Cryonics: A Sure Bet or Wishful Thinking?

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For decades, cryonics has been a subject of fascination for everyone from working scientists to armchair enthusiasts. The idea focuses on the freezing of human bodies at cryogenic temperatures right after death, in hopes that future medical advances may one day resuscitate and cure them. Though cryonics rests heavily on speculation, occupying an enigmatic middle ground between living and deceased, it forces consideration of profound queries regarding the essence of human life, our relationship with the passage of time, and whether traversing eras could ever be a reality.

Cryonics is fundamentally based on the principles of cryobiology, which is the study of the responses of living organisms to extreme cold conditions. As soon as a person is legally declared dead, the process of cryopreservation begins. Deceleration of decay processes is accomplished by cooling the body with ice and maintaining minimal tissue viability through blood circulation, which is reestablished with the help of a heart-lung resuscitator. Subsequently, blood has to be exchanged with a cryoprotectant solution. This prevents the formation of ice crystals since ice has the capability of irreversibly damaging cell membranes and tissues.

Once the body is made perfused with cryoprotectant, it is maintained indefinitely at a temperature of -196°C using liquid nitrogen. The main purpose of doing so is to retain the cellular structure until future medical sciences have the potential to revive and repair it.

One of the primary scientific challenges in cryonics is preventing ice formation during the cooling process. Ice crystals can cause extensive damage to tissues, particularly in complex organs like the brain. To address this issue, cryonics relies on vitrification, which is a process where the body is cooled so rapidly that water within cells solidifies into a glass-like state without forming ice. However, achieving complete vitrification, especially in large organs or whole bodies, remains a significant challenge.

The research has made strides in improving vitrification techniques. For example, a study some time back demonstrated the successful vitrification of a porcine heart, although the organ suffered cracking during the rewarming process. This highlights one of the key limitations of current cryopreservation technology: while we can freeze bodies, safely thawing and reviving them without causing further damage remains a major hurdle.

Advancements in Cryoprotectants

Cryoprotectants are substances used to prevent ice formation during cryopreservation. Over the years, researchers have developed extremely effective cryoprotectant solutions that reduce the toxic effects on cells while providing better protection against damage caused by freezing.

These developments have been critically important for the vitrification of larger tissues and organs. Hence, moving closer toward achieving robust whole-body cryopreservation. But extending those improvements in a full human body, without compromising it and keeping it intact for future revival remains a challenge.

The Future of Cryonics

The future of cryonics will likely be shaped by advancements in several key areas of science and technology, like:

1. **Molecular Nanotechnology:** the development of nanobots capable of repairing cellular and molecular damage is crucial for the successful revival of cryopreserved bodies. While current nanotechnology is far from this goal, ongoing research in materials science, robotics, and molecular engineering may eventually make it possible.
2. **Regenerative Medicine:** advances in stem cell therapy, tissue engineering, and organ regeneration could enable the repair and replacement of damaged tissues in cryopreserved individuals. Techniques such as 3D bioprinting and organ scaffolding are already showing promise in regenerative medicine and could one day be applied to cryonics.
3. **Artificial Intelligence and Machine Learning:** AI could play a pivotal role in optimising cryopreservation protocols, predicting potential damage during freezing and thawing, and assisting in the complex task of cellular repair and revival. If computer programs can be made to examine mountains of data and gain an understanding of general principles about why different tissues respond differently, we could make far more refined cryopreservation techniques.

One interesting area of research that could be beneficial to cryonics is the field of epigenetics, the study of how genes can express & regulate without a change in DNA sequence. And researchers are investigating how epigenetic effects could impact ageing. In 2024, scientists at Brigham and Women's Hospital developed an advanced epigenetic clock capable of predicting biological age with remarkable accuracy. This research could help to identify key biomarkers of ageing and determine the best strategies for reversing or halting the ageing process in cryopreserved individuals.

Ethical Considerations and Societal Impact

Cryonics has always been a controversial topic with polarised views. Supporters claim that cryonics is a rational extension of the human yearning to avoid death and believe it will merely require one more advancement. But opponents have accused its supporters of blindly banking