate of the industry. The lackluster response of the market has consequently been the focus of many spirited debates among cryonicists. A number of hypotheses have been generated regarding why the American public has been so slow to embrace the central tenets of cryonics.

One of the most clearly articulated hypotheses is that presented by one of the pioneers in cryonics, Saul Kent. Mr. Kent is currently the Director of 21st Century Medicine. This research firm is currently involved in several lines of research, one of which is investigating the viability of vitrification as an effective suspension protocol. His recent essay titled, "The Failure of Cryonics"[3] concludes that consumers are not attracted to cryonic services for the simple reason that there is no convincing evidence that cryonics will work. He characterized cryonics as "a bad product," insisting that emphasis needs to be placed on research aimed at better suspension techniques. Only when it can be demonstrated that humans can be revived will we see a significant increase in the number of people interested in signing up for cryonics, according to his essay.

Some contributors to the Cryonet newsgroup suggest that resistance among consumers is strongly related to the difficulty they experience dealing with the idea of their own death. Some say that many people object to the notion of cryonics on religious or ethical grounds. Others suggest that the general populace is not attracted to cryonics because they do not fully understand the concepts which underlie it. Some argue that the concept of cryonics is marketable, but the correct marketing strategy has yet to be discovered. In fact, some suggest that a sophisticated marketing strategy has yet to be undertaken. Others insist that the only way to sell someone on cryonics is through persistent and patient persuasion over a long period of time. This paper will examine the survey participants' familiar-

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ity with and attitudes toward cryonics, and in so doing will attempt to address some of the controversy discussed.

METHOD

Procedure

This was an exploratory, correlational study designed to examine relationships between factors relevant to the issues discussed above. For this purpose, a consumer survey was designed to measure the familiarity with and the attitudes toward the ideas of cryonics. The survey was reviewed by a number of cryonicists before the final version was completed and placed on the internet. The survey included four sections; (1) a Demographics Section, (2) a Quiz Section measuring familiarity, (3) an Attitudes Section, and (4) an Answers Section providing the correct answers to the items presented in the Quiz Section. Respondents were unable to proceed from one section to the next until all the items for that section had been answered. The majority of the items were in a 5 point Likert-type, multiple-choice format.

Participants

Participants in the study were subscribers to a weekly internet magazine/newsletter known as "The Tourbus" (http://www.tourbus.com). Information on various web sites and internet-related issues is e-mailed to approximately 80,000 subscribers according to the editor on a bi-weekly basis. The following paragraph appeared on the front page in the September 1, 1998 edition of The Tourbus:

> **Is It Cold In Here?**
> If a person's body is frozen just after clinical death, could they perhaps be revived at some future time when medical technology permits? That question is the essence of Cryonics. I recently found a really interesting and educational web site which deals with Cryonics, and all the questions that surround the issue. The Associated Cryonicists Consumer Survey is a fun way to explore this fascinating subject, and learn whether cryonics is just wild-eyed idealism or serious science. You can find it here:
>
> Cryonics Survey - http://homepages.waymark.net/cgi-bin/cgiwrap/wbadger/demoinfo.cgi

Approximately 250 completed surveys were collected over the next two weeks. The survey was mentioned once again on September 23rd as follows:

Variable	Percent	Variable	Percent	Variable	Percent
Gender		Marital Status		Income	
Males	57.1	Married	58.6	<25K	19.5
Females	42.9	Single	41.4	25-49K	41.0
				50-74K	26.3
				75-99K	7.5
				>100K	5.6
Age		Ethnicity		Occupation	
<25	8.7	African American	6.8	Agricultural Field	3.5
25-34	24.8	Asian American	2.3	Engineering	6.0
35-44	26.9	Caucasian	80.5	Computer Field	23.0
45-54	25.1	Hispanic	0.8	Health Care	7.0
55-64	9.9	Native American	1.9	Legal Field	1.9
>64	4.6	Other	7.7	Research Scientist	2.1
				Sales	5.8
				Service Industry	6.4
				Social Services	1.0
				Teacher/Instructor	9.1
				Other	34.2
Children		Education		Religion	
0	42.2	Elementary	1.7	Agnostic	16.4
1	14.3	High School	25.5	Atheist	6.6
2	24.4	Associate's Degree	12.6	Buddhist	2.5
3	12.2	Bachelor's Degree	27.5	Christian	57.1
4	4.1	Master's Degree	21.5	Hindu	1.5
5	1.9	Doctoral Degree	2.7	Jewish	4.4
6	1.0	Medical Doctor	0.4	Moslem	1.2
		Jurisprudence	1.0	Taoist	10.3
		Other	7.2		

Table 1. Demographic Variables' Frequency Distributions for Survey Respondents

> **WHO LEFT THE REFRIGERATOR DOOR OPEN?**
> Before we begin our tour for the day, I wanted to remind you about the Cryonics survey we mentioned in a previous issue. It's really quite fascinating, and you'll be surprised at some of the answers. Is Walt Disney's body frozen? Find out soon, because the survey is closing in a few days.
>
> Cryonics Survey - http://homepages.waymark.net/cgi-bin/cgiwrap/wbadger/demoinfo.cgi

As of October 1, 1998, a total of 517 responses were collected after 32 accidentally repetitious and clearly disingenuous replies were deleted. Table 1 outlines the demographic profile of the sample.

Limitations of the Study

It is important to point to some of the limitations of the current study. First, the sample of participants used for this study was not randomly selected. Participants were solicited through the internet. Therefore, they may not be (and probably are not) representative of the larger population. Consequently, findings may have limited generalizability. Also, the sample population appears to be disproportionately Caucasian and Christian. The small size of a number of subgroups (e.g. Hispanics, Hindus) may have suppressed significant results related to their responses. It should also be noted that a large percentage (25%) of the participants marked "Computer Field" for their occupation. In addition, the overall response rate was less than one percent. A larger and more representative sample, and possibly a different sampling source may address some of these problems in future studies.

RESULTS

Familiarity Questions

The first question examined in this study addresses the assertion among some cryonicists that increased publicity designed

to educate the public on cryonics will be ineffective since the public is already sufficiently familiar with the essential elements of cryonics. Question #2 examines self-reported levels of familiarity and appears below. The frequency distribution in percentages lies to the right of each group.

2. How familiar would you say you are with Cryonics compared to the average person?

Group 1=
Much less than the average person. 5.2%

Group 2=
About as much as the average person. 64.4%

Group 3=
Somewhat more than the average person. 27.3%

Group 4 =
Quite a bit more than the average person. 3.1%

Self-reports may now be compared to other quiz items to determine how accurate respondents' self-evaluations are. In addition, we can compare responses between the four groups created in Question #2 using one-way Analysis of Variance (ANOVA) and Tukey HSD post-hoc strategies. ANOVA is a statistical procedure used to determine whether there are any group differences overall on a variable. Tukey HSD is a follow-up procedure used to detect specific group differences. Unless otherwise specified, the parameter for statistical significance will be set at $p < .05$. This means that if one group is said to be "different" from another (e.g. males and females) on a particular variable (e.g. Q23), then there is less than a 5% chance that there is, in fact, no difference between the groups.

There were a total of 16 questions in the Quiz section of the survey. In the interests of limiting the scope of this article, only three variables considered to have particular relevance to the study (Q5, Q6, and Q7) were investigated. Upon examination, the responses to these three questions ranged widely, and the frequency distributions appeared to be highly skewed. The reader will note that the mean values are almost 10 times the median values, and that the median values are considerably closer to the estimated true values. This degree of skewness threatens the validity of the ANOVA procedure which requires a relatively normal distribution as one of its assumptions. Consequently, the three variables were transformed using a log function which resulted in a lognormal frequency distribution for each variable. The means of these transformed distributions (log means) were then used for the ANOVA procedures to look for group differences. The log means were then transformed back (exponentiated) into figures which may be more easily compared by the reader to the original means.

Questions #5 and #6 were designed to determine how popular or successful participants perceived the cryonics industry to be.

Q5. What is your estimate of the number of people that have already been cryonically suspended?

Groups	Normal	Exponentiated Means of Logs
1	842	86
2	1296	190
3	1327	207
4	896	158

The mean and median values of the non-transformed distribution was 1,271 and 100 respectively. The correct answer, as previously asserted, is approximately 100 suggesting that the log means of all four groups were fairly accurate. In addition, there is no statistically significant difference between the four groups at the .05 level, suggesting that those who claim to have much greater familiarity than the average person are no more accurate in their estimates than those who claim to have much less familiarity. It should be noted, however, that 144 individuals (27.9% of the total sample) estimated there were 1,000 or more people already cryonically frozen, overestimating by a factor of 10.

Q6. What is your estimate of the number of people that have made arrangements to be cryonically suspended upon their death?

Groups	Normal	Exponentiated Means of Logs
1	4571	400
2	10,030	1026
3	10,864	1229
4	8,813	849

The overall normal mean and median values of the non-transformed distribution was 9,969 and 1,000 respectively (once again a 10:1 ratio). The log means in this instance are again relatively accurate given the estimated "true" value of 700-800 described earlier. No statistically significant differences were found between the groups at the .05 level even though it appears that Group 4 (those claiming superior familiarity) are closer to the true estimate. It may be worth noting that 106 individuals (20.5% of the total sample) estimated there were 10,000 or more people already signed up to be cryonically frozen, overestimating by at least a factor of 10.

Question #7 was designed to assess participants' familiarity with the costs of being cryonically preserved.

Q7. How much do you believe it costs to have your body cryonically preserved?

Groups	Normal	Exponentiated Means of Logs
1	626,288	42,480
2	588,343	58,489
3	303,606	58,402
4	150,937	65,303

The overall normal mean and median values of the non-transformed distribution was $499,545 and $50,000 respectively. Log means for the four groups are fairly accurate estimates of the previously asserted range of $28,000 to $165,000. Although no statistically significant group differences were detected at the .05 level, one can see that the estimates appear to decrease as the level of alleged familiarity increases on the non-transformed figures, while the opposite seems to be the case with the lognormal means. Since there are no statistically significant differences between the means, these trends should be disregarded. It is noted once more, however, that 91 individuals (17.6% of the total sample) estimated the cost of cryonic preservation to be $300,000 or more, overestimating by at least a factor of 10 based on the least expensive suspension service available.

At this point, one might ask, "Are the gross overestimates across variables Q5, Q6, and Q7 being consistently made by the same group of people from the sample?" A

bi-variate correlation analysis measures the degree of association between two variables. The results of correlation analysis indicates that the responses to Q5 correlate significantly with the responses to Q6 ($r = .31$, $p < .000$), but there are no other statistically significant correlations among these three variables at the .05 level. For the most part, it appears that the answer to the question posed is, "Most of the responses appear to be independent of each other."

Attitude Questions

Participants were asked to respond to six positive statements and ten negative statements about their attitudes toward various aspects of cryonics. All of the items in this section were in the form of a Likert scale as shown below. The numbers of the Likert scale are treated as interval values rather than as categorical or ordinal values. This means there are equal differences between measures (e.g. temperature, IQ, etc.).

1 = Strongly Agree
2 = Agree
3 = Not Sure
4 = Disagree
5 = Strongly Disagree

Mean (arithmetic average) Likert scores and standard deviations for the positive statements appear in Table 2.

It can be seen that the mean response to Questions 18 and 19 fell about midpoint between "Strongly Agree" and "Agree" indicating a moderately positive attitude towards extended lives and towards cryonics as representing a chance for achieving that end. Questions 20 through 23 fell about midway between "Agree" and "Unsure" suggesting a mildly positive view towards those statements. Though all means fell on the left (favorable) side of the Likert scale, respondents were least positive overall about the statement made in Question 23.

Mean values and standard deviations for the negative statements appear in Table 3. The values in Table 3 suggest that people perceive cryonics as unaffordable, and they have mildly negative feelings about what the impact of being frozen would be on their friends and relatives as well as not having those friends or relatives around when they are revived in some future time. There was mild to moderate disagreement with the idea that considering one's own death is so difficult that cryonics is hard to think about. There was also mild to moder-

Table 2. Means and standards deviations of positive attitude statements

Positive Statements	Mean	Std. Dev.
Q18. I love being alive and I want to remain alive and healthy for as long as I can.	1.46	0.78
Q19. Being frozen is no guarantee that I will be revived someday, but I know my chances are zero if I am buried or cremated.	1.57	0.88
Q20. I could accomplish much more with my life if it were significantly extended.	2.49	1.03
Q21. I'm very optimistic about humankind's future and want to be there to see and participate in the amazing advances that will be made.	2.40	1.09
Q22. I look forward to a time when we won't have to suffer the loss of our friends and family because of aging and disease.	2.50	1.20
Q23. I'm excited about the prospect of waking up in a body made young again through bio-technological advances.	2.77	1.25

Table 3. Means and standards deviations of negative attitude statements

Negative Statements	Mean	Std. Dev.
Q24. Cryonics doesn't interest me because I just don't think it will work.	3.11	1.12
Q25. The cost of having my body frozen is far too expensive for me.	2.21	0.95
Q26. Dealing with wills, insurance policies, and other legal matters is too much trouble to make Cryonics worthwhile.	3.22	1.00
Q27. Extending one's life span through Cryonics is unnatural, selfish, and immoral.	3.20	1.16
Q28. Cryonics is a bad idea because it would lead to an overpopulation problem.	2.90	1.11
Q29. I don't think about Cryonics because I don't like thinking about death.	3.69	1.02
Q30. Cryonically preserving me would be too hard/weird for my family/friends to handle.	2.83	1.06
Q31. I'm too young and healthy to even care about it at this point.	3.52	1.03
Q32. I would not want to wake up in a future time without my family or friends around.	2.73	1.19
Q33. I don't think that people in the future will have any interest in reviving frozen bodies.	3.36	1.09

ate disagreement with the idea that people do not care about cryonics because they are young and healthy. There is also mild disagreement with the negative statement regarding all the paperwork involved in signing up for cryonics.

Disposition Questions

Finally, a series of statements were presented which required participants to consider different conditions under which they might become favorably disposed toward the idea of cryonics. The purpose was to identify variables which may or may not be helpful in motivating individuals to give favorable consideration to being cryonically preserved. The stem for each statement is, "I would feel more favorably toward the idea of cryonics if . . ." Table 4 summarizes the means and standard deviations for this group of questions.

A simple examination of the descriptive statistics in Table 4 indicates that the participants are less likely as a whole to be motivated to sign up for cryonics because celebrities sign up or even if large numbers of others sign up. It also appears that successfully reviving mice or dogs (and presumably any other non-human animals) will be mildly ineffective motivators. The two variables which appear to have some mild motivational potential was Q41 (the revival of a human being) and Q42 (if it were cheaper).

The final item in the survey was:

Q44. I believe that Cryonics is an exciting idea and intend on looking into it further.

Using the same Likert scale as before the overall mean was determined to be 2.09 suggesting that there is fairly solid agreement with this statement among those surveyed.

Group Differences

Descriptive statistics such as the majority of those discussed above can be useful in developing a general profile of the sample population. They can also act as indicators that point to productive areas of inquiry. The second section of this report will examine differences between groups formed by demographic dissimilarities within the sample. In other words, the groups created by the participants' responses to the questions in the Demographic Section will be compared to see if they differ with respect to their responses to various questions in the survey. Examination of the distribution frequencies of the Q18 through Q44 indicates they are relatively unskewed, and lognormal transformations will not be necessary.

Table 4. Means and standards deviations of motivation statements

Motivation Statements	Mean	Std Dev
Q34. Thousands of other people were signing up.	3.58	0.95
Q35. Millions of other people were signing up.	3.48	1.08
Q36. My physician approved of and recommended the idea.	3.26	1.06
Q37. Celebrities I admired were signing up.	4.09	0.88
Q38. Someone in my family were signing up.	3.15	1.06
Q39. a mouse were completely revived after cryonic storage.	3.30	1.02
Q40. a dog were completely revived after cryonic storage.	3.20	1.07
Q41. a human were revived.	2.52	1.19
Q42. if it were cheaper.	2.85	1.12
Q43. Under no circumstances.	3.45	1.12

Table 5. Gender

Group #	Gender	#Participants
1	Male	295
2	Female	222

Gender differences appeared early on in the survey with several differences uncovered on a number of items. On item Q2, males perceived themselves as more familiar with cryonics than females ($p < .00001$). Responses to Q20 indicate that males feel they could be more productive if their lives were significantly extended while women were less prone to agree ($p < .0015$). Women had a higher degree of agreement with item Q22 suggesting than men were less concerned with the loss of family and friends ($p < .083$). Males were more agreeable than females to the idea in Q23 of waking up in a young and healthy body in the future ($p < .022$). Women perceived cryonics as less affordable than men ($p < .009$). Item Q27 results indicated that men disagreed more strongly than women with regard cryonics being immoral, selfish, or unnatural ($p < .036$). Women were more agreeable than men with the idea (Q32) that it would be unpleasant to awake in the future without one's family and friends ($p < .00001$) Women also appeared less confident than men that people in the future would have any interest in reviving frozen bodies (Q33) ($p < .032$). Finally, men were found to agree more strongly than women with item Q44 which stated, "I believe that cryonics is an exciting idea and intend on looking into it further" ($p < .0002$).

Table 6. Occupation

Group #	Occupation	# Participants
1	Agricultural Field	18
2	Engineering	31
3	Computer Field	119
4	Health Care	36
5	Legal Field	10
6	Research Scientist	11
7	Sales	30
8	Service Industry	33
9	Social Services	5
10	Teacher/Instructor	47
11	Other	177

Few differences were found between the occupational groups. Individuals in the Service Industry expressed a greater willingness to feel favorably toward cryonics if thousands of others signed up as compared to Research Scientists and those in the Computer Field. When that number was raised

to millions instead of thousands, Research Scientists were still more reluctant to think favorably of cryonics than either those in the Service Industry or Engineers. When asked whether cryonics was unnatural, selfish, and immoral, those in Health Care replied more affirmatively than did Engineers. It is worth noting that 177 participants fell into Group 11 while many other Groups had quite small numbers suggesting that a different set of occupational fields may be advisable in future surveys.

Table 7. Age

Group #	Age Range	# Participants
1	< 24	45
2	25 – 34	128
3	35 – 44	139
4	45 – 54	130
5	55 – 64	51
6	> 64	24

A relatively large number of group differences was found on the basis of age range. Group 2 appeared to be more concerned with population problems arising as a result of cryonics than either groups 3 or 4. In responding to items Q34 and Q35 (I would feel more favorably toward cryonics if thousands (millions) were signing up), Groups 2 and 3 disagreed most strongly, both having significantly higher scores than Group 1 which was the most agreeable group. The same group differences were found for Q36 (if my physician approved of and recommended the idea). Group 2 also disagreed more strongly with item Q44 (I believe that Cryonics is an exciting idea and intend on looking into it further) than Group 1. Group 2 appears to be the Group least disposed toward the idea of cryonics. There may be a cohort effect for those in this age range due to cultural events in their lives, or it may be that people at this stage of life are more skeptical in general than other age groups.

Although there were a number of statistically significant mean differences between ethnic groups, it was felt that little value could be placed in any interpretations drawn from the analysis due to the relatively small group memberships for all except Caucasians.

Table 8. Ethnicity

Group #	Ethnicity	# Participants
1	African American	35
2	Asian American	12
3	Caucasian	416
4	Hispanic	4
5	Native American	10
6	Other	40

Table 9. Religion

Group #	Religion	# Participants
1	Agnostic	85
2	Atheist	34
3	Buddhist	13
4	Christian	295
5	Hindu	8
6	Jewish	23
7	Moslem	6
8	Taoist	53

Several group differences were found to exist as a function of this demographic. The reported level of familiarity with cryonics was significantly higher for Agnostics and Atheists as compared to Christians. Even so, no group differences were found with respect to the answers given on the Quiz Section. Agnostics and Atheists also agreed more strongly than Christians with Q20 (I could accomplish much more with my life if it were significantly extended). Agnostics had a significantly lower (more agreeable) mean score than Christians on Q21 as well, suggesting they are more optimistic about the future of humans. The same was true for Q23 indicating that Agnostics look forward to waking up in a young body in the future more so than do Christians. Christians were found to agree more strongly with Q24 (Cryonics doesn't interest me because I just don't think it will work.) than did Agnostics. Christians also viewed cryonics to be less affordable than did Agnostics (Q25). Christians perceived the paperwork and legal work associated with cryonics as more troublesome than Agnostics (Q26). Christians were more disposed to perceive cryonics as unnatural, selfish, and immoral than either Agnostics or Atheists (Q27). Agnostics and Atheists had fewer concerns with the negative perceptions of family and friends toward cryonics than Christians (Q30). They were also less concerned about waking up in a future time without family and friends around (Q32) than either Christians or Jews.

Questions 34 through 43 all began with the same sentence stem; "I would feel more favorably toward cryonics if . . ." and were designed to assess the relative value of various social, financial, and technological motivators. No group difference were found among social motivators. Differences first appear with Q39 "if . . . a mouse were completely revived after cryonics storage" with Agnostics more favorably disposed than Christians. Atheists join Agnostics in being more favorably disposed than Christians toward cryonics if and when a dog is completely revived. The same was true for Q41 ("if . . . a human were revived."). Finally, Christians agreed more strongly than Agnostics or Atheists with Q43 (. . . under no circumstances.").

The last question of the survey (Q44) addressed overall interest in the idea of cryonics. Among all the religious groups, Christians had the highest (least interested) mean score and these scores were significantly different from Agnostics and Atheists who appear to be among the most interested. It may be helpful for the reader to know for comparison's sake that the mean scores on Q44 were: Christians = 3.12; Agnostics = 2.57; Atheists = 2.41. It is interesting to note that out of 295 Christians participating in the survey, 20 marked "Strongly Agree" for Q44 and 57 marked "Agree." This suggests that about 26% of those from the Christian faith seem to be approachable on the subject of cryonics.

Table 10. Marital Status

Group #	Marital Status	# Participants
1	Married	303
2	Single	214

Married individuals expressed significantly greater reluctance toward cryonics due to family-related issues (Q30, Q32) than did single respondents.

High school graduates agreed more strongly with Q29 ("I don't think about cryonics because I don't like thinking about death."). than did individuals with Associates, Bachelors, or Masters degrees. They

Table 11. Education

Group #	Education	# Participants
1	Elementary	9
2	High School	132
3	Associate's Degree	65
4	Bachelor's Degree	142
5	Master's Degree	111
6	Doctoral Degree	14
7	Medical Doctor	2
8	Jurisprudence	5
9	Other	37

also expressed greater concern about waking up in the future without family and friends being there as compared to individuals with Master's degrees.

Table 12. Income

Group #	Income	# Participants
1	< 25K	101
2	25 - 49K	212
3	50 - 74K	136
4	75 - 99K	39
5	> 100K	29

It was found that individuals in Group #5 believed themselves to more familiar with cryonics than those in Groups # 2 or #3. Even so, individuals in Group #5 fared no better on the items in the Quiz Section than any of the other groups. Although all groups were in at least moderate agreement with Q18 ("I love being alive and I want to remain alive and healthy for as long as I can."), Group #4 most strongly agreed with this item. Similarly, all groups generally agreed with Q19 ("Being frozen is no guarantee that I will be revived someday, but I know my chances are zero if I am buried or cremated."), but Group #5 agreed most strongly. As would be expected, group #5 was least concerned with the affordability of cryonics while Group #2 was the most concerned. Group #5 was also the least concerned group when the issue of overpopulation was brought up while Group #3 was found to be the most concerned. When presented with factors which might favorably dispose them to cryonics, Group #1 appeared to be the group most motivated by the idea of large numbers of other people signing up and to the idea of cryonics being recommended by their physician, while Group #2 disagreed most strongly with these items.

Group differences based on Income approached statistical significance (n = 516, p = .07) on Item Q44 ("I believe that cryonics is an exciting idea and intend on looking into it further."). Group #5 most strongly agreed with this item (mean = 2.69) while Group #2 most strongly disagreed (mean = 3.05).

Factorial Analysis

The factorial analysis of variance is a statistical procedure designed to examine the effect of two or more independent or classification variables (e.g. gender) on a set of dependent variables (e.g. Q23) (Stevens, 1995). One of the purposes of this procedure is to determine whether there are any interaction effects between demographic variables (e.g. "Do male agnostics differ from female agnostics?" "Do older married people differ from younger married people?" etc.). No significant interaction effects were found to exist between these variables indicating that only main effects have any statistical or practical significance in this study.

Multiple Linear Regression Analysis

In multiple regression we are interested in predicting a value for a dependent variable from a set of predictor (independent) variables. The final question addressed in this study asks, "To what degree does each demographic variable contribute to the variance observed in the responses to Q44." ("I believe that cryonics is an exciting idea and intend on looking into it further."). A stepwise linear regression analysis was performed to identify which demographic variables significantly contributed to explaining fluctuations in Q44. The results indicate that Gender alone reached the .05 level of significance required to be entered into the regression equation. Some may ask why other demographic variables such as Religion, where important group differences were previously discovered, failed to enter into the equation. It must be remembered that although Christians differed from Agnostics and Atheists, there were no other statistically significant group differences found. In other words, there was relatively little overall variance observed for the Religion variable so it was unable to explain a significant amount of variance in Q44. The equation derived from the multiple linear regression procedure follows:

$$Q44 = 2.40 + .35\ (\text{Gender}) + \text{noise}$$

$$R^2 = .0259$$

(standard error of the regression coefficient = .09)

Noise is a term used to represent error. R^2 is a value that reflects the degree to which the regression equation explains the variance in Q44. In this case, $R^2 = .0259$, so only about 2 1/2 % of the variance in Q44 is explained by Gender. Four other variables achieving significance levels of $p < .10$ but not $p < .05$ are included in Table 13. These variables may be considered to be approaching significance. Nevertheless, regression analysis suggests that demographic factors have limited usefulness in predicting dispositions toward cryonics.

Table 13. Regression Analysis #1

Demographic Variable	Significance of T
Gender	.0002
Age	.0843
Marital Status	.0750
Occupation	.0689
Ethnicity	.0797

A similar analysis was performed using the items from the Attitude Section (Q18-Q33) as the independent variables and regressing them on to Q44, the dependent variable. The following regression equation was derived:

$$Q44 = 3.35 + .08\ (Q21) + .30\ (Q23) - .25(Q24) - .14\ (Q27) - .08\ (Q30) + \text{noise}$$

$$R^2 = .49$$

Using the same parameters, a relatively impressive R^2 value of .49 was obtained indicating that almost half of the variance in Q44 can be explained by the five variables in the equation. This equation suggests that those who find Cryonics to be an exciting idea and intend on looking into it further are also those who (1) are optimistic about humankind's future; (2) are excited about the prospect of waking up in a body made young again; (3) tend to believe that cryonics will work; (4) disagree that cryonics is unnatural, selfish, and immoral; and (5) disagree that cryonic preservation would be too hard/weird for their family/friends to

Table 14. Regression Analysis #2

Variable	B Value (Coefficient)	Standard Error of the Coefficient	Significance Level of T
Q21	.081577	.038534	.0347
Q23	.299711	.034873	.0000
Q24	-.253954	.035224	.0000
Q27	-.142850	.037327	.0001
Q30	-.083530	.036120	.0211
Constant	3.355794	.223347	.0000

handle.

Precise coefficient values and associated standard errors are presented in Table 14.

SUMMARY

In the Quiz Section, survey participants expressed a considerable amount of variability in their responses to "fill-in-the-blank" questions. After being transformed into lognormal distributions to compensate for their overly skewed distributions, Q5, Q6, and Q7 provided log means that were relatively accurate. ANOVA procedures indicated that there were no statistically significant differences between those who claimed to be familiar with cryonics and those who claimed they weren't. Even so, a portion (17.6 - 27.9%) of the sample overestimated in their responses to Q5, Q6, and Q7 by a factor of 10. This suggests that a sizable segment of the population greatly over-estimates the number of people frozen and those signed up for cryonics. Further, a sizable portion may also greatly over-estimate the cost of cryonics. This result indicates that the affordability of cryonics through life insurance policies is a message that may be failing to reach the general public.

In the Attitudes Section, the average participant was moderately positive toward life extension and toward cryonics as a means to that end. They were mildly agreeable with the remaining statements associated with positive and optimistic attitudes toward the promise of future developments in anti-aging and other technological advances. When given a chance to respond to statements representing negative attitudes, results indicated that participants were most negative about the perceived cost of cryonics. They also had mildly negative attitudes toward the idea of becoming alienated from their family and friends as a result of signing up and being frozen. Though it is often cited as an important reason why people resist considering cryonics, participants most strongly disagreed with the idea that they are uncomfortable thinking about their own mortality.

Survey participants indicated overall that the successful revival of a cryonically frozen human being would be the most persuasive factor of those considered. The next most persuasive factor was lowered costs. Although many have suggested that membership rates would likely increase if more celebrities would sign up for cryonics, results demonstrate that this statement was more strongly disagreed with than any other.

In terms of differences along demographic variables, a number of statistically significant results were uncovered. Men perceived themselves as more familiar with cryonics and had, for the most part, more positive attitudes toward cryonics than women. With respect to age, it appears that individuals between the ages of 25 and 34 and those older than 65 are most strongly opposed to the idea of cryonics while those younger than 24 express the greatest amount of interest. This finding fails to support those who hypothesize that the young lack interest in cryonics for one reason or another.

It became clear when examining group differences between religious groups that Agnostics and Atheists were consistently more favorably disposed toward cryonics than were Christians. No other group differences were found based on religion. Married individuals were more concerned about family issues related to cryonics than were single individuals, but there was no difference in overall interest in cryonics between married and single individuals. Those with no more than a high school education were more uncomfortable thinking about death in general and more concerned with family issues than those with more education. Individuals making more than $100K were generally more favorably disposed toward cryonics while those making from $25K - $49K appeared to be the least favorably disposed income group.

CONCLUSIONS

Keeping the aforementioned limitations in mind, the data gathered points to a number of tentative conclusions. It suggests that, for the most part, people are able to make reasonably good estimates of the current memberships and costs associated with cryonics, although about one-fifth over-estimate these values by a factor of 10. Some will maintain that this tends to support those who have contended that the cryonics industry has received sufficient publicity and thus, more publicity will not significantly increase membership. Others might argue, by way of analogy, that there would be great concern in the computer industry if one-fifth of the public believed that the average computer was priced at $10,000. The data also suggests, however, that publicity aimed at the general public may not be the most effective approach. A more effective marketing effort might be one targeted at male agnostics and atheists. There may also be some value in targeting individuals who are single, fairly well-educated, or younger than 25 or between 35 and 64 years of age. It is reasonable to assume that individuals who meet more than one of these criteria are likely to have an increasingly favorable disposition toward cryonics.

The results also suggest that the content of marketing efforts focus on certain issues. Emphasis should be placed on (1) the affordability of cryonics, (2) promoting optimism with regard to the future, and (3) the idea of receiving a young and healthy body in the future. Results also suggest that the most important negative attitudes which need to be overcome include: (1) beliefs that cryonics will not work, (2) beliefs that cryonics is unnatural, selfish, and immoral, and (3) the belief that cryonic preservation would be too hard/weird for their family/friends to handle.

A number of cryonicists express strong opinions in their subjective assessments of the public's perception and attitude toward the idea of cryonics. Although the results of the current survey assist in clarifying some aspects of the debate on this issue, several questions remain unresolved. Additional surveys designed to replicate and extend the scope of the current study may provide the beginnings of an empirical foundation for guiding the efforts of firms offering cryonic services.

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Cryonics and Emergency Medicine

by Thomas Donaldson, Ph.D.

I will begin with a simple statement: Yes, I do think that we'll someday find means to revive most of those suspension patients frozen with current methods, now or in the past. Revival of patients suspended by future methods will be even easier. However, all of human history suggests that revivals will not occur within just a few years, and they will certainly not occur at any one given time. If theoretical ideas tested only by computer need no revision, current scientific ideas about memory are close to correct, money for the required research becomes available instantly, everybody cooperates, no one stands up to oppose the changes, and no one insists on proof before we can proceed . . . then means to revive suspended patients will arrive quite soon.

Yet to assume that everything will go so smoothly is simply to dream. To believe that we might specify repair processes based on nothing more than computer studies looks to me like the belief of a novice programmer; since he can easily write flawless "Hello" programs, he assumes he can write a million-line program totally without bugs.

Then too, explicit reports of suspensions published by cryonics organizations suggest that patients will not be revived by only a few repairs. We already know that such patients have experienced a wide range of conditions, from those whose brains alone were straight-frozen, to those suspended under the best conditions according to current knowledge (which may be mistaken!). Repair must deal not with one kind of problem but with many. We will not simultaneously solve every problem of reanimation, regardless even of how far we develop the suspension process itself.

No, improving cryonics-style procedures to the point of reversible suspended animation will not alleviate *all* of our problems. How many people will decide, *in full health*, that they want to enter suspended animation? They would be helpless for an unknown length of time, and would arrive in an unknown world missing all of their friends and requiring their extensive re-education. Given these likelihoods, the choice of suspended animation while healthy looks almost as irrational as the choice of cryonic suspension in a similar condition*. (Yes, some people would subject themselves to either one, but not many).

Beyond the rationality of this choice, there is the price tag. Few people would happily decide to spend in excess of $75,000 without prolonged deliberation. Certainly reversible suspended animation will be no less expensive than this, and so its cost will affect the circumstances under which someone might choose it. Again, most people would probably not submit to suspended animation (or cryonic suspension) until near the end of a terminal illness.

Here we encounter our main problem: death does not follow a schedule. Cryonicists die by accidents that occur thousands of miles from their cryonics society, they die suddenly in the apparent peak of physical health, and they die all alone in their private homes and apartments. Even in cases for which their time of death is predicted, they may doubt that prediction, holding out until the very last minute. If we had true suspended animation, they might take this option before death, but they also might only come to that decision in circumstances which made their suspended animation just as difficult as many cryonic suspensions today.

We will not have completed our research if we only go so far as reversible suspended animation. For emergency medicine we need much more: the equipment to perform suspended animation must become portable. Ideally, such equipment must allow *only one person* to carry out a full procedure. Facilities able to carry out suspended animation must become easily accessible on very short notice. And we'll *still* have to work out just how to deal with patients who have experienced cessation of breathing and heartbeat many minutes before the suspended animation team arrives. Yes, if a deanimation is expected, we *might* avoid these difficulties, but not all deanimations will be expected — *ever*.

What this means is that even if 21st Century Medicine succeeded in its basic aim of perfecting reversible suspended animation, cryonics organizations such as Alcor would still be far from obsolete. Full suspended animation might demand as much research to extend its practical application as was necessary to develop it in the first place. And we must never forget that we will *inevitably* find ourselves in situations where the patient is so damaged or long deanimated that suspended animation would not be feasible. We will always need some form of cryonic suspension as a safety net.

***** It may still prove useful in special cases, such as the need to move someone from one hospital to another because the other hospital has devices the prior one lacked. Some uses will require further development, since the first versions of suspended animation will probably leave a revived suspendee needing time (and money) to recover. Once fully developed, we might see its use in space exploration. We might also see suspensions for economic or justice reasons: people choosing suspension until "revival" of the industry that employed them, or suspension as an alternative to jail.

Cryonics Family Values?

by Brian Shock

Whom do you trust with your life?

Most of us trust our families. Why shouldn't we? Family gave us life. In most cases, family provided food, clothing, and shelter during our formative years. Even as adults, many of us can still look to our families for occasional aid, advice, and comfort.

But the family unit behaves according to a fairly rigid cultural and biological program. Cryonicists in particular know that the same family members who nurtured them through life may very well expect them to embrace certain customs of death such as burial, decomposition, and nonexistence. In my editorial from last quarter, I suggested that technology had outstripped the evolution of instincts, leaving us with powerful but obsolete feelings about "death." Now I would like to suggest something very similar about the evolution of culture, particularly the culture of families.

I have encountered many within the cryonics community who harbor a tacit belief that cryonicists with family relationships to cryonics patients must serve as the most reliable custodians of such patients. A dramatic example of this belief is Alcor's Patient Care Trust, which currently requires that at least three trust board members have relatives in suspension. Of course a cryonics organization owes respect and consideration to the families of its patients — if only to maintain good will and cooperation — but how did a non-traditional movement like cryonics develop such reverence for family connections?

Cryonics belongs to an extremely small social fringe. We as cryonicists may find ourselves descending into a "siege mentality," coming to believe that everyone outside our immediate group must stand against us and our cause. In the end, our instinctive need for safety and comfort within the tiny tribe of cryonicists reminds us (if unconsciously) that family was our first source of such safety and comfort.

Our instincts take us even further in this direction when we consider the archetypal family's active protection of its members. With tooth and claw, mothers feel an instinctive need to protect their children, and husbands feel an instinctive need to protect their wives. It's quite easy to imagine relatives of suspension patients in violent confrontations, defending their frozen loved ones with all the tenacity of Davy Crockett at the Alamo. But how useful are these instincts?

Certainly we would value familial ferocity if there were any evidence whatsoever that suspension patients were at immediate risk. Of course, this has not been the case for several years (though our siege mentality will no doubt drive us to reject evidence of peace). If we consider possible decades of patient storage carried out in a relatively calm environment, overactive defense becomes initially embarrassing and, eventually, counterproductive.

Even if we value the mindless reactions of family defense instincts, why would we assume that they might become active for the benefit of cryonics patients? Again, in last quarter's editorial I postulated that humans might possess some instinctive sense of "death" in others. With no heartbeat, breathing, or body warmth, cryonics patients may appear "simply dead" to the primitive parts of our brains, thereby deactivating any defensive instincts. Would a mother defend the child she knew was "simply dead?" We might like to believe so, but health considerations alone suggest that the death instinct probably also includes avoidance behaviors; in primitive situations, defending a corpse for too long would have resulted in the illness and probable death of the defender.

Still, family members of suspen-

sion patients *do* experience very real, very violent emotions at the death of their loved ones. As much as these grieving individuals deserve sensitive treatment, we must recognize that grief is a well studied condition, not a mystical state that confers special knowledge and abilities.

Whatever role the irrationality of instinct may play in grief, people in the throes of this emotion are obviously *not* rational. At least once a month (and usually two or three times that) Alcor receives calls from individuals who just lost a parent or spouse. Over the years we have observed that grieving family members will say or do almost anything — up to and including flat misrepresentations of fact — to use cryonics as a means of dealing with their initial grief. More than once I have asked such a caller, "Can you pay the $120,000 suspension minimum?" and received a reply that "money was no problem"; further probing usually revealed that money didn't present a problem for these individuals because they had no interest in paying for the service they demanded!

Even when last-minute suspension prospects seem to have sufficient funding, Alcor rarely accepts them; it's all too easy for us to imagine a family member recovering from his grief, looking at this $120,000 expenditure with more rational eyes, and then suing Alcor for taking advantage of his pain. This illustrates another important aspect of grief: it's a process with a discrete beginning, middle, and end. When an individual grieves properly (as most do), he works through his emotional problems within a finite period and then *stops* grieving. Relatives of suspension patients may appear keenly interested for this period (days, weeks, months, or years), but if they retain any capacity for emotional balance, they inevitably lose any profound attachment to the patient.

The early history of cryonics is choked with examples of this phenomenon. Patient after patient was suspended by the Cryonics Society of New York (CSNY) and the Cryonics Society of California (CSC), with the expectation that relatives would pay for suspension maintenance in perpetuity. When these relatives recovered from their grief, however, they either stopped paying or looked for ill-considered economic shortcuts. Though many would rightfully blame Robert Nelson of CSC for misleading some of these family members, most of his poor advice revolved around impractical ways families could *save themselves money*, such as convincing the husband of suspension patient Ann DeBlasio to move her dewar to a cemetery for personal care, or allegedly offering the family of suspension patient Mildred Harris the option of an inadequate lump-sum for perpetual storage (which Nelson still denies).

Are the overly enthusiastic pioneers of cryonics responsible for the loss of almost all patients suspended before 1972, or should we in part look to the relatives who completed the grieving process and went on with their lives? With that sort of precedent, do we really want family members retaining *any* responsibility for suspension patients today?

Finally, we come to the topic of professionalism and emotional detachment. How often is a surgeon allowed to operate on his son or daughter? When does an attorney act as defense counsel for her own husband? Do the police draft a murder victim's children to play investigators in his case? Of course not — over the years, professionals have learned that efficient performance of a task requires *emotional detachment*. Anxiety, rage, and grief have no place in rational decision making, and individuals in situations that evoke such feelings often have *no* insight into how their judgment is affected.

Emotionalism — the primary case against relatives of suspension patients — looks worse still when you consider that 90% of all reported physical violence in the U.S. occurs between family members. Your husband, mother, son, etc. are far more likely to injure or kill you than any random stranger (though our siege mentality will probably force us to remain much warier of the random stranger). By that token alone, relatives are also *far* more likely to sabotage your suspension, even if they happen to have suspension arrangements themselves.

Cryonics patients may have to remain safely suspended for hundreds of years. As much as we might wish to romanticize the force of familial emotion, maneuvering safely through such vast amounts of time requires foresight and emotional balance. The extremes of emotion we have valued in relatives of suspension patients may actually *strip* them of these vital characteristics and render them the *worst* possible choices for suspension patient custodians!

Alcor's Legal Battles

by R. Michael Perry, Ph.D.

1. Make-believe confrontation. The legal establishment vies with those who seek to benefit humankind through cryopreservation, in this 1940 movie.

Science fiction may have presaged legal battles in cryonics even before the fact of cryonics itself. One example is the 1940 sci-fi flick, *The Man With Nine Lives*, in which there was a spirited showdown between the local sheriff and a Mad Scientist (played appropriately by Boris Karloff) who had developed reversible cryopreservation.[1] Though cryonics history in years to come was almost as melodramatic as this, the roles of protagonist and antagonist went through considerable revision.

When the real cryonics movement started in the 1960s, real legal confrontations were not far off. Generally such confrontations involved unhappy relatives of someone who had been frozen. The relatives either wanted the money that had been set aside for suspension and weren't interested in keeping the patient frozen, wanted someone else to assume the expenses they had been paying to maintain the suspension, or (as in the Chatsworth incident) were suing because somebody had not been kept frozen. Ev Cooper came up with an early slogan for cryonics, "Freeze, wait, reanimate." But Curtis Henderson, who had helped start the first organization for real cryonic suspension (Cryonics Society of New York, Aug. 1965), suggested that it should really be, "Freeze, wait, litigate."[2]

By the late 1980s, the legal battlefield had shifted, almost adaptively, so that new kinds of confrontations were more prevalent. These skirmishes primarly involved one organization, Alcor, which had been set up in large part to avoid the problems that plagued cryonics in the past. Rather than ask relatives to pay year by year for the maintenance of suspensions, Alcor required the all funds as a lump sum at the time of deanimation (or before). Alcor also established safeguards, financial and otherwise, to maintain patients even in adverse circumstances, such as when funding problems developed.

The legal confrontations I'll cover here mainly involve two Alcor patients, Dora Kent and Robert Binkowski, frozen within months of each other in 1987 and 1988. These cases and their consequences cover the most important (though not the only) legal battles directly or indirectly involving Alcor. As is so often true in these columns, there is enough material here to fill a good book or two; I'll only be able to skim some of the highlights.

2. Real-life confrontation. Attorney Christopher Ashworth pleads the case for Dora Kent in Riverside Superior Court, Feb. 1, 1988.

Dora Kent

The mother of long-time cryonics activist Saul Kent was frozen in December, 1987. In an effort to give Mrs. Kent the best suspension possible, Alcor personnel brought her to their organization's facility, then in Riverside, California, where she deanimated with no physician present. (Her attending physician was called in and found the death had occurred from natural causes.) From a technical point of view, the objective was achieved: Dora Kent's body washout and cryoprotective perfusion proceeded swiftly, and within a few hours she was being cooled to dry ice temperature (as a neuro-patient). The local coroner, sensing that something out of the ordinary had happened, became interested. (This man, Ray Carrillo, had recently gained notice for having ordered an autopsy of a prominent Riverside County resident, Liberace, establishing, against the family's wishes to conceal it, that the well-known entertainer had been an AIDS victim.) Alcor cooperated with the coroner's request for Mrs. Kent's headless remains, being allowed to retain the now-cooling head to complete her cryonic suspension. An autopsy was conducted and a death certificate issued, giving the mode of death as natural causes, seconding the conclusion of Mrs. Kent's physician.

For a short while, the potential crisis seemed to have been averted. However, soon afterward the coroner called a press conference and aired suspicions that "maybe she [Dora Kent] wasn't dead after all" when the freezing process started.

Matters took a new and menacing turn: the coroner's office conducted a raid of the Alcor facility in early January, 1988. The raid's stated goal was to seize the frozen head of Dora Kent for autopsy, on grounds that it too must be tested to further clarify the cause and mode of death. (Such a damaging procedure would, of course, inflict irreparable harm and compromise the patient's chances of reanimation.) Fortunately, the coroner's contacts with the press had given ample warning; prior to the raid, Dora Kent was moved to another location. Despite the coroner's failure, though, word of this case spread far and wide.[3]

At first public opinion favored the coroner, but it soon swung toward the beleaguered cryonicists, several of whom were detained in handcuffs for several hours during the raid, and who, after all, did not seem much like "criminals." A second raid, conducted a few days later, resulted in seizure of much of Alcor's equipment, including computers. Alcor meanwhile fought the autopsy order in court and won. On Feb. 1 a local judge (1) found no evidence of foul play on Alcor's part, and (2) issued an order barring the coroner from autopsying Dora Kent or any other Alcor patient.[4]

That might have ended the matter, except that Coroner Carrillo was a "fighter." Not one but at least three separate legal challenges would be launched over this incident. The most serious was a murder claim: a *revised* death certificate proclaimed that Dora Kent was a victim of "homicide," and that she had died of barbiturates deliberately administered to "help" her deanimate, not of natural causes after all. According to a pathologist and others marshaled by the coroner's office, Dora Kent wasn't dead when the suspension process had started because her body metabolized the drugs supposedly given after her decease (an effect that could also have resulted from the metabolic support that cryonics patients are routinely given post-mortem).[5]

The "murder" case would drag on for years. It foundered, finally, for lack of evidence. No charges were ever filed. The physical evidence was hardly conclusive. Alcor personnel, the only witnesses present at the suspension, could also claim "transactional immunity." This meant they could not be prosecuted for each other's testimony, a point upheld when the matter was pursued all the way to the California Supreme Court by Alcor's opponents.[6]

Meanwhile, the fortunes of Ray Carrillo ground slowly downward as blunders in his administration became public. In one case, a body needed for criminal investigation was cremated by mistake. In another, a couple that performed freelance dissections for the coroner's office left boxes of human body parts in their garage when they moved to another house; when the house's new owners discovered these grisly leftovers, the event made local news.[7] Not surprisingly, in 1990 Carrillo lost his bid for reelection. Not long afterward, the pathologist who helped make the "finding" against Alcor died of Creutzfeldt-Jacob's disease (which he possibly contracted by handling infected human tissue during an autopsy), a brain disorder related to bovine spongiform encephalitis or "mad cow" disease. The coroner's office relaxed its grip, telling inquirers that it was no longer pursuing an investigation into the death of Dora Kent.[8] Nevertheless, the case remained on the books as a "homicide." Ironically, this classification was actually to benefit Alcor in other struggles.

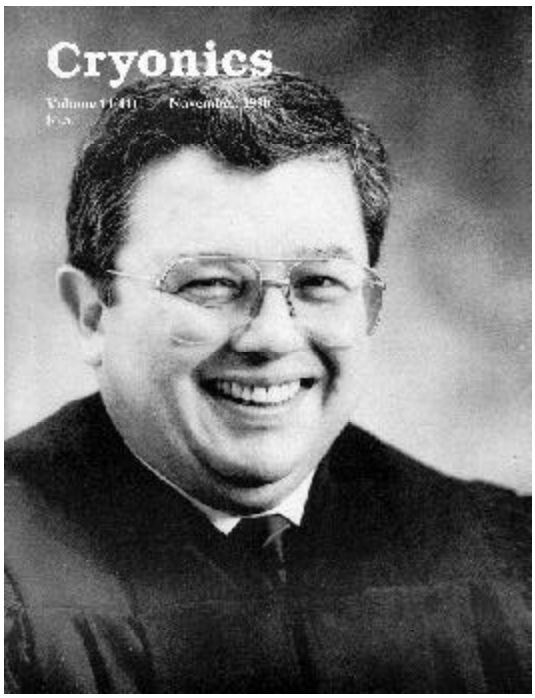
3-4. Two Special Patients. The Suspensions of Dora Kent and Bob Binkowski provoked lengthy and costly legal confrontations which, however, ultimately strengthened Alcor and cryonics.

The second legal challenge in the Dora Kent saga was a claim by the California Medical Board (earlier known as the Bureau of Medical Quality Assurance) that Alcor personnel involved in the Kent suspension were guilty of "felony practice of medicine without a license." The physician who participated was "aiding and abetting the practice of medicine without a license," according to the CMB.[9] One important issue was whether the patient was dead or alive when any "medicine" was practiced, something presumably the "murder" investigation would settle. In any case, the CMB action was stopped in its tracks by the ever-pending but dormant homicide case. Alcor personnel or associates could and did refuse to testify unless granted transactional immunity, which stymied the CMB. No testimony was taken, and this case too was eventually abandoned after some bizarre harassment, including an incident in which an angry Alcor staffer ejected a CMB official from the facility at gunpoint.[10] (True, this action was inappropriate, and the staff member was promptly dismissed.)

Finally, there was the third and silliest legal attack, in which authorities claimed that Alcor was guilty of grand theft of medical supplies and equipment from UCLA. In fact, Alcor did have a lot of these items — all legitimately purchased, many at UCLA's surplus sales department. In most cases, receipts existed to prove Alcor's legal ownership. However, both the materials *and* the receipts were seized during the raids on Alcor's facility, complicating any attempt to prove how the goods were obtained. One particular item was a large, stainless steel utility cart or "rolling rack," which, authorities said, *could not* have been purchased as surplus because it was brand new (and worth over $1,000)! Eventually an investigation determined that the rolling rack, while new, had been superseded by an even newer model, allowing UCLA to sell it to Alcor as obsolete equipment. (This investigation, by the way, was skillfully concluded by an Alcor member's detective work after officials had waffled for many months and accomplished very little.) So the "theft" case collapsed too, and the whole Dora Kent affair was finally laid to rest.[6,11,12,13] (Of course homicide cases have no statute of limitations, and so theoretically the Dora Kent file could still be reactivated, though this seems highly unlikely. One hopes that the "homicide" finding will be revoked by the time, assuming we are so fortunate, that Dora Kent herself is reanimated!)

There were two other repercussions of the Dora Kent case that deserve mention, additional legal confrontations in which Alcor members received some compensation from the harassing bureaucrats. A false

arrest suit was filed against the coroner's office shortly after the first raid. The eventual out-of-court settlement, finalized in the summer of 1991, awarded $90,000 for the several hours that 6 Alcor personnel had spent handcuffed that day at the Riverside Police Station.[14] (As a party to this incident, I should mention that generally the police department was sympathetic to Alcor's plight, though constrained by an official request to cooperate.[15]) The second Dora Kent spin-off case involved the seizure of computers at Alcor during the second raid in January, 1988. The Alcor Bulletin Board Service (BBS) was disabled by this action, and electronic correspondence confiscated. This, it turned out, violated a federal law protecting the privacy and privilege of e-mail services. The case involving 15 Alcor members was also settled out of court in their favor, for a total of $30,000.[14,16]



5. Superior Court Judge Aurelio Muñoz, who handed down a favorable ruling in the Mitchell case, graces the cover of the Nov. 1990 *Cryonics*.

Robert Binkowski

This suspension occurred in May, 1988. It was the next one at Alcor after Dora Kent, and also Alcor's first whole body suspension. Binkowski, a Florida resident, died of a heart attack in his home, attended by his family. After some negotiations with generally cooperative local officials, his ice-packed body was flown cross-country to the Alcor facility to be frozen. Thus there was no question of his being legally dead at the time of suspension. The suspension went off as planned, and matters after that should have been routine.

They weren't. The California Public Health Service objected to this suspension, claiming that Alcor (and by implication, any cryonics organization in California) lacked authority to do what it was doing. David Mitchell, chief of the Office of Registrar that oversaw the PHS, rumbled that, "Existing California statutes provide no basis to authorize cryonic facilities to store human remains. Therefore, if the Alcor Foundation has any bodies or body parts stored in the facility, the foundation is guilty of a misdemeanor ... and should be reported to the local district attorney for investigation and prosecution as appropriate."[17]

Why was there such a heavy-handed response, when cryonics organizations had been operating in California for so many years? Apparently this was not a backlash from the Dora Kent case, but instead the result of a memo issued by the PHS in 1980, relating to the Chatsworth disaster. (The *style* of the PHS response, though, seems to have taken its cue from the coroner's harassment over Dora Kent.[6]) In this incident, several neglected patients of a badly managed cryonics operation had thawed out and decomposed, leaving a legacy of distrust and revulsion for cryonics among officials who were called in to investigate.[18] The PHS memo denied that cryonics organizations were authorized to receive anatomical donations under the Scientific Use provision of the Uniform Anatomical Gift Act. Mitchell echoed this denial, noting that no organization had a license to practice cryonics, whether for scientific or other purposes. (On the other hand, there was no way an organization could obtain such a license — it didn't exist.)

Though Mitchell advised that Alcor be "reported" for investigation and prosecution as appropriate," the actual prosecution was put on hold pending the homicide investigation.[17] Alcor's suspensions continued unhindered, though the disposal permits required for storing whole bodies were unobtainable. (No such permits were required for head-only cases, which could be treated as tissue samples.)

The hold-up in prosecution gave some breathing room for Alcor to strike back. In August, 1988, terminally ill Alcor member Dick Jones filed suit against Mitchell and Kenneth Kizer, head of the PHS. (Jones, a well-known TV script writer and producer who had won several Emmy awards, used the name John Roe in this suit to remain incognito.) The suit claimed the legal right to choose cryonics irrespective of "existing California statutes," which, while not endorsing the practice, did not forbid it either.[18] A ruling favorable to Jones and Alcor was obtained

6. "Grand Theft." The famous rolling rack "stolen" from UCLA is still in use at Alcor.

in October, 1990 (nearly two years after Jones was suspended).[19] The State appealed; the ruling was upheld at the appellate level in June, 1992,[20] and not appealed further.[6] So after years of delay and resistance, the disposal permits for Alcor's growing total of whole-body suspensions were finally obtained, and other cryonics organizations in the state were similarly benefited.

Alcor's legal battles cost hundreds of thousands of dollars, most of which were never compensated. One of the staunchest and ablest supporters of Alcor and cryonics, Jerry Leaf, lost his researcher's job of long standing at UCLA over the Dora Kent incident.[21] It's very possible the stresses contributed to his own untimely death and suspension, at the age of 50, in 1991. Aside from these negatives (and the unhappy experiences of others during the bitter struggles), I think both Alcor and cryonics gained tremendously. Cryonicists proved they could fight and win against far more powerful — if misguided — opposition. Fundamental rights were upheld, including the right to choose cryonic suspension itself. The seriousness of the commitment to patients in suspension, whom we hope to recover alive someday, was well demonstrated. Cryonics gained a new, more positive image, with its legality now firmly established.

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I also thank Hugh Hixon for consultation while writing this article.

Picture credits: 1. Favorite Films Corp. 2. (Based on) Miller, K. Riverside Press-Enterprise Feb. 2, 1988 B-1. 3-6. Alcor Foundation.

Alcor Member Profile

Louise Murray

Profile Editor: Russell Cheney

Date joined Alcor: 8/98.

Place of birth: Dallas, TX.

City and state of current residence: LA, CA.

Date of birth: 1/22/56.

Occupation: Financial analyst.

Marital status: Legally separated.

Children: Dallas, a 20-lb super-sweet Maine Coon (only native North-American domestic cat), and Hanson, a majestic graceful orange long-haired Persian (the breed of the king's courts).

Educational background: A.S., Criminal Justice; B.S., Accounting, Southern Methodist University, Dallas, TX.

Height / Weight: 5' 5", 114.

Best feature: Mental: Curiosity; Physical: Legs. My curiosity helps me decipher peoples' psychological motivations. My strong legs enable me to enjoy and excel in my favorite sport: running.

Favorite author: Ayn Rand, because of her wonderful writing on the rationale for living, the importance of the individual, and the importance of being fulfilled with one's work.

Favorite book: *Atlas Shrugged.*

Book you are currently reading: *Sperm Wars*, on the evolutionary/biological basis of social and individual sexual behavior.

Favorite non-cryonics magazine: *Runners' World*.

Favorite movie: "Say Anything."

Favorite artist: The prolific painter Jose Capuletti.

Hobbies: Running, hiking, concerts (classical and rock & roll), reading.

Make of car you drive: Chevy Cavalier.

Make of car you'd like to drive: Chevy Corvette.

Greatest adventure: 18-hour technical climb of Longs Peak, northern Colorado, Rocky Mountain National Park. Gorgeous country. I was reaching beyond.

Favorite vacation destination: Paris.

Political affiliation: Libertarian. I ran for Texas State senate. I'm considering running in CA.

Religion: Atheist.

Most-prized possession: The memories associated with the reasons for a very special gift: my Rolex watch.

Most-prized possession you've arranged to have upon reanimation: I will treasure rejoining my cryonics friends.

Personal hero: Nathaniel Branden, author of *The Six Pillars of Self Esteem*, and a number of other books relating self esteem to the psychology of romantic love and other feelings.

Favorite famous quote: "Take what you want, says god, and pay for it." This can be interpreted as, "Be careful what you ask for — you may get it."

Personal philosophy: To love and work wisely, and enjoy every single day of living.

Short-term goal: To obtain CA CPA (Certified Public Accountant) license. This will require nine more months at my current position.

Long-term goal: First, to have sufficient assets to fund my cryonic suspension using personal financial resources, rather than insurance. Second, to be mentally and physically very active throughout this life.

Immediate goal upon reanimation: Check and see if I can still run.

Longer-term goals after reanimation: With enhanced physical and mental abilities, acquire artistic skills, including singing, painting, photography and ice skating.

Achievements for which you are most proud: Successfully passing the CPA exam, winning three races (Dallas 10K & 20K, and German 10K), and the completion of 25 marathons.

Pet peeve: People who are afraid to trust in love.

Greatest fear: Reanimation as a conscious guinea pig.

Happiest memory: Finishing first in my age division at Fort Worth Cowtown Marathon. Not expecting to place, I'd gone home. I was contacted at home later that day, and given a separate personal award-ceremony by race management the following day.

Secret ambition/fantasy: Become famous rock and ballad singer/dancer *a la* Janet Jackson.

First choice to share your dewar: Nathaniel Branden.

First became interested in life extension: Via Extropians.

Most effective things you do to promote your own longevity (other than being an Alcor member): Regular running, healthy eating.

Least: Not having achieved personal financial strength (yet).

Biggest surprise since becoming a member: How positively most people react to my being a cryonicist and my reasons for this life decision.

Cryonics idol and why: James Halperin, an excellent writer on future possibilities, savvy businessman, devoted family-man, open hearted.

Why you are a cryonicist: Want to live to have a variety of experiences, vocations, partners, living places.

Advice you have for other cryonicists: Make the most of this life. Keep your body and mind in good order; don't use cryonics as an excuse not to live and love during this lifespan.

Nanotime

by Bart Kosko

Avon Books, New York, 1997

Reviewed by Brian Shock

Let's get our "Relevance Scorecard" out of the way immediately.

Cryonics: ~3% (I picked out a few weak references; what the heck, Kosko's a cryonicist)

Future Speculation: ~90%

Life Extension: ~30% (uploading was a major theme)

Nanotechnology: ?% (I stumbled across technologies that seem to require Drexlerian Nanotechnology, but I could discern little or no explicit reference to the field itself)

Synopsis:

In 2030, young polymath scientist John Grant develops a "smart molecule" which can split water into oxygen and hydrogen. This, in conjunction with his work for the Israelis, sets him at odds with Sufi mathematician/terrorist Hamid Tabriz. After Tabriz converts Grant's fiancee into a murderous computerized zombie (her brain replaced with a microchip, onto which Tabriz may or may not have uploaded her personality), Grant runs to his Israeli allies. Israeli Intelligence promptly replaces Grant's brain with a chip (onto which his personality *has* graciously been uploaded), in order to use him as an agent against Tabriz. The inevitable confrontation between Grant and Tabriz occurs, with World War III as a backdrop.

Miscellaneous Observations:

1) Although *Nanotime* has a human protagonist, the "main character" is really Kosko's future history. With impressively broad knowledge and insight, Kosko extrapolates realistic events, trends, and technologies, from nuclear terrorist attacks, to the imminent exhaustion of world oil supplies, to inexpensive artificially intelligent missiles. You may not like the landscape of this future, but you'll probably believe it.

2) Technophiles will happily wallow in this novel's fluency of cyberpunk "bafflegab." You'll find no "bolognium" or "unobtainium" here; Bart Kosko is at least as accomplished a scientist as "John Grant," and never allows the reader to forget that fact.

3) The title "Nanotime" does not mean "time for nanotechnology," but refers to uploaded individuals' speed of thought: nanoseconds.

4) *Nanotime*'s scope and pace? Think of Tom Clancy on methamphetamine.

5) Halfway through *Nanotime*, Kosko writes one of the most wonderfully disturbing scenes of mind-uploading since Rudy Rucker's novel *Software*. Enjoy!

6) As a newcomer to fiction, Kosko demonstrates a few minor weaknesses:

a) We never come to know John Grant well. He's a brilliant, egocentric, rage-filled bundle of energy who yearns for freedom in a surveillance-intensive society. Since the typical first-time novelist tends to draw heavily on his own personality for portraying a protagonist, I wonder . . .

b) Another common trope for the science fiction beginner is to plaster intervening chapters with lists of "future current events." Sometimes this helps to fill difficult expository gaps, and sometimes it reads as though the author wants to justify his logical leaps with footnotes.

c) Although Kosko employs the legitimate technique of switching viewpoint characters between chapters, many story threads for these characters meet only in a very indirect fashion. This feels like padding.

d) Forgive the minor quibble, but Grant's AI buddy sports an annoyingly adolescent nickname: "JiSM," for John Steward Mill. Perhaps John Grant *is* an annoyingly adolescent character, but realism should never become an excuse for less-than-optimal fiction.

Conclusion:

If you're searching for comforting stories of a gentle, pastel-colored future, search somewhere else. If you want a ruthless flash of things to come, you may be in luck.

Carpenter's Human Neuroanatomy

by Andre Parent

9th Edition, 1996, ISBN 0-683-06752-4

Reviewed by Thomas Donaldson, PhD

I am reviewing this book not because it should be read and owned by every cryonicist, but because it gives the best discussion I know of the neural anatomy of human beings, both for our brain and our peripheral nerves. I am reviewing a library copy, of which 2 exist in Australia. I plan to buy it for myself (the price quoted comes to about $85.00 US), mainly because I've been intensively involved in writing about this subject. It isn't a book to be read straight through, but rather a valuable reference as to the state of our knowledge of brain structure *and* function in 1996, when it was published. (The first edition was written in 1948, by Carpenter.) If you are interested in neuroanatomy, try to get your local university library to buy this book. You might also combine with other cryonicists to donate a copy to a local university library.

Why is brain neuroanatomy so important to us as cryonicists? If we are to do any worthwhile thinking at all about how to *repair* brains damaged by the freezing process, we need to understand their original state. This book distinguishes itself by close attention not just to the detailed anatomy of our brains, but to the biochemical anatomy too: the distribution of various chemicals and chemical markers within our brains. This knowledge is important both for testing the result of a new suspension method and for repair of those previously suspended. For example, the presence of particular biochemicals in a neural fragment will identify it quite definitely as belonging to a particular type of neuron, each of which has its own form and character. Such information might be useful for sorting and reassociating the cell fragments found in frozen tissue.

Nanotechnology alone will not be sufficient for repairing cryonics patients — before anything else, we will need to know the original structures of tissue we wish to repair. Neural anatomy, especially neural *chemical* anatomy, will give these to us. Freezing (even without cryoprotectant) damages relatively few *molecules*; most freezing damage involves the disruption of *molecular arrangements* of cells, synapses, axons, dendrites. To repair such damage, we want to restore that original arrangement. Although some kinds of nanotechnology may give us ways of working out post-damage arrangement, only a thorough knowledge of original structures will allow accurate restoration.

Carpenter's Human Neuroanatomy is very rich in detail of all kinds, not just distributions of different biochemicals but in the detailed physical structure of our brains as well. I can hardly do justice to it in a short review. As a very short taste of its depth, I will discuss our cerebral cortex, that part of the brain which holds many of our memories (our *cerebellum* may hold memories, too, but there isn't room here to discuss that now). Chapter 20* begins with a discussion of the different kinds of neuron in our cortex: *pyramidal cells* and *granule cells* (which use glutamate or aspartate for their transmitter), and a list of the different inhibitory neurons (generally called *interneurons*). Axons from other brain areas, using acetylcholine, dopamine, serotonin, and other neurotransmitters also connect with our cortical neurons. (Interesting fact: synapses of different kinds have different forms, depending on the neurotransmitter they use.) The book discusses both location and form of these axons from outside the cortex.

Our cortical neurons occur in 6 different layers, with different forms for each kind. (The layers have names, but often are referred to simply with Roman numerals. "I" is the layer on the outside of our brain, "VI" the innermost layer.

Pyramidal neurons will have different sizes and connectivity at each layer. The frequency of other kinds of neuron varies with the layer in a

characteristic manner. Our cortex generally also has a "vertical" structure of pyramids, perpendicular to the layers. This structure contains neurons of all the different cortical types, with a great deal of internal connection and a certain amount of linkage to other such pyramids. Moreover, the thickness of the layers, the exact proportions and form of the different neurons in each layer, and the vertical pyramidal structures vary depending on the particular brain area. The book again discusses these differences in detail. It also details the different brain areas involved with our senses, and finally with our prefrontal cortex (where, very primitively put, we do our "thinking"). Naturally all these areas connect with one another, usually with indirect connections which pass through our *thalamus*.

Anyone who wants to think seriously about reviving brains should at least have access to this book. Our knowledge about the structure and chemical distribution of the human brain continues to increase. *Carpenter's Human Neuroanatomy*, ninth edition will become outmoded, as did the previous eight versions. Yet it still gives in book form what was known on all these questions in 1996. We can hope that Parent or someone else continues to update this book into the future.

***** For those totally unfamiliar with brain anatomy, here are some facts and definitions:

Axons send impulses. *Dendrites* receive them. Neurons will only conduct impulses received, either at *synapses* or (more rarely) at *gap junctions*, from their dendrites through their axons. Neurons have a widely varying number of connections with other neurons, from over 100,000 down to as few as 6,000. Chemicals transmitting such impulses are generally released at synapses, which have two sides, the sending side on an axon *branch* of the sending neuron and the receiving side on a *dendrite*. Synapses have different forms. They can also either exist on the neuron cell surface or else on a projection of it (a *dendritic spine*). *Electrical impulses* can pass through gap junctions, but generally the electrical impulse occurs during conduction through the axon of an individual neuron. Such axons may be orders of magnitude longer than the neuron cell body itself.

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