In the 150 years since Darwin wrote On the Origin of Species our knowledge of biology and genetics has increased enormously, leading to vast improvements in health and life expectancy. How might further understanding in these areas affect healthcare 150 years from now?

Sixth-form winning entry (Yuming Mei, Hills Road Sixth Form College)

When Charles Darwin wrote *On the Origin of Species* in 1859, biology as a science was still in its infancy, having gradually emerged from the unification of disciplines such as medicine, botany and physiology. Since then, thanks to the invention of new tools facilitating scientific study (such as the electron microscope), the field of biology has grown exponentially, giving rise to an incredible array of new disciplines such as ecology, genetics, and Darwin's brainchild itself, evolutionary theory. The new discoveries of biology revolutionised healthcare over the next 150 years and as a result, human health improved drastically: for example, life expectancy at birth in the USA nearly doubled in this time, from about 40 years to almost 80 years[1]. This trend can be extrapolated for Europe as well[2].

However, this does not mean that life expectancy will double again by 2159. Most experts agree that the biggest cause by far of the increase in life expectancy in the past 150 years was a huge reduction in infant mortality[2] (in the UK, this occurred around the period 1900-1950[3]). Infant mortality has a large effect on the statistics for life expectancy at birth: in 1850, the infant mortality rate[1] of 150 per 1000 live births represented about a quarter of all deaths per year[4]. A reduction in the rate to fewer than 10 per 1000 therefore caused a huge increase in life expectancy by effectively eliminating that quarter of deaths. By the 1950s, life expectancy had risen to 68 years[5]. Today, it is about 78 years. Therefore in the past 50 years or so, we have only seen an increase in life expectancy of 10 years and this is a slower rate of increase compared to before.

Strangely, it would seem that the most recent developments in biology and genetics have not had as great an impact on life expectancy as previous ones. In fact, the current consensus is that any further increase in life expectancy is not going to take place as quickly or as easily as the one that occurred as a result of reducing infant mortality[2]. Graphs of life expectancy against time show a slight levelling off after the 1950s: the gradient of the graph becomes less steep, indicating a slower rate of increase of life expectancy than before[5]. Also, a recent study estimated that if all deaths from cardiovascular disease in the USA (representing 41% of total deaths every year!) were prevented, life expectancy would still only go up by 7 years[6]. This implies that other causes of death will step in to fill the gap left by the elimination of cardiovascular disease.

In order to raise life expectancy by a large amount we would need to eliminate many different causes of death simultaneously. This is not going to happen quickly by improving the success rate of surgery or by curing diseases like HIV. Instead, an alternative method that stalls the effects of aging completely would be required, not a treatment for a specific illness or health problem.

This all raises the question of whether human life expectancy can increase indefinitely or not. According to evolutionary theorists, there is no evolutionary advantage in longevity[2]. This is because there would be no positive selection for genes prolonging life beyond the fertile years since reproduction does not occur in those extra years of life. This pessimistic hypothesis would suggest that there is a sort of "cap" on life expectancy. In many ways, this is a good thing because an increase in life expectancy means more people alive at any one time. This extra population would put extra pressure on the Earth's resources.

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[1] *Number of deaths before reaching the age of one as a proportion of total births (number per thousand)*

So what will happen in the future?

It is true that everything does depend on what human life expectancy is in 150 years. Broadly speaking, there are two possible scenarios for healthcare in 150 years time. In one scenario, life expectancy will reach a cap which current estimates put at about 100 years. In the other and what I believe is the more likely scenario, humans will have a vastly extended lifespan that is well over 100 years. This could be achieved in many ways. For example, if stem cell research leads to regenerative medicine, people would be able to regenerate the tissues in their bodies that slowly decay with age and therefore live for longer. In the mean time, new techniques would be developed that would extend life expectancy even further. So we could find ourselves back in a situation that last occurred in the Middle Ages (when there was high infant mortality) where life expectancy increases with every year that you live: at the age of 70, your predicted number of extra years of life might be 27, but if you live to 71, your predicted number of extra years of life might rise to 28 as a result of new progress in science!

But before we get carried away, let's look at what is common to both scenarios:

In the next 150 years, the long-term problem of bacterial and viral drug-resistance as a result of evolution will probably not go away. Darwin's idea of natural selection would seem to ensure that whatever we do, we cannot prevent bacteria from eventually developing immunity to our drugs. This could be problematic for healthcare in 150 years.

The next 150 years are likely to see developments in organ transplantation. In fact, it is likely that the world will see the first completely artificial organs being produced and over time, there will no longer be any need for human organ donors. This would revolutionise human health, increase life expectancy and further blur the definition of a human being. Another development that could occur is the use of robots to perform surgery instead of human professionals. This would vastly reduce costs and make such services available to everyone.

Drugs will be developed to speed up the regrowth of tissues and over time, perhaps whole organs will be able to be regrown. This would solve the problem of lost limbs because new body parts could simply be grown to replace them. In a similar way, drugs will be developed to combat aging and to prevent the accumulation of harmful proteins in the body.

But that is roughly where developments would stop if humans were still only living to the age of 100 in 150 year's time. Though undoubtedly there would be new treatments that impact healthcare in ways that would be unthinkable now, this scenario implies that the evolutionary limit is too great to overcome. Humans would still live roughly as they do now and would die from chronic afflictions that gradually accumulate and kill them off. The biochemistry of cells would prove just too complex for scientists to able to determine the function of specific metabolic pathways quickly enough for there to be many discoveries.

However on a timescale of 150 years, I think we can make some truly crazy guesses that make it much more likely that healthcare will be revolutionised. For example, what would happen if biologists found a way for humans to sleep much less without feeling tired and without developing psychological problems? On a 22 hour working day, how would the physical components of the human body such as the cardiac muscle in the heart cope? As we understand more and more about the brain and therefore find out methods to manipulate it for our own ends, it is likely that such possibilities will be investigated. The discoveries that we make as a result will challenge the idea of consciousness and the special place of humans in the world.

In a further redefinition of what it means to be human, artificial selection of human beings (like in Gattaca) could become the norm in 150 years as it is seen as a more efficient way to improve life expectancy and compete against bacterial and viral resistance to drugs. In fact if discoveries in neuroscience confirm that it is the brain that is responsible for the

experience of "self" then people may choose to inhabit new bodies by swapping their old ones for newer, biochemically more healthy bodies. This kind of trend eludes proper definition using current vocabulary.

If the growth in computer processing power and capacity continued at the current rate, perhaps the human body could be connected up to a supercomputer that would monitor its state and respond to any possible threats from bacteria, viruses, or rogue cells in the body itself. This would mark a huge change from the mostly responsive medicine that occurs in the world today, i.e. medicine delivered in response to visible symptoms, to preventative medicine, a system that keeps track of the body's performance all the time and nips any malfunctions in the bud.

Mysteries in biology such as the placebo effect may finally be understood as being the result of chemical signals within the body. Parallel to this, the next 150 years may finally see the death of pseudoscientific health practices such as homeopathy, just like the death of phrenology after the Victorian Era.

These are just some of the possibilities and yet I haven't even mentioned cloning, cognitive biology or psychology. Perhaps psychological illnesses will be the biggest incurable illnesses by 2159. Who knows? The truth will probably be even more incredible.

One hundred and fifty years is a long time and colossal changes could occur that we have no chance of predicting. In the 20th century, scientific progress has proceeded exponentially: with simultaneous increases in human population, interconnectedness of the population and average knowledge per person of the population. This led to an unprecedented yet always accelerating rate of change. To illustrate the point, supercomputers have now been developed that are capable of performing calculations that would have appeared unthinkably complicated to scientists even 30 years ago.

The funny thing is, these scientists are still living today.

Such is the pace of change in an exponential world.

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