



## Open Letter to the Medical, Scientific, and Government Communities Regarding Brain Preservation

We, the undersigned, hereby publicly profess our human right to undergo a high-quality elective chemical brain preservation procedure immediately upon our physical death, and demand that such a procedure be made legal and accessible *within the existing medical system* in our countries of residence. We further demand that if medical evidence exists that an individual's brain is being substantially damaged by Alzheimer's, tumors, or other disease processes that elective brain preservation be available *prior* to that individual's natural death.

We profess this right because we realize that sooner or later we will contract an illness for which current medical practice is insufficient to prevent our death. At which time, instead of simply allowing the natural decay process to proceed, we should have the option to have the exact structure of our brain's neuronal circuits immediately preserved by the best means possible, which by today's laboratory standards is rapid glutaraldehyde fixation (via vascular perfusion) followed by further chemical fixation and embedding in plastic for long-term storage.

We choose brain preservation over natural decay because we accept the current scientific consensus that our unique conscious self is generated by processes within our physical brain. Further, we accept that all the memories, skills, and personality traits that make us unique are *hardwired* into the physical and molecular connections among our brain's hundred billion neurons. Such a structural basis of memory and personality is demonstrated by the fact that surgical patients are often put into a state of Profound Hypothermia and Circulatory Arrest (PHCA) in which all patterned brain activity is halted for up to a full hour, yet these patients revive with memory and personality completely intact. The structural basis of memory and personality – the synaptic connectivity between neurons – can be preserved essentially perfectly by today's chemical fixation and plastic embedding techniques. Extrapolating from current technologies for the nano-imaging of plastic embedded brain tissue, we believe that one day science will have advanced sufficiently to allow complete retrieval of memories from such a preserved brain. Thus, to us, brain preservation is a way to prevent the permanent loss of our uniqueness and a way to pass this uniqueness on to future generations.

As individuals, we are motivated to profess this right to a high quality brain preservation for reasons which may include, but are not limited to, the following:

- a. To leave behind personal memories and experiences for potential use by future society (history, anthropology, tradition, science).
- b. To leave behind memories and experiences to create richer and more meaningful personal histories and personality simulations for our descendants (genealogy, heritage, digital aids to family and loved ones).
- c. To attempt repair and re-integration of our preserved brain, or some reproduction of it, into a future biological, robotic, or virtual body to continue life experience.
- d. To attempt high-resolution scanning and computer simulation of our preserved brain for uploading into a robotic or virtual body to continue life experience.

As the last two points illustrate, our acceptance of modern neuroscience and our faith in the continued advancement of technology have led us to the conclusion that a high quality chemical brain preservation offers a real chance for personal survival when all other existing medical interventions have failed. We consider the future repair of our preserved brain and/or the future high-resolution scanning and simulation of our preserved brain to be scientifically plausible means of overcoming personal death and reaching the distant future. To us then, this is literally a professing of our *inherent right to life*.

## **High-quality brain preservation as a universal human right**

To expand on this, as citizens of the free world we believe we have an individual, unalienable right to life as proclaimed in the United States Declaration of Independence (1776), the United Nations Universal Declaration of Human Rights (1948), and the European Convention on Human Rights (1953). In most modern societies this right has been interpreted to include the right to immediate emergency medical care when possible and the associated rules and regulations regarding its proper application by licensed professionals in hospitals. Just as a person undergoing cardiac arrest in a hospital has the right to immediate cardiopulmonary resuscitation (CPR) and electrical defibrillation by well trained medical staff, we believe a person who does not respond to such resuscitation attempts should have a similar right to an equally immediate Emergency Glutaraldehyde Perfusion (EGP) procedure. Such an EGP procedure is proven to quickly halt the decay processes which if left unchecked would rapidly destroy the person's neural circuitry.

We fully appreciate the fact that perfusion of such *toxic* fixatives into a person's blood stream ensures death by today's standards, and that the further chemical fixation and plastic embedding steps involved in preserving the brain's fine structure for long-term storage seemingly serve only to move the individual further from the traditional image of a living person (the end result being a completely inert block of plastic

containing a “perfect fossil” of the person’s brain circuitry). We insist however that this inert block of plastic-embedded brain tissue be given rights as a “suspended” human being. As discussed above, during surgical procedures employing PHCA the patient is equally inert and ‘dead’ by all colloquial standards. For up to a full hour, a PHCA patient is cold, not breathing, their heart and circulation is stopped, and their brain’s activity halted. However, a person in such a state in an operating room today is not devoid of rights because of the *potential* that they might be revived from this state, something that has been demonstrated again and again since the procedure was first employed in the 1950’s (e.g. Sullivan 1999). We are simply asking that the same rights be conferred onto a chemically-fixed and plastic embedded brain, and for the same reason – because the person may be revived again.

We do not claim this possibility of revival out of ignorance of the relevant science; on the contrary we claim this possibility because it is essentially a direct corollary of the central tenet of modern cognitive and neural science– that our mind (our unique conscious self) is solely a product of the functioning of the physical brain (e.g. Kandel et al. 2000, Anderson 2007). The modern scientific understanding of the human mind is that it is a pattern of information processing that is fully determined by the physical and molecular connections between neurons as well as their internal functional properties. Today’s chemical fixation and plastic embedding techniques are proven to preserve the precise structure of neurons and their synaptic connections down to the nanometer level, and the aldehyde bonding employed fixes in place ion channel and receptor membrane proteins yet does not destroy their amino acid sequence – thus the very proteins that are key to determining a neuron’s or synapse’s functional properties are well preserved in their original positions by today’s techniques (e.g. Hayat 2000).

Similarly, we do not claim this possibility of revival out of blind irrational faith in future technology; on the contrary, the techniques necessary for revival already have precursors today. The last few years have seen the development of new automated techniques for imaging the 3D synaptic connectivity of plastic-embedded brain tissue at the nanometer level (Denk & Horstman 2004; Hayworth et al. 2006; Knott et al. 2008), and plans are underway at several institutions to scale these techniques up to map entire mammalian brains. We have also recently seen the first truly large-scale, biologically-realistic simulations of brain networks (Markram 2006). These advances and others suggest that in the relatively near future a brain preserved in plastic by today’s best techniques will be able to be completely scanned at the nanometer level and the resulting neural connectivity uploaded into a computer simulation controlling a robotic or virtual body (Sandberg & Bostrom 2008). In this way, the same unique pattern of information processing that was present in the original biological brain will again be dynamically controlling a body – that is, the original person’s conscious self will again be awake and alive and interacting with the world.

## **Responsibility of the Medical, Scientific, and Government Communities**

As described above, we believe that the development and deployment of a reliable high-quality brain preservation procedure in hospitals has the potential to save thousands, perhaps millions of lives. If we or one of our loved ones is faced with imminent death in the near future, we want the real opportunity to choose such a brain preservation procedure. Unfortunately we are currently being denied this choice because of the indifference and inaction of the general scientific and medical communities, and by direct legal blockage by governmental laws. The central purpose of this Open Letter is to help rectify this situation by educating the relevant parties about the potential of brain preservation to prevent permanent death, and by reminding these parties of their particular responsibilities in developing and deploying such a brain preservation procedure within in the existing regulated medical system. The listing of our signatures on this Open Letter is meant to reinforce the urgency for such action, for until such a high quality preservation procedure is deployed in hospitals our right to life is not being upheld.

### **Responsibility of the scientific community:**

Over the last five decades biological scientists have developed extremely effective chemical preservation and plastic embedding protocols to preserve tissue for imaging in electron microscopes at the nanometer and even sub-nanometer level, as well as to allow molecular imaging with antibody labeling etc. Much of what we understand about how the brain's circuits underlie its functioning is owed to these preservation techniques. But the development of these techniques has so far been driven solely by pure research interests – no serious work has been performed to optimize tissue preservation protocols for use on volumes the size of a whole human brain. The open literature is clear that preservation of neuronal structure across an entire human brain is possible if chemicals are perfused directly through the vascular system (e.g., Palay 1962) yet a rigorous demonstration of such a feat has yet to be performed on a large mammalian brain. We believe it is the responsibility of the scientific and medical research community to perfect such a whole brain ultrastructure preservation technique and to verify it by performing comprehensive electron microscopic surveys across the whole preserved brain.

### **Responsibility of the medical community:**

If, in a laboratory setting, the brain tissue of a mouse is to be imaged at a fine enough level of detail to trace its neuronal circuits, great care is taken to ensure that glutaraldehyde is perfused into the heart *immediately* after the animal is sacrificed; in fact, it is considered best practice to perfuse into the still beating heart. A sufficiently high concentration of fixative must reach every cell in the brain in order to prevent subsequent decay and destruction. This will not succeed if the blood vessels of the brain are blocked or damaged, something which can occur quickly after clinical death. As such, the initial glutaraldehyde perfusion step in a brain preservation procedure must be considered an emergency surgical procedure demanding as rapid a response as CPR and defibrillation. We believe it is the medical community's responsibility to develop an absolutely reliable and repeatable Emergency Glutaraldehyde

Perfusion (EGP) procedure that ensures rapid and complete perfusion throughout a patient's brain. Such a surgical protocol may employ a variety of diagnostic tests (for example x-ray or MRI imaging) to verify that fixative has reached all parts of the brain, and may employ special measures including open skull surgical interventions if this is not initially achieved (as may occur, for example, in patients with pre-existing vascular damage). Once developed, it is the medical community's responsibility to train physicians in its proper and timely application and to make sure that it is available in all hospitals.

In concert with the above EGP procedure, the medical and scientific communities must immediately begin the development and deployment of a standardized, high quality Whole-Brain Plastic Embedding (WBPE) procedure which further processes a glutaraldehyde perfused brain into a state suitable for long-term (>100 years) storage. This would involve further perfusion of the brain with a fixative for lipids (e.g. osmium tetroxide), followed by alcohol dehydration, solvent-assisted infiltration with plastic resin, and plastic curing. These particular methods are based on the best available procedure currently employed in laboratories worldwide for the preservation of animal brain tissue for study at the electron microscope level. As previously noted, these particular chemical procedures have proven sufficient to preserve the precise structure of neurons and synapses down to the nanometer level, and have also demonstrated the ability to preserve the identity and location of ion channels, receptor proteins, and other molecular components of neurons which are key to brain function.

Because the WBPE procedure is not as time critical, it could be performed outside of hospitals. However, the procedure should still be considered a medical procedure and thus be performed only by licensed medical professionals and be regulated for quality. Likewise, storage of a plastic embedded brain should be regulated for quality and security wherever private storage is contracted.

### **Responsibility of the government:**

First and foremost, it is the responsibility of the government not to interfere with an individual's pursuit of life in accordance with his or her own intellectual, moral, and religious views. This is regardless of whether these individual views reflect the views of the majority. By today's laws, if a patient's respiration and blood flow has ceased, if there is no brain activity, and if current medical techniques are unable to restore these processes within a relatively short period of time then the patient is declared legally dead. In current law there is no consideration given to the possibility of preserving the patient in a static state for long periods of time (decades) so that they can reach future medical technology capable of bringing them back to life. These laws must be modified to reflect the advances in science and technology that have made such a scenario likely.

For example, current laws would severely delay the timely perfusion of glutaraldehyde into a patient by requiring physicians to wait until the proper legal paperwork is filed certifying death and certifying that the patient's body has been "donated" for "experimental" preservation. Physicians that failed to jump through these time-consuming legal hurdles would open themselves up to prosecution for manslaughter. This

possibility is not hypothetical as it has occurred in attempts to cryonically preserve individuals in a timely manner. In addition, autopsies currently take precedence over a patient's desire to be preserved – clearly incompatible with a timely glutaraldehyde perfusion. Again, this possibility is not hypothetical as it has occurred in cryonic preservation attempts.

More extensive changes to existing laws need to be implemented to respect the right to life, happiness, and dignity of those individuals whose brains and bodies are being ravaged by diseases like cancer, Alzheimer's, etc. It makes no sense to require these patients to die by "natural" means (either by letting the disease run its destructive course or by self-inflicted death by refusal of food and water), yet these are the only recourse available today for many people in countries and states with no (or restrictive) physician-assisted euthanasia laws. Once again, this possibility is not hypothetical. Laws that truly respect an individual's right to life and self-determination would allow the person, in consultation with their physician, to decide what course of action and timing is best suited to their particular case. This may mean that a person diagnosed with a brain tumor would, after a certain time, forgo further chemotherapy treatments and instead schedule a glutaraldehyde perfusion procedure as their means of physician-assisted euthanasia.

One can see that upholding the "right to life" of those of us that desire brain preservation requires similar legal reforms as the "right to die" movement which advocates for more progressive physician-assisted euthanasia laws. We believe that it is a person's right to choose life and it is also a person's right to choose death. It is our right to choose to undergo an uncertain medical procedure (chemical brain preservation) which may indeed shorten our life, but which we believe has the possibility of extending it, in quality as well as in duration, almost immeasurably. It is also a person's right to refuse such a procedure based on his or her own intellectual, moral, and religious views.

## **Conclusion**

Over the last half century medical practice has seen some startling additions – routine organ transplants, minimally invasive laparoscopic surgery, robot-assisted surgery, profound hyperthermia and circulatory arrest, cochlear implants, Lasik eye surgery, deep brain stimulation, frozen embryos used for in-vitro fertilization, and sex reassignment surgery. We are moving quickly into an era where the scanning of whole animal brains at the nanometer level will be commonplace, and there is already serious contemplation of producing an entire connection-level atlas of a human brain.

With these recent advances in mind, it is no longer appropriate to simply dismiss the possibility of brain preservation as a medical procedure. Preservation should instead be evaluated with an open mind as a means for putting a person in suspended animation in order that they reach future medical technology able to cure them.

We are calling on the medical and scientific community to seriously evaluate the possibility of chemically preserving an entire human brain at the ultrastructure level, to develop the surgical techniques necessary to do so, and when a verified protocol is developed, to work with appropriate members of the medical and governmental community to integrate an elective chemical brain preservation procedure into mainstream medical practice in hospitals in every country of the world.

For the [list of signatures](#) to this Open Letter see...

<http://www.ipetitions.com/petition/brainpreservation>

***For additional information see...***

<http://www.brainpreservation.org>

## References

- Anderson, J. R. (2007). *How can the human mind occur in the physical universe?* Oxford ; New York: Oxford University Press.
- Denk, W., & Horstmann, H. (2004). Serial block-face scanning electron microscopy to reconstruct three-dimensional tissue nanostructure. *PLoS Biol*, 2(11), e329.
- Hayat, M. A. (2000). *Principles and techniques of electron microscopy : biological applications* (4th ed.). Cambridge, UK ; New York: Cambridge University Press.
- Hayworth, K. J. 2008 Automated creation and SEM imaging of Ultrathin Section Libraries. Society of Neuroscience conference. November, 2008 Washington D.C.
- Kandel, E. R., Schwartz, J. H., & Jessell, T. M. (2000). *Principles of neural science* (4th ed.). New York: McGraw-Hill, Health Professions Division.
- Knott, G., Marchman, H., Wall, D., & Lich, B. (2008). Serial Section Scanning Electron Microscopy of Adult Brain Tissue Using Focused Ion Beam Milling. *The Journal of Neuroscience*, 28(12), 2959 –2964.
- Markram, H. (2006). The blue brain project. *Nat Rev Neurosci*, 7(2), 153-160.
- Palay, S. L., Mc, G.-R. S., Gordon, S., Jr., & Grillo, M. A. (1962). Fixation of neural tissues for electron microscopy by perfusion with solutions of osmium tetroxide. *J Cell Biol*, 12, 385-410.
- Sandberg, A., & Bostrom, N. (2008). Whole Brain Emulation: A Roadmap. *Technical Report #2008-3, Future of Humanity Institute, Oxford University*.

Sullivan, B. J., Sekhar, L. N., Duong, D. H., Mergner, G., & Alyano, D. (1999). Profound hypothermia and circulatory arrest with skull base approaches for treatment of complex posterior circulation aneurysms. *Acta Neurochir (Wien)*, 141(1), 1-11; discussion 11-12.