Alcor Life Extension Foundation
A Non-Profit Organization

CRYONICS

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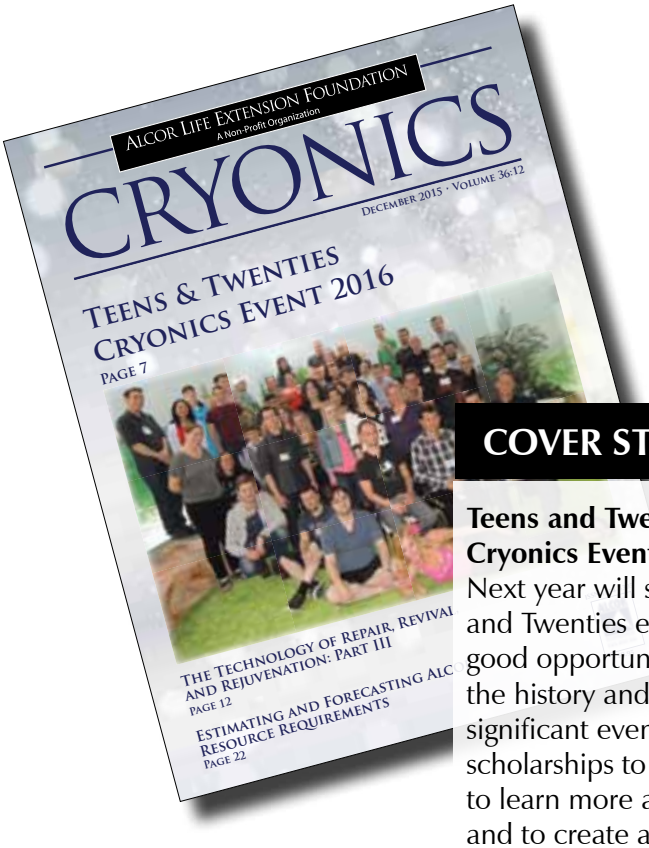
CRYONICS



On the cover:
Teens and Twenties Meeting 2015

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Teens and Twenties Cryonics Event 2016
Next year will see another Teens and Twenties event. This is a good opportunity to look at the history and the aims of this significant event which offers scholarships to young cryonicists to learn more about the field and to create a supportive community.

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ALCOR LIFE EXTENSION FOUNDATION
A Non-Profit Organization
CRYONICS

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2015 Annual Giving Program

Alcor provides a wide array of services for you the member, and the general public. We inform and educate, we protect and preserve, and we strive to remain at the forefront of cryonics technology.

Since its founding, Alcor has relied on member support to maintain its mission and attract new members. Your support, regardless of size, can provide a better future for all cryonicists. **Please act now.**

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We encourage every member to donate. Even if you can only afford $5 right now, you will make a significant contribution to Alcor's future.

Donations may be made via the Donations button on the Alcor website or by contacting Alcor's Finance Director, Bonnie Magee, at bonnie@alcor.org. Your donation may be made as a lump sum or divided into easy monthly payments. ■

The James Bedford Society

Gifts have played a fundamental role in the cryonics movement since its earliest days. Dr. James Bedford, a man whose extraordinary vision led him to become the first person to be cryopreserved, and the first to make a bequest to a cryonics organization, exemplified the determination of the early pioneers of cryonics. We invite you to follow in his footsteps, and join the James Bedford Society.

The James Bedford Society recognizes those who make a bequest of any size to the Alcor Life Extension Foundation. If you have already provided a gift for Alcor in your estate, please send a copy of your relevant documents to Alcor's Finance Director, Bonnie Magee.

If you'd like to learn more about setting up a bequest, send an email to bonnie@alcor.org or call 480-905-1906 x114 to discuss your gift. ■

QUOD INCEPIMUS CONFICIEMUS

Photo: Cryo-Care Equipment Corporation at 2340 E. Washington St., Phoenix, AZ. Dr. Bedford's "home" in 1970 or 1971.

SUSPENDED ANIMATION AS A RESEARCH GOAL AND CASE BENCHMARK

By Aschwin de Wolf

Cryonics is a complicated idea to explain and one of the most common misunderstandings is to confuse it with suspended animation. This leads critics to conclude that cryonics cannot work because we are not yet capable of placing a patient in cryostasis and reversing this procedure without causing damage. Advocates of cryonics have written careful expositions to make the point that human suspended animation is a desirable goal but not necessary for cryonics to succeed. I will not go into these arguments here but want to discuss what role the idea of suspended animation *can* play at Alcor.

First of all, the development of human suspended animation can be a formal research goal of a cryonics organization. As obvious as this may be, I am not aware of any cryonics organization that has communicated that this is their ultimate research objective. This is unfortunate because it is important for our credibility to develop a form of reversible biostasis. After all, if our procedures are fully reversible we do not need to evoke alternative definitions of death and can then claim that a critically ill patient who is cryopreserved is still alive (without the need for quotation marks around the word death). Offering human suspended animation as a form of biostasis leaves critics to argue that a disease will never be cured as the only remaining objection, which would be a rather preposterous claim.

The goal of offering suspended animation can also guide a cryonics organization to decide which new technologies to introduce and upgrade. For example, suspended animation is incompatible with the presence of fractures (which would need repair) and a transition to cooldown or long term care technologies that prevent fracturing would be a necessary step to move further into the direction of suspended animation. It is important to understand the piecemeal nature of this. A cryonics organization does not go from offering straight freezing to suspended animation overnight but seeks to introduce improved procedures towards that goal on an incremental basis. The more obstacles to suspended animation we can eliminate (ice formation, fracturing), the more identifiable and recognizable the remaining challenges, like cryoprotectant toxicity, will be.

One major misunderstanding about the role of suspended animation is that until we have perfected our technologies, this concept cannot be used as a benchmark to evaluate cases. In fact, we can use the concept of suspended animation in a meaningful way when we write our case reports and discuss case outcomes right now. The reason why we can do this is because loss of viability is not a characteristic of all our procedures but happens further downstream. In an ideal case, we suspect that viability is lost somewhere mid-way during cryoprotective perfusion where the concentration of the cryoprotectant and exposure time render organs non-viable by contemporary criteria. Another way of phrasing this is that our procedures should be *reversible* up to that point. This benchmark is extremely important in evaluating the quality of care at a cryonics organization and guiding procedures in an actual case. It is even possible to identify the point at which viability is lost by monitoring the patient during stabilization procedures and taking a small (microliter) brain or spinal cord biopsy after cryoprotective perfusion.

If Alcor takes itself seriously as a scientific organization, each case report should contain a discussion about how successful the organization was in sustaining viability as long as possible, and if not, whether these problems were beyond Alcor's control or reflect errors made during the case. This allows us to observe patterns and trends and introduce measures and upgrades that push reversibility further downstream in our procedures. ■

Options for Safe, Secure and Legal Asset Preservation for Post-Resuscitation Access

The Seventh Annual *Young Cryonicists* Gathering

Teens & Twenties 7 2016: Getting to Know You - You Getting to Know Each Other

Fri-Sun; April 8-10, '16 Ontario CA Host: *Life Extension Foundation* SCHOLARSHIPS AVAILABLE

★★★

Greetings to *Young Cryonicists*,

You are receiving this invitation because you are among the future leaders in cryonics.

All attention will be focused on:
our getting to know you and
you getting to know each other.
PLUS: an update on the latest emergency response technologies and revival strategies.

Who is Eligible?

Fully signed up young cryonicists from all cryonics organizations in their late teens through age thirty *(18-30) as of April 10, 2016* - may apply to attend.

Younger Cryonicists With Parent(s):

Thirteen through seventeen year olds may attend when accompanied by their parent(s) or guardian(s).

Parents/guardians of attendees aged 18-19 are also encouraged to accompany their child. All attending parents will be put in touch with each other should they choose to have their own "get together" during the "young cryonicists" gathering.

Program

Some individuals are social butterflies. This is not so for everyone. And we want *everyone to meet everyone.* Therefore, I have designed a diverse range of "getting to know you" activities. *IF* you would enjoy participating in these various getting acquainted activities, *THEN* this is for you.

Enjoy this exciting & fulfilling weekend.

SCHOLARSHIPS:

Life Extension Foundation, through a generous education grant, is offering *40 scholarships* that pay for ALL of the following:

- U.S. airfare to/from South Florida (or up to $1000 for origin outside the U.S.)
- Hotel accommodations for Friday & Saturday nights - plus Thursday & Sunday nights for scholarship attendees who room together.
- Meals and beverages on Friday night, all day Saturday, & Sunday breakfast & lunch
- Registration fee - $350 - also covered

Please click on this website for a full packet with all details and application forms.

http://www.alcor.org/T2_7_2016_details.pdf

Forever,

Cairn Erfreuliche Idun
Founder/Director: T2

PS Come Early. Stay Late.

Some attendees to T2 enjoy spending *extra time in California* - especially since their flight is already paid for via their scholarship.

This is at their own expense for additional lodging and food.

I look forward to getting to know you.

The Young Cryonicists Gathering
Teens & Twenties

Getting to Know You | You Getting to Know Each Other

By Cairn Erfreuliche Idun

PHOTO: Teens and Twenties Meeting 2015

A BRIEF HISTORY

"Not normal." Thank-you! Think about what is normal. Do you really want to be "normal?"

We, members of our Asset Preservation Group (Options for Safe, Secure and Legal Asset Preservation for Post-Resuscitation Access – OSSLAP), have enjoyed "getting to know" six annual gatherings of young cryonicists. And these exceptional, not normal, young cryonicists have, likewise, been getting to know us and each other.

Diverse city. An amazing and supportive community. Similar in long range foresight, a desire to continue living into that long range future AND, most importantly, astute (smart) enough to take action on that foresight and desire by signing up for cryopreservation now. Legal death occurs at ALL ages. Yet, beautifully diverse in personality, interests and goals, I have loved watching their community form and branch out into a variety of connections.

Benefits have been derived from all sides. Some were already active in cryonics and others have become professionally employed in cryonics and life extension related fields. I will conclude with a review of a few of these outstanding individuals and their accomplishments. I should be clear that we have no expectation that all T2s become professionally involved in cryonics. They are becoming a scientifically informed and supportive community.

But first, how did this all come about? That is the question I have been asked to shed some light upon.

In the late 80s, Walter Vaninni came to Fort Collins, Colorado, in response to my libertarian Freedom Now project. When he expounded upon nanotechnology and cryonics I was a split second convert. I, quite mistakenly, thought that anyone who became informed of this option would also become an eager participant.

In June, 1992, my husband, Jim Glennie, was cryopreserved. That fall I took my first, and best, transport certification course. And I met other cryonicists. It was wonderful. Over the years I attended every Alcor cryonics event. I did not meet many of our young cryonicists. Plus, I was informed that it was common for young cryonicists to eventually drop out.

Over time I outlined a plan to help these valuable members of our future form a supportive community—to not feel quite so isolated—to meet other cryonicists their own age—to spend time with others of like mind—a place where they could talk about other things, because cryonics was already a natural "of course" part of life … and … be regularly updated on the latest scientific advances.

But how to make it happen? Ideas are a dime a dozen. It's making it happen that matters. And then—***Bill Faloon and the Life Extension Foundation!*** At one of our APG annual gatherings … well, let me just copy a portion from the first page of the packet mailed to all young cryonicists.

> "Bill Faloon had related his appreciation to those who had helped him to attend a meeting of life extension/cryonics pioneers when he was a young man. He noted the resulting payback benefits that both the cryonics and the life extension movements have received from his subsequent

Teens and Twenties Meeting 2011

involvement, leadership and financial contributions. Now he would like to do the same for other young cryonicists. Cairn Idun proposed her long held idea for a "Teens and Twenties" gathering. Not only did Bill agree to host the gathering through the Life Extension Foundation—*LEF would also provide travel, lodging and registration scholarships.*"

And so it began. Here are *just a few* highlights regarding the accomplishments of *just a few* of our T2s past and present. The latest WOW comes from:

Xiaoxi Wei—scientific:
Xiaoxi and her innovative company, X Therma, recently became a winner in the: PATRICK SOON-SHIONG INNOVATION AWARDS 2015. "X-THERMA is developing a radical new highway of non-toxic, hyper-effective antifreeze agents to fight unwanted ice formation in regenerative medicine, advanced formulation cosmetics, enhanced quality frozen food, and industrial deicing applications using nature-inspired, biomimetic nanoscience." LA Business Journal. In addition, Xiaoxi recently became a member of Life Extension's Scientific Advisory Board.

Rebecca Lively—legal:
Rebecca's unique position involves membership in both our Asset Preservation Group (OSSLAP) and Teens and Twenties. Her multiply reproduced article, "How to Protect Your Cryonics Arrangements from Interference by Third Parties," available on Alcor's website: http://www.alcor.org/BecomeMember/toprotectarrangements.html, is included in Alcor's anniversary book, *Preserving Minds, Saving Lives*, and was a presentation to our OSSLAP gathering, thus also included in our online book—available on the Cryonics Society website.

Keegan MacIntosh—legal:
In July, Keegan Macintosh and the Lifespan Society of British Columbia filed a notice of civil claim in B.C. Supreme Court, arguing sections of the province's Cremation, Interment and Funeral Services Act are unconstitutional because they prohibit the sale of cryonics. Macintosh claimed the Cremation, Interment and Funeral Services Act infringes on his right to life now by denying him the possibility of extending his life in the future. He alleges that sections of the law infringe on the charter rights of life, liberty and security of person and are inconsistent with the principles of fundamental justice. B.C. is the only jurisdiction in the world that prohibits the sale or offer for sale of cryonics services.

Nuno Martins—preparedness:
Nuno became a part-time volunteer for Alcor in July 2008. In a 2009 Alcor article he explained how he soon realized that the most important project (at least for him and for those living in Portugal) was to improve Alcor's capacity to perform standby, stabilization and transport in Portugal. And he did it. He made it happen. Nuno continues to maintain a website, regular gatherings and up to date equipment and training for Portugal's cryoncists.

Chana Phaedra—scientific:
Chana is President of Advanced Neural Biosciences, Inc. where she conducts research into cryopreservation of the brain and studies the effects of ischemia on cryopreservation. Chana earned her B.S. in Psychology at the University of North Texas in 2001 and her M.S. in Cognition and Neuroscience at the University of Texas at Dallas in 2003. She has been an Alcor member since 2007 and attended the first Teens and Twenties meetings in 2010 and 2011.

Maximus Peto (MBA, BBA)—scientific:
Diverse experiences and education include biotechnology research and entrepreneurship, with an emphasis on the reversal of human aging, as well as 6+ years of biochemical lab experience. Topical foci have included energy metabolism, insulin resistance, A2E, lipofuscin, macular degeneration, and recombinant protein manufacture. He also has a background in finance and accounting. Max currently performs scientific literature research and reporting for the SENS Research Foundation, and is a Project Manager for the Life Extension Foundation.

Caitlin Campbell—legal:
In May, 2015, Caitlin Campbell announced the following results for West Virginia. Requests to Coroners Granted. After Caitlin spoke with the *chief medical examiner of the state of West Virginia*, he agreed to: *give cryonics patients priority in queue statewide*. He further agreed that: his office would instate a policy whereby, if his office was aware that patients desired a noninvasive autopsy and he was not legally bound to give a full autopsy, he would *forgo the full and give a noninvasive autopsy*.

John Schloendorn, PhD—scientific:
John founded Gene And Cell Technologies in 2013 and serves as its Chief Executive Officer.

From 2009 to 2012 John was the CEO of ImmunePath, a venture-backed regenerative medicine startup where he oversaw the development of immune cell therapies from embryonic stem cells. John also served as the Director of SENS Foundation's intramural Research Center from 2006 to 2009, where he oversaw the development of enzyme therapies for age-related storage diseases and other projects through the pre-clinical stages.

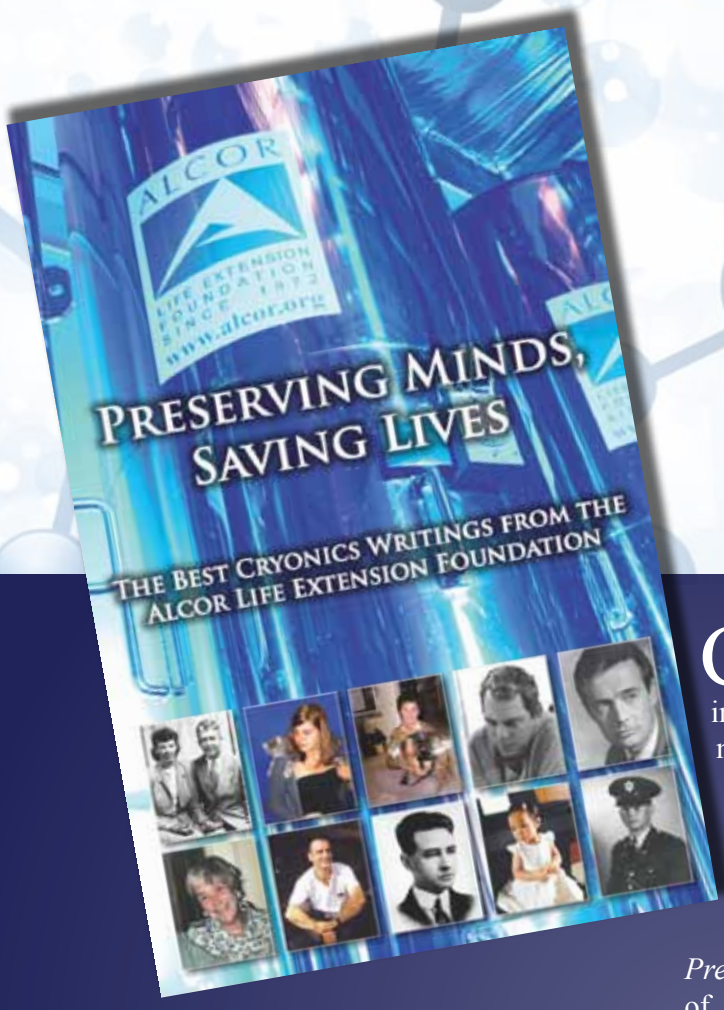
Quite an impressive group. Not normal. I look forward to new and returning T2s, April 8-10, 2016, in Ontario, California. ■

Teens and Twenties Meeting 2012

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 restore them 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.

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References

1. *Public Health Nutr*. 2006 Dec;9(8A):1136-40.
2. *Am J Prev Med*. 2005 Nov;29(4):335-46.
3. *J Am Diet Assoc*. 2005 Mar;105(3):428-40.
4. *Nutrition*. 2005 Feb;21(2):131-6.
5. *Biochem Biophys Acta*. 2004 Jun 1;1682(1-3):80-91.

Note: While the health benefits of omega-3s from fish oil are universally recognized, the critical importance of olive oil in maintaining healthy vascular function remains largely overlooked.

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THE TECHNOLOGY OF REPAIR, REVIVAL, AND REJUVENATION

PART III

By York W. Porter

MERKLE AND FREITAS'S JOINT WORK

Ralph Merkle and Robert Freitas's 2008 paper, "A Cryopreservation Revival Scenario Using Molecular Nanotechnology"[80] reminds one of NASA's initial methods of thinking about a moon landing. ("What do we need? A rocket. A straight shot to the moon or earth orbit first? Earth orbit first. How many stages does the rocket need, one or more? Three stages … and so on). The paper begins by considering what temperature repair should be attempted at, liquid nitrogen or a higher temperature where things are fluid, then goes from there.

The lower temperature is, of course, the better choice. Deterioration of tissue is halted, and things stay put while you do your excavating or patching or whatever. Critical biological structures are "locked down" at the molecular level and will stay in place when not intentionally altered. You can also correct such problems as fractures in tissue, before they become the gaping, leaking wounds they would be if you warmed up to fluidity. (Actually, Merkle and Freitas envision at least a two-stage process for correcting fractures, starting at a very low temperature—see below.) The brain especially should benefit from the most delicate, painstaking restorative procedures that could proceed unhindered for indefinitely long periods of time, and also in massively parallel projects that restored different parts concurrently.

Will the tools be available, molecular machines that can operate at the desired temperatures? Merkle and Freitas, who consider the tiny components such machines would be made of, are optimistic: "Gears, bearings, ratchets, sliding interfaces work quite well regardless of temperature."[81] Such components can operate in a vacuum and do not need lubricants. A second needed feature would be intelligent control of the molecular machines. Tiny computers able to work at low temperatures, in the range needed, have been designed using "rod logic" (a type of computation using mechanical movement of parts rather than electrical switching). Communications could be by molecular cables designed to transmit data at gigabit rates or higher. The onsite devices, machines with onboard computational control that work inside or in close proximity to the patient, could be connected to a large, offsite computer. In this way considerable extra computational power could be brought to bear on the problems at hand, without risking harmful side-effects such as warming up the patient at the wrong time. Power to operate the on-site devices could be transmitted via carbon nanotubes.

So what will we do, presuming we have the necessary tools for nanoscale operations at low temperature? Our little tools and the offsite support become instruments for excavation, analysis and restoration. Merkle and Freitas suggest we start with the circulatory system, clearing it out of solidified or vitrified fluids or other obstructing, nonessential material. In this way we obtain a network of tunnels for accessing any point in the brain to within 20 micrometers or a few cell diameters. Other parts of the body should also be adequately accessible, in many cases to within the same distance.

An exciting proposal in the paper is the use of a so-called "vasculoid."[82] As opposed to Freitas' early thinking on "respirocytes" which would work alongside of other, naturally occurring blood components, the vasculoid is essentially an artificial circulatory system that would transport oxygen, food molecules, glucose, hormones, et cetera through the vasculature, and do so even in a state of cardiac arrest, as would be found in cryonics patients. Merkle and Freitas propose adapting the vasculoid to operate at low temperatures, using the cleared out vascular system which could still serve as its "vasculature," to carry out necessary operations of excavation and tissue repair.

The problem of fracturing is to be handled in a two-step fashion. Starting at a low temperature, a "stable support sheet" is constructed in each gap between two adjacent fracture planes (or other surfaces). The support sheet maintains stability as the tissue is warmed. Then, with the greater fluidity that occurs at a higher temperature, another operation is performed, to simultaneously remove the support sheet bit by bit and bring the fracture surfaces together and join them. In the end, the tissue becomes whole and intact as if no fracture had occurred.

One expected problem is that some proteins will probably have been denatured during the cryopreservation process. A bit of heartening news here is that "most proteins should spontaneously recover."[83] If critical functioning doesn't return, properly shaped proteins could be introduced when an appropriate temperature is reached so that normal cell activity can take over and complete the recovery process.

As the cryonics patient is warmed and increasing fluidity returns, other problems are expected. The processes that were used in the cryopreservation, coupled with changes prior to clinical death, will probably result in abnormal levels of various cell or tissue chemicals: sodium, potassium, glucose and oxygen, ATP, et cetera. The very chemicals ("cryoprotectants") used to protect against the normally damaging effects of ultra-low temperatures, may or may not be optimal at any particular repair temperature. So it may be wise to replace them with more appropriate and/or newly developed cryoprotectants.

Due to the relatively easy access to any cell and/or tissue bed in the body, coupled with the substantial computer power available offsite, the process of repair, revival, and rejuvenation will probably be totally automated. The control system of the vasculoid/cell repair devices should be able to adjust levels of chemicals, deal with rates of warming, and do repair of fractures when an appropriate temperature is reached. So in short, with proper programming and devices, it will be largely a "hands off" operation like a plane on autopilot, with little if any human intervention needed.

As warming proceeds there will be a point where the patient is not yet functional but in a state of moderate hypothermia. Now-unnecessary devices including the vasculoid, if it is still there, would be removed. The patient would then be taken to normal body temperature with full return of consciousness and awareness. To the person revived, the intervening time since arrest and cryopreservation will seem only an instant, even if centuries had passed.

The efforts of Ralph Merkle and Robert Freitas to address the problem of reviving cryonics patients should be heartening to anyone who is interested in cryonics. The 2008 paper continues a long quest that will go on until the goal is reached.

CHANA PHAEDRA AND "RECONSTRUCTIVE CONNECTOMICS"

Holding a Master's Degree in Cognition and Neuroscience, Chana Phaedra is president of Oregon-based Advanced Neural Biosciences, Inc., founded in 2008. According to the LinkedIn website, ANB's research areas are "improving outcomes for sufferers of cerebral ischemia and bridging the gap between neurophysiology and cryobiology." Through ANB Phaedra and her research partner, Aschwin de Wolf, are contracted by cryonics organizations, including ANB's initial supporter, the Immortalist Society, to investigate cryonics procedures and how they might be improved. Starting with a very modest $20,000 grant, the company has grown over seven years to a half-million dollar annual research budget.

Phaedra published a paper, "Reconstructive Connectomics" (*Cryonics* Jul. 2013)[84], whose title borrows terminology her research partner, Aschwin de Wolf, introduced in the same magazine two months before, in an editorial, "Resuscitation Research Can Start Now!"[86] Phaedra's paper seconds the case, she tells us, "to pursue meaningful cryonics resuscitation research today."

The "connectome" is "a comprehensive description of how neurons and brain regions are interconnected," essentially, a "wiring diagram" for the brain. Connectomics seeks to map that wiring, thus treating the brain as an interactive whole system, analogous, in a much more complicated way, to a massive telephone wiring/switching system. The complexity comes from basic properties: "The human cerebral cortex alone contains on the order of 10^{10} neurons linked by 10^{14} synaptic connections. By comparison, the number of base-pairs in a human genome is 3×10^{9}." (Wikipedia[85]).

Research in connectomics has obvious implications for cryonics. Detailed information gathered about how the brain works and how it is wired together, whether at the gross anatomical, microscopic, or biochemical level, and that wiring's moment-to-moment and overall functioning, can provide significant clues to how a brain might be repaired from any damage. The damage could have happened before cryopreservation, during the process, or after. (In addition, connectomics knowledge will be quite useful in working on medical conditions in the living state!)

Connectomic information would help us in working backward from the state the brain is in to its original, undamaged state. By analogy, a damaged automobile may tell a trained mechanic what parts are malfunctioning and exactly in what ways. Aschwin de Wolf, originator of the phrase "reconstructive connectomics," had this to say in "Resuscitation Research Can Start Now!":

> A major obstacle to strengthening the case for cryonics is the perception that meaningful research aimed at resuscitation of cryonics patients cannot be done today. Attempts to be more specific than evoking the need for a technology that can manipulate matter at the molecular level are considered to be vague and unproductive. … The first thing that needs to be recognized is that if we want to say something *specific* about the nature and limits of repair we need to be able to *characterize* the damage in detail.[87]

In the specifics of damage that may occur in cryonics, Phaedra speaks of general damage categories as follows:

> Much work has already been done in characterizing damage in cryonics. In brief, damage falls into the following categories: damage incurred prior to cryopreservation (i.e., "pre-mortem damage"), cerebral ischemia, cryoprotectant toxicity, ice formation, chilling injury, and dehydration. The question of utmost importance in considering these forms of damage is whether we should expect any of them to destroy (our ability to reconstruct) the connectome.[88]

Phaedra's answer to whether the forms of damage will prove insurmountable is a definite "No." She notes that if more than just knowledge of the connectome

will be needed, such as more detailed information at the synapse level, and/or details of microtubules, ion channels, neurotransmitters, et cetera, further research can establish this. In the words of Theodor Meynert, the German-Austrian anatomist/neuropathologist of the 1800s:

> If we are acquainted with the principles upon which this mechanism [the brain] operates, we may infer its function from its structure, regarding the former as a natural outcome of the latter.[89]

The converse should also be true with sufficient knowledge. Observing the function in enough detail over a wide enough theater of possibilities should allow one to infer what structure, both normal and abnormal, must be there. Someone studying a damaged brain thus has many potential ways to infer what specific structures are damaged and how they are damaged. This is a long way from simply "evoking the need for a technology that can manipulate matter at the molecular level"[90] which, as de Wolf correctly points out, is for many people too generic a "repair solution" for them to take cryonics seriously.

Knowledge which already exists in great quantities about the proper anatomical structures that should exist in a functioning brain, combined with knowledge that will be gathered through the relatively recent field of connectomics, can be combined with other knowledge from cryobiological and physiological studies to form what is known as "Fault Tree Analysis."

At first, of course, this type of analysis will be somewhat limited, depending on the amount of knowledge in any particular area. "Branches" of the fault tree may be very sparse in terms of information and proposed actions. Over time, however, those same branches can gradually be filled in and expanded with real world and specific approaches to dealing with the problems in placing individuals in solid-state hypothermia. Fault Tree Analysis can help provide rational decisions on specific alterations in approaches used in dealing with cryonics patients. As de Wolf writes about one specific type of concern in cryonics, the toxic effects of chemicals used to protect tissue from the effects of the "super-cold" liquid nitrogen that patients are stored in:

> If someone would claim that cryonics is hopeless because of the "toxicity" of the vitrification agents we can ask for more specifics about what kind of biochemical damage is being alleged and why such alterations irreversibly erase identity-critical information.[91]

(One might also add, "and/or, specifically why such alterations are believed to make the ability to regain normal function unlikely or impossible")

The point of all this is that, even at the present, still-early point in its history, cryonics can make advances from the generic vision of Robert Ettinger toward actual implementation of resuscitation protocols. A continued emphasis on dependable and verifiable scientific information and technological development will gradually make headway and provide increasingly solid underpinnings of progress. This would include amelioration, as far as possible, of problems that can currently be dealt with or, at the very least, recognition of what those problems are or are likely to be. Practices to deal with them can be tentatively developed and then improved. Existing technological developments and practices could be adapted from other fields as well. Fault Tree Analysis is one case in point. Fracture Match, currently used in modern forensics, could possibly be another.

It is known, for instance, that even for something as mundane as duct tape, tearing a piece results in a unique pattern of fracture that allows matching one side of the torn tape with the other side. Murderers who thought they had "gotten away with it" have been brought to justice through such telltale clues. Knowledge such as this may possibly be used to help determine that fractured segments of cells/tissues have not just come apart in random, inscrutable ways. Inferring what ought to be there from what still is there might then be feasible. Quoting from Thomas Donaldson's 1987 *Cryonics* article, "Neural Archaeology," Phaedra writes:

> Reconstructive connectomics is the modern-day realization of what Thomas Donaldson termed "neural archeology," a concept described in detail in his 1987 article of the same name. In general terms, Donaldson equates the task ahead of cryonicists with that encountered by traditional archeologists. Though space limits our ability to consider this prescient article in full, let us look at a most illuminating section:
>
> "The first thing done in examining an archeological site is to carefully plot the relation of all the fragments to one another. Debris has a structure too. We discover this structure by looking at the relations of its parts to one another, not just by looking at the parts. (Archaeologists in Central America complain constantly that valuable artifacts are taken away and sold, with no record of where they were found, in relation to what.) If a protein has two degradation parts, we can learn a lot by knowing where these parts are found in the remains of a cell.
>
> "In fact, one way of looking at cryonics is that it is simply a way of making such a detailed record. Here is a patient's brain, in the condition it was when we lost him."[92]

Winding up her 2013 paper by discussing the most primitive form of cryonics, a "straight freeze" without cryoprotection, Phaedra optimistically concludes: "Even such 'worst case scenarios' may not be as bad as we think."[93]

MOVING IN ON THE ULTIMATE GOAL

The inability of Robert Ettinger to provide specific details of how cryonics patients will be revived has given way to in-depth

thinking by other smart, educated and dedicated people. Their imaginative and well-considered proposals continue to shed strong light on what started out as basically a glimmer of hope. This is not to say the problems are not formidable. Nanotechnology is still pretty much in its infancy, the strenuous efforts of many notwithstanding, including, at the thought level and close to home, Merkle, Drexler and others. Still, in the various scenarios that have been proposed through the years for preventing or repairing the damage sustained by cryonics patients, we see the groundwork for more substantial advances yet to come. The suggestions, as outlined above by several obviously competent, involved researchers in relevant fields, foster the optimistic conclusion that progress is ongoing and will continue.

The Wright Brothers didn't simply invent the "flying machine" one afternoon while thinking about it for an hour or two. Instead centuries' worth of brilliant precursors figured in the task, from Leonardo da Vinci onward (and, no doubt, some before him). And the two brothers themselves spent many hours on the problem before they solved it. Numerous routes were tried, discarded, then picked up again, in whole or part, as they seemed useful and/or more knowledge was gained. Dead ends when they occurred still added something to the knowledge base. Some apparent dead ends no doubt turned out to be re-explored when additional insight was gained. As in most human endeavors, it was sometimes "one step forward, two steps back." But the goal was reached and humankind has been, overall, the better for it.

Similarly, the effort to apply nanotechnology and cryobiology to cryonics involves many minds over many decades (at least) and will not bear the hoped-for fruit of cryonics resuscitation overnight. Instead it will seem highly forced, convoluted and futile in the eyes of many, yet progress is ongoing and has been for five decades now, both from the theoretical and the experimental sides of the problem.

We have considered various proposed approaches for repair, rejuvenation and resuscitation of cryonics patients. There was Jerome White's modified virus, Mike Darwin's "anabolocyte," Thomas Donaldson's "repair bacteria," Brian Wowk's "cell repair device," Ralph Merkle's "offboard repair" scenario, the "SCRAM" method of Mikhail Soloviev, and the "realistic" repair proposal of Greg Fahy. Other proposals came from Robert Freitas, Thomas Donaldson, Tad Hogg, Aschwin de Wolf, and Chana Phaedra, the latter two dealing with connectomics. The different proposals made thus far are real and substantive, even if speculative. They show that cryonics is far from "an act of faith" but is, at bottom, an endeavor based on realistic and hard-nosed thinking. Whatever one thinks of any particular approach, these or others, we can be especially heartened that, as Eric Drexler has written in a newer book from 2013, *Radical Abundance*, "Every major nation now supports nanotechnology research."[94]

As Ralph Merkle said in response to Greg Fahy's critique of Merkle's "Molecular Repair of the Brain":

> This exchange on the subject will not be the last, nor should it be. As repair scenarios become more detailed, there will be more points of disagreement, not fewer. Consensus does not emerge at once, full blown. Instead, it emerges bit by bit, a single piece at a time, as the various issues are argued and discussed in greater and greater detail.[95]

No doubt true—and no doubt there will be further excellent exchanges in the future as nanotechnologists and cryobiologists continue to trade information and debate. This is how excellent science has always been done and how, it is reasonable to contend, cryonics ought to be done also.

SOME GENERAL CONTROVERSY IN NANOTECHNOLOGY

No field of scientific endeavor is without its share of controversy; nanotechnology is no exception. In a 2001 article in the well-known, widely respected *Scientific American*, Dr. Richard Smalley, who had won a Nobel Prize in chemistry in 1996, argued that the development of assemblers as proposed by Eric Drexler was simply not feasible.[96] The position of Smalley seems strange indeed since he wrote of nanotechnology, *a year later*, that "It holds the answer, to the extent there is one, to our most pressing material needs including energy, health, communications, transportation, food, and water."[97] Further, in August 2000, Smalley had remarked in a National Public Radio interview: "It is true that it seems as though almost anything can be done if one can position atoms in the right place, but it's not going to be simple and overnight."[98] Eric Drexler had never maintained, of course, that the development of assemblers would be "simple" or "overnight."

Nevertheless, for some time a debate raged between Drexler and Smalley as to the basic feasibility of Drexler's concept. Others weighed in on the discussion, among them Ray Kurzweil, noted inventor and futurologist. In his book *The Singularity Is Near*, Kurzweil wrote " … if Smalley's critique were valid, none of us would be here to discuss it, because life itself would be impossible, given that biology's assembler does exactly what Smalley says is impossible."[99]

Kurzweil's observation reminded this author of something once remarked by well-known cryonics pioneer Curtis Henderson. Though he never saw combat, Henderson had been trained as a fighter pilot near the close of World War II. He said it was always amazing to him how reputable scientific figures in the centuries before the Wright Brothers could maintain that a heavier than air flying craft was impossible "with birds flying around their heads every day." Similarly, Smalley seemed to be arguing from the standpoint of being a living example of what he said couldn't be done.

In 2003, the Center for Responsible Nanotechnology also added their voice to the discussion:

> Smalley's strategy, both in the 2001 Scientific American article and in the current debate, has been to equate Drexler's proposals with something unworkable and then explain why the latter can't

> work. Thus Smalley's comments do not directly address Drexler's proposals, but attempt by example to show fundamental problems with his underlying theory. However, both of Smalley's attempts have failed, and the second failure is noteworthy for what it reveals about the weakness of Smalley's position.[100]

Further, Eric Drexler had, during the controversy, published a point-by-point rebuttal to Smalley's position, to which Smalley never replied. Regrettably, Smalley succumbed to cancer at age 62 in 2005 (with no interest in cryonics, to the author's knowledge).

Whatever one's viewpoint, the fundamental standard in any scientific dispute is what does the evidence say. Carl Sagan very well explained this in his book *Broca's Brain*. Paraphrasing, he pointed out that there was no essential difference between believing in DNA or in UFOs, in sorcery or in nuclear physics, in a lot of other things *except for the evidence*. That standard is what has to apply to cryonics and to Drexler's concept of assemblers or Smalley's critique of it.

There has been progress in the factual and evidentiary basis of nanotechnology, both in general and, recently, in the very specific area that Drexler originally referred to, now frequently known as Molecular Nanotechnology or MNT. In his famous 1959 talk, Richard Feynman gave the resolution of electron microscopes, useful in determining an atom's position, as about ten angstroms. Today, the same general type of electron microscope (there are different "families" of them), can resolve around a half an angstrom. An instrument Feynman said needed to be improved and which might be crucial for progress in nanotechnology, was enhanced several fold. Another, even better instrument for revealing fine scale, the scanning tunneling microscope or STM, makes it possible to image individual atoms but also to manipulate them. STMs were long in use for atomic manipulations at the time of Smalley's objections, one famous, early example being the 1990 effort of IBM's Almaden Research Center in San Jose, California. There the letters "IBM" were spelled out in 35 xenon atoms on a nickel substrate. The STM, of course, is now far too big and cumbersome to be of much use for cryonics resuscitations, yet it is a strong sign of ongoing progress, and there are others. Over the years, numerous reports of applications based on nanotechnological thinking have appeared. Each advance, however small (pardon the pun!), adds credence to this dynamic and interesting field.

If nanotechnology, as it appears, will ultimately attain the dream of Drexler's MNT, Michael Rieth's remark in his book, *Nano-Engineering in Science and Technology*, becomes quite relevant: " … if we can build anything in any quantity, the practical question of 'What can we build?' becomes a philosophical one: 'What do we choose to build?' … "[101] One thing we, as human beings, will surely build is devices to aid the sick and injured among us. Our nanotechnology must work at the subcellular level to help physicians in unprecedented ways. Dr. Sam Bhayani, a surgeon who works with the revolutionary DaVinci robotic surgery system, is already saying it makes him feel like "the Six Million Dollar Man … it makes me faster, better, stronger …."[102] The DaVinci surgery system allows the surgeon to be in any location in the world as long as the unit is hooked up via a telecommunications link to the mechanical end that would service the patient. Bhayani goes on to say "I imagine a future where robots don't only go into the body and take out tumors but also can go into our genes and alter how we produce tumors, alter our longevity … that nanotechnology is going to happen in the next hundred years, it's just on the cusp of today … "[103]

Bhayani's focus is on surgery and other normothermic medicine, but involves the ability to work with sub-cellular structures, to repair those structures, to replace molecules where they need replacing, and to move molecules from their incorrect to their correct position. The more or less identical technology will be useful in the revival, repair, and rejuvenation of cryonics patients. Further, some very recent evidence indicates that Bhayani may be way too conservative in his time estimate of "the next hundred years," plus striking a severe blow against Smalley's anti-assembler argument. It is that *the first molecular assembler has actually been developed!* The advance was reported by David Leigh and his team at the University of Manchester School of Chemistry.[104] The device developed by Dr. Leigh and his group is primitive compared to the body's "natural assembler," the ribosome, that works inside living cells, and also to Drexler's idealized concept of an assembler. Yet it is a big, big step in the right direction.

An analogy with aviation comes to mind. The magnificent aircraft that routinely cruise the skies today are a long remove from the rattling contraption of fabric, wood, wire, and chains that the Wright brothers first coaxed aloft at the turn of the last century. That, however, was the prototype of today's great mechanical birds and we are similarly confident that today's scientific minds are on the right track in perfecting the assembler—and even if another route entirely from Leigh's work is ultimately chosen. This work will continue, regardless of what anyone may say or think.

ERIC DREXLER AND "RADICAL ABUNDANCE"

In 2013 Eric Drexler published *Radical Abundance: How A Revolution in Nanotechnology Will Change Civilization*. This book is an excellent companion and addendum to his earlier work, *Engines of Creation*, which appeared in 1986. It is a cautionary note but also is filled with hope for better days ahead for the whole human race. In an interesting sideline Drexler reports that the word *nanotechnology* he used, for the controlled manipulation of matter at the atomic scale, came into his head between the first and second drafts of *Engines*; in *Abundance* his preferred term is *Atomically Precise Manufacturing* (APM).[105]

In high school Drexler was concerned over the pressing question (still a valid one) of whether modern civilization could be sustained given its finite resource base. Oil reserves cannot last forever, as one for instance, with the gargantuan consumption our society demands and the geologically slow rate that nature produces new oil

from dead organic matter. Drexler studied the book *The Limits to Growth* by Donela H. Meadows; there it said that economic growth would eventually be halted by the world's limited resources. But Drexler saw a serious flaw in the argument: nowhere did it consider resources off-planet, neither in the solar system nor beyond it. NASA at the time was engaged in a vigorous space exploration effort, including manned lunar landings, while attempting to make spacefaring a routine endeavor. As Drexler put it:

> The restricted vision embodied in Limits to Growth raised questions that led me to explore what might be found outside the world it had framed—to look outward, at first, toward deep space, but later inward, to explore the potential of technologies in the nanoscale world.[106]

Drexler contacted Dr. Gerard K. O'Neill, an MIT professor whose 1976 book, *High Frontiers: Human Colonies in Space*, offers daring plans for extending human civilization beyond the confines of our planet. At a time when NASA vehicles were cramped for living space, O'Neill proposed miles-wide, sun-orbiting habitats with spin-induced artificial gravity so humans could begin colonizing the "high frontier" under something like familiar conditions. Drexler, however, wondered what resource base would sustain such an effort. The space colonists would need the usual food, clothing, shelter and many other things. Majoring in "interdisciplinary science," Drexler studied everything from plant physiology to vacuum metallurgy with much in between related to space settlement. One particularly interesting topic was lightsails or solar sails, miles-wide rotating structures in space with thin, reflective panes which are pushed around by the pressure of sunlight. Data indicated that lightsails using aluminum sheets 100 nanometers or about 300 atoms thick would work.

300 atoms across is pretty tiny; another step or two and you are working right at the atomic level. Drexler patronized the MIT library system to study up on this. The wonders of the molecular world were fascinating, along with the concept of building things with atomic precision. Calling himself an "information omnivore,"[107] he hit on a burning question: "What could be built using the machines that nature's own machines could be programmed to build?" Beyond this was a further question: "What could be built using machines that could be built using *those* machines?" and so on.[108] Indeed:

> Looking at the molecular machinery of life, we find that proteins can fit together to form motors, sensors, structural frameworks, and catalytic devices that transform molecules; protein-based devices also copy and transcribe data stored in DNA. Most important of all, machine systems built of biomolecules can serve as programmable manufacturing systems that build components for new molecular machines.[109]

In short, APM ought to be possible starting from nature's own tools developed in and for living systems. And APM, in Drexler's view, will underwrite the fourth of the great historical revolutions that have shaped civilization, the worthy successor of the agricultural, industrial, and information revolutions. The first two of these sparked the one that followed, and so we expect that the information revolution, the explosive growth in computerized control and data processing and exchange, will set the stage for the revolution in the human condition wrought by APM. High quality goods and complex, automated services should then be ours at extremely low cost. Currently many manufacturing operations are automated and require little in the way of human intervention. Continuing this trend, in the ultra-high tech world of APM, computerized manufacture from common and inexpensive raw materials should give us a world in which many problems of industrial civilization will be greatly minimized or disappear. More expensive and scarce materials such as iron, lead and tin could be replaced by more abundant and cheaper ones, such as carbon, nitrogen, oxygen, and silicon, which will also befriend the environment. (Mining interests might suffer but that should be a relatively minor issue.)

One plus would be the ability to do complex manufacturing on a local basis, instead of depending on lengthy supply chains to get raw materials from supplier to consumer. It should make abundance widespread, notwithstanding the economic disruptions that would have to be managed along the way, from the shutdown of industries of long standing that are no longer essential. Inevitably, there will be losers as well as winners. (An old cartoon that illustrates the general point shows the chairman of a failing company back in the 1960s dressed up in late 1800s garb, exclaiming to his Board of Directors, "I don't understand it! Why are we losing money? We make absolutely the best candle snuffers in the world!") But the benefits overall should far outweigh the downsides.

One heartening thought is that no new physics should be involved. The APM revolution will be based on engineering not any new science. As Caltech physicist Sean Carroll puts it:

> Over the last four hundred or so years, human beings have achieved something truly amazing: we understand the basic rules governing the operation of the world around us. Everything we see in our everyday lives is simply a combination of three particles—protons, neutrons, and electrons—interacting through three forces—gravity, electromagnetism, and the strong nuclear force. That is it; there are no other forms of matter needed to describe what we see, and no other forces that affect how they interact in any noticeable way. And we know what those interactions are, and how they work … As far as our immediate world is concerned, we know what the rules are.[110]

Once you know "what the rules are" the job is then to begin applying them to the desired aims. No doubt great improvements in individual engineering capabilities must occur before APM can be feasible. But once it happens the prospects are vast indeed, including substantial improvements in human health, for are we not made of atoms also? There, as Ralph Merkle put it, the job is to make sure to *"change arrangements of atoms that are 'unhealthy' to arrangements of atoms that are 'healthy'"*(emphasis again added). The relevant physics is well-understood. So it is then an engineering problem to make sure the "right atoms are in the right place" for a particular solution, a task for which APM is particularly suited since that is, at bottom, its basic design principle and goal.

Which doesn't, of course, make the problem simple. It's nearly three decades since *Engines* appeared, but APM is still basically on the drawing boards. And the problems aren't just technical either. Social and political issues also come into play, as in any human endeavor, and even semantics raises impediments. While to Drexler himself *nanotechnology* meant atomically precise manufacturing or fabrication, others broadened the meaning to include anything pertaining to the atomic scale. In the confusion sound science and engineering too often gave way to science-free fiction:

> In retrospect, a clouded perception of facts marked the start of a perfect storm of dreams, nightmares, and confusion. The dreams boosted efforts to bring federal funding, while the nightmares threatened to block it, and confusion ensured misguided responses.[111]

To make things worse:

> … neither facts, nor up-to-date concepts, nor technical publications could anchor discussions to reality.[112]

The result was, for a while, a loss of opportunities. Fortunately, here as in many other venues, the "Dark Ages" lasted a while but not forever:

> Struggles fade, new leaders rise, opinions change, and actions follow. Even in the United States there's been a strong rebound from the times I've described.[113]

Another of the basic problems is a fundamental difference between the way science and engineering work at achieving their results. A scientific theory, no matter how well constructed and how authoritative its original proponent (even the great, revered Albert Einstein), just needs one solid but contrary example to bring the whole edifice crashing down. A case in point is the belief, prevalent around 1900, in the "ether" as a medium for propagating light waves. This theory was dispelled by experiments showing something far more strange and subtle: the speed of light measured constant in all inertial reference frames, independently of their motion relative to other frames, something that could not happen with the ether theory as formulated. The theory simply died on the vine (albeit reluctantly for some), to be replaced by Special Relativity. In engineering, however, one design failure doesn't mean that all designs will fail. Instead, concrete reasons and, frequently, already known general methods of failure, are examined, the design is strengthened or altered as needed, and the whole project begins again, albeit in a slightly new direction.

An example of this in the traditional engineering world was the failure, in the 1950s, of the Lockheed Electra L-188 passenger airliner. Two crashes in which a wing on each aircraft came off in flight, resulting in the death of all aboard, were due to a problem involving "whirl mode flutter" which was, at the time, quite well-known to the engineering community. After the problem was investigated and this method of failure was determined to be the cause, structures on the aircraft were redesigned. With these highly successful modifications, some versions of this plane, such as the PC-3 Orion military craft, fly into hurricanes during weather- and research-related flights today.

Regrettably, the breakup of the wing structure due to a mode of failure that was already well-understood led, in part, to low sales of this aircraft and its eventual discontinuation as a regular passenger airliner (although some still fly in passenger service in remote locations). At bottom, though, the problem wasn't a scientific one but an engineering one which required engineering thinking to solve it.

Which is why, ultimately, folks in the engineering community are generally better suited when, as in APM, systems-based engineering is needed to move things forward. This isn't to denigrate scientific qualifications or work in the least. It's just that engineering is a type of thinking that is as specialized and recondite in its own way as scientific thought. And when you're in another area of specialty than your own, it's very easy to make mistakes in your reasoning, even if you're well-educated and highly intelligent.

As an example of this in cryonics, a Ph.D. cryobiologist who is an opponent of cryonics wondered aloud on a nationally televised program where the blood to revive cryonics patients was going to come from. Any blood banker in day-to-day hospital work could have told him. The cryobiologist was not lacking in high-level competence and qualifications for his specialty. It's just that this particular issue was not in his areas of expertise, due to our modern need for highly specialized work assignments.

In *Radical Abundance* Drexler talks about the scientist who wrote that nanogears and other moving parts of nanotechnological devices could not work in some circumstances since they would be "gummed up" by biomolecules: "The answer, of course, is to keep gears in a gearbox, and to place all the critical moving parts inside a sealed shell."[114]

It's easy to criticize this scientist who didn't think of the answer or the cryobiologist who didn't think of the earlier one. It's just, again, that science isn't engineering and engineering isn't science. The two are deeply intertwined and exchange information and influence, but still have rather different ways of thinking and approaching goals. Anyone

from either side, no matter how intelligent or competent, is going to have limitations in specialties not his own.

A more mundane example of the problems of thinking outside one's areas of expertise is seen in the movie *Von Ryan's Express*, a fictional film set in World War II Italy. There, a group of Allied POWs riding a commandeered train are trying to escape to neutral Switzerland. A section of track ahead of them is hit by German aircraft, rendering it impassable. Meanwhile a train behind them full of German troops is in hot pursuit, though still some distance away. Voices murmur, What to do? Lay new track! Yeah, where from? From behind the train! Uh—yeah, makes sense … . You tear up track behind the train—you don't need it anymore nor do you want the guys behind you to have it—and use it to repair the damage ahead, so you can move forward. (The train does finally make it to Switzerland, with some, at least, of the POWs escaping to freedom.)

Once the answer is thought of, as above, it seems obvious. The average moviegoer, however, will be distracted by all the rapid-fire action in not-too-familiar settings so that this solution is likely to be a surprise, in a situation that appears hopeless. In this case, if you aren't thinking like a railroad worker, the answer isn't readily apparent.

Similarly, if you're a scientist and not used to thinking like an engineer (and vice versa), it's all too easy to make mistakes in judgment in what can and can't be done outside your specialty. In addition, for even highly trained and experienced personnel in any field, such as aviation, a moment's distraction or confusion can lead to sometimes deadly errors.

With engineers in charge the path to APM may be feasible yet still not "easy and quick." A parallel case is the launching of the first artificial Earth satellite, Sputnik 1, in October 1957. Work going back to the 1800s preceded this landmark event. A pioneer of space flight, Konstantin Tsiolkovsky, played an important, preliminary part, working out orbital details and other requirements in a paper published in 1903, a few months before the Wright brothers made their first, historic flights at Kitty Hawk. (Though largely self-taught Tsiolkovsky was for a while instructed by scientific immortalist philosopher Nikolai Fedorov. He was also was inspired by the science fiction of Jules Verne). Tsiolkovsky died in 1935, long before Sputnik was launched or Apollo 11 roared into orbit on its journey to the moon. But his determination to search for answers to what has been one of humanity's greatest exploits, his working in what are, to us, primitive conditions with no Internet or other easy, electronic communication, is a shining example of what Drexler calls "exploratory engineering"[115]

Exploratory engineering is not, Drexler reminds us, a guaranteed superhighway to all we might desire. Instead it charts a path between engineering as presently practiced and what has not been achieved but is still, as far as one can tell, permitted by physical law. It means constantly questioning your designs and whether your attempts at what you are trying for are reasonable based on existing engineering (and scientific) literature and known scientific facts.

This has to be coupled with the constant caution of making sure your chain of logic in deriving your engineering concepts is sound and solid. It also means, as in the case of Tsiolkovsky, having the courage of your convictions and the willingness to have your concepts and designs subjected to the criticism of your peers (and others). It also means being subjected to naysayers who may be well-intentioned and seemingly highly qualified, but also could be dead wrong. (The case of the scientist concerned about "gumming up" nanomachinery comes to mind.) In short, it's no place for dreamers who dismiss the real concerns with waves of the hand, but instead is for those whose bent is the long, hard work needed to turn dreams into reality.

And Eric Drexler and others certainly have begun to do just that. The possibilities outlined in *Radical Abundance* are numerous: from tremendously improved computing devices and software to cheap sources of power, medical technology that modern day health care workers can only dream about, and other things not even touched on here. As Drexler puts it in his writings about the time of "a perfect storm of dreams, nightmares, and confusion": "The opportunities are greater today than ever before"[116]

THE FUTURE OF NANOTECHNOLOGY AND CRYONICS

The bottom line for cryonicists will be the effect of nanotechnological efforts in two areas. The first is the more restricted area of technologies needed to revive, repair, and rejuvenate cryopreserved humans. The second will be to ensure that these recovered patients will be adequately supported and provided for as they reenter society, with provision for fellow humans who would be important to them. Drexler is right in remarking, about the future of nanotechnology: "Timelines, pathways, and ultimate potential will remain persistent unknowns."[117] Still, as this and other technologies become available, those that are tested and found safe and useful will be more or less automatically put to use in ways that have always been of concern to humans. Applications in agriculture, power generation, the use of non-polluting raw material resources, the development of stronger and better materials for use in construction, aviation, and myriad other places, etc., will transform the plight of humans.

Besides this, there is medicine. Medical knowledge and treatment has been and will continue to be of great concern to humanity. This certainly applies to those of us who are involved in cryonics—and we are fortunate. For we should benefit from much the same technology that will become available for more general medical application: the same instruments and devices and the ability, with the assistance of nanotechnology, to enlist both diagnostic and therapeutic techniques and regimens unheard of today.

As Eric Drexler puts the future of nanotechnology:

> Today a radical abundance of symphony and song—and words, and images, and more—has brought luxuries that once had required the wealth of a king to the ears and eyes of ordinary people in billions of households.

> It seems that our future holds a comparable technology driven transformation, enabled by nanoscale devices, but this time with atoms in place of bits. The revolution that follows can bring a radical abundance beyond the dreams of any king, a post-industrial material abundance that reaches the ends of the Earth and lightens its burdens.[118]

There are, basically, two areas of work essential to cryonics improvement and ultimate success. One is increasing the capability to safely store tissues and organs (and, ultimately, one hopes, organisms) at cryogenic temperatures. This goal can be summed up as "damage free cryonics." It would not, of course, be the full fruition of Robert Ettinger's statement of fact plus his assumption. But cryonics patients, after cryopreservative procedures had been applied and they were safely stored at low temperature, would be no worse off than when the cryonics team first got to them. The damage to the patients would be limited to whatever disease or injury they were suffering from combined with whatever period of ischemic damage occurred due to delays in getting to them. One would hope that, as time passes and cryonics gains more acceptance, the amount of ischemic damage would be kept to a minimum due to more available teams with faster response. Tissue ischemia is also a big concern of conventional medicine. Interventions by highly competent researchers, with specifics as yet unknown, may occur independently of cryonics and reduce this difficulty to a minimum.

The other area of work is in developing full capabilities of reviving, repairing, and rejuvenating those who have already undergone solid-state hypothermia (again, one of the phrases for the "end state" of cryonics patients). The "bad news" is that there is no way to predict exactly when either one or both of those areas of work will reach their maximum effectiveness. The "good news" is that, for those already cryopreserved, time has been suspended and centuries can pass in pursuit of the needed technology. For those who are yet to be cryopreserved, the further "good news" is that each day that passes brings new opportunities for improving cryonics protocols and possible resuscitation procedures.

With or without any urging from cryonicists, Eric Drexler, Ralph Merkle, David Leigh, and others mentioned here (and, no doubt, yet to be born), will continue determinedly and doggedly to work in their respective fields wherever the facts and evidence lead them. The work will go on whatever each person's opinion of cryonics is. It will fully complement the equally important efforts of another man of science who was also the "father of cryonics," Robert Ettinger himself.

What is now generally known as nanotechnology (or, as Drexler now prefers, Atomically Precise Manufacturing), was not even named back when Ettinger wrote *Prospect* in the early 1960s. Today it offers a solid rationale for how cryonics can ultimately succeed in its life saving mission. The continued work by dedicated professionals in cryobiology offers the "other side of the coin" in the continued scientific improvement and, we believe, ultimate success of the world-changing concept of cryonics.

Robert Ettinger stated in *The Prospect of Immortality* (emphasis added):

> Most of us now living have a chance for personal, physical immortality. This remarkable proposition—which may soon become a pivot of personal and national life—is easily understood by joining one established fact to one reasonable assumption. *The fact*: At very low temperatures it is possible, *right now*, to preserve dead people with essentially no deterioration, indefinitely. (Details and references will be supplied). *The assumption*: If civilization endures, medical science should *eventually* be able to repair almost any damage to the human body, including freezing damage and senile debility or other cause of death. (Definite reasons for such optimism will be given).[119]

The "fact" that Ettinger mentions in this world-changing book was already well-established in the 1960s when he wrote. Since then there has been continuing work by numerous researchers: Eric Drexler, Ralph Merkle, David Leigh, Brian Wowk, Robert Freitas, Greg Fahy and many others. Their efforts cover both cryobiology and nanotechnology. In addition there is ongoing effort to apply the lessons learned by persons in the various cryonics organizations and their associates worldwide. In this way Ettinger's "assumption" comes closer to fact every day and the connection between cryonics, cryobiology, and nanotechnology has gotten and will continue to get stronger with every passing year. ■

This article is an updated version of a chapter which appeared in the book *The Prospect of Immortality: Fifty Years Later* edited by Charles Tandy, Ph.D. Readers interested in a copy of the book may check on Amazon.com

About The Author

York W. Porter, born in 1952, attended Berea College in Berea, Kentucky for two and a half years and, in Fall 1974, began working in a rural Kentucky hospital in the Department of Radiology. Diversifying through the years, Mr. Porter worked for one year on an ambulance crew and spent several years in a hospital laboratory setting, plus about a year doing respiratory therapy work. He has worked fairly continuously in the field of medical radiography, serving as a staff tech at various times in four rural Kentucky hospitals, primarily in the fields of general radiography and computed tomography. He also works on rare occasions at a Magnetic Resonance Imaging (MRI) center. He presently holds certifications as a Kentucky EMT-B, as a Licensed Radiation Operator (Kentucky's phrase for an x-ray tech), and as Medical Laboratory Scientist, ASCP(cm). He is the President of the Immortalist Society, at the time of this writing, and serves as Executive Editor of its "house publication," *Long Life Magazine*.

SOURCES (REFERRED TO IN ENDNOTES, BELOW)

AdW. Aschwin de Wolf, "Resucitation Research Can Start Now!", Aschwin de Wolf, *Cryonics*, (34) 5 (May 2013), 5.

BD. Brian Dodson, "Molecular Assembler Finally Created," Gizmag, http://www.gizmag.com/molecule-assembler-synthesis-peptide-ribosome/25759/, accessed 1 Dec. 2015.

CP. Chana Phaedra, "Reconstructive Connectomics," *Cryonics* (34) 7 (Jul. 2013), http://www.alcor.org/Library/html/ReconstructiveConnectomics.html, accessed 1 Dec. 2015.
Co. https://en.wikipedia.org/wiki/Connectome, accessed 27 Nov. 2015.

CRN. "Of Chemistry, Nanobots, and Policy," Center for Responsible Nanotechnology, http://crnano.org/Debate.htm (Dec. 2003), accessed 1 Dec. 2015.

ED. K. Eric Drexler, *Radical Abundance: How A Revolution in Nanotechnology Will Change Civilization*, New York: Public Affairs, 2013.

FP. Robert A. Freitas and Christopher J. Phoenix, "Vasculoid: A Personal Nanomedical Appliance to Replace Human Blood," *Journal of Evolution and Technology* 11 (Apr. 2002), http://jetpress.org/volume11/vasculoid.html, accessed 1 Dec. 2015.

GF. Greg Fahy, "'Molecular Repair of the Brain': A Scientific Critique," *Cryonics* 12(2) (Feb. 1991) and 12(5) (May 1991), http://www.alcor.org/Library/html/MolecularRepair-Critique.html, accessed 1 Dec. 2015.

MF. Ralph C. Merkle and Robert A. Freitas, "A Cryopreservation Revival Scenario Using MNT (Molecular Nanotechnology)," *Cryonics* 29(4) (4Q 2008).

MP. R. Michael Perry, "For the Record," *Cryonics* 35(3) (Mar. 2014), 10-11.

MR. Michael Rieth, *Nano-Engineering in Science and Technology: an Introduction to the World of Nano-Design*, Singapore: World Scientific Publishing Co, Ltd., 2003, Preface, vii.

RB. Ronald Bailey, "Small Wonders: The National Science Foundation Promotes Nanotechnology," Ronald Bailey, reason.com (20 Mar. 2002), http://reason.com/archives/2002/03/20/small-wonders, accessed 1 Dec. 2015.

RE. Robert Ettinger, *The Prospect of Immortality*, New York: Doubleday, 1964, 12.

RK. Ray Kurzweil, *The Singularity is Near: When Humans Transcend Biology*, New York: Viking, 2005, 237.

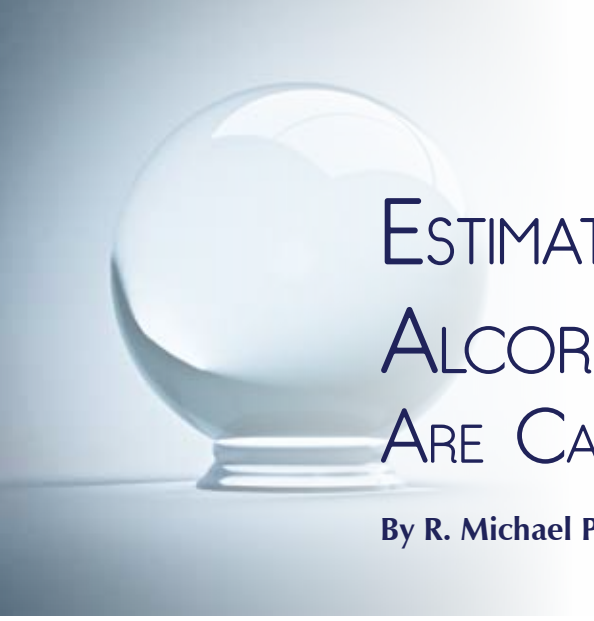
RS1. Richard E. Smalley, "Of Chemistry, Love, and Nanobots," *Scientific American* 285(3):76-7 (Sep. 2001), http://cohesion.rice.edu/NaturalSciences/Smalley/emplibrary/SA285-76.pdf, accessed 1 Dec. 2015.

RS2. NPR Radio Interview with Richard Smalley, August 2000, National Public Radio, 1111 North Capitol Street, NE, Washington, DC 20002.

SB. Sam Bhayani, Robotic Surgery Performed by Sam Bhayani, MD at Barnes-Jewish West County Hospital, http://www.youtube.com/watch?v=5kyGlp3-6Bw, accessed 1 Dec. 2015.

ENDNOTES

80 MF, 7-8.
81 MF, 7.
82 FP (additional material on vasculoids).
83 MF, 8.
84 CP, 26.
85 Co.
86-87 AdW.
88 CP, 28.
89 CP, 26.
90-91 AdW.
92 CP, 26-27.
93 CP, 28.
94 ED, 194.
95 GF.
96 RS1.
97 RB.
98 RS2.
99 RK.
100 CRN.
101 MR.
102 SB, 4:16-4:22.
103 SB, 4:31-4:51.
104 BD.
105 ED, 197.
106 ED, 13.
107 ED, 25.
108 ED, 25.
109 ED, 26.
110 ED, 96.
111 ED, 202.
112 ED, 204.
113 ED, 210.
114 ED, 125.
115 ED, 132; MP.
116 ED, 212.
117 ED, 281.
118 ED, 286.
119 RE.



Estimating and Forecasting Alcor Resource Requirements: Are Cases Random?

By R. Michael Perry, Ph.D.

INTRODUCTION

Alcor is a growing organization and we want to keep up with any demands that might be made on us for cryopreservation and storage services. In particular we need to know how much to expect in the way of occasional, unusually heavy demands and be prepared. For example, how often might we expect to have two or more cryopreservation cases starting in a single day? Or five or more cases in a month? Could we handle the load at such times? Then there are issues connected with long-term storage; how many spare dewars should we should keep on hand, for instance? At the board meeting Jul. 11, 2015 it was requested that I start addressing this problem in a systematic way, including regular reports. Some progress had already been made; for example, Ralph Merkle did an analysis (unpublished) of our resource requirements making a simple assumption about our cases, that they occur essentially at random, yielding a Poisson distribution. (This would be similar to the way atomic disintegrations occur with a radioactive sample, events—disintegrations in this case—are random and uncorrelated with each other.) Unanswered at this point is whether real cases are "random enough" that this assumption can be trusted to tell us what we need to know. (The assumption of randomness could be faulty because members age, unlike radioactive atoms, and for other reasons such as demographic changes in membership over time.) Ralph in email suggested that early in my investigation I try to verify that our cases indeed occur "randomly enough." We could then safely use the assumption of a Poisson distribution (or a binomial distribution to better fit a finite baseline, see below), that is to say, a radioactivity model, as a starting point for projections relating to caseloads and resource requirements.

So how should one test the assumption of randomness? Here I report results with one sort of test, in which the first step was to extract data from records relating to membership totals and occurrences of cases. Results tentatively seem to confirm the radioactivity model, as underscored by similar results obtained with randomly simulated case occurrences. The number of cases per fixed time interval, in the limit of an infinite baseline, fits a Poisson distribution.

An approximately ten-year period was chosen as baseline, from Jan. 1, 2005 through Jan. 26, 2015 (actually a few days longer than ten years, so the "adjusted" baseline would be a whole number of years—see below). Member totals were obtained from board reports, and starting dates of cases from records. It is important to emphasize that cases are a function of member totals; with twice the membership and other factors equal, there should be twice as many cases per unit time interval. (This would fit the radioactivity model, in which the number of disintegrations per time unit is proportional to the sample size.) This expected property was used to resolve a complication in the analysis due to the variability of member totals over time.

Dates of cases were converted to dates that would have occurred had membership totals been constant, set to some particular value (in this case 1,000). This in turn was done, first by assigning a day number on which each case started, counting the start of the time period (1 Jan. 2005) as day 1. So, for instance, a case may have actually started on day 100. Suppose there were 700 Alcor members during this time period, that is, from day 1 through day 100. This means we have one case in 700 x 100 = 70,000 member-days. Now, suppose we had maintained this frequency of case occurrence but there were instead 1,000 members during the time period. The case then would have occurred on day 70. This rationale would also apply if the number of members had varied during the time interval, so long as the sum of the members from day 1 through 100 was still the same, 70,000. (It will be seen that this sort of assumption also is valid under the radioactivity model.) In general, for day n, the constant-membership adjusted day is obtained by taking the sum of the member totals from day 1 through n, dividing by 1,000, and rounding upward to an integer. Member totals in turn were determined by linear interpolation from yearly totals (with expectation that exact totals would not differ much, saving the labor of lengthy records searches. Totals around the end of the time period, after 1 Jan. 2015, were obtained by interpolating between member totals for 1 Jan. and 1 Feb. 2015).

CASES PER YEAR PER 1,000 MEMBERS

With adjusted days of occurrence assigned to patients, we find that the original 10+-year time interval running from day 1

to day 3,684, now shrinks to terminate at (adjusted) day 3,287, a total (within roundoff) of 9 years (dividing number of days by 365.2422 = length of sidereal year in days). During this interval there were 63 cases, giving an estimated 7 cases/year/1,000 members. Using the assigned adjusted days of cases gives the following table, showing patient totals per (adjusted) year and additionally, totals obtained by uniform random placement of the same number of cases in the baseline interval:

Year	Patients	Simulated
1	7	10
2	3	7
3	6	5
4	5	5
5	10	8
6	8	8
7	3	5
8	9	10
9	12	5

Table 1. Actual and randomly simulated occurrence of cases over 9-year baseline interval.

There was an unusual occurrence of actual cases in the last year (12) but overall it appears the incidence of cases is roughly constant with time, again, about 7 per 1000-member year, and randomly distributed. (It remains to be seen whether recent developments will change this statistic, for example, by an influx of members who will soon be needing services. As of writing there have been 5 cases in the approximately a half year since year 9 ended in January.)

CLUSTERS OF CASES

To further test the hypothesis of the radioactivity model of case incidence an analysis was done of the frequency of clusters of cases as a function of time interval length. (Such a study would be important in estimating unusual demand conditions, for example, how often we might expect two cases in one day or five or more in one month.) According to the radioactivity model the incidence would follow a Poisson distribution, in which the likelihood $p(n,t)$ of exactly n cases occurring in a time interval t is

$$p(n,t) = \exp(-ct)\,(ct)^n/n! \qquad (1)$$

where c is the expected number of cases per unit time interval. For the present analysis we assume the derived estimate (above) of 7 cases/year. Since days rather than years are more convenient in considering small numbers of cases, a day rather than a year was used as the unit time interval. This yielded c = 7.000/365.2422 = 0.019166 cases per unit time interval, an adjusted, 1,000-member day, for a total baseline of N = 3,287 days.

Actually the above expression, eq. (1), is exact only in the limit of an infinite baseline ($N \to \infty$). The corresponding expression for finite N (binomial distribution) is

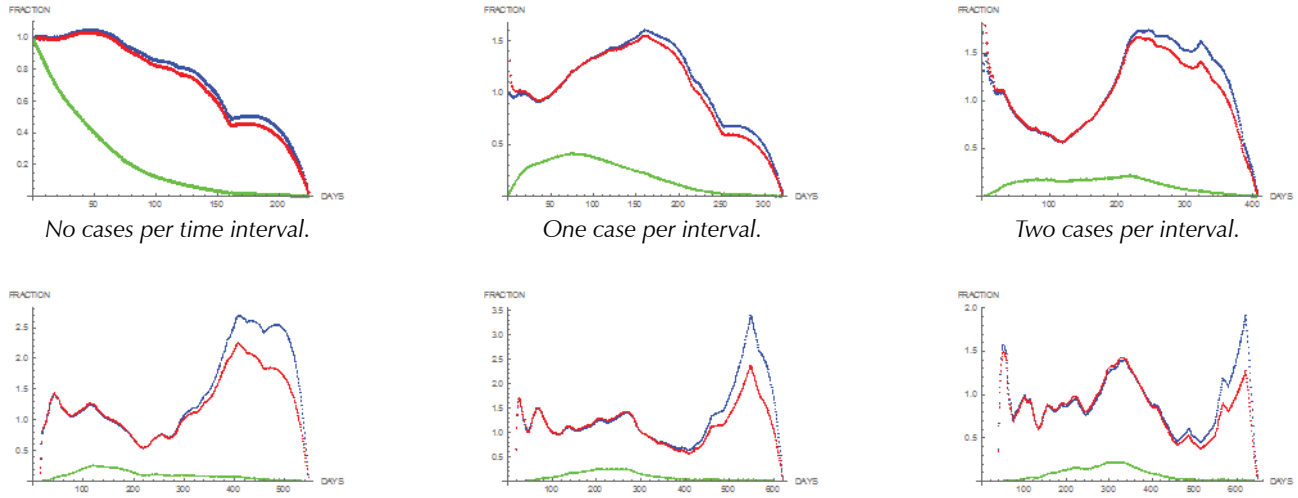
$$p(n,t) = \binom{cN}{n}\left(\frac{N-t}{N}\right)^{cN-n}\left(\frac{t}{N}\right)^n \qquad (2)$$

The analysis had twin goals. First we wanted to determine, from the actual case/member data, what was the frequency of occurrence of n cases for an interval of length t, for appropriate values of n and t. Second, we wanted to compare these experimentally derived quantities with the theoretical predictions given by eq. (1) or eq. (2). (In practice eqs. (1) and (2) did not usually differ greatly in their estimation of probabilities; see below.) In this way we could both get an idea of what to expect in the actual clustering of cases, and also get an idea of how valid is our assumption of a radioactivity model of case occurrence for making future projections of resource needs and the like.

For this study we consider time intervals with numbers of cases n ranging from 0 to 5, for an overall interval from 1 to N = 3,287 adjusted, consecutive days containing 63 cases. For each number of cases n ranges from 0 through 5 and we are interested in how many of the possible t-length intervals contain exactly n cases—the "n-matching intervals." More precisely we would like to know what fraction of all the possible t-length intervals are n-matching intervals. To obtain this latter quantity, which can then be compared with theoretical predictions, eqs. (1) or (2), we divide the number of n-matching intervals by the total number of t-length intervals, which in turn is N-t+1.

The main results are shown in Fig. 1 (completed with the help of Mathematica 10.0.0.0). The green graphs give the fraction of n-matching intervals t, for t, in theory, covering the entire range of possible lengths 1 to N. In practice there were enough cases to preclude very long intervals for any of the tested n-values. On the other hand, very short intervals for more than two cases, which have very low though nonzero expected probability, also were not found, again as expected. Accompanying the green graphs are red and blue graphs showing the experimentally determined frequencies divided by the theoretical prediction given by eq. (1) (red) and eq. (2) (blue). In this instance a constant value of 1 represents a perfect fit between theory and experiment. The actual results certainly do not show this but do appear to show at least a rough confirmation of the radioactivity model. (It will also be seen that the predictions of eqs. (1) and (2) are only slightly different in many instances, rising to somewhat larger differences for more exceptional conditions. Overall the differences do not seem very significant, compared with differences between theory—via either formula—and experiment.) Some of the discrepancy between theory and experiment can be attributed to the small sample size; for instance the actual number of intervals, hence the fraction and the ratios with the predicted values, must drop to zero for some finite interval size, whereas the corresponding predicted values, eqs. (1) or (2), are never zero. It may be that overall the discrepancies can be accounted for in this way, as an artifact of sample size, something that was tested, in a simple way, by simulating a case history by using a uniform random-number generator to pick 63 cases over the baseline used, the (integer) interval [1,3287]. (These simulated cases were also used for Table 1.) Results, fig. 2, seem strikingly similar, overall, to those of the actual experiment, fig. 1. We might be cautiously confident in using the assumption of randomness as a starting point in the estimation of human

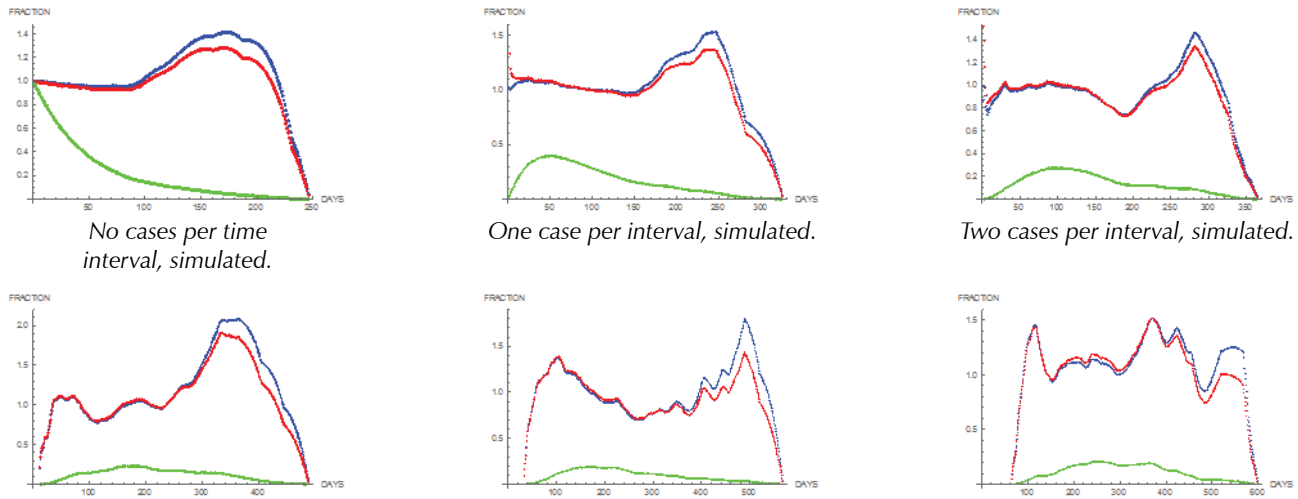
case occurrences, recognizing, of course, that there could be further complications which call for eventual modifications in our model. ■



No cases per time interval. *One case per interval.* *Two cases per interval.*

Three cases per interval. *Four cases per interval.* *Five cases per interval.*

Figure 1. Green graphs show the fraction of time intervals of given length in days (x-axis) having a given number of cryonics cases, for numbers of cases ranging from zero through five. Results are based on 63 Alcor cases occurring 2005 Jan. 1 -2015 Jan. 26 and intervals are adjusted to assume constant total of 1000 members. Red and blue graphs show ratio of experimental data to theoretical predictions via eq. (1) (Poisson distribution, red; infinite baseline) and (2) (binomial distribution, blue; actual baseline), with 1 indicating perfect fit.



No cases per time interval, simulated. *One case per interval, simulated.* *Two cases per interval, simulated.*

Three cases per interval, simulated. *Four cases per interval, simulated.* *Five cases per interval, simulated.*

Figure 2. Similar to figure 1 except with simulated data obtained by random placement of cases in the baseline interval (same simulated data as used for Table 1).

Reference: Andrew Chamberlain, "Deriving the Poisson Distribution from the Binomial Distribution," http://www.the-idea-shop.com/article/216/deriving-the-poisson-distribution-from-the-binomial, accessed 10 Aug. 2015.

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**

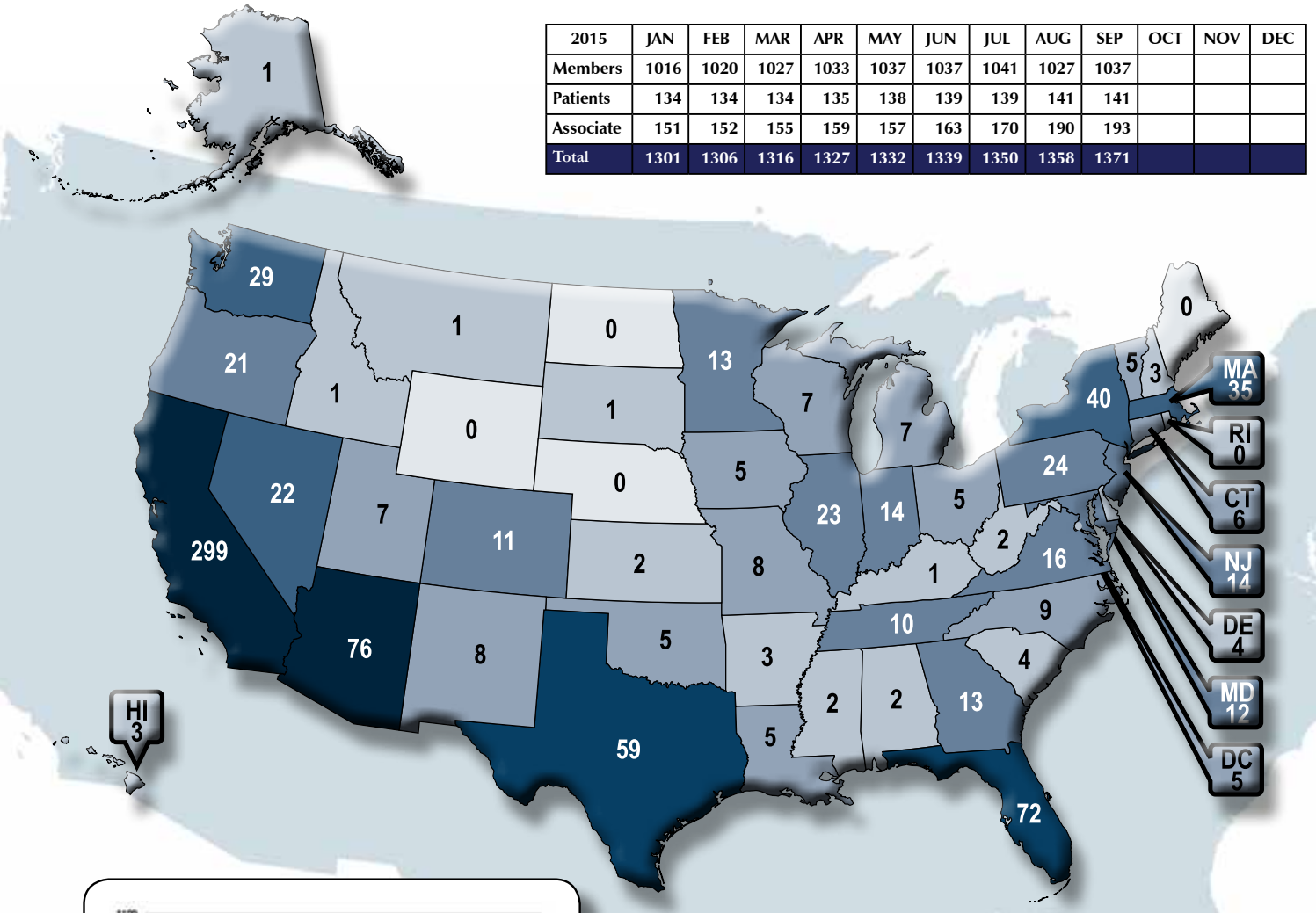
To become an Associate Member send a check or money order ($5/month or $15/quarter or $60 annually) to Alcor Life Extension Foundation, 7895 E. Acoma Dr., Suite 110, Scottsdale, Arizona 85260, or call Marji Klima at (480) 905-1906 ext. 101 with your credit card information.

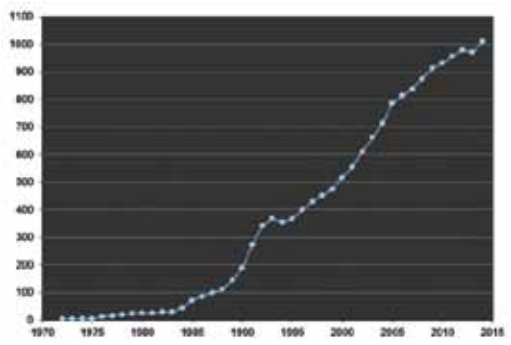
Or you can pay online via PayPal using the following link: http://www.alcor.org/BecomeMember/associate.html (quarterly option is not available this way).

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.

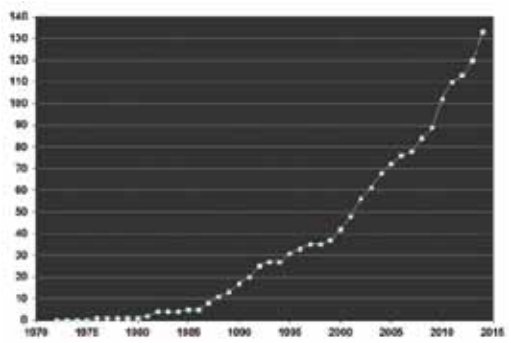
Membership Statistics

2015	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Members	1016	1020	1027	1033	1037	1037	1041	1027	1037			
Patients	134	134	134	135	138	139	139	141	141			
Associate	151	152	155	159	157	163	170	190	193			
Total	1301	1306	1316	1327	1332	1339	1350	1358	1371			





Number of Alcor members



Number of Alcor patients

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

International

Country	Members	Patients
Australia	11	3
Canada	46	2
China	0	1
Germany	8	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	3	1
United Arab Emirates	1	0
United Kingdom	25	2
TOTAL	119	11

Superior-Absorbing CURCUMIN

Item # 00407 Item # 01808

Curcumin has turned into a nutrition **superstar** because of the enormous health-promoting effects it provides for almost every organ system.[1,2]

However, most curcumin extracts are neither well ***absorbed*** nor well retained in the body.

Life Extension®'s curcumin supplements utilize a patented preparation of curcumin that can reach up to **7 times higher** concentration in the blood than standard curcumin![3]

As the graphs on this page illustrate, the **400 mg** of curcumin in either of our formulas supply the body with the equivalent of **2,500 mg** of most commercial curcumin products.

In recent studies comparing the effects of standard curcumin against Life Extension's turmeric extracts, researchers observed:[4,5]

- Nearly twice the support for immune health and approximately **2 times** the support for healthy inflammatory response.
- Almost double the free radical-fighting support. A separate study indicated that curcumin extract provided powerful support for heart health.

References

1. *Nat Sci Biol Med.* 2013 Jan-Jun;4(1):3-7.
2. *Biofactors.* 2013 Jan-Feb;39(1):2-13.
3. *Indian J Pharm Sci.* 2008 Jul-Aug;70(4):445-9.
4. *Int J Pharmacol.* 2009;5(6):333-45.
5. *Food Nutr Res.* 2009;48(3):148-52.
6. *J Med Food.* 2012 Mar;15(3):242-52.
7. *Cancer Chemother Pharmacol.* 2007;60:171-7.
8. Bioavailability study of BCM-95® in rats. Orcas International Inc.

TWO CURCUMIN FORMULAS TO CHOOSE FROM

Those who want a curcumin standalone can order a bottle of 60 vegetarian capsules of **Super Bio-Curcumin®** (Item #00407) for $38. If a customer buys four bottles, during **Super Sale** the price is reduced to **$23.63** per bottle. Each bottle lasts a typical user two months.

Those seeking additional support against cell changes that promote prolonged functional inflammatory response may choose **Advanced Bio-Curcumin® With Ginger & Turmerones**.

While both of these formulas provide the superior ***absorbing*** curcumin, **Advanced Bio-Curcumin® With Ginger & Turmerones** also contains:

- ***Turmerones*** to increase the amount of curcumin inside cells.[6]
- ***Ginger***, which provides complementary health benefits.
- ***Phospholipids*** that further enhance absorption.[7]

A bottle of 30 softgels of **Advanced Bio-Curcumin® With Ginger & Turmerones** (Item #01808) retails for $30. **Super Sale** price is reduced to **$20.25** per bottle. The suggested dose for either of these highly ***absorbable*** curcumin supplements is one capsule daily.

CAUTION: Do not take if you have gallbladder problems or gallstones. If you are taking anticoagulant or antiplatelet medications, or have a bleeding disorder, consult your healthcare provider before taking this product.

Compared with Plant-Bound Curcumin with Piperine[3]

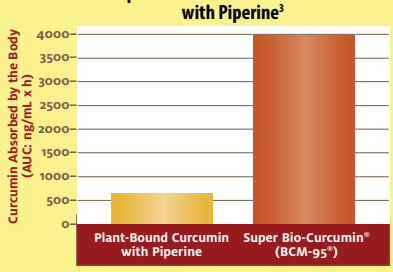


Chart 1. Super Bio-Curcumin® showed 6.3 times greater bioavailability (absorption and sustainability over eight hours) in humans compared with plantbound curcumin with piperine (as measured by the area under the curve [AUC] in a plot of blood levels against time, that is, the total amount of curcumin absorbed by the body over eight hours).

Absorption of Super Bio-Curcumin® in Humans Compared with Conventional Curcumin[3]

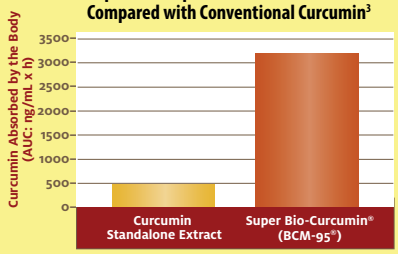


Chart 2. Super Bio-Curcumin® showed 6.9 times greater bioavailability (absorption and sustainability over eight hours) in humans compared with conventional curcumin (as measured by the area under the curve [AUC] in a plot of blood levels against time, that is, the total amount of curcumin absorbed by the body over eight hours).

Absorption of Super Bio-Curcumin® in Rats Compared with Conventional Curcumin[8]

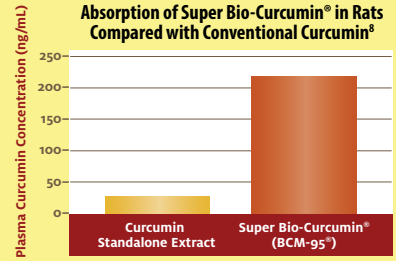


Chart 3. Bioavailability in rats fed with 7.8 times higher than conventional curcumin.

Call toll-free 1-800-544-4440 to speak to a live operator (24 hours) or visit www.LifeExtension.com.

502.62L A3 1115

RNA-Based Drugs Give More Control Over Gene Editing

In just the past few years, researchers have found a way to use a naturally occurring bacterial system known as CRISPR/Cas9 to inactivate or correct specific genes in any organism. CRISPR/Cas9 gene editing activity runs continuously, though, leading to risk of additional editing at unwanted sites. Now, researchers at University of California, San Diego School of Medicine, Ludwig Cancer Research and Isis Pharmaceuticals demonstrate a commercially feasible way to use RNA to turn the CRISPR-Cas9 system on and off as desired—permanently editing a gene, but only temporarily activating CRISPR-Cas9. The study is published Nov. 16 by *Proceedings of the National Academy of Sciences*. "These findings provide a platform for multiple therapeutic applications, especially for nervous system diseases, using successive application of designer CRISPR RNA drugs," said senior author Don Cleveland, PhD. The new approach introduces chemically modified, RNA-based drugs to transiently activate the CRISPR/Cas9 gene editing system.

UC San Diego Health / Heather Buschman, PhD
16 Nov. 2015
https://health.ucsd.edu/news/releases/Pages/2015-11-16-RNA-Based-Drugs-Give-More-Control-Over-Gene-Editing.aspx

China's Bold Push into Genetically Customized Animals

China's western Shaanxi Province is known for rugged windswept terrain and its coal and wool, but not necessarily its science. Yet at the Shaanxi Provincial Engineering and Technology Research Center for Shaanbei Cashmere Goats, scientists have just created a new kind of goat, with bigger muscles and longer hair than normal. The goats were made not by breeding but by directly manipulating animal DNA—a sign of how rapidly China has embraced a global gene-changing revolution. Geneticist Lei Qu wants to increase goatherd incomes by boosting how much meat and wool each animal produces. For years research projects at his lab in Yulin, a former garrison town along the Great Wall, stumbled along, Qu's colleagues say. "The results were not so obvious, although we had worked so many years," his research assistant, Haijing Zhu, wrote in an e-mail. That changed when the researchers adopted the new gene-customizing technology called CRISPR–Cas9, a technique developed in the U.S. about three years ago. CRISPR uses enzymes to precisely locate and snip out segments of DNA.

Scientific American / Christina Larsen
17 Nov. 2015
http://www.scientificamerican.com/article/china-s-bold-push-into-genetically-customized-animals/

Tracking Single Molecules in 3D with Nanoscale Accuracy

An innovative approach to calibrating high-tech microscopes enables researchers to track the movement of single molecules in 3D at the nanoscale. A Stanford University research team, led by W. E. Moerner, extends the work that earned Moerner and colleagues Eric Betzig and Stefan W. Hell the 2014 Nobel Prize for Chemistry. Betzig and Moerner pioneered the development of super-resolution imaging, which broke the diffraction limit of optical microscopy by using the fluorescence of single molecules for the first time. The new work, published in the Optical Society's high impact journal *Optica*, demonstrates a marked improvement in the accuracy of this imaging technique and for tracking molecules in three dimensions. Tracking how molecules move, form shapes and interact within the body's cells and neurons offers a powerful new view of key biological processes such as signaling, cell division and neuron communication, all of which impact people's health and susceptibility to disease. Super-resolution microscopy uses lasers to excite fluorescence from single molecules.

Optical Society of America
27 Nov. 2015
http://www.osa.org/en-us/about_osa/newsroom/news_releases/2015/breakthrough_allows_tracking_of_single_molecules_i/

3-D Imaging Becomes 1,000 Times Better

MIT researchers have shown that by exploiting the polarization of light — the physical phenomenon behind polarized sunglasses and most 3-D movie systems — they can increase the resolution of conventional 3-D imaging devices as much as 1,000 times. The technique could lead to high-quality 3-D cameras built into cellphones, and perhaps to the ability to snap a photo of an object and then use a 3-D printer to produce a replica. Further out, the work could also abet the development of driverless cars. "Today, they can miniaturize 3-D cameras to fit on cellphones," says Achuta Kadambi, a PhD student in the MIT Media Lab and one of the system's developers. "But they make compromises to the 3-D sensing, leading to very coarse recovery of geometry. That's a natural application for polarization, because you can still use a low-quality sensor, and adding a polarizing filter gives you something that's better than many machine-shop laser scanners."

MIT News / Larry Hardesty
1 Dec. 2015
http://news.mit.edu/2015/algorithms-boost-3-d-imaging-resolution-1000-times-1201

Ethicists Square Off over Editing Genes in Human Embryos

Debate over the use of powerful new gene editing tools in human eggs, sperm and embryos grew heated December 1 as scientists and ethicists gathered at an international summit to discuss the technology, which has the power to change the DNA of unborn children. Several groups have already called for restrictions on use of the technology known as CRISPR-Cas9, which has opened up new frontiers in genetic medicine because of its ability to modify genes quickly and efficiently. But John Harris, a professor of bioethics at the University of Manchester in Britain, argued strongly in favor of the technology. "We all have an inescapable moral duty: To continue with scientific investigation to the point at which we can make a rational choice. We are not yet at that point. It seems to me, consideration of a moratorium is the wrong course. Research is necessary," Harris said. Opponents worry about unknown effects on future generations and the temptation for future parents to pay for genetic enhancements such as greater intelligence or athletic ability.

NewsDaily / Reuters / Julie Steenhuysen
1 Dec. 2015
http://newsdaily.com/2015/12/ethicists-square-off-over-editing-genes-in-human-embryos/

Fast DNA-Based Motor Holds Potential for Disease Diagnostics

Physical chemists have devised a rolling DNA-based motor that's 1,000 times faster than any other synthetic DNA motor, giving it potential for real-world applications, such as disease diagnostics. *Nature Nanotechnology* is publishing the finding. "Unlike other synthetic DNA-based motors, which use legs to 'walk' like tiny robots, ours is the first rolling DNA motor, making it far faster and more robust," says Khalid Salaita, the Emory University chemist who led the research. "It's like the biological equivalent of the invention of the wheel for the field of DNA machines." The speed of the new DNA-based motor, which is powered by ribonuclease H, means a simple smart phone microscope can capture its motion through video. The researchers have filed an invention disclosure patent for the concept of using the particle motion of their rolling molecular motor as a sensor for everything from a single DNA mutation in a biological sample to heavy metals in water. "Our method offers a way of doing low-cost, low-tech diagnostics in settings with limited resources," Salaita says.

ScienceDaily / Emory Health Sciences
1 Dec. 2015
www.sciencedaily.com/releases/2015/12/151201152310.htm

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.

Greg 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 de Wolf (now Phaedra), **"Reconstructive Connectomics,"** *Cryonics* 34:7 (July 2013), 26-28.

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 first 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/.

BRITISH COLUMBIA (CANADA):

The contact person for meetings in the Vancouver area is Keegan Macintosh: keegan.macintosh@me.com.

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

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.

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(at)yahoo.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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