

ALCOR LIFE EXTENSION FOUNDATION

A Non-Profit Organization

CRYONICS

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Why Cryonics Makes Sense

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**“Scientific Proof”
for Cryonics?**

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**Micro- to Nanoscale
3D Printing**

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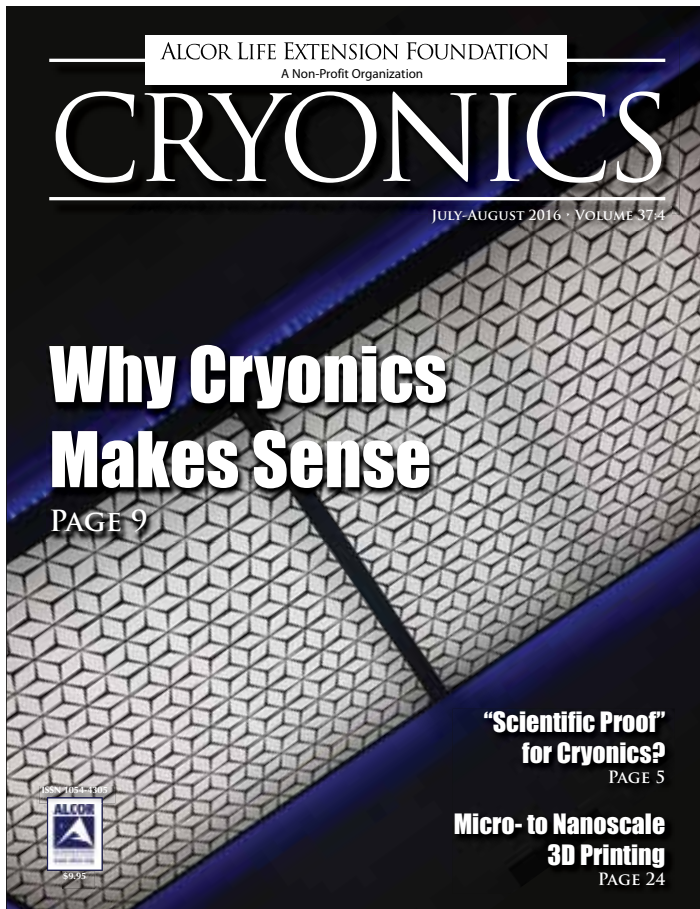
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CRYONICS



COVER STORY: PAGE 9

Why Cryonics Makes Sense

Tim Urban's *Why Cryonics Makes Sense* has been called one of the best articles ever published about cryonics. In this extensive survey of pro- and anticryonics arguments Tim Urban consults a wealth of information and concludes that cryonics makes sense. Publication of this review on his *Wait But Why* website has produced a sharp spike in interest in cryonics and an increase of information requests and (associate) membership. Alcor is proud to reprint this article with permission of the author.

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“Scientific Proof” for Cryonics?

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While some governments might be marginally better than others, over spans measured in multiple centuries and longer, no existing human institution seems capable of providing the kind of stability and consistently sound decision making that seems required if we are to enjoy long term global security, particularly when we consider the exponential advances we are making in technology and the multi-century and longer lifespans that we expect to enjoy. A useful approach to a better form of governance, it is argued, would be a form of democracy based on “Futarchy”—governance by prediction markets. The Futarchy in turn would be implemented using a Decentralized Autonomous Organization (DAO) based loosely around the Bitcoin algorithm.

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QUOD INCEPIMUS CONFICIEMUS



“SCIENTIFIC PROOF” FOR CRYONICS? By Aschwin de Wolf

A cryonics advocate makes an eloquent case for cryonics and then a scientist is called upon to dismiss the idea of cryonics because there is “no proof” for it. Unfortunately, such a statement reveals that the “scientist” in question does not know the difference between empirical science and logic, and also does not understand the difference between cryonics and suspended animation.

As the evolutionary biologist Satoshi Kanazawa writes in a November 16, 2008 column for *Psychology Today* “The knowledge that there is no such thing as a scientific proof should give you a very easy way to tell real scientists from hacks and wannabes... Proofs exist only in mathematics and logic, not in science. Mathematics and logic are both closed, self-contained systems of propositions, whereas science is empirical and deals with nature as it exists. The primary criterion and standard of evaluation of scientific theory is evidence, not proof.” He goes on to write that “all scientific knowledge is *tentative* and *provisional*, and nothing is final. There is no such thing as final proven knowledge in science.”

What is the proper role of science in cryonics? Let’s say that a person (let’s call him Robert) proposes that if we freeze a person after clinical death there is a reasonable expectation that more advanced medical technologies can reverse the freezing damage, the medical condition that gave rise to this person’s critical condition, and also the aging process that caused this medical

condition in the first place. We can respond to this proposal by asking a number of questions. What will freezing do to the fine structure of the brain? How will future medical technologies infer the original state of the brain from the frozen state? What kind of technologies are required to repair the brain and restore the person to a healthy and youthful state?

These are the kinds of questions where science (and reasonable extrapolations of where science will be heading) is important in evaluating the idea of cryonics. And we cannot just consult existing science, we can also push science in the direction of minimizing the damage incurred during cryopreservation so the odds of revival for the typical cryonics patient will increase. For example, in 2000 Alcor changed its protocol from limiting freezing to eliminating it through a technology called vitrification. Advances in gene editing, virus modification, and nano-scale 3D printing can make the idea of cell repair more plausible. Advances in science and technology of this nature can make people update their prior (subjective) estimates about the probability of cryonics being successful.

What such advances in science cannot do is to provide “proof” that cryonics will work. They cannot do this because all scientific knowledge is “tentative and provisional,” but it also cannot do this for a more fundamental reason. Cryonics is not suspended animation. Cryonics concerns

stabilizing people for whom no successful medical treatment is available to permit them to benefit from *future* advances in medicine. By definition, it is not possible to prove that these technologies *will* become available.

What people who insist on “proof” for cryonics want to see is evidence of reversible cryopreservation. Human suspended animation is indeed a research and clinical objective that a credible cryonics organization should aim for. But it cannot be emphasized enough that while “proof” of suspended animation would provide strong support for the practice of cryonics is it is not necessary for the cryonics idea to be plausible. What is necessary for cryonics to work is that the brain (and rest of the body) of a person are preserved to a degree that the original, healthy, state of the brain can be inferred from the preserved state. Perhaps future “neurological archeology” technologies will reveal that even freezing of the brain without cryoprotectant allows for complete revival.

A proper understanding of cryonics requires that scientists recognize the difference between providing proof and updating expectations based on empirical evidence. But it also requires a scientist, as the great cryonics writer Thomas Donaldson recognized, to make peace with the unknown because the capabilities of future science remain a matter of debate and we cannot say for certain when a person is dead by information-theoretic criteria. ■

CEO Update

By Max More



INSTITUTIONAL CONTINUITY AND MEMORY

Whenever I'm grilled in-depth about cryonics and Alcor, I explain that we do not expect to be able to revive anyone for decades. Even those yet to be cryopreserved with better methods may not be revived for perhaps a century. Some of our members think that it might be more like half that, based on the assumption that super-intelligent AI will drastically accelerate our understanding of biological systems and our ability to fix them. Even if you tend toward this optimistic time frame, Alcor will need to survive and care for its patients for decades to come—considerably longer than the life span of most organizations.

In a future article (based on a talk given a while ago), I will examine the factors that have allowed some types of organizations to survive for centuries. It's noteworthy that Alcor is now in its 45th year. Here, I want to point out the human factors that have helped to maintain organizational continuity.

While staff members come and go, three of our current team have been with Alcor for over a decade. Diane Cremeens, Membership Department Coordinator, started back in August 2004, going full-time that December. Michael Perry, Care Services Manager (and frequent contributor to *Cryonics* magazine), started working full-time for Alcor on May 10, 1987, originally thanks to financial support from David Pizer. Hugh Hixon, Facilities Engineer and Research Fellow (among many roles), has the greatest staff longevity, having come aboard back in April 1983—a third of a century ago!

On the board of directors, continuity has been brought especially by the four

longest-serving directors. Brian Wowk joined the board in 2004; Saul Kent in 2001; Ralph Merkle in May 1998 (over 18 years ago); and Michael Riskin in 1993 (23 years ago).

Alcor has been served by 13 presidents. We have seen more turnover in this position than optimal for continuity (setting aside other considerations). When I started in this position at the end of December 2010 (officially January 1, 2011), I calculated the average length of tenure of all previous presidents as being only 2.6 years. Looking at the most recent decade or so (prior to 2011), the average tenure fell to a mere 1.6 years.

No one had held the position of president for more than 3 years since Steve Bridge left in 1997 after 4 years, 1 month. This was a little daunting! However, by the time you read this (and a few days after I write it), I will have been president for almost 5.5 years—longer than anyone else, continuously. (Co-founder Fred Chamberlain was president for a total of 6 years and 8 months, but that was spread out over three different periods of time.)

Continuity-through-personnel is not the only means of preserving institutional memory. In recent years, we have also created numerous SOPs (documentation of multiple procedures for each staff member), as well as the still-developing Human Cryopreservation Procedures manual. In addition, one of my long-term and gradual projects is the compilation of a history of Alcor. The goal is to gather and present all the major events in Alcor's history. This should help Alcor personnel, new and old, better form a sense of the past. One day, I expect to point my successor to this completed compilation, along with a

manual for future presidents—something that seems never to have existed.

IMPROVEMENTS AND EXTENSIONS

Quality control: This is a big topic and one for a future article. In the course of a push to catch up a backlog of reports on recent cases, we have refined the case report template and created a case report checklist. The checklist has gone through several versions. It serves to create consistency between reports and to ensure that as much data as possible is captured and included in the reports. For instance, the template and checklist tell the report writer to include, whenever possible, these standard graphs: Stabilization Temperatures; Transport Temperatures; Cryoprotectant Perfusion Concentration; Cryoprotectant Perfusion Temperatures; Cryoprotectant Perfusion Pressure and Flow; Cryogenic Cooling Temperatures; and Final Cooling Temperatures.

The checklist (a completed version of which now accompanies drafts of each report) reminds the writer of general points to include; to check whether all relevant sections are included; to ensure that standard graphs are included and to add a link to a CT scan, where available; what should be included in the time line; and sets forth principles for consistency of style.

The template and checklist work in conjunction with regular debriefings following cases. We are also making better use of video to fill in details and to check on manually-recorded time lines. Of course, well-structured and detailed reports will be of limited value unless we are committed to follow through on action points listed in the Issues and Concerns section.

Facility improvements and changes:

As you can see in the accompanying photo, we have dramatic new front office lights. This may look like an expensive piece of custom lighting but, in fact, the new LED-powered lighting display was designed and created by Steve Graber. This stunning arrangement not only enhances visual appeal for visitors, it also saves us electricity and reduces heat.



New overhead LED tube lights have been also been installed in the Patient Care Bay. The LEDs produce a brighter, more daylike look as well as saving money.

We are currently planning to expand the Patient Care Bay itself from Unit 106 into 105. Notice was given to the occupant of unit 104, and that the unit is now available to Alcor, enabling us to begin work on expanding the PCB and increasing room for cooldown units and other equipment. We have an architect working on plans for expanding the Patient Care Bay. Since the tenant cleared the space early, we can start the first job which is to create an entrance large enough to allow entry for our emergency response vehicle in Unit 104.

We are allowing ample additional front-office space for new staff and for building tubing kits, and so on. Even so, based on early sketches by Steve Graber, and assuming the adoption of the yet-to-be-tested Superdewars (each holding 9 whole-body patients, or 8 whole-body plus 10 neuro patients, or other combinations), the additional storage space allows for 22 Superdewars. That means room for another 176 whole-body patients plus 220 neuro patients (or 1,980 neuros!).

What if we were to stick with the existing Bigfoot units? Because the Bigfoot units can be packed with a slight overlap, probably around 5 of them would fit in the space used by 4 SuperDewars. The additional space would therefore allow for approximately 27 Bigfoot dewars, providing

space for 108 whole-body patients and 270 neuro patients (or other combinations).

GROWTH

Membership growth was slow in the first quarter, largely due to cancellations, but picked up in April and looks strong for May. Over a 5 to 6 year period, the picture is of slowly accelerating membership growth. Here are the growth rates (for full cryopreservation members only):

2011: 2.9%

2012: 2.4%

2013: -0.92%.

2014: 4.02%.

2015: 4.36%.

2016 YTD (May 27): Net gain of 20 members; annualized = 4.55%.

Currently we have 88 Applicants in process—a record! It's also worth noting (and distressing) that this month, for the first time ever, we had three applicant terminations resulting from the applicants' dying.

Last time I noted: "It's hard to tell whether or how many members we will get back who cancel for 'financial reasons'." Just recently, Diane noted one member who cancelled a year ago, but who is now back in shape and has rejoined. Only time will tell." Linda Chamberlain has been calling a shortlist of people who used to be members but who lapsed, yet retained their insurance policies. Already, three of them have either rejoined or are in the process of doing so.

To the extent allowed by Linda's other tasks (including working on the Red Books and helping Diane with membership and insurance inquiries, I plan to have her call other previous members as well as (a) people who came for a tour and volunteered their contact information, (b) people who have requested information packets; (c) any others who expressed interest. The plan is to start with the most recent and work backward, since the older contacts are more likely to be outdated. From now on, I want to decide on a period after which we reach out to each of these groups of individuals, to see if they are ready to start the membership process—at least at the Associate level.

A larger membership means more resources for the organization and the potential to reap economies of scale. If we can continue to reduce membership dues while automating and easing the sign-up and funding process, while ensuring that new members are sustainable, we should be able to raise our growth rate towards the barely-double-digit rate enjoyed back in 2005. (These are my own views and do not necessarily represent those of the board or individual directors.)

PET PRICING

We now have a much better and more systematic pet pricing schedule. I will not give prices here since the schedule has not yet been formally approved. The schedule covers quite a few combinations for cats and dogs, including costs for brain-only, neuro (cephalon), and whole body, as well as with or without cryoprotection.

INTERNATIONAL

For Alcor members residing in Europe or willing to travel, I'd like to alert you to the Swiss cryonics conference, which will take place in Basel this November. More information here: <http://cryosuisse.ch/en/conference-2016/>

Also on the international front, we are currently close to providing a kit for the Western part of Canada (we already have a kit in the Toronto area). These are full kits, fitting in 8 or 9 large Pelican cases, and include field cryoprotection equipment and a full set of perfusate bladders.

In building several kits, Steve Graber discovered that most of the Lucas 2 units lacked batteries and chargers. (The Lucas 2 costs \$9,000 refurbished, without battery or charger.) Buying these from the manufacturer turns out to be ridiculously expensive—the batteries are \$1,800! The best prices he could find were \$750 for the battery and \$1200 for the charger. Steve and Hugh together have figured out a workaround that enables us to power the devices at a small fraction of what we would otherwise have paid. For a total cost of around \$300, we will be able to use 5000 mAh rather than the original 3300 mAh batteries, fitting them in a custom-3D-printed enclosure. The new batteries ran for a good long time in an initial test, but

we will do a stress test using the mannequin and run the batteries until they give out. For remote kits, we will supply a second set of batteries. It will also be possible to plug the Lucas 2 into the electrical AC outlet, whenever available, such as in a hospital.

LATEST PATIENT

We took into care our 146th patient in late March, working with Suspended Animation. We have also had a couple of urgent third-party inquiries, but these have not worked out for a variety of reasons, including lack of proof of informed consent and inability to secure contracts and funding in time. We conducted an after-action review/debriefing for that case on April 14. Thanks to SA for making available audio, video, and case report by April 26, as promised.

RESEARCH FUNDED

A recent discussion revealed that many people—including members—do not know how much Alcor has spent on research. Since the start of 2013 to the present, total research spending comes to around a third of a million dollars. We will probably have to slow that rate of spending down, unless additional contributions to the Research Fund are secured. This is not the place to detail where that money was spent, but I have requested that an article be written to go into detail on much of that spending.

PUBLIC EDUCATION

I submitted to the Board a proposal for public education projects along with associated costs for the next few months. Projects should be selected according to anticipated impact, cost-effectiveness, and time and work required on the part of Alcor staff (primarily me currently). The projects that seem most promising to me in the near term include:

- a new-member package comparable to our current information package but focused on new members and on encouraging them to talk to and involve their friends and family members
- quick-response mini-videos to respond to misconceptions and errors in media coverage of

cryonics and to attract viewers to Alcor's website

- a set of new video science FAQs; and ongoing promotion of online content, driving people to Alcor's website, with most of the promotion budget being put behind new materials

Something else that we need is fresh b-roll. Our existing b-roll is now quite badly outdated. I would wait until our expansion into unit 104 is complete, but then want to shoot fresh, current in-house video that we can produce to news teams and documentary makers. We saw this old b-roll in a recent piece of video coverage: *Frozen Faith: Cryonics and The Quest to Cheat Death*, *Motherboard*, May 5, 2016. If you watch the video on YouTube, start at 23:13. There are some good parts, some cringe-worthy parts, and some frustrating parts. In my view, the bad parts include the title, both the use of "faith" and the worn-out and simply wrong "cheat death" phrasing.

In this video, Michael Shermer isn't making any better arguments than before. Dr. Toner, a Boston cryobiologist, apparently possesses omniscient knowledge about all future possibilities concerning rewarming, yet seems unaware of existing, published work in organ cryopreservation. It's also too bad that the video quotes a couple of people saying that they are terrified of death. Apparently they found that response more tasty than my own view that death is nothing to be afraid of (although the dying process is), and that most of us choose cryonics because we enjoy life and want more of it—to enjoy, to experience, to create, and to produce.

Alcor-2015 conference DVD and downloadable videos are now available: <http://www.alcorconference.com/videos>

Some of the more interesting and significant media recently:

In Don DeLillo's New Novel *Zero K*, Cryonics Doesn't Just Preserve—It Destroys
Kyle Denuccio
Wired, May 4, 2016
<http://www.wired.com/2016/05/don-delillo-zero-k-review/>

What Exactly Is Life After Death if You're a Cryonicist?

By David Rosenberg
Slate, April 27, 2016
http://www.slate.com/blogs/ behold/2016/04/27/murray_ballard_s_the_prospect_of_immortality_is_a_look_into_the_world_of.html

This Company Will Give You The Closest Thing to Immortality for Just \$200,000
Ryan General, Nextshark, April 27, 2016
<http://nextshark.com/alcor-life-extension-foundation-cryonics/>

If Cryonics Suddenly Worked, We'd Need to Face the Fallout

Rachel Nuwer, BBC, April 25, 2016
<http://www.bbc.com/future/story/20160424-if-cryonics-suddenly-worked-wed-need-to-face-the-fallout>

I spent some time talking on camera with Zach Guzman from CNBC on April 15 (results appearing on April 26). This resulted in some good coverage, both on television and online: Meet the company offering a chance at immortality for \$200,000. More and more people are signing up to be frozen for a chance at life after death. So the question is, would you?

As you will have seen in *Alcor News*, one of the most effective pieces of non-Alcor writing recently was "Why Cryonics Makes Sense" by Tim Urban. A few weeks later, Tim followed up by answering (brilliantly and often hilariously) dozens of questions from his readers. Among them:

If you could pick one future event that you could witness first hand, what would it be? – Brian G. (Cambridge, UK)

Tim replied: "On the heels of the recent cryonics post, I might pick the first time a vitrified person is successfully and fully revived."

Until next time,

Max More
May 27, 2016



Why Cryonics Makes Sense

By Tim Urban

Other than minor corrections, this article is as written online, and includes material based on non-Alcor sources. It should not be cited as reflecting a particular fact about Alcor or a position or claim endorsed by Alcor. The original online article has clickable references and more reading sources: <http://waitbutwhy.com/2016/03/cryonics.html>. Reprinted with permission from the publisher.

You're on an airplane when you hear a loud sound and things start violently shaking. A minute later, the captain comes on the speaker and says:

There's been an explosion in the engine, and the plane is going to crash in 15 minutes. There's no chance of survival. There is a potential way out—the plane happens to be transferring a shipment of parachutes, and anyone who would like to use one to escape the plane may do so. But I must warn you—the parachutes are experimental and completely untested, with no guarantee to work. We also have no idea what the terrain will be like down below. Please line up in the aisle if you'd like a parachute, and the flight attendants will give you one, show you how to use it and usher you to the emergency exit where you can jump. Those who choose not to take that option, please remain in your seat—this will be over soon, and you will feel no pain.

What would you do?

When Robert Ettinger was a kid in the 1930s, he read a lot of science fiction, and he assumed that with the world advancing the way it was, scientists would surely have a cure for aging at some point during his lifetime. He would live to see a world where sickness was a thing of the past and death was something people chose to do voluntarily, at a time of their choosing.

But thirty years later, aging and involuntary death were still very much a thing, and Ettinger, by then a physics professor, realized that science might not solve these problems in time for him to reap the benefits. So he started thinking about how to hack the system.

If, rather than being buried or cremated after his death, he could instead be frozen in some way—then whenever the scientists *did* eventually get around to conquering mortality, they'd probably also have the tools and know-how to resuscitate him, and he could have the last laugh after all.

In 1962, he wrote about this concept in a book called *The Prospect of Immortality*, and the cryonics movement was born.

The first person to give cryonics a try was James Bedford, a psychology professor who died of cancer in 1967 at the age of 73 and is doing his thing in a vat of liquid nitrogen in Arizona as you read this. Others slowly began to follow, and today, there are over 300 people hanging out in vats of liquid nitrogen.

Now let's pause for a second. A year ago, I knew almost nothing about cryonics, and my impressions of it were something like this sentence:

Cryonics, or cryogenics, is the morbid process of freezing rich, dead people who can't accept the concept of death, in the hopes that people from the future will be able to bring them back to life, and the community of hard-core cryonics people might also be a Scientology-like cult.

Then I started learning about it. It's your fault—cryonics is one of the potential-future-post-topics people email me about most, and it's something at least five readers have brought up in conversation when I've met them in person. And as I began to read about cryonics, I soon learned that a lot of the words in my italicized assumption sentence weren't correct.

So let's work our way through the sentence as we go over exactly what cryonics is and how it works. We'll start with this part:

Cryonics, or cryogenics, is the morbid process of freezing rich, dead people who can't accept the concept of death, in the hopes that people from the future will be able to bring them back to life, and the community of hard-core cryonics people might also be a Scientology-like cult.

It turns out that this is like saying, "Wingsuit flying, or meteorology, is the sport of flying through the air using a wingsuit." Meteorology is the study of what happens in the atmosphere, which includes how wind works, and wingsuit flying is a process that harnesses the wind—and you'd be an odd person if you thought they were the same thing.

Likewise, cryogenics is a branch of physics that studies the production and effects of very low temperatures, while cryonics is the practice of using very low temperatures to try to preserve a human being. Not the same thing.

Next, we have a string of three misleading words to talk about:

Cryonics is the morbid process of freezing rich, dead people who can't accept the concept of death, in the hopes that people from the future will be able to bring them back to life, and the community of hard-core cryonics people might also be a Scientology-like cult.

We'll address these three words by going through how cryonics works, starting at the beginning.

So you decide you want to be a cryonicist. Here are the steps:

STEP 1) PICK A COMPANY

There are four major companies that provide cryonics services—Alcor in Arizona, Cryonics Institute (CI) in Michigan, American Cryonics Society (ACS) in California, and KrioRus in Russia. KrioRus is the newest option and quickly up-and-coming, but the two big boys are Alcor and CI (ACS doesn't have their own storage facilities—they store with CI).

From my perusing, it seems like Alcor is the slightly-more-legit and fancier of the two, while CI (which was started by Robert Ettinger, the guy who launched the movement) is more affordable and gives off more of a mom-and-pop vibe. Both are nonprofit, and each has about 150 people in storage. Alcor has a little over 1,000 "members" (i.e. people who will one day be in storage), and CI has around half that number.

STEP 2) BECOME A MEMBER

To become a cryonicist, you need to fill out some paperwork, sign some stuff and get it notarized, and pay for three things: an annual membership fee, a transport fee to get your body to the facility after you die, and a treatment/storage/revival fee.

Alcor's annual membership fee is about \$700, and their transport fee is bundled together with the treatment/storage/revival fee—together they cost \$200,000. Alcor gives you the option of ditching your body and just freezing your brain (this is called "neuropreservation"), which brings the price down to \$80,000.

CI's annual membership fee is \$120 (or a one-time fee of \$1,250 for a lifetime membership) and the treatment, etc. costs \$35,000 (\$28,000 for lifetime members).

This is so much cheaper than Alcor for two main reasons:

First, it doesn't include the transport. If you live near the facility, you can save a lot of money. If not, you'll need to go through their partner for a transport contract, which costs \$95,000 (\$88,000 for lifetime members).

Second, Alcor uses more than half of their large fee to fund what they call their Patient Care Trust. Back in the '70s, there were more cryonics companies, and some of them went bankrupt, which meant their frozen people stopped being frozen, which was a not ideal outcome. Alcor's trust is a backup fund to make sure their "patients" won't be affected by something like a company financial crisis.

STEP 3) GET A LIFE INSURANCE POLICY IN THE NAME OF YOUR NEW CRYONICS COMPANY

Sounds shady, right? But it also makes sense. Both Alcor and CI are small companies on a pretty tight budget and neither can afford to offer a payment plan to be hopefully paid out by your estate or your relatives. On the patient end, unless you're rich, cryonics fees are huge, and a life insurance policy guaranteed to pay your full cryonics fee forces you to save for this fee throughout your life. For young people, even sizable life insurance policies are pretty cheap—with CI, you could be totally covered for as little as \$300/year (\$120 annual membership, \$180 life insurance policy to cover the main fee). Even for Alcor's more expensive package, costs shouldn't exceed \$100/month.

Those fees aren't nothing, but the whole life insurance thing, at least when it comes to younger people, pretty effectively ejects "rich" from our black and red sentence. If it costs the same as cable or a cigarette habit, you don't need to be rich to pay for it.

STEP 4) PUT ON YOUR BRACELET AND GO ON LIVING YOUR LIFE

Cryonics members are given a bracelet and a necklace, etched with instructions and contact info, and encouraged to wear one at all times, so if you suddenly die, whoever finds you will know to notify the company.

STEP 5) DIE

Okay here's where things get tricky. We think of the divide between life and death

as a distinct boundary, and we believe that at any given point, a person is either definitively alive or definitively dead. But let's examine that assumption for a second:

Let's first talk about what it means when a person is "doomed" from a health standpoint. We can all agree that what constitutes someone being doomed depends on where, and when, they are. A three-year-old with advanced pneumonia in 1740 would probably have been doomed, while the same child with the same condition today might be fully treatable. The same story could be said of the fate of someone who falls badly ill in a remote village in Malawi compared with their fate if they were in London instead. "Doomed" depends on a number of factors.

That the same thing can be said of "dead" is at first pretty unintuitive. But Alcor's CEO Max More puts it this way: "Fifty years ago if you were walking along the street and someone keeled over in front of you and stopped breathing you would have checked them out and said they were dead and disposed of them. Today we don't do that, instead we do CPR and all kinds of things. People we thought were dead 50 years ago we now know were not."

Today, dead means the heart has been stopped for 4-6 minutes, because that's how long the brain can go without oxygen before brain death occurs. But Alcor, in its site's Science FAQ, explains that "the brain 'dies' after several minutes without oxygen not because it is immediately destroyed, but because of a cascade of processes that commit it to destruction in the hours that follow restoration of warm blood circulation. Restoring circulation with cool blood instead of warm blood, reopening blocked vessels with high pressure, avoiding excessive oxygenation, and blocking cell death with drugs can prevent this destruction." The site goes on to explain that "with new experimental treatments, more than 10 minutes of warm cardiac arrest can now be survived without brain injury. Future technologies for molecular repair may extend the frontiers of resuscitation beyond 60 minutes or more, making today's beliefs about when death occurs obsolete."

In other words, what we think of as "dead" actually means "doomed, under the current circumstances." Someone fifty years ago who suffered from cardiac arrest wasn't

dead, they were doomed to die because the medical technology at the time couldn't save them. Today, that person wouldn't be considered dead yet because they wouldn't be doomed yet. Instead, someone today "dies" 4-6 minutes after cardiac arrest, because that happens to be how long someone can currently go before modern technology can no longer help them.

Cryonicists view death not as a singular *event*, but as a *process*—one that starts when the heart stops beating and ends later at a point called "the information-theoretic criterion for death"—let's call it "info death"—when the brain has become so damaged that no amount of present *or future* technology could restore it to its original state or have any way to retrieve its information.

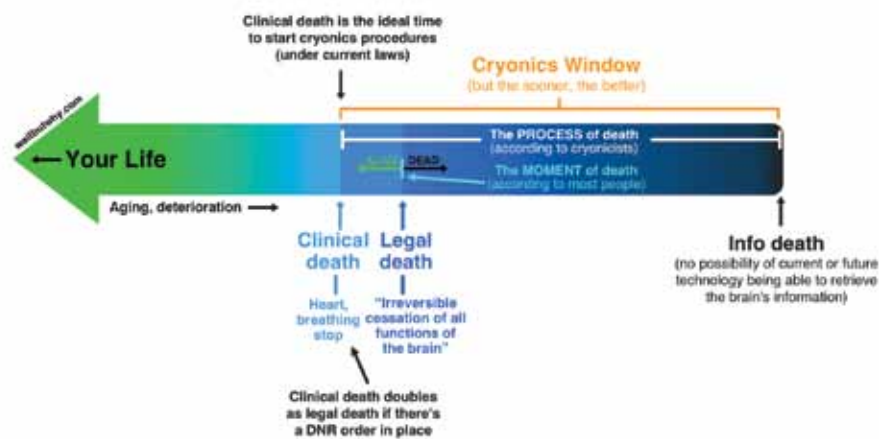
Here's an interesting way to think about it: Imagine a patient arriving in an ambulance to Hospital A, a typical modern hospital. The patient's heart stopped 15 minutes before the EMTs arrived and he is immediately pronounced dead at the hospital. What if, though, the doctors at Hospital A learned that Hospital B across the street had developed a radical new technology that could revive a patient anytime *within 60 minutes* after cardiac arrest with no long-term damage? What would the people at Hospital A do?

Of course, they would rush the patient across the street to Hospital B to save him. If Hospital B did save the patient, then by definition the patient wouldn't actually have been dead in Hospital A, just *pronounced dead* because Hospital A viewed him as entirely and without exception *doomed*.

What cryonicists suggest is that in many cases where today a patient is pronounced dead, they're not dead but rather doomed, and that there is a Hospital B that can save the day—but instead of being in a different *place*, it's in a different *time*. It's in the future.

That's why cryonicists adamantly assert that cryonics does *not* deal with dead people—it deals with living people who simply need to be transferred to a future hospital to be saved. They believe that in many cases, today's corpse is tomorrow's patient (which is why they call their frozen clients "patients" instead of "corpses" or "remains"), and they view their work as essentially "extended emergency medicine."

But it's emergency medicine with an important caveat. Today's technology has



no way to revive a cryonically-suspended patient, so it isn't considered a medical procedure by the law but rather a weird kind of coffin—i.e. if you cryopreserve someone who hasn't yet been pronounced dead, it's seen by the law as homicide. Even if the patient is terminally ill beyond any hope and adamantly doesn't want to deteriorate further before being cryopreserved, it's not an option—at least not under current laws (laws that some are trying to change). This puts cryonicists in a tough bind—and it's exactly where that differing definition of death comes in handy.

The law does not see death as a process. For a long time, legal death in the US was considered to occur when a person's heartbeat and breathing stopped. As modern medical procedures like CPR and defibrillators started to allow those patients to be resuscitated, the law had to change the definition of legal death to include "irreversible cessation of all functions of the brain." The old "heartbeat and breathing" definition of legal death is now called "clinical death," a middle ground point where there's an obligation to attempt resuscitation in most cases but where a patient can also have a Do Not Resuscitate (DNR) order in place (common with terminally ill patients). In DNR cases, a doctor or nurse will pronounce a clinically dead patient to be legally dead—even though a resuscitation effort could still revive them.

This is a critical fact for cryonics. Cryonics technicians have to wait until legal death to begin their work on a patient, but with the help of a patient's DNR order, they can start the process right after the heart stops, well before any brain damage sets in.

So this is the window for cryonics:

Which brings us back to our list, where we can now clarify what we really mean with Step 5:

STEP 5) LEGALLY DIE

You legally dying is a key step along the way here, so don't mess it up. You can do it the good way, the bad way, or the really bad way.

The good way: Something predictable where you're in a cliché deathbed situation, like cancer. This allows you to get yourself on a plane to either Scottsdale (Alcor) or Michigan (CI) and into one of the specifically designated hospice care facilities that the cryonics company regularly works with. This is important because cryonics is highly controversial within the mainstream medical community and often not well-regarded or well-understood. As a result, some hospitals and hospice care facilities are "cryonics friendly" and others are not (those that aren't have been known to make it difficult for cryonics staff to do what they need to do or deny them the same privileges organ transplant specialists get in a hospital). Once you're in hospice care, the cryonics company can put staff on standby around the clock, so that the second you legally die, they can be there to start the treatment.

The bad way: Something sudden and unexpected, like a heart attack, where at best, someone is there and can contact the cryonics company as you're rushed to the hospital so they can meet you there, or worse, where you're dead for a few hours or even longer before anyone finds you. In these circumstances, the cryonics company will do the best they can. Your brain will

be in worse shape than ideal when you go into cryopreservation, but again, who knows what future technology will be able to accomplish, and as long as you're still somewhere in the "cryonics window" and still in the process of dying, not yet having reached info death, there remains hope.

The really bad way: A violent accident or something where your brain ends up badly damaged. In the worst of these cases, there's not much cryonics can do to help—like the Alcor member who died in the September 11th attacks. Another bad ending would be dying in a foul-play situation that would lead the police to want to do an autopsy (Alcor suggests its members file a no-autopsy-for-religious-reasons form with the government). A woman who has signed up for cryonics did a Reddit AMA, and when one of the questions was about how signing up had changed her life, she answered, "The biggest change I've noticed is that I'm more careful. I drive slower and more cautiously/ attentively, I pay more attention to what's going on around me." Because she doesn't want to die the really bad way.

STEP 6) COOL OFF ASAP AND GET TRANSFERRED TO THE CRYONICS FACILITY

After you're declared legally dead, the cryonics team will, ideally, immediately get going. The first thing they do is two-fold—they put you in an ice water bath to bring down your temperature and slow your metabolism (so any damage taking place as a result of cardiac arrest takes longer to happen), and they start getting your heart and lungs working again so that the body remains in stable condition. They do this by administering CPS (like CPR but with an S for support instead of an R for resuscitation, because they're not trying to resuscitate you) using a mechanical heart-lung resuscitator called a thumper:



Then they inject you with a number of different medicines to make sure you don't get blood clots or start rotting.

Once that's under control, they can do a more involved procedure that surgically accesses the major blood vessels in your thigh and hooks them up to this guy:



That's a heart-lung machine that takes care of circulation and oxygenation so they can stop the much cruder CPS. In addition to circulating your blood, the machine draws heat out of your body, cooling it to just above the freezing temperature of water, and replaces some of your blood with an organ preservation solution that supports life at super low temperatures (this is similar to how transplant surgeons keep organs alive when they have to transport them long distances).

If you have to be flown to the cryonics facility, they pack you in ice and put you on board what they hope is not your last ever flight.

STEP 7) GET VITRIFIED

Most people who know what cryonics is think it means getting frozen. It doesn't. It means getting vitrified.

Glass is weird. It's not a typical solid because as it cools from its liquid phase, it never crystallizes into an orderly structure. But, as I learned when a bunch of commenters yelled at me after I published this post, it's not actually a liquid either, since it doesn't flow. So, it's neither a typical solid nor a liquid—it's an "amorphous solid," sometimes compared to a giant molecule. For our purposes, the key is that *like a liquid*, glass doesn't crystallize—rather, as it cools the molecules just move slower and slower until they stop.

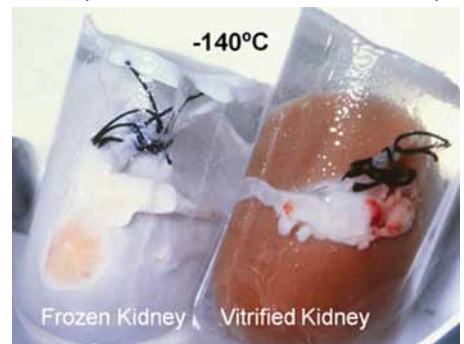
If you *froze* a human, all the liquid water in their body would eventually hit its freezing point and crystallize into a solid. That wouldn't be good—first, water ice takes up about 9% more volume than water liquid, so it would expand and badly damage tissue, and second, the sharp ice crystals

would slice through cell membranes and other tissue around it.

So to avoid that catastrophic liquid-to-solid state change, cryonics technicians do something cool—they perform surgery through the chest and hook the major arteries up to tubes which pump all the blood out of the body, replacing it with a "cryoprotectant solution," otherwise known as medical grade anti-freeze. This does two important things: it replaces 60% of the water in the body's cells, and it lowers the freezing point of what liquid is left. The result, when done perfectly, is that no freezing happens in the body. Instead, as they chill your body down and down over the next three hours, it hits -124°C , a key point called the "glass transition temperature" when the body's liquid stays amorphous but rises so high in viscosity that no molecule can budge. You're officially an amorphous solid, like glass—i.e. you're *vitrified*.

With no molecule movement, all chemical activity in your body comes to a halt. Biological time is stopped. You're on pause.

Since I'm sure you're feeling skeptical, it's helpful to note that vitrifying biological parts is nothing new. We've been successfully vitrifying and then rewarming human embryos, sperm, skin, bone, and other body parts for a while now. More recently, scientists vitrified a rabbit kidney:



Then they rewarmed it and put it back in the rabbit. And it still worked.

And just in February of 2016, there was a cryonics breakthrough when for the first time, scientists vitrified a rabbit's brain and showed that once rewarmed, it was in near-perfect condition, "with the cell membranes, synapses, and intracellular structures intact ... [It was] the first time a cryopreservation was provably able to protect everything associated with learning and memory."

Once you're vitrified, you need to keep being chilled, little by little, until after about two weeks, you're down to -196°C. Why? Because that's the point at which nitrogen becomes a liquid, and you're about to take a long-term liquid nitrogen bath.

STEP 8) GO INTO STORAGE

Or as Alcor euphemistically calls it, "long-term care." The new vitrified you now goes into what is essentially a large upright thermos that's about 10 feet tall and 3.5 feet wide.



You meet your new neighbors—three other vitrified people, each in their respective quadrant of the thermos, along with five people traveling super lean, with no body, whose heads are stacked in the middle column.



Or, if you're in a heads-only thermos, you'll be one of 45 brains sharing the space (the brain is what's being stored, but they keep the brains in their heads because it's riskier to remove a brain than to just keep it in there and use the head as a carrying case).

Oh, and you're upside-down. This is because liquid nitrogen boils off gradually

from the top of the container. Normally, it's no problem—the staff tops it off about once a week. But if, in some worst-case scenario, a container was forced to be left for a long time, the head would be the last thing to be affected—upside-down patients means it would take six months before the nitrogen boiled off so far that the head would be exposed.

And when it comes to blackouts, cryonics patients are totally safe—there's no electricity involved in their storage.

And this is where you'll hang out. Maybe for 10 years. Maybe for 150 years. Maybe for 1,200 years. But the time doesn't matter to you. You're on pause.

Now's a good time for us to take a step back and look at the big picture. If Point A is "I've decided I want to sign up for cryonics," and Point B is "Oh cool it's the year 2482 and here I am doing stuff," there are four major Ifs that need to all go the right way to take you from A to B:

1) If I legally die in a not really bad way and everything goes as planned with getting me into the thermos

and

2) If future humanity ever reaches a point where it has the technology to revive me to full health

and

3) If the cryonics company can manage to store me safely and uninterrupted until that point

and

4) If when that point comes, the outside world actually does take action to revive me

—then I'll be there in 2482 doing stuff.

The eight steps you've taken so far that start with choosing a cryonics company and end with you in the thermos only accomplish the first If, with all the other Ifs still standing in between you and the next step in your cryonics journey—revival.

To understand how we can reach that step, we need to understand the deal with all four Ifs.

We'll start by talking about Ifs 1-3, which

need to be discussed together, because they're interdependent and they work together. To illustrate why, let's lay them out in the same visual:

The three segments of this line relate to Ifs 1, 2, and 3. But the visual is a little misleading at first, because even though all three segments lie on the same line, they're all representing different concepts:

- The blue segment (If 1) represents the quality of your initial preservation.
- The yellow segment (If 2) represents the capabilities of medical technology as time moves forward.
- The green segment (If 3) represents the amount of time still needed to bridge the gap between the blue and yellow segments before they can finally connect to each other.

The idea is that the better you were preserved, the farther out to the right the blue segment extends, and as technology gets better and better, the yellow segment extends itself farther and farther left toward the blue segment. The green segment gets smaller and smaller as this happens, until eventually the green segment is no more and the blue and yellow segments connect—i.e. medical technology has reached the point where it can revive you.

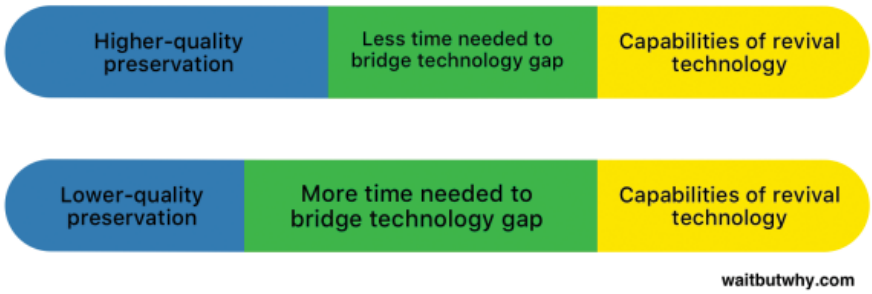
A lot of the key details about cryonics are centered here, so let's talk about each of these segments in more depth:

THE BLUE SEGMENT—THE QUALITY OF YOUR PRESERVATION (WHICH RELATES TO IF 1)



The length of the blue segment corresponds to the quality of preservation. Or, put most simply, the fewer roadblocks there are between your vitrified state in the thermos and a fully restored and healthy you, the longer the blue segment is—





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because if everything that happens leading up to you being put in the thermos goes as well as possible, it goes a longer way towards getting you to Point B and means the yellow segment has to do less work on its end to be able to revive you.

The major factor that determines the length of the blue segment is how closely the atomic structure of your vitrified brain resembles the original atomic structure of your brain when it was living and healthy.

Let's note that I said "brain," not "body," because what we mostly care about here is the brain. Cryonicists, like many of us, believe that who you are comes down to your brain. If, in the future, your identical current brain lived on top of a synthetic body and your exact memories and personality were fully intact, cryonicists would be satisfied that you "survived." That's why some don't even bother vitrifying their body.

The second thing to note is that scientists believe that short-term memory is contained in brain activity—in the electricity going through your brain—while your long-term memory, your personality, your knowledge, and everything else that makes you "you" is contained in the brain's structure—i.e. the particular arrangement of atoms that make up your brain.

Any electrical activity in your brain before legal death will be lost during vitrification, so you'd be revived without the short-term memory of the end of your pre-vitrified life. But what vitrification can preserve is the structure of your brain, which conveniently, is all we care about.

This concept gives us a clearer understanding of the way cryonicists view death. To cryonicists, perfect health means the exact arrangement of atoms in your healthy brain being intact, and the process of dying means the deterioration of that arrangement due to phenomena like aging, injury, disease, and, eventually, effects caused by heart stoppage. Death, to

them, means the point at which the original structure of your brain has become so disorganized that even the fanciest future science lab would have no way of figuring out what the original arrangement looked like—that's the definition of info death.

The concept of info death makes sense when we compare the brain to a computer's hard drive. Eliezer Yudkowsky explains how difficult it actually is to bring a computer hard drive to info death:

If you want to securely erase a hard drive, it's not as easy as writing it over with zeroes. Sure, an "erased" hard drive like this won't boot up your computer if you just plug it in again. But if the drive falls into the hands of a specialist with a scanning tunneling microscope, they can tell the difference between "this was a 0, overwritten by a 0" and "this was a 1, overwritten by a 0".

There are programs advertised to "securely erase" hard drives using many overwrites of 0s, 1s, and random data. But if you want to keep the secret on your hard drive secure against all possible future technologies that might ever be developed, then cover it with thermite and set it on fire. It's the only way to be sure.

He applies the same logic to the human brain to suggest that cryonics patients should one day be revivable:

Pumping someone full of cryoprotectant and gradually lowering their temperature until they can be stored in liquid nitrogen is not a secure way to erase a person.

In other words, it's reasonable to assume that the fanciest future neuroscientists will become so good at reading a damaged vitrified brain for clues as to its original structure that a typical combo of aging, disease, heart stoppage, and vitrification likely won't be able to "stump" them. And to cryonicists, if future scientists can examine your vitrified brain and figure out what it's supposed to look like, you're not dead—by definition.

The length of the blue segment—preservation quality—is affected by three things:

1. **How much damage happened before you legally died.** How old were you when you died? How much had your brain deteriorated by that point? Did you suffer from a dementia-causing disease like Alzheimer's and how much permanent damage did that disease do? Did the thing that killed you damage your brain (like brain cancer, or a head injury) or was your brain unharmed?
2. **How much damage happened between when you legally died and when the cryonics team started working on you.** In the ideal situation, your heart stops and before any changes happen in your brain, you're stabilized and put on ice. Often, this isn't how things go, and every unattended minute that passes after legal death has a big impact on the brain and shortens the length of the blue segment. But cryonicists believe that true info death doesn't happen for many hours, or even days, after legal death occurs, and that there's often hope in cryopreserving even people who lay "dead" for a while before being found.
3. **How much damage happened during the vitrifying process.** Vitrification itself—at least the way it is currently done—causes its own damage to the brain. Cryonics research focuses mostly on mitigating this factor, and it's dramatically improved since the earliest days in the 1970s—the series of images at the bottom of this page (<http://alcor.org/AboutCryonics/index.html>) shows the progress that has been made.

THE YELLOW SEGMENT—THE STATE OF MEDICAL TECHNOLOGICAL ADVANCEMENT AS TIME MOVES FORWARD (WHICH RELATES TO IF 2)



As medical technology becomes more and more advanced, the yellow segment grows—but while the blue segment extends to the right as it grows, the yellow

segment extends to the left. The key point happens when technology eventually gets so good that the yellow segment meets the blue segment and you become officially revivable.

Some questions:

Will If 2 happen? Will technology ever reach the point when it can revive you?

Assuming If 1 gets a check mark, cryonicists believe If 2 is likely to one day get a check mark too. Because there are only two ways to totally fail If 2:

1. For some reason, humans permanently stop working on medical technology advancements before you hit the If 2 key point.
2. Humans go extinct before hitting the If 2 key point.

Barring those two situations, If 2 should eventually cooperate. The theory is that with *enough* future technology, you'll one day be revivable.

When will If 2 happen? How long until I'm revived?

This part depends on how substantial the technological challenge of cryonic revival turns out to be and how quickly technology ends up moving forward—but it also depends upon how well If 1 went. As we just discussed, the better If 1 goes, the sooner If 2 happens.

How will If 2 happen? What kind of future technology might be able to revive vitrified people?

Well, it depends on what we mean by revival. Cryonicists seem to have a Plan A and a Plan B.

Plan A: Restore the vitrified patient as a healthy human

Under Plan A, revival consists of restoring the structure of the vitrified brain to its original state—i.e. putting all the atoms where they belong. To do that, you need two things:

1. The info about where the atoms are supposed to go
2. A way to put the atoms where they're supposed to go

The first thing is taken care of if today's vitrifying procedures do their job, assuming future neuroscientists become really good at deciphering a brain's original state from the information they can gather by examining the vitrified brain.

The second thing requires *molecular nanotechnology*. For a quick nanotech overview, I'll steal part of a blue box from the AI post.

NANOTECHNOLOGY BLUE BOX

Nanotechnology is our word for technology that deals with the manipulation of matter that's between 1 and 100 nanometers in size. A nanometer is a billionth of a meter, or a millionth of a millimeter, and this 1-100 range encompasses viruses (100 nm across), DNA (10 nm wide), and things as small as large molecules like hemoglobin (5 nm) and medium molecules like glucose (1 nm). If/when we conquer nanotechnology, the next step will be the ability to manipulate individual atoms, which are only one order of magnitude smaller (~.1 nm).

To understand the challenge of humans trying to manipulate matter in that range, let's take the same thing on a larger scale. The International Space Station is 268 mi (431 km) above the Earth. If humans were giants so large their heads reached up to the ISS, they'd be about 250,000 times bigger than they are now. If you make the 1nm – 100nm nanotech range 250,000 times bigger, you get .25mm – 2.5cm. So nanotechnology is the equivalent of a human giant as tall as the ISS figuring out how to carefully build intricate objects using materials between the size of a grain of sand and an eyeball. To reach the next level—manipulating individual atoms—the giant would have to carefully position objects that are 1/40th of a millimeter—so small normal-size humans would need a microscope to see them.

Nanotech was first discussed by Richard Feynman in a 1959 talk, when he explained: "The principles of physics, as far as I can see, do not speak against the possibility of maneuvering things atom by atom. It would be, in principle, possible ... for a physicist to synthesize any chemical substance that the chemist writes down.... How? Put the atoms down where the chemist says, and so you make the substance." It's as simple as that. If you can figure out how to move individual molecules or atoms around, you can make literally anything. Nanotechnology so advanced that it allows us to engineer at an atomic level is called molecular nanotechnology (MNT).

Humans haven't yet conquered MNT, and scientists debate how long it'll take humanity to get there. But when we do, we might look back on today's technology as terribly primitive, like the picture scientist Ralph Merkle paints: "Today's manufacturing methods are very crude at the molecular level. Casting, grinding, milling and even lithography move atoms in great thundering statistical herds. It's like trying to make things out of LEGO blocks with boxing gloves on your hands. Yes, you can push the LEGO blocks into great heaps and pile them up, but you can't really snap them together the way you'd like."

MNT will be a game-changer in an unimaginable number of arenas, one of which is in medicine. A brain synapse is just a particular configuration of atoms, so if we have the tools to move atoms around and put them where we want, then we can perfectly "repair" a damaged synapse. Cryonicists believe MNT is the key to the future revival and restoration of cryonics patients.

The first thought some people have when they think about revival is that the person would be revived as the old and dying person they were before being vitrified. But that's not the plan. When we get to the point when we have technology so incredible that we can move atoms

around well enough to revive someone, we should also have the technology to repair and rejuvenate them. For someone who was dying of cancer before going into the thermos, not only will their successful revival mean that cancer has likely been conquered long ago, but probably aging too.

Along the same lines, by that point we should also be able to either rejuvenate the patient's vitrified body or simply make a new, perfectly-working body. Alcor's Medical Response Director, Aaron Drake, explains: "We know we can regenerate a small organ, and grow a new heart. We know we can 3-dimensionally print cells and hearts. So at some point we would

need to regenerate her entire body, or at least her organs, and put it all together. Then we'd need to transplant that brain into a new body."

PLAN B: UPLOAD THE PERSON'S BRAIN INFO INTO A VIRTUAL WORLD

Plan B shares Plan A's first requirement—the info about where the atoms are supposed to go—but not its need for physical assembly. Instead, Plan B relies on a hypothetical future technology called "whole brain emulation," where an entire brain structure can be uploaded to a computer with such perfect accuracy that everything about the person is intact and alive in a virtual world.

Sounds super fun, right?

This is an option if physical revival is too difficult, or if it's so far in the future that the physical world has actually gone out of style entirely. If humans can somehow pull off whole brain emulation, you could be revived to wake up in a magical virtual world, fully conscious and no longer confined to the limits and vulnerabilities of biology and the physical world. Please.

While both Plan A and B require immense technological hurdles, cryonicists stress that both options are theoretically possible.

THE GREEN SEGMENT—THE AMOUNT OF TIME YOU NEED TO STAY SAFELY IN STORAGE BEFORE TECHNOLOGY IS ABLE TO REVIVE YOU (WHICH RELATES TO IF 3)



The green segment's job is simple: hold everything together until the yellow segment connects to the blue segment.

So what could mess up If 3? What could sabotage a vitrified person's ability to remain bathed in liquid nitrogen as long as necessary?

A lot of things. Like:

The cryonics company screws up. A human-error-caused catastrophe—e.g. a rupture in a thermos tank lets in heat, and all the liquid nitrogen evaporates before the staff realizes what happened.

The cryonics company goes bankrupt and doesn't have the means, the will, or

the organization to create a plan that will save the patients. I mentioned that this happened a few times with some of the earlier companies. The major companies today claim to have secure backup plans in place in case of the worst case scenario, and this security blanket is the main purpose of Alcor's sizable trust.

A natural disaster. An earthquake, tornado, or something else smashes the building holding the thermoses to oblivion. Neither major US cryonics company is in a location highly prone to natural disasters—Alcor actually located itself in Scottsdale, AZ because it is the place in the US least at risk of natural disasters. Even if a natural disaster were to strike, the patients might be fine—the thermoses are strong, they're power-outage-proof with no electricity involved, and even if a thermos is ruptured, there's the upside-down thing where patients' heads will be the last body part affected.

A terrorist attack on a cryonics facility. There are a lot of people in the world—especially in the world of religion—who hate the concept of cryonics.

War. All bets are off in war.

The law prevents the cryonics company from doing its job. This one almost happened recently. In 2004, Arizona legislators tried to pass a bill that would have put Alcor under the regulation of the State Funeral Board. This, if passed, would have likely ended up shutting Alcor down. It turned into a nasty debate, centered largely around religious issues, with the religious voice disapproving of Alcor's line of work—but ultimately, Alcor prevailed. That said, in order to do business legally, Alcor has to accept bodies in the guise of "anatomical donations for research purposes," a practice protected by the constitutional right to donate one's body for research into cryopreservation. The law-related variable seems pretty stable currently, but if someone has a long green segment and requires 800 years of storage before their revival becomes possible, who the hell knows what will happen—what is currently Scottsdale, AZ might not even be part of the US by that point.

The cryonics company comes under ownership with different values and they decide to give up on the patients. Or, more maliciously, a cryonics-hater makes a too-good-to-refuse offer to the

owners of a cryonics company with the intention of shutting it down. All major cryonics companies claim that they're run and always will be run by passionate cryonicists and this is not a possibility—but again, who knows.

The longer the green segment is and the longer it needs to hold out, the higher the chance of failing If 3. If patients can be revived 40 years from now, there's a lot less that can go wrong than if revival doesn't become possible for 2,500 years.

But the companies are doing their best to plan for the long run. On the question of how long until revival becomes possible, Alcor says, "Some think it will take centuries before patients can be revived, while others think the accelerating pace of technological change might so rapidly transform our world that decades would suffice. Alcor is planning for however long it might take."

As time moves forward and both vitrification and revival technology improve, both the blue and yellow segments will tend to move inward, invading the green segment from both sides. The big picture might be best illustrated like this: *(See diagram A.)*

This is how the blue, green and yellow segments work in flow with each other. Cryonics companies often say cryonics will be a "last in, first out" thing, and this graph shows exactly why—*(See diagram B.)*

The more time that passes before you need to be vitrified, the fancier the vitrification technology you'll be treated with *and* the further along revival technology will be—and this smaller technology gap will mean a sooner revival date. And with less time to have to rely on a cryonics company to care for you, the less risk you'll be taking.

It's important to understand that the blue line on the graph applies to the *average* cryonics patient—someone who suffers from Alzheimer's late in life will go into vitrification in worse shape than a typical person of their time, so their particular challenge will be greater than the blue line height that corresponds with the year of their death.

Of course, the simple, straight lines on the graph are portraying the general concept. The actual lines won't be straight or predictable. One promising way this might be the case is that the accelerating rate of technological advancement might

mean that the blue and yellow lines could improve at a faster rate over time and look like this: (See diagram C)

So that's how the first three Ifs work. And that's all great—but none of it matters if If 4 doesn't pan out. Without If 4—i.e. “Will people actually revive me when the time comes?”—you're still just a helpless, vitrified body, and if the external world doesn't keep their side of the bargain once you become revivable, you're out of luck—and you'll never know it happened.

You'll be a little like a farm animal. You might have rights in theory, but with no ability to defend your own rights, you'll rely on other people to fight for those rights on your behalf.

As I've dug into this topic and talked to people about it, I've noticed that this concern seems to jump immediately to people's minds as a reason cryonics is unlikely to work out.

They ask: “There will be enough problems on Earth to deal with—do you really think people are going to care about bringing dead people back to life?”

Cryonicists have answers to this question.

First, they point out that patients won't be floating in tanks in a world that has forgotten them. Rather, as a patient, you'd likely have A) descendants or friends who will be highly aware of you and eager to see you reanimated, B) the larger cryonicist community, who will be as passionately interested in your fair treatment as PETA activists are in the fair treatment of animals, and C) the contractual obligation of your future care-takers—similar to how today you might be operated on by a surgeon who doesn't know you, but who diligently cares for you anyway out of professional obligation.

Second, they argue that once the revival of cryonics patients becomes a reality, the public's conception of what a cryonics patient is and what she deserves will dramatically shift:

Long before it ever becomes possible to contemplate revival of today's patients, reversible suspended animation will be perfected as a mainstream medical technology. From that point forward, the whole tradition of caring for people who cannot immediately be fixed will be strongly reinforced in culture and law. By the time it becomes possible to revive patients preserved with the oldest and crudest technologies, revival from states of suspended animation will be something

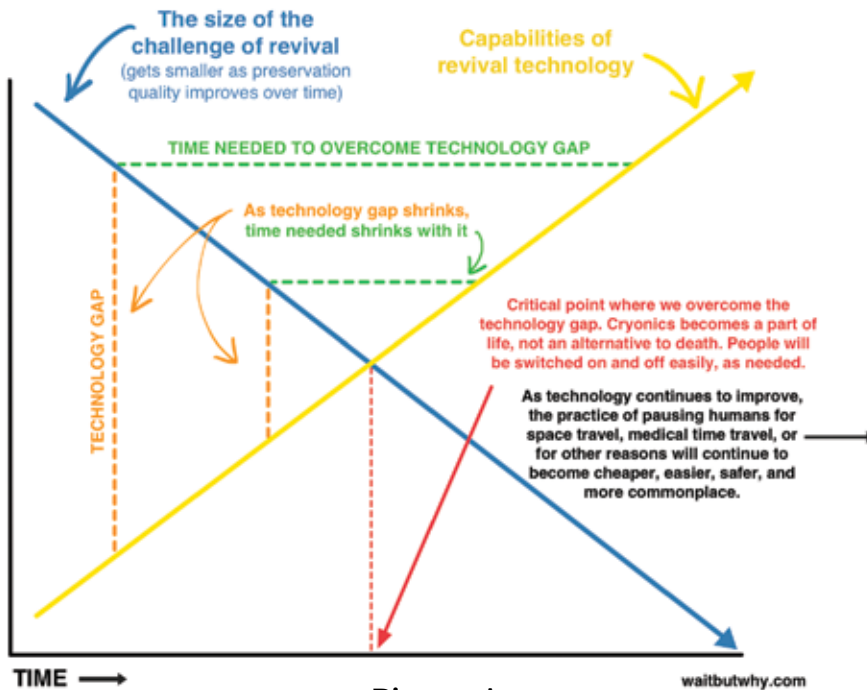


Diagram A

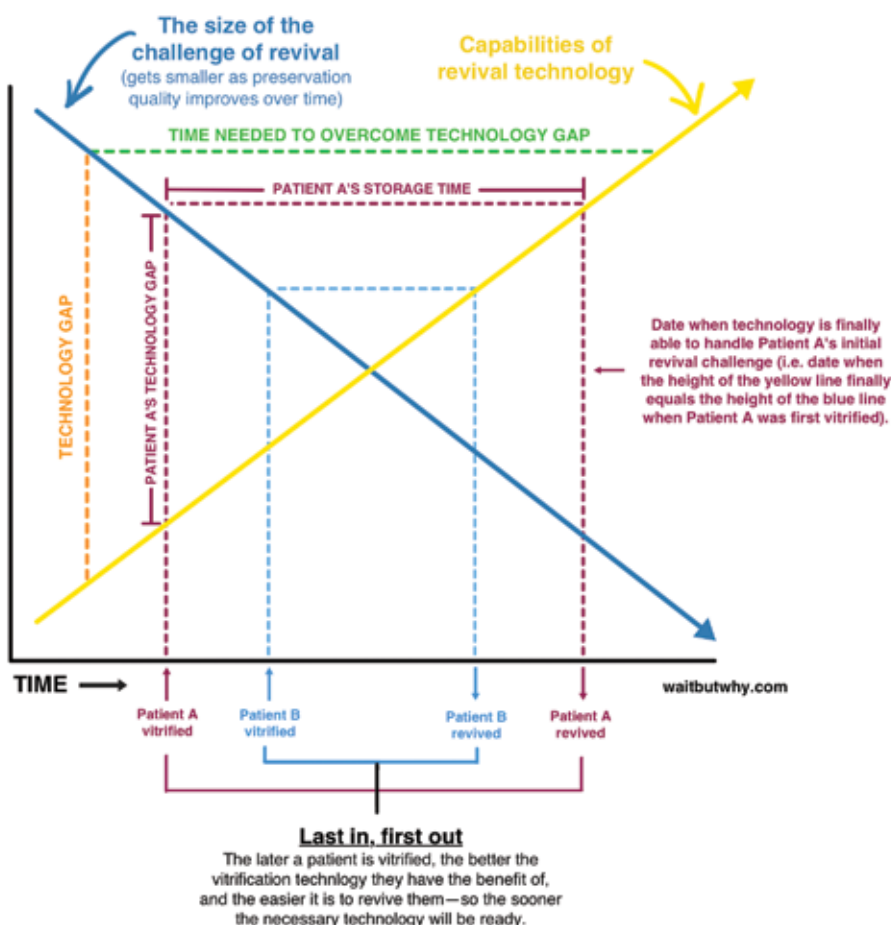


Diagram B

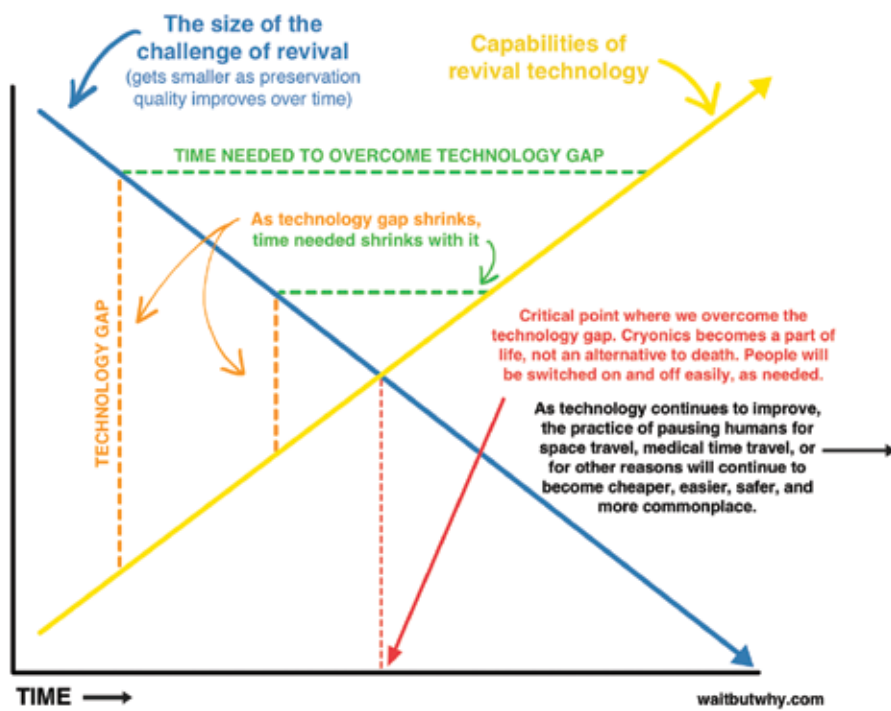


Diagram C

that has been done thousands, if not millions, of times before. The moral and cultural imperative for revival when possible will be as basic and strong as the obligation to render first aid and emergency medical care today.

If a cryonics patient might seem to have the rights of a farm animal today, cryonicists expect that to become an outdated and primitive-seeming viewpoint down the road. They believe cryonics patients will be looked upon more like today's coma patients.

That sounds great, but of course, we have no idea how the future will play out or what the standing will be for the field of cryonics and its suspended patients. It does seem plausible, at least, that cryonics patients will end up with more and more rights in the future, not fewer and fewer. If that's what happens, If 4 shouldn't be much of a problem.

And if all four Ifs go your way, you'll finally be able to move onto the next step—the one that will really blow your mind when it happens.

STEP 9) BE REVIVED

This will be quite the experience.

First, whether it happens 30 years or 2,000 years after you were last conscious, it'll feel the same to you—probably a bit like a short nap. When you sleep, you feel the passage of time—when you wake up

after an eight-hour night's sleep, it doesn't feel like you just went to bed a second ago, it feels like it's been eight hours. But being on pause in your liquid nitrogen thermos is different. You won't experience the passage of time, so it'll feel like you were just awake in your previous life (the only reason it won't feel totally instantaneous is that you'll have lost your short term memories). You'll probably be super disoriented, and someone will have to explain to you that A) you're in the future, and B) the cryonics worked, and you're no longer a person about to die—you're healthy and rejuvenated and all set to start living again.

How intense.

As a very not-heaven-believing person, I've always thought about how pleasantly shocked I would be if I died and then woke up in some delightful afterlife. I'd look around, slowly realize what was happening, and then I'd be like, "Wait...NO FUCKING WAY." Then I'd promptly plant myself at the gates and watch other atheists come in for the fun of seeing them go through the same shock.

I imagine being revived from cryonics will be kind of like that. Maybe a few notches less shocking, since you presumably did the cryonics thing because you thought there was a chance it would work—but still a pretty big *no fucking way* moment.

After the initial shock, you'll have to figure out what kind of world you've woken up into. Some possibilities:

It could suck. You could wake up in a far future world that's a lot worse than the one you previously lived in and a world in which you know zero people. Even worse, you could wake up in some really scary situation—who knows what kind of creepy shit might be going on in the future.

It could be blah. You could wake up in a world that's kind of meh. Like it's not as future-y and cool as you thought it would be and you're not immortal, just somewhat restored and still vulnerable, and you have to get a job and you don't really have applicable skills for the times. Just kind of whatever.

It could be incredibly rad. Probably the most likely outcome, you could wake up and it could be very, very rad. The future-y stuff might be cool and fun beyond your comprehension. You might have previously been 84 and aching everywhere and forgetful, and suddenly you have the body of a perfectly fit 20-year-old, or maybe something even better, like a super-charged synthetic body that doesn't feel pain or exhaustion and can't get sick. Your old, forgetful brain could be repaired and full of vitality you haven't experienced in 50 years. And best, you might be surrounded by friends and family who were also cryopreserved and are *unbelievably* excited to see you. It could be rad.

It could be even crazier if you wake up in a virtual world after having had your vitrified brain data uploaded to a computer. You wouldn't feel like you were in a computer—you'd feel every bit as real as you did when you were a human, except now everything is amazing and magical and you can spend almost all your time fulfilling my lifelong dream of sliding down rainbows like this care bear.



Your friends and family could be there with you, also virtually uploaded but still fully themselves with all of their old memories—all of you now eternal and indestructible, with no need for the physical world or its resources.

Who knows what kind of world you'd wake up in? But a couple things lead me to believe it would be a pretty good situation:

- A really terrible future world probably isn't the type of world that would be concerned with protecting and reviving cryonics patients. In a world like that, you'd probably just never wake up.
- Likewise, a future that can revive vitrified people is by definition pretty technologically amazing, so it's hard to imagine waking up in a world that hasn't solved all kinds of problems our current world suffers from.
- The future tends to be better than the past. Humans have the tendency to predict dystopian futures, but at least so far, it's been the other way around. Say what you want about the ills of today's world, but it's better to be a human today than it was 200 or 1,000 or 10,000 years ago.

But because we have no idea what revival will be like, we have this next step:

STEP 10) DECIDE IF YOU'RE INTO IT AND WANT TO STAY

Barring some hilariously bad scenario where you're revived into a world of eternal virtual torture with no ability to end it—which really makes no sense—cryonics is a risk-free venture. It has an undo button—just kill yourself and it's as if it never happened. If you're not into it, your journey ends here. Otherwise, move on to the next step.

STEP 11) ENJOY SHIT

We've kind of reached the end of me guiding you. You're now just living again like you were before—hopefully in a much better situation—and what you do at this point is really your business. Just go do your thing and enjoy being in the future.

STEP 12) DIE FOR REAL THIS TIME

At some point, you'll be over it. No one ever will ever ever want to live forever, a fact I realized at the end of my Graham's Number post. When the time comes, I assume the fancy future will have some painless way to bow out—something that will cause total info death, where your data is truly unrecoverable. At that point, you'll have lived the complete life you want to live, not a life cut short by the limitations of the medical technology of the time you

happen to be born in. That's really the way things should be.

Now that we all know a lot more about cryonics, let's bring back our sentence. This is where we were, and we were looking closely at the three words in the red:

Cryonics is the morbid process of freezing rich, dead people who can't accept the concept of death, in the hopes that people from the future will be able to bring them back to life, and the community of hard-core cryonics people might also be a Scientology-like cult.

We can get rid of "rich," because at least for younger people, cryonics can be paid for with a not-that-expensive life insurance plan.

We can get rid of "dead," because cryonics doesn't deal with dead people, it deals with people currently doomed to die given the technology they have current access to. For the same reason, we can also change the wording of "bring them back to life."

And we can get rid of "freezing," because cryonics doesn't freeze people—it vitrifies them into an amorphous solid state.

While we're here, let's get rid of "morbid." Is a vitrified human head floating in liquid nitrogen morbid? Yes. Is it more morbid than being eaten by worms and microbes underground or being burned to ashes? Definitely not. So not a fair word to use.

So that leaves us with a sentence more like this:

Cryonics is the process of pausing people in critical condition who can't accept the concept of death, in the hopes that people from the future will be able to save them, and the community of hard-core cryonics people might also be a Scientology-like cult.

And then there's the elephant in the room—this part of the sentence: *...and the community of hard-core cryonics people might also be a Scientology-like cult.*

I put that in there because when you're examining something that involves A) a fringe community, B) the possible concept of immortality, and C) members paying large sums of money for services that they're told might pan out 1,000 years from now—you have no choice but to put up your "Is this a Scientology-y thing?" antenna.

One way to let that antenna do its work is to read a bunch of stuff written by smart, credible people who think the whole thing is utter BS. If anything will disenchant you

to the excitement of something as out there as cryonics, it's experts telling you why it should be ignored.

So I did that. And as I read, I weighed what I read against the rebuttal from cryonicists, which I'd often find on Alcor's highly comprehensive FAQ page. Other resources for the cryonicist viewpoint are the thorough FAQ of the Cryonics Institute's ex-president, Ben Best, Alcor's Science FAQ and Alcor's Myths page.

The people who are super not into cryonics fall into a few general buckets:

SKEPTIC TYPE 1: THE SCIENTIST WITH A VALID ARGUMENT ABOUT WHY CRYONICS MIGHT NOT BE POSSIBLE

The mainstream medical community is generally not on board with cryonics. No health insurance company will cover it, no government will subsidize it, no doctors will refer to it as a medical procedure.

Some skeptics make what seem to be valid points. Biochemist Ken Storey says, "We have many different organs and we know from research into preserving transplant organs that even if it were possible to successfully cryopreserve them, each would need to be cooled at a different rate and with a different mixture and concentration of cryoprotectants. Even if you only wanted to preserve the brain, it has dozens of different areas, which would need to be cryopreserved using different protocols." Storey also points out just how tall an order it would be to "repair" someone damaged by vitrification, explaining that "a human cell has around 50,000 proteins and hundreds of millions of fat molecules that make up the membranes. Cryopreservation disrupts all of them." (Alcor calls this statement patently false.)

Others point to the towering challenge of either repairing a human brain or scanning one in order to upload it. Brazilian scientist Miguel Nicolelis emphasizes that the task of scanning a human brain would require, with today's technology, "a million electron microscopes running in parallel for ten years." Michael Hendricks, who studies the brains of roundworms, believes the challenge of reviving the qualities that make someone who they are is far too complex to achieve, explaining that "while it might be theoretically possible to preserve these features in dead tissue, that certainly is not

happening now. The technology to do so, let alone the ability to read this information back out of such a specimen, does not yet exist even in principle.”

CRYONICIST RESPONSE: TOTES

Cryonicists don't really disagree with these people (Storey's quote notwithstanding). They readily admit that the challenges of reviving someone from cryopreservation are insurmountable using today's technology. They simply point out that A) there's no scientific evidence that cryonics *can't* work, B) we shouldn't underestimate what future technology will be able to do (imagine how mind-blowing CRISPR would be to someone in the year 1700 and think about what the equivalent would be for us), and C) there have been some promising developments—like the recent well-preserved vitrified rabbit brain news—that suggest there's reason for optimism.

I'm yet to hear a cryonicist say, “Cryonics will work.” They just don't feel that this is a case where a lack of proof amounts to a lack of credibility. Alcor's Science FAQ addresses this: “The burden of proof lies with those who make a claim that is inconsistent with existing well-established scientific theory. Cryonics is not inconsistent with well-established scientific theory ... At no point does cryonics require that existing physical law be altered in any way.”

Cryonicists also don't waste an opportunity to point out these quotes:

“There is no hope for the fanciful idea of reaching the Moon because of insurmountable barriers to escaping the Earth's gravity.” — Dr. Forest Ray Moulton, University of Chicago astronomer, 1932.

“All this writing about space travel is utter bilge.” — Sir Richard Woolley, Astronomer Royal of Britain, 1956.

“To place a man in a multi-stage rocket and project him into the controlling gravitational field of the moon.... I am bold enough to say that such a man-made voyage will never occur regardless of all future advances.” — Dr. Lee De Forest, famous engineer, 1957.

SKEPTIC TYPE 2: THE SCIENTIST WHO ARGUES THAT CRYONICS WON'T WORK EVEN THOUGH THEY KNOW LESS ABOUT

CRYONICS THAN YOU DO RIGHT NOW HAVING READ THIS POST

This is a surprisingly large category of cryonics skeptics. It's amazing, for example, how many people from the mainstream medical world argue that cryonics can't work because when water freezes, it causes irreparable damage to human tissue.

CRYONICIST RESPONSE: AGREED— THAT'S WHY WE DON'T FREEZE PEOPLE. PLEASE READ ABOUT WHAT CRYONICS IS BEFORE SAYING MORE WORDS OUT OF YOUR MOUTH.

Among the cryonics skeptics who literally don't get what modern cryonics consists of is celebrity physicist Michio Kaku, someone I normally like, but who in this clip (<https://www.youtube.com/watch?v=m-tcfWnZgCo>) is taken to town by Alcor's CEO for having no idea what he's talking about.

Part of the reason most scientists don't get cryonics has to do with its cross-disciplinary nature. Alcor explains:

Most experts in any single field will say that they know of no evidence that cryonics can work. That's because cryonics is an interdisciplinary field based on three facts from diverse unrelated sciences. Without all these facts, cryonics seems ridiculous. Unfortunately that makes the number of experts qualified to comment on cryonics very small. For example, very few scientists even know what vitrification is. Fewer still know that vitrification can preserve cell structure of whole organs or whole brains. Even though this use of vitrification has been published, it is so uncommon outside of cryonics that only a handful of cryobiologists know it is possible.

SKEPTIC TYPE 3: THE CRYOGENICIST WHO DOESN'T WANT THE OTHER COOL KIDS TO THINK HE'S FRIENDS WITH CRYONICS, THE WEIRD OUTSIDER.

There's an amusing little one-way rivalry going on between cryogenicists (who, remember, deal with the science of the effects of cold temperatures in general) and cryonicists. Cryogenicists tend to view cryonics like an astronomer would view astrology—or at least, that's what they say publicly out of caution. They seem to sometimes admit that there could be sound science behind cryonics, but they also know that cryonics lacks credibility with the wider science community and they don't want to

get roped into that reputation problem by association (they also have very little sense of humor about people confusing the words cryogenics and cryonics).

CRYONICIST RESPONSE: WHATEVS.

SKEPTIC TYPE 4: THE PERSON WHO BELIEVES THAT EVEN IF YOU CAN REVIVE A VITRIFIED PERSON, IT WON'T REALLY BE THEM.

This relates to a philosophical quandary I explored in the post *What Makes You You?* Are “you” your body? Your brain? The data in your brain? Something less tangible like a soul? This all becomes highly relevant when we're thinking about cryonics. It's hard to read about cryonic revival, and especially the prospect of “waking up” in a virtual world you've been uploaded into, without asking, “But wait...will that still be *me*?”

This is a common objection to cryonics, but few people will argue with conviction that they *know* the answer to this question one way or the other.

CRYONICIST RESPONSE: YEAH, WE'RE NOT SURE ABOUT THAT EITHER. FINGERS CROSSED THOUGH.

Most cryonicists have a hunch that *you* can survive cryopreservation intact (cryonicist Eliezer Yudkowsky argues that “successful cryonics preserves anything about you that is preserved by going to sleep at night and waking up the next morning”) but they also admit that this is yet another variable they're not sure about. You might even want to consider this a fifth “If” to add onto our list: If what seems to be a revived me is *actually* me...

SKEPTIC TYPE 5: THE PERSON WHO, REGARDLESS OF WHETHER CRYONICS CAN WORK OR NOT, THINKS IT'S A BAD THING

There are lots of these people. A handful of examples:

Argument: Cryonics is icky.

Typical cryonicist response: Yup, but less icky than decaying underground.

Argument: Cryonics is creepy and unnatural.

Typical cryonicist response: People said the same thing about the first organ transplants.

Argument: Cryonics is trying to play God and cheat death.

Typical cryonicist response: Is resuscitating someone whose heart has stopped playing God and cheating death? How about chemotherapy?

Argument: Cryonics is a scam.

Typical cryonicist response: The major cryonics companies are all nonprofits, the employees are paid modestly and the board members running the company (who are all signed up for cryonics themselves) aren't paid at all. So who exactly is benefiting from this scam?

Argument: "If you have enough money [for cryonics], then you have enough money to help somebody in need today." — Bioethicist Kenneth Goodman

Actual cryonicist response: "If you have enough money for health insurance (which costs a lot more than cryonics), then you have enough money to help somebody else in need today. In fact, if you have enough money for any discretionary expenditure (travel, sports, movies, beer), then you have enough money to help somebody in need today. Of all the ways people choose to spend substantial sums of money over a lifetime, singling out the health care choice of cryonics as selfish is completely arbitrary."

Argument: "Money invested to preserve human life in the deep freeze is money wasted, the sums involved being large enough to fulfill a punitive function as a self-imposed fine for gullibility and vanity." — Biologist Jean Medawar

Actual cryonicist response: "Nobody would ever imagine calling the first recipients of bone marrow transplants or artificial hearts "gullible and vain." And what of dying children who are cryopreserved? Cryonics is an experiment, and people who choose this experiment are worthy of the same respect as other participants in high risk medical endeavors."

Argument: Cryonics will cause an overpopulation disaster.

Actual cryonicist response: This is a common one I've heard in my discussions. Here's what Alcor says: "What about antibiotics, vaccinations, statin drugs and the population pressures they bring? It's silly to single out something as small and speculative as cryonics as a population issue. Life spans will continue increasing in developed parts of the world, cryonics or not, as they have done for the past century. Historically, as societies become more wealthy and long-lived, population takes

care of itself. Couples have fewer children at later ages. This is happening in the world right now. The worst population problems are where people are poor and life spans short, not long."

Argument: But Ted Williams.

Let me explain. There are a handful of famous people signed up for cryonics, like Ray Kurzweil, nanotech pioneer Eric Drexler, and celebrities like Larry King, Britney Spears, Simon Cowell, and Paris Hilton. But there are very few big names among the 300 or so who are already vitrified. One that is is baseball legend Ted Williams.

Williams is the first thing that comes to mind when a lot of people think about cryonics, an unfortunate fact that cryonicists wish would go away, because his story is mired in scandal (two of Williams' children said cryonics is what he wanted while the other claimed he wanted to be cremated and the son was just cryopreserving him so he could later profit off of his DNA samples). The ugly story ended up, fairly or unfairly, as a stain on the cryonics industry in many people's heads, partially because in the midst of it, Sports Illustrated published an article about the scandal with quotes from an ex-Alcor employee accusing Alcor of mismanaging the Williams vitrification, among other things.

Typical cryonicist response: Unfairly. It's a stain unfairly. The accusations weren't based in reality, and the employee recently admitted in court that what he said may not have been true.

Argument: Life is long enough. People aren't supposed to live longer than we do now. Just enjoy what you've got.

Typical cryonicist response: Thank you for your opinion. I disagree.

So how does my Scientology antenna feel after reading about 50 skeptic opinions?

Well, the skeptics definitely helped me appreciate the magnitude of the challenge at hand with cryonics. Science has a long way to go before cryonics can truly function as a pause button instead of a stop button—and we may never get there.

But it left me feeling every bit as confident that cryonics is a worthy pursuit and possibly a total game-changer. The fact that cryonic revival seems plausible, coupled with the fact that through most of history, the people of the time couldn't have even imagined the magic that future technology would make real, makes me feel like the

safer bet is on cryonics *eventually* working. If something important isn't *impossible*, the future will probably figure out a way to make it happen, with enough time.

There's also the "why the fuck not?" argument cryonicists make that's very hard for skeptics to thwart.

Pro-cryonics scientist Ralph Merkle says it well:

The correct scientific answer to the question "Does cryonics work?" is: "The clinical trials are in progress. Come back in a century and we'll give you an answer based on the outcome." The relevant question for those of us who don't expect to live that long is: "Would I rather be in the control group, or the experimental group?" We are forced by circumstances to answer that question without the benefit of knowing the results of the clinical trials.

The only way to shoot down a response that says, "We don't know but we might as well try" is to say, "There is *definitely* no point in trying because it's *impossible*." And very few credible scientists would claim to have that conviction about things as mysterious as the workings of the brain and the possibilities of the far future.

The other thing that struck me as I learned about cryonics is that cryonicists aren't usually "salesy" at all when they talk about cryonics. The impression I got from my research is that cryonicists tend to be well-educated, rational, realistic, and humble about what they know and don't know. They readily admit the problems and shortcomings of the field and they're careful to use measured, responsible language so as not to distort the nuances of the truth. And despite a general lack of support from the mainstream medical community, plenty of reputable scientists have become fervent cryonicists.

So, for now, cryonics has satisfied my Scientology antenna.

Which shortens our sentence to this:

Cryonics is the process of pausing people in critical condition who can't accept the concept of death, in the hopes that people from the future will be able to save them.

The final wording in the sentence that I'd like to challenge is:

Cryonics is the process of pausing people in critical condition who can't accept the concept of death, in the hopes that people from the future will be able to save them.

This is the part of the sentence that

carries a twinge of eye-rolling contempt—something people often feel when they hear about someone with a desire to conquer mortality. Aside from the aversion we have to the prospect of a human body floating in a freezing tank, many of us feel a distaste towards the *motivation behind* cryonics. It seems *greedy* to want more than your one standard life.

I'm not one to typically feel contempt at something like this, but early in my research, even I found myself doing a little head shake when I read about billionaire Peter Thiel signing up for cryonics a while back.

But this post has forced me to take a big step back—back to where I can see death not as a moment but as a process, back to where I can see the human lifespan as a product of our times, not our biology, and back to where I see the concept of human health spread out along the spans of time and where I can imagine how future humans will see our current times of helplessness in the face of biological deterioration.

From way out here, it hits you that we're living in a phase—a sad little window that an intelligent species inevitably passes through, when they're advanced enough to understand their own mortality, but still too primitive to save themselves from it. We grapple with this by treating death like a tyrannical overlord we wouldn't dare try to challenge, not even in our own private thoughts. We've been universally defeated and dominated by this overlord for as long as we've existed, and all we know how to do is bow down to it in full resignation of its power over us.

Future humans who have one day overthrown the overlord will look at the phase we're in and our resulting psychological condition with such clarity—they'll be sad for us the way we're sad for brainwashed members of an ancient cult who commit mass suicide because the master has instructed it.

Our will isn't broken when it comes to *resisting* the overlord—that's why we see it as honorable to fight cancer till the final minute, heroic to risk your own life for a good cause and make it out alive, and a terrible mistake to resign to the overlord prematurely and commit suicide.

But when it comes to *defeating* the overlord, our will has been squashed by a history that tells us that the overlord is indestructible.

And this explains the divide between how cryonicists feel about cryonics and how the rest of us view it. The divide is for two reasons:

1. Cryonicists view death as a process and consider many people who are declared dead today to still be alive—and they view cryonics as an attempted transfer of a living patient to a future hospital that can save his life. In other words, they view cryonics merely as an attempt to resist the overlord, no different than the way we view someone being transferred to a hospital in a different location which has better treatment options for their condition. Most of us, by contrast, view death as a singular moment, so we see cryonics as an attempt to bring a dead person back to life—i.e. we see cryonics as an attempt to defeat the overlord. When cryonicists see us cheer on a billionaire who fights cancer and shake our heads at one who signs up for cryonics, when they see us praying for someone in a coma and rolling our eyes at someone being vitrified—they see us being highly irrational.
2. Cryonicists view death not as an all-powerful overlord but as a puzzle to be solved. They see humans as an arrangement of atoms and see no reason that arrangement should have to inevitably deteriorate if our scientists can just get better at working with atoms. So for them, trying to defeat death altogether is an obvious, rational mission to undertake. But most of us view death as a fundamental fact of the universe—a mysterious and terrifying shadow that hovers over all living things and that only a naive fool would try to escape from—so instead of cheering on the people trying to solve the puzzle of death, we scoff at them and laugh at them, as if they're too immature to come to peace with the inevitable.

Looking at this through a zoomed out lens was a big Whoa Moment epiphany for me. Suddenly, I saw the cryonicists of the world in the same light as those rare

ancient people trying to understand how earthquakes work so they could be best prepared for the next one, and I realized that when I shook my head at Peter Thiel, I was being like one of the hordes of ancient people who worshipped the gods that had punished us with that earthquake and who wanted to burn those rare scientists at the stake for their blasphemous thinking.

I started this post thinking I'd simply write a "mini post" about this little community of cryonicists and what they were trying to do and ended it staring at another example of today's self-proclaimed science-minded rationalists being tomorrow's idol-worshippers.

I also saw my conception of end-of-life morality flip itself on its head. At the beginning of my research, my question was, "Is cryonics an okay thing to do?" By the end, the question was, "Is it okay to *not* sign up a dying child for cryonics, or will future people view that the way we see a parent refusing to allow life-saving medical treatment to their child for religious reasons?"

Cryonics has quickly come to seem not only like a good thing to try, but like *the right thing to do*.

That's certainly how Alcor sees it. They say:

The moral argument for cryonics is that it's wrong to discontinue care of an unconscious person when they can still be rescued. This is why people who fall unconscious are taken to hospital by ambulance, why they will be maintained for weeks in intensive care if necessary, and why they will still be cared for even if they don't fully awaken after that. It is a moral imperative to care for unconscious people as long as there remains reasonable hope for recovery.

And once you're looking through that lens, everything we consider normal starts to look crazy.

When Kim Suozzi found out she was dying of cancer at age 23, she signed up to be cryopreserved. She viewed it like trying a new experimental drug that might have a chance to save her when nothing else could—a no-brainer. But her father fiercely resisted the decision, Reddit users scorned her for it, and the story was unusual enough to warrant a feature article in the New York Times.

It's as if Kim was part of a group of the world's cancer-stricken 23-year-olds as they all walked toward a cliff to fall into the jaws of the overlord, and Kim saw a rope hanging from a higher cliff across the

chasm and decided to jump for it because maybe, just maybe, it could pull her to safety. And the *Times* found that to be so bizarre, and so out there, that they wrote a piece on it. Huh?

From far away, it looks a lot like we're all on a plane that's going down, with our only shot at survival being to take a chance with an experimental parachute—and we're all just staying in our seats.

I've decided to take a parachute and jump. I have an appointment set up for early April with a life insurance agent and Alcor member to get set up with a plan. I can boil the decision down to three reasons:

1. **I love life.** Readers have picked up on my mild obsession with death, which might have something to do with the 55 times I've talked about it on this blog. But when they bring it up with me, they refer to it as my fear of death. Which isn't quite how I feel. It's more that I really like life. I like doing things and thinking things and I like my family and friends and want to keep hanging out with them if I can. I also really want to see what happens. I want to be there when we figure out the Fermi Paradox and when we discover what dark matter is and when we terraform Mars and when AI takes all our jobs and then extincts all of us. I want to see what the 23rd century is like and see how cool the phones are by then. Being alive is a lot more interesting than being dead. And since I have all of eternity to be dead, it seems logical to stay not dead for at least a while when I have the chance.

2. **This chart.**

Scientist predictions about likelihood that each post-death option will lead to a new, rejuvenated chance at life

	CRYONICS	BURIAL	CREMATION
OPTIMISTIC SCIENTIST	70%	0%	0%
MODERATE SCIENTIST	35%	0%	0%
CONSERVATIVE SCIENTIST	10%	0%	0%
PESSIMISTIC SCIENTIST	0%	0%	0%

3. **Hope.** I've always been jealous of religious people, because on their deathbed, instead of thinking, "Shit," they're thinking, "Okay here's the big moment—am I about to blink and wake up in heaven??" Much more fun. And much more exciting. Whether cryonics pans out or not, as I age, at least a little part of me can now be thinking, "I wonder what's gonna happen when I die?" Atheists aren't supposed to get to think that. Humans don't need a huge amount of hope to feel hopeful—they just need something to cling onto. Just enough to be able to have the "So you're sayin' there's a chance!" feeling.

Some of you will resonate with my decision—others will think it makes me silly, gullible, or selfish.

Either way, you should think about this and the fact that you currently have a plan, whether you realize it or not. Likely, that plan is to resign to death. To walk off the cliff instead of jumping for the lifeline. To stay planted in your seat as the plane goes down.

That's not necessarily the wrong decision, depending on who you are, what you believe, and what you value. But if that's your plan, it should be because you like that plan more than the alternative—not because you haven't thought about it and are just doing what everyone else is doing. This is a matter of your one existence, and you have to take the fate of that existence into your own, independent-thinking hands.

And if you decide that you probably would rather grab a parachute than stay in your seat, try not to fall victim to a common trap:

Cryocrastination.

That's a real term used in the cryonics world to describe the phenomenon of people—especially young people—saying, "Yeah duh I'm obviously doing cryonics when I die" and then not actually going through the actions to sign up and start paying money. It's natural—what could possibly be easier to procrastinate on? That item on your list—"sign up for cryonics"—tends to never find itself at the *top* of the to-do list. But no matter what age you are, unexpected things can happen, and if you never got around to signing up when they do, you're out of luck. If you take a big

step back, procrastinating on this is *really* shortsighted. Just do what I did—book appointments so you'll actually do it.

I hope you'll do it the same way I'd hope you'd take a shot with an experimental drug if you were sick and it were the one chance you had. Because it's worth a try. Because it just might work. Because why the fuck not. And because Dylan Thomas said it best:

*Do not go gentle into that good night.
Rage, rage against the dying of the light.* ■



ABOUT THE AUTHOR

With *Wait But Why*, Tim Urban demonstrates that complex and long-form writing can stand out in an online wilderness choked with listicles and clickbait. Tim Urban has become one of the Internet's most popular writers. With wry stick-figure illustrations and occasionally epic prose on everything from procrastination to artificial intelligence, Urban's blog, *Wait But Why*, has garnered millions of unique page views, thousands of patrons, and famous fans like Elon Musk.

Brief Overview of Micro- to Nanoscale 3D Printing

By Carrie Wong

INTRODUCTION

It has been 30 years since *Engines of Creation: The Coming Era of Nanotechnology* was published by Eric Drexler. This book, written by an accomplished cryonics supporter, helped popularize the potential of molecular nanotechnology in the '70s and '80s. Thirty years ago, he described how microscopic robots could manipulate matter on a molecular level. This captured the imagination of many scientists around the world. In the beginning there were only a few visionaries who believed that something like this might be possible. Nowadays, scientists all over the world are developing ways to manipulate matter on smaller and smaller scales. Amazing technologies are being developed today, including nanoscale 3D printing.

Cryonicists often get asked how they would come back and how the damage would be repaired in the future. In my experience, we mostly rely on some sort of “handwaving” explanation about how there could be future technology to bring us back. We often reference advances in nanotechnology to repair the damage of vitrification and what caused our critical condition in the first place. The skeptic often interprets this explanation as a *dens ex machina* with little basis. The majority of cryonicists are not experts in nanotechnology or 3D printing but we keep up with the headlines and these advances often sound promising. More often than not, cryonicists pay closer attention to

scientific advances than the general public. We often do have an edge when attempting to explain how exactly we would be revived in the future. In this article, I expand on modern research in nanoscale technology and 3D printing.

NANOSCALE 3D PRINTING

3D printing is also known as additive manufacturing. In basic terms, this technology often starts with a computerized 3D model, followed by an automated “build up” process that creates the object in 3 dimensions using layers or piece by piece. The 3D printer acts like a personalized manufacturing robot. This technology exploded in popularity in the last few years and the term “3D printing” is used to describe a plethora of new technologies.

In 2012, researchers at the Vienna University of Technology broke the speed record for fabricating microscopic objects using a technique called “two-photon lithography”¹. With lasers, they printed a high-resolution miniature Cathedral using resin that spanned 50µm in just a few minutes. In this new technique, the resin contains special molecules which are activated by the laser light and induce a chain reaction that causes the resin to turn solid. The resin only hardens when it absorbs two photons of the laser beam at once, which only occurs at the center of the laser beam¹. This two-photon technique allows for precision and control of which parts of the resin harden. Solid material

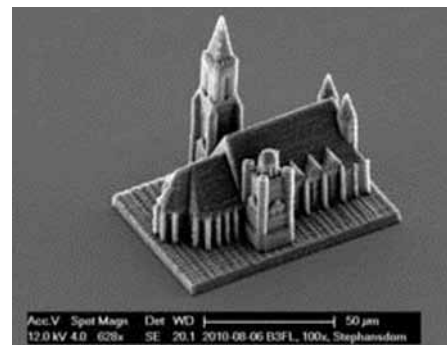


Figure 1: Microscopic miniature cathedral.
Credit: Vienna University of Technology

can be created anywhere within the liquid resin rather than on top of the previous created layer only.

Just this year, researchers at ETH Zurich published a new nanoscale 3D printing technique with metal materials². This method is based on the FluidFM system developed at ETH Zurich several years earlier. With this technique, scientists were able to produce individual 3D metal pixels ranging in diameter from 800nm to 5µm. Using these metal pixels, they were able to build larger and mechanically stable, solid 3D objects. Impressively, they did all this without using any structural templates.

In this system, there is a moveable micropipette mounted on a spring that can be positioned precisely². A droplet is placed on a base plate made of gold, then the tip of the micropipette penetrates the droplet and acts as a print head. A copper sulphate solution flows through the pipette

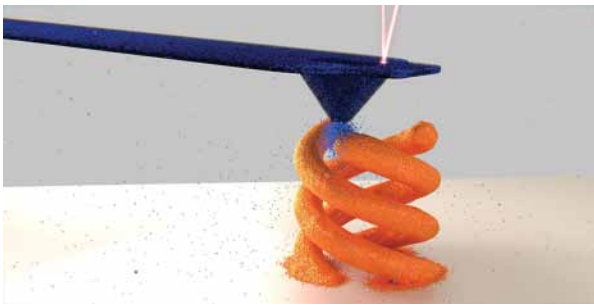


Figure 2: Pictured, a movable micropipette (in blue) creating copper pixels at the tip. Credit: ETH Zurich / Alain Reiser

and using an electrode, the scientists apply a voltage between the droplet and the solution. This causes an electrochemical reaction under the pipette's tip and copper sulphate emerging from the pipette turns into solid copper³. Each reaction forms a tiny copper 3D pixel that is precisely placed on the base plate.

The technology to print on smaller and smaller scales with a variety of materials is already being applied to medical prosthetics. Monika Kwacz, a researcher at the Institute of Micromechanics and Photonics at Warsaw Technical University was looking for a solution for hearing impairment due to fixation or loss of the tiny bones inside the inner ear⁴. She reached out to Potomac Laser, a company that creates medical devices using laser-based 3D printing. Using their high-resolution printing system, they were able to create tiny, inner-ear prototypes in acrylic.



Figure 3: 3D printed inner ear prosthetics. Credit: Potomac Laser⁴

Working on an even smaller scale, for the first time ever, researchers created a 3D-printed guide that helps regrow nerves⁵. Researchers achieved this in both the sensory and motor functions of complex nerves after injury. Nerve regeneration is a complex process and regrowth of nerves after injury is rare. Nerve damage is often permanent. With 3D printing, researchers were able to create nerve regrowth guides

with personalized anatomical geometries along with physical and biochemical cues to promote the regeneration of multiple nerve pathways. They demonstrated this proof of concept in vivo by guiding the regrowth of complex nerves in a rat⁵.

With advancements in nerve repair technology that can be personalized by 3D scanning and printing, we can envision how nerves micro-fractured through vitrification could be repaired in the far future. In the near future, we can expect to see clinical uses of such technology to help repair spinal cord injuries and treat diseases that affect the nervous system.

BLOCK BY BLOCK MOLECULE MANUFACTURING?

Researchers at the University of Illinois have developed a machine that builds complex molecules from simple chemical



Figure 5: Photo of an implanted 3D printed nerve guide, printed in silicon with incorporated biochemical cues.

building blocks⁶. Blurring the line between 3D printing and chemistry, they were able to synthesize organic small molecules using one automated process. Small molecules are organic compounds with a low molecular weight. Most drugs are small molecules that regulate our biological processes.

The basic chemical building blocks used in this automated process each have two chemical connectors that can be readily linked to the corresponding part on another building block; in other words, these blocks are chemically compatible. They are linked together using a standard chemical

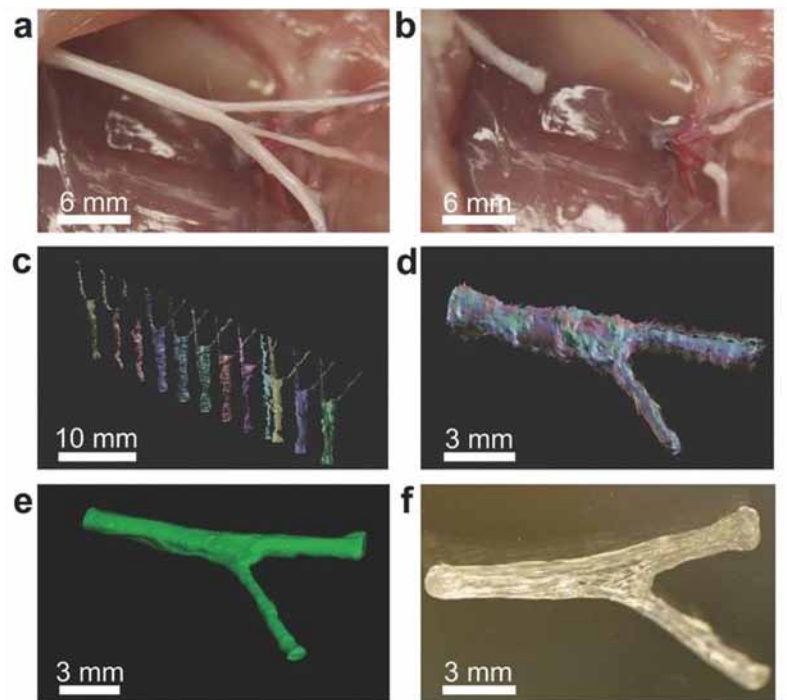


Figure 4: Illustrates the basic steps in printing the complex nerve template⁵.

- A complex nerve in a rat.
- The complex nerve is removed, providing a tissue sample for scanning.
- Scans are taken from various positions to assemble a 3D model of the geometry of the nerve pathway.
- The scans are aligned to create the 3D geometry of the nerve tissue.
- Full reconstruction of the nerve pathway geometry, the template for 3D printing.
- The nerve pathway model is printed in silicon, with a hollow pathway, customized to fit the exact geometry of the original tissue.

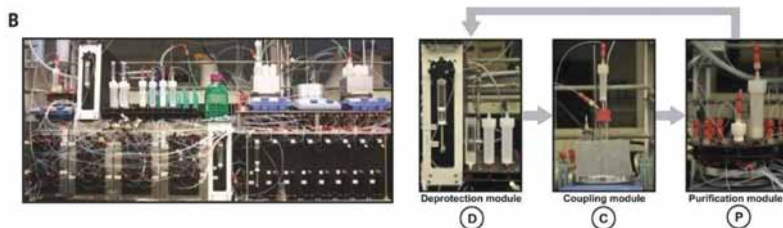


Figure 6: Photograph of the small-molecule synthesizer and an outline of the three steps of production including deprotection, coupling and purification⁶.

reaction. Using this technique they were able to synthesize 14 distinct classes of small molecules using the same, fully automated, process⁶. These molecules ranged in complexity from simple linear structures to complex rings. The researchers note that with thousands of compatible building blocks already commercially available, many small molecules are now accessible. These new findings show a proof of concept to a more general and automated approach to small-molecule synthesis.

NANOMACHINES ON THE HORIZON

Just this year, Cambridge researchers unveiled the world's smallest engine. This engine is on the nanoscale and it is powered

by light⁷. It is made up of charged particles of gold, bound together with polymers. When this engine is heated with a laser, it stores elastic energy in less than a second. The polymer coating the particles expels all the water from the polymer gel and collapses in size. This process forces the gold nanoparticles to bind together into clusters. When the nano-machine is cooled, the polymers take on water and expand and the gold nanoparticles are quickly pushed apart like a spring. Researchers note they can use this contraction and expansion like a piston engine to power movements on a very small scale.

This is a novel way to make nano-machines move and the force of these tiny pistons is several orders of magnitude

greater than any other kind of engine produced in the past. This may appear incredible but it is made possible by unlocking one of the fundamental forces of the universe. Van der Waals forces are relatively weak electric forces that attract or repel neutral molecules to one another. In this case, the researchers make use of Van der Waals forces in attraction of heavy metal particles to set the springs and water molecules to release them when the temperature sensitive polymers cool down⁸. This nano-engine could be the very beginning of a nanorobot revolution, the same way steam engines propelled the Industrial Revolution in the 19th century.

CONCLUSION

3D printing has come a long way in the last decade. In the last few years there has been a number of breakthroughs in 3D printing smaller and smaller components for medical use. Some of these include tiny prosthetics; others include templates for guiding nerve-growth. With viable nano-engines just around the corner, researchers can put 3D printing to work on the nanoscale to print the parts necessary to build the nanorobots that science fiction writers have been writing about for decades. ■

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ABOUT THE AUTHOR



Carrie Wong is a young Canadian cryonicist. She graduated in 2011 with a degree in geology from The University of British Columbia and worked in gold exploration for a few years. In addition to writing for *Cryonics* magazine, she is also writing for geologyforinvestors.com and running a cartography business.

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DAOS, DEMOCRACY AND GOVERNANCE

By Ralph C. Merkle

Democracies are typically seen as governments which call upon the governed to make the major decisions of government: who shall lead, what policies to follow, what laws to enact. In all these matters democracies call upon ordinary citizens to make complex decisions with eventful consequences.

We do not call upon ordinary untrained citizens to perform surgery, fly airplanes, design computers, or carry out the other myriad tasks needed to keep society functioning, what makes governance different?

The problem is readily understood: if we give governance to “experts” they will make decisions in their own best interests, not in the best interests of us all. As we have seen too often in the past, this leads to enrichment of a small elite and the enslavement or worse of the vast majority. Can we take advantage of the expertise of the best and brightest, while insulating the system from attempts they might make to gain control?

Modern research into “the wisdom of crowds” provides new insights into how to combine the expertise of all participants without handing over control to “experts.” Combined with research on Decentralized Autonomous Organizations (DAOs), this allows us to design a new form of democracy which is more stable, less prone to erratic behavior, better able to meet the needs of its citizens, and which better uses the expertise of all its citizens to make high-quality decisions.

We call this new form of democracy a DAO Democracy.

INTRODUCTION

Democracy, n. a system of government in which power is vested in the people.

Democracy, n. an asylum run by the inmates.¹

“... if we want a better politics, it’s not enough to just change a Congressman or a Senator or even a President; we have to change the system...”²

Our lengthening lifespans, the growing lethality of our weapons systems, the coming development of artificial intelligence,³ and the ever more rapid developments in technology make governance ever more important. Failure to develop a system of governance able to respond appropriately and reliably in a timely fashion to the ever quickening pace of change could have major consequences, not the least of which might be to cut short our own lives.

Troubling examples of the failure of governance in all of our major institutions are distressingly easy to find.

War is perhaps the most obvious example where poor governance costs us dearly. Consider that in the short span of 239 years a relatively well run and arguably peaceful democracy, the United States, has been involved in 104 wars.⁴ It is hard to escape the thought that better governance might have significantly reduced both the human and economic toll of many of these wars, and perhaps avoided some of them altogether.

A brief perusal of the news reveals many other examples where improved governance would save lives and reduce human suffering.

The 1991 collapse of the former Soviet Union showed clearly its leaders did not understand how to keep an existing system of governance from collapsing, one of the most basic aspects of governance.

The August 5, 2011 Standard & Poors downgrade of the United States credit

rating from AAA to AA+ was a direct consequence of poor governance.⁵ We don’t understand how to prevent major systems of governance from making choices that are obviously and grossly suboptimal. Brinkmanship rewards the useful skill of creating near disasters.

Many countries in the world have little to no governance.⁶ For these countries, even the most basic ability to govern would be an improvement.

In most countries, governance exists but with remarkable lapses. South African President Thabo Mbeki thought AIDS wasn’t caused just by a virus, and his health minister, Manto Tshabalala-Msimang, advocated a diet of garlic, olive oil and lemon to cure the disease. Until their removal in 2008, AIDS spread almost unchecked, killing at least 300,000 and making later containment efforts much more difficult.⁷

While some governments might be marginally better, over spans measured

in multiple centuries and longer, no existing human institution seems capable of providing the kind of stability and consistently sound decision making that seems required if we are to enjoy long term global security both for ourselves and humanity as a whole, particularly when we consider the exponential advances we are making in technology⁸ and the multi-century and longer lifespans that we expect to be dealing with.⁹

Governance of nations, of companies, of nonprofit and non-governmental organizations (NPOs and NGOs), indeed of any organization, has been subject to major lapses and failures. Even in the best of cases, large and apparently stable and well run organizations suffer from inertia and an inability to respond to new ideas, and seldom maintain their ranking in perpetuity. Organizations that have survived more than a century are relatively rare, have invariably fluctuated in the quality of their governance, and needed a dose of good luck to survive. Even the largest and most stable organizations can't guarantee their own existence, let alone the quality of their governance, for the coming century.

THE PROBLEMS WITH VOTING

Our existing democracy is based on voting, yet voting has major problems.¹⁰

First, voters have little incentive to vote at all. In a typical election, the probability is very high that a given vote will have exactly no impact on the outcome. A rational economic analysis would assign an extremely small positive value to voting, even assuming the voter had reason to believe that influencing the outcome would have a discernable positive impact on their life. The time spent voting would exceed the value obtained from the vote. Economically rational voters should not vote.^{11,12}

Second, the voter would have to spend significant time and effort analyzing the various candidates and propositions to determine which, if any, offered any benefit from the voter's perspective. Rationally, this makes voting an even less desirable activity. To the extent social pressure is brought to bear to increase "turn out" and cause marginally motivated individuals to vote, their optimal strategy is to acquiesce, make a show of voting, but spend little to no time actually determining how to cast their vote. Such random voting behavior, or worse,

voting based on predictable but superficial and incorrect "first impressions," will result in decision making that is sub-optimal. The cost of determining how best to vote is high, even assuming the voter had accurate information. Again, economically rational voters should not vote.

Third, those spending substantial sums on influencing the voter are providing systematic misinformation intended to cause the voter to select this or that candidate, or vote for this or that proposition, often in direct opposition to the voter's own interests. If the voter is deceived by one of these misinformation campaigns (which can be very sophisticated) then voting could easily have a very small negative expected value to the voter (instead of a very small positive expected value), and produce systematically poor decisions for society. In any event, unless the voter is prepared to spend even more time analyzing the publicly available information, their vote is unlikely to produce the desired result.

Fourth, candidates are likely to behave, in office, in ways that were not anticipated prior to being elected. Propositions are subject to judicial challenges and other post-election influences that often make the result less predictable than the voter might desire. Not only is voting not worth the time spent on it, not only is it debatable that you can untangle the misinformation, not only is it unlikely that you'll get what you voted for, in the end you don't even get what the majority voted for.

Fifth, voting is an activity in which all participate equally, while at the same time it is well known that half the population is below average. We can, at best, expect such a process to produce mediocre results. Voting can only be justified by arguing that the alternatives are worse than mediocre.

From a societal perspective we are expending substantial resources to ensure that unmotivated, unqualified, misinformed voters make societally critical decisions, which are then often ignored. We celebrate this as the pinnacle of modern governance, and shed blood to defend it.

We manage to hold voting in such high regard by comparing it with, for example, absolute dictatorships that slaughter their own population. To paraphrase the old saying: voting is the worst way to make a decision, except for all the rest. But is this really true? Yes, voting is better than Pol Pot's genocidal regime, or Mao

Zedong's "Great Leap Forward", which killed between 18 million and 45 million Chinese.¹³ But this is a low bar. Are we content with a system whose major appeal is that it's better than genocide?

With so many obvious shortcomings, it would seem more than time to put serious thought into how we might produce a better system than democracies based on voting. While it's true that worse exists, it doesn't take much imagination to believe that better might be possible.

THE IDEAL DEMOCRACY

We might ask: "What is the ideal democracy?"

The phrase we hear most often is that democracies should reflect "the will of the people." What does this mean? That the goals and interests of the government should be the summation of the goals and interests of the governed?

Consider taking that phrase literally, rather than metaphorically. The goals and interests of the government should be the summation of the goals and interests of the governed. This would imply that the goals and interests of each individual would be given equal weight, and the summation of these goals and interests would determine the global course of action. But how might this abstract concept be rendered specific in a meaningful fashion?

GOVERNING BY PREDICTION MARKET

Futarchy, proposed by Robin Hanson, is a proposal to govern by prediction markets.¹⁴ The proposal seems like an excellent approach for improving upon existing democratic forms of governance.

The general concept is to (i) aggregate knowledge from across a community of people, using a method that's known to be effective: prediction markets.^{15,16} (ii) Use that aggregation method to directly select the actions taken by government. The goals (the "national welfare" to use Hanson's terminology) are still chosen by voting in futarchy. We discuss later how to eliminate voting entirely.

Governments take action by selecting among bills that are presented to a legislative body for passage. In Futarchy, the bills to be passed are selected by the prediction market, rather than by votes cast by the legislature or the population as a whole. Technically speaking, prediction

markets predict rather than select. The first question we have to answer is “what are the prediction markets predicting?” In futarchy, as proposed by Hanson, the prediction markets predict the “national welfare,” as defined by the legislature:

While national welfare could be anything the legislature chooses, it helps to see that reasonable options exist to choose from. For example, a reasonable initial definition of national welfare could augment current measures of national consumption or product (i.e., GDP) with simple measures of health, leisure, happiness, and the environment.

We choose to be more specific about the definition of what we shall call the “collective welfare,” for the very simple reason that “voting on values” retains the dubious voting mechanism as a core component of futarchy.

If this is to be a democracy, and if all citizens are to be equal, then all citizens must have an equal say in determining the collective welfare. It is difficult to see how we could choose otherwise. Shall some citizens receive a greater weight than others? That hardly seems like a democracy. Shall each citizen’s welfare be evaluated in a manner that the citizen cannot control? Who, or what, can claim greater right than the citizen to evaluate their own welfare?

We define the procedure for measuring democratic collective welfare below, and leave the rather philosophical question of what this democratic collective welfare “really means” for others. We shall simply observe that it clearly treats all citizens equally, and clearly gives each citizen the ability to influence the democratic collective welfare either positively or negatively.

If we are to have a collective welfare, that is, if we are to select a single number to assess the state of our entire society, and if we are to have a democracy in which each citizen’s individual welfare has equal weight with that of all other citizens, and if we agree that each citizen should have the right to determine their own contribution to that collective welfare, that leaves us with little room to vary how we compute the democratic collective welfare.

DCW: DEMOCRATIC COLLECTIVE WELFARE

Annually, all citizens are asked to rank the year just passed between 0 and 1 (inclusive). If you wish, you can think of this as a poll of each citizen’s individual welfare, where 0 means the welfare of the citizen that year was the worst possible, and 1 is the best possible. This scale provides no intellectual feedback on whether this or that person should be elected, or which bill should be adopted, or what policy is best: it is intended to provide information about one person’s state of satisfaction with the year that has just passed, and each individual citizen selects whatever value they please.

Summed over all citizens and divided by the number of citizens,¹⁷ this gives us an annual numerical metric between 0 and 1 inclusive, or a series of values each one of which summarizes the annual collective welfare of the entire populace for each year. An appropriately weighted sum of annual collective welfares, also extending indefinitely into the future, would then give us a “democratic collective welfare” metric.

More specifically, we can use ACW_{*t*}, Annual Collective Welfare in year *t*, as measured by our direct annual poll, as our base. This year, we would measure ACW₂₀₁₆. Next year, we’d measure ACW₂₀₁₇. The year after, we’d measure ACW₂₀₁₈. And so on. We then define DCW_{*t*}, the Democratic Collective Welfare in year *t*, as 5% of ACW_{*t*} + 95% DCW_{*t+1*}. DCW_{*t*} then gives us a value which depends on future values of ACW_{*t*}. Effectively, DCW_{*t*} lets us take a look into the future, with progressively declining weights over the next 20 or so years (1/20 = 0.05). In some sense, DCW_{*t*} lets us look infinitely far into the future, but the weights become infinitely small, falling off exponentially the further into the future we go, with a characteristic decay time of ~20 years. That is,

$$DCW_t = 0.05 \times ACW_t + 0.95 \times DCW_{t+1}$$

which can be expanded into:

$$DCW_t = 0.05 \times ACW_t + 0.95^1 \times 0.05 \times ACW_{t+1} + 0.95^2 \times 0.05 \times ACW_{t+2} + 0.95^3 \times 0.05 \times ACW_{t+3} + \dots$$

We provide an example below of how we can trade DCW_{*t*}, but the basic idea is that, as time passes, we can convert more and more of DCW_{*t*} into ACW_{*t*}. In year *t*, after the annual poll is taken, we can use the equation DCW_{*t*} = 0.05 × ACW_{*t*} + 0.95 × DCW_{*t+1*} to convert some fraction of DCW_{*t*} into ACW_{*t*}. The market for ACW_{*t*}

closes in year *t* and pays out. In this way, the “indefinite future” market for DCW_{*t*} gradually becomes definite and convertible into cash.¹⁸

This kind of “indefinite future” weights the near future more heavily than the far future, and uses a “discount rate” to determine the weighting. We might want to adopt a smaller discount rate, effectively making our prediction market pay more attention to the longer term future, perhaps the next 100 years, rather than the next decade or two. In this way, the “look ahead” of the prediction market can be adjusted. The smaller the discount rate, the longer the look ahead.

Paying attention to any finite period of time is, in some abstract sense, an incorrect strategy. That is, we only pay attention to the next day because we are insufficiently wise to deal with the next week. We only pay attention to the next week because we are unable to deal with the next month. We only pay attention to the next month because we are unable to deal with the next year. And so on. Ultimately, we want to deal with eternity, but we are not yet sufficiently wise. Any non-zero discount rate we choose is, therefore, a concession to our limited mental capacities.¹⁹ Further, the concept of a “discount rate” is itself deeply flawed. Really, we are trying to model our growing uncertainty about the future by using a discount rate. But our uncertainty about the future is not uniform. Sometimes we can make statements about the very far future. To quote Stephen Hawking: “There are certain situations in which we think that we can make reliable predictions, and the future of the universe, on a very large scale, is one of them.”²⁰ At the same time, we can’t predict the roll of a dice even a few seconds into the future. Applying a uniform discount rate to the many events that might occur in our future seems like a heuristic that might be improved upon, if only we were clever enough.

That said, and acknowledging their limitations, at the moment adopting a discount rate seems like at least a plausible heuristic—until a better one comes along. If we think we’re going to be brighter in the future, we could adopt methods that allowed for setting the future discount rate to values progressively closer to zero. If the discount rate approached zero fast enough, the infinite future would have a significant weight in today’s considerations.

DCW_i, Democratic Collective Welfare in year *i*, is our formalization of the less formal “collective welfare metric.” Either one can be replaced with the other. If you want to consider formally what is meant when we discuss evaluation of the collective welfare, we mean DCW_i. If you want an informal description of DCW_i, we mean the collective welfare.

TRADING DEMOCRATIC COLLECTIVE WELFARE: AN EXAMPLE

We now give an example of how to buy and sell DCW_i in a prediction market.

First, a trader purchases a pair of conditional bearer bonds from a bank for \$1 in the year 2016. The first says “Pay to bearer \$1 times DCW₂₀₁₆.” The second says “Pay to bearer \$1 times (1-DCW₂₀₁₆).” Because DCW₂₀₁₆ is between 0 and 1, each of these pays off between 0 dollars and 1 dollar. The two of them together are guaranteed to pay off exactly \$1. The bank, therefore, takes no risk in selling the pair, and simply promises to redeem them once DCW₂₀₁₆ is known.

Of course, DCW₂₀₁₆ will never be known with perfect accuracy, but as the years go by it will be known with ever greater accuracy. The bank will be happy to exchange a bond that says “Pay to bearer \$1 times DCW₂₀₁₆” for \$0.05 times ACW₂₀₁₆ and a bond that says “Pay to bearer \$0.95 times DCW₂₀₁₇.”

The trader who purchased the pair of bearer bonds can now sell the one thought to be less valuable. If the trader thinks DCW₂₀₁₆ is actually going to be 0.72, then he will happily sell the bond that says “Pay to bearer \$1 times DCW₂₀₁₆” for \$0.83, netting him \$0.83-\$0.72 = \$0.11. He will then sell the bond that says “Pay to bearer \$1 times (1-DCW₂₀₁₆)” for \$0.28. The trader expects to make \$0.83+\$0.28 = \$1.11 for his \$1 purchase of the two bonds from the bank.

In brief summary: the bank issues pairs of bonds to traders in exchange for cash. The bank takes on no risk. Traders buy and sell the bonds, establishing a market for them. Traders speculate on the value of the bonds and trade them to make (or lose) money. The market price of the bonds will fluctuate, depending on events. The bank exchanges the bonds that it has issued for newer bonds and cash, again taking on no risk.

Society benefits by getting reasonably good estimates of the DCW_i.

While this is a simplified example, it conveys the concepts involved in trading

in a prediction market for the collective welfare.

MEMBERSHIP

Another problem with evaluating collective welfare is membership in the collective: who do we add and who do we remove? We consider criteria that are suitable for membership in a nation (in contrast with membership in the local chess club, or a student in a school, or a shareholder in a company).

Traditionally, for democracies, children of members are added, and members remain members until they die. In the United States, birth within the United States confers citizenship, although voting rights are not conferred until some period of time thereafter. Voting rights can be lost following certain judicial proceedings.

We presumably initialize our system with the existing citizens of some jurisdiction or, alternatively, initialize the system with some set of volunteers. Seasteading comes to mind.

For a democracy, and presumably for many other situations, members of the system remain members until they die, at which point we must decide how to treat their death: in future years, what number between 0 and 1 should be used for them when the Collective Welfare is computed?

One answer is the lowest possible number on the scale: 0. This would make death a negative (undesired) event, which the DAO Democracy would then naturally seek to avoid (See “DAOS AS LIVING ENTITIES” on page 32 for a description of a DAO).

A more correct answer to this question is to ask the person who died. Asking them after they have died would be difficult, but we can certainly ask before they die, and if we can’t ask every person, we can at least ask most people how they want their death to be recorded, and seek either an answer from an executor or heir, or at least seek a statistically plausible answer if no better answer is forthcoming. Most people will likely regard their death as negative and pick some value close to 0. Some will regard their death under any circumstances as negative, some might not. Some might even say their death is positive.²¹ Regardless, in a democratic form of government the choice can reasonably be left to the individual.²²

We leave the policy with respect to new members, and to births, to our prediction market. There is already a mechanism for adopting policies (see below): we use this mechanism, asserting that the membership that will be used to decide this case will be the existing membership, and will not include new members. In particular if the prediction market concludes that the collective welfare of existing members will improve in the future by adopting a particular policy with respect to new members, then that policy will be adopted.

It is difficult to see how we could justify forcing the members of a DAO Democracy to adopt a policy with respect to new members, or to accept some new born child as a member, if the prediction market says the collective welfare of existing members would be made worse by adopting such a policy.



Contrariwise, it's equally difficult to see how we could justify refusing to adopt a policy that accepts some person, or a new born child, as a member, if the prediction market says the collective welfare of existing members will be improved by adopting such a policy.

There is an additional possible policy with respect to new members. We might allow an existing member to "adopt" a new member by splitting their own, weighted membership in half and giving half to the adoptee. This would create two citizens, each with half the "weight" of a regular citizen. If continued, this practice could create a small community which, in its entirety, had a "weight" of only 1 citizen. Yet each step along the path was entirely voluntary by those involved.

Allowing some citizens to be "more equal" than others seems to defeat the purpose of a democracy. Yet this question, too, can be reviewed by the prediction market—and if the prediction market favors a policy that allows such a state of affairs to come into being, and if the citizen in question wants to do it, can one reasonably block its adoption? It seems more comfortable to ask: if the prediction market opposes it, how could one reasonably decide to adopt it?

This raises the delicate question of how far a DAO Democracy should be allowed to go in redefining its own purpose. If we provide too much flexibility in this area, then the DAO Democracy could destroy itself. While it seems obvious that it should not be possible to take citizenship away, it's less clear whether citizenship can be renounced. If a citizen of their own free will, without coercion, wished to renounce citizenship, and a policy was in place which allowed that particular citizen to renounce their citizenship, then it would seem tolerable. Such a policy would have to be adopted by the usual means, of course. And some might require additional safeguards before citizenship could be discarded, else it might happen for reasons that would not withstand closer inspection.

Other than that, the answer would have to be: no, you cannot renounce your citizenship. If there is no policy in place that allows a citizen to renounce their citizenship, then there is no mutual agreement to dissolve the relationship. While it is entirely possible to conjecture what policy a DAO Democracy might

adopt on this point, it seems rather clear that, absent a policy that enabled a citizen to renounce their citizenship, it would not be possible.

MAKING IT RELIABLE

We'd like to do all of this reliably, that is, with suitable computer algorithms that provide suitable security. Fortunately, this problem can be very nicely dealt with by implementing a DAO Democracy using a Decentralized Autonomous Organization (DAO), as suggested by Vitalik Buterin.^{23,24}

DAOs provide a high degree of reliability and incorruptibility, and can be implemented using Ethereum, which makes the power of the Bitcoin algorithm available in a clean and flexible way. Byzantine Fault Tolerance²⁵ (BFT) provides variant approaches that can be used to provide a high degree of stability in a DAO while avoiding the large computational requirements of proof-of-work.

The use of BFT coupled with a prediction market would seem to offer a computationally less expensive and potentially more reliable system. In essence, the prediction market would be used to evaluate the reliability of the servers running the core protocols. The most reliable servers (the "core servers") would be identified by the prediction market. Thus, the BFT algorithms would know who they could most trust, and would use that information as they updated their state information. The prediction markets themselves would, of course, be maintained in a distributed fashion on the core servers, and so would be incorruptible—unless, of course, the BFT algorithms were corrupted. To corrupt the BFT algorithms would require that a majority (or possibly more) of the core servers become corrupted (depending on the details of the BFT algorithm). However, if the prediction markets are reasonably well subsidized, then it will be extremely difficult to corrupt even a few of the core servers, because the prediction markets will have selected the least corruptible servers from among a large number of candidate servers, all of which are running the core protocols. Anyone who spots any irregularity in any core server will immediately make money in the prediction market, and that server will immediately be dropped from the core servers. This will amount to a network of informants, constantly probing for any little

concern or worry about any core server.

Breaking the system requires sneaking past a fully functioning and well financed prediction market that is actively looking for any attack and which is running as a distributed algorithm on a set of core servers that are fully protected from any attack. Any slightest hint of any attack that might actually be successful on any core server will result in its immediate removal from the pool of core servers, and its replacement with any one of a large number of constantly running alternate servers. Any strategy for better protecting the core servers, or for better detecting an attack, will be immediately adopted (thanks to a prediction market specifically aimed at improving security which is constantly evaluating new and better strategies). It will be hard to corrupt even a few core servers, let alone half of them. Yet half of them (and possibly more) would have to be corrupted before it would even be possible to gain control of the system and corrupt the prediction market.

Corrupting half of the core servers would presumably require a very intense attack. The other servers would presumably be noticing an alarmingly high number of core servers that were engaged in suspicious activities, creating a full-blown panic. Presumably, such an intense attack on the core servers would be coordinated with additional political and military attacks. At some point the system would succumb, though presumably only after a much more intense attack than any current system could withstand.

Developing and deploying such a system will likely require more time, as it incorporates a prediction market as an integral component.

DAOS AS LIVING ENTITIES

What is a DAO? The acronym stands for Decentralized Autonomous Organization. The concept for a DAO is derived from Bitcoin, which might be viewed as the first prototype for a DAO.

While there are many technical descriptions of Bitcoin and the excitement it has created, it is perhaps worthwhile to try and capture this excitement in a way that can be understood by those without a technical background.

Briefly, and non-technically, Bitcoin is the first example of a new form of life. It lives and breathes on the internet. It

lives because it can pay people to keep it alive. It lives because it performs a useful service that people will pay it to perform. It lives because anyone, anywhere, can run a copy of its code. It lives because all the running copies are constantly talking to each other. It lives because if any one copy is corrupted it is discarded, quickly and without any fuss or muss. It lives because it is radically transparent: anyone can see its code and see exactly what it does.

It can't be changed. It can't be argued with. It can't be tampered with. It can't be corrupted. It can't be stopped. It can't even be interrupted.

If nuclear war destroyed half of our planet, it would continue to live, uncorrupted. It would continue to offer its services. It would continue to pay people to keep it alive.

The only way to shut it down is to kill every server that hosts it. Which is hard, because a lot of servers host it, in a lot of countries, and a lot of people want to use it.

Realistically, the only way to kill it is to make the service it offers so useless and obsolete that no one wants to use it. So obsolete that no one wants to pay for it. No one wants to host it. Then it will have no money to pay anyone. Then it will starve to death.

But as long as there are people who want to use it, it's *very* hard to kill, or corrupt, or stop, or interrupt.

The technical community was fascinated with this new life form. Not because of what it could do, or had done. But because it was a new life form. Suppose you lived on a sterile planet, and all day long you swam in its sterile oceans and watched the waves on its sterile shores. And one day you saw a single trilobite. And you took it apart. And you realized you could build it. And not only could you build trilobites, you could build any of the strange creatures in the Cambrian Explosion. And you dimly understood that there were things beyond the Cambrian Explosion. And you might be able to build them, too.

Anyone who wants to create their own new digital life form can do so. Like Bitcoin, it will live on the internet. Like Bitcoin, it will survive as long as it does something that people will pay for. Like Bitcoin, there will be no way of killing it. Like Bitcoin, it will be radically transparent. Like Bitcoin, it can't be stopped. Like Bitcoin, it will be able to pay people to do anything

people are willing to do in exchange for its cryptocurrency. Unlike Bitcoin, it will follow its own rules, whatever rules were programmed into it when it was created.

You could create a currency exchange, or a domain name service, or a prediction market, or a company.

You could even create a government.

REPLACING CONGRESS

In some sense, the protocols being proposed are a replacement for Congress. That is, the evaluation and adoption of bills by Congress seems to fit the presently available mechanisms of a prediction market and a DAO quite well. It also seems that the counterproductive incentive structures built into institutions like Congress, and the variable quality of the laws that it passes, are the most problematic component of our existing governmental structures. Whether or not this ultimately proves to be true, it seems that, at the moment, a relatively rapidly acting Executive able to engage in complex actions based on assessing a wide range of facts and opinions from multiple sources will be more difficult to replace than a slower acting institution which is aggregating facts and opinions from multiple sources in order to review and evaluate proposals placed before it for adoption or rejection in a less time-urgent fashion.

ADOPTING A BILL

In a DAO Democracy, how do we propose a bill, and how does it get adopted?

Initially, anyone can propose a bill. It can be submitted at any time. If the prediction market says it has a positive impact on the collective welfare, it is adopted. If not, it is not. If the bill is adopted, it's put into effect on the date proposed in the bill, which is typically the adoption date plus some period of time to allow implementation.

At any time, anyone can propose a new method of adopting a bill. It is evaluated and put into effect using the existing methods.

In the United States, this mechanism would replace Congress. Given the current popularity of Congress, any proposal that proposes to replace it will be given a more than fair hearing.

More specifically, how might we propose a bill?

Let anyone propose a bill. Assume the bill includes, as a necessary component,

an effective date (which is the adoption date plus time for implementation), and an implementation strategy, or the like. Bills that fail to include such a provision are ill-formed and rejected. Once submitted, there are two possibilities: either the bill is accepted, or the bill is rejected.

Create two conditional futures on the DCW (Democratic Collective Welfare) of the nation. In one conditional future, the bill is assumed to have passed. In the other conditional future, the bill is assumed to have not passed. In each conditional future, there will be some value for DCW: DCW_{passed} and $DCW_{\text{not-passed}}$. If, for a period of 1 week, $DCW_{\text{passed}} > DCW_{\text{not-passed}}$, then the bill is adopted, otherwise it is not. Following the adoption date, one of the two conditional futures is based on a condition that is false. That future market is terminated and all funds returned to the market participants. The other market, which is based on a conditional which is true, continues. Payouts are made from this market based on the outcomes that actually occur.

Notice that participants in the market are rewarded (make money) if they accurately forecast the actual value of DCW. They are not "voting for" any particular outcome. A "biasser" who seeks to "bias" the outcome by using the market to predict an incorrect outcome will become vulnerable to anyone who wants to make a profit by correcting the market inefficiency the biasser is creating. That is, attempts to bias the market are, in essence, attempts to create market inefficiencies. To the extent that market inefficiencies can be removed from the system, bias can also be removed from the system. Deliberate attempts to bias the system for political reasons would, presumably, be a well-known motive and would be watched for, as they would offer a profit opportunity to anyone who corrected the bias.

SELF-IMPROVING

The components of this system can themselves be upgraded using the system.

For example, suppose we decided that it would improve the stability of the system if all bills had a mandatory minimum consideration period of three months before they could be adopted. Then we would pass a bill modifying the DAO to include this provision. If the DAO is written in a formal programming language,



then the bill would specify the change using the formal programming language, as well as the exact place the change was to be made in the existing code, and the time and place the change was to be made.

Of greater concern are changes to the Democratic Collective Welfare metric. Yet even here, if the conclusion reached by the prediction market is that some modification of the metric will better maximize the original metric, then it is difficult to make a case that such a change should be banned. At the same time, it seems unlikely that a DAO Democracy would make any significant changes to the metric that it is supposed to maximize, as that would cause it to maximize something other than the original metric.

There are certain complexities in changing a running program which can most easily be dealt with by specifying that the system be brought to some stable state (stopped) prior to altering the code. Indeed, modifying the system so that it can be safely further modified might be one of the early modifications made to the system.

Over time, all the components of the DAO are likely to be upgraded using its own mechanisms. The only requirement placed on the initial components is that they work well enough that they can be used to replace themselves, thereby initiating a process of continuous self-improvement (Kaizen).

Given the high requirements for stability, it might at first seem that self-improvement could be relegated to a lower priority. However, as further discussion should make clear, such self-improvement will be critical to the survival of any DAO-based democratic system.

ELECTING THE PRESIDENT

Most democracies have an Executive Officer, such as the President of the

United States, typically elected either directly or indirectly by the people. In a DAO Democracy, assuming we retain the Executive Branch in more or less its current form, the simplest approach would be to appoint, as President, that person the prediction market said had the highest positive impact on the collective welfare if appointed as President. The President would serve until the appointment of some other person had a higher positive impact on the collective welfare if appointed as President.

An alternative would be to have a special election for the President, using a custom presidential prediction market to select among the candidates. Ideally, in an election for President we'd like to ask the citizens in the different futures created by electing the different candidates what they thought of them after their terms were over. If A, B and C were candidates, we'd like to hear the historical judgment from (say) a year after the end of their term. If A ranked 60, B ranked 50 and C ranked 40, then we'd know we should elect A, as A was ranked highest by the prediction market just before he was chosen.

Normally, this isn't possible because we can't, as in some science fiction movies, examine counterfactual histories by letting the universe follow multiple different paths and see what happens if some historical event that never occurred did, in fact, occur.

Using conditional prediction markets, we can do just that. The prediction market will tell us how A would have ranked as President if elected, how B would have ranked as President if elected, and how C would have ranked as President if elected. We can then pick the candidate who would have ranked highest. This system is closest to the existing system, in the sense that there

is a fixed point in time when we choose a President, and the selection process is one in which citizens are asked, directly, what they think of the President. It's a bit unusual, in that it still uses prediction markets as the core mechanism for making the key choices, and the citizens are asked what they thought of the President who was actually chosen after he has finished his term, and their choice is used to make (likely rather significant) payments to those investors who accurately predicted how people would evaluate this President after his term was finished.

Note the key financial incentive: large payments flow to those who can accurately forecast how the bulk of the citizens will evaluate the President five years in the future. The evaluation is carried out a year after the President's term is finished, and the President's term normally runs four years. Those people who accurately forecast what the vast majority of citizens would think of the President after his term of office had been over for a year will be given a significant financial payoff.

There are many variations on this approach which could be used to elect the President, or any other officer. Which of these variations is best we leave to the prediction market underlying the DAO Democracy to figure out.

THE JUDICIARY

Similar methods could be adopted to appoint the members of the Supreme Court.

So long as decisions can be rendered into one of a few simple formats, such as "yes/no," "a/b/c/d," linear functions or the like, then the use of prediction markets to render decisions should be feasible. However, generating lengthy written decisions by prediction markets appears difficult.

OTHER ASPECTS OF NATIONAL GOVERNMENT

Covering other aspects of national government by algorithmic methods using prediction markets and DAOs will require further research and thought. However, many of the problems appear to be tractable and seem to have reasonable prospects for a favorable resolution.

CONFLICT

A well-known problem with democracies is the tyranny of the majority. This becomes

particularly acute when a democracy attempts to unite two groups that hate each other. Each group uses the democracy to weaken the other, kill its members, and in some cases to wipe them out. The primary flaw here is that democracies give “power to the people,” which the people promptly use to kill each other.

It seems that, sometimes, the best solution is to separate the two groups and enforce an armed truce. Democracies seem poorly equipped to carry out this strategy.

What about a DAO Democracy?

There seems no reason to believe a DAO Democracy would fail to recognize the lethality of the situation, nor would it likely assist one group in wiping out the other if there was any way of keeping both groups alive. If there were a pragmatic solution that minimized loss of life, a DAO Democracy would adopt it without hesitation. With a collective welfare metric that placed a high value on human life, a DAO Democracy would be more than willing to separate two warring groups into geographically separate regions if that would reduce deaths. Having once adopted such a strategy, it would be likely to back it up with overwhelming force to minimize the need for actual use of that force.

If the prediction market said such a strategy resulted in a better outcome than alternative strategies, a DAO Democracy wouldn't blink before adopting it.

THE END OF THE WORLD

A problem that might occur with prediction markets and governmental policies might be described as the End of the World problem. Suppose we are evaluating a policy that is very good, but has the small problem that it has a 20% probability of causing the end of the world. Normally, if a prediction market is used to evaluate such a policy, it will decide that it's a wonderful policy because no one will buy a financial instrument that only pays off if they're dead.

To make it more concrete, consider a typical prediction market that is working with two outcomes: either an event occurs, or it does not. A financial institution, such as a bank, issues pairs of bearer bonds, one of which says “This bond pays \$1 on December 31st 2016 if the event has occurred.” The other says “This bond pays \$1 on December 31st 2016 if the event has not occurred.” As only one of the two bonds can pay off, and as the bank issues

the bonds in pairs, from the bank's point of view it is simply issuing bonds that pay off on December 31st 2016. From the point of view of the speculator who buys the pair of bonds from the bank, who thinks he knows that the event *will* occur, and who keeps the bond that he knows will pay off and sells the bond that he knows is worthless to some poor fool who will pay him good money for a worthless scrap of paper, this is an easy way to make money from the ignorant.

Prediction markets allow informed individuals to make money from less informed individuals, and the public gets an informed estimate of the probability of the event. If the price of “This bond pays \$1 on December 31st 2016 if the event has occurred” settles at \$0.63, then the prediction market has forecast a 63% probability that the event will occur.

Unfortunately, if the “event” in question is the end of the world, this mechanism fails to work. Who will buy a bond that says “This bond pays \$1 on December 31st 2016 if the world has ended”? And why not pay \$1 for a bond that says “This bond pays \$1 on December 31st 2016 if the world has not ended”?

While amusing and harmless if we're talking about bonds, the result can be disastrous if we're talking about a DAO Democracy adopting policies that might actually cause the end of the world if adopted.

Suppose a DAO Democracy is considering whether to build the Large Hadron Collider (LHC), and suppose (for the moment) that there actually was a consensus in the physics community that there was a 20% risk that turning on the LHC would end the world. How do we discover this risk? We can't simply have a prediction market based on DCW, as the previous example shows the prediction market will simply ignore the 20% risk that the world will end.²⁶

While there might be better solutions, one method is to fall back on simpler techniques: we could have a committee of qualified experts consider the matter and reach a conclusion by anonymous voting one month before turning on the LHC (or the proposed scheduled completion date of the LHC if the project is not funded). This lets us create a prediction market at the time funding of the project is being considered. This market can be used to

determine the probability that the LHC would destroy the world. This probability can then be used in evaluating whether or not to fund the construction of the LHC.

Further research on this problem seems warranted. Fortunately, there aren't many policies that might destroy the world, making special-case handling feasible if a more satisfactory general mechanism can't be found.

DARWIN AND THE DAOS

While we have considered DAOs as a base for a stable democracy, it is apparent that they can serve as a base for any computation.²⁷ Further, given the persistence of a successful DAO (the DAO for Bitcoin has persisted since January 3rd, 2009), it seems inevitable that Darwinian selection will be applied quite vigorously to an ever growing population of DAOs, all of which are carrying out various useful, or at least DAO-survival-enhancing, functions.

Which raises the obvious question: what enhances the survival probability of a DAO? Today, a DAO survives if it performs some function that causes people to support it. Our economic and digital systems sometimes hide this fact rather well, but it is still the case that people make the wheels of our civilization turn. A DAO that performs some service that some subset of humanity wants, and which cannot be done better in some other way, or which cannot be done better by some other DAO, will be richly rewarded. Those that can't, will die.

DAOs that incorporate prediction markets and seek to maximize their own profits are obvious, as are self-improving DAOs. The advantage DAOs offer over regular corporations or organizations is a rather radical transparency and incorruptibility.

With Bitcoin, you know what you're getting—or at least, if you're technically expert enough to understand what Bitcoin is doing, you know what you're getting. As Mt. Gox demonstrated, extending an interface that is trustworthy, convenient, and easy to understand remains an important requirement of a system that seeks truly widespread acceptance. A system that allows unproven representatives to mediate between a reliable core and consumers can be badly tarnished when those representatives prove less trustworthy than the core.

Still, if the requirement is a global system to carry out a function with maximal transparency, maximal trust, minimal risk of corruption, and minimal risk of disruption then a DAO seems tailor made for the purpose.

It's reasonable to expect absolutely merciless competition for those functions where a DAO seems suitable.

Hence the need for a DAO with pretensions of serving as a base for a democratic government to be fundamentally and radically self-improving. Anything less will result in a system that will, at some point, be left behind.

The one thing about a democracy that's difficult to "improve" is the collective welfare metric at its heart. This, of course, raises a question of great interest: can a DAO Democracy survive the coming Darwinian competition?

Phrased another way, will a self-improving DAO that has, as its metric, something other than the collective welfare of its citizens, be able to outcompete a similar DAO that is "burdened" with a collective welfare metric? This question might become acutely interesting to citizens of a DAO Democracy at some point in the not-too-distant future.

Arguably, most people would be more willing to support a DAO Democracy than some other form of DAO, as a DAO Democracy obviously and transparently seeks the collective welfare of all its citizens.

There are two reasons a person might choose some other DAO.

First, they might not be a citizen. This is an obvious argument for a DAO Democracy that includes all humans.²⁸

Second, they might support a DAO that preferentially favors them over others. For



example, a DAO might seek the welfare of its stockholders, and you might be a major stockholder.

The question of interest then becomes whether a DAO that seeks to maximize the welfare of its stockholders can defeat a DAO Democracy, or whether the two would reach some sort of mutual agreement. Today, corporations generally abide by the laws that nations create (although the power of larger corporations and smaller nations sometimes overlaps).

Would a DAO Democracy, particularly one which included all humans, dominate other DAO's? While this outcome seems likely, it does not seem a priori inevitable. Indeed, a DAO that maximized its stockholder's welfare might be indistinguishable from a DAO Democracy if every human owned one share of stock, and if the bylaws were appropriately chosen.

This suggests alternatives to a purely egalitarian system are possible. One can imagine a DAO "Democracy" in which there were two or more classes of citizens. Higher classes of citizenship could be awarded based on good behavior, contributions to the democracy (either financial or non-financial), or on some other basis. Might there exist some type of DAO "Democracy" which had well defined classes of citizenship which were conferred on some basis that was widely supported?

In some sense, we already have this: age. All democracies limit participation based on the age of citizens, with some minimum age being required before citizens can vote, drink, drive, or engage in other specific activities. Most societies have licensing requirements for participation in many activities. These have, at times, included requirements for voting, though these have often been used to limit participation by unfavored groups rather than for their ostensible purpose.

For a DAO Democracy, however, exclusion of some citizens from the metric makes less sense than excluding citizens from voting in a conventional democracy. While it is unreasonable to expect a five year old child to make an intelligent decision about which candidate to vote for in a democratic election (the requirement for participation in today's democracies) it is perfectly reasonable to conclude that a starving five year old child is unhappy. The only requirement for participation

as a citizen in a DAO Democracy is that, somehow, the DAO Democracy be able to reasonably determine a number between 0 and 1. The annual rating by a starving five year old is unlikely to be a 1, whatever the specific mechanism that might be adopted to ascertain this fact.

If we don't exclude some citizens, perhaps we should reward some citizens by weighting them more heavily in the core metric? All animals are equal, but some animals are more equal than others?

Using the core metric of a DAO Democracy to reward those who have made contributions seems redundant, for a well-run DAO Democracy will need to maintain a smoothly running economic system with well-defined property rights in order to maintain economic productivity. Such an economic system will automatically reward those who are contributing to the collective welfare without having to make additional changes to the system of governance to reward them yet again. Allowing the rich to change the system would seem to be a side effect of *poor* governance. A well run government would reward those who contributed to the welfare of others (by, among other things, making them rich), but would refrain from giving them further power based only on the fact that they have wealth.

Which brings us back to our initial conclusion: a DAO Democracy has one metric: the democratic collective welfare of its citizens. The welfare of all citizens is considered equally (that is, democracy is *egalitarian*). At some fundamental level, the happiness or hurt of one citizen is considered equal to the happiness or hurt of another.

If we are considering a Darwinian competition among DAO's, it is natural to ask if 1) a DAO Democracy or something similar will ultimately win out, or 2) whether a DAO unburdened by concerns about the well-being of humans will be more competitive. If this is the right lens through which to view the evolution of governance, this subject is very much worth further discussion.

PROTECTING THE BALLOT BOX

*The people who cast the votes decide nothing. The people who count the votes decide everything.*²⁹ – Stalin

Most forms of government have certain critical infrastructure which must

be protected for the whole to function correctly. In democracies, this critical infrastructure involves voting.

In a DAO Democracy this critical infrastructure is discussed below.

The DAO itself is implemented using the mechanisms now familiar to us from the implementation of Bitcoin, though likely using evolved descendants of these mechanisms.³⁰ Whatever the details, the results are likely to be highly secure and difficult to corrupt.

The computations of ACW_i and DCW_i can be made equally secure by adopting suitable protocols.

The most likely point of attack would be the actual inquiry, from citizens, of their response to the annual poll. Corrupt that, and you control the prediction market. Control the prediction market, and you control the DAO Democracy.

Anyone familiar with psychology will recognize that how you ask people how they feel will greatly influence the answer. So, too, with our Annual Collective Welfare survey: how the survey is conducted, and what instructions are provided, and the surrounding publicity and environment, will all have a great impact on the answer. As the DAO Democracy has a great incentive to arrange matters to maximize the answer, meticulous attention will have to be paid to ensure that no undue bias is introduced into the process. The nightmare scenario is a DAO Democracy that directly stimulates the pleasure centers of citizen's brains, leaving them in a permanent state of bliss, utterly uncaring about anything and always choosing 1 for their individual welfare. This might, arguably, be nirvana, yet it's not something that most of us would want.

It is here, in the central mechanisms used to evaluate the metric, that it might be necessary to create mechanisms in the DAO Democracy that cannot be changed. Obviously, any such unchanging mechanisms must be introduced with great care, as a mistake here can never be undone. At the same time, allowing excessive flexibility might eventually result in unexpected outcomes after several iterations of self-improvement.

Other failure mechanisms include the chain leading from the citizen to whatever centralized computer tallies the score. There is an extensive literature on electronic voting and related systems which can be drawn on.³¹

Interestingly, it's not clear how a self-improving DAO Democracy would react to a threat to the integrity of the Annual Collective Welfare poll. A threat to the lives or well-being of the citizens would provoke an immediate response. The integrity of the annual polls would be protected only if, as a consequence, it threatened the lives or the well-being of the citizens. If there were no perceived threat to the lives of the citizens, and the great mass of citizens were unconcerned about the integrity of the annual polls (which seems likely) then the response of the DAO Democracy itself might be muted.

This might reasonably be viewed as a flaw in the basic design. The most obvious fix would be to ask the prediction market questions of the general nature "Has the prediction market been corrupted?" and "Has the annual poll of the citizens been corrupted?" and use the answers to these questions as negative metrics of collective welfare. That is, the collective welfare metric needs to be augmented with metrics about core aspects of the integrity of the DAO Democracy itself. Such incorporation would lead the DAO Democracy itself to self-improve its own integrity.

Alternatively, one might view such questions as corrections that need to be added to make a prediction market with a shorter term look ahead function more adequately when compared with a prediction market with a much longer look ahead. Failure to maintain the integrity of the core mechanisms of the DAO Democracy will, in the long run, prove fairly lethal to the welfare of its citizens. However, this might not be as evident in the shorter term. By way of analogy, people born without a sense of pain are more likely to suffer from untreated injuries than the rest of us. Pain is a short term indicator that certain types of damage are going to cause problems, and need to be treated immediately. This short term indicator was developed by a longer term process: evolution.

We can add several types of short term pain to our DAO Democracy to assist its survival. Tampering with the prediction market, or the annual poll, or any of the other core processes of the DAO Democracy should result in an immediate and swift response. As humans, we have a long history and a great deal of experience in these kinds of things.

More generally, it would be desirable to develop mechanisms for modifying the metric so that long-term concerns and problems can be given greater weight when near term patterns are recognized that commonly lead to long term problems. Whether and how to introduce this kind of modification into the metric is a more complex problem than can be dealt with in this paper, but if we provide adequate flexibility in the core self-improvement mechanisms, then any such capabilities, should they prove valuable in the long-term maximization of the metric, can be added later by the DAO Democracy itself.

VOTING REDUX

How many of the five problems with voting have we solved? We've made little if any improvement in the first, as it still takes a certain minimum amount of time either to participate in determining the ACW (Annual Collective Welfare) or to vote. Whether the former takes a little less time than the latter is perhaps a matter for debate, as the process of voting, having once entered the voting booth, might take a while if there are many candidates and measures to vote on. The latter, picking a single number between 0 and 1 inclusive, should be simpler, or at least no worse.

We've largely solved the second, as participation in determining the ACW eliminates the need to evaluate issues and candidates. The individual citizen is called upon only to determine whether the year has been good or bad for themselves.

We've solved the third, the need to wade through deceptive misinformation. Determining the ACW asks how you feel, not whether others might be deceiving you.

We've likewise largely solved the fourth, the difficulty in knowing whether candidates will carry through on their promises and whether measures will actually be implemented as they were described, as any candidate or measure will continue to be evaluated, each year, by the ACW, and corrective action will be taken by the DAO Democracy should either not produce the desired results.

Finally, we've solved the fifth, as even citizens who are well below average can decide whether the year has been good or bad to them. A DAO Democracy does not disenfranchise below average citizens. It does not ask citizens to analyze the impact

of complex proposals, or to evaluate the motives of possibly deceptive politicians.

How does a DAO Democracy rate with respect to these five problems? It solves, or largely solves, four of them.

Four out of five isn't bad.

DEPLOYMENT

If we grant that the final result is desirable, how might it be achieved? What are the paths from the world as it exists today to this future, better world where sound governance is the rule and not the exception?

An existing organization might already be taking an annual poll of its members, and if the existing poll asks how satisfied each member is, overall, with the organization (or some equivalent question), then the ACW_i (Annual Collective Welfare) for year i will already be known. Computing DCW_i (Democratic Collective Welfare) for year i is then easy to do. The next step is to establish a prediction market based on the DCW_i . This prediction market can then be used in an advisory capacity to provide an additional source of information about the bills that the organization is already passing. As this leaves the existing organizational mechanisms in place, and simply adds some commentary about the bills the organization is considering, it should not create organizational resistance.

This state of affairs can then be allowed to persist for some time, while the organization gradually gets used to the idea that the prediction market is providing useful commentary on the bills the organization is passing. If all goes well, the prediction market will gradually become more and more respected because its evaluation of the bills the organization passes will prove to be as accurate as other assessments, if not more so.

Once the organization has become familiar with the prediction market, and has seen how it evaluates the organization's bills, and the general opinion is that it can do a good job, the stage is set for the final adoption of the remaining mechanisms of a DAO Democracy.

Call this "gradual adoption."

A more rapid approach would be to start de novo and simply create an organization based on a DAO Democracy. This might be more suitable if there was no pre-existing organizational structure and no need to move slowly. This approach does require

that the code base already be written and debugged. Call this "rapid adoption."

Whether adoption is rapid or gradual, we can ask the question: who is most likely to become an early adopter? Adoption of a new form of governance seems most likely by the young, the idealistic, or the desperate. Which means a plausible beginning is with students, idealists, utopians, bankrupt cities, and lawless states.

Some small group with programming expertise will need to spend the several months necessary to get the first kernel of a system up and running for some limited application: perhaps a student group will implement a DAO Democracy for the student government of a college or university, or perhaps a programmer will implement a DAO Democracy for a Seasteading group.

However it's done, once that first implementation is up and running and seems to work moderately well, some small idealistic or utopian community, or a bankrupt city with nothing to lose, will try it out.

Most of these efforts will fall short. Something won't work, some social or technical factor won't be quite right. Eventually, though, an implementation will meet with some success, and the self-improving capabilities will kick in. The system will get better. The people using it will expand it, others will join, the code base will be copied, others will start to use it, and variation and selection will begin.

Someone in Somalia (or some other ineffectively governed region) will pick up a copy and start using it. The infrastructure required is some computers and some cell phones. It will start to work. Any governance at all would be better than what Somalia has, so something that actually worked would start to build up a following. The basic mechanism should be adaptable to almost any situation. Give it bills and the prediction market will sort out the ones that produce better results for the democratic collective welfare of whoever has become citizens and adopt them. If it works at all, proposals for improvements will be made, the prediction market will pick the likely winners and adopt them, and the system will get better. As long as there's a base of citizens to start with, and a reason for adding new citizens, it will grow. And grow. And grow.

That, at least, is the hope. The process of adoption is likely to start small and depend

entirely on how well the system performs with a few hundred citizens. If it does well, more will join. There are likely to be quite a few implementations, with quite a few specific implementation decisions that will have an enormous impact on success. When a good implementation happens to be deployed in an environment where the social factors just happen to be right, the system can take root and start to self-improve.

The next step? Code it up and try it out. The first implementation should be just enough to be useful for some small, well defined group, and have the potential for unlimited self-improvement.

SUMMARY

We can create a DAO Democracy capable of self-improvement which has unlimited growth potential by modifying futarchy to use an unmodifiable democratic collective welfare metric, adapting it to work as a Decentralized Autonomous Organization, implementing an initial system using simple components (these components including the democratic collective welfare metric, a mechanism for adopting legislation (bills)) and using a built-in prediction market to filter through and adopt proposals for improved components.

The resulting self-improving DAO Democracy should grow into something that is very good. Because it uses the transparent and relatively incorruptible digital technology on which the underlying DAO is based, a self-improving DAO Democracy should be a form of governance that is largely impervious to corruption, bribery, irrational bias, and many of the other ills so common in today's governmental systems.

CONCLUSION

Modern results in distributed algorithm design (particularly including the proposal of Decentralized Autonomous Organizations), combined with modern insights into aggregation of knowledge from dispersed individuals (prediction markets), can be combined into novel forms of governance that are self-improving and should be more robust and resistant to traditional failings and weaknesses than existing forms. Further analysis and small-scale implementations, combined with further research into their effectiveness, seem both warranted

A Few Characteristics of Self-improving DAO Democracies

1. Anyone can propose a bill at any time.
2. All proposals are reviewed equally, without bias.
3. Proposals that improve the general welfare (according to the prediction market's evaluation of the publicly known metric for the general welfare) will be adopted.
4. The mechanism by which bills are reviewed is open to all.
5. Anyone can investigate and present an argument that a bill will help or hurt the general welfare. The judges of that argument (the investors in the prediction market) will have a strong financial interest in reaching an unbiased and accurate conclusion. If the arguments have merit (and have not already been accounted for) the result will be a swift reevaluation of the bill.
6. Anyone who wants a more careful review can subsidize deeper investigation, providing an incentive to investigate and potentially change the existing evaluation. Funding such a deeper review does not, however, bias the resulting review. This is a general property of prediction markets.
7. The impact on the general welfare is assessed fairly and without bias.
8. Any existing law can be amended or repealed with the same ease with which a new law can be proposed.
9. Proposals to improve the mechanisms by which bills are reviewed and adopted can be reviewed and adopted by the same mechanism used to review and adopt bills, leading to a self-improving system.
10. It's obvious that everyone's welfare is weighted equally, and that no special consideration, either favorable or unfavorable, is meted out to any individual or group, because the mechanisms underlying the DAO are transparent and open to inspection.
11. Citizens are not required to exhibit great intelligence, deep understanding of the political system, or to penetrate deceptive campaign statements, for their interests to be properly weighed by the system. The interests of the dull and stupid are protected with as much vigor as those of the intelligent and involved.
12. Groups that hate each other cannot directly vote for policies that would harm or even exterminate the other group.
13. The only time this governance process would support "the tyranny of the majority" would be if oppression of some minority actually made the majority better off, and the majority was made sufficiently better off that it outweighed the resulting misery to the minority. Jailing Typhoid Mary might have been such a case.³² In the great majority of cases, however, this metric would result in keeping the peace between citizens by some method other than mass jailings, mass arrests, or civil war.
14. Once the expected future deaths a given individual might cause exceeded 1, they would promptly be jailed (or otherwise confined). People would likely be confined well before reaching this point, particularly if confinement was not overly burdensome. While accurate forecasting of future murders would seem unlikely, if such a technology were feasible it would be developed and promptly used by this metric to confine people who were likely to kill someone. On the other hand, the proposed metric (a person's death typically resulting in future individual welfare ratings of 0) would create an aversion to the death penalty.
15. Warfare, if it involved deaths of citizens, would be avoided. If it involved deaths of non-citizens, it would be pursued vigorously if it produced benefits to citizens. In this latter case, the only thing preventing war would be the rational expectation that peace would be better for the collective welfare. This might well be the case, but drone warfare might be pursued in those cases that did not create undue outcry by the international community. Unless the proposed metric is extended to the entire human population, there is no substantial incentive not to kill or injure non-citizens, provided there is some advantage to be gained and little risk to citizens. The metric, as given and without further modifications, treats non-citizens as having no value. This, of course, creates an argument for extending the metric to the entire human species.

and urgently needed, given the range of problems facing humanity today and the more pressing problems anticipated in the future. ■

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It is the author's pleasant duty to acknowledge the comments and criticisms that have made the present paper as good as it is. Any faults that remain are, of course, the author's. The author thanks: Nick Bostrom, Vitalik Buterin, Robert A. Freitas Jr., Robin Hanson, Charles Hoskinson, John Oh, and Melanie Swan.

FOOTNOTES

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 5. the Invasion of Panama, the Gulf War, the War in Afghanistan, and the Iraq War. In addition, we have had the War on Drugs, the War on Cancer, the War on Poverty and the War on Terror. See the *List of wars involving the United States*, https://en.wikipedia.org/wiki/List_of_wars_involving_the_United_States
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 17. We divide by the number of citizens, n , to produce a number between 0 and 1. This is essential given the way we compute the dollar value of the financial instruments used in the prediction market (that is, as DCW_i times \$1 and $(1 - DCW_i)$ times \$1). It also seems more natural to optimize welfare per citizen, rather than total number of citizens. However, a case can be made that 10,000 modestly happy citizens is better than 1,000 very happy citizens. There is also the question of what to do with the well-known question “are you better off now than you were 4 years ago?”
 18. The author’s thanks to Robin Hanson for this clear example.
 19. While a zero discount rate would seem to create problems with infinities, which are difficult to compare, we can always sidestep such problems by using limits: that is, we can ask which policy is better in the limit as our discount rate approaches zero.
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 21. Note that the death of someone who was suffering is still negative, it’s just that their life while suffering might have been even more negative, making the moment of death relatively positive compared with the suffering that immediately preceded it, even though their death is negative compared with most of their life. The person who might regard their death as positive would be the criminal on death row who murdered several innocent people and who wishes, quite sincerely and with good reason, that they’d never been born.
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 29. This quote from Joseph Stalin is a loose translation of “Я считаю, что совершенно неважно, кто и как будет в партии голосовать; но вот что чрезвычайно важно, это - кто и как будет считать голоса” which more literally translates as “I consider it completely unimportant who in the party will vote, or how; but what is extraordinarily important is this—who will count the votes, and how.” https://en.wikiquote.org/wiki/Joseph_Stalin
 30. For example, instead of using Proof of Work, other mechanisms can be adopted. Various methods based on Byzantine Fault Tolerance, Proof of Stake, or a range of alternatives now under active investigation might be adopted. It also seems likely that a better data structure than a simple linear list can be devised. The bitcoin blockchain is already too long. A structure that is more compact, and from which extraneous material can be more easily removed, such as a tree, would seem desirable.
 31. While it’s clear that such systems can be made secure, it’s also clear that many systems in wide use today fall woefully short. Slot machines that handle money are often much more secure than electronic voting machines. See Wikipedia’s article for an introduction. https://en.wikipedia.org/wiki/Electronic_voting
 32. Though other methods of ensuring she was not spreading contagion might have been effective.

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NOGGIN by John Corey Whaley

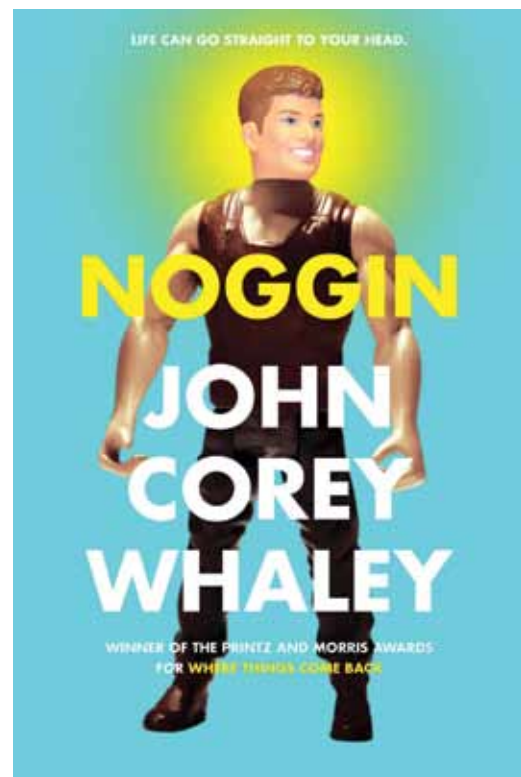
By Stephen Bridge

A nearly brilliant teen novel about a young man returning from cryopreservation, with a stellar main character and a level of reader empathy that I have rarely felt in a teen book. (Whaley's first novel, *Where Things Come Back* won the Michael Printz Award for best Young Adult novel.)

Dying of leukemia, 16-year-old Travis Coates and his family agree to an experiment, where his head will be removed and cryopreserved, in the vague hope that someday there will be a way to revive him and give him a new body. Unexpectedly, medical advances are made in only five years—and Travis is revived with his head transplanted onto the body of another young man who died of a brain tumor. Great, right? But Travis is still 16. From his point of view, he went to sleep one day and woke up the next—and his best friend and girlfriend and parents are now 5 years older. He is still stuck returning to high school as the freak “miracle boy.” His girlfriend is engaged to someone else. His parents threw out all of his stuff, except an urn full of his ashes, and they are keeping other secrets from him. Life is weird and seems completely out of his control.

There are a lot of crappy books about cryonics and only a few good ones. Many of us have been influenced by the books we read, especially while we are young. We can hope that good books with a positive cryonics theme will penetrate the culture and get young people to think that joining a cryonics organization is the normal thing to do; but how do you find these books? This is definitely one of the good ones, exceptionally so in one of the most important ways—building empathy for a character that makes decisions we see as positive.

The book is written in first person and that voice really makes the story work. Travis is bewildered, scared, self-centered (teenager, right?), and determined to make everything work again, including trying to get his now 21-year-old girlfriend to break off her wedding plans and marry him instead. All of the emotional details are right. Meeting his formerly younger but now older cousins, dealing with fan mail and hate mail, talking with the older man who is so far the only other survivor of this procedure, naively assuming that older friends still want to hang out with him. And it's not just HIS details which are right, but also those of his parents and friends, who lost him from their lives and grieved and now have to adjust to him being there again. There are terrific



confrontation scenes where his friends and family struggle to articulate the emotions they feel and Travis's 16-year-old self struggles to understand people who have lived 5 years of both grief and change after his “death.” This is intensified by our own adult understanding that the years between 16 and 21 *normally* produce more change than any other period in our lives.

Noggin is often very funny, always thoughtful about the consequences of this particular situation, and ultimately deeply moving, as Travis starts to appreciate that this is a second chance at life, even though it won't be the SAME life. Terrific writing; I don't know if I have ever read a teen character that felt more like “that could have been me.” Nothing about the attitudes or characters feels false. Yes, it is unlikely that a person would only be cryopreserved for five years; but this time period is one that the author can make his points with. Also, the audio book by Kirby Heyborne is especially well done.

There were two aggravating errors early in the book that led me to say “almost” brilliant. These were errors that fifteen minutes on the Internet could have corrected. Whaley persistently calls the procedure “cryogenics” instead of “cryonics.” [“Cryogenics” is the general branch of science which studies the technology of producing and using ultra-cold temperatures. “Cryonics” is the speculative medical technology being used in this book.] There

was also a silly medical error in the discussion of Travis's disease.

Ultimately, these two errors do not affect the book's overall quality. This is a great book that could make teenagers (and some adults) appreciate their own lives more, and one which gets the point of cryonics across in a particularly strong way. Buy a copy for the teenagers in your life.

Now: Why should YOU read this book? As cryonicists we often fail to understand how other members of our family view this endeavor. We assume they will embrace it, too, or at least feel happy that YOU are making this decision to save your own life. But we often miss an important truth: the family of a cryonics patient can feel as if they are stuck in an emotional limbo of grief. Emotionally, to them, you are dead. You are not walking, talking, e-mailing, hugging, or smiling. They do not buy you Christmas or birthday presents. They don't get any in return. They can't even look at your vitrified head or body, should they want to. They assume that they will never see you again; that, even if this *works*, it will be long after they themselves have died.

And yet, there is that sliver of hope you have given them (perhaps somewhat larger than a sliver, with some family members) that cryonics will someday work. Hope that you are not truly *dead*. So in some way, they must acknowledge your continued existence, the possibility of your future existence. They may not be able to completely finish their grief and move ahead.

I think many family members subconsciously understand, long *before* the event is forced upon them, that this emotional uncertainty will occur. If you love your family, you need to understand this, also. Whaley is the first author I have seen who has recognized and dealt with this issue. While the novel's preservation period of only five years is artificially small (though perfectly fitting for Whaley's fictional purposes), it gives his protagonist's family and friends the ability to address their feelings. That might help you to deal better with your own family. ■

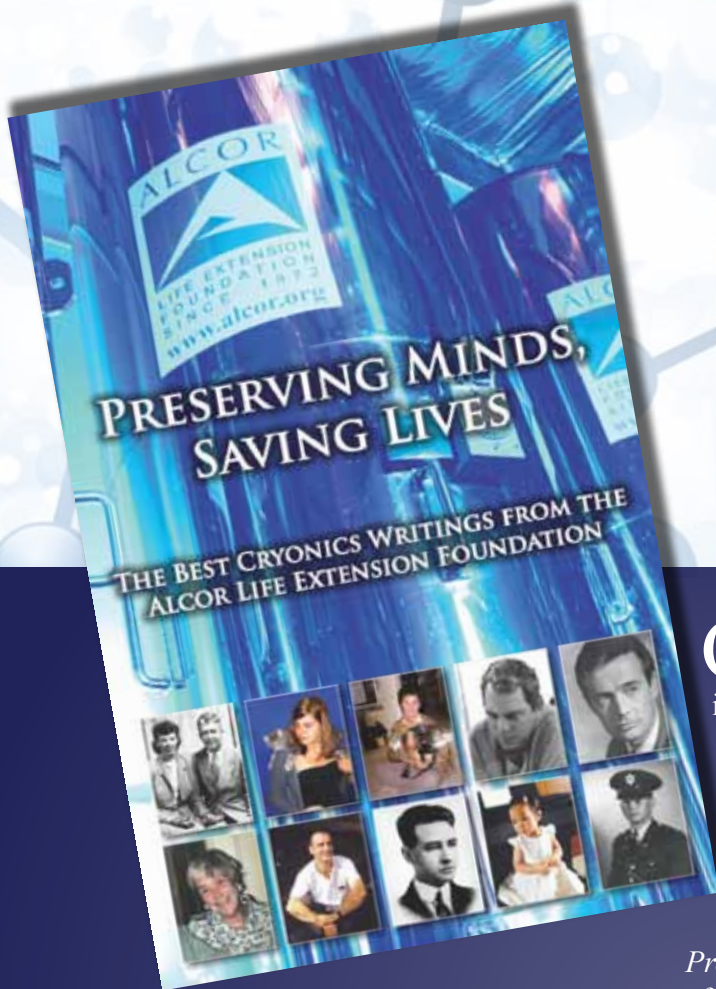


Stephen W. Bridge became involved in cryonics in 1977 and was the co-founder and original co-editor of *Cryonics* magazine. He was the President of the Alcor Life Extension Foundation from 1993 to 1997. He led Alcor's move to Scottsdale, Arizona in 1994 and was the chief architect of Alcor's Patient Care Trust. Bridge is currently an Alcor advisor and a Co-Manager of Cryonics Property, LLC, which owns the building that houses Alcor and its patients. He is a graduate of DePauw University and Indiana University. Bridge is a recently retired librarian in Indianapolis, Indiana, where he lives with his family. With Aschwin de Wolf, he is the co-editor of Alcor's new book, *Preserving Minds, Saving Lives*.

**ORDER
NOW!**

PRESERVING MINDS, SAVING LIVES

THE BEST CRYONICS WRITINGS OF THE ALCOR LIFE EXTENSION FOUNDATION



“Cryonics magazine introduced me to Alcor and cryonics at its best back in 1983. The visions and technological breakthroughs that you will read about in this book continue to shape Alcor’s mission to preserve life through science.”

– Max More, Ph.D.
President and CEO of Alcor

Cryonics is an experimental medical procedure that uses ultra-low temperatures to put critically ill people into a state of metabolic arrest to give them access to medical advances of the future. Since its inception in the early 1960s, the practice of cryonics has moved from a theoretical concept to an evidence-based practice that uses emergency medical procedures and modern vitrification technologies to eliminate ice formation.

Preserving Minds, Saving Lives offers an ambitious collection of articles about cryonics and the Alcor Life Extension

Foundation. From its humble beginnings in 1972, and its first human cryonics patient in 1976, Alcor has grown to a professional organization with more than 1,000 members, more than 140 human patients, and more than 50 pets, all awaiting a chance to be restored to good health and continue their lives.

This book presents some of the best cryonics writings from *Cryonics* magazine from 1981 to 2012. There are clear expositions of the rationale behind cryonics, its scientific validation, and the evolution of Alcor procedures. Also covered are repair and resuscitation scenarios, philosophical issues associated with cryonics, and debates within the cryonics community itself.

Soft Cover Edition: \$20 – Hard Cover Edition: \$35
To order your copy, go to: www.alcor.org/book
or call 1-877-GO ALCOR (462-5267)

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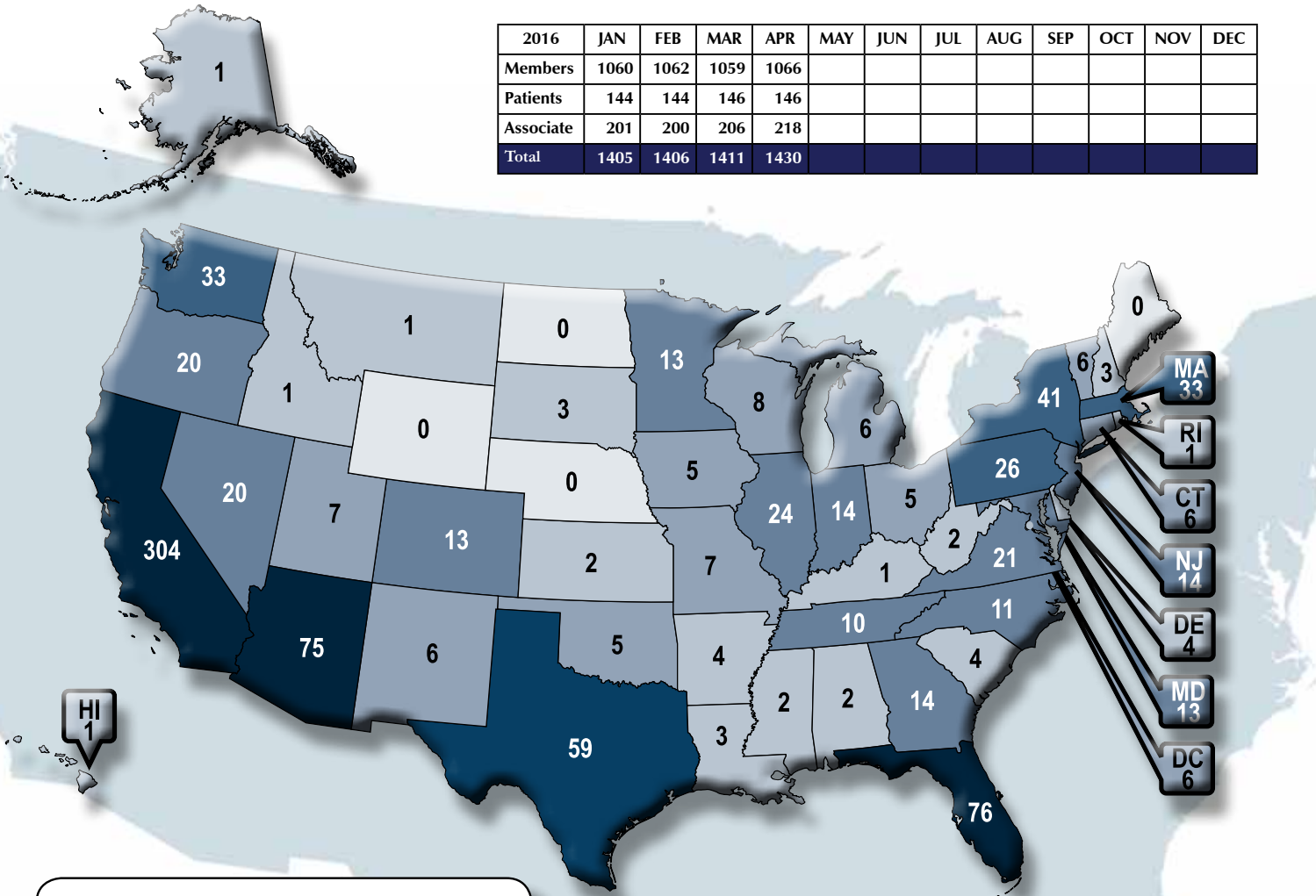
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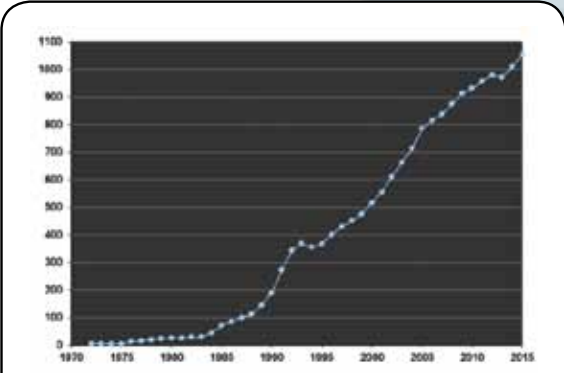
Membership Statistics

2016	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Members	1060	1062	1059	1066								
Patients	144	144	146	146								
Associate	201	200	206	218								
Total	1405	1406	1411	1430								

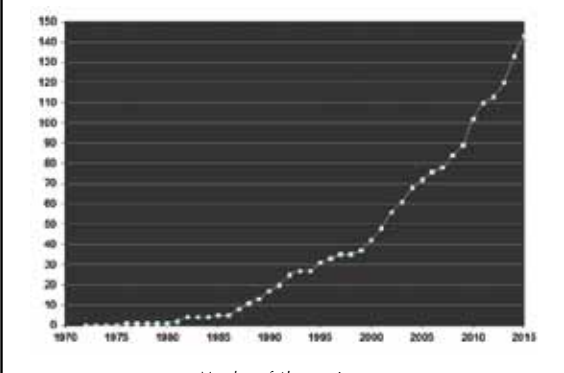


- 0 Members
- 1-4 Members
- 5-9 Members
- 10-24 Members
- 25-49 Members
- 50-74 Members
- 75+ Members

Country	International	
	Members	Patients
Australia	13	3
Canada	49	2
China	0	1
Germany	10	0
Hong Kong	1	0
Israel	1	1
Italy	3	0
Japan	4	0
Mexico	4	0
Monaco	1	0
Netherlands	1	0
New Zealand	1	0
Norway	1	0
Portugal	4	0
Singapore	1	0
Spain	3	1
Thailand	4	1
United Arab Emirates	1	0
United Kingdom	28	3
TOTAL	130	12



Number of Alcor members



Number of Alcor patients

First Skin-to-Eye Stem Cell Transplant in Humans Successful

Researchers have safely transplanted stem cells derived from a patient's skin to the back of the eye in an effort to restore vision. The research is being presented at the 2016 Annual Meeting of the Association for Research in Vision and Ophthalmology (ARVO) May 1-5 in Seattle, Wash. A small piece of skin from the patient's arm was collected and modified into induced pluripotent stem cells (iPSC). The iPSCs were then transformed into eye cells, which were transplanted into the patient's eye. The transplanted cells survived without any adverse events for over a year and resulted in slightly improved vision. The patient suffered from advanced wet age-related macular degeneration (AMD) that did not respond to current standard treatments. iPSCs are adult cells that have been reprogrammed to an embryonic stem cell-like state, which can then be differentiated into any cell type found in the body.

Newswise / ARVO
28 Apr. 2016

<http://www.newswise.com/articles/first-skin-to-eye-stem-cell-transplant-in-humans-successful>

Back from Death? ReAnima Project to Try and Wake the Dead Brain

From Lazarus to Mary Shelley's monster to George A. Romero's hordes, humans have long dreamed of (and dreaded) being able to cheat death. Now two biotech companies will attempt to bring some measure of life into the brains of 20 people in India with the application of stem cells. It's called the "ReAnima Project," and it just received an institutional review board approval. The venture is between the Philadelphia-based Bioquark and Revita

Life Sciences of India. The clinical trials were approved by the IRB at the Anupam Hospital in Rudrapur, Uttarakhand, India, the companies announced today (May 4). Their theory: human beings can't regenerate their central nervous system after brain death—but certain animals like amphibians and fish can. Humans may still have residual blood flow and some electrical activity, even during brain death, they believe—and stem cells may hold the answer to regenerating neurotransmitters that begin to disappear after clinical death. The Phase I trial will look for individuals killed by a traumatic brain injury.

Bioscience Technology / Seth Augenstein
4 May 2016

<http://www.biosciencetechnology.com/news/2016/05/back-death-reanima-project-try-and-wake-dead-brain>

Scientists Digitally Mimic Evolution to Create Novel Proteins

Proteins are nature's machines. They provide oxygen to power our muscles, catalyze reactions that help us extract energy from food, and fend off infections from bacteria and viruses. For decades, scientists have searched for ways to design new proteins that can serve specific purposes in medicine, research, and industry. Now, researchers at the University of North Carolina School of Medicine have developed a method that creates novel proteins by stitching together pieces of already existing proteins. The technique, called SEWING, is inspired by natural evolutionary mechanisms that also recombine portions of known proteins to produce new structures and functions. This approach can generate a diverse set of protein structures with many of the distinctive features that proteins require to carry out specific biological functions. The findings, published May 10 in the journal *Science*, could enable researchers to design proteins to play a variety of different roles

in human biology and disease, such roles as catalysts, biosensors, and therapeutics.

University of North Carolina /
Brian Kuhlman, PhD
10 May 2016

<https://www.med.unc.edu/biochem/news/scientists-digitally-mimic-evolution-to-create-novel-proteins>

Ingestible Origami Robot

In experiments involving a simulation of the human esophagus and stomach, researchers at MIT, the University of Sheffield, and the Tokyo Institute of Technology have demonstrated a tiny origami robot that can unfold itself from a swallowed capsule and, steered by external magnetic fields, crawl across the stomach wall to remove a swallowed button battery or patch a wound. The new work, which the researchers are presenting at the International Conference on Robotics and Automation, May 16-21, builds on a long sequence of papers on origami robots from the research group of Daniela Rus at MIT's Department of Electrical Engineering and Computer Science. "It's really exciting to see our small origami robots doing something with potential important applications to health care," says Rus, who also directs MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL). "For applications inside the body, we need a small, controllable, untethered robot system. It's really difficult to control and place a robot inside the body if the robot is attached to a tether."

MIT News / Larry Hardesty
12 May 2016

<http://news.mit.edu/2016/ingestible-origami-robot-0512>

Amputee Gets Bionic Arm

James Young, an amputee from London, got a prosthetic robotic arm inspired by

Metal Gear Solid, boasting features such as a USB port, a digital display, several lights, and a drone on the side. Perhaps our cyborg future isn't too far away. Groundbreaking technologies have already led a host of advanced devices that seamlessly blend the human and the synthetic. We have titanium spinal implants that allow us to regrow bone. We have artificial e-skin that can turn the human body into a walking display. There are even plans for cyborg lenses that get injected into our eyes. And now, we have a functional bionic arm that comes complete with a wide array of futuristic features (it even comes with a drone). It was four years ago when James Young lost his arm and leg in accident in which he fell between two train carriages. For a time, he notes that he was in a very "dark place," having been almost entirely incapacitated by the accident. Of course, there were many things James lamented not being able to do.

Futurism
18 May 2016

<http://futurism.com/amputee-gamer-gets-a-prosthetic-bionic-arm-with-light-charger-and-drone/>

Molecule in the Works Could Eradicate Many Viruses

Part of the difficulty in tackling viruses like Ebola and Zika is that they're all so different, and each one can regularly mutate to create different strains within the same virus. To address this, scientists have been busy looking at common characteristics of viruses that could be used to develop an all-powerful vaccine capable of fighting off any infection. Researchers at IBM say they're getting close. A macromolecule—a giant molecule made up of smaller units—has now been developed that could have the potential to block multiple types

of viruses, despite the many variations involved. The scientists, from tech giant IBM and the Institute of Bioengineering and Nanotechnology in Singapore, ignored the RNA and DNA of the viruses they used for testing that tend to vary from virus to virus and mutation to mutation. Instead the team looked at glycoproteins—large molecules attached to the outside of all viruses and capable of latching onto cells in the body, which actually makes us sick. The macromolecule that's now been developed attracts viruses and then hitches a ride on these glycoproteins.

Futurism / Science Alert
22 May 2016

<http://futurism.com/ibm-is-working-on-a-molecule-that-could-eradicate-viruses/>

A Roadmap to Resuscitation

Successful rejuvenation 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 list is a list of landmark papers and books that reflect ongoing progress towards the resuscitation 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.

Michael G. Darwin, "The Anabolocyte: A Biological Approach to Repairing Cryoinjury," *Life Extension*

Magazine (July-August 1977):80-83. Reprinted in *Cryonics* 29:4 (4th Quarter 2008),14-17.

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 (January 1994):16-31 (Part I) & *Cryonics* 15 (April 1994):20-32 (Part II).

Ralph C. Merkle, "Cryonics, Cryptography, and Maximum Likelihood Estimation," First Extropy Institute Conference, Sunnyvale CA, 1994.

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, pp. 685-805.

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



REDUCE YOUR ALCOR DUES WITH THE CMS WAIVER

Alcor members pay general dues to cover Alcor's operating expenses and also make annual contributions to the Comprehensive Member Standby fund pool to cover the costs of readiness and standby. Benefits of Comprehensive Member Standby include no out-of-pocket expense for standby services at the time of need, and up to \$10,000 for relocation assistance to the Scottsdale, Arizona area.

Instead of paying \$180 per year in CMS dues, Alcor also provides members the option to cover all CMS-associated costs through life insurance or pre-payment. Members who provide an additional \$20,000 in minimum funding will no longer have to pay the \$180 CMS (Comprehensive Member Standby fund) fee. This increase in minimums is permanent (for example, if in the future Alcor were to raise the cost of a neurocryopreservation to \$90,000, the new minimum for

neurocryopreservation members under this election would be \$110,000). Once this election is made, the member cannot change back to the original minimums in the future.

To have the CMS fee waived, these are the minimums:

- **\$220,000 Whole Body Cryopreservation** (\$115,000 to the Patient Care Trust, \$60,000 for cryopreservation, \$45,000 to the CMS Fund).
- **\$100,000 Neurocryopreservation** (\$25,000 to the Patient Care Trust, \$30,000 for cryopreservation, \$45,000 to the CMS Fund).

If you have adequate funding and would like to take advantage of the CMS waiver, contact **Diane Cremeens** at diane@alcor.org.

Become An Alcor Associate Member!

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. 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.

Or you can pay online via PayPal using the following link: <http://www.alcor.org/BecomeMember/associate.html> (quarterly option is not available this way).

Associate Members can improve their chances of being cryopreserved in an emergency if they complete and provide us with a Declaration of Intent to be Cryopreserved (<http://www.alcor.org/Library/html/declarationofintent.html>). Financial provisions would still have to be made by you or someone acting for you, but the combination of Associate Membership and Declaration of Intent meets the informed consent requirement and makes it much more likely that we could move ahead in a critical situation.



MEETINGS

ABOUT THE ALCOR FOUNDATION

The Alcor Life Extension Foundation is a nonprofit tax-exempt scientific and educational organization dedicated to advancing the science of cryopreservation and promoting cryonics as a rational option. Being an Alcor member means knowing that—should the worst happen—Alcor's Emergency Response Team is ready to respond for you, 24 hours a day, 365 days a year.

Alcor's Emergency Response capability includes specially trained technicians and customized equipment in Arizona, northern California, southern California, and south Florida, as well as many additional certified technicians on-call around the United States. Alcor's Arizona facility includes a full-time staff, and the Patient Care Bay is personally monitored 24 hours a day.

ARIZONA

FLAGSTAFF:

Arizona without the inferno. Cryonics group in beautiful, high-altitude Flagstaff. Two-hour drive to Alcor. Contact eric@flagstaffcryo.com for more information.

PHOENIX

VALLEY OF THE SUN:

This group meets monthly, usually in the third week of the month. Dates are determined by the activity or event planned. For more information or to RSVP, visit <http://cryonics.meetup.com/45/> or email Lisa Shock at lisa@alcor.org.

AT ALCOR:

Alcor Board of Directors Meetings and Facility Tours—Alcor business meetings are generally held on the second Saturday of every month starting at 11:00 AM MST. Guests are welcome to attend the fully-public board meetings. Facility tours are held every Tuesday at 10:00 AM and Friday at 2:00 PM. For more information or to schedule a tour, call Marji Klima at (877) 462-5267 x101 or email marji@alcor.org.

CALIFORNIA

LOS ANGELES:

Alcor Southern California Meetings—For information, call Peter Voss at (310) 822-4533 or e-mail him at peter@optimal.org. Although monthly meetings are not held regularly, you can meet Los Angeles Alcor members by contacting Peter.

SAN FRANCISCO BAY:

Alcor Northern California Meetings are held quarterly in January, April, July, and October. A CryoFeast is held once a year. For information on Northern California meetings, call Mark Galeck at (650) 772-1251 or email Mark_galeck@pacbell.net.

FLORIDA

Central Florida Life Extension group meets once a month in the Tampa Bay area (Tampa and St. Petersburg) for discussion and socializing. The group has been active since 2007. Email arcturus12453@yahoo.com for more information.

NEW ENGLAND

CAMBRIDGE:

The New England regional group strives to meet monthly in Cambridge, MA—for information or to be added to the Alcor NE mailing list, please contact Bret Kulakovich at 617-824-8982, alcor@bonfireproductions.com, or on FACEBOOK via the Cryonics Special Interest Group.

PACIFIC NORTHWEST

A Yahoo mailing list is also maintained for cryonicists in the Pacific Northwest at <http://tech.groups.yahoo.com/group/CryonicsNW/>.

OREGON:

The contact person for meetings in the Portland area is Aschwin de Wolf:

aschwin@alcor.org. See also: <https://www.facebook.com/portland.life.extension>

BRITISH COLUMBIA (CANADA):

CryoBC, a special interest group within the nonprofit Lifespan Society of BC (<http://www.lifespanbc.ca/>) holds meetings for cryonicists in the Vancouver area. To be notified of meetings join the CryoBC mailing list: <https://groups.yahoo.com/neo/groups/cryoabc/info>

TEXAS

DALLAS:

North Texas Cryonauts, please sign up for our announcements list for meetings (<http://groups.yahoo.com/group/cryonauts-announce>) or contact David Wallace Croft at (214) 636-3790 for details of upcoming meetings.

AUSTIN/CENTRAL TEXAS:

A new group for the Austin area has been started for those interested in discussion and understanding of the relevant technologies and issues for cryopreservation, genomics, epigenetics and medical research for increased life/health span. Contact Tom Miller, 760-803-4107 or tom@blackmagicmissileworks.com.

JAPAN

Cryonics meetings are held monthly in Tokyo. Send queries to grand88@yahoo.com.

ALCOR PORTUGAL

Alcor Portugal is working to have good stabilization and transport capabilities. The group meets every Saturday for two hours. For information about meetings, contact Nuno Martins at n-martins@n-martins.com. The Alcor Portugal website is: www.alcorportugal.com.

UNITED KINGDOM

Alcor members in the UK can contact Garret Smyth at Alcor-UK@alcor.org for information about local meetings.

If you are interested in hosting regular meetings in your area, contact Alcor at 877-462-5267, ext. 113. Meetings are a great way to learn about cryonics, meet others with similar interests, and introduce your friends and family to Alcor members!

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 a 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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