Independent Cryonics Educators Program

2.3: The justification of cryonics

In the first section, we looked at three ideas that are essential to understanding cryonics: the real nature of death; the power of cold; and the projection of future repair and revival capabilities. In this section, we consider three facts that justify the practice of cryonics:

1. Cells and organisms need not operate continuously to remain alive.
2. Current cryopreservation techniques can preserve the fine structure of the brain.
3. We can foresee feasible future technologies capable of biological repair and revival.

Continuous operation unnecessary

Cells and organisms need not operate continuously to remain alive or to return to life from a dormant state. The extremophile tardigrade known as the water bear can tolerate complete arrest of its normal metabolism. Other large animals have survived three hours of cardiac arrest near 0 °C. The use of general anesthesia and therapeutic hypothermic circulatory arrest in medicine demonstrates that humans can be cooled to hypothermic temperatures (as low as +18 °C) with stoppage of brain electrical activity and can be recovered with no adverse neurological consequences.

Consider what happens in organ donation. The person is declared clinically and legally dead, sometimes with no blood circulation for a short time. Yet living organs are harvested and transported to make it possible for another person to go on living. When those organs are removed from donors, they have only minutes to live after cessation of blood supply. By using special preservation solution and cooling, organs can survive for hours.

Deep cooling slows some biological processes but completely stops others. Brain electrical activity usually ceases at temperatures below +18 °C (64 °F) and disappears completely in all cases as freezing temperatures are approached. These temperatures can still be survived. Humans have recovered from temperatures as low as +9 °C.

Brain electrical activity has been detected in animals rewarmed after seven years of frozen storage. The below-freezing rat and hamster resuscitation studies of Audrey Smith and Radoslav Andjus also support the idea that brains can be cooled to subzero temperatures and restored to functionality. In the late 1990s, rat hippocampal slices

were vitrified and then recovered from -130 °C without loss of viability and with excellent ultrastructural preservation.

The fine structure of the brain can be preserved

Although electrical activity in the brain is necessary for consciousness, it is not necessary for preservation of long-term memories and other aspects of personality. We know for certain since neuro-electrical activity ceases during deep hypothermia, interrupted blood circulation, and certain types of coma that people have recovered from. The pattern of electrical activity when a brain is active is determined by its underlying structure – the ways that neurons are connected as well as the physical state of the neurons. So long as the brain's physical structure is preserved, the potential for consciousness is maintained.

Cell bodies, cell membranes, synapses, mitochondria, general axon and dendrite patterns, metabolites such as neurotransmitters, chemical constituents such as proteins and nucleic acids, and general brain architecture are preserved reasonably well or excellently with current techniques.

We have several lines of evidence for believing that the microstructure of the brain is preserved through cryonics– at least under reasonably good conditions. On a relatively crude level, CT scans show how well a particular individual's brain has been protected against ice formation. Ice will damage cell membranes but does not destroy neurons. Sufficient structure may well exist even in frozen brains. When brains are protected against ice formation through partial or complete vitrification, damage is massively reduced. We can then expect good preservation of brain structure.

We can infer much from the common observation of a high level of functional recovery of frozen-thawed brains, brain tissue, or brain cells which depends on a high degree of both local and long-range ultrastructural integrity. Robust preservation has almost always been found whenever either brain structure or brain function has been evaluated after freezing to low temperatures and thawing. In some cases, good preservation has been documented in the complete absence of vitrification or cryoprotection.

Electron micrograph (EM) studies of vitrified neural tissue as well as vitrified rabbit kidney show remarkably good preservation of tissue ultrastructure. A 2004 study showed no ice damage in a vitrified rabbit brain. A 2016 study showed images of rabbit brain structure indistinguishable from controls when a chemical fixative was used before vitrification. Another study found that nematodes could not only be revived after cryopreservation but also demonstrated retention of imprinting memory of tasks learned before cryopreservation. The evidence in favor of preservation of brain microstructure through cryopreservation continues to grow.

Feasible future technologies capable of biological repair and revival

Memory and personality do not depend on continuous operation of the brain. The person remains potentially viable so long as the relevant neural structures are preserved. What remains is to plausibly envision a means of eventually being able to repair the damage of the dying process and any additional damage from the cryopreservation process and then revive patients.

Early on in cryonics, the argument for eventual future repair and revival was more speculative. However, speculative does not mean unsupported. The core argument was that:

- repair of cryopreserved patients requires technologies far more advanced than today's but those technologies violate no physical laws
- given enough time, technology will advance far enough to enable repair and revival
- cryopreservation provides the time necessary for technology to advance

For many cases – including those who are preserved within the capability of current cryoprotectants – we will need the ability to repair cells at the molecular level before revival of cryonics cases can take place. Cell repair is likely to be applied in four ways:

1. Treatment of the disease or insult that prompted the cryopreservation of the patient.

2. Repair of ischemic injury resulting from delays between pronouncement of legal death and the start of cryonics stabilization procedures.

3. Repair of damage incurred during the cryopreservation process itself.

4. Reversal of the aging process and associated co-morbidities.

The technical feasibility of cryonics does not depend exclusively on a particular conception of cell repair technologies. The **biological approach** to cell repair notes that evolution demonstrates the technical feasibility of manipulation of matter at the molecular level. Bio-nanotechnology aims to harness, modify, and guide biomolecules to accomplish new tasks.

The **mechanosynthesis** (or deterministic nanotechnology) **approach** instead directs molecules towards desired configurations through the use of mechanical means, as opposed to chemosynthesis which involves the interaction of molecules through random motion in an aqueous medium.

Whatever specific approach ends up being used, such technology could repair and/or regenerate every cell and tissue in the body if necessary. Technology of this kind will mean that any patient retaining inferable brain structure (the physical basis of their mind) will be viable and recoverable.

This is the argument for why cryonics should work, even though it is not reversible today.

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References and Further reading

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Next: 2.4: Cryonics vs. suspended animation

ICE Program

Part I: ICE: Why is it important.

Part 2: Introduction to cryonics

Part 3: Procedural aspects

Part 4: Technical aspects

Part 5: Science

Part 6: Membership

Part 7: Concerns about cryonics

Part 8: Philosophical and ethical issues

Part 9: Cultural, religious, and social issues
