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Renewed Interest in Liquid Ventilation

By Charles Platt

In 1969, at Duke University Medical Center in North Carolina, a Dutch physiologist named Johannes Kylstra began a series of experiments demonstrating the survival of animals whose lungs were filled with liquid. The concept of liquid breathing, known as liquid ventilation, was of interest to the U. S. Navy's Office of Naval Research, which hoped that it could protect deep-sea divers from decompression sickness commonly known as "the bends."

Kylstra used a perfluorocarbon liquid for his research because it has the convenient ability to transport oxygen and carbon dioxide while being mostly nonreactive and safe in contact with human tissue. The Navy never implemented his work, probably because there were less controversial ways to safeguard the health of divers, but liquid ventilation enjoyed a renaissance in the late 1980s and early 1990s as an experimental treatment for premature infants suffering acute respiratory distress syndrome (ARDS). Although the concept is not well known, the safety of perfluorocarbon liquid in human lungs has been demonstrated beyond question.

In 1996 Mike Darwin and Steve Harris, MD became interested in liquid ventilation as an option to achieve rapid cooling in cryonics cases. A cold liquid can absorb far more heat, per unit volume, than a cold gas. Darwin and Harris reasoned that if a perfluorocarbon is chilled before being infused into the lungs, it should absorb heat from the blood in vessels around the lungs, and if chest compressions are applied concurrently to maintain circulation, the blood will flow up to the brain and cool it internally. This should be much more efficient than immersing a patient in an ice bath.

The two scientists imagined that perfluorocarbon could be administered through an endotrachial tube, which is often used in cryonics cases and can be placed within seconds by a paramedic. No surgery would be needed, and if the equipment was portable, the process could begin in almost any location immediately after the patient was pronounced.

This would expedite the cooling process, which is so vitally important to inhibit brain injury in cryonics patients. It would also allow washout with an organ preservation solution to begin at a lower temperature.

Darwin and Harris started to do some benchtop experiments at Critical Care Research (CCR), a privately funded laboratory that has pursued many initiatives of relevance to cryonics. Because I was familiar with everyone at CCR as a result of my participation in cryonics cases, I knew about the new research informally. I never imagined that I might become personally involved.

A Sobering Experience

The elementary principle of liquid ventilation is shown in Figure 1. In practice, however, the scientists at CCR discovered that rapid cooling required them to mix oxygen with the liquid, possibly because it created turbulence inside the lungs. In addition, any usable liquid ventilation device would have to control the flow rate and volume, probably with monitoring and feedback to protect the lungs from excessive pressure.

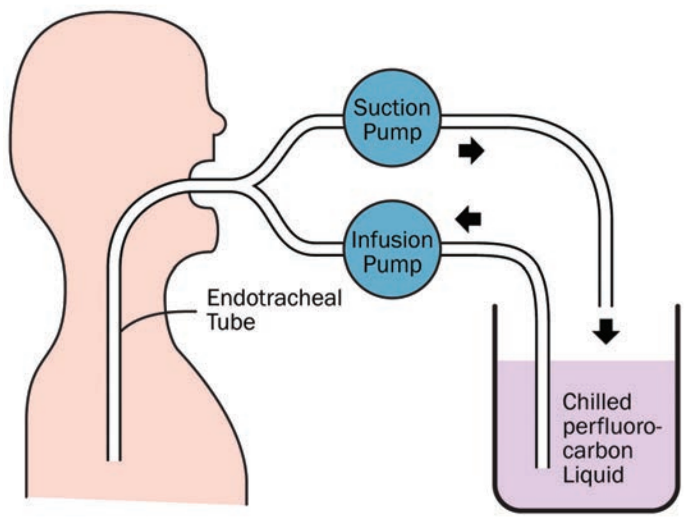


Figure 1

In 2004, CCR commissioned an engineering company to develop a preliminary prototype for laboratory testing. This did not perform satisfactorily, so CCR went to another engineering company—which also failed to build a successful prototype. When I heard about this, I remarked to Steve Harris, "Why is it such a problem? Surely, it isn't rocket science."

Harris was kind enough to explain some of the issues, and showed me the prototypes that had been built so far. This was a sobering experience, as everything was far more complicated than I had expected. But when I thought about it some more, I wondered if complexity was part of the problem. For instance, one company had attempted to meter each infusion of liquid by weighing it. This was a major challenge, as the flow was turbulent and reversed itself every few seconds. I thought that a simpler method would have a better chance of success.

Also, both prototypes had been computer-controlled, which I thought was overkill. And they used medical roller pumps, which were very heavy and might be unnecessary, as the lungs are not sterile. Each liquid infusion must be free from contaminants, but I wondered if some lightweight off-the-shelf 12-volt centrifugal pumps should work. In fact, I thought the whole system could run on 12 volts, making it fully portable.

A Primitive Prototype

At this time I was managing Suspended Animation (SA), where we were developing standby-transport capability. We had a well-equipped workshop, and I had collaborated with two of the employees, Gary Battiato and Piotr Ruck, designing and building standby equipment such as a collapsible ice bath. I asked Saul Kent, who supervised the company, if we could try to design a liquid ventilation device. He agreed.

The liquid in liquid ventilation must be as close as possible to 0 degrees Celsius, but never below that temperature, to avoid freezing the lungs. The most obvious way to achieve this is by using a mixture of ice and water, which is convenient in standby work as teams already use ice to surface-cool the patient. But the insulated perfluorocarbon reservoirs which CCR had used for some of their trials would be bulky and cumbersome.

Gary had the clever idea of getting rid of the insulation. Just put ice and water in a Pelican transport case, and then immerse a perfluorocarbon reservoir in it. An ice-water mixture will always remain close to 0 degrees so long as ice is still melting; thus the only penalty for getting rid of insulation is that someone will have to replenish the ice a little more often. We planned to use

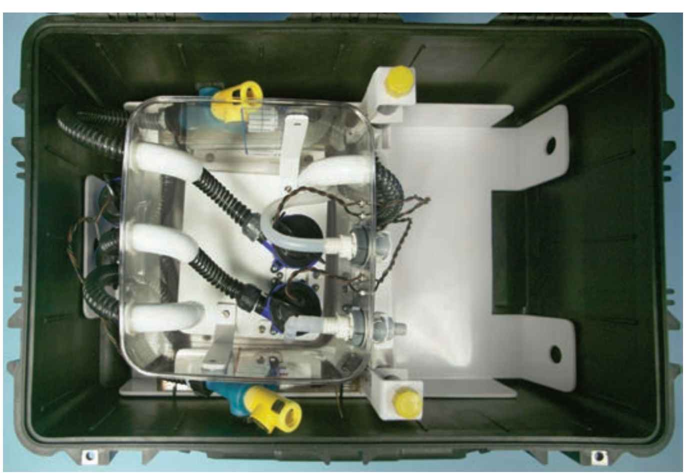


Figure 2.

a heat exchanger to cool the perfluorocarbon actively, while the ice and water would protect the perfluorocarbon from ambient heat in the environment.

A snapshot of our first, rather primitive prototype, to which we assigned the unimaginative name LV1, is shown in Figure 2. Mindful of the need for simplicity, I did not use computer control. I cycled the pumps with a 555 timer chip, which dates back to the 1970s. Ice was loaded into the right-hand side of the Pelican case, while the heat exchanger was included below the plastic reservoir. The approach was so utterly simple, I thought it had to work. The only question was whether it would work well enough.

Bench tests allayed my concern that the pumps might not function reliably with perfluorocarbon liquid, which is almost twice as dense as water and has a much lower surface tension. We obtained some satisfactory flow rates, so the next step was to build something more practical.

LV2

The control system for LV2, as I called it, was slightly more complicated. It had to allow adjustment of infusion volume, infusion rate, and suction rate, so that CCR could run tests to find a sweet spot where there was maximum efficiency.

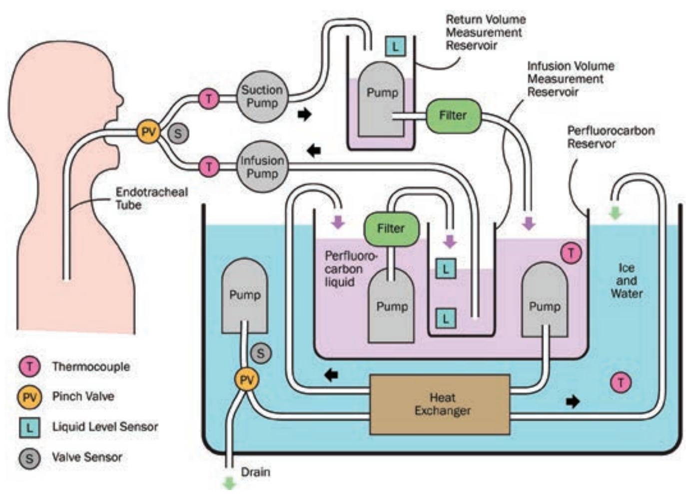


Figure 3.

Figure 3 shows the concept for LV2. This has remained basically unchanged in subsequent versions built for CCR. Instead of trying to weigh each infusion, I used a subsidiary reservoir with a float switch that activated a pump to refill it. This had the same kind of simplicity as a ball valve in a toilet tank.

Figure 4 shows the perfluorocarbon reservoir mounted with heat exchanger and pumps on a removable subframe that lifted out of the Pelican case for easy cleaning. A control panel, shown in Figure 5, allowed adjustments. Inside this panel, as shown

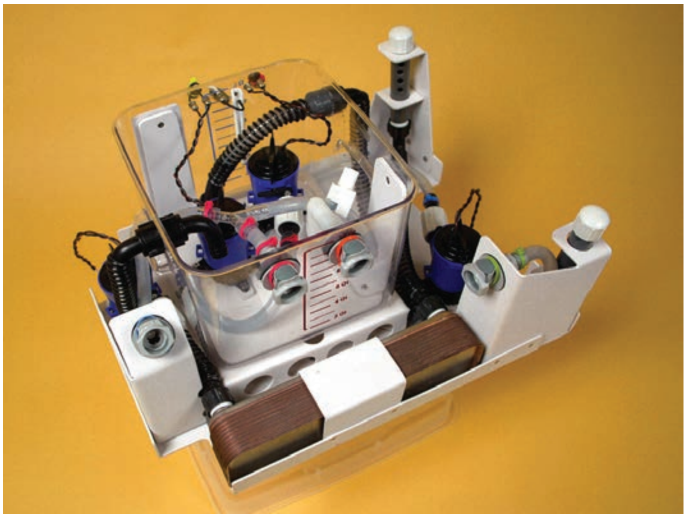


Figure 4.

Figure 5.

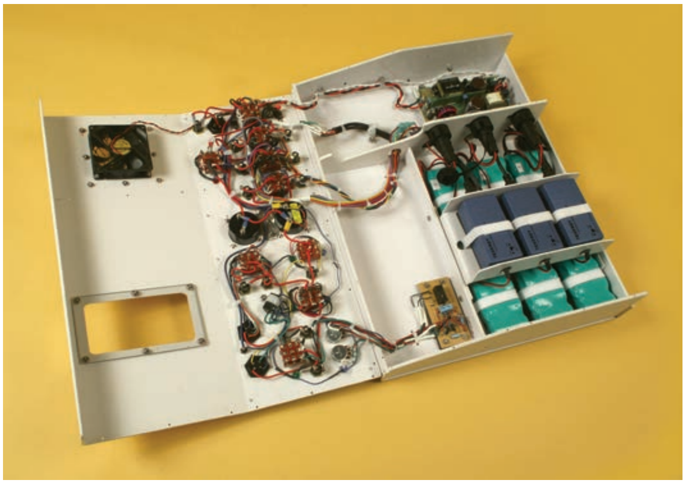


Figure 6.

in Figure 6, an AC adapter allowed operation using 110VAC or three NiMH battery packs, each rated for 10 amp-hours. The high current capacity of the batteries required heavy-gauge wiring and precautions when the packs were linked together.

Figure 7.

The completed prototype is shown in Figure 7. It could be rapidly disassembled without any tools, and loose parts could be stored for transport underneath the control panel in the lower Pelican case. We demonstrated it at an open house in 2007 at Suspended Animation before it was shipped to CCR.

A Plague of Microcontrollers

LV2 wasn't beautiful to look at, but it functioned better than anyone expected, enabling a peak cooling rate of about 1 degree Celsius per minute. This was twice as fast as benchtop equipment that CCR had tried previously, and more than five times as fast as the cooling rate that can be expected in an ice bath.

My clients were happy, so they did what happy clients usually do: they suggested extra features. I foresaw that a lot more development would be necessary, so I left my position at Suspended Animation and moved to a location near CCR. Six months later I delivered LV3, shown in Figure 8. Some of its features could be patented, and a page from my application is shown in Figure 9.

Figure 8.

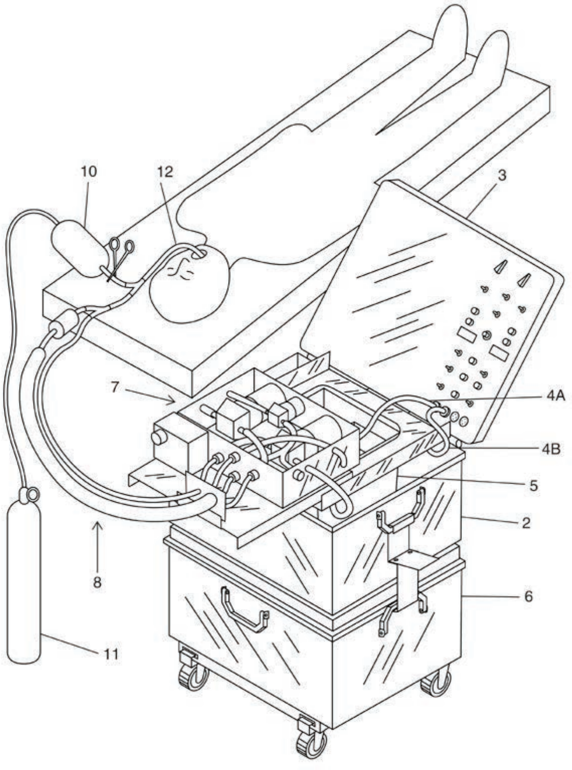


Figure 9.

Meanwhile, the new general manager at SA was hoping to use liquid ventilation in cryonics cases. She wanted an automated, pushbutton device, for which I foresaw the need to use microcontrollers.

A microcontroller is a very simple computer-on-a-chip. They are found everywhere from production lines to microwave ovens. I had never programmed a microcontroller before, but I had programmed desktop computers—so how hard could it be?

Unfortunately I underrated the requirements and overrated the capabilities of the PIC microcontroller that I chose for what would be known as LV4. One chip was insufficient to manage screen prompts, error messages, temperature sensors, tubing configuration errors, and data logging, in addition to the relatively simple task of switching pumps on and off. The number of microcontrollers eventually increased to six, with one of them governing the others via a simple serial bus—which turned out to be not so simple at all. As the circuit board got

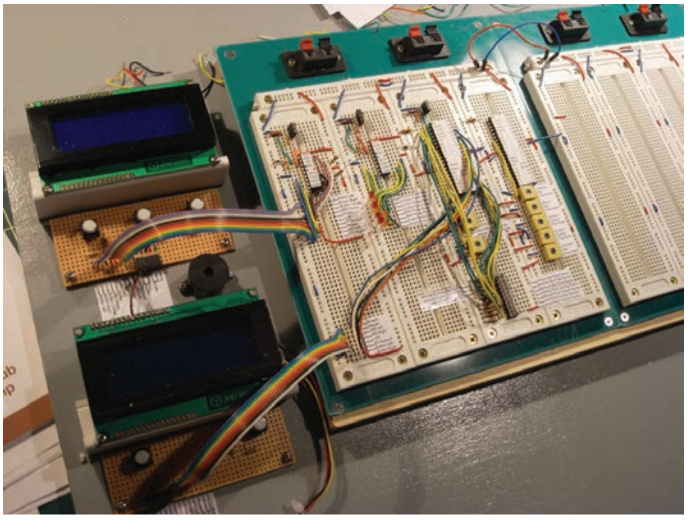


Figure 10.

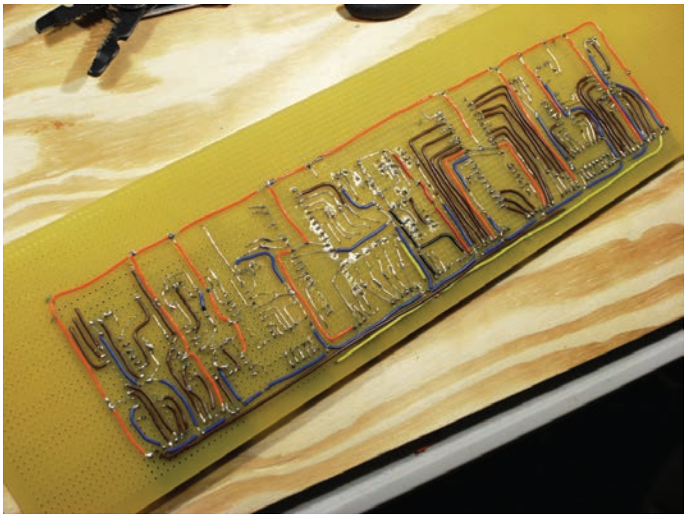


Figure 11.

bigger, its wire runs acted as antennas for electrical interference. Electrical noise from the pumps was also a problem.

Some preliminary testing is shown in Figure 10, which includes a couple of the LCD screens that displayed messages. The underside of the first complete hand-wired circuit board is shown in Figure 11. I began to wish I had used a tablet computer instead, but that would have been less suitable for the dozens of sensor inputs and relay-control outputs, and would have been less rugged. Also, the idea of using a Windows computer to run cryonics procedures made me uneasy.

LV1 had succeeded largely because it was so simple. I realized now that I had fallen into the trap of making LV4 complicated, and I was beginning to feel overwhelmed.

In 2009 I contacted a friend who had worked at JPL as systems integrator on the first Mars rover. He was now an independent contractor at Mojave Air and Space Port, where I visited him and described the project in detail. "It's very much like the climate control system in a space suit," he said.

I was impressed. Maybe liquid ventilation *was* rocket science, after all!

My friend seemed confident that he could solve all the problems, but he wanted more money than Saul Kent was willing to spend. In retrospect, if he had been successful, I think it would have been a bargain.

Writing books had been my primary occupation before I became actively involved in cryonics, and I wanted to go back to that. With this in mind, I asked Suspended Animation if they would take over LV4 and finish the job. They seemed happy to do so—probably because they suffered from my early misconception that it shouldn't be very difficult. Two people came out to my workshop, packed up all the unfinished equipment, and took it away.

Rapid Cooling with LV5

The people at SA hired someone to deal with the electronics. I had no formal role anymore, but I heard that their engineer abandoned microcontrollers and started using LabView, a programming language that is popular in laboratories. LabView requires a desktop or laptop computer, along with some other hardware, which didn't sound very portable to me. But none of this was my concern anymore—or so I thought.

Meanwhile, CCR had some issues with LV3, so they asked for a simple upgrade without any user-friendly features. That sounded easy, so I built it, named it LV5, and delivered it to California. Figure 12 shows LV5 in my workshop with a laptop computer uploading code to the internal microcontroller. The completed equipment is in Figure 13, and one of the hand-fabricated components (a switchable pinch valve) is shown in figures 14 and 15.

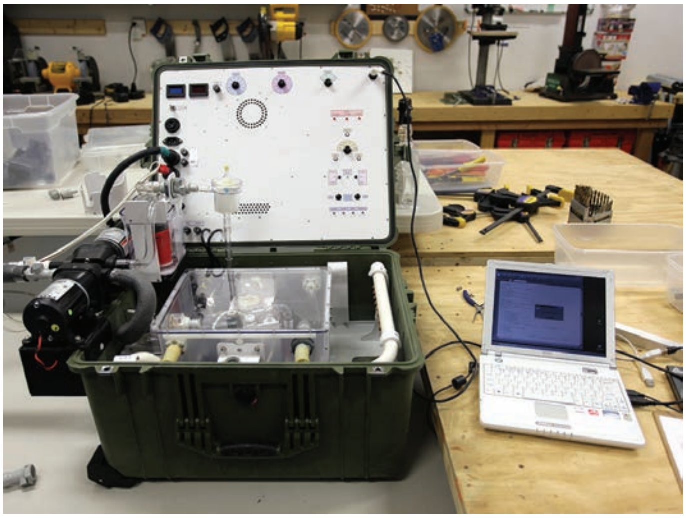


Figure 12.

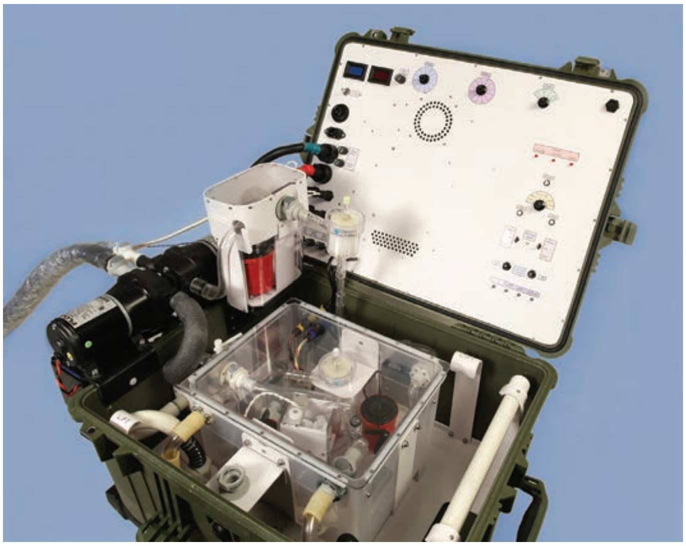


Figure 13.

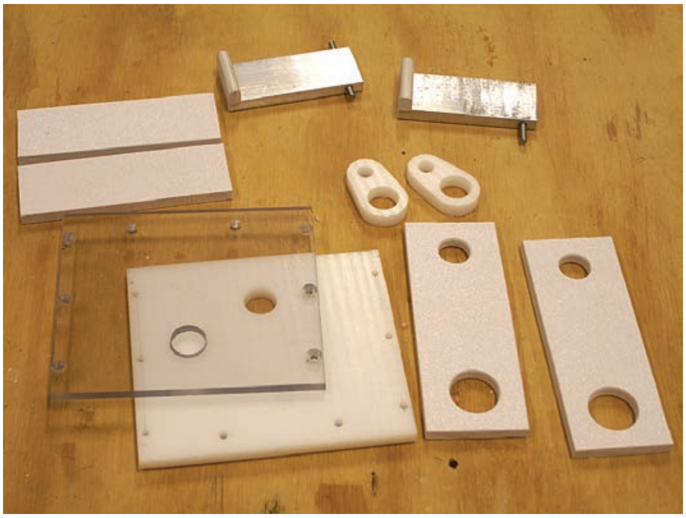


Figure 14.

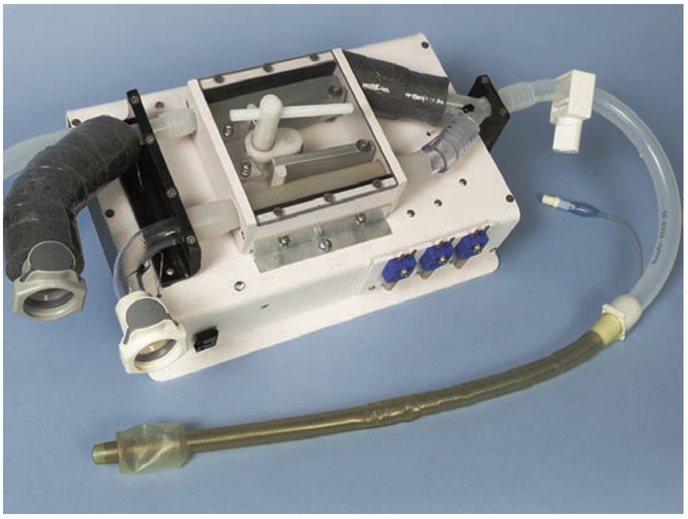


Figure 15.

Figure 16 shows cooling rates in four experiments at CCR using various infusion volumes measured in milliliters per kilogram of animal body weight. The initial temperature was approximately 37 degrees in each instance, but is shown as 0 on the vertical axis of the graph.

Other laboratories are now experimenting with liquid ventilation, because it has applications in conventional medicine. If someone suffers cardiac arrest, rapid cooling may minimize subsequent brain injury. However, so far as I know, the cooling rate achieved by LV5 has not yet been equaled.

Seven Years Later

From 2012 onward I retreated from cryonics. Once in a while I heard that Suspended Animation continued to wrestle with their version of the project, although they did not publish any details. They relocated from Florida to California, hired new employees, and redesigned liquid ventilation from the ground up, now using discrete components for the control system.

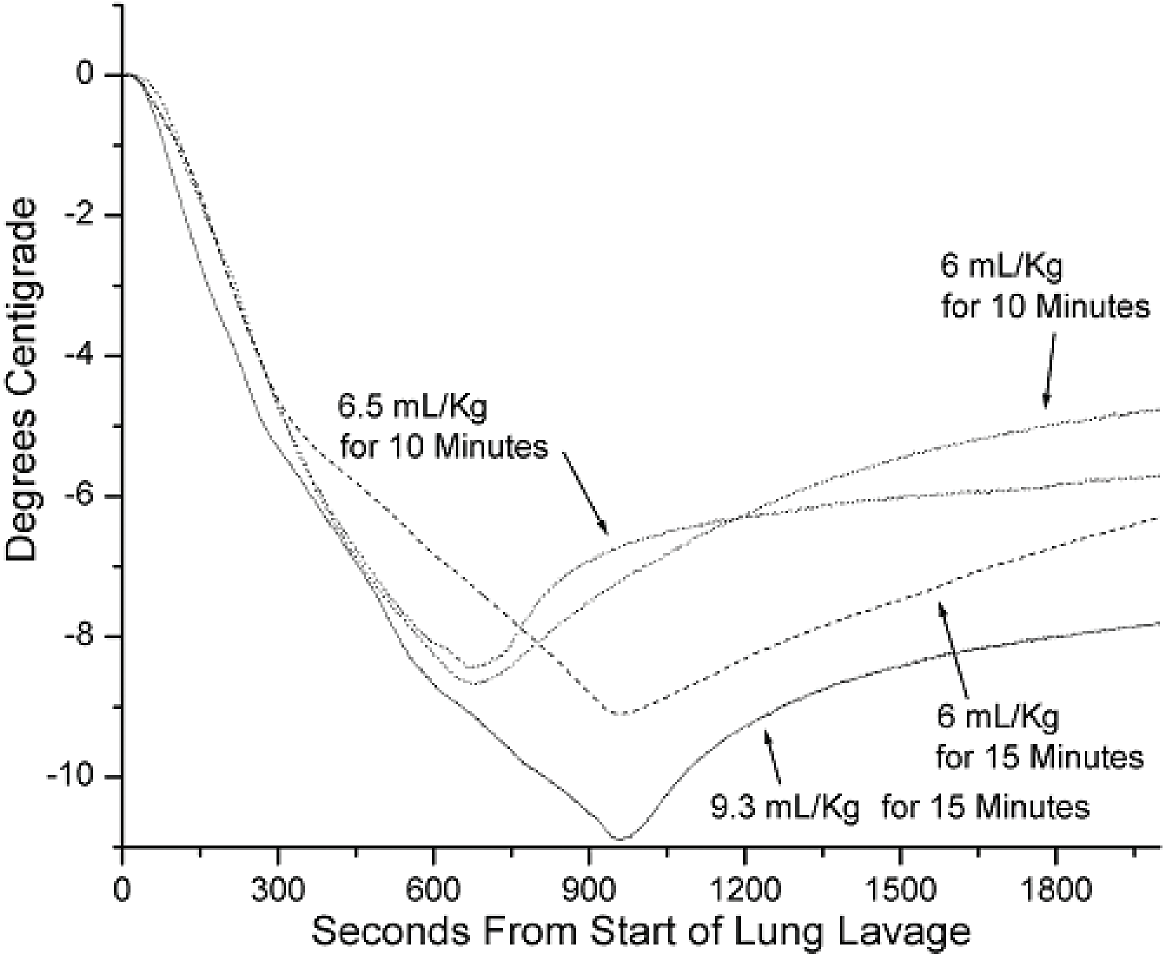


Figure 16.

CCR continued to use LV5 to test various different perfluorocarbon liquids in a pursuit of optimization.

In 2018, a comparison test was organized to compare LV5 with the most recent SA system. I was asked to attend, so I came out of cryo-retirement and was fascinated to see that SA had followed a very different development path. Ice chests were now used instead of Pelican cases, and instead of maintaining a reservoir of perfluorocarbon liquid near 0 degrees, each infusion was cooled by passing it through a heat exchanger on the fly.

The SA equipment was not entirely successful, for reasons that were the subject of some debate. I didn't entirely agree with their design philosophy, but I did see the value of some of their ideas. Bearing in mind that Alcor had been endowed with a fund for research, I wrote a proposal for a compromise system that would be easy to use but not too complicated to build, and would be owned by Alcor.

The field of microcontrollers had changed significantly since my problems with LV4, as chips with unlikely names such as Arduino, Raspberry Pi, and BeagleBone were now providing an amazing range of features. On the other hand, if I still wanted to use PIC chips, they could now be driven at higher clock speeds and could be interconnected with a simple I2C bus. One way or another, the electronics should be much simpler than in 2011.

Steve Graber, at Alcor, kindly agreed to put together the pumps and tubing, while I would deal with the electronics. My proposal was approved in 2018, and Steve and I started swapping ideas with CCR. As so often happens in cryonics, there were differences of opinion about the best way to proceed. In addition, CCR was concerned that LV5 was now eight years old, and really needed to be replaced. In the end, Steve followed a more innovative approach while I started work on another version that was more similar to LV5, while still being usable on human patients. As of June, 2019, we don't yet know how these initiatives will work out.

Looking Ahead

The biggest unanswered question in liquid ventilation is how chest compressions may interact with liquid infusions into the lungs. Chest compressions are essential in a cryonics case, to squeeze the heart and circulate the blood. Emergency medical equipment to perform this function goes under names such as Thumper, LUCAS, and AutoPulse. But if the squeezing process coincides with a pumped infusion of perfluorocarbon liquid, what happens? Animal testing can provide some answers, but they will never be conclusive. We really won't know how a human patient will respond until we try it.

Fortunately many people choose the neuro option for cryopreservation. Only the cephalon will be preserved in these cases, and the body will be cremated. Consequently a patient should not be concerned about the hypothetical risk of lung damage caused by liquid infusions, and I am hoping that a definitive test can be performed when a neuro patient arrives at Alcor immediately after being pronounced locally. Because liquid ventilation is noninvasive, it cannot be hazardous to the outcome; and if it accelerates the cooling rate, it should be beneficial.

In the future, I still hope that a portable system may be usable in standby work, either remotely or locally. Remote deployment will require an air-transportable version, and when perfluorocarbon liquid is included, I'm not sure that everything will fit into two Pelican cases. Reducing the size of the equipment is a significant challenge that Steve Graber has already started to address.

Liquid ventilation must also be simplified to the point where it mostly runs itself. While increasing the initial rate of cooling is highly desirable, implementing it must satisfy practical requirements. LV5 required two people to operate it. Future systems ideally should be managed without increasing the number of people in a standby team.

These requirements are daunting, but I believe the development effort will be worthwhile if cooling can be achieved at rates comparable to those we have seen in the laboratory. ■

Charles Platt has participated in more than 20 cryonics cases and was Director of Cryopreservation Services at Alcor in 2003. After managing Suspended Animation, Inc. in Florida and pursuing liquid ventilation development in California, he has retreated to a wilderness area of Arizona where he writes books such as Encyclopedia of Electronic Components (in three volumes) and Make: Electronics, a hands-on intro-level guide.

Scholar Profile: J Storrs Hall

By Nicole Weinstock

"Well, when I was a kid, I was really on the horns of a dilemma because I didn't know whether I wanted to be a spaceman or a dinosaur. After I got a little older I realized, well, I probably wasn't going to be a dinosaur." So says the refreshingly humorous pragmatist, science visionary, and author, Dr. Josh Storrs Hall.

At the very minimum, an astronaut must have a bachelor's degree in engineering, biological/physical/computer science or mathematics, three years of related and steadily progressing professional experience or 1,000 hours of pilot-in-command jet aircraft experience, and a passing NASA physical. Hall's approach to space has been equally rigorous (arguably moreso), earning him a presentation at the 1997 NASA Ames Research Center and publication in its earlier 1993 Vision-21 symposium proceedings, among other honors. Yet, his career reflects a distinct eclecticism and cross-disciplinary nature that may prove far more vital to the exploration and colonization of the universe than that of any single astronaut.

After graduating with his Ph.D. in Computer Science from Rutgers University, Dr. Hall contributed to several related fields of interest, co-inventing adiabatic logic and designing the CAML and Linear C languages for associative processing. An optimistic futurist and early proponent of robotics and artificial intelligence, Hall published the first book on machine ethics (also known as "AI safety") a full decade before the field rose to popularity. Part of the nanotechnology vanguard favoring the schools of Richard Feynman and Eric Drexler, Hall founded Nanorex, Inc, a startup that succeeded in developing a CAD system for nanomechanical engineering. He also served as the President of the Foresight Institute, the well-known nonprofit focused on advancing nanotechnology and other emerging technologies. Josh has been a Research Fellow with the Institute for Molecular Manufacturing since 1998 and an active inventor of original nanotech concepts such as Utility Fog, the Weather Machine, and Hall Tower; he is currently in the process of building a flying car.

Early years

Born in Druid Hills, Georgia, Josh Storrs Hall was the first of five children in his family. His father was a Methodist minister and his mother was a primary school teacher. Though religion and science are often at odds, the Hall household was proof of a lesser known alliance between faith and reason in rural America.

"Do you have any idea what proportion of scientists were sons of ministers?" Josh questions rhetorically. "The idea is that the minister—especially in a small town—is going to be the only one who has a house full of books. I grew up in a house full of books … My father was a voracious reader. Many of the science fiction books I read were actually his." In addition to drawing from the vast family collection, Josh frequently took advantage of mobile libraries or "bookmobiles" as well as their brick and mortar parentage, often cutting out from school lunches to peruse the stacks.

Perhaps another force at play in the cultivation of Hall's inner literati was the extended absence of television in daily life. Though TVs were common household items by the 1950s, Josh and his four sisters didn't have one in their home until he reached his teens. Despite the allure of sci-fi space series like *Star Trek* and *Fireball XL5*, Hall's curiosity was still largely fueled by reading and books. Decades later, it hasn't changed.

University

The Hall family moved to different small towns throughout Josh's life, from his Georgian birthplace on up to New Jersey, where he spent his final year of high school. To his earlier point linking science and religion, generous scholarships in response to both his strong academic merits and his father's ministry supported his next phase in life at Drew University.

Drew University included this image of a studious Hall hard at work in his 1976 yearbook.

Situated in Madison, New Jersey, just 16 miles west of Newark, the so-called "University in the Forest" was aptly named for its bounteously treed environs. For a young man whose most treasured hobby was reading books under the shade of trees, it could not have been a better fit. Though Hall was keen to make his career in science, he was uncertain which specific subdiscipline to pursue. He appealed to practicality by majoring in mathematics, which he reasoned had applications in an array of professions. When he graduated with his Bachelor of Arts, his cap held the additional feather of a Ciba-Geigy award, named after the two Swiss pharmaceutical companies that merged to eventually form the pharma powerhouse that we now know as Novartis.

In 1975, one year prior to Hall's graduation, IBM released the first ostensibly portable computer, weighing in at 55 pounds. That same year, Ed Roberts coined the term "personal computer" as he introduced his Altair 8800. The computer was quickly becoming a nexus of technology, a wave which carried many mathematically-inclined students like Josh. He worked as a systems programmer at Drew's computer center for the majority of his undergraduate education, uncovering a promising new direction for his graduate studies in the process.

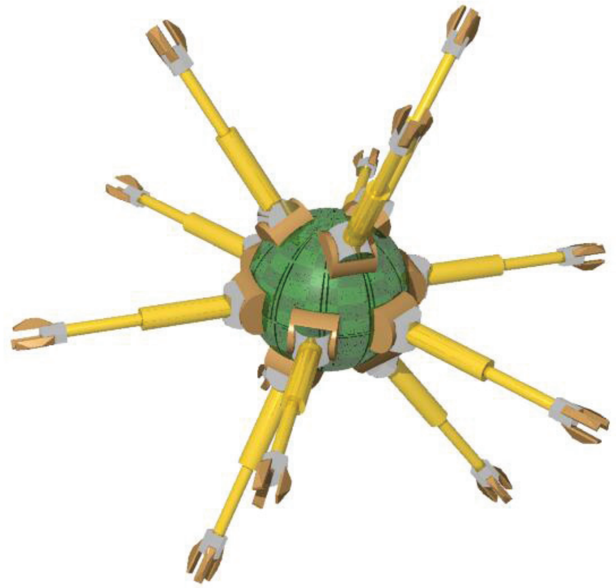
Hall's knack for programming and a growing interest in AI and robotics led him to the computer science department at Rutgers University (formally known as The State University of New Jersey), where he would successfully defend his Ph.D. thesis on associate processing in 1994. Being the eighth oldest institution for higher learning in the country, the university formed an ironically historical backdrop for a burgeoning futurist such as Hall.

Discovering nanotechnology

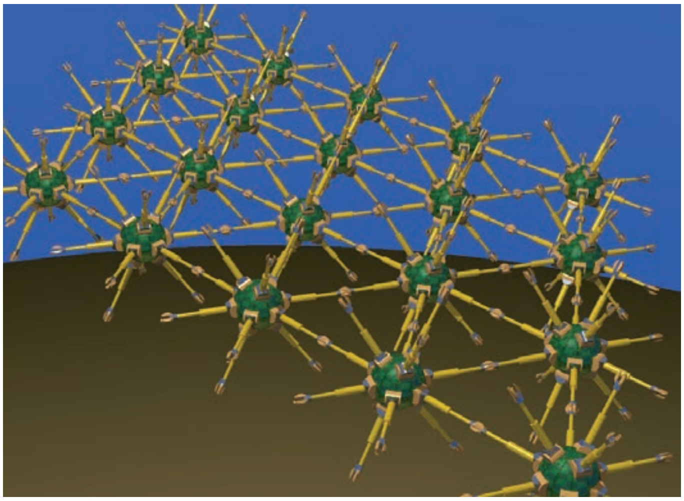
Hall completed the majority of his Ph.D. research in the 80s during a rather paradoxical decade with respect to nanotechnology. On one hand, it marked twenty-plus relatively stagnant years since Richard Feynman first introduced the idea of atomic manipulation in his 1959 Caltech speech, *There's Plenty of Room at the Bottom*. On the other, it was the launchpad for the revival and extension of Feynman's suggestion through Eric Drexler's *Engines of Creation: The Coming Era of Nanotechnology*, published in 1986.

Concurrent with the subsequent wave of "Drexleria" (as Josh calls it), amongst the newly anointed, was the proliferation of online forums, which had been largely illegal on ARPANET (Advanced Research Projects Agency Network), the Internet's predecessor. Science fiction fans formed a significant basis for these groups, a subset of which gave birth to various political discussion groups. Dr. Hall was a moderator for one such group.

"Having had enough experience to weather the storms of that kind of thing, I made a bet with a friend of mine, who was a professor at Rutgers, that I could form the most popular discussion group on the Internet. He didn't think I could." Thus, on a wager that Josh humorously recalls as "probably something like [dinner] or a quarter," he founded and moderated sci.nanotech, an online nanotechnology group that received more favorable votes than any previous forum election.



A foglet, as featured in this diagram, is the 100-micron robotic cell that forms the building block of utility fog.

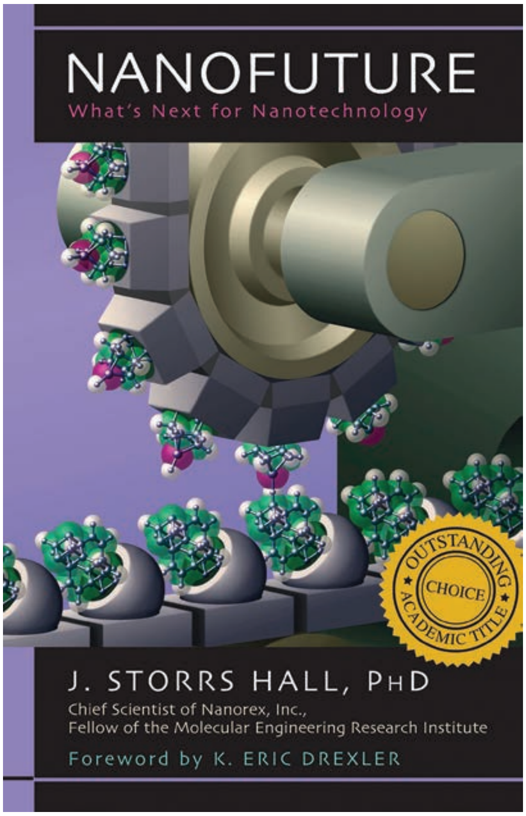


A layer of foglets joined together.

During sci.nanotech's first year, Hall inadvertently put Rutgers on the map for nanotechnology. "There was actually no nanotechnology research going on at all at Rutgers at the time," he laughs, but his connection to both the school and sci.nanotech stirred quite the reputation. When he attended the 1989 First Foresight Conference on Nanotechnology a year later, his association with the field through that forum alone preceded him. Dr. Hall continued to moderate sci.nanotech for the next decade.

Though he was completing his Ph.D. in the early 90s, Josh still found time to devote to the conceptual side of nanotechnology. In 1993, he debuted Utility Fog in a NASA conference publication. It is a hypothetical concept involving microscopic robots that can arrange themselves, and rearrange themselves to form any physical structure, however simple or complex. Like a robotic expression of the human "castell" towers of Catalonia, these tiny mechanisms are built with arms that extend to link one unit to the next, and so on. Utility fog was the answer to restless interior designers, who long to change the color of their walls each week, or gearheads who want to drive a different car every day. It could form the very furniture you sit on and cover the roads that you drive on, invisibly safeguarding you and your passengers from harm. The theoretical possibilities of the original utility fog concept and any more contemporary interpretations are endless, as Dr. Hall explains:

> Almost anything that you can do physically could be done by utility fog…. Instead of having 17 different kinds of tape players and recorders and so forth, you just have one computer and it handles all your information. The utility fog is the physical parallel to a computer for information. It can do just about anything on the appropriate scale.



Hall considers the self-replicating manufacturing system featured on the cover of Nanofuture: What's Next for Nanotechnology *as one of his greatest professional achievements.*

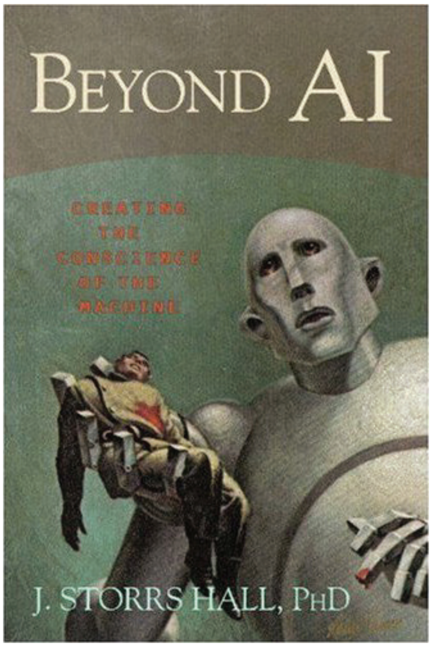
Hall's inventiveness in the field of nanotechnology didn't end there. He envisioned the Weather Machine, a blanket of GPS-controlled nano-balloons that cover the Earth's atmosphere, (re) directing sunlight through moving inner mirrors that effectively control planetary climate. More recently, he invented Hall Tower, an advanced low-cost orbital-launch concept. In 2005, Hall published *Nanofuture: What's Next For Nanotechnology*, featuring an advanced self-replicating machine that would form the basis for his predictions. In his own words from an introduction on his personal website, www.autogeny.org, "[This book] is about real nanotechnology, i.e. molecular machines (as opposed to films and powders re-branded 'nanotech' as a buzzword)."

His point of distinction between nanotechnology and "real" nanotechnology demands a brief historical jump back to the turn of the 21st century when President Bill Clinton committed a sizable amount of funding to the development of the field. Yet, as Hall pointedly describes in both conversation and writing, most of the projects that followed did not focus their efforts on the original objective of nanotechnology as defined by Drexler and Feynman before him: the ability to manipulate matter on an atomic scale.

"Anything that becomes a very popular word and talks about a great technological advance or anything else for that matter, is going to get borrowed, and people are going to stretch the meaning and try to make their stuff look fancier by using the same word that the other people are using, and so forth. That really happened to nanotechnology in space," says Josh. "It's kind of a shame because one of the things that happened... was that the people who were doing that actually got control of the word and managed to exclude the original technology as envisioned by Eric Drexler and his friends, including me. That's why we don't have cell repair machines and self-replicating assemblers and all the other stuff that you read about in Eric's early writing, because in the meantime, a lot of the work that should have been done on them actually got actively suppressed. Basically, I would say now we're a good ten years behind where we could have been in nanotech."

Launching machine ethics

As is evidenced by the role of tiny robots in nanotechnology and the concepts put forth by Dr. Hall throughout his career in the field, AI and robotics form an inevitably related branch of technology to which he has also made notable contributions. One of the landmark moments of his career was motivated by a *Wired* magazine essay from April of 2000 entitled, *Why the Future Doesn't Need Us*. Written by computer engineer and Sun Microsystems co-founder, Bill Joy, the article's arguably luddite leaning is rather well-summarized by its subtitle: "Our most powerful 21st-century technologies—robotics, genetic engineering, and nanotech—are threatening to make humans an endangered species."



In 2007, Dr. Hall published his second book,
Beyond AI: Creating the Conscience of the Machine*,*
focused on machine ethics.

The doomsday undertone of Joy's piece struck Dr. Hall as exceedingly reductionist. In response to the essay, he released an Internet paper entitled *Ethics for Machines* later that same year. The paper introduced the then-novel concept of ethical approaches to the design and proliferation of AI. "We just have to do it right," says Hall, explaining his argument. "It's obviously dumb to make a super intelligent AI that's also a psychopath, but we don't have to. If we know enough to make a super intelligent AI, we know how to make one that has a conscience."

His paper got traction in the hands of more optimistic futurists, and eventually became a chapter in one of the major works on machine ethics (the 2011 book was simply titled *Machine Ethics*—yet more evidence of the field's novelty). Even before that, Hall developed his arguments into the book, *Beyond AI: Creating the Conscience of the Machine*. It was released in 2007, but it would be another ten years before the importance of AI safety was recognized in tech circles. Hall observes, "The book is somewhat dated simply by the fact of when it came out. I had to build up a little credibility for the fact that there might actually be AI in the first place. Nowadays everybody takes that for granted."

Flying cars & Machiavelli

The Jetsons, an animated TV series about a futuristic nuclear family that travels around in a pared down electric VTOL (vertical takeoff and landing aircraft), saw its 50th anniversary in 2012. Six years later, Hall released his third book, W*here Is My Flying Car?: A Memoir of Future Past*. A meditation on the challenges of facilitating true nanotechnology and ethical AI, as well as the inability of the flying car to gain traction in 20th century transportation, *Where Is My Flying Car?* artfully explores the marked stagnation of technological advances in the last several decades. One of the major contributors that Hall identifies, and which earns a full chapter's worth of real estate, is what he calls the "Machiavelli Effect." He pulls a rather key passage from Niccolò Machiavelli's 1532 treatise, *The Prince*, in an effort to explain the phenomenon's namesake:

> There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things; because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new. This coolness arises partly from fear of the opponents, who have the laws on their side, and partly from the incredulity of men, who do not readily believe in new things until they have had a long experience of them. Thus it happens that whenever those who are hostile have the opportunity to attack they do it like partisans, whilst the others defend lukewarmly, in such wise that the prince is endangered along with them.

The excerpt clearly outlines Machiavelli's perception of human psychology surrounding any suggestion of change to the status quo. It may not seem particularly novel at face-value but can prove rather lethal to progress in any research-dependent field. As Dr. Hall comments, "It's a purely natural phenomenon in the kind of environment that defines especially government-funded scientific research these days, because to some extent everybody sees, 'Here's a pot of money, and I'm going to get mine, and if it means that you can't get yours for me to get mine, I'll do whatever I can to make sure you don't get yours.'"

Josh looks to the evolution of cooperation as a method for transforming this zero-sum game into a positive-sum game. "That means a growing economy and expanding resource base and all that sort of stuff," he says, prefacing his positioning outside of an economics specialization. These things come with good tidings for Hall who has always envisioned expansion in a big way. "To some extent, for me, this is a self-reinforcing conclusion, because I always wanted to go out into space and settle the solar system, and have spaceships and robots and all that in the first place. But now I know there's a really good reason that we have to do that."

Real nanotech for cryonics

Josh was first introduced to early notions of cryonics through one of the "Big Three" science fiction writers, Robert Heinlein. In his 1957 book, *Door Into Summer*, an alcoholic businessman elects to cryosleep through the aftermath of the hostile takeover of his company following his design of a novel domestic robot.

In line with Drexler's take in *Engines of Creation*, Hall sees significant crossover benefit from advances in nanotechnology to cryonics. It could be a legitimate gamechanger, as he relays in a mountaineering metaphor: "You're standing in a deep crevice and you're looking at the pathways where you're going to put your crampons or wedge your way up the chimneys and find the best way to the top...Unless you're sitting by a helicopter... Nanotech is the helicopter."

In 2012, Dr. Hall was the keynote speaker at the 2012 Writers & Illustrators of the Future Awards in Hollywood.

The success of nanotechnology could significantly impact many of the debates that arise in cryonics circles, such as the cryopreservation of the whole body versus the brain. Many cryonicists elect the former cryopreservation method to safeguard themselves against the unforeseen. Should something occur that compromises the body, the brain still remains. Should the body prove to be more valuable to the fulfillment of certain activities—playing sports or music, for example—the original form remains. Pending certain progress in nanotechnology, however, the scales could begin to tip in favor of neuropreservation, or even favor mind uploading as a preferential alternative to cryopreservation. Hall shares an important reminder in the conversation:

> By and large, a steak and a hamburger are made of the same atoms. A steak and a piece of living meat are made of the same atoms. Diseased tissue and healthy tissue are made of the same atoms. They're just arranged differently. The power to rearrange atoms, just broadly conceived, is the power of life and death, of restoration, of preservation, and all of the other things that we would like to do.

Yet again, as he underscores throughout his commentary on the subject, the successful application of nanotechnology in the field of cryonics necessitates the same attention to its founding notions as any other application of nanotechnology. "It all comes down to the arrangement of atoms," says Dr. Hall. "Until we have a technology that is broadly capable of rearranging atoms, we're shooting in the dark a little bit." In this, he sees significant trickle-down benefits to the understanding of the Machiavelli Effect and efforts to infuse the sciences with more cooperative economics.

An actual flying car

In 2012, Josh and his wife Sandy left their previous residence in rural Pennsylvania to move to their current hometown of Onancock, Virginia. "It just felt right," says Josh. "They had the same kinds of birds and animals and trees and flowers and so forth that I had grown up with."

A small town measuring just one square mile, Onancock faces the Chesapeake Bay on a southern-reaching tentacle of land separating this predominantly shallow estuary from the Atlantic Ocean. It is, in Hall's witty estimation, "mostly a retirement community, about half college professors and half military officers. At least, that's my joke about it. It's half true." In actuality, just seven miles away in neighboring Melfa stands the Eastern Shore Community College, where the local science of philosophy club regularly hosts visiting speakers on the subject. Josh and Sandy are regular attendees when they're in town.

That said, their enthusiasm for tennis, wine, and flying keep them out and about quite frequently. At the time of our interview, they had returned from burgundy wine tasting in Beaune, France not one month prior, and were taking turns flying an autogyro that same morning. A cross between an airplane and a helicopter, the autogyro emerged as an immediate source of interest during Josh's flying car book research.

For a forward-looking mind such as Hall's however, the allure of adventure ultimately leads back to his home office. Following the publication of *Where Is My Flying Car?* in 2018, writing has taken a back seat to his next great undertaking: building a real flying car. He is currently assembling models and computer simulations. He hopes to translate theory into practice in the very near future. ■

To find out more about Josh Storrs Hall, please visit his personal website www.autogeny.org or email him directly at josh@autogeny.org. Amazon has more information and pricing on his books: *Where Is My Flying Car?: A Memoir of Future Past*; *Beyond AI: Creating the Conscience of the Machine*; and *Nanofuture: What's Next For Nanotechnology.*

Q&A

What is the most exciting development going on in (true) molecular nanotechnology right now?

There's a kind of squeeze play going on between top-down approaches (additive manufacturing, for example) and bottom-up ones like DNA origami. When these meet, maybe in about a decade, you'll begin to see some of the things we have been predicting.

How could a mature nanotechnology address concerns about climate change?

On a technology sophistication scale of 1 to 10, where 1 is current technology, 5 is where you could correct climate change without losing too much in the effort, and 10 is where you could correct it trivially without noticing the cost, true mature nanotech rates about 100. Or maybe 1000.

Here are some numbers: in the best estimates I know, CC is expected to cost us $6 trillion in 2100. But that's against an economy of $200 trillion (current growth rates and technology). With nanotech, you could easily double the growth rates and be taking that $6T out of $2000T, less than half a percent.

In more descriptive terms: Nanotech could easily generate and store energy without emitting any CO_2. Nanotech could easily build the kinds of things we would like to build to be more weather-resistant, whether it has anything to do with climate change or not. Simple examples are homes more resistant to storm surge, and air conditioners. Or even domed, air-conditioned cities! Or just make everyone rich enough to have summer homes in Canada and Siberia. Or Mars.

By the way, I am an accredited Expert Reviewer for the IPCC in the area of computer modeling, and I would strongly urge taking climate model results with a grain of salt...

For someone interested in developing molecular nanotechnology, what kind of education and experience would you recommend?

When I went to college, I didn't know which science I would ultimately specialize in, so I studied math, with minors in physics and philosophy. If I had to do it over I would take chemistry instead of the philosophy, but by and large it was a good choice. There's a good chance they are not now teaching what you'll need to know in 2030.

How has the field of artificial intelligence ethics evolved since your publication?

It's caught fire and is the latest academic fad. I was 10 years ahead of my time (although it's arguable that Norbert Wiener was 50 years ahead of me!). Right now, though, and for at least 20 more years, the most important thing in the field will be to make people writing critical software (e.g. control systems for the 737MAX) play smarter and be more aware of how their stuff fits into the rest of the world.

Could you foresee any applications of utility fog or similar concepts for cryonics?

Sure. UFog can do anything a human can, physically, so it's likely to be the common general factotum in the world you wake up in. It can also simulate any environment at the level of human senses, so it would be the perfect "holodeck" for waking people up in a world that makes familiar sense to them. What the real world would be like at that point I can't even imagine myself.

One of the biggest challenges for cryonics revival is the need to perform molecular manipulations at cryogenic temperatures (accessing the circulatory system, imaging etc.). What kind of technological solutions do you envision here?

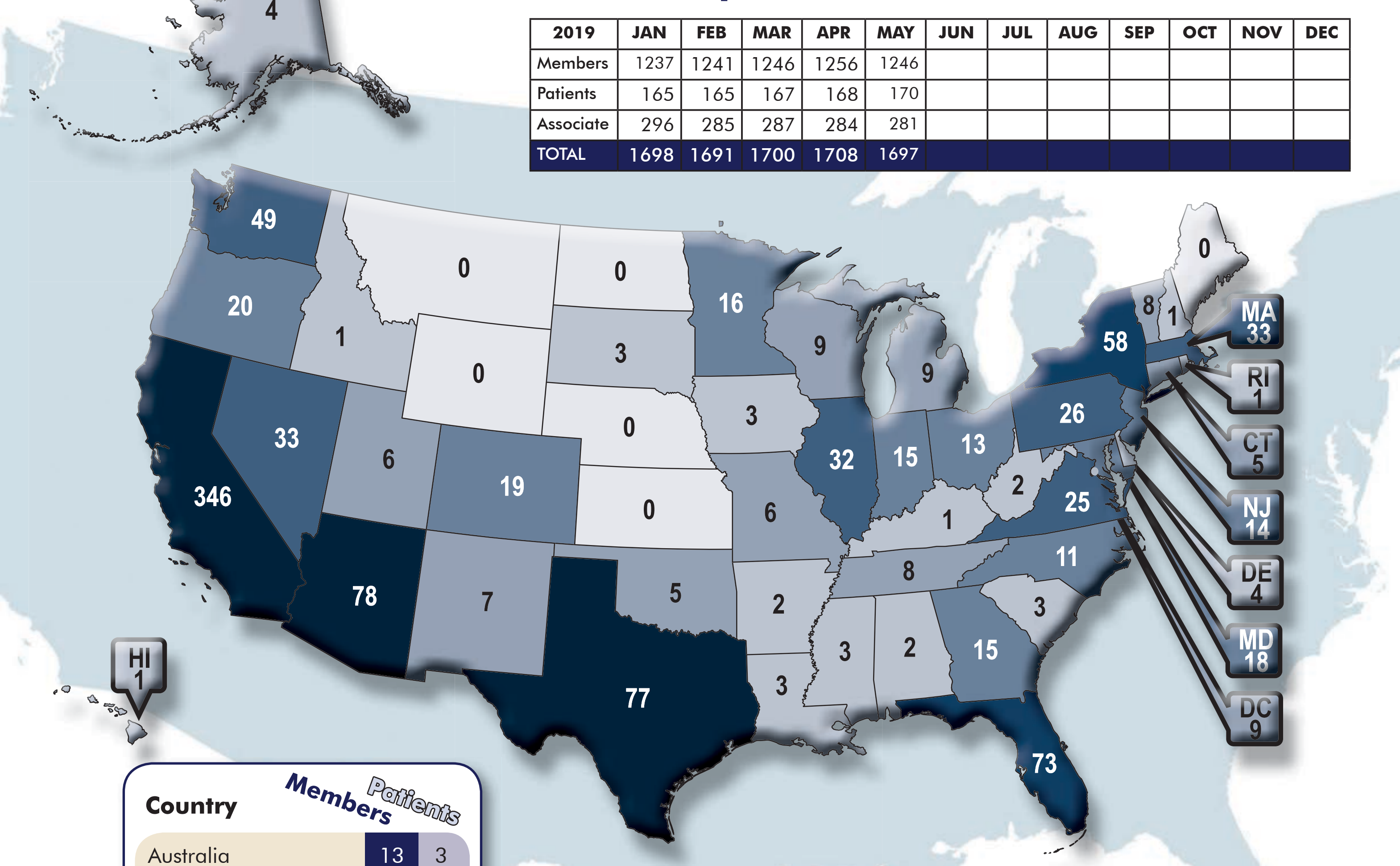
Unlike biotech-based approaches, diamondoid nanotech would work perfectly at cryogenic temps, and the subject would be a lot easier to deal with if it were all solid. So that's a pure plus for nanotech.

How might the flying car alleviate cryonicists' concerns about the risks of air travel?

If you're worried about air travel, there's no way to alleviate your concerns, since it's the safest way we have to travel as it is! Nanotech-based personal flying cars could be an order of magnitude safer yet. Pretty much the only way you could have better peace of mind would be to develop a non-destructive scan method where you get your brain recorded periodically, just in case of any kind of accident whatsoever.

Membership Statistics

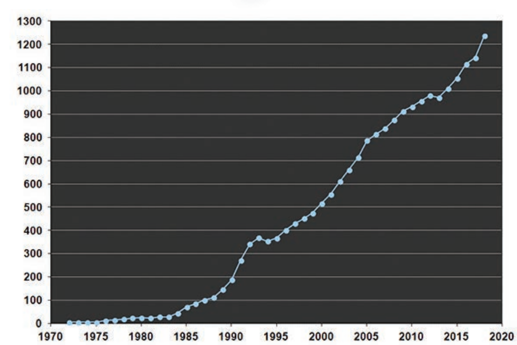
2019	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Members	1237	1241	1246	1256	1246							
Patients	165	165	167	168	170							
Associate	296	285	287	284	281							
TOTAL	1698	1691	1700	1708	1697							



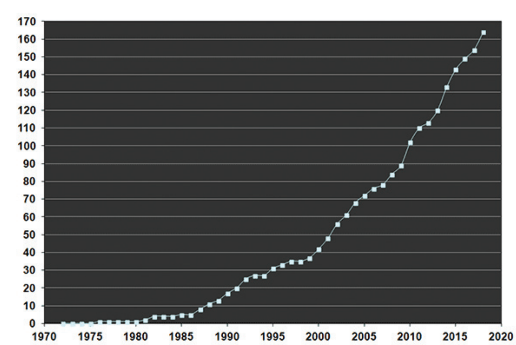
- 0 Members
- 1–4 Members
- 5–9 Members
- 10–24 Members
- 25–49 Members
- 50–74 Members
- 75+ Members

International Members & Patients

Country	Members	Patients
Australia	13	3
Austria	1	0
Belgium	1	0
Brazil	1	0
Bulgaria	1	0
Canada	62	3
China	0	1
France	0	1
Germany	18	0
Hong Kong	2	0
Israel	1	1
Italy	2	0
Japan	5	0
Luxembourg	1	0
Mexico	4	0
Monaco	1	0
Netherlands	1	0
New Zealand	1	0
Norway	2	0
Portugal	4	1
Puerto Rico	1	0
Singapore	1	0
South Korea	1	0
Spain	5	1
Taiwan	1	0
Thailand	2	1
United Kingdom	38	3
TOTAL	172	15



Number of Alcor members



Number of Alcor patients

Further Reflections on the Timescale of AI

By J Storrs Hall, Institute for Molecular Manufacturing

Abstract

Solomonoff [9] explored the possibilities of the future course of AI development, including social effects of the development of intelligent machines which can be produced with exponentially decreasing costs. He introduced arguably the first formal mathematical model of what has since come to be known as the technological Singularity. Since that time a veritable plethora of such models has appeared [8]. We examine the milestones and models in light of 25 years more experience, and offer a revised version.

Milestones for AI

Ray Solomonoff, in [9], proposes a list of milestones for a discussion of the further course of AI. Briefly, they are:

A. Dartmouth, 1956: AI began as a distinct enterprise. This is the only milestone which was considered to have been accomplished at the time of the paper.

B. A general theory of problem solving is achieved: it would cover such capabilities associated with intelligence as learning, concept formation, and knowledge representation.

C. A self-improving machine (or program) is created.

D. Computers are able to learn by reading existing natural language text.

E. An AI has a problem solving capacity equivalent to a human.

F. An AI has a problem solving capacity near that of computer science community.

G. An AI has a problem solving capacity many times that of CS community.

In the intervening 25 years, much has happened, but milestone A is still the only one which has actually occurred. However, at least something has been learned, so we can say more about the milestones as they might happen in the future.

Milestone B, a general theory, was presumably to be the sort of crowning formalization to AI that the science of thermodynamics was to the engineering of steam engines. In some sense, Solomonoff's own work and the succeeding efforts by such researchers as Levin and Hutter remain the best attempts we have in that direction. Furthermore, there is a substantial subfield of machine learning theory, and outside of AI there has grown up a substantial field of optimal control theory and estimation. We might well look for the ultimate origins of an AI theory in the unification of these fields.

Even so, it should be remembered that engineers had been building steam engines for a century before Carnot conceived the basic principles of thermodynamics. What current best theories of AI lack is the ability to analyze a given learning or problem-solving design and predict its performance, the way we can analyze any given steam engine using thermodynamics. Historical precedent tells us that we will probably have working AIs, built heuristically and improved by experimentation, before we have a proper theory. Thus we should expect Milestone B to be one of the later, rather than one of the earlier, ones to occur.

It is not clear that Milestones C and D are distinct, especially as AI has developed since 1985. Consider how a human learns: the vast majority (for many people, the entirety) of what we learn is not original discoveries but the takeup of culturally accumulated knowledge from peers, parents, teachers, and books. A completely competent AI might operate exactly the same way; it would not be a Newton or an Einstein (nor indeed a Solomonoff!), but it would be human-level as measured against the average representative of *homo sapiens*.

This is not to say that such a machine would not need endogenous learning capability. It is clear that human learning is not simply storing symbolic representations, but the construction of mental programs for prediction and control. Contrast, for example, the verbal instruction with the internal control-system formation attendant on learning to ride a bicycle. Solomonoff writes:

> ... many of the more interesting human activities are mainly performed by the unconscious mind. If the unconscious mind works very much like the conscious mind (but we are merely less aware of its workings), then there is no difficulty here. However, if as is widely suspected, the unconscious mind is significantly different from the conscious, then the present expansion of expert systems will have serious limitations.

And so it proved. Today's more competent AI and robotic systems have, in addition to the logical superstructure of the 80s' expert systems, a substantial semantics of their domains of expertise composed of predictive simulation codes, control systems, statistical models derived from vast corpuses of relevant data, and so forth. An AI that learned from reading (or other symbolic instruction) would presumably use the symbolic input to form a scaffolding that would greatly accelerate, but not eliminate, the subsequent (perhaps search-based) program-construction effort.

Thus at least one reasonable view of the ultimate shape of learning machines implies that milestones C and D are complementary, rather than separable, achievements.

If the capabilities of a C-D AI are integrated into an appropriate cognitive architecture, one would be fairly close to milestone E, human equivalence. Solomonoff [10] discusses the qualities desirable in a human-equivalent (or better) machine:

> I would like it to give a better understanding of the relation of quantum mechanics to general relativity. I would like it to discover cures for cancer and AIDS. I would like it to find some very good high temperature superconductors. I would not be disappointed if it were unable to pass itself off as a rock star.

It seems reasonable to imagine that if such a machine had a human brain's equivalent of processing power, it might make discoveries at the rate of a human. (We discuss this in more detail below.) If so, milestones E, F, and G are primarily a function of available processing power. When we have a working version of a human-equivalent AI, we can readily duplicate it into one or more research communities, corporations, or similar enterprises. It might or might not be possible to integrate minds, enhance communication, or the like, by redesigning various mental processes and/or applying more processing power or memory to a given individual AI than the human brain affords. However, for the sake of this (or Solomonoff's original) argument, that would be merely an optimization and not necessary to the main point.

Singularity

[9] contains arguably the first formal model of an increase in processing power leading to a mathematical singularity of intellectual capacity.[1] This predicted an asymptotic rise at a date that depended on various model parameters, and very likely was influential in the adoption of the name "Singularity" for the concept.

The intuition for such a hyperbolic growth curve is straightforward. Suppose that technological progress can be parceled into a series of fixed-size problems, the solution of each of which can be done with some fixed number x of machine operations. Current progress, with roughly a fixed number of human minds (and thus a linear rate of problems solved), appears capable of inducing an exponential improvement rate in computing hardware (measured in operations per dollar). The rate is usually measured in time, but in the model, could just as well be measured in (the linearly related) total number of problems solved.

Once we can obtain, for an affordable outlay, problem-solving capability, in AI form, of a size comparable to the current technical community, the dynamic changes. If we double the brains available, we halve the time to solve the next problem in our list. Since we're measuring computational improvement in problems solved, the next generation of computers is available in half the time, and (again for a fixed cost) we can redouble our problem-solving ability. Thus the next set of problems is solved in one quarter the original time, and the next in one eighth, and so forth, providing us the solution of an infinite series of problems in a finite time.

As Solomonoff hastens to point out,

> Usually, when infinities like this one occur in science, they indicate a breakdown of the validity of the equations as we approach the infinity point.

He proceeds to speculate that the breakdown in this case would be the end of the Moore's Law computational improvement. In practice, it could be any of a vast number of things. Computational speedup is only one of the many feedback loops in the improvement of technology as a whole. Most of these have to go through various physical processes (starting with building the capital equipment which fabricates microchips, but including such mundane necessities as the transportation of raw materials and finished machines). Any one of these would form a bottleneck if the rest were significantly accelerated.

There is a second, perhaps more subtle problem with a hyperbolic model. As the problem-solving intervals decrease exponentially in duration, causing an asymptotic increase in problems solved, they also cause an asymptotic increase in the fixed-per-interval expenditure for machinery. In other words, the model consumes an infinite amount of physical resources in finite time, as well.

We can form a more realistic model of the self-improvement process by considering a sector where Moore's Law is strongly active already, namely the semiconductor industry.

Moore's Law

Consider the (US) semiconductor industry over the past 15 or so years, where a measurable Moore's Law has been operating. Notably, in this period, design automation has contributed enormously to the ability of mere human beings to design the staggeringly complex microprocessors and other components that make up current-day computers. This ranges from architecture to electronic phenomena to geometric design of chip masks to allow for refraction effects of the UV light used to expose the chips under construction.

Thus feedback from increasing processing power and software sophistication in semiconductor manufacture is an excellent proxy for the kind of increased smarts to be expected in an AI takeoff, and in a sector with nicely measurable results. Furthermore, for the past 15 years, the industry (in the US[2]) has been remarkably stable: it can be considered statistically to have a constant annual output value of $75 billion, spending $15 billion on raw material, $8.25 billion on capital equipment, and $12.75 billion on research and development.[3] The number of production workers has been more or less even over the period at about 85,000, but the number of non-production workers has shrunk from 93,000 in 1997 to 62,000 in 2007.

Meanwhile the performance of the product has been increasing at a faster-than-exponential rate:

The equation for the quadratic fit is $f(t) = 0.000723t^2 - 2.69t + 2{,}496$, i.e. ops/sec/$1000 is predicted to be $Q(t) = 10^{f(t)}$ for t the year number.[4] This is the form of the integral of the product of a linear term and an exponential, which suggests a model with a linear network effect as well as capital re-investment.

Given that the raw material input to the industry is essentially constant and the dollar value is constant, $Q(t)$ can be taken to represent the intelligence with which the atoms of raw materials are rearranged into products; a relatively pure measure of innovation. Thus the semiconductor industry as a whole manages a $Q(t)$ improvement from a fixed 28% reinvestment rate.

According to the curve, cost of computation has dropped by a factor of 152,000 since 1985. The net present value of a human engineer of the sort participating in the semiconductor industry is about $1 million. The amount of computation necessary to host an AI at a human level, given reasonably optimal algorithms, can be estimated at (very roughly) 100 teraops, or 10^{14} ops/sec. On the curve, this will be available for $1 million in 2013, and for $1000 in 2026.

A Series of Growth Modes

Hanson [3] analyzes the economic history of the human race as a series of distinct changes in the growth rate. At least two major accelerations can be identified. The growth rate for humanity's

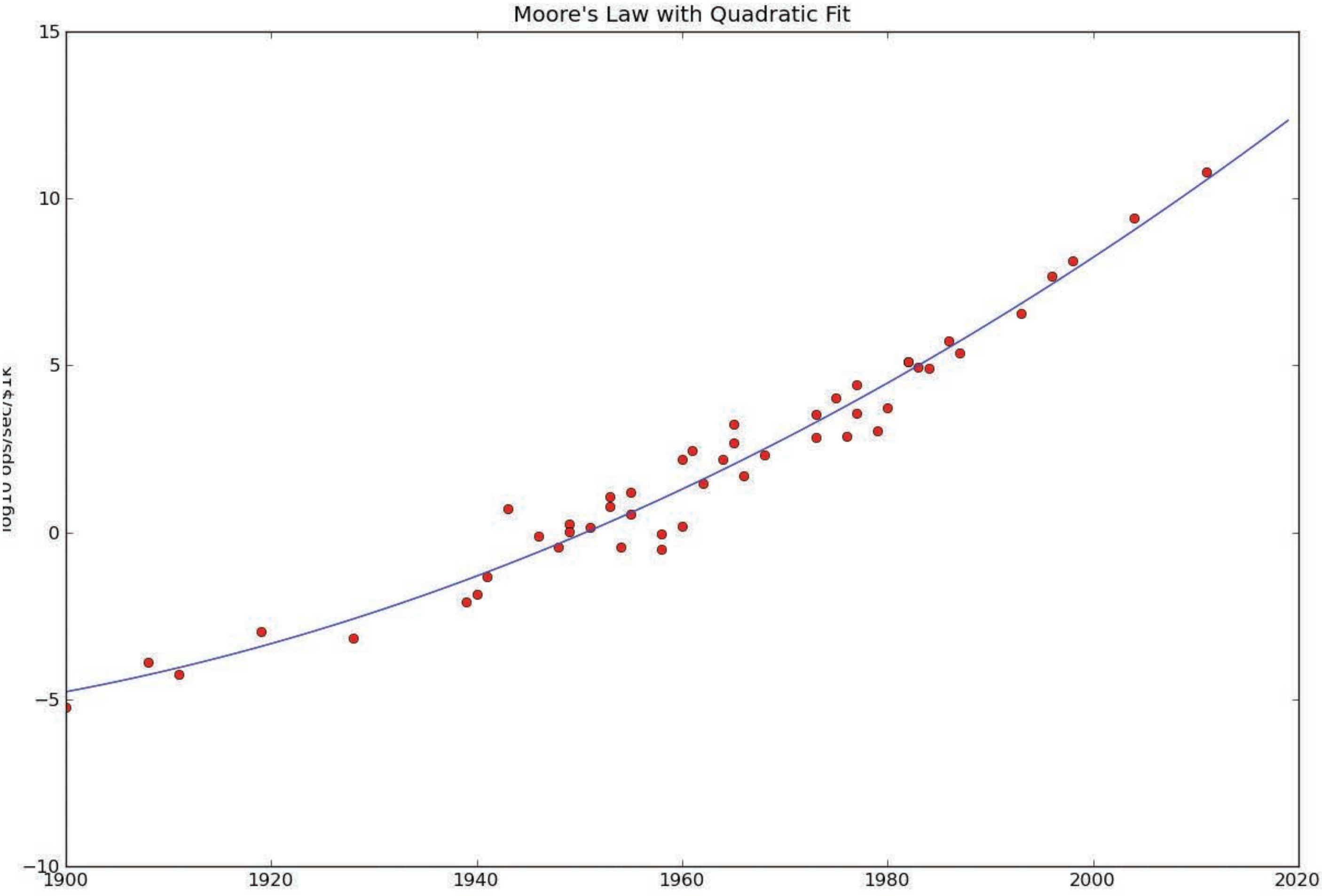


Figure 1: Moore's Law with a quadratic growth-rate fit, from Kurzweil's and the author's data.

gross output jumped by about a factor of 250 with agriculture, and by a factor of 60 with the Industrial Revolution.

The fact that the Moore's Law growth rate is changing lends credence to a proposition that it might be in the process of shifting from one mode to another.

Hanson speculates that the next jump in the series, assuming the pattern holds, might well occur within the coming century: the industrial economy has seen roughly as many doubling times as the agrarian period did.

We find the analysis of historical growth as a series of growth modes with intervening phase changes to be compelling, but the endogenous model in which phase changes are precipitated simply by the number of doubling times from a previous one to be little short of numerology. We will advance an alternative theory below.

What Technology Wants

Von Neumann [6] hypothesized what he called the "complexity barrier:"

> There is thus this completely decisive property of complexity, that there exists a critical size below which the process of synthesis is degenerative, but above which the phenomenon of synthesis, if properly arranged, can become explosive, in other words, where syntheses of automata can proceed in such a manner that each automaton will produce other automata which are more complex and of higher potentialities than itself.

Three recent studies of the phenomenon of technological progress in human communities [5, 4, 7], give credence to von Neumann's concept of the complexity barrier. Technological progress in human societies depends on the complexity – size and network effects – of the economic and intellectual community within which economic and intellectual intercourse are possible. Isolated societies, even though composed of people just as industrious and intelligent as the larger ones, tend to regress and lose technologies instead of progressing and inventing new ones. Aboriginal Tasmania is a classic example of this phenomenon. There seems to be some point of complexity above which a society is self-improving, and below which it is not.

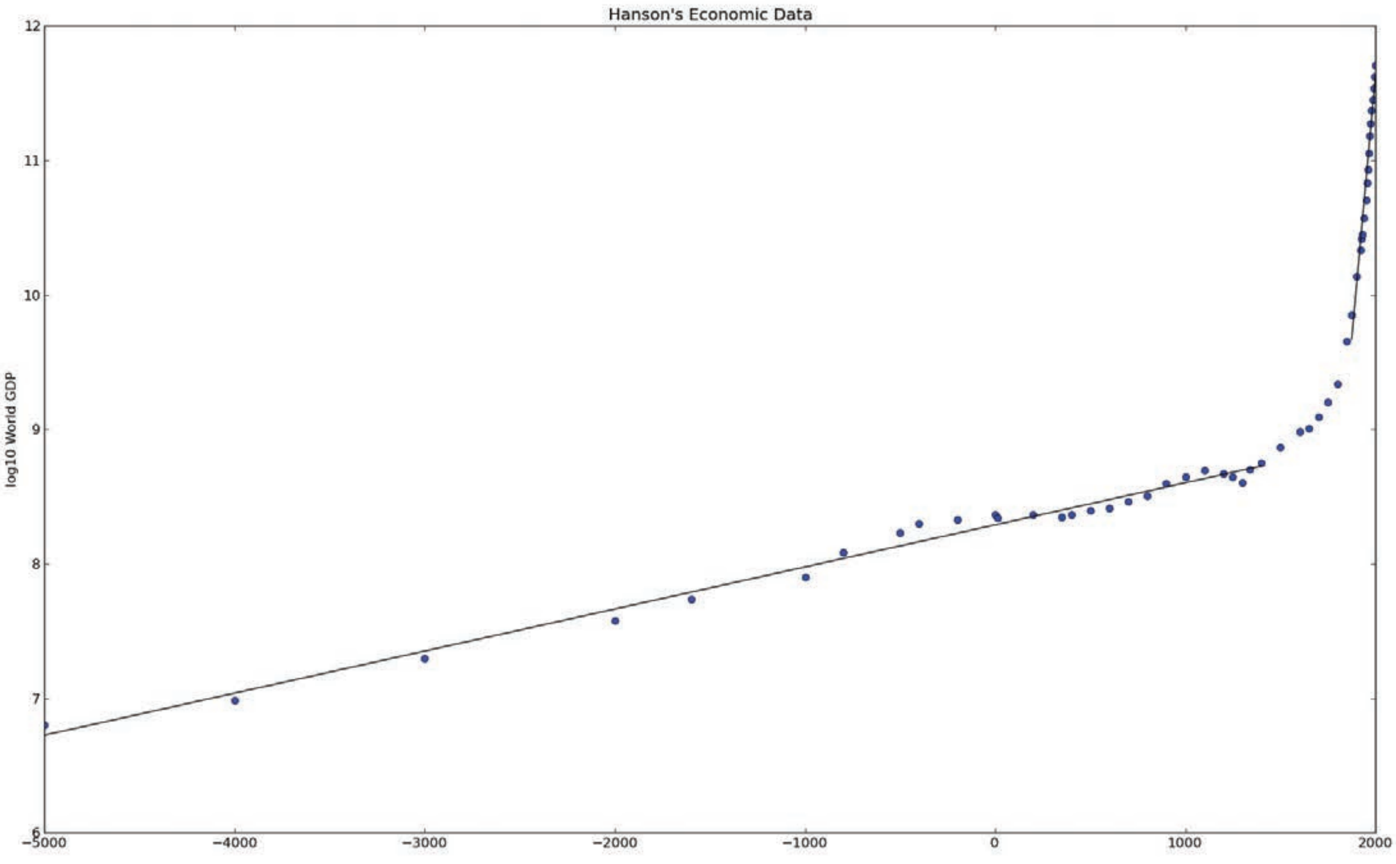


Figure 2: Hanson's data for agrarian and industrial growth modes, with the Renaissance / Industrial Revolution knee between.

We hypothesize that the complexity barrier is closer to milestone F (CS community) than to E (single human) – and possibly past it.

Kelly's work in particular is strongly based on the notion that at any particular state of knowledge, there is a certain set of inventions available to be discovered as the next step. Thus in some sense, technological creativity is analogous to explorers in a landscape following valleys and mountain passes; the directions they take are determined by the landscape rather than their internal compasses. Visionary geniuses who are ahead of their time – da Vinci, Babbage, and Drexler spring to mind – find their ideas impossible to implement. Ideas on the frontier of the technium, to use Kelly's term for the corpus of technical knowledge at a given time, tend to be independently and simultaneously reinvented. Substantial empirical evidence is given for this position.

An Exogenous Model of Technological Growth

On this view, Hanson's model of growth-rate phase changes can be reinterpreted. Instead of some internal dynamic in the technium producing a phase change after some number of doubling times, the roughly regular progression of phase shifts can be better explained as a result of the terrain in the idea-space through which the technium is expanding. A fractal distribution of "fertile valleys" – of volumes of idea-space affording rapid growth and high productivity – would account for the overall shape of the series of growth phase changes. The timing and other parameters, however, would depend on particulars of the terrain and could not be predicted in detail from the preceding series. Valleys would occur at random with a frequency inversely proportional to their sizes.

On this view, the technium is an expanding volume in an idea space of high dimensionality. When it contacts a valley, expansion into the valley proceeds at a higher-than-normal rate, producing the super-exponential growth characteristic of a phase shift. Once the valley is saturated, growth reverts to the simple exponential but at a higher rate due to the increased size and dimensionality of the frontier.

For example, a very early technium consisting of fire, clothing, crude shelter, and chipped flint tools – the "Mousterian toolkit" – vastly expanded the inventory of geographical locations in which humans could live. This afforded a higher population growth rate than a steady-state existence in clement climes. In this case the entropy increase in the accessible space was very literally determined by the actual physical terrain.

While it is perilous to generalize, it is possible to discern a pattern to the phase changes, which we hope tells us something about the typical forms of the terrain. Arguably, each phase change in physical capability is accompanied by (and somewhat preceded by) a corresponding increase in informational capability:

Informational development	Physical development
Manual dexterity	Mousterian toolkit
Language	Agriculture
Writing	Civilization
Printing press, science	Industrial Revolution
Internet, AI	?

One striking aspect of the list is that each stage involved mastery of some self-replicating phenomenon: fire, crops, ideas, machine tools, and, we presume, ultimately programs.

It is difficult to attribute growth rates to many of these phenomena, but the penultimate pair has a compelling symmetry: with the introduction of the printing press and the acceptance of the scientific method, scientific publication shifted from a growth mode essentially the same as the existing overall economic one of about 0.1% to about 5%. Within a few centuries – very quickly on the timescales under discussion – physical economic output shifted into a 5% growth-rate mode.

The speculation that suggests itself is that the core of an idea-space valley affording a given growth mode is surrounded by a halo, which the frontier of the technium reaches first, of techniques by which information can be handled in the growth mode. The obvious inference is that current Moore's Law information technology growth will be completed by a revolution in physical capability that brings the rest of the economy up to a Moore's Law-like growth rate. We cannot say where this will stabilize; our $Q(t)$ fit indicates a growth rate of 100%, doubling time one year, around 2069.

A (very vague) Prognostication

Here is a revised list of milestones, with speculation on when they might occur:

1. Solomonoff's C and D, a program able to learn from the corpus of human-readable information, might well happen in the coming decade, although it would not be too surprising if it happened in the 2020s instead.

2. Convincing evidence of the economic productivity of 1. causes capital to flow into AI in a manner similar to the build-up of the internet in the 1990s.

3. Within a decade, programs have been constructed and educated to the point of being productive scientists, engineers, doctors, lawyers, accountants, etc. Investment in these is in proportion for the demand for them in the overall economy.

4. A Moore's Law-like trend in physical manufacturing, already visible today in technologies like rapid prototyping, produces by 2030 or so a capability for Moore's Law-like growth rates in physical capital formation.

5. AI inventors and designers are necessary – and sufficient – to find something useful to do with the capacity in 4.

6. The confluence of design and manufacturing capability in 5., and neither factor by itself, will make it possible for the economy as a whole to move into a 70% to 100% annual growth mode.

The key to natural language understanding has been known since Winograd's work [11] in the 1970s. With a deep semantic model – programs able to simulate, predict, and perform what is being talked about – just about any parsing method will work, albeit some more efficiently than others. The "road not taken" in AI was to combine this insight with machine learning and automatic programming into a system which could use linguistic context to formulate learning problems at the frontier of its knowledge, e.g. picking up the meaning of new words from context, that were small enough to be tractable to the machine learning and automatic programming techniques.

Since that time, machine learning has acquired a substantial theoretical basis and an arsenal of powerful methods. Automatic programming has received less attention but computing power is now such that relatively primitive approaches such as genetic programming have achieved substantive results, e.g. patentable designs.

Meanwhile, interest in inferring information from text has burgeoned, along with the amount of text available on the Internet. The rapidly increasing amount of video available means that the primary human venue for learning new words – examples of their use in reference to objects and phenomena that can be independently seen and heard – is now a viable pathway to language acquisition. Progress in the field is such that an estimate of success within a decade is mildly optimistic but not outrageously so.

The single most important determiner of the economic growth rate is the productivity of capital: how long it takes a given unit of capital to produce an equivalent unit of product. Currently this is about 15 years, for a growth rate of 5%.

Moore's original observation had to do with shrinking transistors, making them not only more numerous and cheaper but faster as well. The same phenomenon holds for physical devices: physical production machinery with parts the size of current VLSI transistors (22 nm) could operate at megahertz mechanical frequencies [1], making them thousands of times faster than current machines at capital-replication tasks.

To sum up: the "Singularity" can best be thought of as the second half of the information technology revolution, extending it to most physical and intellectual work. Overall economic growth rates will shift from their current levels of roughly 5% to Moore's Law-like rates of 70% to 100%. The shift will probably take on the order of a decade (paralleling the growth of the internet), and probably fall somewhere in the 30s or 40s.

Reflections on Social Effects

If we built a system of 1,000 AIs, all running 1,000 times faster than biological humans and connected by appropriate communications networks, it would be difficult to avoid the impression that a hyperhuman intellect had been created. But it wouldn't, in principle, be able to understand anything that those humans couldn't have understood given enough centuries. In some sense, the point is moot: no individual can understand all that the scientific community knows, in any event. What happens in the future will become more and more fantastic, and understandable only in broad, vague generalities by current-day humans, whether done by AIs or flesh-and-blood humans. With AIs it may happen faster, but it will follow the same track. Given a graph of knowledge and capabilities as they would have increased in a purely human future, the one with AIs is the same, following the same valleys in idea space, but with the dates moved up.

The scientific community in some sense isn't composed of people, but of ideas. Human brains are a substrate, and AIs can be, if we are reasonably careful how we build them, a similar substrate. This is particularly obvious in the case of AIs which learn primarily from uptake of the cultural corpus. AIs will be composed entirely of human ideas, and everything they ever think of will be traceable back to us in direct line of memetic descent.

There is one proviso: a future in which we understand AI could well be different from one in which we don't understand it [2]. It seems possible that the knowledge of how to build a formal, mechanical system that nevertheless exhibits learning, adaptability, and common sense, could revolutionize the effectiveness of our corporate and political structures – whether we built physical robots or not.

We can only end by agreeing with Solomonoff's closing sentiment:

> What seems most certain is that the future of man – both scientific and social – will be far more exciting than the wildest eras of the past. ■

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Endnotes

1 Von Neumann and Good had earlier advanced informal models, and Asimov predicted "an Intellectual Revolution" by analogy to the Industrial Revolution.

2 The semiconductor industry in other regions, notably Asia/Pacific, has expanded considerably over the period.

3 US Bureau of the Census, Economic census numbers for semiconductor manufacturing sector (NIACS code 334413), economic census for 1992, 1997, 2002, and 2007. *cf*. http://factfinder.census.gov/home/saff/main.html?_lang=en. After correcting for correlation with the overall US economy, a null hypothesis of the steady state given cannot be rejected at a 95% confidence level.

4 Figures before 2000 from Ray Kurzweil, *The Singularity Is Near: When Humans Trenscend Biology*, New York: Viking, 2005. Figures from 2004 and 2011 from machines constructed by the author.

Singularity: How close?

By J Storrs Hall, Ph.D.
Institute for Molecular Manufacturing

This paper, *Further Reflections*, is a sentimental favorite of mine. It was written for the memorial conference in celebration of the life of Ray Solomonoff. Ray was a friend, but was also one of the deep original thinkers from the origins of AI some 50 years ago. He always took the big picture view. His key invention of algorithmic probability anticipated what we now call Kolmogorov complexity and machine learning. It provided a simple proof that a computer could learn anything, in the same sense that Claude Shannon's information theory showed that bits could represent anything – one of the great conceptual revolutions of the 20th century. His analysis of John von Neumann's and I. J. Good's "intelligence explosion" idea, in the original Reflections paper of which mine was an echo, was a keystone in the development of that line of thought, leading to what Vernor Vinge labelled the Singularity.

Why should you, as a fan and possible participant of cryonics, care about this? There are two somewhat separable reasons: first, the shape of Singularity or whatever hyperbolic orbit we may take around it makes a huge difference to what kind of future you may wake up in. But more importantly, it has a huge impact on when it might become feasible to revive a suspendee.

Let us take Ray's accustomed big-picture view. The problem of revitalizing a frozen body is, from the point of view of nanotech, simply one of rearranging atoms. That splits the problem into parts: we need the tools to examine and move atoms, and we need the knowledge to know where to put them. Then we need the skills and attention to detail to actually do it.

How many atoms are there in a human body? A very cursory estimate would be $6x10^{27}$, ie. 10,000 times Avogadro's number. Suppose you need to make a decision for each atom and you can make one decision per second, but suppose we can automate 99.99% of the process. Divide by seconds in a working year and the number of people in the human race, whom we will assume have all volunteered to help. You still need 10 million years to do one revival. Even if we increase automation to 15 instead of 4 nines of completeness, you still have a project the size of Apollo, which took 300,000 of our best and brightest 10 years.

Obviously we are going to need some help. An intelligence explosion might be just the thing.

The question of the relative roles of nanotechnology and AI in forging the shape of the future has been a perennial one in techno-futurist circles for decades. Eric Drexler mentioned AI as a potentially disruptive technology in *Engines of Creation*, and it was discussed at the very first Foresight Conference 30 years ago.

It is generally assumed that a self-improving super-human level of AI is part and parcel of the Singularity. But let's assume, for the sake of a scenario, that self-improving AI is just a lot harder than we think, and that we aren't going to invent it until well after we have flat-out molecular nanotech with the ability to build fast self-replicating diamondoid nanomachines. What then? We still need someone to drive all those machines.

By the way, Ray never assumed in his original paper that there would be one single giant super-AI. His model fits just as well with a community of human-level ones. Indeed it implicitly assumes that the artificial research community works alongside the human one for a time.

One thing Drexler predicted in Engines was that without needing to create true human-level intelligence, automated design systems – narrow as opposed to general AI – would enable the creation of highly complex nanosystems, well beyond the capabilities of mere human designers. How did that prediction pan out? I would have to say that it was so accurate, and happened so soon, that it's taken for granted today – human designers with only pencil and paper would have no chance of designing, say, a modern computer, or indeed any of today's complex engineered systems. Design automation is one of many fields that was once considered ground-breaking AI but today is merely taken for granted.

Back at the seminal AGI Roadmap working group meetings a decade or two ago, the question came up in the form of a test or yardstick for a "true" AGI. Here are the opposing viewpoints:

- **Pro:** The Artificial Scientist Test: Almost every human can't do this. Are you suggesting that most humans don't have human-level intelligence?? (None of us has gotten a Nobel Prize!) It is important to set the bar at a reasonable level. For example, an IQ of 85, say, should be good enough to have human-level intelligence. We needn't set the bar at the genius level!
- **Con:** This can be a touchy subject. I think that a lot of people in our field aim for an AI that is at least capable of AI programming.

Personally, I think that Pro is putting the bar too low: an AI that could only score 85 on an IQ test would almost certainly fall short of human-level intelligence, because an AI is likely to be better at the kind of abstract symbolic manipulation that IQ tests measure than humans are, compared to its other abilities. IQ tests will have to be recalibrated, and possibly re-written entirely, to give an accurate measure of artificial intelligence.

On the other hand, Con is surely putting it too high. Only people at the IQ 140 (or so) level are typically capable of writing the kinds of AI programs we have now; and nobody has written one – so far – that is actually successful in capturing human intelligence.

It is clear that these descriptions bracket the level of intelligence and competence that the average human actually has. There are two things about having AIs at that level that will be critical in shaping the future when human-level AI is achieved.

First, AIs will be able to do the jobs that average humans do, and in general do them better. Better because of special additions: AI taxi drivers will have built-in GPSs; AI accountants built-in calculators; AI librarians built-in Google access. Better because they will work 24/7, not get tired or sick, not make mistakes, not lose their patience. And most importantly in an economic sense, better because they will get cheaper along a Moore's Law curve. AIs like this will clearly revolutionize the economy, and that's key to our question here. In addition to the raw ability to manipulate atoms, in order to do revivals we need the ability to manipulate anything in quantities that are astronomically beyond what our entire economy can do now. But a Moore's Law improvement rate in AI/nanotech/robotics could give us that capability inside a century.

But, secondly, what they won't do is improve themselves at an accelerating rate. An average human is incapable of that, and an average human-level AI, while being a perfectly good policeman or tax accountant, will not be able to any more than a human policeman or tax accountant would be. They will improve themselves the way humans do, by practice, study, and exchanging information, albeit probably somewhat faster than humans do this.

So we can build a world full of human-level AIs, capable of completely revolutionizing the economy and giving all humans a lifelong vacation/retirement, without ever building one capable of "recursive self-improvement" or turning itself into a superintelligence overnight. This is good, because in my at least somewhat-educated guess, the recursive self-improvement superintelligence model is wrong, based on analogies rather than reality. AIs will join, augment, and ultimately power, human culture and science; it is science as a whole that is self-improving.

What does a Singularity look like with just nanotech and human-level AI? Let's consider the standard list of transhumanist concerns:

- **Life extension:** playing around with the interiors of our cells and so forth is clearly a nanotech application. Uploading, cryonic revival, or radical body improvement is the same.

- **AI:** perhaps we get AI by uploading, doing lots of neuroscience, and understanding how the brain works. Perhaps the current AI boom maxes out at something like human level. We get human-level AI but not super-intelligent ones. We do ultimately get faster ones, but our uploads can be faster too.

- **Personal nanofactories and ubiquitous wealth:** nanofactories wouldn't be quite as powerful without a superintelligence to drive them – they could only make what someone invented and designed, rather than inventing things themselves. But that would be enough to kick the entire physical economy over into a Moore's Law-like growth mode, eradicating hunger and poverty in about 11 weeks.

- **Robots:** robots with up to human mental capabilities and virtually any physical capabilities would be straightforward, and would rapidly become affordable for everyone.

- **Flying cars, space travel, ocean and space colonization:** again, these are clearly nanotech applications. The modifications to the standard human body necessary to thrive in space require significant nanotech capabilities.

All of these areas require more scientific knowledge than we have now, but not more than the current rate of scientific progress is likely to produce – using just the human scientists we have now – in the next few decades. The current techniques of narrow AI are capable of automating pretty much any well-defined task, albeit with more programming effort than would be necessary if the machine could learn all by itself.

One of the things that a nanotech revolution, with its Moore's Law rates of increasing capability and reducing costs for really high-tech physical equipment, could do is to make scientific instrumentation more and more available. Existing efforts toward open-source science would be enhanced and given more headroom. The scientific knowledge, ingenuity, and experience necessary for the full utilization of the physical capabilities of nanotech could grow as rapidly as the Internet and cell phone use has over the past couple of decades.

So, back to the present: I don't really expect AI to lag nanotech as much as this analysis suggests; at current rates of progress, I think it will precede it. But even if AI were to stall at roughly human level of capability, something like a Singularity, a reprise of the Industrial Revolution that boosts our civilization from terrestrial to solar, making us all long-lived, healthy, wealthy, and maybe a little bit wiser, is not only possible but very likely. ■

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"Society's failure to take cryonics seriously is a tragedy that is probably costing countless lives. Alcor, notably via its magazine, is leading the fight to change that."
– Aubrey de Grey, Ph.D.
Biomedical Gerontologist and Chief Science Officer of the SENS Research Foundation

"Alcor appears to be the leading organization in the application of cryonics in medicine. I'm proud to be a part of this effort."
– Michael D. West, Ph.D.
Stem Cell Scientist and Chief Executive Officer of BioTime, Inc.

FOR THE RECORD

Cryonics Newsletters: Some Historical Highlights, Part 4a, Cryonics Society of Michigan, 1970-72

By R. Michael Perry, Ph.D.

For part 4 of our multipart series on cryonics newsletters we look at the Cryonics Society of Michigan. Their newsletter, first simply titled *Cryonics Society of Michigan Newsletter*, started in January 1970. With the third issue, March 1970, the title changed to *The Outlook*, where it remained through February 1976. All issues during this time were letter-sized pages with upper-left corner stapling. With the March 1976 issue, the title changed to *The Immortalist*, where it remained until Nov.-Dec. 2006, when it became *Long Life* magazine, where it continues today. Now in its 50th year, the publication has enjoyed a record "long life" of its own among cryonics periodicals. Such a long history is a lot of ground to cover, and part 4 of our series is limited to the first few years, extending only through the issues of *The Outlook*. That in turn, though, is still a bit much for one article, so again the coverage is subdivided. The present installment, 4a, will cover the issues of the first three years 1970-72, with 4b reserved for the remainder of the *Outlook* issues, extending into 1976. Lengthy quotations here are in `(condensed)courier new` font. Ellipses, indicating material omitted, are of two sorts. Those in the original are indicated by the usual three dots ..., while omissions by editorial decision of what was originally present have the dots in square brackets [...]. Otherwise square brackets are used for the usual editorial insertions. In one instance there is an editorial insertion in the original, enclosed in slanting square brackets which the typist, working with a keyboard that lacked these characters, simulated with overstrikes of slashes and raised and lowered hyphens. This in turn is here approximated in italics square brackets in courier new font: *[]* and should be distinct from insertions by the writer. Spelling corrections in a few places have been silently made, notably in the case of variant, incorrect spellings of proper names.

Cryonics newsletters are important for the history they record with the lessons it teaches, granted the inevitable imperfections as in any human endeavor. In the time period covered here, the primitive cryonics movement would experience some of its greatest challenges. From its optimistic sendoff in the 1960s, the movement would falter in the first half of the following decade as freezings were abandoned to burial and few additional among the dying were preserved. Through this troubled time the CSM publication bravely continued, doggedly supported by Robert Ettinger and others determined to make cryonics succeed, and in the process, relating a history we would do well to study.

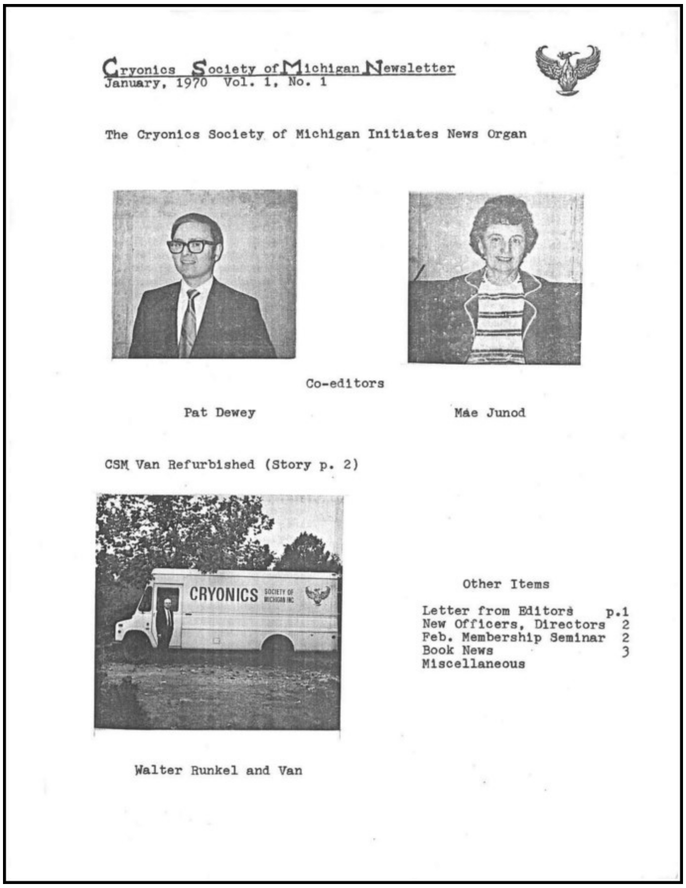
Startup

CSM was founded in October 1966 with Robert C. W. Ettinger, the principal founder of the cryonics movement, as president.[1] For a few years CSM had no newsletter of its own. The two leading cryonics publications of the time were *Freeze-Wait-Reanimate* of the Life Extension Society in Washington, D.C., and *Cryonics Reports* of the Cryonics Society of New York (title changed 1970 to *Immortality*). By 1970 some major changes had occurred or were about to occur. The LES publication would cease with the September 1969 issue. CSNY's newsletter would similarly end with Spring 1971. The Cryonics Society of California (CSC) was also producing newsletters, but by 1972 these too had virtually ceased.[2] The appearance in 1970 of the CSM newsletter was timely, though no particular concern is voiced early on; cryonics seemed vigorous and progressing, with a conference upcoming in May, and numerous activities to report.

The first issue of the newsletter opens with an article "from the editors," who in this case were Patrick Dewey and Mae Junod (later Mrs. Robert Ettinger), encouraging readers to take part in the new endeavor:[3]

`As co-editors of the Newsletter we want you to know that this is not only a source of news related to CSM but an opportunity as well to express your views and to add anything you think would lend interest or information to these pages. We will appreciate suggestions, interesting items we may have missed in other publications, humor, poetry, tales, anything and everything that might both stimulate and inform our readers.`

`As for goals: we regard this organ as a force to promote greater commitment and involvement on the part of members as well as a promotional instrument to interest non-members and induce them to join us in our efforts to bring about the establishment of cryonic interment as one of the predominant ways of modern life. Essentially the most important aspect of this entire endeavor is you. You are a part of the total effort. So don't leave us off in a corner toiling away with pencil and paper. Give us of your inspiration, your knowledge and your creativity.`



Cryonics Society of Michigan Newsletter
January, 1970 Vol. 1, No. 1

The Cryonics Society of Michigan Initiates News Organ

Co-editors

Pat Dewey

Mae Junod

CSM Van Refurbished (Story p. 2)

Walter Runkel and Van

Other Items

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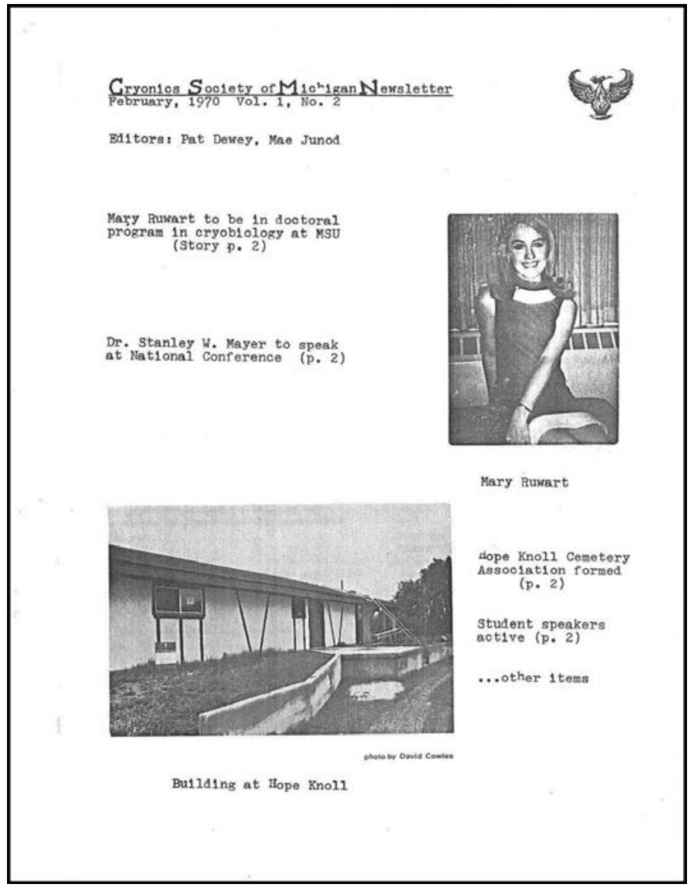
First issue of the CSM newsletter, cover page, showing co-editors Pat Dewey and Mae Junod.



Cryonics Society of Michigan Newsletter
February, 1970 Vol. 1, No. 2

Editors: Pat Dewey, Mae Junod

Mary Ruwart to be in doctoral program in cryobiology at MSU (Story p. 2)

Dr. Stanley W. Mayer to speak at National Conference (p. 2)

Mary Ruwart

Hope Knoll Cemetery Association formed (p. 2)

Student speakers active (p. 2)

...other items

photo by David Cowles

Building at Hope Knoll

Second issue cover of the CSM newsletter features Mary Ruwart, who showed interest early in cryonics and eventually became prominent in the libertarian movement. Also shown is Joe Cannon's "Hope Knoll" facility in Wisconsin, a brave if unsuccessful attempt to establish a cryonics service in that state.

The rest of the issue is taken up with such matters as the recent refurbishing of the CSM Rescue Van, the recent election of officers and directors of the CSM, arranging for speakers at your desired location, and recommended books. Robert Ettinger receives special notice for his speaking activities in his home state and is said to stand "second only to [civil rights leader] Julian Bond in the minds and hearts of Michigan community college students. At least that is what a recent survey revealed when students indicated preferred speakers for the Association of Community Colleges of Michigan."

Mary Ruwart

The second issue features a young Mary Ruwart on the cover and reports on her activities as a student in cryobiology:[4]

MARY RUWART IN DOCTORAL PROGRAM

Mary Ruwart, who has been a member of CSM since September of 1969, is planning to embark upon a doctoral program in cryobiology at Michigan State University (where she is now a student) either this summer or fall. She will be working at first in the broad field of biophysics under Dr. E. M. Eisenstein, but will eventually work under some other person in the more specific field of cryobiology related to cryoprotection.

One of the big roadblocks in development of the cryonics program is the lack of full knowledge about effective cryoprotective methods. Complete control of damaging cell reactions to freezing has not yet been accomplished. It is in some aspect of this area that Mary will eventually specialize.

She reports that there is at present no Cryonics Club at Michigan State and she has encountered some hostility to the concept. She hopes to initiate a club at some future time. Her efforts in the scientific field will undoubtedly make those in the social field easier.

(Ms. Ruwart went on to become prominent in the libertarian movement, and was a presidential contender in 2008, losing in the primary to Bob Barr.[5] But, we wonder, is she still interested in cryonics?)

Also noted in this second issue are the efforts of one activist to establish a cryonics operation in Minnesota:[6]

Joe Cannon tells us that on January 13 the Hope Knoll Cryogenic Cemetery Association was formed, with nine trustees, in Wisconsin. This is the first cemetery association in the world formally incorporated for this purpose. (The California and New York facilities are portions of previously existing cemeteries). The building, near Appleton, has yet to be approved for vault use.

(This brave attempt would later have to be abandoned, in large part because of a hostile regulatory environment in the state of Wisconsin. Joe Cannon eventually became an Alcor member, along with his wife, Theresa; both are now patients at Alcor.[7])

Name Change; "No Party Line"

The third issue (March 1970) reports a change of title. Henceforth the newsletter becomes *The Outlook*, a title it would keep until further change to *The Immortalist* in March 1976. A short note near the beginning announces some new policies:[8]

The scope of the news organ has been expanded to include world wide as well as local news, and in line with this expanded coverage the content is being changed from less to more formal. The editorial staff has been enlarged and now includes Robert Ettinger.

It is felt that the new format and style will be better suited to general readership. Two copies will be sent to each CSM member, along with brochures. It is urged that the extra copy, and brochure, be given to someone who might join the Society or provide some other type of help or cooperation.

The editors intend to work for continuous improvement and have a number of interesting projects for future development.

Submissions for possible publication are welcome.

In this issue there is an interesting, short editorial by the new staff member, Robert Ettinger, with good-natured criticism of the recently-expressed views of another prominent cryonicist, here quoted in full:[9]

NO PARTY LINE

In the January issue of the Cryonics Society of New York newsletter there is an article by Saul Kent dealing with a certain religious conference and religious questions. Saul saw fit to attribute to "cryonics" certain views that not all of us possess, and to make statements of a very dubious kind.

Among other things, he said, "Cryonics has grown out of the realization that death ends all meaning, and that the continuity of consciousness is essential to existence. ...Life after death is an impossibility and any line of thought that accepts death is nihilistic."

In fact, these views are not shared by everyone in cryonics. Nicholas DeBlasio, for example, who froze his wife, Ann, is a devout Christian and would not have proceeded if his priest and bishop had not approved. Furthermore, the "impossibility" of life after death has not been proven; it is at most, for the scientist, a tentative conclusion. These questions are extremely subtle and complex, and to be dogmatic--on either side--is unreasonable.

Even disregarding religion entirely, there are many ways in which one might conceivably live after total destruction of the body. For example, according to one school of thought, information is never irretrievable, and in some distant future it might be possible to reconstitute an individual's personality, and thus --they say--the individual. Again, it is conceivable that mind is not just an aspect of brain; possibly there is a material, although very elusive "soul", which might bear the same relation to the body, in very rough analogy, that the neutrino bears to the neutron. It took a long time, remember, for the existence of the hypothetical neutrino to be experimentally verified, and many scientists thought there was no such thing.

Since these questions remain open, we should not be dogmatic, and we should not gratuitously offend religious people who might otherwise join with us. It is not necessary that everyone in cryonics have "religious fervor". We do not demand total allegiance, and we do not make people toe any ideological line. Our success to date--modest though it is--has been based on a balanced, reasonable, non-dogmatic, non-fanatic approach.

Of course, tactics are debatable. Many organizations and movements have had considerable success based on conviction amounting to dogmatism and zeal amounting to fanaticism. Perhaps one perfervid worker is better than a dozen lazy, though friendly, kibitzers. But I see no evidence that this approach would work for cryonics, even if we were cynical enough to adopt it.

In cryonics there is no dogma and no heresy. Like the Republican and Democratic parties, in our house are many mansions. We are practical people, cooperating for a practical purpose--to save and extend our lives. We are not opposed to philosophical discussions--far from it--but no one can establish cryonics orthodoxy.

“Freeze the Living”

In April 1970 there is another interesting Ettinger editorial, “Freeze the Living?,” dealing with the prospect of premortem cryopreservation.[10] Ettinger notes that by cryopreserving “only those whose death certificates have been signed, we have escaped most legal problems and we have set up a kind of Pascal’s wager, a situation in which here is nothing to lose, physically, since a failure merely means that the patient remains dead.” Nevertheless, he continues, “we have lost many potential advantages which may be crucial to the cryonics program.” For example, a terminal illness could be better addressed before nature runs its full course, and better preparations would be feasible for a predictable chain of events. (Otherwise it can be very difficult to guess when cardiac arrest is likely to occur, and much time and resources can be wasted on false alarms.)

Noting that starting cryopreservation before legal death “would raise serious problems, both in law and public relations,” Ettinger nonetheless is optimistic that “these may not be as formidable as we have assumed.” Suda’s cat brains “showed nearly normal brain wave tracings when thawed after several months in frozen storage. Since experts believe brain waves represent the best single criterion of life, we could make a fairly good case for saying that these cats survived freezing and thawing, and that human patients similarly frozen might also remain alive.” So “it is not certain that freezing with present techniques is lethal, even by present standards.” Ettinger notes that heart transplants, which by then were legal and accepted by the medical mainstream, nonetheless were far from a guaranteed success. Might premortem cryopreservation be treated in a similar way, as a possible route to survival and recovery, even though success is uncertain? To summarize some main points:

There are many secondary benefits in freezing the terminally ill, both to the patient and the program. Much suffering could be avoided, and much expense; the money needed to prolong the agony of dying could be applied, instead toward freezing. There would be tremendous psychological advantage in “treating the ill” rather than “scavenging the dead”. “Suspended animation” is enormously more appealing than “cryogenic interment”. And while it would open a new legal can of worms, there are great potential advantages in not having to treat the patients as corpses.

Ettinger concludes by suggesting a legal judgment be sought granting permission for premortem freezing “under certain specified conditions”. (Nearly half a century later, no such permission has been granted and cryopreserved patients are still considered legally dead, though progress in choosing “death with dignity” continues.)

1970 Conference

The June 1970 *Outlook* devotes several pages to the cryonics conference held the previous month, starting with a summary by Ettinger:[11]

The Third Annual National Cryonics Conference--May 15 and 16 in Los Angeles--was stimulating, enjoyable and productive, with a good mix of scientific papers, cryonics polemics, interpretation, and entertainment. All this was topped off on Sunday, May 17, by a visit to the permanent storage facility of Cryonic Interment, Inc. in a cemetery [near Los Angeles].

CSM representatives included Conley Hall, John Erfurt, Robert Ettinger, George Lantos (now a student at Cal. Tech.), and Neil Lucas (now an Air Force test pilot in California).

Other delegations from out of town included John Bull and family from New York; Mr. and Mrs. Loren Fitzgerald from San Diego; Mr. and Mrs. Joseph Cannon from Appleton, Wisconsin; Dr. M. Coleman Harris, Roy Yates, Ashley Hendrix, Michele Navarette, Jerry White and Art Quaife from San Francisco; and a number of speakers.

At one of the informal gatherings during the week-end, it was proposed by Dr. Harris, and tentatively approved by the others present (subject to ratification by the directors of the various Cryonics Societies) that the Fourth Annual Cryonics Conference and Scientific Congress would be held in San Francisco, perhaps the first week-end of May, 1971.

At the Friday evening banquet there was professional entertainment by the television comedy team of Clair and McMahon, and by countrymusic singer and composer Dorsey Burnette.

Dick Clair (actually Richard Jones) has been a long-time member of the Cryonics Society of California, and a tireless worker for cryonics. Mr. Burnette recently joined CSC. One of his songs, “Suspended Animation”, delighted the audience. (We have a copy of the record. The song may be used in the film version of Robert Nelson’s and Sandra Stanley’s book, We Froze the First Man.)

The conference was concluded late Saturday afternoon. [...]

Ettinger’s article continues with summaries of the main presentations at the conference; prominence is given to the talk of Dr. Peter Gouras who describes his work in restoring functionality to neural tissue after long ischemia:[12]

Among other things Dr. Gouras' work shows that the cat retina--a part of the central nervous system, an extension of the brain--even though an extremely sensitive and rapidly metabolizing subsystem is much hardier than previously thought; it can stand at least one hour without blood supply (ischemia). [...] Dr. Gouras--who is a research physician at the National Institutes of Health and a member of the Scientific Advisory Council, CSA [Cryonics Societies of America]--reminded us that almost every scientist and physician has believed that 10 minutes of ischemia means irreversible damage to the mammalian brain and ultimate death. Now we see this was a myth.

Among the other speakers mentioned is mortician Joseph Klockgether, who would work on many cryonics cases over a long career, including some with Alcor, and whose talk has survived (to be included in a future issue).

Joseph Klockgether speaks at the 1970 Cryonics Conference

Mildred Harris Case

In September 1970 there was a cryopreservation, reported at some length by Ettinger in the October issue:[13]

MRS. MILDRED HARRIS

Mrs. Mildred Harris, the first patient to be frozen in Iowa, "died", Sunday, Sep. 20 in Des Moines, creating another emergency situation and emphasizing some old lessons.

Mrs. Harris' sons, Terry and Dennis, had been in touch with the Cryonics Societies of New York, Michigan, and California for about a week. I had warned them immediately that, in our experience, death almost always comes sooner than expected, often much sooner. (Mrs. Harris was terminally ill with bone cancer.) Arrangements were under way; Mrs. Harris had signed legal documents including a codicil to her will, in the presence of her attorney, and Robert F. Nelson had arrived in Des Moines Friday, representing CSC and Cryonic Interment, Inc., with whom the Harris family had decided to make their arrangements. But on Sunday Mrs. Harris began sinking rapidly--even though several weeks more had been predicted by her physician--and the physical arrangements were incomplete, with no perfusion chemicals on hand.

Bob Nelson called me from Des Moines about 11:00 A.M. to report this, and to ask if we could send the chemicals CSM had on hand--DMSO and Ringer's solution. It turned out that air freight was not available until the next day, so I agreed to fly there myself and bring the chemicals as baggage.

While preparations were being made, the call came that Mrs. Harris had died, and had been immediately packed in ice. (She died at home, and the registered nurse in attendance was given permission to make the determination of death; apparently the physician can delegate this authority in appropriate situations, at least in Iowa.)

Walter Runkel and family had pitched in with their usual reliability and efficiency, and packed most of the chemicals in six suitcases. By 4:00 P.M. I was on the way, and arrived in Des Moines about 8:00. Last to arrive was Joseph Klockgether of the Renaker Mortuary in Buena Park, California, one of the two most experienced men in cryonic perfusion. The perfusion was done by him, with the help of Mr. Nelson and myself, taking most of the night. By about 4:00 A.M. the patient was packed in dry ice. This was in the embalming room of Arnold's Highland Park Funeral Home, with the cooperation of its director, Mr. Robert Major.

On Monday there was a funeral service, with the casket closed to protect the patient against warmth and to avoid upsetting relatives. Several relatives were strongly opposed to cryonic suspension, and the sons, Terry and Dennis, had to cope with them in trying circumstances including great fatigue, since they and Bob Nelson had had little sleep for three days while they tried to complete the arrangements. But the sons held firm, speaking patiently and reasonably with the relatives; and they had the backing of Mrs. Harris' attorney that this was indeed her wish. (She had not mentioned it to any relatives but her sons, thinking to spare them disturbance.) In a letter dated two days later, I am glad to say, Terry Harris tells me that some of the relatives have become more understanding and sympathetic.

Tuesday morning the patient was sent to California, where she is being kept in the facility of Cryonic Interment, Inc. in a cemetery near Los Angeles. At a press conference that morning--to which the Harris sons had agreed to help further the program--information was given to the Des Moines Tribune and the Des Moines Register, which ran extensive and generally objective articles, although many of the usual inaccuracies were present. There was also an Associated Press story on the wires.

Among the lessons to be learned by the general public from this case, and by Society members, is the very simple but still largely ignored one of advance preparation. Mrs. Harris had known of cryonics for some time, but no steps had been taken until it was clear she was dying; fortunately, she and her sons were strong enough to carry it off under these circumstances, but most people are not.

Among lessons to be learned by the leaders of the Societies are several technical ones involving preparation and perfusion, most of which cannot be detailed here. But it is clear, for example, that we should have at least enough chemicals for one perfusion always packed and ready for air shipment. This is not easy, even in terms of expense, but we should soon have this, in addition to our local stand-by stock.

At any rate, another potential immortal is waiting her chance, and we salute her courage and her sons', as well as the skill and strength, demonstrated yet again, of Bob Nelson and Joe Klockgether. On another pleasant note, we hear that Terry and Dennis Harris may organize a Cryonics Society in Des Moines. Much success!

(Unfortunately, a few years later, with funds running low, Mildred Harris would be among those lost at the facility in Chatsworth, California.[14])

Scientific Reasons for Optimism

The next issue (November 1970) has an interesting editorial by Ettinger where he reports on some recent speculations in physics involving the Everett many-worlds formulation of quantum mechanics. According to this thinking, our reality is constantly splitting so that near-copies of ourselves experience different possible event sequences. While saying the theory is "probably wrong," Ettinger notes that reality is mind-boggling and incredible in its vastness, whatever theories might apply, and finds the thought not at all unsettling but comforting:[15]

For the cryonicist, an old lesson is reinforced, a lesson left implicit (and probably unrecognized) by Shakespeare, when he said, "There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy," and by J.B.S. Haldane when he said, "The world is not only queerer than we realize, but queerer than we can realize." It is simply that, if there are so many things, and if the world is so queer, then opportunity is multiplied, and the apparent traps of destiny and doom are illusions. In all this strangeness, in all this confused complexity, surely there is room for us to live and grow--indefinitely.

Cryonics Humor

Cryonics is a serious enough subject, and a bit of humor now and then is a welcome relief. The following is excerpted from "25 REASONS WHY YOU SHOULD NOT BE FROZEN" by Editor Patrick R. Dewey, in the January 1971 issue. (In the interests of readability, I've added bullets • and omitted ellipses [...] in this reformatting of the original (also used the times typeface).)[16]

- It costs money, which your relatives could use to buy a yacht.
- It might not work.
- Someone might drop your frozen body, with shattering consequences.
- You might be taken for a Popsicle.
- Your neighbors might think you're frigid.
- You've already done and seen everything, so why come back?
- It hasn't been approved by the AMA.
- You haven't yet seen anybody who's been frozen, and revived, and rejuvenated, and lived forever.
- It isn't natural like TV and cars.
- You could use your insurance premiums for something important, like booze.
- You heard a rumor it's a racket, so it's better to play safe and spend the money on a bronze conventional casket and a mountain of lilies.
- When you're revived, you might crowd somebody.

- It will put trocar manufacturers out of business.
- The world will end next week (or at least by the first Monday of next month).

The following month (February 1971) there is also a funny piece by Mae Junod, about how the media do not always treat cryonics fairly, but sometimes the results are a good belly laugh anyway. "FRENCH COMIC EPIC" starts off with Bob Ettinger in January receiving a telegram from Paris with a message in French but translating proved to be too much for Ettinger and family so they had to judge for themselves what was coming. Meanwhile a package has arrived at the Metropolitan Airport in Chicago. After paying $123.70 in customs charges for three large caps of film and an additional $17.00 to transfer the film to a format viewable on available equipment, Ettinger invited Mae to join him in watching it. The film, it turned out, had been made the previous June (1970) by Claude Otzenberger for the French Television System.[17]

[At this time] Otzenberger and crew visited Bob Nelson and other CSC members in California, Curt Henderson and his group in New York, and Bob in Michigan. Shots were taken of the van and Walter Runkel and a visit to Joe Oskin's home was made as well.

[...]

We had received very bad reports on the film, which was run on French television sometime in July. Anatole Dolinoff [a French cryonics activist] has been thinking seriously of suing Otzenberger. So we expected something derogatory, but nothing as devastating as the films we viewed. The most difficult aspect is the subtlety with which the cryonics concept and movement is denigrated.

Personally I would like to get in on the suing. On the other hand, I have never seen anything any funnier than Curt Henderson in his little white truck scurrying to and fro with three dewars of liquid nitrogen standing upright in the open bed of the truck.

The film is the greatest comedy since silent films. It has a Mack Sennett quality about it that has to be intentional. The effect was achieved by the way shots were interspersed more than anything else. For instance, there is an interesting sequence where Walter and Bob rush up (to Walter's house) in the van, leap out and quickly wrestle a wheeled stretcher out of the back. They double time to the door of the house and disappear inside.

Shortly they hurry out with a body (Walter's daughter) under a blanket and stow her in the van then take off in an unseen cloud of exhaust vapor. The van scuds down the road with as much vigor as Curt's truck.

Now that we were all hepped up to see what happens next we were suddenly presented with Dorsey Burnette singing "Suspended Animation" in all its twangy folksiness.

Then Curt's truck speeded across the scene (for about the third time). Next we are pulling up to what looks like a garage mortuary and Fred Horn raises the overhead door. We advance with the camera and Curt, Diane and Fred (in a white coat) go to work on the patient.

One of the most damaging parts of the film is the music. It is weird; and an adenoidal chanter, either a deep voiced woman or a tenor male, keeps intoning at the most inopportune moments--and most lugubriously, in English:

LORD HAVE MERCY! LORD HAVE MERCY! CHRIST HAVE MERCY!

I laughed so hard I had tears in my eyes. (This coupled with an incipient cold caused me to somewhat deplete Bob's supply of tissues).

It's a shame to ruin this masterpiece of comic editing. However--to show it anywhere to the public would be to denigrate an honest and sincere effort on the part of many people who were genuinely courteous and cooperative as well as hospitable to Otzenberger, et al.

In my opinion Otzenberger is a nasty man. He took unfair advantage of people who trusted him. But revenge cannot be ours. All we can do is re-edit the film and put the parts back into context in the way they were intended. We should be able to salvage perhaps as much as a half hour of good action shots--maybe less. (Not Bob Nelson climbing up the ladder from the Cryonic Interment vault and telling his son, John, to hold the ladder because he slipped once before when there was no one to hold it, or Curt's bomb shelter, or Bob's basement desk, which looks like after the bomb).

However, before we take apart this epic I believe all the directors of CSM should have the opportunity to view the film as it was received from Otzenberger. Such titillation of the risibilities should not be denied them in this grim age. The problems are finding a convenient projector and a place to use it. Any suggestions?

"For a Better Tomorrow"

In the March 1971 issue, a reader, York Porter, offers advice on how to strengthen the cryonics movement and present a better image to the public:[18]

FOR A BETTER TOMORROW

To the editors:

I have for some time been an interested reader of THE OUTLOOK and find that my interest has led to the desire to express some opinions.

I feel strongly that the cryonics societies of America must bind together, work together and grow strong together. I think this can be most effectively accomplished through the medium of a national newsletter, one highly organized and widely distributed, not only to subscribing members but to newsstands and to people in general at a non-profit price. Perhaps a few introductory or "feeler" issues would increase awareness.

The point I wish to make is that to gain the support of the people we must first reach them, not as a commercial effort but in a person to person rapport. We must present our arguments in as logical a way as possible and then we must get people to realize (as we must realize ourselves) that in order to succeed we need their personal involvement, their time and their talents. I do not feel that such phrases and terms as the following will accomplish such invo1vement:

"the average citizen who doesn't even have the prudence to save his money against an uncertain future...." (THE OUTLOOK, Dec., 1970, p.7)

"the mindless masses" (THE OUTLOOK, Jan., 1971, p.1.)

This is not the way to influence people to embrace cryonics. No one likes to think of himself as an "average citizen" or a member of "the mindless masses". Each person believes (and rightfully so) that he or she is unique, someone special in the world. It is to this sense of uniqueness that we should appeal.

In developing a national newsletter we must approach the questions of expense, control, sponsorship, etc. with an attitude of giving rather than taking. Perhaps a plan of proportional ownership and control would be the solution with financial support as the criterion.

In the December, 1970 issue of THE OUTLOOK Mr. Robert Ettinger asks the following questions on how we may influence people in favor of cryonic suspension:

"Precisely how do we convey a sense of reality? By what artistry do we make the citizen yearn to transcend his mortality and humanity? How do we translate superficial understanding to a passion? How do we make the worm perceive his lowliness, and strive to outgrow it?"

I think the answers to his questions have already been provided in a previous issue, that of July, 1970. In stating a new policy, the editorial board of THE OUTLOOK made the following statement:

"In examining the goals (and efforts to achieve them) of the cryonics movement, a salient fact has appeared: While some people are satisfied merely to hope that they will continue to live, through cryonics, many others need the reassurance of being able to look forward to an improved life in a better world." (Underlining my own.)

This statement hits the very crux of the matter; that is, the fact that the majority of people are not merely content to be told that cryonics is the key to an infinity of life span. Living is not enough in itself. They need to be reassured that the "tomorrow" that cryonics will bring holds something for them personally. It is not enough for them to read "In a simplified, representational sense, then, one may picture the Golden Age society in which every citizen owns a tremendous, intelligent machine which will scoop up earth, or air, or water, and spew forth whatever is desired, in any required amounts--whether caviar, gold bricks, hernia operations... ." (THE PROSPECT OF IMMORTALITY, MacFadden-Bartell edition, p. 100).

Such a view is too abstract and too far-removed from the "now" world to attract potential immortalists. It is not enough to speculate about "sports on the Moon". It is not enough to say, "Those of us who have committed our lives to the pursuit of immortality have seen before our eyes the stupidity, apathy, and incompetence of most of the world's people, and we have been amazed at the powerful irrational forces that motivate people." (THE OUTLOOK, December, 1970). We must offer the people of the world a logical, well planned alternative to the "today" that they are compelled to exist in.

In short, the cryonics societies of America must become not only an organization of scientifically based philosophy but it must be sociologically oriented as well. We must formulate and stand for a social philosophy that is as logical as our goal of immortality. In doing this we will further clarify the goals of the cryonics program and thereby give potential immortalists something concrete to grasp. In the words of Saul Kent:

"Ultimately the responsibility for our fate lies entirely in our own hands. If we are to be immortal, we must raise the money required for our purposes, discover new concepts and invent new machines; ...."

Discover new concepts, invent new machines, perhaps fight political battles; these are the challenges that stand before us. We must rise to meet them with new vigor. In this endeavor YOUR help and YOUR time and talents are needed. Each of us has something to contribute. Our destiny, our posterity and our immortality stand beckoning us. We live now, we work and we hope for a better tomorrow.

Editor Mae Junod responds:[19]

Mr. Porter certainly practices what he preaches. His interesting article, which was included as a communication to the editors, was accompanied by a contribution check of $5.00. There are over two million people in the United States. [Actually, over two hundred million by the 1970 Census--RMP.] It is fascinating to contemplate the wonders that could be achieved in cryonic research and perhaps even a national non-profit facility--to say nothing of a national newsletter--if even half the people in the United States sent in such contributions.

The editors also are pleased to hear from Mr. Porter and hope we will again--also from any others who would like to contribute of their talents to our pages.

There has been quite a bit of activity of late surrounding the matter of a national newsletter. The primary obstacle has been financial. No society has, at present, the means of financing such a venture, nor are many societies in a position to support a national newsletter along with organs already being published. This is true of CSM. We do not want to discontinue THE OUTLOOK, which now circulates on a national basis. We cannot support two publications. This is my view.

(Today York Porter is president of The Immortalist Society, a descendant of CSM, and editor-in-chief of their newsletter and *The Outlook's* current incarnation, *Long Life* magazine.[20])

Skeptical "Expert" Answered

The April 1971 issue has an interesting article, "A Biologist's Opinions," with skeptical comments interspersed with editorial commentary. Prof. Keith Wittenstrom, of the Biology Department at Oakland Community College, had mainly negative thoughts on cryonics, but pessimistic rather than unfriendly. He acknowledges that cryonics might work, though is doubtful about it, while urging that he has no desire himself "to live a thousand years." In the evolutionary process which created us, he notes, individuals are replaced by others rather than living indefinitely themselves. "Death to the individual is a fact of life" and over time things change. Bringing back someone or some creature from the past to a world they were not familiar with might be a cruel mistake.[21]

[...] Let's say that some Australopithecus had been frozen by some miracle and we revived him, I don't think he will overly enjoy his new environment. He's going to be structurally different and he's not going to be able to function the way the other organisms are functioning now. Structurally he'll have a smaller cranial capacity, his brain and behavioral patterns won't be so well developed. The poor guy is sitting there with possibly longer arms, different physique. I don't think that it's going to be that enjoyable.

To this the editors respond that in the future we expect to gain control of our biology and will be able to direct our own evolution to adapt to whatever conditions might be present. Moreover, the period of our cryopreservation should not be so long as that envisioned by Prof. Wittenstrom, far less in fact! Wittenstrom also questions whether people of the future would want to revive the cryopreserved.

What would be the impetus of people a thousand years from now for reviving you? If I had the chance to revive my great, great, great, great grandfather would I do it? Would I spend the money to revive him if I had to choose between him and having a daughter or a son? That's why I don't think it's practical. If you had four million people or so frozen I don't see why there would be any hope that people would choose to bring them back. Why bring back four million people? You'd cause problems in doing so. You'd have to house them, clothe them, cure them and everything else. I don't think they'd elect to bring you back.

The editorial response notes that anticipated revivals will not be haphazard or whimsical but by prior arrangement:

The "impetus" is that contracts will continue to be honored and every citizen's right to life upheld, we hope. The money is not out of the descendant's pocket, but the suspendee's trust fund. Population pressures will result much more from life extension than from cryonic suspension; and if, at a certain period, in history, there really isn't room for more people, the frozen can remain in storage until there is room, resulting from new discoveries or space colonization... And storage should not demand too much space. [...]

I would add that humanitarian concerns would demand that those who can be revived be revived, irrespective of whether "contracts" to do so are still in force, though having such contracts, as at present, is additional assurance. But if you can rescue someone from coma you do it, barring strong contraindications. Resources should become available in a world of greater abundance than we have today, so hopefully this problem will be a minor one at worst.

One of Prof. Wittenstrom's stated concerns is whether it would be appropriate, if we could do so, to revive a specimen of Australopithecus. It would be a stretch to think that such a creature would be frozen so long, awaiting rescue as it were, but more generally we can ask about nonhuman (non-*homo-sapiens*) sentient life forms. What should be our thinking and policies in the future regarding animals both domestic and wild, which are subject to our intervention in some way? Another article in the same (April 1971) issue, this by Robert Ettinger, addresses this matter, in a slightly humorous but still serious way.[22]

SUPERMAN AND THE LOWER ORDERS

If the cryonicist's optimism proves justified, there will be biological improvements for ourselves as well as our descendants, including expanded mental faculties. The future is not just one of better gadgetry (although we must never belittle gadgetry), but of different relations between people--and doubtless between people and the lower orders.

While some people feel that the absence of "soul" distinguishes the beast, it is clear that many of them have thoughts and feelings somewhat like our own. An ape can show courage, a dog can exhibit loyalty, and a bird can feel pain. Who has not occasionally felt uneasy about the misery we allow these creatures, or even inflict? Is anyone completely unaffected by the howling of a dog in a medical laboratory?

Most of us do not allow such qualms to disturb us much, or often; we simply can't afford it. We have other troubles, more urgent worries, and custom insulates us from too much sympathy. But is not this callousness a remnant of savagery? As our wealth and power increase, will we not be faced with the duty of strictly justifying everything we do, and everything we allow? Will not a humane ethic be required for our own mental health?

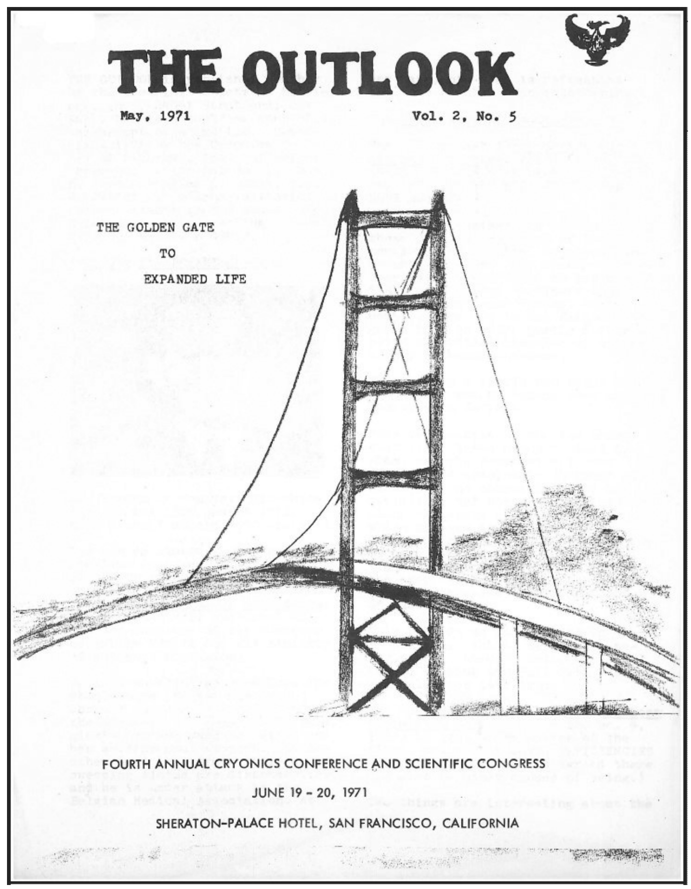
We can "justify" our treatment of the lower orders in any number of ways, e.g. by the ledger argument: since our cattle and sheep, say, are alive in the first place only because we breed and raise them, we are entitled to cut off their lives at any time. But we do not allow favors to humans to justify later abuse, and perhaps in 2287 some lawyer will successfully plead his case before the Supreme Court on behalf of his client, a pig, and win a permanent stay of execution, at which point we shall all be vegetarians, and the last ham sandwich will be enshrined in the Smithsonian Museum. (I refuse to look forward to the time when people start to worry about the feelings of spinach.)

There is also the matter of wild animals: can we forever wash our hands of their sufferings? Are we not our cousins' keepers? When we can afford it, shall we not have the obligation of imposing civilization on the remaining pythons, crocodiles and hyenas? And along this road, where can we stop? Must we, indeed, eventually join the Jains in holding all life sacred?

Or will the ultimate rationality dismiss all compassion as maudlin sentimentality, making a piker of Nietzsche? Surely no one can yet say; but the decisions will have to be made, and it is not too soon to start thinking about them. Abrupt transitions are painful.

Well, let's hope the suggested scenario of greater callousness does not materialize. Greater compassion, not less, should hallmark the future. When the relative cost of being compassionate goes down, as we may hope it will with the anticipated advances (a world of abundance in particular), the amount of compassion should naturally increase. Having more should make life more worthwhile and may be essential if our future civilization is to survive and thrive, and each individual achieve maximum benefit.

1971 Conference



May 1971 Outlook Cover Announces Upcoming Cryonics Conference

The exuberance and optimism that invigorated the early years of cryonics would continue through 1971. In June that year there was another cryonics conference, continuing a long tradition, by the standards of the fledgling movement. Ev Cooper's annual Life Extension Society conferences had started in 1963 and extended through 1968 with one omission; that same year the Cryonics Society of New York started the namesaked "Cryonics Conferences" which continued annually. 1971 would be the last year of this tradition, however. (After this there were no more cryonics-related conferences until Alcor's first conference, in 1978.)[23]

The 1971 conference was held in San Francisco, June 19-20, hosted by the Bay Area Cryonics Society (BACS, now American Cryonics Society, ACS). This is reported in the July *Outlook*, with later followup; Mae Junod offers an enthusiastic appraisal:[24]

FOURTH ANNUAL CRYONICS CONFERENCE INSPIRATIONAL

The Fourth Annual Cryonics Conference in San Francisco was one of the most inspiring experiences I have been lucky enough to encounter.

A sense of solidarity and an even greater awareness of really solid progress in the cryonics movement sent me away, as I'm sure they did others, with a feeling that at last we are on the brink of something prodigious, some simultaneous and enormous surge forward of events that will more than fulfill the hopes we have so long cherished that the future is indeed ours. Reports of and ideas for outstanding advances in perfusion techniques, perfusion equipment, public relations and graphic representation kept audiences intensely occupied.

Along with kudos to the excellent speakers and presentations should go great praise to the Program Committee: M. Coleman Harris, Chairman; Roy R. Yates, Co-Chairman; Ashley Hendrix, Photographer; Donna J. Allison, John Bear, Lucius Cooper, Judy Geiwitz, Fred K. Martin, Holly Martin, Michele Navarette, Art Quaife and Grace Talbot.

The timing and style of the entire production were impeccable.

It was a joy, as well, to meet again with friends encountered only seldom, but still warmly appreciated. There were members of cryonics societies from almost every state in the union. CSM members attending were: Robert Ettinger, Conley Hall, who took the conference photos for this issue, Pat Dewey, Mae Junod, James Pesagno, Hugh Hart and Paul Landrum, who has moved to California and is in the process of transferring to CSC.

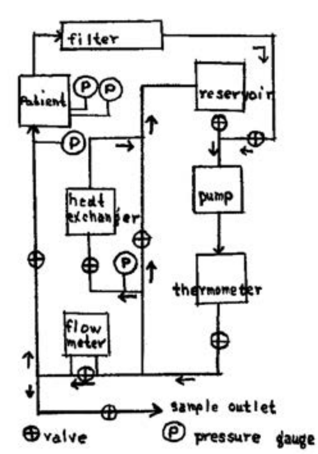
There was also a good turnout from both CSNY and CSC--and, of course, BACS.

Because they involve two of the most vital issues, perfusion technique and equipment, we present first the new information and advances reported by Dr. Peter Gouras and Fred and Linda Chamberlain. [...]

Dr. Peter Gouras discussed the new procedure for cryonic suspension, not yet reduced to written form, on which he has been working for some months, with advice and help from Art Quaife, Fred Chamberlain, Prof. Armand Karow, Prof. James A. Miller Jr., Dr. L.O. Pilgeram, and others. Gouras' procedure, a preliminary to cooling the patient to cryogenic temperature, is in two steps, like modern practice. First is body washout, replacement of blood and body fluids with "base perfusate" containing no cryoprotectant; then, the base perfusate is replaced with cryoprotectant. Details are given; the main ingredient of the cryoprotectant is DMSO (dimethylsulfoxide), which is still in use today, though concentrations and other details have changed. Gouras' research is also noted; he has recovered cat retinas after 2 hours at body temperature and 45 minutes at -20°C, in the latter case using a cryoprotectant mixture of 40% DMSO.

One of the biggest attractions and sensations of the meeting was the prototype perfusion machine built and exhibited by Fred Chamberlain. It is a response to the many problems already encountered and to be encountered in perfusing patients in a carefully controlled and measured way under changing conditions and with different requirements at different stages of the perfusion process and in different parts of the body. [Fred himself comments:]

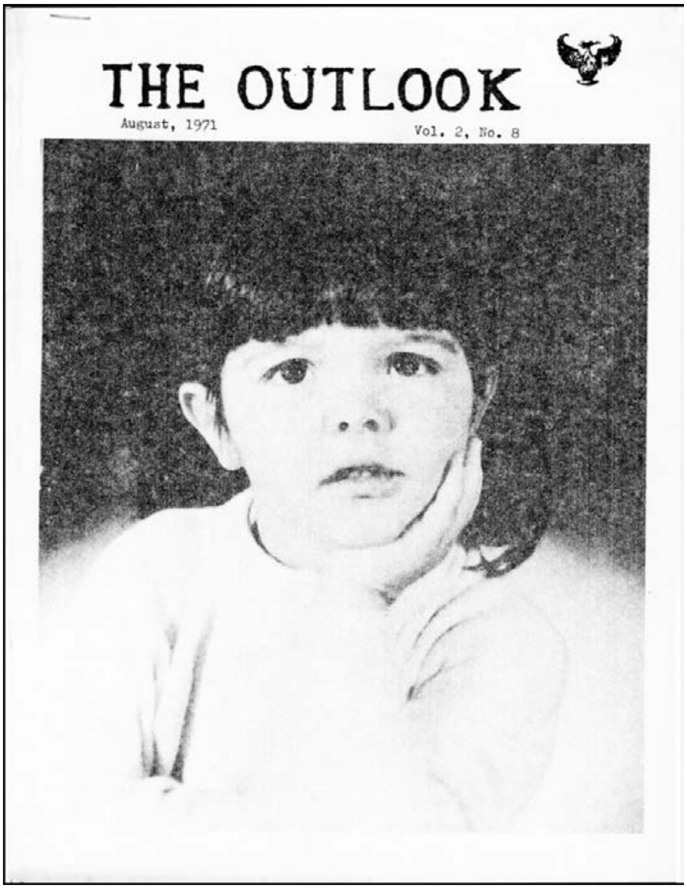
The system block diagram shown presents a 'two loop' system with perfusion and heat exchanger circuits driven through a common pump. The perfusion circuit embodies a flow meter, perfusion flow valve, pressure



From left: Linda and Fred Chamberlain with perfusion machine, from cover of The Outlook, *Jan. 1972; Fred Chamberlain's perfusion circuit,* The Outlook, *Jun. 1971.*

gauges, and return filter, while the heat exchanger with bypass and a main reservoir are located in a second loop. Instrumentation currently installed includes a thermometer. Projections for future improvements include a thermistor sampling network and device measuring pH, specific gravity, and refractive index. In future models, a drip chamber and isolation reservoir will be added, as well as other improvements.

Genevieve de la Poterie



Genevieve de la Poterie, 8-year-old cancer patient, cover of The Outlook, *August 1971*

In the August 1971 issue there was a first report of a pending case that would tug at heartstrings and ultimately have a tragic conclusion, like most other cryonics cases in this early era. A French-Canadian child living in Montreal, the seven-year-old Genevieve de la Poterie (pronounced, approximately, *Zhahn-vee-ev duh lah poh-TRAY*) was dying of kidney cancer when her father heard about cryonics. Ettinger was contacted, then Robert Nelson of the CSC. The report concludes on an optimistic note:[25]

DEATH TO LIFE, MONTREAL TO L.A.

Genevieve de la P. is our cover girl for this issue. (For the time being, we prefer not to identify the parties involved.) She is alive today because of the love and initiative of her parents and the help of the Cryonics Societies, particularly that of California.

In the middle of July a Montreal hospital decided Genevieve was doomed to die, her second kidney succumbing to cancer which (they said) was spread too far to check. But her father remembered seeing a Canadian TV program on cryonics, particularly the mobile emergency unit with "Cryonics Society of Michigan" identifying it; he got our number from Detroit Information and asked for help in arranging cryonic suspension.

After a review of available facilities, he was put in touch with CSC. Robert F. Nelson, President of CSC, and mortician Joseph Klockgether flew to Montreal, wasting no time; our experience proves that death often comes sooner than expected, and Genevieve had been given only weeks at the most. They brought equipment and chemicals with them; additional DMSO needed was sent from CSM's stock--again in Walter Runkel's suitcases, as in the case of Mrs. Harris in Iowa, but this time in Conley Hall's plastic jugs instead of glass bottles.

Events thereafter appear to include false information given, and false promises made, by physicians and administrators at the Montreal hospital. We omit the details until we can be more nearly certain of the facts. In any event, Genevieve was apparently near death when she was taken to Los Angeles by her father the last week in July.

In L.A., emergency action was coordinated by CSC members including Fred and Linda Chamberlain, Paul Porcasi, Marce Johnson, Holly Martin, and others--not only to prepare for a quick freezing if necessary, but to get the child into a good hospital immediately, and this seems to have been decisive.

In the L.A. hospital the picture brightened dramatically, physicians there expressing the opinion that Genevieve could be saved through dialysis (use of a kidney machine) followed by a kidney transplant when a suitable donor could be found. The first week in August, dialysis having already been started, her second kidney was removed, and the surgeons' findings seemed to confirm their previous optimism.

At this writing (Aug. 9) the picture is not entirely clarified, but Genevieve will probably be brought back to Montreal, to one of the hospitals with a dialysis and transplant program. Local standby arrangements for cryonic suspension will have to be made, but with luck the gift of life Genevieve received in L.A. for her 8th birthday will be hers to keep for a long, long time.

The following month there was more to report:[26]

GENEVIEVE BETTER: GOING HOME

Last month we reported on Genevieve de la P., the eight year old Canadian child who was taken from Montreal to Los Angeles, apparently terminally ill. The intention was to provide cryonic suspension; but new hope was given by California physicians. Genevieve was put on a kidney machine while awaiting a transplant opportunity.

There were ups and downs. Her second kidney was removed, and for a while her chances appeared slim. It seemed she might have to be frozen after all. However, she rallied and is feeling and looking much better. At this writing the picture is still not completely clear. There is not absolute assurance that the malignancy destroying her young life has been conquered, but everything medically possible to conquer it is being done.

She was able to enjoy a trip to Disneyland and to attend a going away (returning home) party given for her by the Cryonics Society of California in Santa Monica on September 11. The party was held at the Fox and Hounds restaurant. Genevieve sparkled despite her difficulties.

The child is on a special diet and may have only 13 oz. of water per day. She will spend most of her time at home after her return to Montreal to await a suitable kidney donor but must visit a hospital regularly for dialysis.

It is a source of joy to cryonics workers that this child's chances for a longer and healthier life have been enhanced through the help of the cryonics program, most especially the operations of the Cryonics Society of California and its dynamic leader Robert Nelson and other members.

The most dramatic evidence produced by this entire episode is that there is a place for cryonics in the life saving efforts of our society, for it is true that Genevieve had been adjudged beyond medical help at the time her father contacted Robert Ettinger, president of CSM. Mr. Ettinger has many times stated that cryonics is a holding program. Robert Nelson, at the San Francisco conference, expressed the cryonics goals of saving lives, slowing down, and perhaps stopping the dying process. Genevieve is at this moment living proof of the sincerity and truth of these statements.

A further report in the December issue, referencing a writeup in the CSC newsletter, notes the child had been doing well, but now has returned to the hospital.[27]

REPORT ON GENEVIEVE DE LA POTERIE

In its October/November issue, Cryonics Review (Cryonics Society of California) has published the story--and the full name, which we had previously kept confidential--of the Canadian child who had appeared to be dying of cancer, and who so far has been saved through the determined efforts of her parents and the Cryonics Society of California.

At the date of the Cryonics Review story, Genevieve was doing fairly well on a kidney dialysis machine and spending most of her time at home, with a kidney transplant expected within a few months. (Both kidneys have been lost.) We are sorry to report, however, that since then she has had to go back to the hospital, and the prognosis is guarded. This lovely child and her brave parents still face a difficult struggle.

Finally, the struggle is too much and the little girl succumbs, still leaving the hope of cryonics, as reported in February 1972:[28]

GENEVIEVE DE LA POTERIE SUSPENDED

Genevieve de la Poterie, the eight year old cancer victim from Montreal, whose continuing story we have carried in past issues, passed into clinical death on Jan. 25 at 6:50 A.M. in Los Angeles. She was immediately prepared for cryonic suspension--the 15th patient known to have been frozen in hope of future rescue. She is also the first child frozen, and the first patient from outside the U.S.A.

Earlier hopes were dashed when it became clear that removal of her diseased kidneys did not halt the spread of the cancer, and at last dialysis had to be terminated. Her last weeks were spent in a private hospital, watched over by her parents, Guy and Pierrette, and by members and associates of the Cryonics Society of California under the direction of its President, Robert F. Nelson.

Cryonic suspension was primarily in the hands of Joseph Klockgether, the California mortician who has frozen several previous patients. This time new and improved techniques were used, after consultation with Art Quaife, Fred and Linda Chamberlain, Paul Segall, and others. It is assumed she will be kept in the permanent storage facility near Los Angeles operated by Cryonic Interment Inc.

Because of her youth, and because she seems to have been frozen under the best conditions to date, our optimism for her eventual rescue is much encouraged. We mourn the present loss of this plucky child, but we share with her courageous parents the hope that one day she will be with them again, alive and whole.

Sadly, if this outcome is to happen, it will have to happen outside the bounds of cryonics. Little Genevieve, as we have noted, was one of the patients lost at the cemetery in Chatsworth (the "permanent storage facility near Los Angeles"). (It is worth noting that the parents of the little girl did not sue Nelson or Klockgether for malpractice, unlike some of the other patients' relatives.[29])

The Chamberlains: Freezing Manual and Formation of Alcor

Meanwhile, as they say, "life must go on," not excepting the world of cryonics. Backtracking slightly, the January 1972 newsletter reports on the energetic efforts of Fred and Linda Chamberlain to create a better cryonics movement all around by documenting the best available procedures for doing cryopreservations. (Not in the report: the Chamberlains had recently founded an organization, Manrise Corporation, which was devoted to the technical problems of cryonics and how best to resolve them.[30] They published a journal, *Manrise Technical Review*, inviting contributions from all in the movement.) The report notes that the Chamberlains "have published on schedule the first 33 sections of their promised freezing manual, *Instructions for the Induction of Solid State Hypothermia in Humans*," and continues:[31]

The manual represents Herculean labor and fills an acute need, long felt, for a summary in print of up-to-date procedures and alternatives to guide those involved in cryonic suspension.

The pages come in loose-leaf form, with a special binder, and careful arrangements have been made to allow continuous updating and to prevent the distribution of outdated material. Technical references are given, but the writing style is intended to make the information accessible to the layman as well as to physicians, morticians, and other professionals. The suggestions include not only procedures leading to freezing, but also first aid measures and resuscitation techniques that in some cases might revive patients apparently dying or dead. Alternative procedures are given for many different situations, depending on the condition of the patient, the availability of equipment and professional assistance, etc.

The 33 sections now ready cover procedures to the point of certification of death; those upcoming relate to the details of cooling, perfusion in different phases, transportation of the patient, record-keeping, and the equipment and teamwork advised for these and other facets of the protocol.

Every Society, and every individual seriously interested in cryonics and willing to assume some degree of responsibility, should have the manual. Price for members of a Cryonics Society in North America is $15 including binder, plus $6 annual subscription to MANRISE TECHNICAL REVIEW, which will contain the new sections as they become available.

The following month reports an additional 23 sections printed (nos. 34-56):[32]

These deal with procedures and alternatives at the site of death after the finding of medical death, beginning with strategies to avoid autopsy or minimize its effects and continuing with detailed techniques for external cooling and transportation in a variety of circumstances, medical tests and record keeping, assignment of duties to the task force, preparation for internal cooling and perfusion, and directions for cannulation or intubation of the patient, among other things.

The instructions include not only verbal directions but careful drawings showing: the anatomy involved and the instruments needed; thus the instructions can be easily followed by professionals (surgeons or morticians) after a little study, or by apt laymen after much study and practice. The drawings and directions can also serve as memory refreshers for those who once knew what to do but may have become rusty. Sources of supply for instruments and chemicals are also listed in an appendix.

Fred and Linda Chamberlain deserve our renewed thanks for taking on this vital task that no one else, until now, has been willing and competent to shoulder. [...]

The Chamberlains, meanwhile, were making another, very important contribution, the formation of a new cryonics organization, as reported in the August 1972 *Outlook*:[33]

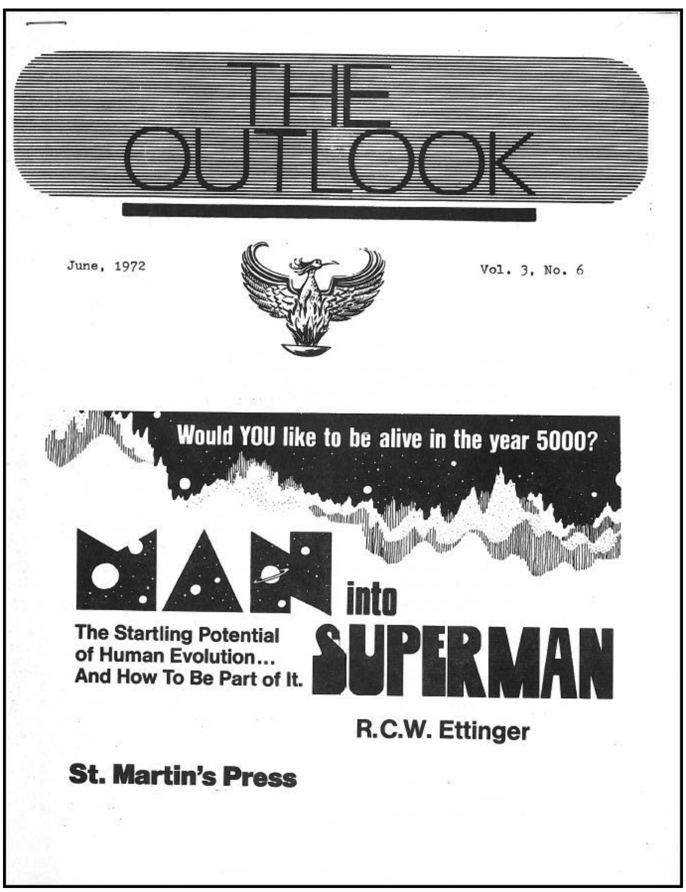
NEW CALIFORNIA ORGANIZATION

The Alcor Society for Solid State Hypothermia [...], Verdugo City, California, [...] is a new nonprofit corporation, apparently somewhat along the lines of the cryonics societies, and sharing personnel with Manrise Corporation. Its brochure does not provide details of membership requirements and fees, but indicates that it will provide physical services in freezing patients at death and will sponsor or carry on cryonics-related research, including the viability-assay work with frozen animals, according to the proposal renewed recently by Fred Chamberlain and reported in last month's OUTLOOK. [Quoting from the previous month's OUTLOOK, July 1972: "Fred Chamberlain has now revived an idea that we have considered, off and on, for years: to concentrate on experiments with large mammals, freezing them whole by the methods we envision for human patients, and then by taking tissue samples assay the viability of cells from all parts of the body.”]

As usual, one cannot be sure whether the disadvantages of fragmentation will be offset by the advantages of diversified efforts. Perhaps the new organization, with its emphasis on high standards and currency in technology, will strengthen the movement in certain areas.

Present plans call for efforts to obtain tax-exempt grants and donations, with whole-organ viability research to be initiated in the 1975-1980 period. The time-scale is sobering indeed, and reflects considerable pessimism about other aspects of the cryonics program, based on the extremely limited success of recent years. But this reminder should serve to renew and redouble the efforts of the Societies to accelerate progress.

(After nearly half a century, the Chamberlains’ organization continues as Alcor Life Extension Foundation, title adopted in 1977.[34])



Man into Superman

Robert Ettinger is noted for having largely started the cryonics movement with his first book, *The Prospect of Immortality* (Doubleday, 1964). Eight years later, St. Martin’s Press brought out his second book, *Man into Superman: The Startling Potential of Human Evolution … And How To Be Part of It*, as reported in the *Outlook* (June 1972):[35]

Although Ettinger’s latest is indeed another effort to invigorate the cryonics program, it is not only that, and the book is not just a warmed-over and updated Prospect of Immortality. It includes a review of the history and status of cryonics, but the bulk of it represents an ambitious fusion of fun and philosophy, an overview of the human agenda from an individual standpoint, with details likely to provide both amusement and outrage. Some hints may be conveyed by the following excerpts and comments:

The Preface is called “Superman in the First and Second Person,” and it begins: “By working hard and saving my money, I intend to become an immortal superman.”

In Chapter 1, “The Sculptor Sculpted” we read: “To be born human is an affliction. It shouldn’t happen to a dog ... To what extent, and in what way, can man design superman?”

Chapter 2, “The Deficiencies of Natural Man.” A savage attack on human complacency leads to the conclusion that “... man ... can be considered only a beginning and a dubious compromise, in both mind and body.”

Chapter 3, “From Gilgamesh to Olaf Stapledon.” A lively look at previous insights and failures in the effort to envision superman.

Chapter 4, “Changes in the Chassis.” Options in the physical form of superman, from the near to the distant future, self-modifications trivial and profound.

Chapter 5. “Transsex and Supersex.” So you think you’ve heard everything?

Chapter 6, “Growing Pains.” What will it feel like to be a superhuman, especially of the transitional variety? How will our mental and emotional lives change; how will our personalities be affected?

Chapter 7, “Morality for Immortals.” Superman--ourselves if we become immortal--will have different values. Something to offend everyone.

Chapter 8, “The Penultimate Trump.” “It’s no disgrace to be poor, but it’s no great honor either.” Fun and games again, including glimpses of everyday life among ordinary billionaires of the near future.

Chapter 9, "Tuesday in Eternity." The cryogenized Christian and the gelid Jew, the future of religion.

Chapter 10, "Copouts and Dropouts; The Threat of Immortality." Dissecting the critics of cryonics and the apologists of humanity. Lots of fun.

Chapter 11, "Cryonics and the New Meliorism." The hard sell.

Appendix, References & Notes, Index. [...]

Bedford Wins Lawsuit, Stays Frozen

From the August 1972 *Outlook*:[36]

Prof. James H. Bedford, the first male patient to undergo cryonic suspension, and the first publicized freezing case, will not have to submit to thawing (murder?) by relatives who wanted his money and claimed he never intended to be frozen.

According to UPI reports, and prior conversations during the course of the suit between Norman Bedford (the patient's son) and Robert Ettinger, this is what happened:

Thirteen days before his "death" from cancer on Jan. 12, 1967, the 73-Year old Dr. Bedford revoked a trust set up for his 12 grandchildren and instead bequeathed the money, $100,000, to the International Foundation for Cryonics Research Inc., for the benefit of himself and other frozen patients. His action was bitterly opposed by the grandchildren and by Dr. Bedford's attorney, who was the trustee of the original trust.

The lawsuit developed during the process of probating the will, with the defense devolving on Norman Bedford and his mother, the professor's "widow". Plaintiffs apparently claimed (1) that Dr. Bedford never intended to be frozen, and that it was all the idea of the son and widow, and (2) that in any case Dr. Bedford was incompetent at the time and improperly influenced by his wife and son. Plaintiffs also attempted to disparage and ridicule the cryonics concept.

The defense included testimony by the proprietors of the nursing home where Prof. Bedford "died", to the effect that he was of sound mind and wanted to be frozen. Ettinger sent a deposition and correspondence from Dr. Bedford, proving that both his desire to be frozen and his intention to finance it with $100,000 dated back at least as far as July 28, 1966, when he had read The Prospect of Immortality and knew he had terminal cancer.

During the trial, Norman Bedford went through two attorneys, who apparently only succeeded in antagonizing the judge, and finished by acting as his own counsel. Judge Julius M. Title (Superior Court) seems to have remained unfriendly, but ruled on the evidence that Prof. Bedford was mentally sound and had made a decision that the court could not set aside.

Thus, the heroic efforts of Robert Nelson and the Cryonics Society of California, and of James Bedford himself and his wife and son, continue to bear fruit, and the intrepid chrononaut has weathered another storm. It is still a long way to port, but if the cryonics program grows sufficiently in the next few years, the rest may be smoother sailing.

(James Bedford, the longest surviving cryonics patient, is presently at Alcor, having been committed to their custody by relatives in 1987. At that time, he was in an old-style, horizontal capsule he had been transferred to – from an earlier capsule of the same type – in 1970. In 1991 Bedford's capsule was opened, which required the talents of an expert welder and the careful use of a cutting torch, keeping the interior cold, and he was transferred to his present, upright, "Bigfoot" container. The presence of cube ice on his chest in this 1991 viewing, with the corners sharp and unmelted, was good evidence that Dr. Bedford had remained frozen since the day he was cryopreserved in January 1967, when the ice had been placed around his body during the initial cooling.[37])

Art Quaife and Trans Time

Art Quaife from the December 1971 Outlook *cover, photo by Ashley Hendrix.*

From time to time in the pages of the *Outlook* the name of Art Quaife comes up. Art was an early cryonics activist (now retired, still in cryonics) who lived in the San Francisco Bay area and majored in mathematics at the University of California, Berkeley. (He received a Ph.D. there in 1990, with a dissertation on automated proofs of Gödel's results and other foundational theorems of mathematics.[38]) The December 1971 *Outlook* carried this report:[39]

As most of our readers know, work has been going on for many months, based on the recommendations of Dr. Peter Gouras and others, to update and formalize the protocol for cryonic suspension, including the makeup of the cryoprotective solution and of the solution used for perfusion in the hypothermic phase.

This work is still in progress, being coordinated mainly by Arthur Quaife of the Bay Area Cryonics Society and Fred Chamberlain of the Cryonics Society of California. It is expected that early in 1972 Manrise Corporation (headed by Fred and Linda Chamberlain [...]) will publish the detailed recommendations with full notes and references. Meanwhile, Art Quaife has summarized his recommendations regarding perfusion solutions, and the reasoning and experiments on which they are based, in an article to be published in Manrise Technical Review. [...]

In the April 1972 issue we hear of Quaife's mathematical studies regarding perfusion procedures in cryonics, along with mention of the newly formed organization, Trans Time:[40]

NEW PERFUSION STUDIES BY QUAIFE

Art Quaife, of the Bay Area Cryonics Society and Trans-Time Corp., has written an important new paper on the Mathematics of Perfusion.

Cryonicists insist that imperfect freezing procedures are better than none, and that it is irrational to set arbitrary limits on the repair and rescue capabilities of scientists of the indefinite future. Yet we realize, better than the shrillest of our critics, the difficulty of finding optimal freezing methods for a large organism, and the urgency of improving our techniques. So far, in common with the cryobiological "establishment", we lack the resources for laboratory work with large organisms on a substantial scale. We hope this situation will soon improve. Meanwhile, Mr. Quaife has gone well beyond any known previous work in applying detailed analysis to the problems involved, including the major questions of cooling rates and control of concentration of perfusate and its ingredients, and the related questions of temperature gradients, concentration gradients, minimizing of times and costs, etc.

The degree of sophistication, both biological and mathematical, is considerable. Differences between organs and tissues are considered, and formulation of some problems leads to differential equations to be solved by the method of the Laplace transform. Nevertheless, it is hoped that as many as possible will read the paper, get what they can out of it, and feed back any useful comments. A revised draft will be published in an early issue of Manrise Technical Review. (Write Manrise Corporation, P.O. Box 731, La Canada, California 91011.)

A report in the November 1972 *Outlook* offers some further glimpses of long-ago efforts that, it is fair to say, helped save the cryonics movement when others failed:[41]

TRANS TIME INC.

Art Quaife, president of Trans Time, Inc., a commercial Cryonics organization, has sent us news from their California base that is bound to be of interest to all cryonicists. Following are quotes from Mr. Quaife's communication:

"... the current status of the Modular Perfusion Apparatus being manufactured by Manrise Corp. for Trans Time. Their original prototype has been completely reworked, and a new prototype is largely finished. Trans Time has requested that Manrise deliver sufficient equipment to be able to perform emergency suspensions by the end of this year, and Manrise hopes to comply. As further development of the system takes place, they will continually supply us with upgraded versions. The total cost we pay will be just their charge for the final system, with no price penalty for having traded in intermediate models.

.... The possible purchase of a step van to be used as a mobile rescue vehicle was discussed.

.... Art has talked with three Berkeley morticians concerning their possible cooperation with us. *[One has since definitely agreed to assist.]* .... two morticians pointed out that we should purchase our own cannulation instruments, since theirs are not kept in a sufficient state of sterility. These will cost us approximately $180.

.... Art was recently contacted by William Koreski, an engineer who has been working with Dr. Lillehei's group at the University of Minnesota. They have recently successfully frozen two (out of five) dog kidneys to -40°C and -70°C; the kidneys sustained life after reimplantation and contralateral nephrectomy.

In the same issue there is a report of someone just frozen by CSC:[42]

Another cancer victim, this patient is a 51 year old woman from Westwood, California. [...] Arrangements had been made well in advance at the request of her husband, a doctor, and her son, an attorney. The patient was packed in ice within seconds of clinical death, as the first step in the cryonic suspension procedure used. She is expected very soon to be in permanent storage in liquid nitrogen (indefinite storage, that is, until the means for her rescue become available), presumably at the California facility of Cryonic Interment Inc.

The family apparently learned about cryonics, or was reminded, through the publicity attending the suspension of Genevieve de la Poterie, the Canadian child who was frozen earlier this year.

Because of lack of time to gather more details, and to determine the degree of privacy requested, we defer a lengthier report until a later time. Again we salute CSC, Bob Nelson, and an intelligent and courageous family.

(As if to underscore the need for better policies and organization in cryonics, this person also was later lost, not at Chatsworth but a "sister" facility that Nelson had helped set up in Butler, NJ.[43])

The World at Large

There are many other items of interest in the early *Outlook* which must be omitted due to limitations of space. One thing to note briefly is the important role played by the *Outlook* in documenting cryonics activities outside the U.S. in the early 1970s, notably England, Spain, and France, covered in a previous article.[44] Overall, *The Outlook* under its capable editorship became the steadiest source of information as well as inspiration during the difficult decade of the 1970s, when major cryonics operations failed and most of the early patients were lost.[45]

To be continued. ■

The author thanks York Porter, current editor of *Long Life Magazine* (formerly *The Outlook*) for assistance and kind permission to reprint portions of the still-being-issued newsletter.

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Cryonics, Immortality, and Philosophy

By Francesca Minerva
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ABSTRACT

In this article, I summarize the key issues discussed in my latest book *The Ethics of Cryonics,* published by Palgrave in 2018. In particular, I analyse the main arguments against cryonics as well as the main arguments pro and against immortality.

In 2018, Palgrave published my monograph entitled "The Ethics of Cryonics, is it immoral to be immortal?" in which I discuss some of the most common objections to cryonics and to indefinite life extension more generally.[1] The book chapters are grouped into three main parts as follows: 1) Cryonics as an ethical problem; 2) Cryonics as a step towards immortality; and 3) Alternative uses of cryonics. In this article, I will only focus on the first two parts of the book, as in the third part I discuss the possibility of using cryonics as an alternative to euthanasia and of using the (hypothetical) cryopreservation of fetuses as an alternative to abortion.

The first part of the book introduces cryonics, a new technology, the object of somewhat "old" objections. Those who are familiar with objections against cryopreservation of human embryos for In Vitro Fertilization (IVF) when it was first introduced in the 1980s won't be too surprised to see that there are a number of arguments against cryonics that are pretty similar to those against embryo cryopreservation (and many new biotechnologies, including human cloning, or genetically modified organisms).

New technologies are often accused of being "against nature" or "against God's will". In the case of cryonics, the main complaint is that dying is natural and/or what God has planned for humans, so trying to escape death is a form of hubris, an attempt at interfering with natural laws or God's law, with potentially devastating consequences for humanity.

The same people who are against a new technology because it is not natural, or because it goes against God's will, usually don't apply the same kind of objections to technologies that are no longer new, even though such technologies are as much "against nature" as the new ones. So, for instance, these people are not against using Intensive Care Units when they are necessary to save someone's life, even though, quite obviously, such therapies are not "natural" and, given their goal of extending the life-span of someone who is dying, they are also against God's plans.

So, quite often, this kind of objection stops being used against new technologies when such technologies are no longer perceived as "new", and people get used to them. It wouldn't be too surprising if, in a future when cryonics is used routinely, it would no longer be perceived as against nature.

Another common argument against new technologies is that only rich people can afford them (at least, this is often the case when they are first introduced on the market). The high cost of these technologies promotes inequality because they provide an advantage to people who can afford them (as they usually do), and therefore they increase the gap between the rich and the poor. In the case of cryonics, this gap would be particularly significant because it could make a difference between living for a few decades (as we all currently do) and living indefinitely. A common response to this kind of objection is that the price of new technologies usually decreases over time, and this could certainly apply to cryonics as well, although it doesn't mean that people who can afford cryonics now are advantaged compared to those who can't. It's worth remembering that if a certain technology is considered necessary at a societal level, it usually gets subsidized by the state (for instance, in countries with a public health system, the first IVF cycle is free). Cryonics can be relatively affordable if paid for through an insurance plan, but of course, this doesn't mean that everybody could afford it through an insurance plan, because some people live in such poverty that they can barely afford food and shelter. But although it is undeniable that extreme poverty is one of the greatest plagues of humanity, it seems that worrying about it only with respect to new technologies is rather inconsistent. There are people who are so poor that they cannot afford basic care, and die of very curable diseases. So, it seems reasonable to argue that the main issue here is not the gap between people who can afford cryonics and those who can't, but rather a much bigger problem with social and economic inequality, a problem that a ban on cryonics (or any other expensive biotechnology) wouldn't help to solve.

In this first part of the book, I also discuss objections that are specific to cryonics, such as its being a waste of resources, and its being too risky an investment. Cryonicists are sometimes accused of being selfish, either because they waste organs that could be used for transplants (hence, they choose a relatively small chance of surviving over a very high chance of saving several lives) or because they spend on cryonics the economic resources that they could have donated to an effective charity aiming at saving the lives of people living in extreme poverty.

As far as organ donation is concerned, I agree that neuropreservation might be the most moral choice, because it allows use of the cryonicist's organs for transplants. However, it is fair to say that not all cryonicists would qualify as organ donors, especially those affected by cancer with spreading metastases, so not all cryopreservations, and indeed, probably not even most of them, constitute a waste of organs for transplants.

I find another argument quite compelling, however, and harder to dismiss. The money used on cryonics could be used instead to save the lives of people in developing countries.

Consider that the cost of cryonics (depending on the type of cryopreservation one chooses and the company involved) ranges between $28,000 and $200,000 and that, according to the meta-charity Give Well the median estimate of a lifesaving donation is between $900 and $7,000. So a cryonicist could save between 4 and 220 lives if she decided instead to donate the money she would have allotted to cryonics to one effective charity. If one thinks that they have a duty to maximize utility, these numbers are quite compelling (not all people do, of course, but I think that one indeed has such a duty).

This objection based on wasting money does apply to almost all non-necessary expenses in our lives, from bottled sparkling soda to big houses, from cruises to cars. However, one could object that cryonics is different from other non-effective or selfish investments because it is an investment with no returns. While one can enjoy driving an expensive car, cryonics has a very small chance of succeeding (or at least I am assuming that for the sake of argument), hence it's unlikely to provide any increase in wellbeing to the people spending money on it. This objection, however, seems to fail to fully acknowledge the potentially extremely high gain one could have from cryonics. If cryonics works, it could allow people to gain indefinite life extension, being therefore the most cost-effective treatment one could possibly undergo. So even though the chances of cryonics succeeding are quite small at the moment (again, assumed for the sake of argument), its potential enormous gain makes it, I argue, a reasonable monetary investment.

A different order of objections to cryonics is based on the idea that, even if future technology allowed the revival of people who undergo cryonics now, future people wouldn't be interested in using it to revive the cryopreserved.

There are various reasons why future people wouldn't revive the cryopreserved: one is scarcity of resources (hence no interest in bringing back to life people who would contribute to exhausting such resources, be they economic or natural). Another reason could be lack of interest in homo sapiens. This scenario would be more likely if enhancement were to become so extreme as to transform us to a different species altogether, let's call them the posthumans. If the differences between us and them were so dramatic that they would view us as we perceive insects, they would have no particular reason to revive the cryopreserved. Cryonicists often refer to themselves as a community and they rely on future members' willingness to resuscitate them. The sense of community shared by past, present and future cryonicists should (hopefully) be stronger than any future disincentive to revive the cryopreserved. Of course, there is no guarantee that future members of such a community would feel a duty to revive people who had been cryopreserved centuries before, but the uncertainty about this scenario doesn't seem to justify giving up on cryonics altogether. Let's call them transhumanists.

Finally, another set of objections focuses on the possibility that life as a revived person would be so bad that cryonics would end up being a bad investment even if, technically, it worked out.

One possibility is that revived humans would lack the physical or cognitive features that could become necessary in order to have a good life in the future world. If this were the case, and life on Earth turned out to be too difficult or too painful to the revived, they could end up having a miserable life, or even choosing death. It is also possible that, despite a future world being a wonderful place to inhabit, the revived would struggle to adapt to a dramatically different environment where everything is new and nothing feels familiar. Also in this case, the distress experienced by the revived could be so intense that their life could be perceived as not worth living.

However, it is impossible to predict which hypothesis about the future world is more likely to be right. Given the uncertainty, being optimistic and hoping cryonics will succeed at shipping people to a happy indefinitely long life is not unreasonable. After all, uncertainty about the future is the hallmark of human existence, with or without cryonics.

In the second part of the book, I focus on cryonics as a necessary step toward indefinite life extension. Even though immortality is not necessarily a shared goal of everyone choosing cryonics, cryonics currently is a necessary step to anyone who would like to achieve immortality or indefinite life extension.

In modern societies, death is often perceived as something negative, as the ultimate evil that one should avoid as long as possible. Curiously enough, though, immortality is also considered undesirable.

One of the most famous philosophy papers on the topic of longevity/immortality was published by Bernard Williams in 1973: “The Makropulos Case: Reflections on the Tedium of Immortality”[2]. Elina Makropulos is given an elixir that extends her life by 300 years, and can be taken many times. However, after taking it once at 42 years, she decides not to take it again and to die at the age of 342. The elixir not only extends Elina’s life well beyond average, but also allows her to stop the ageing process, so that she is healthy and doesn’t suffer from age-related issues. And yet, Elina chooses to die instead of continuing to live because “Her unending life has come to a state of boredom, indifference and coldness. Everything is joyless: ‘in the end it is the same’, she says, ‘singing and silence’.”

Williams identifies three features that make Elina Makropulos’ life (or any very long life) undesirable: 1) fulfilment of all categorical desires; 2) dramatic change in categorical desires with consequent loss of identity; 3) living an unrecognizably human life.

Let’s start from the first argument against immortality introduced by Williams, the fulfilment of all categorical desires and the consequent lack of interest in continuing to live. According to Williams, categorical desires are those desires, projects, and plans that propel people to the future. Examples of categorical desires are the desire to learn to play an instrument or to write a book. Once these desires are satisfied, the interest in continuing to exist quickly declines. Of course, one could develop new ones, but at some point, after a few decades or centuries, boredom and lack of interest in the future would necessarily become unbearable and make death more desirable than life.

Although this is a possibility, it is also plausible to imagine someone whose categorical desires have been depleted, or have never been present, and yet has a desire to live. Not all our desires have the form of projects and goals we want to achieve in the future. Some desires are just contingent (this is the term used by Williams), in the sense that they are prompted by needs. However, it is not so absurd to imagine a life worth living where only contingent desires are satisfied. Indeed, it seems that most human animals don’t have categorical desires, but the satisfaction of contingent desires is sufficient to make their life worth living. It is not unthinkable that some humans (at least) would consider their life worth living even if their categorical desires had been fulfilled and they were only left with contingent desires to be satisfied. Also, it is not so obvious that categorical desires would necessarily be fulfilled with time, as some of them adapt to new circumstances. If we think of someone who has the categorical desire of helping family members, then as long as the family keeps growing, the desire cannot be fulfilled. But let’s now concede, for the sake of argument, that categorical desires are indeed necessary in order to live a life that is preferable to death. It is still plausible that someone living a very long life would develop new categorical desires, so that, once the older ones are satisfied, she is propelled to the future by new ones she has developed. According to Williams (and this is the second part of his argument), such a person would cease to be herself, as personal identity, so to speak, is held together by one’s categorical desires. This objection, however, seems to apply also to average-long lives. Most people, if not all people, have different categorical desires through their life, as it is normal to have different plans and aspirations as children, teenagers and adults. However, we do have the perception that such desires are part of different stages of our lives, rather than being parts of someone else’s life. If our life-span were much longer, or even indefinitely long, we could have the same perception of being the same person through time even though our plans, desires and goals changed quite radically many times. Of course, this doesn’t mean that having a coherent narrative of our own story is not important in order for each of us to be able to say “*I*’ve made it, *I*’ve been revived after cryonics and *I* have lived a thousand years.” We humans organize the past events within a narrative that enables us to make sense of them, that is, in a way that constitutes a coherent story. If we perceived our past as scattered images or episodes, without the framework of a coherent story, it would be very difficult for us to make sense of the past, and hence, to remember it. We don’t know if the human brain can coherently organize past experiences and thoughts for hundreds, thousands or millions of years. If at some point over a very long life the ability to keep the pieces of the past linked coherently to each other got lost, then we would know that we had reached the maximum length of human life. But until that point is reached, it seems that it makes sense to keep living.

Finally, let’s consider the last argument against immortality put forward by Williams, i.e. the one according to which an indefinitely long life would not be recognizably human.

An indefinitely long life, especially when paired with rejuvenation treatments, would bring about a separation between chronological and biological age. This means that someone could appear to be a 20 year old whereas instead they could well be 20,000 years old. One interesting question I discuss in the book is whether there is, to a certain extent, a correspondence between biological and psychological age. As noted by philosopher Samuel Scheffler, we understand life as made of stages, and we attribute proper behaviours and goals to each stage of life[3]. This means, for instance, that whereas we don’t find it impressive for a 20 year old to be able to cook themselves a meal, we would find it impressive if a 10 year old were able to cook for themselves. Understanding life as a sequence of stages, allows us to set goals for ourselves and to compare ourselves to others. We know that there is no infinite time available in order to achieve our goals and to go through certain stages of life, and knowing that we have only limited time forces us to progress at a certain pace. If we were immortal, or if our lives were indefinitely long, and in any case *much* longer than they currently are, the stages of life as we currently know them would become irrelevant. As these stages would dissolve, we would lose out current guide to prioritize certain activities over others.

For instance, if we had the goal of climbing Mount Everest, we would currently make plans to do this by about age 30, because the human body starts declining after a certain age, as professional athletes know very well. However, if the human body never aged and imposed no time constraints, the mountaineering feat could be postponed until we were (chronologically, not biologically) much older, say 50,000. It is hard to predict whether we would have a motive to do things in the present, or procrastinate as much as possible. Moreover, we don't know if, given endless time and endless youth, we would still go through the same stages of life. Many people get married between their 20s and their 30s, then have children, and become grandparents in their 60s. Would people still have children in their 20s or 30s if life were indefinitely long, or would they want to have children at all? What if the desire to have children comes from perceiving that the body is ageing, or from knowing that a third of our life has passed by? It is quite plausible that an indefinitely long life would change or dissolve the correspondence between biological and chronological age, and our current understanding of the stages of life.

It is not possible to exclude that, as Bernard Williams argued, becoming extremely long-lived or immortal would deprive us of a distinctive feature of being human, and would make our life not recognizably human. However, it is not necessary to be human in order to enjoy being alive, and to benefit from cryonics and subsequent life-extension. It is possible that becoming immortal would turn future humans into post-humans, but that wouldn't make cryonics a worthless investment, as long as such creatures would be able to appreciate their life (and there is no reason to assume they wouldn't).

Finally, I consider the argument that an immortal life would be boring as put forward by other philosophers, besides Bernard Williams. According to Shally Kagan, an immortal person would become disengaged with the world, because they would reach all their goals.[4] Todd May has argued that, after a very long life, one would become bored of learning new things, and therefore could not develop new goals.[5] But I don't think it is possible to predict if everyone would become bored over a very long life, or if some would be more bored than others. In a sense, life becomes more and more boring the longer we live, because the excitement of novelty fades away in almost all realms of life, and even novelty itself can become, in a sense, familiar and less exciting. However, not all bored people would rather be dead than bored, and we don't know if future technologies, such as for instance virtual reality or brain uploading, would solve this kind of problem. Of course, it is not impossible that, even after the advent of new technologies, life would become too boring or too tiring, after a certain number of centuries or millennia. But, I argue, the possibility that one would want to stop living at some point of their very long life doesn't make cryonics a useless investment. Just like we don't think it's useless to save a three year old, even though they'll probably die after a century or so, we have no reason to think that cryopreserving an 80 year old would be useless because they might want to die when they turn 300 or 50,000 years old. ■

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Supporters of Alcor who are not yet ready to make cryopreservation arrangements can become an Associate Member for $5/month (or $15/quarter or $60 annually). Associate Members are members of the Alcor Life Extension Foundation who have not made cryonics arrangements but financially support the organization.

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I've Gotta Be Me!
(But who will you be after cryonics revival?)

By Stephen W. Bridge

In her book, *Unthinkable: An Extraordinary Journey through the World's Strangest Brains*, Helen Thomson discusses the case of Tommy McHugh, an English/Irish tough guy, drunk, and criminal. In 2001, Tommy had a stroke and after he recovered, he said, "I could see the beauty in everything. I had all these thoughts in my head that I'd never had before. I suddenly had these emotions and cares and worries."[1] He became enamored with nature, poetry, and art. He completely lost any interest in fighting or theft. His personality completely changed (this was backed up by his family).

This kind of sudden change is a major surprise. A tough drunk has a stroke and becomes a super nice guy. But if he had been asked before the stroke if he wanted his personality to be changed, do you think he would have said "Yes"? Our growing understanding of brain anatomy and physiology and our growing ability to perform delicate brain surgeries mean that neurosurgeons will one day be able to alter a patient's brain structure in order to deliberately change his personality. You might be given that choice someday. But remember – each of our brains is already unique. A particular surgery performed on my brain and the same surgery performed on your brain might have very different effects, just like putting a roof on a house in Phoenix, Arizona where no snow was ever expected might have different results if the same roof were put on a house in Minnesota, where many feet of snow might land on it.

Maybe you would like a change in personality, to be braver or more confident, less shy, a better salesperson, calmer under pressure so you can qualify for your dream job as an astronaut. Your doctor might say, "I can change your personality with some brain surgery. Life will be different for you in many ways afterwards." Would that much change effectively make you a *different person*? Would you consent to someone changing your brain?

If you are signed up for cryonics, YOU ALREADY HAVE.

If cryonics works, neurosurgeons in the future will repair your presumably aged and damaged brain. But how will they know what "perfect repair" is for YOU? Your brain wasn't perfect in the first place. They could "fix" something in your brain that results in you having a very different personality. Will that still be "you?"

Who are YOU?

That question exists at the very center of the Venn diagram of philosophy, psychology, and neurobiology. We all think we have a "Self", a unique being that is distinct from other humans. We use some terms interchangeably in our casual discussions, but we need to clarify the differences here.

Your *identity* is the name and description you give to that individual person you are. It involves the narrative you tell about your life and your connection to other people in your life. It includes your DNA, your family, your abilities, your job, your physical appearance, your sexual preferences, and your name. We might say that your identity is what you construct for yourself. It is the "inside" view. (There is also a legal component to the word "identity", of course, that allows your name and other continuing identifiers to be linked to you, for purposes of finance, contracts, liability, and inheritance.)

Your *personality* is how we describe the ways you interact with other people — intellectually, physically, and emotionally. Personality is what is seen and defined by the people around you. It is the "outside view," and it might be very different from your "identity."

Underneath both of those views is what neurologists and psychologists call the Self. The Self might be defined as that product of your brain that can tell the difference between "you" and "not you." A fine introduction to the theories of "the Self" is *The Man Who Wasn't There; Investigations into the Strange New Science of the Self* by Anil Ananthaswamy. This author believes that the Self begins to develop in the very young, as a person experiences sensory inputs from both outside and inside the body. Ananthaswamy describes the Self as a type of prediction engine, in that the Self attempts to determine where the input is coming from and predicts the results. For example, a child very soon learns to reach out and touch things. The sensation of touching himself is different from touching other things partly because the input is coming from internal sources, so that dichotomy develops quickly. As the child continues to develop, he begins to discover that some outside things are food, some can make noise, some can bring comfort, and others can bring pain.

Ananthaswamy writes that we do not see other people as just physical objects that move around. We see them as people with minds. "We are constantly inferring what's going on in someone else's mind, to understand their behavior, intentions, and desires as well as to predict what they might do next. In a sense, we are constantly theorizing about other people's mental states. We have a *theory of mind*."[2] (emphasis in the original) That also means we believe that our own emotions, senses, and behavior are linked to *our* minds.

A number of psychologists quoted in this book believe that many non-normal mental conditions may be viewed as disturbances of the Self, perhaps as a failure in growing up to have developed that theory of mind. For example, schizophrenia might be seen as a person not having the ability to determine where the Self ends and the outside world begins, including knowing which sensations (such as voices) are internal and which are external. The various forms of autism might be seen as a development begun when the parts of the brain involved in prediction cannot learn to determine what any particular sensation will lead to. A brain that cannot predict will not be able to read other people's faces or know which inputs are safe and which are not, so the autistic person is unable to act upon unfamiliar situations.

You might say that you are not a person with schizophrenia or autism or some other brain difference; but everyone assumes their view of the world is normal and that other people are the odd ones. If enough people tell you that *you* are the odd one, you might start to question yourself a bit; but even then the human tendency is to acknowledge that you are "different" but still "right." As a neurologist told me many years ago, "Everyone is brain-damaged. Some of us are just brain-damaged in more socially acceptable ways than others are."

In cryonics, if we are looking to preserve everything that makes you "You," preserving your personality (the way others see you) is as important as preserving your Self and your experience of identity. This may be trickier because few of us deeply evaluate our interactions with others, from an outside point of view. We don't see ourselves as others see us.

How different is your perception of yourself from that of the perceptions of other people? Melissa Dahl discusses the psychological research in that area in her book, *Cringeworthy; A Theory of Awkwardness*. She focuses on what psychologist Philippe Rochat calls "the irreconcilable gap" between the way you see yourself and the way other people see you. Note that in general we cannot even see what we look like or sound like to others. We generally only see our mirror images and we only hear our voices through the soundboard of our skull. Much of the feeling of awkwardness is based on the assumption that we are the center of our story and that other people are paying attention. They are *not*. Very few people actually notice much of anything about anyone outside themselves. As Dahl puts it, "You are the world's leading expert on you. You know so much about yourself that you can't help expecting others to see you the same way you see you, which is yet another reason why the irreconcilable gap can come as such a shock…. If you're nervous while giving a presentation, you imagine others can read those nerves all over your face. You imagine that others register your awkwardness and that because this moment is standing out to you, it will stand out to them, too."[3]

Most of the books I have read recently ignore this outside view, but it may be very important for cryonics revival in the future. The cryonics organization will need to help you re-establish your legal identity, to give you access to whatever property you may have saved, to connect you with family and friends, and to carve out an individual place for you in that future world. If you look like Fred but act like Joe or Alice, even people who knew you today might have difficulty believing your claimed legal identity is correct. It will be even harder if Fred and Joe and Alice *looked* a lot alike in the first place. You may know now what you *think* like; but you may have only a vague idea of how you *act*.

There is one step even deeper than the Self which we may need to understand in order to appreciate the difficult task of reviving cryonics patients. Will we still view "reality" in the same way?

What is Reality?

Since the answer to that question has eluded humans for millennia, you certainly are not going to find ultimate enlightenment in these pages. But since we are just focused on brain repair and how we acquire a more or less shared reality, I can make some useful points. From the point of view of physics, the real world on Earth contains a near-infinite number of strongly-associated clumps of atoms (solid matter), separated by another gargantuan amount of rather more weakly-associated atoms (liquid or gas). We can ingest or inhale some of those atoms for food, oxygen, and water in order to survive. Some of those clumps of matter will seek to ingest us.

But that's not the way we see the world around us. We learn very young to use our senses of vision, touch, hearing, taste, and smell to discriminate food from non-food, rough from smooth, our mother's voice from the dog's bark, and our mother's face from our father's face. Donald D. Hoffman, in his 1998 book, *Visual Intelligence, how we create what we see*, points out that children begin visual discrimination as young as one month and are already constructing 3-D visual images by their fourth month. Hoffman carefully explains how the brain takes visual images that could have many different interpretations and assigns 3-dimensional space and meaning to them. Much of that ability to assign meaning is innate; some of it is learned by experience; some of it is learned by sharing the interpretations of others (especially parents). But *vision* is in the brain, not in the eyes.

More recently Hoffman has theorized that evolution doesn't favor us perceiving exact reality. It favors us perceiving what is necessary to survive. Seeing the world as it really IS would probably be a detriment to survival.[4]

In *Hallucinations*, famed neurologist and writer Oliver Sacks discusses many types of hallucinatory phenomena, including many that he has experienced. He suggests that everyone has hallucinations of various kinds, though of course they can be overwhelming under brain conditions such as stroke or schizophrenia. "Hallucinations" are, more or less, things we sense (see, hear, feel, smell, etc.) while we are awake that no one else perceives to be there. (I worded that cautiously because there are other questions to be asked before we can use the phrase "that are not really there.") If you asked most people what they think if the word "hallucination" is used, they will assume that it refers to someone who is schizophrenic or on illegal drugs.

But Sacks points out that there are many other conditions and situations which cause hallucinations. In fact nearly all of us may have some experience in our life which qualifies for that definition. For instance, most people who have epilepsy or migraine headaches experience all kinds of visions and distortions as part of their attacks, from flashing lights to three-dimensional visions of people appearing before them. And not only visual disturbances – people with these conditions may hear phantom music or smell familiar childhood smells that seem to be completely "real." Brain tumors, concussions, strokes, or other forms of brain injury typically cause the individual to see visions, hear voices, or be convinced that some part of his body no longer belongs to him. Many patients have been misdiagnosed as being schizophrenic when in reality they had a stroke or a brain injury or a severe reaction to a prescription drug.

A very common form of hallucination is caused by "Charles Bonnet Syndrome" (CBS). This is what happens to as many as 30% of older people who lose their vision, especially from macular degeneration. The brain seems to fill in the visual blankness with extremely real-seeming hallucinations, from geometric patterns to printed music to faces to elaborate shows with actors marching up and down the walls. The part of the brain responsible for vision seems to be compensating for the loss of a major sense by finding something internally to occupy those neurons. A similar syndrome occurs with older people who lose their ability to hear, with the brain supplying a real-sounding substitute. You could see how a busy or under-educated physician or nurse could assume this was produced by mental illness.

Even more common are the brief aural or visual hallucinations that most of us have one time or another just as we are falling asleep or waking up (a different brain state than the actual dreams of deep sleep, Sacks tells us). This might include hearing someone call your name or someone seeming to be beside you in the bed, when the house is actually empty.

Ananthaswamy goes into this in more detail, with descriptions of the precise brain regions that appear to be involved in hallucinations like out-of-body experiences, phantom limbs, and other body confusions. Interestingly, even completely healthy adults can be fooled by certain illusions to have out-of-body experiences or to identify another body as their own. These are confirmed as brain phenomena by various kinds of scans.

This suggests that small errors in brain repair in the future, even ones which might not be noticed by the repair team, could severely disrupt our sense of reality, our sense of what belongs to us and what does not.

So let us ask ourselves, is what we label as "reality" better described as a conveniently shared hallucination? What kinds of future brain repair or reconstruction might prevent us from sharing the same form of reality that we do now? Could fixing what appears to be a brain flaw actually result in us not being able to perceive the same reality as everyone else?

What will happen to revived cryonics patients?

You probably have the same fantasy that I do. You'll quietly wake up in a lovely room, young and healthy, fully aware of your identity, with complete memories of your past, and with your friends there to say hello. You want to have the same identity you had before – same personality, same skills (perhaps enhanced), and same sense of "reality." This would include a perfectly functioning brain with no depression, mental illness, or addictions, but with a better memory. And of course a perfect body with no injuries, no diseases, inherited or acquired, and with the prospect of a long life with no aging.

With a few days of physical therapy, historical updating, and new cultural awareness training, you'll be an honored member of society, prepared to become a happy, skilled part of careers that do not even exist today, and ready to explore the galaxy.

Let's pull back the reins on that fantasy. First, the Alcor staff of the future will not know what changes you would like to make to yourself. Even if you provide Alcor with explicit instructions for your revival and enhancement, you can't expect future Alcor to take those instructions seriously. What you ask for may be illegal in that society or impossible for the technology available. Changes in the culture or unexpected developments in the technologies being used in that future might provide an entirely different set of choices at that time. Your failure to imagine the unimaginable might make your current list of demands appear foolish then.

What revival actions has Alcor actually promised in its documents?

Alcor's Mission Statement: *To save lives through the following prioritized principles:*

3. *Eventually restore to health and reintegrate into society all patients in Alcor's care.*

***Alcor's Cryopreservation Agreement**, Section V. REVIVAL*

c) Alcor represents that, in attempting to revive the cryopreserved Member, the objective will be to restore the Member to a state of healthy function with retention of memories, life experiences, skills, and personality (personal identity).

d) Where it is possible to do so, Alcor represents that it will be guided in revival of the cryopreserved Member by the Member's own wishes and desires as they may have been expressed in a written, audio, or video Statement of Revival Preferences and Desires, which the Member may at his/her discretion attach to this Agreement.

Alcor's Patient Care Trust:

SECOND: The Trust shall be for the exclusive non-profit scientific research and educational purpose of providing care for individuals (hereinafter called "Patients") who have been placed into cryonic suspension or other forms of biostasis as long-term research specimens by Alcor until such future time as it may be possible to repair and revive them to such a condition as will allow them to be considered legally alive, functional, and independent.

Let's focus on this: *the objective will be to restore the Member to a state of healthy function with retention of memories, life experiences, skills, and personality (personal identity).*

It's a good objective; but note that it only refers to who and what the Member was *in the past*. Alcor cannot promise now to make unknown choices for you in the future. It seems much more reasonable to assume that Alcor's goal should be to return you to as healthy a state as it is possible to get, and then let you decide what enhancements you may want once you have understood the fresh possibilities in front of you. Note that Alcor does not promise to be the organization that gives or sells you the enhancements.

This does mean, however, that it is Alcor's goal to do more than simply return your brain to the state it was in right before you were cryopreserved. For nearly everyone, that state would still be "dead" or "almost dead." Some of you might say that advanced computing power and knowledge will allow future researchers to infer the various structure and connections that would have been in the brain before cryopreservation. Even if that were true, your goal is NOT to return to the level of health and awareness you were in just before you were cryopreserved. Remember? "Functional, healthy, independent."

It would be extremely difficult and probably impossible without a time machine to infer the state a patient's brain was in before *the dying process* began. It is not just Alcor-caused damage that must be reversed. It is the combination of aging, brain cancer, atherosclerosis, concussions, diabetes, viruses, coma, ischemia, Alzheimer's disease, etc. over a period of days, weeks, and years. Your particular combination of heredity, birth condition, learning, memory, and damage will be unique. Will neurologists of the future be able to tell which variations from the theoretical norm are the results of birth, development, and learning and which occurred as a result of various forms of brain damage? It looks possible that, for most of us, achieving even basic repair goals may require some brain reconstruction and educated guesses.

But what if it is impossible to achieve both a fully working brain and the complete retention of your identity? What if "who you are" and even your talents and base personality are the result of the brain and body imperfections you were born with and how they changed over your life?

What if the basic traits of creativity, imagination, and worldview are inherently produced by individual brain quirks? Are the brains of the most creative and imaginative people the ones furthest away from the "standard" brain? Would a perfectly repaired brain, or even an *adequately* repaired brain, leave you at a competitive disadvantage in fields that require creativity? Would a world full of perfectly functioning human brains reduce the creativity and invention which have propelled progress for thousands of years?

And even then, I am making this process of brain repair sound much simpler than it will be. Over the past few years, Alcor has without a doubt improved its ability to preserve brain structure. Is it good enough? Improved as it might be, brain research in general has still not progressed far enough to determine what "good enough" is, so we can't answer that question. But even if we have crossed some useful boundary of preservation, it is highly likely that your brain even now has some damage associated with aging or with some as yet unrecognized disease process. We can't predict what will happen to the brains of revived cryonics patients – because it has never been done before. That hasn't even been accomplished with animals yet. We have no test subjects to compare. Let's face it – no one else besides us is even *asking* this question.

A lot of learning about the tiniest details of brain structure will be required over the next several decades. Even more importantly, we will have to gain a thorough understanding of how the various parts of the brain *connect and interact* to produce a Self which comprehends the world. Many years ago Alcor writer Thomas Donaldson suggested that perhaps many of the parts of the brain were interchangeable and could be repaired or replaced easily, as long as the parts which made up the individual were carefully preserved and repaired. Based on my reading for this article, I am increasingly dubious that such an approach would reproduce the individuals that we think we are.

And if a significant part of developing a Self is done through experiential learning — even the basic process of learning what things are us and what things are "not-us" — how will future technicians know the ways to implant those connections? Will we have to start over as mental infants?

As I alluded to earlier, what if our *Selves*, our identities, were actually tied to the imperfections in our brains? Perhaps it is not merely the things you are bad at that are the result of your imperfect brain. Is it possible that your talents are also a result of the unique way your brain areas connect and communicate? As an extreme example, what if a very talented person with Asperger's were to have his brain "fixed" after cryopreservation so that he was "normal." Is that the same person? What if the process of cryonics revival meant that you as an individual no longer remembered how to speak your native language or that you were a computer programmer or heterosexual or a parent, etc.? How are the brain repair specialists of the future supposed to know your *personality*, in order to bring you back to the same *identity*?

There is one more aspect of the future to consider. Could the definition of "sane" be different some decades or centuries into the future? Certainly there are any number of behaviors that were acceptable or tolerated 200 years ago that would be evidence for psychiatric intervention today. And vice versa. If right now you took a time machine trip back to the 1700s, are you sure your attitudes and behaviors would be considered sane then? If you leave instructions that you want to be "upgraded" to the levels of health, intelligence, and sanity available in the future, what kinds of brain reconstruction alterations in your identity and personality will be required? Do you want future repairs specialists to make those decisions for you; or would it be better to wait for the future version of you to look at the real possibilities?

There is fortunately *some* room for optimism. We have long hypothesized that the first patients to come out of cryopreservation will be some of the last people who went into that state. Assuming that cryonics rescue is an accepted and common medical technology and that medicine has progressed to a point where most disease states are preventable and repairable, then cryonics patients at that time will often be people who had the least amount of damage from disease and from the preservation process itself. In such a situation, researchers will have spent many years testing their procedures on preserved animals and will be able to examine the recoveries of those first revived patients. Knowledge is everything. We have a long way to go but we can count on human medical knowledge to expand.

What should I do now?

If you put together a billion megabytes of information about yourself but your brain is not well preserved, it is difficult to imagine how brain repair specialists of the future will be able to translate that information into structure. Even *if* your brain is well-preserved, will anyone ever figure out how to translate information into structure that integrates with other brain structures?

It seems very possible that even if everything goes well, "perfect" brain repair will result in … an imperfect you. From the point of view of outsiders, it might be a better you or a worse you. From your point of view….? Maybe TODAY'S YOU is worried that you will be different in the future. Your tastes, your interests, your mental and physical abilities, even the way you form relationships could be different after brain repair. The good news is that the FUTURE YOU probably won't notice too much. Whatever you are then is what you will think of as normal. If you go back and research who you were in the past – and who your friends thought you were – you may well think that the old you (i.e., who you are now – are you keeping track of this?) was the odd one. Whether that is pessimistic or optimistic is up to you.

Remember, you got into cryonics because you like being alive, because you have hope for the future, because you like the adventure of the idea, and because death ends the adventure.

Even with the knowledge that your specific personality and memories may be different after brain repair, the adventure is still there. If you expect that you will wake up to a world where everything about you and your life is the same, except with flying cars and better computers, you're not paying attention. "Adventure" always includes an element of danger and uncertainty, or else where is the "adventure" part?

Does the haziness of the details of your future affect how you personally view cryopreservation? Perhaps you should have appreciated that doubt before. Will the future you continue the narrative Self of your story? Will it be merely a genetic continuation with a new Self? Should that person be viewed as a new identity altogether? We can't know that yet. You – or someone labeled as "you" – will find that out someday. No doubt surprises await us, whomever "we" end up becoming.

Enjoy the adventure. ■

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Endnotes

1 Thomson, p. 108.
2 Ananthaswamy, p. 173.
3 Dahl, p.125.
4 Folger, Tim. "Your Daily Dose of Quantum." Discover, November, 2018, p.31-37.

Fight Aging!

Reports From the Front Line in the Fight Against Aging

Reported by Reason

Fight Aging! exists to help ensure that initiatives with a good shot at greatly extending healthy human longevity become well known, supported, and accepted throughout the world. To this end, Fight Aging! publishes material intended to publicize, educate, and raise awareness of progress in longevity science, as well as the potential offered by future research. These are activities that form a vital step on the road towards far healthier, far longer lives for all.

Proposing the IMM-AGE Metric to Measure the Aging of the Immune System

March, 2019

Determinations of biological age based on ever more detailed measurements of human cellular biochemistry are known as clocks. Biological age is distinct from chronological age, as different people age at somewhat different rates. Aging is an accumulation of cell and tissue damage and the consequences of that damage; more damage means a higher biological age. The best known clock examples are the well known varieties of epigenetic clock, based on patterns of DNA methylation that decorate the genome. In recent years, researchers have been rapidly developing other sorts of clock, using other measures of cellular biochemistry and metabolism. The one here is an example of the type, focused on immune system function.

Quote

The immune system is the critical function in the body for managing health. It is a complex system with hundreds of different cell-types. Until now, no metric had existed to quantify an individual's immune status. New data, while requiring further development, describes a metric (called IMM-AGE) by which we can accurately understand a person's immune status, providing increased information for accurate prediction and management of risks for disease and death.

This new capability will have drug development implications: Given the importance of immune status in vaccine response, this new data could play a significant role in both the design of future vaccine trials and in re-evaluating past vaccine trials. Moreover, this new metric for immune aging could see chronological age augmented by "immune age" as a way of improving drug development programs – providing for enhanced clinical trial entry/exclusion criteria that can elicit a more homogeneous response and greater likelihood of success.

The researchers developed their unique data by following a group of 135 healthy volunteers for nine years, taking annual blood samples which were profiled against a range of 'omics' technologies (cell subset phenotyping, functional responses of cells to cytokine stimulations and whole blood gene expression). This captured population- and individual-level changes to the immune system over time, which when analyzed using a range of novel, immune aligned, machine learning analytical technologies, enabled identification of patterns of cell-subset changes, common to those in the study, despite the large amount of variation in their immune system states. The data and metrics generated was then validated against a cohort of more than 2,000 patients from the Framingham Heart Study.

Link: https://www.eurekalert.org/pub_releases/2019-03/c-ndu031119.php

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Thoughts on Attending Undoing Aging 2019

April, 2019

I recently attended the second Undoing Aging conference in Berlin, the big central conference for our long-standing – and recently greatly expanded – community of researchers, entrepreneurs, investors, and numerous supporters, all engaged in some way in the great project of building the technologies needed for human rejuvenation. This year the event was significantly bigger than last year. The conference was hosted by the Forever Healthy Foundation and the SENS Research Foundation, and is in many ways a platform for spreading and building upon the views of Aubrey de Grey and Michael Greve on aging and how it should be tackled by the medical research and development community. That means addressing the fundamental causes of aging, those outlined in the SENS rejuvenation research programs.

Interestingly, there was a strong Russian contingent present, researchers, venture capitalists, and advocates. They don't make it out to the US quite so often. I finally met Mikhail Batin, one of the figures behind the Science for Life Extension Foundation and Open Longevity initiatives, whose writing I have noted over the years. I made a $50 bet with him that senolytics either will or won't be shown to finally work this year. You can probably guess which side of that wager I took. Like many in the Russian longevity community, he perhaps feels that removal of senescent cells is too simple a strategy in the face of the metabolic complexity of aging. It is a little too trite to say that Russians tend towards a programmed aging viewpoint, but it isn't entirely incorrect. Targeting points of comparative simplicity, the causes of aging, is of course the SENS rejuvenation research strategy – but as this exchange illustrates, we advocates have yet to convince everyone, even in the community, and even given the stunning technical successes in senolytic studies of recent years.

Among the Russian investors, Andrey Fomenko of IVAO made an appearance to chat to some of the entrepreneurs present, such as Doug Ethell of Leucadia Therapeutics and the Oisin Biotechnologies team. Fomenko is worthy of note here, distinct from several other Russian venture capital folk, for setting up the Eternal Youth Fund, somewhat analogous to some of the funds in the English language world, such as the Longevity Fund or Juvenescence. Jim Mellon of Juvenescence was also present at the conference, of course, with rarely a spare moment to say hello between being pitched on one project or another. Given that he has funded a good fraction of the companies in the rejuvenation biotechnology space at this point in time, this will probably be a good summary of his daily experience for the next decade or so. This is a vigorous growth market.

You'll have to forgive me for providing few details as to what was actually presented at Undoing Aging, either in posters or the presentations. The science progresses, but these days I am an entrepreneur with my own biotech company working on methods of rejuvenation, and so when I go to conferences I am no longer able to listen to all that many of the presentations. Instead I must pitch investors and network relentlessly. Fortunately, the presentations were recorded, including my outline of how things are going at Repair Biotechnologies with our preclinical work on thymic rejuvenation and reversal of atherosclerosis, and they will be uploaded to YouTube once the technical folk are done with them.

Taken as a whole, a great deal of interesting research and development was announced at the conference, both by startup companies and research groups. Undoing Aging is very much the event to be presenting at if one wants to gain attention for one's work. Like the upcoming July Ending Age-Related Diseases conference organized by LEAF in New York City, this is a meeting of people with funds and the people who can deploy those funds to make progress towards the goal of the medical control of aging. Transactions take place, and a great deal of new funding is entering this space. Numerous organizations and high net worth individuals are setting up funds devoted to the longevity industry, following Juvenescence, Life Biosciences, and the like, or changing their focus to include this novel area of biotechnology as it expands rapidly. A tipping point has passed, and there is now more than enough seed stage funding out there for anyone with a credible project and team.

One of the topics of discussion that came up several times, with a number of different people, quite independently of one another, is that given the amount of time we advocates spend trying to educate entrepreneurs and investors new to the field, we should produce a bible on how to enter the longevity space, either to start a company, or to fund a company. A good dozen people in our core community, those who have been involved for a decade or more, have had that experience over the past few years, so the memories are still fresh. We don't have enough entrepreneurs in the present community to tackle even a tiny fraction of all the rejuvenation biotechnology projects that could proceed to preclinical development in a startup, and thus these entrepreneurs must arrive from somewhere, comparatively ignorant. We want them to take up effective projects based on the SENS view of aging, and not be sidetracked into marginal work.

Equally, on the investment side of the house, investors in any field have traditionally had the challenge of identifying high expectation value projects, when the differences between great, merely good, and useless are extremely technical. When it comes to treating aging as a medical condition, there is an enormous chasm between the benefits that might be realized through traditional small molecule tinkering with metabolism (e.g. calorie restriction mimetics) and new approaches that actually reverse the causes of aging (e.g. senolytics). The latter are reliable, have large effects, and progress is comparatively easy. The former are unreliable, have marginal effects, and progress is challenging and expensive. It can take some time to learn enough to be able to determine which of these categories any given therapy falls into.

Thus we, the advocates, definitely need to step up and become more organized. We can't reach out one by one with a personal connection to every investor and entrepreneur, and carry out an intervention to prevent more marginal initiatives from launching. That doesn't scale. What we can do is establish a baseline of education and common sense regarding the field, and spread that understanding far and wide. We can thus help newcomers enter the community with enough knowledge to further educate themselves, and to make more sensible choices along the way regarding the projects they undertake.

Of the interesting news from the conference, the SENS Research Foundation is (finally) directly spinning out a for-profit company, rather than only being more indirectly involved in the process of commercializing SENS-related biotechnology. The initiative involves an interesting take on how to get rid of the

7-ketocholesterol that is an important cause of atherosclerosis, spurring the condition by turning macrophages into inflammatory foam cells. The SENS Research Foundation researchers have found a class of molecule that seems fairly innocuous in terms of side-effects and is able to bind to 7-ketocholesterol and remove it from cells. We will no doubt be hearing more on this later, as the project progresses beyond the setup phase and into properly running as a business and raising venture funding.

It also seems that the Forever Healthy Foundation crowd have the ambition to establish an aging research institution for Berlin after the model of the Buck Institute in California, to work towards making the city a center for aging research as well as all the other items it is famed for. This is a constructive ambition, and the people involved have the connections and the resources to make it happen, given enough time. I look forward to seeing this project make progress. Per a discussion with the Forever Health Foundation at the end of the conference, the third Undoing Aging conference next year should prove to be yet bigger than this year's. The event has outgrown the present venue quite handily, and was forced to turn people away in the final days of registration. These are all signs of success, I hope. Still, it is now up to all of those working on therapies and the foundations of therapies to take the new opportunities for funding, and use that funding make the biotechnologies of repair and rejuvenation a reality. Convincing the investors and philanthropists of the world to fund these goals is just step one in the process.

Revival Update

Scientific Developments Supporting Revival Technologies

Reported by R. Michael Perry, Ph.D.

Mechanical Computing Systems Using Only Links and Rotary Joints

Ralph C, Merkle, Robert A. Freitas Jr., Tad Hogg, Thomas E, Moore, Matthew S. Moses, James Ryley

www.arxiv.org

27 Mar. 2019

Source(s): https://arxiv.org/pdf/1801.03534.pdf, accessed 19 Jun. 2019

Abstract

A new model for mechanical computing is demonstrated that requires only two basic parts: links and rotary joints. These basic parts are combined into two main higher level structures: locks and balances, which suffice to create all necessary combinatorial and sequential logic required for a Turing-complete computational system. While working systems have yet to be implemented using this new approach, the mechanical simplicity of the systems described may lend themselves better to, e.g., microfabrication, than previous mechanical computing designs. Additionally, simulations indicate that if molecular-scale implementations could be realized, they would be far more energy-efficient than conventional electronic computers.

Introduction (referencing omitted)

Methods for mechanical computation are well-known. Simple examples include function generators and other devices which are not capable of general purpose (Turing-complete) computing, while the earliest example of a design for a mechanical general purpose computer is probably Babbage's Analytical Engine, described in 1837. One of the very first modern digital computers was a purely mechanical device: the Zuse Z1, completed in 1938. At a time when silicon-based electronic computers are pervasive, powerful, and inexpensive, the motivation for studying mechanical computer architectures is not immediately obvious. However, many research groups are currently investigating mechanical, electromechanical, and biochemical alternatives to conventional semiconductor computer architectures because of their unique potential advantages. For example, mechanical systems can withstand much higher temperature and radiation exposure than their electronic counterparts, and hence may be useful in certain niche applications. DNA computing makes use of vast numbers of molecules to solve computational problems in parallel.

One potential advantage of these many alternative computing architectures is energy efficiency. The new mechanical approach presented in this paper is particularly well-suited for implementing physically reversible logic gates. Reversible logic gates are one alternative technology that can, in principle, sidestep fundamental limitations of complementary metal-oxide-semiconductor (CMOS) transistors, and thus facilitate computers that operate with vastly reduced energy dissipation. While previous designs for mechanical computing vary greatly, the few designs capable of general purpose computing require a substantial number of basic parts, such as various types of sliding plates, gears, linear motion shafts and bearings, springs (or other energy-storing means), detents, ratchets and pawls, and clutches. The use of many parts brings with it a number of potential problems, such as increased friction, higher mass, and increased device complexity. Such issues can reduce performance and increase the difficulty of manufacturing. However, reducing the number, complexity, and mass of parts in a mechanical computer is not a simple task due to the need to provide both universal combinatorial logic (e.g., AND, NAND, NOR, etc.) and sequential logic (memory). Sequential logic in particular, being the basis for memory, requires the ability to conditionally decouple logic elements from current inputs. This is because memory cannot be only a deterministic result of just current inputs, otherwise previous states cannot be saved. Storing information, which is easily accomplished in electronic systems using latches or flip-flops, is not as easily accomplished in a mechanical system which may have to actually connect and disconnect parts of the system from each other (e.g., using a clutch-like mechanism) at appropriate times. This paper demonstrates that mechanical computers can be greatly simplified by using only two parts: links and rotary joints.

A Parallel Multiple Layer Cryolithography Device for the Manufacture of Biological Material for Tissue Engineering

Gideon Ukpai, Joseph Sahyoun, Robert Stuart, Sky Wang, Zichen Xiao and Boris Rubinsky

ASME Digital Collection, https://medicaldevices.asmedigitalcollection.asme.org/article.aspx?articleid=2728063, accessed 27 Jun. 2019.

Abstract

While 3-D printing of biological matter is of increasing interest, current linear 3-D printing processes lack the efficiency at scale required to mass manufacture products made of biological matter. This paper introduces a device for a newly developed parallel additive manufacturing technology for production of 3-D objects which addresses the need for faster, industrial scale additive manufacturing methods. The technology uses multilayer cryolithography (MLCL) to make biological products faster and in larger quantities by simultaneously printing 2-D layers in parallel and assembling the layers into a 3-D structure at an assembly site, instead of sequentially and linearly assembling a 3-D object from individual elements as in conventional 3-D printing. The technique uses freezing to bind the 2-D layers together into a 3-D object. This paper describes the basic principles of MLCL and demonstrates the technology with a new device used to manufacture a very simple product that could be used for tissue engineering, as an example. An evaluation of the interlayer bonding shows that a continuous and coherent structure can be made from the assembly of distinct layers using MLCL.

From: **Mass-Producing Biomaterials: UC Berkeley Innovations Speed up 3D Bioprinting** by Linda Vu, Berkeley Engineering, 8 Apr. 2019, https://engineering.berkeley.edu/2019/04/mass-producing-biomaterials, accessed 27 Jun. 2019.

More than 113,000 people are currently on the national transplant list. And with a shortage of donors, this means that about 20 people will die every day while waiting for an organ, according to the U.S. Department of Health.

But this could change thanks to researchers at UC Berkeley, who have developed a device that may be key to the viability of bioprinting, an extension of 3D printing that allows living tissue, bone, blood vessels and even whole organs to be printed on demand. A paper on this work was recently published in the Journal of Medical Devices.

Currently, there are two major hurdles standing in the way of organ printing. Because living cells and functioning organs require specialized temperature and chemical conditions to survive, cells deteriorate during the actual 3D printing of a large organ because the process is too slow. And even if the organ can be printed in 3D, the logistics of transporting it requires storage, which has always been a bottleneck for transplants.

To overcome the storage problem of these manufactured organs, the team relied on seven decades of knowledge and techniques for preserving single cells. Their technique freezes each 2D layer immediately after it is merged into the 3D structure, and this process of freezing a single layer of cells provides optimal conditions for surviving the process of freezing, storage and transportation.

Robotic arm stacking layers of 2D tissues.
(Photo courtesy of Gideon Ukpai, UC Berkeley)

From prosthetics and implants to dental crowns and hearing aids, 3D printers are being used to manufacture a whole host of customized medical devices for patients in need. So, why not organs, too?

Not surprisingly, the intricate, mushy tissues that make up most human organs are not as easy to 3D-print as stiff scaffolds for prosthetic devices or chassis for hearing aids. But a new device created by engineers at UC Berkeley promises to make the 3D printing of biomaterials like organs and food a lot more viable.

Living cells require very specific temperature and chemical conditions to survive and will often deteriorate during a lengthy printing session. The new device uses identical printers to create multiple layers simultaneously, and then stacks them one on top of the other to form the 3D structure. This arrangement speeds up the printing process and makes it more likely that the cells will stay alive.

The device also freezes each layer of cells as it is added to the stack, giving the newly-formed biomaterial a better chance of surviving a lengthy storage period.

"The problem with 3D bioprinting is that it is a very slow process, so you can't print anything big because the biological materials will deteriorate by the time you finish," said Boris Rubinsky, professor of mechanical engineering and leader of the team that designed the device. "One of our innovations is that we freeze the material as it is being printed so that the biological material is preserved, and we can control the freezing rate."

A Roadmap to Revival

Successful revival of cryonics patients will require three distinct technologies: (1) A cure for the disease that put the patient in a critical condition prior to cryopreservation; (2) biological or mechanical cell repair technologies that can reverse any injury associated with the cryopreservation process and long-term care at low temperatures; (3) rejuvenation biotechnologies that restore the patient to good health prior to resuscitation. OR it will require some entirely new approach such as (1) mapping the ultrastructure of cryopreserved brain tissue using nanotechnology, and (2) using this information to deduce the original structure and repairing, replicating or simulating tissue or structure in some viable form so the person "comes back."

The following is a list of landmark papers and books that reflect ongoing progress towards the revival of cryonics patients:

Jerome B. White, "**Viral-Induced Repair of Damaged Neurons with Preservation of Long-Term Information Content**," Second Annual Conference of the Cryonics Societies of America, University of Michigan at Ann Arbor, April 11-12, 1969, by J. B. White. Reprinted in *Cryonics* 35(10) (October 2014): 8-17.

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Gregory M. Fahy, "**A 'Realistic' Scenario for Nanotechnological Repair of the Frozen Human Brain**," in Brian Wowk, Michael Darwin, eds., *Cryonics: Reaching for Tomorrow*, Alcor Life Extension Foundation, 1991.

Ralph C. Merkle, "**The Molecular Repair of the Brain**," *Cryonics* 15(1) (January 1994):16-31 (Part I) & *Cryonics* 15(2) (April 1994):20-32 (Part II).

Ralph C. Merkle, "**Cryonics, Cryptography, and Maximum Likelihood Estimation**," First Extropy Institute Conference, Sunnyvale CA, 1994, updated version at http://www.merkle.com/cryo/cryptoCryo.html.

Aubrey de Grey & Michael Rae, "**Ending Aging: The Rejuvenation Breakthroughs That Could Reverse Human Aging in Our Lifetime**." St. Martin's Press, 2007.

Robert A. Freitas Jr., "**Comprehensive Nanorobotic Control of Human Morbidity and Aging**," in Gregory M. Fahy, Michael D. West, L. Stephen Coles, and Steven B. Harris, eds, *The Future of Aging: Pathways to Human Life Extension*, Springer, New York, 2010, 685-805.

Chana Phaedra, "**Reconstructive Connectomics**," *Cryonics* 34(7) (July 2013): 26-28.

Robert A. Freitas Jr., "**The Alzheimer Protocols: A Nanorobotic Cure for Alzheimer's Disease and Related Neurodegenerative Conditions**," *IMM Report* No. 48, June 2016.

Ralph C Merkle, "**Revival of Alcor Patients**," *Cryonics*, 39(4) & 39(5) (May-June & July-August 2018): 10-19, 10-15.

What is Cryonics?

Cryonics is an attempt to preserve and protect human life, not reverse death. It is the practice of using extreme cold to attempt to preserve the life of a person who can no longer be supported by today's medicine. Will future medicine, including mature nanotechnology, have the ability to heal at the cellular and molecular levels? Can cryonics successfully carry the cryopreserved person forward through time, for however many decades or centuries might be necessary, until the cryopreservation process can be reversed and the person restored to full health? While cryonics may sound like science fiction, there is a basis for it in real science. The complete scientific story of cryonics is seldom told in media reports, leaving cryonics widely misunderstood. We invite you to reach your own conclusions.

How do I find out more?

The Alcor Life Extension Foundation is the world leader in cryonics research and technology. Alcor is a non-profit organization located in Scottsdale, Arizona, founded in 1972. Our website is one of the best sources of detailed introductory information about Alcor and cryopreservation (www.alcor.org). We also invite you to request our FREE information package on the "Free Information" section of our website. It includes:

- A fully illustrated color brochure
- A sample of our magazine
- An application for membership and brochure explaining how to join
- And more!

Your free package should arrive in 1-2 weeks. (The complete package will be sent free in the U.S., Canada, and the United Kingdom.)

How do I enroll?

Signing up for cryopreservation is easy!

Step 1: Fill out an application and submit it with your $90 application fee.
Step 2: You will then be sent a set of contracts to review and sign.
Step 3: Fund your cryopreservation. While most people use life insurance to fund their cryopreservation, other forms of prepayment are also accepted. Alcor's Membership Coordinator can provide you with a list of insurance agents familiar with satisfying Alcor's current funding requirements.
Finally: After enrolling, you will wear emergency alert tags or carry a special card in your wallet. This is your confirmation that Alcor will respond immediately to an emergency call on your behalf.

Not ready to make full arrangements for cryopreservation? Then *become an Associate Member* for $5/month (or $15/quarter or $60 annually). Associate Members will receive:

- *Cryonics* magazine by mail
- Discounts on Alcor conferences
- Access to post in the Alcor Member Forums
- A dollar-for-dollar credit toward full membership sign-up fees for any dues paid for Associate Membership

To become an Associate Member send a check or money order ($5/month or $15/quarter or $60 annually) to Alcor Life Extension Foundation, 7895 E. Acoma Dr., Suite 110, Scottsdale, Arizona 85260, or call Marji Klima at (480) 905-1906 ext. 101 with your credit card information. You can also pay using PayPal (and get the Declaration of Intent to Be Cryopreserved) here: http://www.alcor.org/BecomeMember/associate.html

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