A Personal Preservation Method

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Abstract. A method of personal preservation would enable individuals to suspend their existence at a time of their choosing, then continue that existence in the future, provided suitable decoding technology is eventually created. Previous attempts at personal preservation methods fail to adequately preserve synaptic connections in a clearly traceable manner, leaving the future information-theoretic decodability of neural data uncertain. We present a new method of personal preservation which solves the *preservation fidelity problem*: perfusion delivery of aldehyde crosslinking agents within twelve minutes post-mortem, followed by perfusion cryoprotection and cold storage. Information-theoretic decodability is achieved by mapping all clinically distinct individuals to physically distinct preserved artifacts through morphological preservation of greater than 99.99% of all synapses and retention of virtually all cellular proteins larger than 50 kDa throughout the individual's body. Correct application of preservation can be verified at time of preservation by CT imaging followed by needle biopsy and nanoscale verification of synaptic integrity. Preserved individuals can be stored for years at room temperature, centuries at -32°C, and for geologic time below -122°C.

Introduction.

Current options for end-of-life treatment include hospice care, voluntary cessation of eating and drinking, medical aid in dying, or euthanasia, none of which address core personal issues of destruction of memory and future agency. At a societal level, long-term projects whose timescales are longer than an individual human lifetime are hampered by the *generational principal-agent problem*: any long-term project expected to take longer than a human lifetime is definitionally undertaken by people who expect to benefit from the project only indirectly. Writing, religion, companies, children, and education address these problems to a limited extent, but no mechanism exists for an individual to personally experience the results of their very-long-term projects.

What is needed is a method of personal preservation sufficient to enable information-theoretic decoding of an individual at a later date. Such a technology would immediately expand individual planning time horizons beyond a single human lifespan, with obvious societal and personal benefits. In this paper we introduce a personal preservation method using rapid post-mortem aldehyde perfusion fixation and cold storage. Information-theoretic preservation is achieved through comprehensive preservation of approximately all quadrillion synaptic connections in a traceable state, stabilization of body-wide cellular morphology, and retention of virtually all proteins and nucleic acids.

Preservation method.

1) (24 hours before preservation) blood sample taken and preserved at -196°C for long-term storage. Client begins taking anticoagulant medication.
2) (10-30 minutes before MAiD medication) sufficient anticoagulant to achieve an activated clotting time greater than 5 minutes is self-administered by the client.
3) Client consumes medical aid-in-dying (MAiD) medication.
4) (~4 minutes post-MAiD) client becomes unconscious, and is moved to a suitable surgical suite for preservation surgery.
5) (approx 10-20 minutes post-MAiD) legal death (LD) declared by the attending physician.
6) (immediately after LD) surgery begins.
7) (~4 minutes after LD) surgery complete, perfusion of washout begins at physiological pressure.
8) (~8 minutes post-LD) perfusion of fixative solution begins.
9) (~1 hour post-LD) slow ramp of cryoprotectant-fixative solution begins. Cryoprotectant introduction is continuously adjusted using in-line refractive index measurements to achieve a smooth increase from 0% w/v cryoprotectant to the final cryoprotectant concentration over ~8 hours.
10) (~9 hours post-LD) perfusion ends.
11) (~9.5 hours post-LD) needle biopsy taken from the brain for nanoscale imaging. Whole-brain CT imaging completed.
12) (weeks post-perfusion) funerary rites as desired by the client/family performed. Imaging results sent for third-party quality review.
13) (within one month of perfusion) client's body is placed in cold long-term storage.

Washout solution

$Na_2HPO_4 \cdot 2H_2O$	14.65	g/L
$NaH_2PO_4 \cdot 2H_2O$	2.76	g/L
Sodium azide	0.1	w/v%

Fixative solution

$Na_2HPO_4 \cdot 2H_2O$	14.65	g/L
$NaH_2PO_4 \cdot 2H_2O$	2.76	g/L
Glutaraldehyde	3.0	w/v%
Sodium dodecyl sulfate	0.01	w/v%

Cryoprotectant solution

$Na_2HPO_4 \cdot 2H_2O$	14.65	g/L
$NaH_2PO_4 \cdot 2H_2O$	2.76	g/L
Glutaraldehyde	3.0	w/v%
Ethylene Glycol	65.5	w/v%

Sodium azide is a fast cytochrome-c oxidase inhibitor and is used in the washout solution to prevent respiration-mediated autolysis as well as to allow for long-term storage of washout at room temperature. Sodium dodecyl sulfate is used in the fixative solution to permeabilize the blood-brain barrier and allow for perfusion of cryoprotectant without geometric distortion (Song 2015). All solutions are maintained at 20°C and all fluids delivered to the client are filtered with a high-capacity sterile filter.

We have determined through extensive experimentation with rat, pig, and human models that there is a critical window of 12 minutes post-LD in which perfusion of washout solution must be started to ensure adequate preservation (Song 2026).

Information-theoretic adequacy.

We consider *long-term memory* to be any durable psychological change in a person which lasts more than 24 hours and can be internally or externally observed. This broad sense of memory encompasses episodic memories as well as preferences, skills, and behaviors, and chronic mood and personality states. Long-term memory persists through electrocerebral silence during deep hypothermic circulatory arrest in clinical procedures (Mizrahi 1989) and disruption of extracellular space and complete neuronal depolarization during global ischemia (Raichle 1983), and therefore must be durably encoded in the physical structure of an individual.

We take the following key assumption from neuroscience: **that any change to a person's long-term memories is reflected in a corresponding change to their synaptic structure**, such that two people cannot have different long-term memories but the same synaptic structure (Takeuchi 2014). We call this the *synaptic correspondence assumption*.

Aldehyde fixation retains virtually all proteins, nucleic acids, and lipids near their original positions during life (Griffiths 2012, Ostasiewicz 2010). Aldehyde fixation neither creates nor destroys synapses (El Boustani 2018), but retains their structure and connectivity causing only minor physical transformations (Korogod 2015), which also occur during global ischamia from which full neurological recovery is possible (Raichle 1983), thus preserving synaptic distinctness. Cryoprotection after initial fixation does not further alter the geometry or connectivity of synapses compared to fixation without cryoprotection (Song 2015).

Since aldehyde fixation preserves sub-synaptic details and therefore synaptic structure as a consequence, our personal preservation protocol injectively maps synaptically distinct individuals to physically distinct preserved artifacts. Given the synaptic correspondence assumption, our preservation protocol must also injectively map distinct long-term memory states to preserved artifacts. Therefore, personal preservation archives the information contained in a person's long-term memories for future retrieval.

Preservation of our broad definition of long-term memory leaves open the possibility of future decoding and recreation of a preserved individual in simulation, or molecular reversal of crosslinks and biological revival. As such, personal preservation not only transmits detailed personal information to the future, but offers a method of personal survival.

Storage.

Preserved bodies can be stored at a temperature above the freezing point of ethylene glycol / water mixtures without risk of ice formation, which at our final target concentration of 65% w/v ethylene glycol is around -40°C (Cordray 1996). We have determined using differential scanning calorimetry that the glass transition temperature for our cryoprotectant mixture is around -122°C. Preserved tissue can survive incidental cooling and rewarming between -32°C and -122°C with no crystal formation given the cryoprotectant's tendency to supercool. In the vitrified state below -122°C, biological time is effectively arrested enabling storage for geologic time.

We have successfully stored preserved brain samples at 60°C for one month with no loss in synaptic traceability as determined by volume electron microscopy. As a rough approximation—assuming first-order kinetics, a biologically conservative enthalpy of activation of 60 kJ/mol, and ignoring e.g. lipid phase transitions at 10°C—one month of lossless storage at 60°C is comparable to approximately 326 years of lossless storage at the target temperature of -32°C.

Protein retention alone is adequate to maintain synaptic distinctiveness (Tavakoli 2024). Fixation inhibits endogenous peptolytic enzymes leaving hydrolysis as the main route of decay. Conservatively treating each peptide bond as if it were fully accessible to surrounding water molecules and assuming degradation via non-catalytic hydrolysis with an average enthalpy of activation of 96 kJ/mol yields an expected half-life of 350 years per peptide bond at 25°C (Radzicka 1996). At -32°C we can expect a half-life of approximately 2.3 million years per peptide bond with an expected survival of > 99.99% of all peptide bonds after 300 years of storage, again assuming first order kinetics and a simplistic Arrhenius extrapolation.

Because of the stability of preserved tissue at room temperature it is possible to observe a wide variety of traditional funeral rites before long-term storage with no compromise of preservation fidelity.

Verification.

Our goal is to acquire adequate evidence at the time of preservation that approximately all synapses were preserved in a traceable state, without causing damage during sampling that would be clinically relevant in a living client. To satisfy these constraints we propose brain-wide imaging via CT and nanoscale imaging of a small brain sample acquired via needle biopsy.

We propose to acquire CT datasets of pig and donated human brains preserved under a variety of fixative delivery schedules, then dissect and extensively image those brains to establish an adequate preservative delivery schedule for each brain region. If CT data from a preservation indicates that for each region of brain tissue, preservative chemicals were delivered within the bounds of this schedule, this will imply that each synapse was well-preserved without need for extensive dissection.

To obtain direct confirmation of nanoscale integrity, we propose a post-preservation frameless stereotaxic needle biopsy be taken and volume electron microscopy performed on the resulting sample. Needle biopsy is routine and does not cause clinically-relevant brain damage. Together these imaging modalities can establish nanoscale preservation throughout the brain.

Conclusion.

We have proposed a system for preserving an individual such that they remain information-theoretically accessible to future decoding technologies. Our method, which is essentially a high-quality form of embalming, achieves information theoretic adequacy by transforming individuals into preserved artifacts and maintaining a one-to-one correspondence between clinically distinct initial states and physically distinct preserved states. Individual preservation quality can be verified by third parties via review of whole-brain CT and nanoscale images of tissue extracted by post-mortem needle biopsy. Preserved individuals can be stored for at least years at room temperature, centuries at -32°C, and for geologic time below -122°C.

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