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Living to 150: Is it possible? Do we want to?

“Natural death is measurably the greatest catastrophe humankind has ever faced” says R. Freitas. (2002), it’s a disaster, a “human holocaust”, “each individual is gifted with unique insights possessed by no one else. Almost all of this rich treasury of information is forever lost to mankind when we die.” natural death - death of old age - is undoubtedly horrifying, and tackling it has been described as a “moral and medical emergency” (Farrelly, C. 2008). So why haven’t we defeated it yet?

Well one man seems to have a plan. Aubrey de Grey made a splash a few years ago for controversial claims that the first person to live past 150 has already been born, (Daily Mail Reporter, 2011) in this essay we will be looking at that question. Will technology improve so that people born today may live beyond 150? And if they do, will that be a good thing?

We will be observing two different ways of extending lifespan, the method most commonly used, in which the symptoms of diseases are treated, which we will be calling Risk Factor Targeting, and an alternative idea proposed by Dr. Aubrey De Grey, known as the SENS (“Strategies for Engineered Negligible Senescence”) approach. There exist other proposed methods for extending human lifespan - e.g. nanomedicine (Freitas, 2002) - but to analyse and critique every single one would take an unreasonable amount of time. SENS has had a large amount of notoriety, and encapsulates within it a very broad range of different antiaging technologies, so we will focus on it above other antiaging research.

Risk Factor Targeting

Risk Factor Targeting is a term I will be using the describe the way ageing is currently dealt with. It summarises the general trend of focusing funding on people who already have diseases - hoping to treat and cure them - rather than preventing diseases from occurring. This is the approach we have used for hundreds of years, and it appears to have worked. In the US, the average life expectancy at birth has increased from 38 in 1950 to almost 75 in 2000 (Freitas, 2002). But as R. Freitas points out in the cited article, little improvement has been seen for the older generations. The expected age of death of a 70-year old has only improved from 80 to 83 years over the 150 years that RFT has had to work its magic. So what is wrong?

Scientific flaws in RFT

The SENS website makes it clear: “The fundamental drivers of degenerative aging lie in the biochemical and cellular side-effects of essential metabolic processes in the body.” (SENS research foundation, 2015) Metabolism (a collective name for the processes carried out by the cells in our body in order to keep themselves alive) is not perfect, in the chaotic real world

countless errors are made and it is these errors that accumulate over time and lead to the process we call ageing. De Grey identifies 7 main categories of damage which lead to aging:

- Cell loss and tissue atrophy: The body is capable of replacing lost cells to some extent. But over time this ability is reduced, leading to tissues like the brain heart and muscles losing cells.

- Cancerous cells: Cells that divide uncontrollably due to genetic mutation.

- Death resistant cells: Cells that go abnormal but do not become cancerous, instead they linger in the body, not fulfilling their purpose but not dying away.

- Mitochondrial mutations: There are components within our cells that are responsible for many metabolic processes, and possess their own DNA. When this DNA becomes damaged the mitochondria break down, resulting in them struggling to perform their function and causing large amounts of damage while doing it.

- Extracellular matrix stiffening: Some protein based structures in the body are made when we are very and expected to last a lifetime. These proteins degrade over time, stiffening and leading to things like the clouding of the eye.

- Extracellular aggregates: Proteins that were not made properly by the body and which the body does not possess the ability to remove properly, like the plaques in the brains of Alzheimer's patients.

- Intracellular aggregates: Byproducts of errors in metabolism accumulating within cells and interfering with function.

(SENS research foundation, 2015)

The issues of Risk Factor Targeting is that it uses drugs that alter the metabolic process, (Lowing heart rate or blood pressure, for instance) but does nothing to clear the damage that accumulates due to the these processes. As the SENS foundation observes, “while these medicines slow the rate at which particular forms of aging damage accumulate, they are powerless to stop its buildup in our tissues”

This seems to indicate that, if we continue with our current approach, it is very unlikely we will be able to extend the human lifespan beyond 150 years. And even if we could, would we want to?

Sociological and ethical flaws in RFT

In 2010 £100 billion was spent on pensions, with a government report citing a further £10 billion would need to be spent per year for everyone 1 million new people over the working age. In order to sustain a population in which people regularly live to 150, taxes would have to be a lot higher and government spending (on anything other than sustaining the ageing population) would have to be lower.

The increased strain this would bring on the NHS is incredible, “the average value of NHS services for retired households was £5,200 compared with £2,800 for non-retired.” And, more elderly people put greater strain on the NHS than less elderly people, it would be expect that supporting a population of 150 year olds would be incredibly demanding. (England. House of Commons Library, 2010)

This may be solved by raising the retirement age. Soon, state pension age will be linked to life expectancy, that is to say, that “people should spend a given proportion of their lives receiving a State Pension”. (England. The Department for Work and Pensions, 2013) So if people live to 150, than they would be expected to retire at at least 100, if not 120. Which would of course be impossible, someone at 100 cannot not be expected to work.

So supporting a population that lives to 150 by normal medical methods would require an unrealistically large amount of money.

And even if our economy was somehow strong enough to support living to 150, these don’t touch upon the ethical issues. In a survey carried out in Australia, 40% of 605 participants were concerned that drugs to slow ageing would negatively affect them, even if it were good for others, by extending the amount of their lives they spent weak or frail. (Partridge, Lucke and Hall, 2010)

And that’s the biggest issue with RFT, it extends human lifespan, but doesn’t extend what gerontologists call “healthspan” as effectively, that is, the years that someone spends in a condition of health and happiness, (de Grey, 2005 ‘Life extension, human rights, and the rational refinement of repugnance’). Living a long time by our current methods can in fact be very undesirable both for the person living a long time, who may summer from dementia or cancer and numerous other diseases, and for their family and carers, as their increased frailty puts an ever increasing emotional and often financial burden on them.

The SENS approach

But an alternative has been proposed, the SENS approach. SENS seeks to reverse the 7 symptoms of ageing documented above, therefore preventing aging, and not just the conditions caused by it, as the website says in it’s own words, “instead of merely slowing down the

accumulation of aging damage in our tissues, rejuvenation biotechnologies will remove, repair, or replace the damaged cellular and molecular machinery." The net result of this should be that people will be able to live not just long lives, but healthy lives in which their youth is retained for longer. They even suggest they may be able to reverse signs of ageing in already aged patients, the ultimate fountain of youth. (SENS research foundation, 2015)

The researchers at SENS, headed by Aubrey De Grey, have formulated detailed plan - going over how each one of the 7 symptoms they identified can be treated using technologies that are in development today. The idea being, that citizens would regularly visit their doctor for routine checkups, where the 7 symptoms of ageing would be treated to the best of their abilities. Thus holding age-related damage at bay.

These are the strategies SENS proposes for each of the seven categories:

- Cell loss and tissue atrophy: Stem cells are cells that have not yet decided what they want to be, be it a skin cell or a liver cell or a brain cell. Stems cells have the peotentioal to change into these cell types. They have been around for a while, and many scientists believe these may pose a cure to the issue of tissue atrophy, as stem cells can be encouraged to form new organs and tissues. What would be required is routine injections of stem cells or even replacing weak organs and tissues with those manufactured from stem cells, (organs transplanted this way would not suffer the normal issues of other organ transplants).

- Cancerous cells: There is tons of research into curing cancer all the time and it seems more hopeful by the minute that we may, in fact, be able to. Cancer research UK has recently changed it's slogan to "let's beat cancer sooner" undoubtedly in an effort to create a more positive image, but also probably in response to growing evidence that beating cancer may be something that is possible, (Cancer Research UK, 2014). While there are many methods out there, the specific method SENS suggests is limiting the entire human bodies ability to produce an enzyme called telomerase, which is used by cancerous cells to maintain their rapid division. Telomerase is only required by specific cells in the body but is produced by all of them, so all you would have to do is regularly apply telomerase to the cells that require it in order to prevent the telomerase reduction from killing the patient.

- Death resistant cells: These cells can be killed easily, by targeting them with a drug that is toxic to them, or encouraging the immune system to target these cells. These methods are already being developed in order to treat cancer and can be used to treat these cells too.

- Mitochondrial mutations: This strategy is by far the most elaborate. Requiring setting up a mechanism or framework within cells to regularly move proteins from the nucleus into the mitochondria.

- Extracellular matrix stiffening: The bonds that form that cause this stiffening can be identified and targeted with chemicals designed to break them down. Scientists have already found one such chemical, *alagebrium*, which has been shown to break cross links in mice and rats. It's effect on humans have been limited, but further research and refinement may make this a possibility.

- Extracellular aggregates: Antibodies can be designed that target and destroy these aggregates, these can be injected into the human body, or even better the human body can be encouraged to produce these antibodies itself. The very same mechanisms the body uses to become immune to diseases can be used to "immunise" patients against these buildups.

- Intracellular aggregates: Enzymes exist that can break down the compounds that accumulate within cells. We know this because when a cell dies it leaves behind it's aggregates, after bacteria are allowed to decompose the dead cell the aggregates are gone, meaning the bacteria must have digested them, so must possess enzymes that can do so. What would be needed would be to supply cells with these enzymes, e.g. through genetic modification or by repeated delivery though injection.

(All data - unless stated otherwise - is cited from SENS research foundation, 2015)

In an article for EMBOpress De Grey predicts that within 10 years there's going to be discoveries showing ageing to be "properly treatable", and that that will initiate a movement towards his plan. (de Grey, 2005, 'Curing ageing and the consequences')

It seems hopeful - if ambitious - but SENS is not without it's detractors.

Scientific issues with SENS

Firstly, De Grey's prediction that big changes are coming in 10 years was made in 2005, and there has still not been the kind of "absolute pandemonium" he promised. (de Grey, 2005, 'Curing ageing and the consequences') This falls as predicted by the 28 experts in biology and gerontology (the study of ageing) who jointly wrote against him when he first gained notoriety, describing his plan "exceptionally optimistic" and worthy of "no respect at all from the scientific community". (Warner *et al*., 2005). Others claim, "it is clear why SENS is not taken seriously" (Mobbs, 2004), and in another, 9-author article, SENS was accused of ignoring "A large body of scientific evidence", of being pseudoscience, and relying "on assumptions and technologies that reside firmly in the realm of fantasy". (Estep *et al.,* 2004) Again, here, all 9 of the authors work in biology and medicine with 4 working directly in the field of ageing.

So it is clear that a large part of the scientific community refute De Grey, and the arguments they use against him are numerous.

Charles Mobbs observes that SENS is interested only in treating the symptoms of ageing (the accumulation of the 7 forms of damage) rather than the causes, an approach he calls “braindead”. (Mobbs, 2004) De Grey responds with the argument that treating the causes of these things would be “impossible” as they are necessary consequences of metabolism, (de Grey, 2005, ‘Curing ageing and the consequences’). Mobbs also points out that not all age-related changes are covered by de Grey’s 7 categories. Oxidative damage to proteins, for instance, has been shown to be something that accumulates with age and impairs function, but it is not in any of de Grey’s categories. Other studies show that gene expression changes as we get older, which may also be another form of ageing the SENS plan ignores. But de Grey says that his categories are not meant to cover all forms of change due to ageing, only those that seem to cause damage over the course of the current human lifespan, (de Grey, 2005, ‘Curing ageing and the consequences’) though de Grey doesn’t bother to justify why protein oxidation definitely isn’t important but intracellular accumulation, for instance, is.

A gerontologist pointed out in an article for technology review that just because you can identify 7 steps that cause something doesn’t mean that thing can be resolved. Contrasting De Grey’s plan with his own 7 step plan on how to make pigs fly. (Miller, 2004) De Grey, in an article so laced with sarcasm it’s almost impenetrable, responds, “I am confident that this [pigs not flying] can be overcome, however. The clear feasibility of adapting for porcine use a technique used to such great effect by another mammalian species [flying machines] can only be denied for so long.“ pointing out that if we cared as much about making pigs fly as we should do about antiaging, creating flying pigs would actually be pretty reasonable (de Grey, 2005 ‘Debating immortality 2’).

Other criticism comes from de Grey’s approach to biology. De Grey regards regards life extension as a matter of “bioengineering,” with a heavy emphasis on the “engineering”, some criticise this approach, as they feel it treats the systems of the human body as “individual components in a machine” when in reality, a small change in one system almost always result in “unpredictable and incalculable responses” from the heavily interconnected human body, (Nuland, 2004). Again, however, de Grey has a response to this, calling this an “offhand evaluation”; engineers have plenty of experience dealing with interconnected systems, if they didn’t, engineering would be a very simple subject indeed, “It is the management of those interactions... that defines my approach” says de Grey. (de Grey, 2005, ‘Aubrey de Grey Responds’)

But what about the 7 categories themselves? Well for every one there are individual reasons why breakthroughs may not happen in the timeframe de Grey suggests. However, to give examples of just a few, SENS requires full body constant replacement of cells as one of it’s 7 treatments, (see above) but even for just one cell type, like insulin cells, a practical way of replacement has not been discovered. (Mobbs, 2005) Cancer, another of the items on his list, has been being tackled for 30 years and progress is only just starting to be made (de Grey, 2005, ‘Curing ageing and the consequences’). The SENS plan relies on all 7 treatments, many

of which are similarly as unreasonable as this, to be possible to have the effect it wants, “at the moment, and indeed for the foreseeable future, the available technologies do not allowing even one such modification to be carried out, much less the vast number necessary.” (Mobbs, 2005)

But perhaps the most vicious criticisms come against de Grey himself, who is, after all, not a research biologist. De Grey majored in computer science, and is self taught in natural science, having never actually performed an experiment in biology (Nuland, 2004). Why do we hold credit to the ideas of a man who has never sat down and actually performed any of the experiments he cites when justifying his ambitious claims? A man who is so clearly opposed by the biogerontologists he claims to be a member of? Now, these arguments might be *ad homina*, but they indicate a key underlying tone to the whole of the de Grey debacle, that despite being “impossible not to like” (Nuland, 2004) he is regarded by many as a pseudoscientist, (Estep *et al.,* 2004)

Ethical issues with SENS (and antiaging in general)

And once again we are brought to the question, even if we could live to 150, would we want to?

In his article on De Grey, Prof. Sherwin Nuland, says “both individual fulfillment and the ecological balance of life on this planet are best served by dying when our inherent biology decrees that we do”, which he believes is “about 120” (Nuland, 2004)

De Grey bites back at this, saying that “we have a duty” to investigate antiaging research, that it is a right to choose when one dies, a right that current generations are denied, and one we must provide to future ones. He also doubts Prof. Nuland would hold to his promise if he “reaches the age of 119 in the same fine shape that he is in today,” killing himself upon the dawn of the 120th birthday (de Grey, 2004, ‘Aubrey de Grey responds’). De Grey argues, “this life business is fun... ...there's no reason to suppose it's going to stop being fun as a result of anything other than getting frail”, that if you could be promised many more years of healthy life - which the SENS plan does - you would take them, of course (de Grey, 2005, ‘Curing ageing and the consequences’).

Furthermore, delaying research into antiaging may be “costing lives” (de Grey, 2005, ‘Resistance to debate of how to postpone ageing is delaying progress and costing lives’) as people who would be saved by these treatments pass away. He even goes as far as to accuse fellow Gerontologists of “living a lie”, (de Grey, 2005, ‘Life extension, human rights, and the rational refinement of repugnance’) phrasing their research as having the objective of extending years of healthy life, but not of extending lifespan overall, so that potential funders do not have to worry about overpopulation or any other issues.

And while de Grey gets attacked for making the argument that lives are lost through inaction on ageing, will some considering that sort of argument to be that of a pseudoscientist, (Estep et al., 2004) it has been pointed out that the “Lives are lost through not acting” argument is also used

to argue on acting on climate change, and it's hardly like climate change is pseudoscience. (Farrelly, 2008)

And speaking of these issues, what's to be done about them? If people do love to 150 as de Grey proposes, won't that lead to a huge, unsustainable increase in population? De grey argues that birth rates will simply drop, (Nuland, 2004) he and his wife are voluntarily childless, and the number of couples choosing to live without children is increasing all the time, and if faced with a choice between having three or more children (as this is the requirement to increase the population) and living to 150, most couples would choose the latter. Many couples do not plan to have more than three children anyway. De Grey also believes that the human brain is "flexible" so the reduced birth rate won't mean less mavericks - einsteins and da vincis - being born, rather, that the extended lifespan will give the opportunity for people who would not have realised their genius to discover it. (de Grey, 2005 'Curing ageing and the consequences').

But what about the quality of life, wouldn't living to 150 take the motivation out of life, knowing you have so much more time? De Grey dismisses this as ridiculous, asserting young people are not motivated by their impending death, (de Grey, 2005 'Curing ageing and the consequences').

Furthermore, to all these issues, de Grey stresses, "I don't know and don't need to know." (Nuland, 2004) and repeats that, in the end of the day, the choice about when you die is the most fundamental choice. It is a trump card, beating all other ethical implications, it doesn't matter if it only goes to the rich at first, if it messes with family structures or if it's "playing god", people deserve to choose when they die, that is above all other things, regardless of the consequences. "It's not a question of how long life should be, but whether the end of life should be hastened by action or inaction." (Nuland, 2004)

De Grey argues that a lot of resistance to the idea of extending lifespan comes from an incorrect belief that ageing is not a disease, he argues that ageing should be regarded the same way as the age-related diseases it triggers, like alzheimers. It should be regarded as something treatable, rather than something inevitable. This attitude not only makes scientists less likely to pursue stopping ageing, "Politicians may be inclined to feel that, well, if ageing is not a disease, it is probably not something we ought to be spending much effort combating, then, is it?". (de Grey, 2005, 'Resistance to debate on how to postpone ageing is delaying progress and costing lives')

And it must be noted that de Grey isn't the only person that thinks this, Arthur Caplan argues ageing can "claim to being counted as a disease", (Farrelly, 2008), and as Farrelly points out, "If it is correct to give ageing the label of a disease, then we do not need all the specifics of a potential cure at hand before we can set out to do something about it." but that demand to treat ageing would "dwarf" all other demands for research into disease, due to ageing being something that threatens every living human being, "No one lambasted US President Richard Nixon for declaring "war on cancer" in the 1970s without having an established scientific consensus about how cancer could be cured." so even if de Grey's specific plan does not work,

pursuing research into ageing is something we should be doing - provided we classify it as a disease. (Farrelly, 2008)

And while the SENS approach may be dismissed as unreasonable by a fair amount of the scientific community, and taboo by many others, it's not the first technology to be in this position. For instance when the question "what about poverty? These life extending technologies, if they are developed, will be expensive initially. Is it fair to allow the rich to live long lives while the poor do not? How can we justify spending money on researching this when disease and famine are so prevalent?" is asked, you can point to Assisted Reproductive Therapies like ***in vitro*** fertilisation which were similarly "hotly disputed" by the scientific community, for the same reasons before eventually being accepted. Concerns with the rich getting treatment before the poor, and with the idea of playing god, were raised in both, but eventually dismissed, (Lucke, *et al.* 2010). It might be that life extension technologies may follow a similar path.

Another question that was raised in ART too was the idea of testing. The antiaging therapies de Grey suggests would have to be tested on young human volunteers right? That's not currently allowed by the codes medical ethics we use. But de Grey argues that actually people in their 50s and 60s would be more appropriate test subjects anyway as they have already acquired the biomolecular damage his plan seeks to treat. He also adds, on a more general notes, that he finds the Hippocratic Oath, "becomes less reasonable" when it comes to his research, a few people being tested on is worth it given the overall benefit of life extension. (de Grey, A. (2005) 'Curing ageing and the consequences')

Of course, that assumes that life extension will have an overall benefit.

In conclusion

In this essay I have made several assumptions and ignored several aspects. For instance, I have not considered other forms of antiaging outside of SENS, like uploading your brain into a computer. I have also assumed that things will not go drastically wrong at any point in the future. That civilisation will not collapse, nuclear war will not occur, and the general trend of steadily increasing access to energy and resources and the advance of technology will continue. My justifications for these are numerous, I have chosen to only regard SENS because it combines many other studies together, because it is the most notorious, and because it is the one that promises to happen soon enough to affect the people being born today. To consider all the forms of antiaging that have been proposed and their various ethical and scientific aspects would be completely unreasonable. And to weigh up the possibility of future, unknown events occurring would lead us down endless potential futures and "What if?"s.

In the end of the day, there is a reason why De Grey finds himself being criticised by a large proportion of the scientific community, it's not because of a gut feeling that ageing is not something that needs to be treated - "gerontologiphobia", as he calls it (de Grey, 2005,

‘Resistance to debate on how to postpone ageing is delaying progress and costing lives’) - it’s because his entire theory relies on layers of faulty, overly-optimistic thinking, as has been stated about him repeatedly, over and over again, by nearly every critical source about him I have cited thus far. The overwhelming opinion of his fellow gerontologists (though whether he can even consider himself a gerontologist is up for debate) is that SENS is flawed. And they have the evidence to back up this veiw.

So perhaps the first person to live beyond 150 has not yet been born, but that doesn’t mean they *won’t* be. De Grey admits himself that if his belief of huge changes in the short term fall through, there will definitely be changes “in the next 100 years”, (de Grey, (2005) ‘Curing ageing and the consequences’). And this seems somewhat more reasonable, even if life extension doesn’t happen in the way that de Grey envisions, if the gradual trend of ever improving technology increases, there is no reason to believe that something as fantastic as life extension won’t occur. The technology of today would be like magic to someone in 1915, why shouldn’t the discoveries of 2115 be just as magic to us?

So then the real question becomes, do we want to? What would living any longer gain us? And this is an argument for which it is hard to find a right or wrong. Some, like de Grey argue that people should simply have the choice to as live as long as they want to, and science should attempt to fulfill this desire as much as it can, but others call this desire narcissistic, (Nuland, 2004) and argue that the years that humans are provided with are as many as we need. What is certain is that there is an “increasing likelihood that some forms of [life extension technologies] will be developed in the next few decades”, (Lucke, *et al.* 2010) though perhaps not quite to the degree de Grey believes. It is almost certain that life extension technologies will be developed at some point.

When Lucke *et al.* compares life extension technologies to assisted reproductive therapy they pointed out a correlation, perceptions of ART were shaky at first but gradually became more favourable as the technology because the norm. So perhaps the more important question is not “Do we want to live to 150?” but “Will we?”.

Bibliography

Cancer Research UK. (2015) ***Our strategy to beat cancer sooner***. [Online] Available at: http://www.cancerresearchuk.org/about-us/our-organisation/beating-cancer-sooner-our-strategy (Accessed: 10th of Feburary 2015)

Daily Mail Reporter. (2011) 'Dawn of a new age: The first person to reach 150 is already alive... and soon we'll live to be a THOUSAND, claims scientist' ***Daily Mail,*** July 6th. [Online] Available at: http://www.dailymail.co.uk/sciencetech/article-2011425/The-person-reach-150-alive--soon-live-THOUSAND-claims-scientist.html) (Accessed: 20th of Feb 2015)

de Grey, A. (2005) 'Aubrey de Grey Responds' ***Technology Review,*** January 18th. [Online] Available at: http://www.technologyreview.com/news/403617/aubrey-de-grey-responds/ (Accessed: 25th of November 2014)

de Grey, A. (2005) 'Debating immortality 2' ***Technology Review,*** November 30th. [Online] Available at: http://www.technologyreview.com/news/404957/debating-immortality-2/ (Accessed: 2nd of December 2014)

de Grey, A. (2005) 'Curing ageing and the consequences' ***EMBO Reports***, 6(3). [Online] Available at: http://embor.embopress.org/content/6/3/198 (Acsessed: 2nd of Dec, 2014)

de Grey, A (2005) 'Life extension, human rights, and the rational refinement of repugnance' ***Journal of Medical Ethics,*** [Online] Available at: http://jme.bmj.com/content/31/11/659.full (Accessed: 10th of Feburary, 2015)

de Grey, A (2005) 'Resistance to debate of how to postpone ageing is delaying progress and costing lives' ***EMBO Reports,*** 6(S1). [Online] Available at: http://embor.embopress.org/content/6/S1/S49?ijkey=9128e8142f1cdbb04551460a3845ce743107766b&keytype2=tf_ipsecsha (Accessed: 16th of Dec, 2014)

England. House of Commons Library (2010) ***Key issues for the New Parliament 2010.*** [Online] Available at: http://www.parliament.uk/business/publications/research/key-issues-for-the-new-parliament/value-for-money-in-public-services/the-ageing-population/ (Accessed: 7th October 2014)

England. The Department for Work and Pensions (2013) ***Reveiwing the State Pension age.*** [Online] Available at: https://www.gov.uk/government/policies/reviewing-the-state-pension-age (Accessed: 18th November2014)

Estep, P., Kaeberlein, M., Kapahi, P., Kennedy, B., Lithgow, G., Martin, G., Melov, S., Powers, W., Timmsenbaum, H., (2004) 'Life Extension Pseudoscience and the SENS plan' ***Technology Review,*** Nov 29th. [Online] Available at: http://www2.technologyreview.com/sens/docs/estepetal.pdf (Accessed: 18th of November 2014)

Farrelly, C. (2008) 'A tale of two strategies' ***EMBO Reports***, 9(7). [Online] Available at: http://embor.embopress.org/content/9/7/592 (Acsessed: 16th of Dec, 2014)

Freitas, R. (2002) ***Death Is An Outrage***. [Online] Available at: http://www.rfreitas.com/Nano/DeathIsAnOutrage.htm (Accessed: 21st of January 2015)

Hall, W., Partridge, B., Herbert, D,. Lucke, J. (2010) 'Anticipating the use of life extension technologies' ***EMBO Reports***, 11(5). [Online] Available at: http://embor.embopress.org/content/11/5/334 (Acsessed: 16th of Dec, 2014)

Miller, R. (2004) 'Debating Immortality' ***Technology Review,*** Nov 29th. [Online] Available at: http://www.technologyreview.com/news/404951/debating-immortality/ (Accessed: 25th of November 2014)

Mobbs, C. (2004) 'A Brief Critique of SENS' ***Technology Review,*** Nov 29th. [Online] Available at: http://www2.technologyreview.com/sens/docs/mobbs.pdf (Accessed: 25th of November 2014)

Nuland, S. (2004) 'Do You Want To Live Forever?' ***Technology Review,*** February 1st. [Online] Available at: http://www.technologyreview.com/featuredstory/403654/do-you-want-to-live-forever/ (Accessed: 25th of November 2014)

Partridge, B., Lucke, J. and Hall, W. (2010) 'Listening to public concerns about human life extension' ***EMBO Reports***, 11(10). [Online] Available at: http://embor.embopress.org/content/11/10/735#ref-18 (Accessed: 9th of Dec, 2014)

SENS research foundation. (2015) ***The Path to a New Medicine***. [Online] Available at: http://www.sens.org/research/aging-as-weve-known-it/the-path-to-a-new-medicine (Accessed: 11th of November 2014)

Warner, H., Anderson, J., Austad, S., Bergamini, E., Bredesen, D., Butler, R., Carnes, B., Clark, B., Cristofalo, V., Faulkner, J., Guarente, L., Harrison, D., Kirkwood, T., Lithgow, G., Martin, G., Masoro, E., Melov, S., Miller, R., Olshansky, J., Partridge, L., Pereira-Smith, O., Perls, T., Richardson, A., Smith, J., von Zglinicki, T., Wang, E., Wei, J., Williams, F. (2005) 'Science fact and the SENS agenda' ***EMBO Reports***, 6(11). [Online] Available at: http://embor.embopress.org/content/6/11/1006 (Acsessed: 2nd of Dec, 2014)

Evaluation of sources

Source	Author known?	Free from vested interest?	Free from bias or unreliability?	Bibliography
Cancer Research UK. (2015)	Very well known author	No - cancer research obviously has vested interest in the field.	No - through their sources are reliable their optimism about curing cancer is clearly somewhat biased.	No bibliography.
Daily Mail Reporter. (2011)	Well known but not in the field of biology.	Has no vested interest in ageing.	No - source is mostly repeating things de grey has said.	No bibliography.
de Grey, A. (2005) 'Aubrey de Grey Responds'	Well known in the field of gerontology.	Not really - he runs a foundation that requires funding.	No - a large part of the scientific community disputes his claims including those whose research de Grey sometime cites.	No bibliography
de Grey, A. (2005) 'Curing ageing and the consequences'				Good number of reliable sources.
de Grey, 2005 'Debating immortality 2'				No bibliography
de Grey, A (2005) 'Life extension, human rights, and the rational refinement of repugnance'				Good number of reliable sources.
de Grey, A (2005) 'Resistance to debate of how to postpone ageing is delaying progress and costing lives'				
England. House of Commons Library (2010)	Yes - it's the government.	No.	Yes - they are a government body who are expected to at the very least look unbiased.	Yes, all of the data they have collected themselves.
England. The Department for Work and Pensions (2013)				All information is sourced correctly.

Estep, et al. (2004)	Many researchers actively working in the field of ageing, all working in the field of biology.	Not really - a large number of the authors are members of a research foundation known as Longenity Inc. Working in the field of ageing research just as SENS is.	No - the article starts off openly stating it's objective as to argue SENS as pseudoscientific.	A very good number of reliable sources.
Farrelly (2008)	A researcher in the field though not incredibly well known.	Yes.	Yes the article attempts to give a balanced account of the various arguments for and against each side.	Good number of reliable sources.
Freitas (2002)	Yes - actively researching in his field and making numerous breakthroughs. Winner of numerous prizes.	Yes - he is actively researching in his field but not dependant on people to believe him	No - he makes it clear from the start the stance he will be trying to argue and argues that passionately throughout.	Good number of reliable sources - many of which are his own research.
Hall, et al. (2010)	All researchers in the field.	Yes	Yes - they give a balanced account taking a look at all sides of the issue.	Good number of reliable sources - a few of which are their own research.
Miller (2004)	An academic in the field though not especially well known.	Yes.	No - openly attempts to attack and humiliate de Grey, makes no effort to give a balanced account. Intended to be somewhat comedic.	No bibliography
Mobbs (2004)	An academic in the field though not especially well known.	Yes.	No - openly attempts to attack and humiliate de Grey, makes no effort to give a balanced account. Intended to be somewhat comedic.	A small number of sources for a small article.
Nuland (2004)	Not well known in the field.	Yes - Nuland is not active in the field of gerontology so his outsider status leaves him free of vested interest.	Not really - occasionally provides arguments in favour of the SENS agenda. But the author clearly has a point of view they'd like to get across and occasionally uses	No bibliography

			ad homina and other shaky reasonings to argue his point.	
Partridge, Lucke, and Hall (2010)	Yes - Well known in the field, many having written other reports on antiaging.	Yes	Yes - they take a look at all sides of the argument	A large number of reliable sources.
SENS research foundation (2015)	Yes	No - they are a foundation which requires people to believe their argument in order to continue to exist	No - they have been accused many times of misusing and misinterpreting their sources to assist their arguments.	A good number of sources - but not necessarily reliable ones.
Warner, et al. (2005)	A huge number of people many well known other not so well known, many in the field or in closely related fields.	No - some of them are in foundations actively opposed to de Grey, though many others are not.	No - they make it clear from the start which side they will be arguing for. Though their sources are very reliable.	Yes - but only a small number of sources for the size of their article

Overall, finding sources without vested interest proved to be a difficulty, with most arguments being presented from members of SENS, or research foundations in the same field as SENS, actively competing with SENS for funding. Similarly, it was difficult to find unbiased accounts when antiaging is such a divisive issue, with people on both sides of the argument finding little reason to consider the views of the opposing side. However, it is hoped balance can be found by contrasting the arguments of those biased both for and against, and those vested both for and against.