RAFFLES INSTITUTION
YEAR 5 GENERAL PAPER – SCIENCE & TECHNOLOGY
STUDENTS' INFORMATION PACKAGE 2024

**** denotes foundational readings***

Science & Technology

Enduring Understanding(s):

What will students understand as a result of this unit?

The nature of science:

1. Science attempts to understand, explain and predict the world we live in, through diverse methods of experimentation or observation and theory construction.
2. Like all other disciplines, science rests on assumptions, which may or may not be justifiable.
3. The relationship between science and religion, in the particular the question of their compatibility, is a subject of continued debate.

Science and society:

4. Science is a social enterprise, informed and affected by perspectives, values and interests. Scientific discovery, technological change and social change affect one another and cannot be discussed in isolation.
5. In this way, technology has far-reaching effects, both positive and negative, on norms, values and quality of life.
6. The negative effects and ethical concerns revolving around scientific research as well as technological tools have resulted in calls for regulatory measures.
7. Science, like all other fields, is affected by issues of funding and concerns of profit and practicality.
8. This has an impact on issues such as accessibility to technology, ethical usage and how research is prioritised.
9. For science to advance the human condition, there must be a reciprocal relationship based on trust and respect between it and the society it serves.

Essential Questions:

What are the essential questions of this unit?

1. Is science truly objective and reliable?
2. Should science always serve a practical purpose?
3. What ethical issues may arise in scientific endeavours?
4. How do consumer interest and profit motive affect the field of science?
5. Does more advanced technology necessarily improve lives? / What is the positive and negative impact (individual, social, political, and economic) of technology?
6. Who should be responsible for how science and technology are used in society?
7. To what extent can regulation be effective?
8. How do we balance the different functions of Science and Technology – profit, source of knowledge and human need/problems?
9. Should science and technology be expected to solve all problems society faces?

Essay Questions:

Science and Ethics

Ethics in scientific pursuits

1. Consider the view that spending money on space travel cannot be justified in today's world. (Cambridge 2023)
2. Can space travel ever be justified? (RI Y6 Common Test 2022)
3. 'There is no value in believing in something unless it can be scientifically proven.' How far is this true? (RI Y6 Prelims 2021)
4. Is it fair to say that investment in space exploration is a total waste of resources? (RI Y6 Prelims 2021)
5. Can the use of animals for scientific research ever be justified? (Cambridge 2017)
6. How far do you agree that space exploration is irrelevant to the average person? (RI Y6 CT1 2017)
1. To what extent is space exploration justifiable today? (RI Y5 Promo 2017)
2. Do you agree that exploring space should not be a priority in today's world? (Y5 Promo 2014)
3. Is the pursuit of nuclear technology still desirable in today's society? (RI Y6 Prelim 2013)
4. Can space research be justified nowadays? (Cambridge 2011)
5. Can national nuclear programmes ever be justified? (RI Y6 Prelim 2011)
6. 'The dangers of nuclear energy far outweigh its benefits.' Discuss. (RI Y5 CT 2011)

Science and other human institutions

1. 'There needs to be more emphasis on the arts in the school curriculum than the sciences.' How far do you agree? (RI Y6 CT 2023)
2. 'As Science advances, religion declines.' What is your view? (RI Y5 Promos 2022)
3. 'The arts ask questions while science provides answers.' How valid is this view? (RI Y6 Prelims 2021)
4. Consider the argument that the world would be a better place if people put their faith in science rather than in religion. (RI Prelim 2018)
5. 'The progress of a society is sustained by the sciences rather than the arts.' How far do you agree with this statement? (RI Y6 Prelim 2016)
6. To what extent do we need religion when science can answer most of our questions? (RI Y6 CT2 2016)
7. 'Human actions should be based on scientific fact, not religious faith.' How far do you agree with this statement? (Cambridge 2015)
8. Consider the view that science serves mankind better than religion. (RI Y6 Prelim 2015)
9. 'Science requires more thinking than the Arts.' Is this true? (RI Y6 CT1 2014)

Science and Money

1. How far should profit be the aim of scientific or technological developments? (RI Y5 Promos 2022)
2. Can research into costly technology ever be justified? (RI Y6 T1 Timed Practice 2022)
3. 'In today's world, only scientific research with practical value is worth funding.' Discuss. (RI Y6 Prelim 2020)
4. Do you agree that the benefits of technology are only enjoyed by the rich? (RI Promo 2019)
5. 'Science and business should never mix.' How far do you agree? (RI Y6 CT1 2019)

6. 'Human need, rather than profit, should always be the main concern of scientific research.' Discuss. (Cambridge 2016)
7. 'We should only fund scientific research that improves our quality of life.' Discuss. (RI Y6 CT1 2015)
8. Examine the extent to which expenditure on arms and the armed forces is justifiable in the modern world. (Cambridge 2014)
9. 'Science and profit should never mix.' Comment. (RI Y5 Promo 2013)
10. How far is it acceptable for technology to be used only for financial benefit? (Cambridge 2012)
11. Should scientific research be largely driven by commercial interests? (RI Y6 CT 2012)
12. To what extent is it acceptable for private companies to be involved in financing scientific research? (Cambridge 2011)
13. Should Science serve only the public good and not private gain? (Y5 CT 2010)

Bioethics and public health

1. To what extent has modern medicine removed the need for traditional remedies? (RI Y6 T1 Timed Practice 2022)
2. Should we be concerned with the ethics of medical research when doing so will limit its effectiveness? (RI Y6 Prelims 2021)
3. 'Leading healthy lives is increasingly challenging in today's world. Discuss. (RI Y5 Promo 2019)
4. 'Now more than ever, it is challenging to lead a healthy life.' To what extent is this true in your society? (RI Y6 Prelim 2018)
5. To what extent should the state have a right to intervene in the decisions of individuals when it comes to matters of health? Discuss this with regard to your society. (RI Y6 CT1 2018)
6. How effectively is public health promoted and managed in your society? (Cambridge 2015)
7. Consider the view that advances in gene therapy research have gone too far. (RI Y6 CT1 2014)
8. 'Scientific research into health and diet is unreliable as it so often contradicts itself.' Is this a fair comment? (Cambridge 2013)
9. To what extent should the sale of human organs be made legal? (RI Y6 CT1 2013)
10. Should people be allowed to have children by artificial means? (Cambridge 2012)
11. Should everyone be expected to donate suitable organs after death? (Cambridge 2012)
12. How far should medical resources be used to extend life expectancy? (Cambridge 2011)

Role of Science & Regulating it

1. 'The results of scientific research should be available to everyone.' How far do you agree? (Cambridge 2022)
2. 'We cannot trust science to provide an effective answer to our environmental concerns.' Discuss. (RI Y6 Common Test 2022)
3. Is modern technology a benefit or threat to our safety? (RI Y6 Prelims 2021)
4. To what extent should politicians have a say in scientific research? (RI Y6 CT 2021)
5. Examine the view that the scientist is concerned only with knowledge, not morality. (Cambridge 2020)
6. 'Non-scientists should have little say in how scientific developments are managed.' What is your view? (RI Y6 Common Essay Assignment 2020)
7. 'Scientists should determine how inventions and discoveries are used.' To what extent is this an acceptable view? (RI Y5 Promo 2020)
8. Should we place limits on scientific or technological developments when they have solved many of our problems? (RI Y6 Prelim 2019)
9. Consider the view that there is an increasing need to rebuild trust in science today.' (RI Y6 CT1 2018)
10. 'Our job as scientists is to find the truth.' How far do you agree that this view accurately reflects the role of scientists today? (RI Y5 Promo 2018)

11. ‘Scientific research without limits is undesirable.’ To what extent do you agree? (RI Y5 Promo 2017)
12. How far should technological developments be regulated? (RI Y5 Promo 2016)
13. ‘Unlimited scientific research is the only way to make real scientific progress.’ Do you agree? (RI Y6 Prelim 2015)
14. ‘Science will always have noble intentions.’ Discuss. (RI Y6 CT2 2015)
15. To what extent is it desirable to place limits on scientific research? (RI Y5 Promo 2015)
16. To what extent can the regulation of scientific or technological developments be justified? (Cambridge 2014)
17. To what extent should we limit technology’s influence on sports? (RI Y6 CT2 2014)
18. ‘Science gathers knowledge faster than society gathers wisdom.’ Do you agree? (RI Y6 CT2 2013)
19. ‘Moral considerations hinder scientific progress.’ Comment. (RI Y6 CT1 2012)
20. Do you agree that the barriers to scientific research in the 21st century are more ideological than technological? (RI Y6 CT2 2011)
21. ‘Scientific decisions should be left to scientists.’ To what extent do you agree? (RI Y6 Prelim 2010)
22. Do moral judgements compromise the true spirit of scientific inquiry? (RI Y6 CT1 2010)

Technology’s Impact on Society

Broad impact/reliance as well as in specific areas

1. Discuss the claim that modern technology has made it more difficult for political leaders to govern today. (RI Y6 Timed Practice 2024)
2. ‘Fossil fuels should no longer have a part in the production of energy.’ Discuss. (Cambridge 2023)
3. ‘It is harder than ever to keep children safe in today’s world.’ Comment. (RI Y6 CT 2023)
4. ‘The quality of human interaction is diminished by modern communication devices.’ How far do you agree? (RI Y6 Timed Practice)
5. ‘Technology has changed the world of sport, but not always for the better.’ Discuss. (RI Y6 Timed Practice)
6. Will technology completely replace the role of humans in the future? (RI Y6 Prelims 2022)
7. How far would you agree that technological progress has done more harm than good for gender equality? (RI Y6 Timed Practice 2021)
8. Is modern technology a benefit or a threat to democracy? (Cambridge 2020)
9. Is it fair to say that technology has only worsened conflict in society? (RI Y6 Timed Practice 2020)
10. Does modern technology always have a positive impact on education? (RI Y6 Common Essay Assignment 2020)
11. ‘Technology is advancing too fast.’ Is this a fair comment? (RI Y5 Promo 2020)
12. How far should we embrace the increasing use of technology in the world today? (RI Y5 Timed Practice 2020)
13. To what extent is artificial intelligence replacing the role of humans? (Cambridge 2019)
14. Discuss the claim that science has a positive impact on sport today. (RI Y6 CT2 2019)
15. Has technology made us less human? (RI Y6 CT1 2019)
16. In an age of rapid technological advancement, is a single career for life realistic? (Cambridge 2018)
17. ‘In today’s society, people are slaves to technology.’ What is your view? (RI Y6 Prelim 2018)
18. Now more than ever, scientific pursuits must be undertaken only to achieve practical ends.’ Do you agree? (RI Y6 CT1 2018)

19. To what extent has technology had a negative impact on the arts, such as music or photography? (RI Y6 CT1 2018)
20. Assess the impact of technology on health in today's world. (RI Y5 Promo 2018)
21. Should we be concerned that machines are replacing us at the workplace? (RI Y5 CT 2017)
22. Are machines making humans obsolete? (RI Y6 Prelim 2017)
23. How far has modern technology made it unnecessary for individuals to possess mathematical skills? (Cambridge 2016)
24. 'Modern technology always improves the quality of people's lives.' Discuss. (RI Y6 Prelim 2016)
25. To what extent does technology make us more skillful? (RI Y6 CT2 2016)
26. Why should we bother with remembering when technology can do it for us? (RI Y6 CT1 2016)
27. 'Books serve little purpose in education as technological developments become more sophisticated.' How far do you agree? (Cambridge 2015)
28. In the digital age do newspapers still have a role in society? (RI Y6 Prelim 2015)
29. Is a fear of artificial intelligence justifiable? (RI Y5 Promo 2015)
30. Are we overly dependent on digital technology? (RI Y5 CT1 2015)
31. Is it foolish to be wary of scientific progress? (RI Y5 Promo 2014)
32. Discuss the view that too much faith is placed in scientific knowledge. (RI Y5 Promo 2014)
33. 'Technological advancement has worsened the problem of poverty.' Do you agree? (RI Y5 CT 2014)
34. 'Technology alienates people more than it serves to bring them together.' Discuss. (RI Y6 CT1 2013)
35. Does technology always make life better? (RI Y5 CT1 2013)
36. Discuss the extent to which it has become harder to lead healthy lives today. (RI Y6 CT2 2012)
37. 'Technology has failed to simplify our lives.' To what extent is this true? (RI Y5 Promo 2012)
38. Does technology facilitate crime? (RI Y6 CT1 2011)
39. To what extent has technology had a negative impact on the skill levels of the people? (Cambridge 2010)
40. 'We have become a people unable to comprehend the technology we invent.' Discuss. (RI Y6 CT2 2010)
41. Would you agree that modern technology addresses our human desires more than our needs? (RI Y5 Promo 2010)

Effectiveness in Solving Human Problems

1. 'The solution to climate change is not to be found in technology but by having a simpler lifestyle.' How far do you agree? (RI Y6 Prelim 2023)
2. Do you agree that the promises of technology are exaggerated? (RI Y6 Timed Practice 2023)
3. Do you agree that the use of technology for education is not always beneficial? (RI Y5 CT 2023)
4. To what extent do you agree that the widespread use of artificial intelligence will improve our lives? (RI Y5 Promos 2022)
5. 'Scientific advancement breeds complacency.' How far do you agree? (Cambridge 2021)
6. 'The solution to global hunger is simply about providing more food.' How far do you agree? (RI Y6 Timed Practice 2022)
7. 'To be effective, schools must turn to technology.' How true is this of education today? (RI Y6 CT 2021)
8. Is our trust in science misplaced? (RI Y6 Timed Practice 2020)
9. 'Artificial intelligence creates more problems than benefits.' Discuss (RI Y6 Prelim 2019)
10. Consider the impact of technology on world hunger today. (RI Y6 CT2 2019)
11. 'Science is the only answer to global hunger.' Discuss. (Cambridge 2019)
12. 'Science is Man's best hope for creating a better world.' How far would you agree? (RI Y6 CT2 2018)
13. Should we even be wary of artificial intelligence? (RI Y6 CT2 2018)

14. How far can scientific or technological developments be a solution to global problems? (RI Y5 CT1 2018)
15. How far is science fiction becoming fact? (Cambridge 2017)
16. 'Scientific knowledge cannot be trusted because it is unreliable.' Is this a fair statement? (RI Y6 Prelim 2017)
17. How effective is technology in making us healthier? (RI Y6 Prelim 2017)
18. 'The idea that science and technology will solve our problems is a delusion.' Discuss. (RI Y6 CT2 2017)
19. Do you agree that science offers us the best way to deal with poor health? (RI Y5 Promo 2017)
20. How far do you agree that science and technology promises more than it can deliver? (RI Y5 Promo 2016)
21. 'Science creates more problems than it seeks to solve.' Comment. (RI Y5 CT 2016)
22. To what extent can technology be a solution to social problems? (RI Y6 CT1 2015)
23. Is a fear of artificial intelligence justifiable? (RI Y5 Promo 2015)
24. Discuss the view that, with an increasing global need for energy, every possible source should be exploited. (Cambridge 2014)
25. Discuss how robotics contributes to the modern world. (RI Y6 CT2 2014)
26. Do you agree that the best way to combat disease is through science? (RI Y6 Prelim 2014)
27. 'The problem of global food shortage can never be resolved.' Do you agree? (RI Y6 Prelim 2013)
28. Consider the view that modern technology is the only answer to world hunger. (RI Y6 Prelim 2012)
29. Consider the view that most work these days could, and should, be done from home. (Cambridge 2011)
30. 'Science is unreliable, being based as much on theory as on fact.' Is this a fair comment? (Cambridge 2011)
31. 'The key to good health is lifestyle rather than medicine.' How far do you agree? (Cambridge 2010)
32. Discuss the view that science and technology gives us hope for the future. (RI Y5 Promo 2011)
33. 'One ounce of prevention is worth a pound of cure.' Discuss this statement with reference to the role of modern medicine in the world today. (RI Y6 CT2 2010)

Mathematics

1. Consider the view that mathematics is of little interest to most people as it is too complex. (Cambridge 2022)
2. Where there is mathematics, there is beauty.' Do you agree? (RI Y6 CT 2021)
3. How reliable are statistics as a guide for planning the future? (Cambridge 2020)
4. Evaluate the claim that statistics is more misleading than helpful. (RI Y6 Prelim 2018)
5. How far has modern technology made it unnecessary for individuals to possess mathematical skills? (Cambridge 2016)
6. To what extent can Mathematics be considered a form of art? (RI Y6 Prelim 2015)
7. 'Mathematics is the most reliable way of understanding the world.' Discuss. (RI Y5 Promo 2015)
8. 'Unlike the Arts, such as writing or music, Mathematics lacks the capacity for creativity.' How far do you agree with this statement? (Cambridge 2013)
9. Consider the view that mathematics possesses not only truth, but supreme beauty. (Cambridge 2012)
10. Can mathematics be seen as anything more than a useful tool in everyday life? (Cambridge 2010)

SECTION A: FOUNDATIONAL CONCEPTS

Reading 1: What is science? **EU 1 and 2**

Adapted from Chapters 1 & 2 of Philosophy of Science: A Very Short Introduction (2nd Ed) | Samir Okasha | 2016

This reading will help you:
- Identify some criteria that define science.
- Consider how valid these criteria are.
- Re-evaluate the notions you may have about how science "works".

What is science? What is it that *makes* something a science? Surely science is just the attempt to understand, explain and predict the world we live in? But is it the whole story? After all, the various religions also attempt to understand and explain the world, but religion is not usually regarded as a branch of science. Similarly, astrology and fortune-telling are attempts to predict the future, but most people would not describe these activities as science. Or consider history. Historians try to understand and explain what happened in the past, but history is usually classified as an arts subject, not a science subject.

Many people believe that the distinguishing features of science lie in the particular methods scientists use to investigate the world. This suggestion is quite plausible. For many sciences do employ distinctive methods of enquiry that are not found in non-scientific disciplines. An obvious example is the use of experiments. Not all sciences are experimental though – astronomers obviously do not do experiments on the heavens, but have to contend themselves with careful observation instead. The same is true of many social sciences. Another important feature of science is the construction of theories. Scientists usually want to explain results in terms of a general theory. It is an important problem to understand how techniques such as experimentation, observation and theory-construction have enabled scientists to unravel so many of nature's secrets.

Science vs. Pseudo-science

Karl Popper, an influential 20th century philosopher of science, thought that the fundamental feature of a scientific theory is that it should be falsifiable. To call a theory falsifiable is not to say that it is false. Rather, it means that the theory makes some ***definite predictions that are capable of being tested against experience***. If these predictions turn out to be wrong, then the theory has been falsified or disproved. So a falsifiable theory is one that we might discover to be false – it is not compatible with every possible course of experience. Popper thought that some supposedly scientific theories did not satisfy this condition and thus did not deserve to be called science at all; rather they were merely pseudo-science.

Karl Marx ("father" of modern communist ideology") claimed that in industrialised societies, capitalism would give way to socialism and ultimately to communism. But when this didn't happen, instead of admitting that Marx's theory was wrong, Marxists would invent an ad hoc explanation for why what happened was actually perfectly consistent with their theory. For example, they might say that the inevitable progress to communism had been temporarily slowed by the rise of the welfare state, which 'softened' the proletariat and weakened their revolutionary zeal. In this sort of way, Marx's theory could be made compatible with any possible course of events. Therefore, Marx's theory does not qualify as genuinely scientific, according to Popper's criterion.

Popper contrasted Marx's theory with Einstein's theory of gravitation, also known as general relativity. Unlike Marx's theory, Einstein's theory made a very definite prediction: that light rays from distant stars would be deflected by the gravitational field of the sun. Normally this effect would be impossible to observe – except during a solar eclipse. In 1919, Sir Arthur Eddington organised two expeditions to

observe the solar eclipse of that year, one to Brazil and one to the island of Principe off the Atlantic coast of Africa. The expeditions found that the starlight was indeed deflected by the sun, by almost exactly the amount Einstein had predicted. Einstein had made a definite, precise prediction, which was confirmed by observations. Had it turned out that starlight was not deflected by the sun, this would have shown that Einstein was wrong. So Einstein's theory satisfies the criterion of falsifiability.

Some regard Popper's criterion as overly simplistic. Popper criticized Marxists for explaining away data that appeared to conflict with their theories, rather than accepting that the theories had been refuted. However, this very procedure is routinely used by 'respectable' scientists and has led to important scientific discoveries. Newton's gravitational theory, for example, made predictions about the paths the planets should follow as they orbit the sun. For the most part, these predictions were borne out by observation. However, the observed orbit of Uranus consistently differed from what Newton's theory predicted. This puzzle was solved in 1846 by Adams and Leverrier, working independently. They suggested that there was another planet, as yet undiscovered, exerting an additional gravitational force on Uranus. Shortly afterwards, the planet Neptune was discovered, almost exactly where Adams and Leverrier had predicted.

Now clearly we should not criticise Adams and Leverrier's behaviour as 'unscientific'. But they did precisely what Popper criticised the Marxists for doing. They began with a theory – Newton's theory of gravity – which made an incorrect prediction about Uranus' orbit. Rather than concluding that Newton's theory must be wrong, they stuck by the theory and attempted to explain away the conflicting observations by postulating a new planet. Similarly, when capitalism showed no signs of giving way to communism, Marxists did not conclude that Marx's theory must be wrong, but stuck by the theory and tried to explain away conflicting observations in other ways.

This suggests that Popper's attempt to demarcate science from pseudo-science cannot be quite right. For the Adams/Leverrier example is by no means atypical. In general, scientists do not just abandon their theories whenever they conflict with observational data. Usually, they look for ways of eliminating conflict without giving up their theory. And it is worth remembering that virtually every theory in science conflicts with some observations – finding a theory that fits all the data perfectly is extremely difficult. Obviously, if a theory persistently conflicts with more and more data, and no plausible ways of explaining away the conflict are found, it will eventually have to be rejected. But little progress would be made if scientists simply abandoned their theories at the first sign of trouble. The failure of Popper's criterion throws up an important question: Is it actually possible to find some common feature shared by all things we call 'science' and not shared by anything else? Popper's assumption that science has an essential nature is questionable. After all, science is a heterogeneous activity, encompassing a wide range of different disciplines and theories. It may be that they share some fixed set of features that define what it is to be a science, but it may not – in which case a simple criterion for demarcating science from pseudo-science is unlikely to be found.

Scientific reasoning

Consider the following argument: The first five eggs in this carton were rotten. All the eggs have the same expiry date stamped on them. Therefore, the sixth egg will be rotten too. This looks like a perfectly sensible piece of reasoning. But nonetheless it is not a proof. Even if the first five eggs were indeed rotten, and even if all the eggs do have the same expiry date, this does not guarantee that the sixth egg will be rotten too. It is logically possible for the premises of this inference to be true, yet the conclusion false. This kind of inference is known as inductive inference – moving from premises about objects we have examined to conclusions about objects we have not examined (in this example, eggs). We rely on inductive reasoning throughout our lives. For example, when you turn on your computer, you are confident it will not explode in your face. Why? Because you turn on your computer every day and it has never exploded in your face up to now. The inference from 'up until now, my computer has

not exploded when I turned it on' to 'my computer will not explode when I turn it on this time' is inductive. The premise of this inference does not entail the conclusion. It is logically possible that your computer will explode this time, even though it has never done so previously.

Do scientists use inductive reasoning too? The answer seems to be yes. Consider the genetic disease known as Down's syndrome (DS). Geneticists tell us DS sufferers have an additional chromosome – they have 47 instead of the normal 46. How do they know this? The answer, of course, is that they have examined a large number of DS sufferers and found that each has an additional chromosome. It is easy to see that the inference is inductive. The fact that the DS sufferers in the sample studied had 47 chromosomes doesn't prove that all DS sufferers do. It is possible, though unlikely, that the sample was an unrepresentative one. In effect, scientists use inductive reasoning whenever they ***move from limited data to a more general conclusion***. But what justifies the faith we place in induction?

The Scottish philosopher David Hume argued that we can give no satisfactory answer. He began by noting that whenever we make inductive inferences, we seem to presuppose the ***'uniformity of nature'*** (UN). To see what Hume means by this, recall the inductive inferences above (eggs; computer; DS; even Newton's law of gravity). In each of these cases, our reasoning seems to depend on the assumption that objects we haven't examined will be similar in the relevant respects, to objects of the same sort that we have examined. That assumption is what Hume means by UN.

But how do we know that the UN assumption is actually true? Imagine how you would go about persuading someone who doesn't trust inductive reasoning. You would probably say: 'Look, inductive reasoning has worked pretty well up to now. By using induction, scientists have split the atom, landed men on the moon, invented computers, and so on.' But of course, this wouldn't convince the doubter. For to argue that induction is trustworthy because it has worked well *up to now* is to reason in an inductive way! Such an argument would carry no weight with someone who doesn't *already* trust induction. That is Hume's fundamental point.

Normally we think of science as the very paradigm of rational enquiry. We place great faith in what scientists tell us about the world. But science relies on induction, and Hume's argument seems to show that induction cannot be rationally justified. If Hume is right, the foundations on which science is built do not look quite as solid as we might have hoped.

For discussion/reflection:

- In the section "Science vs. Pseudo-Science", Okasha presents a view that he disagrees with, then an argument against this view. Mark where Okasha: **(i)** presents the opposing view; **(ii)** explains the opposing view; **(iii)** illustrates the opposing view; **(iv)** makes a concession; **(v)** presents a counter-argument; **(vi)** uses illustration to develop the counter-argument; **(vii)** draws a conclusion.
- According to the section "Scientific Reasoning", what assumption do we have to make in order to do science, and why? Why is it difficult to justify this assumption? What does this imply about the "rationality" of scientific thought & practice?
- The illustration the author makes concerning uniformity of nature (UN) demonstrates that science & scientists also rely on a certain amount of trust in the scientific process and progress. How different or similar do you think the trust scientists and non-scientists have in scientific knowledge is compared to religious faith? Explain and illustrate your answer.

Related Cambridge/RI essay questions:

1. 'There is no value in believing in something unless it can be scientifically proven.' How far is this true? (RI Y6 Prelims 2021)
2. Examine the view that the scientist is concerned only with knowledge, not morality. (Cambridge 2020)
3. Is our trust in science misplaced? (RI Y6 Timed Practice 2020)

Reading 2: Why philosophy is at the heart of science **EU 2**

From Why Philosophy is so important in science education | Dr Subrena E Smith | Quartz | 20 November 2017

This reading will help you understand:

- The value of applying philosophical thinking to science
- Key misconceptions concerning why philosophy is separate and subordinate to science, and why these kinds of thinking is wrong
- How philosophers and scientists should collaborate to promote scientific advancement and understanding

Each semester, I teach courses on the philosophy of science to undergraduates at the University of New Hampshire. Most of the students take my courses to satisfy general education requirements, and most of them have never taken a philosophy class before.

On the first day of the semester, I try to give them an impression of what the philosophy of science is about. I begin by explaining to them that philosophy addresses issues that can't be settled by facts alone, and that the philosophy of science is the application of this approach to the domain of science. After this, I explain some concepts that will be central to the course: induction, evidence, and method in scientific enquiry. I tell them that science proceeds by induction, the practices of drawing on past observations to make general claims about what has not yet been observed, but that philosophers see induction as inadequately justified, and therefore problematic for science. I then touch on the difficulty of deciding which evidence fits which hypothesis uniquely, and why getting this right is vital for any scientific research. I let them know that 'the scientific method' is not singular and straightforward, and that there are basic disputes about what scientific methodology should look like. Lastly, I stress that although these issues are 'philosophical', they nevertheless have real consequences for how science is done.

At this point, I'm often asked questions such as: 'What are your qualifications?' 'Which school did you attend?' and 'Are you a scientist?'

Perhaps they ask these questions because, as a female philosopher of Jamaican extraction, I embody an unfamiliar cluster of identities, and they are curious about me. I'm sure that's partly right, but I think that there's more to it, because I've observed a similar pattern in a philosophy of science course taught by a more stereotypical professor. As a graduate student at Cornell University in New York, I served as a teaching assistant for a course on human nature and evolution. The professor who taught it made a very different physical impression than I do. He was white, male, bearded and in his 60s – the very image of academic authority. But students were skeptical of his views about science, because, as some said, disapprovingly: 'He isn't a scientist.'

I think that these responses have to do with concerns about the value of philosophy compared with that of science. It is no wonder that some of my students are doubtful that philosophers have anything useful to say about science. They are aware that prominent scientists have stated publicly that philosophy is irrelevant to science, if not utterly worthless and anachronistic. They know that STEM

(science, technology, engineering and mathematics) education is accorded vastly greater importance than anything that the humanities have to offer.

Many of the young people who attend my classes think that philosophy is a fuzzy discipline that's concerned only with matters of opinion, whereas science is in the business of discovering facts, delivering proofs, and disseminating objective truths. Furthermore, many of them believe that scientists can answer philosophical questions, but philosophers have no business weighing in on scientific ones.

Why do college students so often treat philosophy as wholly distinct from and subordinate to science? In my experience, four reasons stand out.

One has to do with a lack of historical awareness. College students tend to think that departmental divisions mirror sharp divisions in the world, and so they cannot appreciate that philosophy and science, as well as the purported divide between them, are dynamic human creations. Some of the subjects that are now labelled 'science' once fell under different headings. Physics, the most secure of the sciences, was once the purview of 'natural philosophy'. And music was once at home in the faculty of mathematics. The scope of science has both narrowed and broadened, depending on the time and place and cultural contexts where it was practised.

Another reason has to do with concrete results. Science solves real-world problems. It gives us technology: things that we can touch, see and use. It gives us vaccines, GMO crops, and painkillers. Philosophy doesn't seem, to the students, to have any tangibles to show. But, to the contrary, philosophical tangibles are many: Albert Einstein's philosophical thought experiments made Cassini[1] possible. Aristotle's logic is the basis for computer science, which gave us laptops and smartphones. And philosophers' work on the mind-body problem set the stage for the emergence of neuropsychology and therefore brain-imagining technology. Philosophy has always been quietly at work in the background of science.

A third reason has to do with concerns about truth, objectivity and bias. Science, students insist, is purely objective, and anyone who challenges that view must be misguided. A person is not deemed to be objective if she approaches her research with a set of background assumptions. Instead, she's 'ideological'. But all of us are 'biased' and our biases fuel the creative work of science. This issue can be difficult to address, because a naive conception of objectivity is so ingrained in the popular image of what science is. To approach it, I invite students to look at something nearby without any presuppositions. I then ask them to tell me what they see. They pause… and then recognise that they can't interpret their experiences without drawing on prior ideas. Once they notice this, the idea that it can be appropriate to ask questions about objectivity in science ceases to be so strange.

The fourth source of students' discomfort comes from what they take science education to be. One gets the impression that they think of science as mainly itemising the things that exist – 'the facts' – and of science education as teaching them what these facts are. I don't conform to these expectations. But as a philosopher, I am mainly concerned with how these facts get selected and interpreted, why some are regarded as more significant than others, the ways in which facts are infused with presuppositions, and so on.

[1] Giovanni Cassini was an Italian astronomer and engineer most known for his discovery of Saturn's rings.

Students often respond to these concerns by stating impatiently that facts are facts. But to say that a thing is identical to itself is not to say anything interesting about it. What students mean to say by 'facts are facts' is that once we have 'the facts' there is no room for interpretation or disagreement. Why do they think this way? It's not because this is the way that science is practised but rather, because this is how science is normally taught. There are a daunting number of facts and procedures that students must master if they are to become scientifically literate, and they have only a limited amount of time in which to learn them. Scientists must design their courses to keep up with rapidly expanding empirical knowledge, and they do not have the leisure of devoting hours of class-time to questions that they probably are not trained to address. The unintended consequence is that students often come away from their classes without being aware that philosophical questions are relevant to scientific theory and practice.

But things don't have to be this way. If the right educational platform is laid, philosophers like me will not have to work against the wind to convince our students that we have something important to say about science. For this we need assistance from our scientist colleagues, whom students see as the only legitimate purveyors of scientific knowledge. I propose an explicit division of labour. Our scientist colleagues should continue to teach the fundamentals of science, but they can help by making clear to their students that science brims with important conceptual, interpretative, methodological and ethical issues that philosophers are uniquely situated to address, and that far from being irrelevant to science, philosophical matters lie at its heart.

For discussion/reflection:

1. How does Smith illustrate the skepticism that most science students have towards philosophy in lines 18-25?
2. Smith discusses the four reasons (lines 39-65) concerning why philosophy is incompatible with science. Which of those reasons resonate with you? Why?
2. Which argument made by the writer do you find most compelling? Why?
3. According to Smith, what is the main reason why science students end up not 'being aware that philosophical questions are relevant to scientific theory and practice' (lines 78-79)?

Related Cambridge/RI essay questions:

1. 'Non-scientists should have little say in how scientific developments are managed.' What is your view? (RI Y6 Common Essay Assignment 2020)
2. 'Our job as scientists is to find the truth.' How far do you agree that this view accurately reflects the role of scientists today? (RI Y5 Promo 2018)
3. 'Science gathers knowledge faster than society gathers wisdom.' Do you agree? (RI Y6 CT2 2013)

Reading 3: Religion and science in conflict

Jerry Coyne | Yes, there is a war between science and religion | The Conversation | 21 December 2018

EU 1-3, 5

This reading will help you understand:

- What is common about the important role that science and religion each plays
- The differences or contrasts in terms of how science and religion each go about fulfilling their roles
- The reasoning behind why some believe that a conflict exists between them.

As the West becomes more and more secular, and the discoveries of evolutionary biology and cosmology shrink the boundaries of faith, the claims that science and religion are compatible grow louder. If you're a believer who doesn't want to seem anti-science, what can you do? You must argue that your faith – or any faith – is perfectly compatible with science.

And so one sees claim after claim from believers, religious scientists, prestigious science organizations and even atheists asserting not only that science and religion are compatible, but also that they can actually help each other. This claim is called "accommodationism." But I argue that this is misguided: that science and religion are not only in conflict – even at "war" – but also represent incompatible ways of viewing the world.

Opposing methods for discerning truth

My argument runs like this. I'll construe "science" as the set of tools we use to find truth about the universe, with the understanding that these truths are provisional rather than absolute. These tools include observing nature, framing and testing hypotheses, trying your hardest to prove that your hypothesis is wrong to test your confidence that it's right, doing experiments and above all replicating your and others' results to increase confidence in your inference.

And I'll define religion as does philosopher Daniel Dennett: "Social systems whose participants avow belief in a supernatural agent or agents whose approval is to be sought." Of course many religions don't fit that definition, but the ones whose compatibility with science is touted most often – the Abrahamic faiths of Judaism, Christianity and Islam – fill the bill.

Next, realize that both religion and science rest on "truth statements" about the universe – claims about reality. The edifice of religion differs from science by additionally dealing with morality, purpose and meaning, but even those areas rest on a foundation of empirical claims. You can hardly call yourself a Christian if you don't believe in the Resurrection of Christ, a Muslim if you don't believe the angel Gabriel dictated the Qur'an to Muhammad, or a Mormon if you don't believe that the angel Moroni showed Joseph Smith the golden plates that became the Book of Mormon. After all, why accept a faith's authoritative teachings if you reject its truth claims? Indeed, even the Bible notes this: "But if there be no resurrection of the dead, then is Christ not risen: And if Christ be not risen, then is our preaching vain, and your faith is also vain."

Many theologians emphasize religion's empirical foundations, agreeing with the physicist and Anglican priest John Polkinghorne:

"The question of truth is as central to [religion's] concern as it is in science. Religious belief can guide one in life or strengthen one at the approach of death, but unless it is actually true it can do neither of these things and so would amount to no more than an illusory exercise in comforting fantasy."

The conflict between science and faith, then, rests on the methods they use to decide what is true, and what truths result: These are conflicts of both methodology and outcome.

In contrast to the methods of science, religion adjudicates truth not empirically, but via dogma, scripture and authority – in other words, through faith, defined in Hebrews 11 as "the substance of things hoped for, the evidence of things not seen." In science, faith without evidence is a vice, while in religion it's a virtue. Recall what Jesus said to "doubting Thomas," who insisted in poking his fingers into the resurrected Savior's wounds: "Thomas, because thou hast seen me, thou hast believed: blessed are they that have not seen, and yet have believed."

And yet, without supporting evidence, Americans believe a number of religious claims: 74 percent of us believe in God, 68 percent in the divinity of Jesus, 68 percent in Heaven, 57 percent in the virgin birth, and 58 percent in the Devil and Hell. Why do they think these are true? Faith.

But different religions make different – and often conflicting – claims, and there's no way to judge which claims are right. There are over 4,000 religions on this planet, and their "truths" are quite different. (Muslims and Jews, for instance, absolutely reject the Christian belief that Jesus was the son of God.) Indeed, new sects often arise when some believers reject what others see as true. Lutherans split over the truth of evolution, while Unitarians rejected other Protestants' belief that Jesus was part of God.

And while science has had success after success in understanding the universe, the "method" of using faith has led to no proof of the divine. How many gods are there? What are their natures and moral creeds? Is there an afterlife? Why is there moral and physical evil? There is no one answer to any of these questions. All is mystery, for all rests on faith.

The "war" between science and religion, then, is a conflict about whether you have good reasons for believing what you do: whether you see faith as a vice or a virtue.

Compartmentalizing realms is irrational

So how do the faithful reconcile science and religion? Often they point to the existence of religious scientists, like NIH Director Francis Collins, or to the many religious people who accept science. But I'd argue that this is compartmentalization, not compatibility, for how can you reject the divine in your laboratory but accept that the wine you sip on Sunday is the blood of Jesus?

Others argue that in the past religion promoted science and inspired questions about the universe. But in the past every Westerner was religious, and it's debatable whether, in the long run, the progress of science has been promoted by religion. Certainly evolutionary biology, my own field, has been held back strongly by creationism, which arises solely from religion.

What is not disputable is that today science is practiced as an atheistic discipline – and largely by atheists. There's a huge disparity in religiosity between American scientists and Americans as a whole: 64 percent of our elite scientists are atheists or agnostics, compared to only 6 percent of the general population – more than a tenfold difference. Whether this reflects differential attraction of nonbelievers to science or science eroding belief – I suspect both factors operate – the figures are prima facie evidence for a science-religion conflict.

The most common accommodationist argument is Stephen Jay Gould's thesis of "non-overlapping magisteria." Religion and science, he argued, don't conflict because: "Science tries to document the factual character of the natural world, and to develop theories that coordinate and explain these facts. Religion, on the other hand, operates in the equally important, but utterly different, realm of human

purposes, meanings and values – subjects that the factual domain of science might illuminate, but can never resolve."

This fails on both ends. First, religion certainly makes claims about "the factual character of the universe." In fact, the biggest opponents of non-overlapping magisteria are believers and theologians, many of whom reject the idea that Abrahamic religions are "empty of any claims to historical or scientific facts."

Nor is religion the sole bailiwick of "purposes, meanings and values," which of course differ among faiths. There's a long and distinguished history of philosophy and ethics – extending from Plato, Hume and Kant up to Peter Singer, Derek Parfit and John Rawls in our day – that relies on reason rather than faith as a fount of morality. All serious ethical philosophy is secular ethical philosophy.

In the end, it's irrational to decide what's true in your daily life using empirical evidence, but then rely on wishful-thinking and ancient superstitions to judge the "truths" undergirding your faith. This leads to a mind (no matter how scientifically renowned) at war with itself, producing the cognitive dissonance that prompts accommodationism. If you decide to have good reasons for holding any beliefs, then you must choose between faith and reason. And as facts become increasingly important for the welfare of our species and our planet, people should see faith for what it is: not a virtue but a defect.

Reflection questions and related Cambridge/RI essay questions are found at the end of Reading 4.

SECTION A: FOUNDATIONAL CONCEPTS

Reading 4: Where science and miracles meet in the contemporary world **EU 2 and 3**

Adapted from Where science and miracles meet in the contemporary world | Alan Lightman | Scientific American | 22 March 2011

This reading will help you to:

- Understand why the relationship between science and religion is still relevant in the modern world.
- Examine current developments in scientific research and how they might be aligned to religious and philosophical reasons that drive people's search for meaning and purpose in life.

On the morning of October 13, 1917, a year from the end of World War I, a crowd of tens of thousands gathered in the town of Fátima, Portugal. They came to witness a miracle. Three shepherd children had prophesied that the Virgin Mary would miraculously appear on that day and give the world a sign. In the previous several months, the three children—Lúcia Abobora, and Francisco and Jacinto Marto—had claimed to have seen apparitions, visions much discussed by the Portuguese press. On this day, the gathered pilgrims apparently got what they came for, a spectacle since referred to as "the Miracle of the Sun."

One journalist at the scene, Avelino de Almeida, an editor at O Século, reported in his paper:

> One can see the immense crowd turn toward the sun … and we hear the nearest spectators crying, "Miracle, miracle! Marvel, marvel!" Before the astonished eyes of the people … the sun has trembled, and the sun has made some brusque movements, unprecedented and outside of all cosmic laws—the sun has "danced." The greatest number avow that they have seen the trembling and

> dancing of the sun. Others, however, declare that they have seen the smiling face of the Virgin herself; swear that the sun turned around on itself like a wheel of fireworks, that it fell almost to the point of burning the earth with its rays.

According to the Pew Research Center, as many as 79 percent of Americans believe in miracles—events that lie outside natural law and any explanation by science. Not just the parting of the Red Sea or the resurrection of Jesus, but "supernatural" phenomena in the world of today: such things as ghosts, voices from the dead, instructions from God, accurate prophecies, sudden recoveries from grave illnesses, telekinesis, reincarnation. Hundreds of people write in to the evangelical Mario Murillo Ministries website with reports of miracles. A woman recently described there how her brother's stroke and paralysis in March 2019 had been cured overnight by prayer. The violinist and musician Bonnie Rideout wrote to me about her first miraculous experience: "An unexplainable light appeared before me in the alfalfa field. It was a ball of light about six feet off the ground, motionless and accompanied by a warm gentle breeze. I had a feeling of warmth and peace. It was the first experience I had that made me conscious of a mystical entity that has intentions and is aware of me always." These are just two accounts from the roughly 200 million miracle believers in the United States today. Many miracles are associated with God, but not all are. According to Pew, 65 percent of Americans believe in miracles not necessarily connected to God.

In contrast to this widespread belief in miracles, the great majority of scientists firmly and unequivocally reject anything "supernatural." Given some ostensibly miraculous event, almost all scientists will insist on a logical, rational, "natural" explanation. If no logical or rational explanation immediately presents itself, most scientists will conclude that a scientific explanation will eventually be forthcoming, rather than abandon their commitment to a totally lawful universe. This prevailing view was articulated to me recently by the Nobel Prize–winning biologist David Baltimore: "If I could not find any way out of believing that a miracle had occurred, would I then believe it to be a miracle? I think the answer is that I would still not believe it to be a miracle, only some outcome that I can't understand."

When believers and nonbelievers discuss or witness a seemingly miraculous event, they find little common ground. Such radically different attitudes represent radically different views of the world, which are largely impervious to argument or appearance and have some resonance with our deeply polarized society today. And yet, surprisingly, some recent proposals in physics reveal that believers and nonbelievers may have more in common than they think.

The miraculous has meaning and definition only by comparison with the non-miraculous. That is, for an event to be declared "supernatural," we must first have some concept of the "natural," the ordinary course of events. Early human beings had no such concept—except perhaps for individual deaths and the repeated rising and setting of the sun. Phenomena simply happened. Nature was strange, sometimes beautiful, largely unpredictable, and often frightening. Some concept of the "supernatural" must have been understood in the powers attributed to the gods and spirits of early civilizations. These mythic beings could perform feats beyond those possible for mortal flesh and blood.

The development of the so-called laws of nature in science, which began with the ancient Greeks, gave a sharper definition of the natural versus the supernatural. Around 250 B.C., Archimedes proposed his "law of floating bodies," which stated how much liquid would be displaced by a partially submerged object: a weight equal to the weight of the object, regardless of its size or shape. Isaac Newton was a landmark figure in the emerging concept of a lawful and miracle-free universe. His 1687 law of gravity—stating that the gravitational force between two objects is proportional to the product of

their masses and inversely proportional to the square of their distance apart—was not only one of the first mathematical expressions of a fundamental force underlying the motions of bodies. It was also the first proposal that a rule for the behavior of material bodies on Earth should apply in the heavens as well—that is, the first real understanding of the universality of a law of nature. Then, in the 19th century, physicists proposed and confirmed detailed laws for the behavior of electricity and magnetism. By 1900, the absolute inviolability of the laws of nature was well established as part of the central doctrine of science. In the thousands of natural phenomena that scientists have observed—from the orbits of planets to the firings of neurons to the radiation of atoms—they have always found rational, logical, and usually testable explanations, cementing their belief in the lawfulness and predictability of nature.

What is the origin of these strong commitments for and against miracles?

Part of the appeal of miracles was stated by the Scottish philosopher David Hume in his 1748 essay "Of Miracles": "The passion of surprise and wonder arising from miracles, being an agreeable emotion, gives a sensible tendency towards the belief of those events from which it is derived." In their book Wonders and the Order of Nature, the historians of science Lorraine Daston and Katharine Park document humankind's enchantment with wonders and oddities. Things that don't fit. Surprises and peculiarities. Miracles. Marco Polo enthuses over finding completely black lions in the Indian Kingdom of Quilon. Other travellers excitedly record gourds with little lamblike animals inside, beasts with the faces of humans and the tails of scorpions, unicorns, and people who vomit worms.

Ross Peterson, a psychiatrist practicing in the Boston area, told me: "We want miracles as a solution to helplessness. We want miracles for meaning at a deeper level. Miracles lift us out of a humdrum life." Peterson says that all of us fall on a spectrum, with hysterical emotion at one end and emotionless rigidity at the other. I would suggest that those of us who believe in miracles are more able to surrender ourselves fully to our emotional experiences and the nonmaterial world they might represent, without attempting to analyze or reduce such experiences. Those of us who become scientists, through our understanding of scientific achievements and especially the logical construction of the laws of nature, are satisfied by a fully lawful explanation of the world and see no reason to invoke anything supernatural. Scientists have such abiding faith in a lawful cosmos that any personal experience or recounted "story" that seems to violate the laws of nature is recast as "to be understood with a lawful explanation" rather than accepted as fundamentally unlawful or miraculous.

I remember when I first came to the "lawful explanation" viewpoint myself. At the age of 12 or 13, I began making pendulums by tying a fishing weight to the end of a string. I'd read in Popular Science or some similar magazine that the time for a pendulum to make a complete swing was proportional to the square root of the length of the string. With the help of a stopwatch and a ruler, I verified this wonderful law. Logic and pattern. Cause and effect. As far as I could tell, everything was subject to analysis and quantitative testing. I saw no reason to believe in supernatural events or in any other unprovable hypotheses.

To Hume's and Peterson's arguments, I would add one more suggestion as to why many of us believe in miracles. We desire escape from the limited capacities of our material bodies. We yearn for some kind of permanence, something eternal, something beyond our impending personal death. A world in which miracles occur might contain such a possibility. In this regard, it is not surprising that a survey by Pew's 2014 Religious Landscape Study found that 72 percent of Americans believe in heaven, defined as a place where "people who have led good lives are eternally rewarded."

Recent discoveries in science underscore the extreme commitments of believers and nonbelievers to their respective views of the world. In the 1960s, scientists first noticed what has become known as the "fine-tuning problem": The numerical value of many of the fundamental constants of nature, such as the speed of light or the strength of the forces in the nuclei of atoms, must lie within a narrow range for life to arise in our universe—not merely life similar to life on Earth, but any kind of life. For instance, if the strength of the nuclear force had been just a little greater, all of the hydrogen in the early universe would have fused to form helium. With no hydrogen remaining, there would be no water. Biologists believe that water, with its special chemical properties, is needed for life. By contrast, if the nuclear force had been just a little weaker, the bigger atoms needed for life, such as carbon and oxygen, could not hold together.

One of the most striking of these finely tuned constants is the amount of so-called dark energy in the cosmos. Dark energy, first discovered in 1998, fills up all of outer space and acts in the opposite way of normal gravity. It causes the galaxies to move away from one another with increasing speed. The density of dark energy has been measured to be about 100-millionth of an erg per cubic centimeter. If the amount of dark energy in our universe were a little larger than it actually is, gaseous matter could never have pulled together to form stars. A little smaller, and the universe would have recollapsed and ended before stars had time to form. Physicists have strong evidence that all of the bigger atoms needed for life were created at the centers of stars. Without stars, no big atoms and no life.

So how to explain this observed fine-tuning? Why should our universe care about life? There are two explanations, one offered by believers and one by nonbelievers. Believers give the argument of Intelligent Design: that the universe was designed by God, who wanted the universe to have life. Alvin Plantinga, a professor emeritus of philosophy at the University of Notre Dame, wrote, "It still seems striking that these constants should have just the values they do have … It is still much less improbable that they should have those values if there is a God who wanted a life-friendly universe." The majority of scientists are not comfortable with this argument—not because it invokes God, but because it invokes a cause not subject to rational analysis. An explanation that many scientists accept is what is called "the multiverse." If there are lots of universes with different properties—some with 17 dimensions or some with 12 dimensions, some with values of dark energy much larger or much smaller than in our universe, some with nuclear forces much stronger or weaker, and so on—then some of those universes would, by chance, have the right properties to make stars and life. Most would not. By definition, we live in one of the universes that permits life. According to this explanation, our universe is just an accident, a random throw of the dice. An analogous line of reasoning is the explanation of why our planet is the right distance away from the sun to have liquid water. If we were a bit closer, all of the water would evaporate in the high heat, and if we were a bit farther away, it would freeze in the cold. The scientific answer to that seemingly extraordinary fact is simply that there are lots of planets besides Earth. Some are the right distance from their central stars to have liquid water, but most are not.

The inconvenient truth about both of these explanations of the fine-tuning problem—intelligent design, on the one hand, and the existence of a multiverse, on the other—is that neither can be proved. Both must be taken as a matter of faith by their respective supporters. Believers cannot prove the existence of God, much less what God's intentions were in creating the universe. It is likely that scientists will never be able to prove that other universes exist. The different universes in the hypothesized multiverse can never communicate with one another for the infinite future. And if they were connected in some way in the infinite past, confirming that connection would present the same problems as understanding how our universe came into being before the Big Bang. Even with a theory,

testing that theory would be next to impossible. It is a testament to the powerful commitment of scientists to their belief in a totally lawful and miracle-free cosmos that they are willing to invoke a slew of probably unverifiable other universes to uphold their belief.

In 1934, the great philosopher of science Karl Popper introduced the concept of falsifiability in determining the boundaries of science. A scientific theory or idea can never be proved true, because we cannot be certain that tomorrow a new phenomenon won't contradict the theory. However, a scientific theory can certainly be proved wrong, or falsified, by the observation of a single phenomenon at odds with it. Popper argued that if a proposition or belief or theory could not be tested, and thus potentially proved wrong, it did not lie within the realm of what we call science. Philosophy or religion or mythology, perhaps, but not science.

Which brings us back to the proposal of the multiverse. Is it science or not? Are the many physicists who endorse the multiverse idea thinking as scientists? There is indeed a chain of scientific argument supporting the proposal. The Nobel Prize–winning physicist Steven Weinberg used the multiverse idea to predict the approximate value of dark energy before the value was discovered. And the Stanford University physicist Andrei Linde's theory of "eternal chaotic inflation" actually predicts the creation of multiple universes with different properties. But the multiverse idea remains untested and probably untestable.

So we have reached a paradox: The commitment to a totally scientific view of the world has led to theories that may be unscientific, according to Popper's definition of science. In a sense, the miracle believers and the miracle nonbelievers have found a bit of common ground. This is not to say that the transcendent experience of miraculous phenomena has somehow fused with the 0's and 1's of modern science, or that the worldviews of believers and nonbelievers have merged. But both believers and nonbelievers have sworn allegiance to concepts that cannot be proved. Those passionate beliefs must originate from somewhere deep inside our minds, a secret room that all of us share, vital and primitive, like the ancient rituals of our ancestors.

Reflection questions and related Cambridge/RI essay questions are found at the end of Reading 4.

SECTION A: FOUNDATIONAL CONCEPTS

Reading 5: Science and religion together benefits humanity **EU 1-3, 5**

Jeffrey Small | The Common Ground between Science and Religion, The Huffington Post | 30 Oct 2011

This reading will help you understand why:

- Acknowledging the contrasts that exist between science and religion need not necessarily entail that they are in conflict with each other
- How science and religion are on their own each inadequate in representing reality and guiding human progress and development

Which is more truthful: science or art? On its face, this question presents a false choice. Science and art belong to two separate realms. Both express deep truths about existence, but in very different ways. Science uses the symbolic form of mathematical equations to describe the mechanics of reality. Art uses paint, the written word, film and sculpture to depict the human condition and our relationship to the world around us. The scientific method is a rigorous "left-brain" activity. Art taps into our deepest emotions; its creation comes from a "right-brain" intuitive perception.

At the same time, these realms can overlap. The sciences of color theory and perspective have influenced artists for centuries. New technologies, like photography and computer graphics, have spawned new artistic mediums. On the other hand, many of our greatest scientific discoveries were conceived through sparks of creative insight. Astronomers and physicists often use terms like awe and beauty to describe the universe.

If we change the question to science versus religion, however, people flock to either pole of the debate. Some religious fundamentalists close their eyes to the scientific laws that make our 21st century lives possible in the name of preserving the literal words of scripture written down millennia ago by men who had a different understanding of how the universe worked. On the other extreme, scientific atheists look down their noses at those who hold religious beliefs as simpletons belonging to a different age.

The core problem in this debate stems from both sides overstretching their perspectives. A religious worldview that denies scientific knowledge will ultimately be doomed to irrelevancy. A scientific worldview without a larger philosophical, metaphysical or religious system in which to anchor itself strands one like a shipwreck survivor adrift in an ocean of meaninglessness. Neither science nor religion, on their own, can hold all of the answers to existence, but maybe together they can complement and strengthen each other.

Without the laws of physics, chemistry and biology, we wouldn't have cell phones, the Internet, cars, fresh food in our stores 24 hours a day, air conditioning or medicine. Would you fly in an airplane if the laws of aerodynamics didn't work every time? Our life expectancy has doubled in the last two centuries because of the advancement in our scientific knowledge.

Science excels at explaining the mechanics of how our universe works. In centuries past, humans filled in the gaps in their scientific knowledge with supernatural explanations: The sun moved across the sky because the earth was the center of the universe and Apollo pulled it in his chariot. Storms were vengeance from the gods who lived above. Humanity came into existence because a god formed us out of clay. Mental illness was seen as demonic possession. Scientific knowledge has now supplanted all of these supernatural explanations.

But as good as science is at explaining the *how* and the *what* of existence, it falls short with the *why* and the *should*. Science better describes mechanics than it does meaning. Notwithstanding The Big Bang, quantum theories of spontaneous creation of matter and energy, String Theory and concepts of a Multi-Verse, our vast scientific database still struggles to answer the most fundamental of all questions first posed by the Greek philosopher Parmenides in the fifth century B.C.E. and repeated by others through the ages: "Why is there not nothing?" On a personal level, this desire to understand the meaning of being may come out as "Who am I, and why am I here?"

Critics of religion enjoy pointing out how many wars and how much suffering has been caused in the name of religion. But only science has given us the tools to kill each other in ways never before imagined. Biologists have produced viral and bacterial weapons; chemists have developed gunpowder and ever more destructive explosives; physicists have given us the power to destroy our very existence with nuclear weapons. Scientific advances in mechanical and chemical engineering have made our businesses more productive than at any time in history, bringing us comfort and prosperity. These same advances have also polluted our environment to the point of endangering our planet.

We must also be careful not to overstate the infallibility of the scientific method. Scientific knowledge has inherent limitations. Science is not truth; it's an approximation of truth. Math has a beauty, an elegance, to it. But at its heart, math is nothing more than a symbolic representation of an underlying reality, just as language is a symbolic representation of ideas and concepts. Sometimes, we have a tendency to confuse the symbol with the underlying truth it represents. An ancient Chinese saying

cautions that “the finger pointing to the moon is not the moon.” Math, language and scientific theories are merely fingers pointing us toward greater truths.

The philosophical limits of math are no surprise to mathematicians. In 1931, Austrian mathematician Kurt Gödel’s Incompleteness Theorems showed that an arithmetical proof cannot be both complete and internally consistent within itself. In other words, the axioms of the system cannot be proven within the system. For any mathematical system to work, it must begin with certain assumptions.

Another limitation with the scientific method is that all scientific theories rely on human conception, interpretation and evaluation. The history of science shows that the process of one scientific theory supplanting another is a bumpy one. Twentieth century philosopher and historian Thomas Kuhn used the term paradigm shift to describe the upheaval that often accompanies a change in scientific perspective.

The Catholic Church’s reaction to Galileo is often held up as an example of the conflict between science and religion. Not only was Galileo required to recant his writings that argued for Copernicus’s heliocentric solar system rather than an earth-centered one, but the Church didn’t officially admit it was mistaken until 1992! However, Kuhn explained that much of the early resistance to a Copernican view of the universe came not from religious sources, but from other scientists. Bias, preconceived ideas, academic politics, ego and resistance to change are ever-present in scientific and academic communities and often result in institutional opposition to new theories, especially ground-breaking ones. Many scientists initially resisted Copernicus, Kepler and Galileo because they presented a new paradigm of the universe.

Centuries later, when Einstein proposed another fundamental shift in understanding space and time, his theories were also at first doubted by the physics community. In a twist of irony, Einstein himself later rejected the weirdness of the other great scientific breakthrough of his day, Quantum Mechanics. Declaring that “God does not play dice with the universe,” he never accepted the inherent randomness and unknowability of what has now become the most tested and verified scientific theory in history. These scientific disagreements continue today. Go to any research university and ask the theoretical physicists about the ultimate theory of existence, and you will hear heated debates.

As crucial as scientific knowledge is to our lives, it is not itself enough. We need a system of meaning that science alone does not provide. We need meaning not just to supply us a moral code to live by in our communities. We need meaning because humans crave meaning and purpose as worthy goals themselves. Religion doesn’t have to be the system that supplies meaning to our scientific understanding of the world; philosophy can also serve the same purpose. The point is that we need something more than science.

That science cannot provide all of the answers we seek should not, however, open the door to a religious fundamentalism that denies scientific theories like evolution. Nor should we assume that just because we do not understand an occurrence that it was miraculously caused. For someone who believes in a God-created universe, wouldn’t resisting scientific models of the universe be tantamount to resisting God’s creation? Why can’t our religious theories evolve with our understanding of the world, just as our scientific theories do? Must our religious doctrine be frozen in time from a different age thousands of years ago? What is truly infinite and ineffable will never be fully understood or articulated in its entirety. If we think of God not as static in history but immanent throughout, revelation will be an ongoing process — one we can and should participate in ourselves.

Many religious systems do not inherently contradict science. Buddhism, for example, does not depend on a deity for its path to salvation. Its meditation techniques are being studied in universities for the neurological changes they produce along with the corresponding health benefits. In the Judeo-

Christian tradition, where much of the science versus religion debate takes place, we have modern theologies fully compatible with a scientific worldview. Twentieth-century theologian Paul Tillich described God not as a supernatural being but as "the ground of being." Tillich's God is like the infinite ocean out of which each of us is but a wave, arising briefly and then falling back. Process theologians, beginning with Alfred North Whitehead, write of God as that creative power within the universe, a power that is both the source of existence and its boundary as well. They ask us to imagine that we are like cells in the divine body, each having influence over the other.

Atheist critiques of religion, like those from Oxford Biologist Richard Dawkins and Cambridge Physicist Stephen Hawking, are only valid in that they disprove a certain antiquated image of God — the grandfather in the sky who created the universe like a potter or a watchmaker might and who governs it like a cosmic chess master. If we allow our religions to evolve, we might find that science and religion can complement each other: each may open a different window into reality, just as art and science do.

For reflection/discussion:

Reading 3

- Coyne labels the claim that science and religion are compatible, 'accommodationism'. Explain how he uses language to criticise such claims.
- Coyne argues that contrary to some claims, religion too, make 'claims about reality' (lines 20-21). Summarise/explain his reasoning.
- According to Coyne, the 'methodology' (line 35) employed by religion contrasts sharply with that which is employed by science. List and explain the contrasts fully (Read the latter half of the same section carefully).
- a. Explain in your own words Stephen Jay Gould's thesis of 'non-overlapping magisteria' (lines 72-73) b. Outline Coyne's rebuttal of the above thesis c. Do you find his rebuttal convincing? Why or why not?
- What views do you hold about the conflict between science and religion? Consider people who are religious but are also considered people of science: i. Georges Lemaître – Founder of the Big Bang Theory ii. Gregor Mendel – Father of Modern Genetics iii. Johannes Kepler – Astronomer. Research on why they were personally able to reconcile science and religion.

Reading 4

- What are some reasons which sustain people's belief in miracles? What are some criticisms which scientists might offer in response?
- Identify the fields of scientific knowledge or expertise featured in the article. What do they reflect about human desires that science alone may not satisfy?
- The author identifies a key 'paradox' (line 165) in the concluding section of this paper. Identify and paraphrase 2-3 points that support his view.

Reading 5

- In the first three paragraphs, Small establishes his view that science and religion occupy different realms that do/should not necessarily overlap. Identify a specific phrase in paragraph four (lines 18-23) and explain how Small uses it to reinforce the view that science and religion do not necessarily conflict.
- According to Small, what is one way that science has, indeed, 'supplanted' (line 32) religion?
- What might the author's intention be, in raising the example of the Greek philosopher, Parmenides in line 38?
- Express the point that Small makes in Paragraph 8 (lines 41-47) as a topic sentence.
- In paragraphs 12 and 13 (lines 64-80), how does the author illustrate his view that the conflict between religion and science may have been overstated?
- The author believes that science and religion need each other in order to that humanity is able to progress and advance. Do you agree with this view? Why/why not?

Related Cambridge/RI essay questions:

1. 'As Science advances, religion declines.' What is your view? (RI Y5 Promos 2022)
2. 'There is no value in believing in something unless it can be scientifically proven.' How far is this true? (RI Y6 Prelims 2021)
3. Consider the argument that the world would be a better place if people put their faith in science rather than in religion. (RI Prelim 2018)
4. To what extent do we need religion when science can answer most of our questions? (RI Y6 CT2 2016)
5. How far do you agree that science and technology promises more than it can deliver? (RI Y5 Promo 2016)
6. 'Human actions should be based on scientific fact, not religious faith.' How far do you agree with this statement? (Cambridge 2015)
7. 'Science is unreliable, being based as much on theory as on fact.' Is this a fair comment? (Cambridge 2011)

SECTION B: SCIENCE AND BUSINESS

Reading 6: Bezos is pumping $10 billion into climate science. That's both good and bad, some scientists say.

EU 6-8

Sarah Kaplan and Andrew Freedman | The Washington Post | 26 February 2020

This reading will help you understand:

- Corporate philanthropy and the duality of its impact on scientific progress
- Why funding from the private sector has the potential to drive research and innovation, but there are concerns about its true agenda
- Why concerns about the funding of science by private industry are primarily due to differences in terms of how rigorous the process of securing funding is between investors and government agencies, and how findings may be used

Leigh Stearns thought she'd hit the jackpot when the Heising-Simons Foundation awarded her research team $6 million to study a collapsing glacier in Greenland. She had concerns about accepting private funding, which offered less transparency and less accountability to the public compared to federal money, she said. But government funding was scarce, and she sorely needed it for her work on the glacier, important for understanding sea level rise.

Then she saw the news this week that Jeff Bezos intends to give $10 billion to scientists, non-governmental organizations and activists working on climate change. The possibilities presented by that money were mind-boggling, the glaciologist said. But she also wondered about the implications of one person funding the fight against a problem that affects many.

As federal funding for climate research has stagnated and the U.S. government has forfeited its leadership on the issue, Bezos is one of a growing cadre of philanthropists who see an opportunity to set the agenda for climate mitigation and adaptation. At $10 billion, the Bezos Earth Fund is "in a class by itself," said one philanthropy expert — on par with what the United States spends on climate-related research and development in a year.

Yet even as scientists and activists have welcomed the influx of cash from the man who founded Amazon and owns The Washington Post, they caution against private individuals driving climate

science and the search for solutions. “To reach these kinds of ambitious climate goals . . . we’re talking about changing the way we do business, the way we live,” said economist Rachel Cleetus, policy director for the climate and energy program at the Union of Concerned Scientists. “I don’t think we want a system where climate and clean energy policies are co-opted by the private sector.”

A federal funding gap

David Sandalow, a public policy researcher at Columbia University who worked on environment and energy issues in the State Department and the Energy Department under presidents Bill Clinton and Barack Obama, said wealthy donors feel compelled to step into a vacuum left by the Trump administration.

In 2018, the U.N. Intergovernmental Panel on Climate Change projected that humanity must cut its greenhouse gas emissions 45 percent by 2030 and become carbon neutral by 2050 to avoid the worst effects of warming. The scientists estimated that it would require $2.4 trillion per year in climate research, innovation and adaptation measures to limit global average temperature rise to a more tolerable 1.5 degrees Celsius (2.7 degrees Fahrenheit) above pre-industrial levels.

The Trump administration rejects that science. President Trump withdrew the United States from the Paris climate agreement and has repeatedly sought to defund federal climate programs. His latest budget proposal would cut $1 billion from the Energy Department’s science office and reduce funding for the Environmental Protection Agency by 27 percent.

Congress has largely rebuffed those efforts. An analysis of the budgets for six federal agencies that fund scientific research — NASA, the National Oceanic and Atmospheric Administration, the National Science Foundation, the Energy Department, the U.S. Geological Survey and the Agriculture Department — found that $9.4 billion was dedicated to Earth and atmospheric research, environmental monitoring and clean energy projects for fiscal 2020.

Budgets for a few federal programs have even increased. Funding for the Energy Department’s Office of Energy Efficiency and Renewable Energy grew 50 percent in the last years to $2.85 billion. And despite Trump’s proposal to eliminate the Advanced Research Projects Agency-Energy, the high-tech research program’s budget has almost doubled since 2015. But overall spending on climate research is still “insufficient,” said Robin Bell, a longtime Antarctic researcher and president of the American Geophysical Union, which represents Earth and atmospheric scientists.

Meanwhile, other countries have stepped up investments. The European Union has committed to directing 25 percent of its budget — nearly $350 billion — toward climate objectives between 2021 and 2027. French President Emmanuel Macron explicitly sought to lure U.S.-based researchers by offering millions of Euros in grants. And China has probably surpassed the United States to become the world’s biggest investor in scientific research and development, according to the National Science Foundation. “If the [U.S.] government is not acting, it is ceding the field to others who are,” said Jonathan Pershing, a former U.S. special envoy for climate change. Pershing now directs the environment program at the Hewlett Foundation, which gave $168 million in grants in 2018 and was considered the largest philanthropic funder of climate efforts before Bezos’s announcement.

How to spend $10 billion

Little is known about the Bezos Earth Fund apart from what Bezos announced in an Instagram post last week. Beginning this summer, the billionaire said he plans to issue grants to scientists, activists and nongovernmental organizations — “any effort that offers a real possibility to help preserve and protect the natural world.” Bezos’s representatives declined to offer a timeline for the distribution of the money or criteria for who will receive it.

Previously, recipients of grants from the $2 billion Bezos Day One Fund to fight homelessness were selected by a small group of advisers. Rather than issuing a call for proposals and assessing applications, Bezos's team cold-called nonprofit organizations, according to the technology news site Recode.

Sandalow, the former Clinton and Obama administration official, said the Bezos Earth Fund has "transformational potential," depending on how it is allocated. "In relation to funding specifically targeted for climate change, this is very significant. But in relation to the annual capital investments in the energy sector, it's quite small," he said. "It will be important to target it smartly for it to have maximal impact."

Sandalow suggested that the fund would best be spent helping to decarbonize industry, an issue that has received less attention than emissions from the transportation and energy sectors. Bezos could also provide capital for first-of-their-kind projects that more traditional equity investors are reluctant to support. But Bezos might get the biggest bang for his buck by spending his wealth on public awareness and political mobilization, he said. "Businesses can't solve the climate problem without government policy playing a central role," Sandalow said.

Other wealthy donors, such as Democratic presidential candidate and former New York mayor Mike Bloomberg and Microsoft co-founder Bill Gates, have focused their philanthropy on projects that reflect their personal philosophies and interests.

Bloomberg donated $500 million last year to lobby cities and states to close coal-fired power plants, which emit large amounts of greenhouse gases as well as toxins such as mercury and lead. His foundation has committed $1 billion toward countering climate change, a spokeswoman said. And in 2017, when the Trump administration eliminated funding for the office coordinating the Paris Agreement, Bloomberg stepped in to make up the $15 million shortfall.

Gates has largely approached climate spending as a tech investment, creating a $1 billion fund for clean energy start-ups. (Bezos and Bloomberg are also on the board of that outfit.) In an annual letter issued this month, Gates said he plans to devote much of his future philanthropy to climate change, including achieving technological breakthroughs in areas such as battery storage and carbon removal. Tom Steyer, another billionaire who has taken up the climate cause (and who is running for the Democratic presidential nomination), has targeted millions toward electing candidates who favor climate action.

Billionaires' blind spots

Yet experts and activists say there are limits to how much private donations can — and should — drive the world's climate response. Stearns and Bell said the process for receiving foundation grants is less rigorous than the peer review required at federal agencies. Federally funded researchers are also required to make their data publicly available, meaning that the research continues to pay dividends after the initial project is complete. "You can do great science but if you're not sharing the raw data, it kind of ends with you and that's not what we want," Stearns said.

Others expressed concern that, in the absence of ambitious federal policies, billionaires will get to set the agenda for what climate solutions are pursued. The pledges from Bezos and others have rarely mentioned climate justice — an issue that has been a priority for many activist organizations and is at the center of the Green New Deal.

Many green technologies that have been the focus of private financing, such as electric vehicles and solar panels, are still available largely to the wealthy, said Cleetus of the Union of Concerned Scientists.

Meanwhile, issues that affect the most vulnerable citizens — improving transmission lines to get clean energy to rural areas, maintaining maps of flood risk to low-lying communities — are rarely a focus for deep-pocketed donors. And despite the scale of Bezos's pledge, several grass-roots activists continue to consider the Amazon founder and other billionaire philanthropists as part of the problem.

Bezos's announcement came at a time when Amazon employees are increasingly vocal about pushing the nearly $1 trillion company to cut its carbon footprint. Amazon makes money through its emphasis on same-day delivery, a growing airline shipping business and a vast cloud-computing venture whose clients include major fossil fuel companies. The company said it emitted 44.4 million metric tons of carbon dioxide in 2018 — a number that exceeds the annual emissions of Denmark. But it also committed to initiatives that would cut its net emissions to zero by 2040.

For reflection/discussion:

- Economist Rachel Cleetus warned that 'we [don't] want a system where climate and clean energy policies are co-opted by the private sector.' (lines 19-20). What does the use of the phrase 'co-opted' suggests about her view of the private sector's involvement in climate and clean energy policies? What specific concerns can you think of regarding the funding of research into 'climate' and 'clean energy' by businesses? Based on lines 94 to 107, what are several concerns regarding the funding of scientific research by the private sector?
- In what ways could the Bezos Earth Fund be 'transformational' (line 66)?
- Explain how a 'less rigorous [process]' (lines 93-94) in obtaining research grants could lead to scientific research being compromised
- Articulate and explain the possible tradeoffs you can discern from this reading, and for each tradeoff, evaluate why you believe it should or should not be made.

Related Cambridge/RI essay Questions:

1. How far should profit be the aim of scientific or technological developments? (RI Y5 Promos 2022)
2. Can research into costly technology ever be justified? (RI Y6 T1 Timed Practice 2022)
3. 'Science and business should never mix.' How far do you agree? (RI Y6 CT1 2019)
4. Do you agree that the benefits of technology are only enjoyed by the rich? (RI Promo 2019)
5. To what extent is it acceptable for private companies to be involved in financing scientific research? (Cambridge 2011)

Reading 7: Big Pharma's go-to defense of soaring drug prices doesn't add up **EU 7-9**

Ezekiel J. Emanuel | The Atlantic | 2019

This reading will help you understand:

- The reasons used by Big Pharma to justify high drug prices, and why these do not provide a full picture
- The adverse social and medical impacts of charging excessively high prices for drugs
- Why better regulation might be the only way to deal with Big Pharma's monopoly pricing strategy

How is it that pharmaceutical companies can charge patients $100,000, $200,000, or even $500,000 a year for drugs—many of which are not even curative?

Abiraterone, for instance, is a drug used to treat metastatic prostate cancer. The Food and Drug Administration initially approved it in 2011 to treat patients who failed to respond to previous chemotherapy. It does not cure anyone. The research suggests that in previously treated patients with metastatic prostate cancer, the drug extends life on average by four months. At its lowest price, it costs about $10,000 a month.

Abiraterone is manufactured under the brand name Zytiga by Johnson & Johnson. To justify the price, the company pointed me to its "2017 Janssen U.S. Transparency Report," which states: "We have an obligation to ensure that the sale of our medicines provides us with the resources necessary to invest in future research and development." In other words, the prices are necessary to fund expensive research projects to generate new drugs.

This explanation is common among industry executives. To many Americans, it can seem plausible and compelling. But invoking high research costs to justify high drug prices is deceptive.

No matter the metric, drug prices in the United States are extreme. Many drugs cost more than $120,000 a year. A few are even closing in on $1 million. The Department of Health and Human Services estimates that Americans spent more than $460 billion on drugs in 2016, the last year for which there are definitive data. On average, citizens of other rich countries spend 56 percent of what Americans spend on the exact same drug.

Excessive drug prices are the single biggest category of health-care overspending in the United States compared with Europe, well beyond high administrative costs or excessive use of CT and MRI scans. And unlike almost every other product, drug prices continue to rapidly rise over time. HHS estimates that over the next decade, drug prices will rise 6.3 percent each year. Basic economic principles suggest that drug prices should be going down, not up: For most drugs, manufacturing volumes are increasing, and little new research is being conducted on those already on the market.

Reducing these high drug prices has become a major political concern. Yet every time Congress debates doing something about drug prices, the industry—and the advocacy groups it funds—vociferously returns to the point that lower prices will thwart innovative research. But there are many reasons to question the widely held notion that high drug prices and innovative research are inextricably linked.

Peter Bach, a researcher at Memorial Sloan Kettering, and his colleagues compared prices of the top 20 best-selling drugs in the United States to the prices in Europe and Canada. They found that after accounting for the costs of all research—about $80 billion a year—drug companies had $40 billion more from the top 20 drugs alone, all of which went straight to profits, not research. More excess profit comes from the next 100 or 200 brand-name drugs.

Drug companies tend to say they are unique in needing to spend a higher proportion of their capital on research than almost any other industry. But of all the companies in the world, the one that invests the most in research and development is not a drug company. It's Amazon. The online retailer spends about $20 billion a year on R&D, despite being renowned for both low prices and low profits. Among the 25 worldwide companies that spend the most on research and development—all more than $5 billion a year—seven are pharmaceutical manufacturers, but eight are automobile or automobile-parts companies with profit margins under 10 percent. Amazon's operating margin is under 5 percent. Meanwhile, the top 25 pharmaceutical companies reported a "healthy average operating margin of 22 percent" at the end of 2017, according to an analysis by GlobalData.

The pharmaceutical industry and its advocates tend to peg the cost of creating and bringing to market just one new drug at $2.6 billion. This figure comes from a cost report published in October 2016 by the Tufts Center for the Study of Drug Development.

There are several reasons to suspect that number is unreliable. According to the Tufts Center's website, more than a quarter of its budget comes from "unrestricted grants" from pharmaceutical companies and their partners. And no one can verify Tufts' analyses and claims: The authors say the data come from research spending on 106 drugs produced by 10 of the top 50 multinational pharmaceutical companies, but the underlying data are deemed proprietary and confidential. That's not to mention other factors the Tufts team leaves out that reduce the cost of drug development, such as tax credits the federal government offers for research and development.

But in November 2017, a study published in JAMA Internal Medicine examined the costs of developing 10 cancer drugs approved by the FDA from 2006 to 2015 and provided a strong contrast to the Tufts study from a year before. Its authors, from Memorial Sloan Kettering and the Oregon Health and Science University, used annual financial disclosures from the Securities and Exchange Commission for companies that had only one cancer drug approved but had on average three or four other drugs in development. They found that companies took an average of 7.3 years to win FDA approval, at a median cost of $648 million. Adding in the cost of capital at 7 percent increased the median research and development cost to $757 million—less than a third of the Tufts estimate.

Joaquin Duato, the vice chairman of Johnson & Johnson's executive committee, argues that critics fail to deal with the realities of drug R&D. He told me that last year, Johnson & Johnson had $41 billion in prescription-drug sales, of which $8.4 billion went to R&D and $4.5 billion went to sales and marketing. Other costs included manufacturing, finance, IT, taxes, and more. This funds research on 100 candidate drugs, which result in one or two FDA approvals a year. "For drug companies, the return on capital is in the mid-teens, which is nowhere near tech-company returns," Duato said.

Nevertheless, some former pharmaceutical-company executives say that research costs do not determine drug prices—and they explain how. In his book A Call to Action, Hank McKinnell, a past CEO of Pfizer, wrote under the heading "The Fallacy of Recapturing R&D Costs":

How do we decide what to charge? It's basically the same as pricing a car…most important is our estimate of the income generated by sales of the product. It is the anticipated income stream, rather than repayment of sunk costs, that is the primary determinant of price.

Raymond Gilmartin, a former Merck CEO, once said to The Wall Street Journal: "The price of medicines is not determined by their research costs. Instead, it is determined by their value in preventing and treating disease."

Exorbitant drug prices have two bad effects. First, high costs mean that lots of patients are unable to take their medications. Second, the high drug prices distort research priorities, emphasizing financial gains and not health gains. Cancer drugs are routinely priced at about $120,000 to $150,000 a year, and more than 600 cancer drugs are now being tested on humans. This can lead to great societal benefits: The United States is expected to face 1.76 million new cancer cases and more than 600,000

cancer deaths in 2019 alone. But too much investment in oncology means not enough in drugs for other illnesses whose treatments cannot be so highly priced.

Consider antibiotics. The Centers for Disease Control and Prevention ranks antibiotic-resistant infections as one of the nation's top health threats. An estimated 2 million Americans become infected with such bacteria each year, and 23,000 die. A superbug that is resistant to all known antibiotics is an imminent threat. Yet because antibiotics are generally cheap, for most pharmaceutical and biotechnology companies they are not a primary focus. The Pew Charitable Trusts reports that only about 42 new antibiotics with the potential to treat serious bacterial infections were in clinical development for the U.S. market in December 2018. 600 drugs for cancer and only 42 for serious infections seems like profit maximization, not a case of sensible research priorities that reflects "value in preventing and treating disease."

The simple explanation for excessive drug prices is monopoly pricing. Through patent protection and FDA marketing exclusivity, the U.S. government grants pharmaceutical companies a monopoly on brand-name drugs. But monopolies are a recipe for excessive prices. A company will raise prices until its profits start to drop.

The standard economic response to monopoly pricing is price regulation. Every other developed country regulates drug prices, often through price negotiations pegged to cost-effectiveness analysis or some other measure of clinical benefit.

Will R&D go down if the United States follows this model? Not necessarily. Remember, the high drug prices fund R&D but also marketing, manufacturing, administrative expenses, and profits at the companies. Lower revenue from lower drug prices could reduce marketing, administration, and excessive profits before R&D costs have to be reduced.

Where cuts are made is up to drug companies. Their claims of lower R&D costs appear designed to generate fear, but as some former executives themselves have acknowledged, there is no necessary link between a decline in drug prices and a decline in R&D. Drug companies could make other choices that maximally improve the health of all Americans.

Further Reading

On monopoly pricing of drugs in America:

- https://openmarketsinstitute.org/explainer/high-drug-prices-and-monopoly/
- https://www.commonwealthfund.org/blog/2018/its-monopolies-stupid

Reflection questions and related Cambridge/RI essay questions are found at the end of Reading 8.

Reading 8: There is no single, best policy for drug prices **EU 5-8**

Austin Frakt | The New York Times | 15 July 2019

This reading will help you understand:

- The conflict of interest between stakeholders in determining drug prices
- The effectiveness of regulation in controlling drug prices
- The reasons why not all drug prices can be regulated with increased competition

A majority of Americans prefer greater regulation of prescription drug prices, meaning government intervention to lower them. But don't count on a single policy to address a nuanced problem. "All low-priced drugs are alike; all high-priced drugs are high priced in their own way," Craig Garthwaite, a health economist from Northwestern University's Kellogg School of Management, wrote with a colleague.

Outside of a few government programs — like Medicaid and the Veterans Health Administration — low-priced drugs are alike in that competition is the sole source of downward pressure on prices. When many generic versions of a brand-name drug enter the market, competition can push their prices 80 percent below the brand price, or sometimes even more.

In contrast, high-priced drugs lack competition for various reasons, "not all of which imply our goal should be to reduce prices," Mr. Garthwaite said.

Consider two drugs, Humira and Daraprim

Humira, an injectable drug from AbbVie, is a good example. It's used to treat severe rheumatoid and other forms of arthritis, plaque psoriasis and Crohn's disease. It's also the best-selling prescription drug in the world, with a nearly $40,000 annual price tag per person (even accounting for rebates).

Since its approval by the Food and Drug Administration in 2002, Humira has been protected from direct competition by patents and F.D.A.-provided market exclusivity. This government protection from competition is a source of profit intended as an incentive for innovation.

"One-size-fits-all incentives like patents and exclusivity periods may not provide the right incentive for Humira or any other drug," said Rachel Sachs, associate professor of law at Washington University in St. Louis. "We probably are under-rewarding drug innovation for some types of diseases, such as early-stage cancers requiring long clinical trials, and over-rewarding it for others."

Daraprim, currently manufactured by Vyera Pharmaceuticals (formerly Turing), treats a life-threatening parasitic infection. It was discovered in 1952. In 2015, Martin Shkreli, then Turing's chief executive, increased Daraprim's price by more than 5,000 percent, to $750 from $13.50 per pill.

Mr. Shkreli was able to do this because Daraprim lacked competition, but the reason was different than for Humira. Daraprim's chemical structure and means of manufacture may be used by other drug manufacturers to make and market a generic equivalent. The obstacles to doing so aren't governmental. They're found in the market.

If a competitor entered the market, it's likely that Vyera would drop Daraprim's price — exactly what we'd expect and want from competition. But the cost of starting production of the drug, relative to the return on that cost, may prove a deterrent. "At a lower price level, a competitor may not be able to recoup its investment," said Dr. Aaron Kesselheim, a professor of medicine at Brigham and Women's Hospital and Harvard Medical School. "That, coupled with the small market for this drug, makes it relatively unappealing to a for-profit company."

Daraprim isn't alone. Other drugs that have lost their patents have had rapid price increases for similar reasons. The price for captopril, a drug for hypertension and heart failure, rose 2,800 percent in 2013. The same year, the price for clomipramine, which treats depression and obsessive-compulsive disorder, increased 3,700 percent. And the antibiotic doxycycline hyclate's price jumped 2,000 to 5,000 percent (depending on formulation) in six months, from October 2013 to April 2014.

Some ideas to push down prices

The F.D.A. has already taken action to increase generic competition. A 2012 law authorized the F.D.A. to charge generic drug manufacturers user fees, and those funds enabled it to speed up generic approvals. But this doesn't address barriers in the market that keep some prices high for drugs whose patents have expired.

"We could do more through importation to respond to sudden price increases of off-patent drugs," Dr. Kesselheim said. "Manufacturers serving markets overseas might be willing to sell in the U.S. if we were to acknowledge regulatory approvals in other developed countries with high standards."

Not requiring those manufacturers to undergo approvals in the United States would reduce barriers to market entry, potentially increasing competition.

The duration of market exclusivity varies by type of drug. Until recently, the vast majority of new drugs were so-called small-molecule drugs produced through chemical processes. A manufacturer can expect to be granted about five years of market exclusivity from the F.D.A. for these kinds of drugs, though some — like those that treat rare conditions — can obtain longer exclusivity.

Some companies find elaborate ways to effectively achieve much longer periods of exclusivity. "One way is to build up a so-called thicket of patents, claiming ownership of often minor characteristics of a drug or its manufacture," Dr. Kesselheim said. "Many are trivial, but collectively they slow down competition." For example, some pertain to small changes in packaging or formulations.

When the F.D.A. treats these as "new" drugs, it can buy a company additional years of protection from competition and high prices. "More could be done to scrutinize drug patent applications and throw them out if the modifications are trivial," Dr. Kesselheim said.

Competition doesn't work well with biologic drugs

An increasing share of new drugs are biologics, which are much more complex and are regulated differently. They're made up of proteins produced by living organisms and can cost 20 times more to manufacture than small-molecule drugs.

Some of today's most expensive drugs are biologics, including Humira. The first biologic, a human formulation of insulin, was marketed in 1982. By 2016, they accounted for half of F.D.A. approvals. Humira owes its popularity to its effectiveness. The same could be said of many other expensive biologic drugs, like Herceptin for certain kinds of breast cancer. To encourage investment in them, biologics get longer market exclusivity — 12 years — than small-molecule drugs. As with the small-molecule drugs, the exclusivity can be extended in various ways.

But even after that, biologics are protected from competition to an extent because they are harder to duplicate than small-molecule drugs. A biosimilar — a drug intended to mimic the therapeutic effect of a specific biologic — is not like a small-molecule generic drug. A generic drug can exactly duplicate the chemical structure of the brand drug it is intended to mimic, but that's not easily achieved for biosimilars. Because they rely on living organisms, their structure and clinical performance depend on many subtleties of manufacturing. This means biosimilars may not behave exactly like original biologics, giving those original drugs a leg up in the market.

Reflecting this, some of today's drug pricing proposals focus on biologics. A recently proposed change to Medicare would link the prices of many biologics to those in other countries, which are lower.

Another proposal has been to automatically reduce prices once their market exclusivity period has expired.

Lower drug prices could lead to shortages

A final complication in addressing prices is that, for some drugs, it may not be a good way to achieve the pace of innovation we may want. Here, antibiotics offer a good example. Although we desperately need new antibiotics to combat resistant superbugs, few pharmaceutical companies are willing to invest in their development. The problem is that they would serve a market we would want to be as small as possible. Ideally, nobody would need a powerful antibiotic, and there is no price at which a manufacturer would make a product that is never purchased.

"We should not pay for antibiotics by the dose, like other drugs," said Kevin Outterson of Boston University School of Law. "Instead, buying access to new antibiotics — a Netflix model — could encourage innovation even if they're rarely used."

Policy ideas to push drug prices downward are summarized by the Drug Policy Lab at the Memorial Sloan Kettering Cancer Center, at which Peter Bach is director of the Center for Health Policy and Outcomes. In some cases, lowering drug prices could invite shortages. "Though Daraprim's price could be lower and Vyera would still make a profit, if it was pushed too low, there could be a shortage," Dr. Bach said. "For drugs prone to shortage, it might make sense to subsidize the price."

Although there appears to be a mandate to lower drug prices, it's an issue that defies a simple solution.

For reflection/discussion:

- Based on Reading 7, what are the reasons cited by pharmaceutical companies to justify high drug prices?
- What arguments does the author make against such high prices?
- What are the potential tradeoffs involved in maintaining high drug prices for the sake of funding future research and development? What are some relevant factors to consider when weighing the necessity or value of making such tradeoff?
- Based on Readings 7 and 8, what are some regulations and mechanisms used by governments to regulate pharmaceutical companies? How may regulations be rendered ineffective, or circumvented by pharmaceutical companies? Refer to Reading 8 and carry out more research if necessary.
- In what ways does the pursuit of progress in pharmaceutical research and development influence the pricing strategies of drug companies?
- How can policymakers balance the need for innovative drug research with the necessity of keeping drug prices affordable for patients?

Related Cambridge/RI essay questions:

1. How far should profit be the aim of scientific or technological developments? (RI Y5 Promos 2022)
2. 'Science and business should never mix.' How far do you agree? (RI Y6 CT1 2019)
3. 'Human need, rather than profit, should always be the main concern of scientific research.' Discuss. (Cambridge 2016)
4. Should scientific research be largely driven by commercial interests? (RI Y5 CT 2012)
5. Should Science serve only the public good and not private gain? (RI Y5 CT 2010)

SECTION C: SCIENCE & TECHNOLOGY – ETHICS AND REGULATION

The next two readings will introduce you to:

- Developments in genetic engineering technology: the controversy, its possibilities and dangers
- Views that oppose genetic engineering

Reading 9: Gene editing is here – it is an enormous threat **EU 4-6, 9**

Marc A. Thiessen | The Washington Post | 29 November 2018

A Chinese scientist's claim to have created the first genetically edited babies has evoked widespread condemnation from the scientific community. "This is far too premature," one American genetic scientist told the Associated Press.

But here is a larger question: Should we be doing this at all?

The Chinese scientist, He Jiankui, used a gene-editing technique known as CRISPR (**which** stands for "clusters of regularly interspaced short palindromic repeats") to alter the DNA of two children in a petri dish and attempt to make them resistant to HIV. This is not what has American scientists up at arms. In fact, researchers in the United States have done the same thing. In 2017, scientists at Oregon Health & Science University used CRISPR to genetically alter human embryos to make them resistant to an unidentified disease. The difference is that He then implanted his edited embryos. The American researchers killed theirs.

The prospect of genetically eliminating crippling diseases is certainly appealing, but this promise masks a darker reality. First, there is a difference between genetic engineering and the extremely promising field of gene therapy, in which doctors use CRISPR technology to repair the DNA of defective non-reproductive cells — allowing them to treat cancer, genetic disorders and other diseases. In gene therapy, the genetic changes affect only the patient. In genetic engineering, scientists alter the entire genetic structure of the resulting human being — changes that are then passed on to future generations.

Playing with humanity's genetic code could open a Pandora's box. Scientists will eventually be able to alter DNA not just to protect against disease but also to create genetically enhanced human beings. The same techniques that can eliminate muscular dystrophy might also be used to enhance muscles to improve strength or speed. Techniques used to eliminate dementia may also be harnessed to enhance memory and cognition. This would have profound societal implications.

Only the wealthy would be able to afford made-to-order babies. This means the privileged few would be able to eliminate imperfections and improve the talent, beauty, stature and IQ of their offspring — thus locking in their privilege for generations. Those at the bottom would not. This could be a death blow to the American Dream, the idea that anyone who is willing to work hard in this country can rise up the economic ladder. Indeed, genetic engineering could actually eliminate opportunities for those at the bottom. For example, one path to higher education for those at the bottom is scholarships for athletic or artistic talents. But in a world of genetic engineering, those scholarships will disappear for the unenhanced poor — and with them the opportunities to improve their economic prospects in life. Think inequality is bad today? Wait to see what it looks like in the genetically modified future.

If we begin to create perfect children in labs, over time society will begin develop an intolerance for imperfection. If your children have an illness because you didn't genetically eliminate it, or if they can't keep up because of their unenhanced cognitive abilities, then that makes them an unjust burden on the rest of us. As we are separated into the enhanced and unenhanced, respect for the dignity of every

human life will be diminished. So will personal responsibility. If we don't make it in life because we are unenhanced, it's not our fault. And if we do because we are enhanced, we don't get the credit. As Harvard University professor Michael Sandel once wrote, "It is one thing to hit seventy home runs as the result of disciplined training and effort, and something else, something less, to hit them with the help of… genetically enhanced muscles."

Then there is the threat to women's equality. If genetic engineering can offer the promise of eliminating disease, it will also allow parents to choose the sex of their child. That could lead to greater sex discrimination. Just look at China, where the one-child policy led to mass infanticide of girls. If you believe that gender bias exists, then that bias will be expressed through genetic engineering — with potentially disastrous implications.

It will also lead to an explosion in the number of discarded children. For every child born via in vitro fertilization, there are multiple foetuses which are created but never used. Today, the Department of Health and Human Services reports, there are more than 600,000 cryogenically frozen embryos in the United States. If genetic engineering through in vitro fertilization becomes common, that number will skyrocket, sparking a profound moral crisis.

Here is the bottom line: We should not be playing God. Genetic research holds the promise to prevent, cure and even eliminate disease. But when it is used to create made-to-order "super children," we have crossed a moral line from which there may be no return.

Reflection questions and related Cambridge/RI essay questions are found at the end of Reading 10.

SECTION C: SCIENCE & TECHNOLOGY – ETHICS AND REGULATION

Reading 10: Genetic editing is like playing God – and what's wrong with that? **EU 4-6**

Johnjoe McFadden | The Guardian | 2 Feb 2016

The announcement that scientists are to be allowed to edit the DNA of human embryos will no doubt provoke an avalanche of warnings from opponents of genetic modification (GM) technology, who will warn that we are "playing God" with our genes.

The opponents are right. We are indeed playing God with our genes. But it is a good thing because God, nature or whatever we want to call the agencies that have made us, often get it wrong and it's up to us to correct those mistakes. Sadly, of the half a million or so babies that will be born in the UK this year, about 4% will carry a genetic or major birth defect that could result in an early death, or a debilitating disease that will cause misery for the child and their family. This research will eventually lead to technologies that could edit DNA in the same way that we can edit text – to correct the mistakes before the child's development goes to its final draft. Its successful implementation could reduce, and eventually eliminate, the birth of babies with severe genetic diseases.

But surely our DNA cannot be compared to the patterns of printer ink on page? Our DNA is considered to be so special that the phrase "it's in his/her DNA" is said with the same sense of fatalism that our ancestors would have spoken of their fate or their soul. Anti-GM activists, many of whom are devout atheists, often insist that our DNA is somehow special, something donated to us by an all-powerful, wise and benevolent nature, which has taken God's place as our creator. But nature is just blind chance – mutation – combined with the survival of the fittest. There's no grand plan and no reason why nature shouldn't, like the rest of us, occasionally make terrible mistakes. When those errors could lead to terrible human suffering, it is our duty to try to correct them.

Gene editing could provide revolutionary benefits to our children

Our DNA is just a chemical. You can eat it or burn it and it will return to those simple atoms and molecules from which it is made. There is no special magical ingredient between the atoms, no soul, just atoms and space. DNA is the most amazing chemical in the known universe, but it's just a chemical – made of the same atoms of carbon, hydrogen, oxygen and nitrogen you can find in the air. It is no more spiritual than your fingernails or hair. And we don't mind clipping those when we need to.

Gene editing of human embryos to eliminate disease should be considered to be ethically the same as using laser surgery to correct eye defects, or a surgeon operating on a baby to repair a congenital heart defect. DNA is just another bit of our body that might go wrong. Yet gene editing could provide revolutionary benefits to our children. A team based at Great Ormond Street Hospital for Children in London recently used gene editing to treat a one-year-old girl with leukaemia, who is now in remission. More technology is in the pipeline. A team based at Perelman School of Medicine at the University of Pennsylvania reported in this week's Nature Biotechnology that they were able to correct a genetic liver disease in newborn mice. Taking this technology into human embryos could correct devastating genetic diseases in the womb.

But isn't this a slippery slope to designer babies genetically engineered to be healthier, cleverer or more beautiful than they would otherwise be? Wouldn't it provide a technology that would only be available to the super-wealthy, potentially creating the kind of divided society that HG Wells envisaged in his futuristic novel, The Time Machine? Perhaps. But let's worry about the future in the future.

In the present, if those of us with mostly healthy children are worried about the ethics of gene editing, then we should ask the parents of children born with haemophilia, cystic fibrosis or muscular dystrophy whether they would have used this kind of technology if it had been available to them. If science can be used to eliminate human suffering, then let's get on with it.

For reflection/discussion:

- According to Thiessen (Reading 9), what is the difference between gene therapy and genetic engineering (lines 15-18)?
- What are the benefits of gene engineering technologies such as CRISPR listed in Reading 10?
- What are its potential dangers and disadvantages for society? Refer to the readings and carry out your own research. Do you think these vulnerabilities may differ from society to society, and may affect social groups different?
- In your view, should there be limits or controls concerning the use of such technology? Why? What kinds of limits would you propose?

Related Cambridge/RI essay questions:

1. 'Non-scientists should have little say in how scientific developments are managed.' What is your view? (RI Y6 Common Essay Assignment 2020)
2. 'Technology is advancing too fast.' Is this a fair comment? (RI Y5 Promo 2020)
3. 'Science creates more problems than it seeks to solve.' Comment (RI Y5 CT 2016)
4. To what extent can the regulation of scientific or technological developments be justified? (Cambridge 2014)
5. Consider the view that advances in gene therapy research have gone too far. (RI Y6 CT1 2014)
6. 'Science gathers knowledge faster than society gathers wisdom.' Do you agree? (RI Y6 CT2 2013)
7. 'Moral considerations hinder scientific progress.' Comment. (RI Y6 CT1 2012)

Further Reading

To read more about how CRISPR works: https://www.livescience.com/58790-crispr-explained.html

Reading 11: Thousands of Indians die in unethical clinical trials **EU 6-9**

Samanth Subramanian | The National | 17 September 2018

This reading will help you understand:
- The methods and means by which pharmaceutical companies unethically conduct clinical trials
- How governments can be complicit, or helpless, in dealing with this issue
- The rationale for limits and regulations in the pharmaceutical industry

Thousands of Indians have died in unethical clinical trials over the past decade, even as a lawsuit to improve regulation of these trials has dragged unresolved through the Supreme Court for six years.

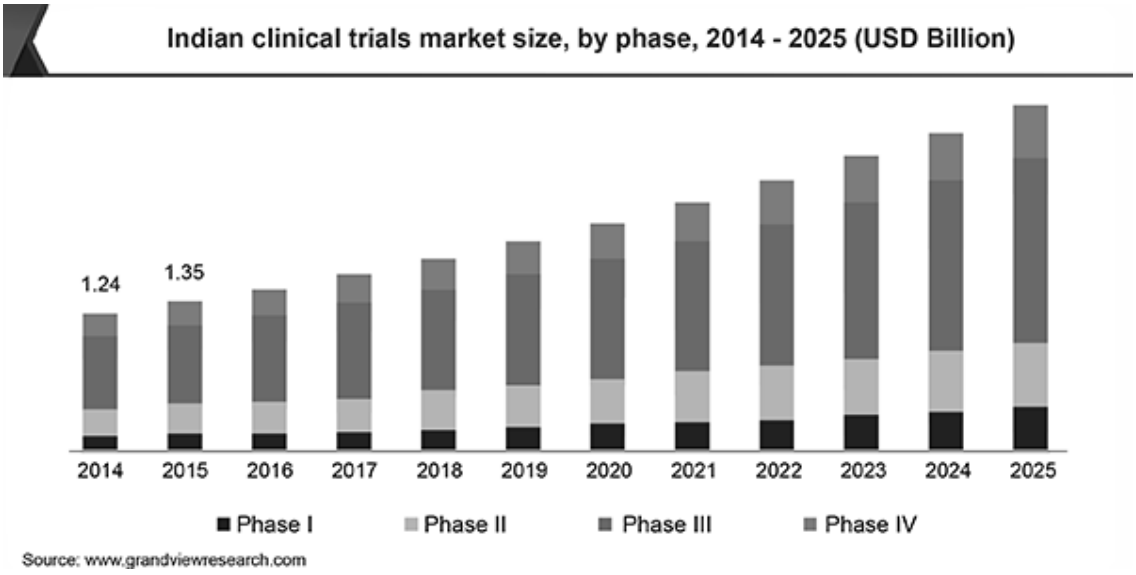
Between January 2005 and November 2017, 4,967 people died during the course of drug trials and research, according to government data obtained by a non-profit called Swasthya Adhikar Manch (SAM). Another 20,000-odd people have suffered adverse reactions in such trials.

Pharmaceutical companies have offered compensation to the families of the deceased only in 187 of these cases, said Amulya Nidhi, who founded SAM. At least 475 drugs have been tested in trials during this time, according to Sanjay Parikh, the lawyer representing SAM in the lawsuit it filed against the government in 2012.

The trials take advantage of loopholes in rules, loose oversight, and India's large population of poor people who are often unaware of their rights as trial subjects, Mr Nidhi said. "We need a strong regulatory system, and we need action on violators."

The number of clinical trials in India rose after 2005, when India relaxed its testing laws. Drug companies began to recruit clinical research outsourcing firms to conduct trials in India, where costs are drastically lower.

The annual revenue of these outsourcing firms has grown from $485 million in 2010-11 to over $1 billion today, according to research from Frost & Sullivan, a market consultancy.



India's regulators have been unable to keep up with this explosion of testing. For instance, Mr Nidhi said, an ethics committee is supposed to oversee every trial. "At one point, in Chandigarh, there were 257 trials going on, but only one ethics committee overseeing them," he said. "How is that even possible?"

Trials take place under the radar as well, Mr Parikh said, sometimes by simply paying poor subjects around 500 rupees a day and enlisting them. The details of the trials and the data harvested remain with the companies. "There's no way to find this stuff out."

In 2013, following an interim order from the Supreme Court, the government made it mandatory for companies to seek written informed consent from each subject before a trial, and for the process of seeking this consent to be recorded on video.

In reality, however, this rarely happens. What is more commonplace, Mr Nidhi said, is the kind of experience Pradeep Gehlot had. His story, as narrated to SAM, forms part of the non-profit's case in court.

Mr Gehlot drives an auto rickshaw in the city of Indore, and when his father Srikrishna, a tailor, fell ill with breathlessness and chest pain, he admitted him to a government hospital.

In the hospital, Mr Gehlot was given a sheaf of papers to sign. They were in English, which he couldn't read very well, but the doctors told him that his father would be treated, free of charge, with imported drugs, so Mr Gehlot went ahead and signed.

"Without his consent, Srikrishna was in a clinical trial for nearly two years," Mr Nidhi said. "His health started deteriorating, and he died in 2012."

When SAM heard about the case and sent a team to talk to Mr Gehlot, they confirmed from the documents that a trial had been conducted.

After Mr Gehlot complained, the doctor's medical license was suspended for three months. SAM uncovered other cases of ethical violations in a different Indore hospital and filed further complaints.

The state government, after investigating the hospital, found that 81 "serious adverse events"—including 32 deaths—occurred during clinical trials on more than 3,000 people. These adverse events had not previously been reported to regulators. A third Indore hospital enlisted 1,833 children and 233 mentally ill individuals in trials without their consent, the investigators' report found.

The report also suggested that doctors and clinicians running these trials had frequently been sent on trips overseas, or had been paid out of process, by pharmaceutical companies.

Punitive measures are weak, however. After its inquiry, the government imposed fines of $100 apiece on 12 doctors for not cooperating with its investigations. Two doctors were barred from conducting further trials for a period of six months.

But Chirag Trivedi, the president of the Indian Society for Clinical Research, a professional body representing pharmaceutical researchers, argued that the country's rules are actually over-stringent, and that they have shrunk the number of ongoing trials.

One regulation, for example, calls for companies to also pay for management of all medical problems during trials, which is unfair, he said.

"There was a cardiovascular drug trial, which is for a heart ailment, where the company had to pay for tuberculosis treatment for nine months," Mr Trivedi said. "We all know that tuberculosis is caused by a bacteria, not by any drug, and not by a clinical trial for a heart ailment."

In every case that has warranted compensation, companies have paid out, he said.

60 Mr Trivedi admitted that, "as in any industry," there were companies that indulged in unethical trials as well. "We cannot condone any irregularities," he said. "Whatever protects the rights and safety of individuals, we will support such that. Every life is precious. We can't treat Indians as guinea pigs."

He also pointed out that clinical trials are vital to drug development. "The medicines that help you and me—they wouldn't be available without trials."

65 The next hearing of SAM's lawsuit in the Supreme Court has been scheduled for December 4, but all parties to the suit have been asked to file their suggestions for an amended law next month, Mr Nidhi said.

But the regulations before 2005 were both sufficient and comprehensive, Mr Nidhi said. "Bring back the law that existed before 2005. That is what we are asking."

For reflection/discussion:

1. Based on the reading, list some ways by which pharmaceutical companies act unethically in clinical trials. What might be certain priorities that may prompt pharmaceutical companies to act this way? What responsibilities should pharmaceutical companies bear in the conducting of medical/clinical trials and why?
2. Why may governments, especially of poor countries, be relatively helpless, or unable to effectively hold pharmaceutical companies accountable for unethical actions in the carrying out of such trials?
3. Given the above, how do propose limits be placed upon commercial interests in scientific research?

Related Cambridge/RI essay questions:

1. Should we place limits on scientific or technological developments when they have solved many of our problems? (RI Y6 Prelim 2019)
2. 'Scientific research without limits is undesirable.' To what extent do you agree? (RI Y5 Promo 2017)
3. 'Unlimited scientific research is the only way to make real scientific progress.' Do you agree? (RI Prelim 2015)
4. 'Science will always have noble intentions. Discuss. (RI Y6 CT2 2015)

Reading 12: Does the necessity of animal research mean that it is ethical? **EU 4-6**

Samual Garner | NPR | 14 Feb 2016

This reading will help you understand:

- That the issue with animal testing is not simply a case of the ends justifying the means (utilitarianism), but also brings into contention the right of human beings to life-saving treatments and medication versus the right of animals not to be subjected to experimentation (virtue ethics)
- That what constitutes necessary research on animals and what constitutes ethical or humane treatment of animals is highly subjective
- That apart from advocacy, concrete actions in terms of exploring and correcting mindsets towards viable alternatives to animal research should be pursued.

A few weeks ago, two prominent scientists, Hollis Cline and Mar Sanchez, wrote a brief piece in *The Hill* newspaper arguing that animal research is "necessary." They were prompted by the recent National Institutes of Health (NIH) decision to phase out the use of primates in controversial maternal deprivation studies.

Scientists have long been fond of claims of necessity — in fact, justifications for animal research have remained largely the same since the writings of 19th century French physiologist Claude Bernard. However, this claim is problematic for a number of reasons.

If animal research is necessary, then it is not necessary in the sense that we have to do it. Rather, it is a choice that we make, a choice that its proponents believe is a necessary means to the end of further medical advances. Such advances are undoubtedly of significant moral importance, but even if we grant the assumption that animals are necessary for medical progress, this does not equate to a moral justification.

Research with *humans* is necessary to medical progress, but we have set strict limits on the extent to which humans can be exposed to risk and harm in research, even though doing so has undoubtedly slowed the rate of medical progress that might otherwise be achievable. Cline and Sanchez claim that animals in research are treated "humanely and with dignity," but the reality is that the level of protection afforded to research animals is far, far less than that afforded to human participants in research. Most animals involved in research are killed at the termination of the experiment, are kept in conditions not conducive to their welfare, and are otherwise harmed in myriad and significant ways, for example through the infliction of physical injuries, infectious diseases, cancers, or psychological distress.

While nonhuman animals cannot provide consent to research participation, we have reasoned in the case of humans that an inability to consent entitles an individual to greater protection and not lesser protection. What justifies our differential treatment of humans and nonhuman animals in research? For present purposes, it isn't necessary to rehearse every possible argument for and against animal research. It is sufficient to note that very few contemporary ethicists defend the *status quo* of animal research and, furthermore, that the burden of proof has now shifted to those who would defend invasive animal research.

Given the state of philosophical scholarship, meeting this burden of proof will not be easy or straightforward. Perhaps the most remarkable aspect of the scientific community's frequent claims of the necessity of animal research is how thoroughly they miss the moral point. For the most part,

ethical criticisms of animal research aren't even addressed — as they aren't in Cline and Sanchez's piece — and when they are, they're usually dismissed with bad arguments, such as the claim that animals have rights, which have been refuted for decades.

Further, the claim that "animal research is necessary to medical progress" assumes a strong causal connection between the two, but what data we have available cast doubt upon the robustness of this connection. Despite strong claims about the historical benefits of animal research from the scientific community, the accuracy of animal models in predicting human responses has not been evaluated sufficiently, and the lack of certain kinds of data make this evaluation especially challenging. Based on existing data, however, numerous reviews have suggested that the accuracy of animal research in predicting human health outcomes appears to be far less than what we once assumed.

Animal studies also frequently appear to be poorly designed. The predictive value of animal research might increase if study design improved, but this isn't certain. Even NIH Director Francis Collins recognized these concerns in a forward-thinking 2011 commentary, stating that, "The use of animal models for therapeutic development and target validation...may not accurately predict efficacy in humans." Given these issues, systematic reviews should become routine and strong statements about the utility of animal models should be tempered. This does not mean that animal research has never produced any or even many important medical benefits, but these claims require empirical validation, not simply repeated assertion.

It also means that scientists and science agencies should be much more aggressive about seeking and funding alternatives to animals in research. Support has certainly grown, but investment of money and human labor into non-animal alternatives has been paltry. Even with this limited investment, some impressive advances are being made — witness the ongoing development of "organs on a chip" — but much more needs to be done, with more money behind it, and with more of a sense of haste.

Beyond funding, the scientific community simply needs to adopt a better attitude toward innovation in alternatives, or else their limitations will continue to be a self-fulfilling prophecy. This is *science* — a discipline with a remarkable history of achievement and innovation despite significant technical challenges. Where are the editorials galvanizing the scientific community to continue to innovate without animals? Where is the Human Genome Project-type investment in alternatives? To say that animal models are "necessary" when alternatives are not aggressively pursued seems a bit dishonest. And given the amount of harm caused to animals in research—whether you think it's justified or not—we should all want the alternatives field to grow.

Literally thousands of books and peer-reviewed papers have been written on the extent of our moral obligations to animals. As a field that is dedicated to rigorous inquiry and rational thought, the scientific community should take seriously the vast philosophy literature on these topics — the same field that gave rise to the conceptual foundations of science — rather than assertions and rhetoric. When it comes to animals and ethics, there have been very few serious attempts to engage the intellectual issues. Scientists can and should do better.

Reflection questions and related Cambridge/RI essay questions are found at the end of Reading 13.

Reading 13: In defence of animal-based research **EU 4 and 6**

Adapted from Contrary to emotive reporting, scientists testing on greyhounds are not Dr Frankensteins | Kemal Atlay | The Guardian | September 2016

This reading will help you understand why:

- The value and necessity of animal research can be clouded by inaccurate, selective and emotive media coverage designed to trigger outrage.
- The sheer complexity of biomedical research aimed at improving the treatment of debilitating diseases makes adoption of alternative research models impractical

In 1985, at the height of the Aids epidemic, scientists in the US made a huge breakthrough in understanding this mysterious, deadly disease by isolating the Simian Immunodeficiency Virus (SIV) in captive rhesus macaques. A few years later, they successfully developed the first effective therapy against HIV/Aids, which gave researchers a foothold to continue investigating the disease.

Today, anti-retroviral therapies have advanced to such an extent that people living with HIV can easily manage the condition with a simple drug regimen and can even suppress HIV levels in the blood to undetectable levels. None of this, or countless other medical advances, would have been possible without animal-based research.

So why are we seeing so many attacks by politicians, activists and even the media on this fundamental aspect of scientific research?

Earlier this month, Crikey published an article about the use of greyhounds in a study conducted by researchers from Monash University and the Alfred Hospital. The words “grisly” and “gruesome” were thrown in to elicit a specific response: outrage and disgust.

The Age then published its own story on the same experiment that used similarly emotive language but took things a step further by heavily featuring the voices of animal rights activists. In both instances, the articles were unashamedly one-sided and demonised not just the researchers involved the study, but the use of animals in science in general. So, what exactly was the experiment in question?

The researchers were investigating how well they could preserve a heart once an organ donor had died and before transplantation occurs, with the aim of improving the success rate of heart transplants in humans. In order to test this, they anaesthetised 12 greyhounds – they were knocked unconscious to prevent any pain or suffering – before they were suffocated to induce circulatory death. The hearts were then removed and preserved for four hours using two different methods of preservation. Half of the dogs then received a heart transplant and were revived to monitor how well the heart functioned before they were promptly euthanised.

It may not sound pretty, but this is how scientific research works and how medical research in particular has advanced to such an incredible extent. Animal models have allowed scientists the study all manner of medical conditions: experiments using mice have provided crucial insights into how Alzheimer’s disease actually progresses in the human brain; Zika-infected monkeys have allowed scientists to slowly decipher how the virus works in order to develop a cure; and surgeries on dogs and cats have allowed researchers to develop and perfect life-saving procedures, like open-heart surgery and organ transplants.

The aforementioned articles did not convey the significance of the study – the researchers concluded that their findings had "potential for clinical application in DCD [donation after circulatory death] transplantation" – and make no reference to the strict ethical approval processes in place.

As a result, they made the scientists look like modern-day Dr Frankensteins performing all manner of experiments with whatever animal they can get their hands on but this couldn't be further from reality. Scientists that use animal models in their work are guided by the 3Rs principles (replacement, reduction and refinement) that make them consider the impact of their work and ensure humane treatment of animals.

On top of that, an animal ethics committee must approve all animal-based research proposals before the scientists can proceed. The Australian Code of Practice for the Care and Use of Animals for Scientific Purposes dictates that these committees must include: a vet, an animal welfare representative, an animal researcher, and an independent representative. They have the power to reject proposals, advise researchers to adjust the proposal according to the 3Rs, and even stop experiments after they've begun.

Earlier this year, neurobiologist Associate Professor James Bourne wrote an impassioned defence of his work and the scientific community in response to federal Greens senator Lee Rhiannon's moves to ban the import of non-human primates for scientific research. Bourne's work is focused on how the brain repairs itself following an injury that results in brain damage, such as heavy impact from contact sports, traffic accidents and workplace injuries. He writes:

Primates share approximately 98% identity with the human genome and many anatomical, physiological, and behavioural similarities. For this reason, primates are critical to biomedical research targeting the causes, progression, prevention, and treatment of a wide variety of diseases.

Bourne goes on to explain that even though researchers are conscious of reducing the use of animal models, often there is "no alternative approach that can replicate the vast complexity of human disorder and disease." He also stresses the importance of transparency in ethical approval processes and in the role of various bodies holding researchers to account – this ensures the public remains confident that the work being carried out by the scientific community is done so in the most efficient, ethical and humane way possible.

Another key failing of the articles is that they linked the use of greyhounds in medical research to the cruelty of some practices in greyhound racing. The New South Wales Baird government's moves to ban greyhound racing have put the issue of animal rights and welfare back in the national spotlight, which will hopefully lead to more positive change and other state and territory governments following suit. But by bringing greyhound racing into the picture, the articles conflate the two issues and make the greyhound racing industry and scientific community one and the same. You cannot compare the use of animal models that has allowed countless medical advances to the wilful cruelty towards animals by a group of people motivated by profit and greed.

No one expects or wants scientists to conduct experiments on human beings to understand things like brain damage or heart transplants. Hence, animal-based research is crucial in ensuring we can still explore and investigate all manner of medical disorders and diseases without putting people's lives at risk.

For reflection/discussion:

- In lines 15-21 (Reading 12), Garner argues that one reason to oppose animal research is that 'the level of protection afforded to research animals is far, far less than that afforded to human participants in research' (lines 17-18). Is the answer then more stringent regulation when animals are used in research? Why or why not?
- What does Garner mean with the claim that the scientific community has 'miss[ed] the moral point' (line 31)? Use your own words as far as possible.
- Summarise the arguments the Garner makes against the necessity of animal research. Select any one of them and attempt to rebut it.
- In lines 21-25 (Reading 13), Atlay outlines the procedures in the research using greyhounds. Are you convinced that the treatment of the animals was sufficiently humane and ethical? Why/why not?
- Identify Atlay's criticisms of the media reporting concerning the greyhound study (lines 33-35). Explain why these omissions may give the impression that the scientists involved are like 'modern-day Dr Frankensteins' (line 36). Additionally, explain why such a description is negative.

Related Cambridge/RI essay questions:

1. Can the use of animals for scientific research ever be justified? (Cambridge 2017)
2. Should we be concerned with the ethics of medical research when doing so will limit its effectiveness? (RI Y6 Prelim 2021)
3. 'Moral considerations hinder scientific progress.' Comment. (RI Y6 CT1 2012)
4. Do you agree that the barriers to scientific research in the 21st century are more ideological than technological? (RI Y6 CT2 2011)

Further Reading

"Factsheet: Alternatives to Animal Testing" (Cruelty Free International)
https://www.crueltyfreeinternational.org/why-we-do-it/alternatives-animal-testing

Reading 14: If Humanity is to Succeed in Space, Our Ethics Must Evolve **EU 4, 7, 8, 9**

Adapted | Daniel Munro | Centre for International Governance Innovation | 4 April 2022

The reading will explain:

- The ethical considerations surrounding space exploration as well as the politics surrounding such considerations
- How an explicit focus on studying the ethics of space exploration as well as measures to improve transparency and foster collaboration may be beneficial in this regard

On July 16, 1969, the day the Apollo 11 mission launched the four-day flight that would land three American astronauts on the moon, one million people made their way to Cape Canaveral, Florida, to watch lift-off. Among them was aerospace engineer Wernher von Braun, a director at the National Aeronautics and Space Administration (NASA), whose leadership and Saturn V rocket were central to the Apollo program's success. A few days after the moon landing, von Braun was lifted onto shoulders in his hometown of Huntsville, Alabama, and paraded around as a "conquering hero."

Twenty-five years earlier, von Braun was a rocket engineer for the German army and a member of both the Nazi party and the SS. His infamous V-2 rocket, produced with slave labour from concentration camps, had killed thousands throughout Europe during the Second World War. Numerous historians and journalists have argued that von Braun was more opportunist than villain — motivated less by Nazi ideology or a desire for Germans to win the war than by his dream to launch rockets into space. Toward the end of the war, von Braun surrendered to American forces and was brought to the United States as part of Operation Paperclip — the top-secret program that brought dozens of Nazi scientists to work in America's science and technology industries.

It is no great mystery why American officials went to extraordinary lengths to obscure von Braun's past from the American public in the 1950s and 1960s, albeit with varying success. His engineering and management talent were unparalleled and would help the United States compete with the Soviets. Yet, the decision to employ von Braun and hide his past set a dangerous precedent: It signalled that deliberation about space exploration could be framed in strategic rather than ethical terms, conducted in opaque ways, and reserved for only a handful of officials already committed to the core aims of the program.

This approach to the ethics of space exploration is no longer sufficient, if it ever was. As exploration accelerates and private commercial activities are added to ongoing scientific and security initiatives, we need an accompanying acceleration and expansion of space ethics. We need to think clearly about what activities should be permitted and prohibited, as well as how, where and by whom such decisions should be made. We need to think about the ethics of space exploration, and the political economy of space ethics.

Key Issues in Space Ethics

Space exploration is motivated by scientific curiosity and discovery, interests in weather and climate observation, improved communication, tourism, resource extraction, and geopolitical and strategic considerations, among others. At the same time, spacefaring involves risks — including risks to astronauts; physical and economic threats posed by space debris; and the potential to contaminate the ecosystems we visit (forward-contamination) or our own planet following space missions (backward-contamination). We also confront trade-offs — such as spending scarce public dollars on space rather than on improving the health and well-being of people on Earth. Space ethics prompts us to ask whether certain motives are defensible, what risks and trade-offs they entail, which activities

should be permitted, and what limits should be placed on space activities in light of important values and principles.

The proliferation of low Earth orbit (LEO) satellites, for example, raises ethical questions. LEO satellites can improve communications and internet access, especially in remote areas, and enhance weather- and climate-tracking capabilities. At the same time, LEO satellites are rapidly cluttering the skies, making professional and amateur stargazing more challenging and intensifying the economic and safety risks associated with space debris. How should LEO space be regulated, recognizing different actors, interests and concerns for fairness? Similarly, there are questions about how we should sequence scientific, strategic and commercial interests when there is the potential for conflict among them. If commercial activities, such as mining, risk contaminating other worlds, perhaps we should prioritize scientific over strategic and commercial missions — or prohibit mining altogether. But if strategic and commercial missions provide the motivation and funding without which scientific missions would not occur, then perhaps a different balance is warranted.

Where these and other issues are addressed is just as important as how they are resolved. Ideally, ethical reflection should be insulated from ideology, interests and bias. But space ethics is an earthbound, human endeavour, with all the good and bad that entails. For much of the history of space exploration, ethical deliberation and decision making have been restricted to a handful of institutions and people. How have they fared?

A Community of Scholars: Space Ethics in Theory

As a field of inquiry, space ethics is relatively new. Following the 1957 launch of the Soviet satellite Sputnik, and the widespread publication of pictures of Earth as seen from space throughout the 1960s, a handful of philosophers and scientists began to ask what it means for humanity to "escape from…imprisonment to the earth." An early intervention was Hannah Arendt's 1963 essay, "The Conquest of Space and the Stature of Man," in which she asked how our being in, and seeing ourselves from, space would affect our sense of our place in the universe and our earthly conceptions of value and obligation. This was space ethics more as geocentric reflection on how space exploration would change humanity's self-conceptions, and less about whether we should go and what we should and should not do in space.

Leading space ethicists James S. J. Schwartz and Tony Milligan note that a more outward-looking space ethics largely emerged only in the 1980s when, as scientists were considering the feasibility of terraforming Mars, many began to ask whether that was "the kind of thing we ought to do." Those involved published their thoughts in a 1986 volume, Beyond Spaceship Earth: Environmental Ethics and the Solar System. Since then, the academic space ethics community has flourished, although Schwartz and Milligan note that only in the past 10 or 20 years have professional ethicists — rather than interested scientists and space practitioners — taken the lead. The field now boasts hundreds of articles and books on space ethics issues, some university-level courses dedicated to space ethics, and a well-connected community of scholars. Our understanding of the ethical implications of space exploration is enriched by their efforts. Yet, space ethicists' influence on decision making has been limited. Although some contribute to discussions and working papers at NASA, the European Space Agency and other space agencies, and occasionally write for policy-oriented publications or conventional media, their insights and knowledge far outpace their opportunities for impact. Institutional realities limit what can be achieved.

The Operational Frontier: Space Ethics in Practice

Engineers, flight directors and managers at the operational frontier of space exploration are better placed than academics to apply ethical considerations to decision making and behaviour, but less equipped and motivated to do so. The operational frontier is concerned with mission success —

whatever mission they have been given — but not so concerned about whether a mission ought to proceed at all. Indeed, the ethical considerations that have been embraced at the operational frontier have tended to emerge through reaction to catastrophic events rather than through proactive reflection.

Only after a fire in the cabin of the Apollo 1 command module, and the deaths of astronauts Gus Grissom, Ed White and Roger Chaffee in 1967, did NASA's Mission Control Center begin to take space exploration's risks to human life more seriously. In a speech following the tragedy, flight director Gene Kranz committed Mission Control to a new "tough and competent" ethos where "tough means we are forever accountable for what we do or fail to do" and "competent means we will never take anything for granted." Less than 20 years later, it took the Challenger space shuttle disaster, which killed all seven crew members — including schoolteacher Christa McAuliffe, the first civilian astronaut — for NASA to recommit to risk-based decision making that prioritizes human life over "impossible schedules" and cost savings and to establish the Office of Safety and Mission Assurance. As the American physicist Richard P. Feynman noted in his report following the disaster, "for a successful technology, reality must take precedence over public relations, for nature cannot be fooled."

While most NASA officials are decent people who would never intentionally behave unethically, all organizations — including NASA — tend to have structural logics that establish implicit boundaries around questions that can and cannot be raised, and incentive structures that impair ethical deliberation when it does occur. NASA does not really question whether space exploration is worth pursuing, and it faces cost, timeline and political considerations that can cloud proper ethical reflection. As more private sector firms launch space activities, the risk of cost constraints and profit incentives impairing ethical judgment is likely to increase.

The Politics of Space Ethics

Academic space ethicists have the independence and insight to ask the big questions, but they lack institutional influence. Practitioners at the operational frontier have the necessary proximity and resources to act, but face institutional constraints on the kinds of ethical questions and concerns that can be addressed. Does democratic politics offer a better path? Elected decision makers are well positioned to set, and consider the ethical implications of, broad goals and plans for space exploration. Their track records on space ethics, however, have been underwhelming.

When President John F. Kennedy announced in 1961 that America would put astronauts on the moon by the end of the decade, he said that "we choose to go the moon," implying that the American people had collectively decided to do so. Yet, no such collective decision was made. In fact, polls at the time showed that only a little more than one-third of Americans supported a moon mission, while more than half were opposed. Moreover, although Kennedy appealed to ideals of "knowledge and progress" and inspired the audience with visions of a "great adventure" and "exploration" in his speech, in reality, the moon shot was motivated by concerns about the security implications of recent Soviet successes in space. The decision to go to the moon may have been ethically permissible, perhaps even imperative, but the actual decision was neither collective nor informed by careful ethical deliberation. That broader ethical deliberation had been discounted in decision making about the moon shot was made strikingly clear in Gil Scott-Heron's 1970 poem "Whitey on the Moon." Scott-Heron offered a biting critique of the Apollo program's enormous costs while Black Americans faced racial, political and economic injustice.

What else could we be doing with the resources dedicated to space exploration, Scott-Heron prompted us to ask. Are promises of progress and trickle-down benefits accurate and substantial enough to justify massive public spending on space-related activities? Given the current state of democratic politics — a system in which monied interests get hearings with decision makers that

ordinary citizens do not, and where regulators are often "captured" by private interests, due to knowledge asymmetries — the rise of privately funded space activity could further undermine the state as a mechanism to consider the ethical implications of space exploration.

Multilateral institutions offer hope, especially the United Nations Office for Outer Space Affairs (UNOOSA). UNOOSA regularly convenes space experts and decision makers to discuss issues of mutual concern, such as how to coordinate LEO satellites to avoid collisions, how to regulate space mining, and how to facilitate international cooperation on shared assets such as the International Space Station. UNOOSA's greatest achievement is the 1966 Outer Space Treaty — an agreement signed by all major spacefaring nations that sets out principles for a peaceful and well-coordinated exploration and use of space, accessible to all, and with explicit prohibition on certain military activities. Yet, like all multilateral institutions, while UNOOSA has been able to articulate and facilitate international agreement on noteworthy ethical principles, its enforcement capacity is limited. That some countries continue to use space for military purposes reveals the challenge.

A More Democratic Space Ethics

Is there a way to conduct ethical deliberation about space activities with the independence it requires while ensuring that its conclusions and insights have practical force? An ideal institution free from the pathologies that confront existing institutions likely does not exist. But there are ways to improve how we do space ethics and enhance their relevance at both the goal-setting and operational frontiers.

At a minimum, we should ensure that academic space ethics is well funded and that its experts are regularly invited to contribute their insights to political and operational decision making through briefings, panels, conferences and committees. Moreover, we should strive for more public discussion and engagement on the ethical implications of emerging space issues and activities. This could include more frequent and informed discussion in the media, occasional citizens' juries and deliberative panels, and even the creation of a non-profit institution (perhaps modelled on the Danish Board of Technology) to facilitate regular research, foresight and public engagement on space-related ethical issues. Expanding the activities of the Outer Space Institute — a Canadian-based space policy think tank — to include more comprehensive and systematic discussion of ethical issues prompted by space exploration, is another option. And, despite its limitations, further support and engagement with UNOOSA is also critical, given its potential as a forum to discuss and coordinate international and interplanetary activities.

As we muddle through ideas and institutional possibilities, our minimum aim should be to avoid the kind of thinking — or lack of thinking — that characterized von Braun's participation in the American space program. Again, von Braun was likely more opportunist than villain, and space program officials are surely decent people who intend no harm. But as the philosopher Hannah Fenichel Pitkin has argued, many of our moral failings are a result not of malevolent intent, but of simply not thinking about what we are doing. If space exploration is to be conducted in ways consistent with core values and interests, we need to engage in more ethical thinking and create better spaces for space ethics.

For reflection/discussion:

- At the start of this reading, Munro raises the example of German-American aerospace engineer von Braun and how his controversial past was deliberately obscured from the American public in view of his expertise in the field, which eventually led to the successful implementation of the Apollo 11 programme.
  - Do you find this decision by the US government in withholding information about the background of von Braun to be justifiable? Why/why not?
  - How might that decision to suppress such information contradict the ideal of responsibility and accountability? Conversely, how might this same decision be seen as a responsible one?

- As outlined from lines 28 to 37, how would you weigh the benefits of space exploration and the risks involved? Given the hefty monetary costs involved, do you think the benefits have proven worthy?
- Munro asserts that 'ethical deliberation and decision making have been restricted to a handful of institutions and people' (lines 52-53), and this idea is supported by the example of the 1961 Moon expedition, where 'only a little more than one-third of Americans supported a moon mission, while more than half were opposed' (lines 111-112). In your opinion, what are the tradeoffs involved when societies insist on making a collective decision for a matter like space exploration?
- How might the rise in privately funded space activities challenge or affect the way ethical deliberation is conducted for space ventures?
- According to Munro, how might a 'democratic politics' (line 105) worsen the way boundaries are set and enforced around space exploration?

Related Cambridge/RI essay questions:

1. Consider the view that spending money on space travel cannot be justified in today's world. (Cambridge 2023)
2. Can space travel ever be justified? (RI Y6 CT 2022)
3. How far do you agree that space exploration is irrelevant to the average person? (RI Y6 CT1 2017)
4. Do you agree that exploring space should not be a priority in today's world? (Y5 Promo 2014)

Reading 15: What is Artificial Intelligence? **EU 5 and 8**

Singularity University | Adapted from The Exponential Guide to Artificial Intelligence | 2018

This reading will help you to understand:
- What Artificial Intelligence is and its impact on different areas of society

What is artificial intelligence?

AI is an "umbrella term" for a branch of computer science focused on creating machines capable of thinking and learning. Based on their experiences, AIs learn to make better decisions in the future. This ability to both learn and apply knowledge closely mimics the way human beings understand the world and allows machines to accomplish tasks that were once only possible with human minds.

Some of the human-like tasks AIs can do include:

- Complex problem solving
- Visual interpretation (computer vision)
- Speech recognition (natural language processing)

These capabilities are accomplished via a collection of computer algorithms that use mathematics and logic to perform the AI's assigned task. So although our most famous science fiction books and movies tend to portray AI in the form of human-like robots, AI is simply computer code running in software.

Unlike the human brain, these intelligent programs can be run in a variety of different hardware types, whether that's your smartphone, a warehouse of web servers, or a self-driving Tesla.

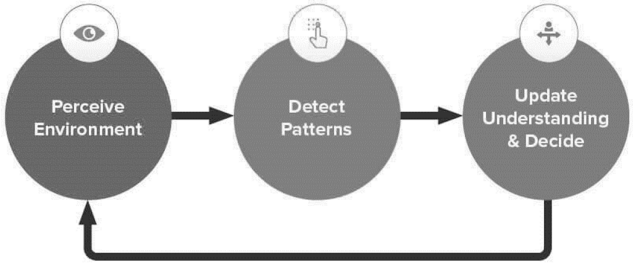
This variety of use cases is what often makes AI so difficult to understand, but it's also what makes it so powerful. The ability to add an AI layer on to nearly every technology means that as AI progresses, the world around us will increasingly seem to come alive. This "awakening" will drastically alter life as we know it, from leisure and business activities to our health and spirituality. To get an idea of how this might happen, let's first take a look at how AI works.

Much like human intelligence, AI works by taking in large amounts of data, processing it through algorithms that have been adjusted by past experiences, and using the patterns found within that data to improve decision-making.

To simulate human intelligence in this way, AI engineers provide their machines with ability to:

1. Perceive their surrounding environment (which may simply be data)
2. Detect patterns in the environment
3. Learn from the patterns and update experiential memory

Then, these steps are repeated until there's enough data to confidently make predictions and support decision-making.



What makes AI remarkable is the speed, accuracy, and endurance it brings to this human-like learning process. Humans have to eat, sleep,

and tend to a variety of personal needs. We are also creatures of comfort, and quite stubborn—too much change makes us uncomfortable. And when presented with new information and experiences, humans tend to let our biases sway us from making the most reasonable and logical decisions.

Machines suffer from none of these shortcomings. For most purposes, they're capable of running indefinitely, allowing AIs to process and detect patterns in massive amounts of data without mental fatigue.

AIs are constantly tweaking their understanding of their environment, updating their "perspective" of reality, and updating the probability of their predictions without clinging to any old ideas. Some people find this cold logic the most terrifying part of AI, however, it's also what allows AIs to find solutions humans may not recognize.

The concept of AI has been around since 1955, but its growth has exploded in recent years because of three factors:

1. Vastly increased computing power
2. Large, inexpensive data sets
3. Advancements in the field of machine learning

But computing power alone wouldn't have accomplished much if not for two key technologies that support AI: big data and machine learning.

How are AI, big data, machine learning, and deep learning related?

As we've mentioned, AI covers a broad field of sciences involved in developing computer systems that think and learn in a way that's similar to human intelligence. AI applications are often divided into "narrow AIs" that perform specific tasks such as playing chess, and "general AIs" that understand language, context, and emotions as humans do. Let's take a closer look at the relationships between AI, big data, machine learning, and deep learning.

Big data

With the rapidly decreasing cost of sensors and the global growth of the Internet of Things (IoT), we have dramatically increased the number of smart and connected devices that are continuously measuring and recording data. Nearly every action we take is now recorded in a database somewhere. This includes mobile device activity, the purchase history on our credit cards, our online browsing activity, our social media feeds, and even our biological data.

Big data is the term for these massive collections of data that we're all contributing to every day. Big data is the fuel that enables AIs to learn much more quickly. The abundance of data we collect supplies our AIs with the examples they need to identify differences, increase pattern recognition capabilities, and to discern the fine details within the patterns.

If you provided an AI with one picture of a dog and one picture of a cat to learn from, you will have an AI that's terrible at the task of determining pet species. Feed that same algorithm millions of pet pictures, and the AI can quickly learn how to distinguish dogs from cats, and also determine the different breeds within the species. Big data enables AIs to learn by example rather than by instructions provided by humans. And they're able to learn this way because of the advances in machine learning.

Machine learning

Machine learning is a method of data analysis that learns from experience, enabling computers to find hidden insights without being explicitly programmed to do so. Machine learning analyzes data and

learns from it to make decisions and predictions, and includes supervised (manual entry of data and solutions) and unsupervised learning.

Machine learning is a subset of the larger field of AI, and it is one of the many processes that enable the creation of AI. Many ways of creating AIs have been explored, but machine learning is important because it does not require human input or interaction. Rather than learning by instruction, machine learning AIs learn by exposure to examples found in data. Through machine learning, AI is able to take advantage of the enormous data sets generated by our daily activities. To learn without human involvement, machine learning works largely by implementing statistical methods into the learning process.

Deep learning

Deep learning is part of the broader field of machine learning that uses artificial neural networks, which are computer simulations patterned after a human brain. Deep learning includes aspects of machine learning algorithms, neural networks, and AI.

The artificial neural networks created from these components are where the field of AI comes closest to modeling the workings of the human brain. Improved mathematical formulas and increased computer processing power are enabling the development of more sophisticated deep learning applications than ever before. Deep learning—also called structured learning and hierarchical learning—is the kind of machine intelligence used to create AIs that beat humans at games of Go and chess.

How does AI affect our lives?

Some of the most powerful and prevalent applications of AI are the ones we often take for granted. These include the AIs that handle your Google searches, deflect spam from your inbox, and select the ads you see across the digital landscape. AIs identify people in your Facebook pictures, and recommend the products you buy from Amazon.

No matter where you live and work, one thing is certain: more and more of our society's technical infrastructure is powered by AI. While many AIs are easy to overlook because they don't talk to us like Siri or perform physical tasks like driving our Teslas, they constantly work behind the scenes, performing crucial functions like pattern recognition, problem solving, reporting, and optimization.

The Singularity is often defined as the point at which exponential technology crosses the threshold of "strong AI" and machines possess a broad intelligence that exceeds human levels. It's a concept that's understandably hard for many of us to accept, because the Singularity also represents a point where human intelligence and AI merge.

On the way to such a merger, human intelligence will undergo an extensive integration with AI, forming a symbiotic relationship where AIs are empowered by human talent for creative, lateral thinking, and humans are empowered by AI's near-infallible memory and rapid computing. So not only is AI likely to be integrated into nearly every electronic system—but also into nearly every person as well.

None of us can predict the future, nor can we stand against the wave of change driven by AI and other exponential technologies. Instead, we can do our best to learn about these technologies, understand their inherent opportunities, and apply them to solving our biggest global challenges. Perhaps the biggest mistake we can make with AI is to underestimate its impact and rapid growth.

Reflection questions and related Cambridge essay questions can be found at the end of Reading 15.

Reading 16: Algorithmic intelligence has gotten so smart, it's easy to forget it's artificial

Geof Nunberg | National PR | 28 June 2019

EU 5, 8, 9

This reading will help you to:
- Understand some of the drawbacks of reliance on algorithmic intelligence

Algorithms were around for a very long time before the public paid them any notice. The word itself is derived from the name of a 9th-century Persian mathematician, and the notion is simple enough: an algorithm is just any step-by-step procedure for accomplishing some task, from making the morning coffee to performing cardiac surgery.

Computers use algorithms for pretty much everything they do — adding up a column of figures, resizing a window, saving a file to disk. But all those things usually just happen the way they're supposed to. We don't have to think about what's going on under the hood.

But algorithms got harder to ignore when they started taking over tasks that used to require human judgment — deciding which criminal defendants get bail, winnowing job applications, prioritizing stories in a news feed. All at once the media are full of disquieting headlines like "How to Manage our Algorithmic Overlords" and Is the Algorithmification of the Human Experience a Good Thing?"

Ordinary muggles may not know exactly how an algorithm works its magic, and a lot of people use the word just as a tech-inflected abracadabra. But we're reminded every day how unreliable these algorithms can be. Ads for vitamin supplements show up in our mail feed, while wedding invitations are buried in the junk file. An app sends us off a crowded highway and lands us bumper-to-bumper in local streets.

OK — these are mostly just inconveniences. But they shake our confidence in the algorithms that are doing more important work. How can I trust Facebook's algorithms to get hate speech right when they've got other algorithms telling advertisers that my interests include The Celebrity Apprentice, beauty pageants and the World Wrestling Entertainment Hall of Fame?

It's hard to resist anthropomorphizing these algorithms — we endow them with insight and intellect, or with human frailties like bad taste and bias. Disney actually personified the algorithm literally in their 2018 animated movie Ralph Breaks the Internet, in the form of a character who has the title of Head Algorithm at a video-sharing site. She's an imperious fashionista who recalls Meryl Streep in The Devil Wears Prada, as she sits at a desk swiping through cat videos and saying "no," "no," "yes."

Tech companies tend to foster that anthropomorphic illusion when they tout their algorithms as artificial intelligence or just AI. To most people, that term evokes the efforts to create self-aware beings capable of reasoning and explaining themselves, like Commander Data of Star Trek or HAL in 2001: A Space Odyssey.

That was the aim of what computer scientists call "good old-fashioned" AI. But AI now connotes what's called "second-wave AI" or "narrow AI." That's a very different project, focused on machine learning. The idea is to build systems that can mimic human behavior without having to understand it. You train an algorithm in something like the way psychologists have trained pigeons to distinguish pictures of Charlie Brown from pictures of Lucy. You give it a pile of data — posts that Facebook users have engaged with, comments that human reviewers have classified as toxic or benign, messages tagged as spam or not spam, and so on. The algorithm chews over thousands or millions of factors until it can

figure out for itself out how to tell the categories apart or predict which posts or videos somebody will click on. At that point you can set it loose in the world.

These algorithms can be quite adept at specific tasks. Take a very simple system I built with two colleagues some years ago that could sort out texts according to their genre. We trained an algorithm on a set of texts that were tagged as news articles, editorials, fiction, and so on, and it masticated their words and punctuation until it was pretty good at telling them apart — for instance, it figured out for itself that when a text contained an exclamation point or a question mark, it was more likely to be an editorial than news story. But it didn't understand the texts it was processing or have any concept of the difference between an opinion and a news story, no more than those pigeons know who Charlie Brown and Lucy are.

The University of Toronto computer scientist Brian Cantwell Smith makes this point very crisply in a forthcoming book called, The Promise of Artificial Intelligence, arguing the systems have no concept of spam or porn or extremism or even of a game — rather, those are just elements of the narratives we tell about them.

These algorithms are really triumphs of intelligent artifice: ingenious systems that can mindlessly simulate human judgment. Sometimes they do that all too well, when they reproduce the errors in judgment they were trained on. If you train a credit rating algorithm on historical lending data that's infected with racial or gender bias, the algorithm is going to inherit that bias, and it won't be easy to tell. But they can also fail in alien ways that betray an unhuman weirdness. You think of the porn filters that block flesh-colored pictures of pigs and puddings, or those notorious image recognition algorithms that were identifying black faces as gorillas.

So it's natural to be wary of our new algorithmic overlords. They've gotten so good at faking intelligent behavior that it's easy to forget that there's really nobody home.

For reflection/discussion:

- Based on the information in Reading 14, identify sectors/industries and areas of human endeavour that might be heavily affected by the leading trends in AI and explain why.
- Identify a specific phrase in paragraph 4 (lines 12-16) of Reading 15 and explain how Nunberg uses it to illustrate that most people are completely unfamiliar with how computer algorithms work.
- In what context does Nunberg think the use of AI algorithms becomes 'harder to ignore (line 8)?
- Why does Nunberg utilise the examples concerning the poor use of AI algorithms that result in 'inconveniences' (line 17) to reinforce his main point in paragraph 5 (lines 17-20)?
- Are there any reasons to persist with or even expand the use of AI algorithms in helping humans carry out 'more important work' (line 18)?

Related Cambridge/RI essay questions:

1. Will technology completely replace the role of humans in the future? (RI Y6 Prelims 2022)
2. To what extent is artificial intelligence replacing the role of humans? (Cambridge 2019)
3. 'Artificial intelligence creates more problems than benefits.' Discuss (RI Y6 Prelim 2019)
4. Is a fear of artificial intelligence justifiable? (RI Y5 Promo 2015)

SECTION D: SCIENCE AND TECHNOLOGY – DISRUPTIONS AND DANGERS

Reading 17: The attack of zombie science **EU 1, 4, 7, 9**

Natalia Pasternak et al | Nautilus | 12 January 2022

The reading will help you to:

- Understand how political pressure and productivism in the academic world have encouraged the rise of 'zombie science'.
- Consider the negative impact of 'zombie science'.

When we think about how science is distorted, we usually think about concepts that have ample currency in public discourse, such as pseudoscience and junk science. Practices like astrology and homeopathy come wrapped in scientific concepts and jargon that can't meet the methodological requirements of actual sciences. During the COVID-19 pandemic, pseudoscience has had a field day. Bleach, anyone? Bear bile? Yet the pandemic has brought a newer, more subtle form of distortion to light. To the philosophy of science, we humbly submit a new concept: "zombie science."

We think of zombie science as mindless science. It goes through the motions of scientific research without a real research question to answer, it follows all the correct methodology, but it doesn't aspire to contribute to advance knowledge in the field. Practically all the information about hydroxychloroquine during the pandemic falls into that category, including not just the living dead found in preprint repositories, but also papers published in journals that ought to have been caught by a more discerning eye. Journals, after all, invest their reputation in every piece they choose to publish. And every investment in useless science is a net loss.

From a social and historical stance, it seems almost inevitable that the penchant for productivism in the academic and scientific world would end up encouraging zombie science. If those who do not publish perish, then publishing—even nonsense or irrelevancies—is a matter of life or death. The peer-review process and the criteria for editorial importance are filters, for sure, but they are limited. Not only do they get clogged and overwhelmed due to excess submissions, they have to deal with the weaknesses of the human condition, including feelings of personal loyalty, prejudice, and vanity. Additionally, these filters fail, as the proliferation of predatory journals shows us all too well.

As scientists and science communicators, we see the harm that a system preoccupied with productivity and quantity of publications is doing to science and to the way science is perceived by the public. Such a system tends to reward zombie science, and research groups are going into it as a response to a perceived need for self-preservation. Zombie science, whether well intentioned or an attempt to game the system, consumes funding and bestows an aura of scientific credibility on results that are not answering real scientific questions.

Some scientists have come forward to denounce zombie science. Piotr Rzymski, a researcher in the Department of Environmental Medicine at the Poznan University of Medical Sciences, complained about the amount of useless peer review he was forced to do during the pandemic. "Some were ridiculous," he told Science Business. "My favorite example is a suggestion to blow very hot air into a patient's lung to eliminate the virus."

Derek Lowe, renowned chemist and Science contributor, has also called attention to zombie science. In his blog In the Pipeline, he lamented the proliferation of papers during the pandemic that don't advance scientific knowledge but fit the sole purpose of enhancing someone's résumé. As a

"designated Pain the Rear," he wrote, addressing his own field of drug discovery, "I have to ask if we needed over ninety different papers screening what in many cases is more or less the same set of compounds, over and over and over." Many papers, he wrote, may as well have been titled "Stuff We've Already Done, Now With a Coronavirus Angle Glued Onto It So It Can Be Published Again."

This trend of worthless science has been exacerbated by the media spotlight, political pressure and, presumably, the strong human impulse in the face of an emergency to do something, anything, even if it is sheer lunacy. This way, zombie scientists get not only peer-review recognition but also the public's impression that they are doing important work.

Zombie science not only pollutes science and generates noise; it also contributes to the hype of miracle cures and false hopes that end up in the press. A paper published by a Brazilian group of scientists on the use of saline solution as COVID-19 prevention accomplished just that. The paper tested the use of saline solution in vitro and concluded that it inhibits viral replication. The authors carried out all kinds of experiments and statistical analyses and presented the results in what looks like rigorous methodology. The conclusion, typical for zombie science, is that more studies are needed to evaluate whether saline solution would be a good alternative to treat and/or prevent COVID-19.

Because the paper was signed by scientists from the University of São Paulo, and funded by one of Brazil's largest funding agencies, it received a lot of publicity. The funding agency's magazine, Revista Fapesp, published an article on how Brazilian scientists had proposed the use of nasal sprays with saline to prevent COVID-19, stressing just how important this discovery could be to help control the pandemic. Another Brazilian magazine also picked up the bait and highlighted the good news, being careful to stress that this was not a cure for COVID-19.

The same was observed with the publication of the clinical trial for the use of nitazoxanide in Brazil, published in the European Respiratory Journal.4 The paper doesn't dare state the vermifuge, a medicine to kill intestinal worms, cures COVID-19 but, of course, concludes that more studies are needed. The authors don't say so in the paper, but they participated in hyping the paper with the federal government. One of the authors of the paper is the current secretary to Marcos Pontes, Brazil's Minister of Science, Technology, and Innovations, responsible for approving funding for the project. Pontes cried when the paper's results were broadcast in a press conference, thanking the Brazilian scientists for their tireless work.

During the pandemic, zombie science has not been restricted to Brazil. Many clinical trials have been small, lacked proper randomization, and have been low in methodological quality. Such poorly designed clinical trials have contributed to hype and misinformation. Brazil, though, has shown us that zombie science is not just insidious, arising out of suspect relations between the academic and political systems, but can be evil. In fact, maybe "evil science" deserves a category of its own. It would be identified by its intent to use science to achieve a political or ideological goal, without excluding, of course, financial gain. It doesn't shirk from fraud and has complete disregard for medical ethics and human rights. The cases of hydroxychloroquine, ivermectin, and other miracle drugs provide sad examples.

Hydroxychloroquine was first promoted in Brazil in March 2020, following the hype in France when physician and microbiologist Didier Raoult went on YouTube to brag about his results, presented in his now infamous Marseille paper. The paper was highly criticized by the international scientific community for its grave methodological flaws.

Shortly after Raoult's publication, the chloroquine hype exploded in the United States and Brazil, with both President Trump and President Bolsonaro promoting the malaria medication as a miracle cure

for COVID-19. A private healthcare operator in Brazil, Prevent Senior, produced a makeshift paper, "the game-changer," which was circulated as a PDF but never appeared in a peer-reviewed journal.

The results of the study showed no deaths in its treatment group. The work, as presented, had shabby methodology and the rosy conclusions were obviously unwarranted, Later, a group of medical doctors fired by the study sponsor came forward and declared the study was rife with fraud, ethical misconduct, and withheld information. It turned out that there had been deaths in the treatment group, but they were removed from the record.

The doctors also accused Prevent Senior of pressuring them to prescribe unproven medication, not just hydroxychloroquine but also other drugs that came to compose what became known in Brazil as the "COVID early treatment kit." The kit contained a huge amount of other unproven drugs such as ivermectin, nitazoxanide, flutamide, vitamin D, zinc, and azithromycin.

Messages from the hospital directors and program coordinators were released to the press and to Brazil's Parliamentary Inquiry Committee (CPI, in the Portuguese Acronym). The messages showed that directors pushed the doctors to prescribe the COVID kit, treating the number of prescriptions as if they were sales goals in a retail marketing campaign. Those who refused were reprimanded. There were also instructions not to inform the patients or their families about the prescriptions.

Prevent Senior's medical director, Pedro Batista, was summoned by the CPI and calmly confirmed that the ICD (International Classification of Disease) of all COVID-19 patients was altered after 14 days. This meant that patients would come in with COVID-19, get treatment, preferably with the COVID kit, and, after 14 days, if they made it out of intensive care, either dead or discharged, the ICD would be altered. Death certificates would state that those patients died from sepsis, pneumonia, or any other COVID-related complications, but the fact that the patients presented with COVID-19 would be omitted.

Prevent Senior is also under the suspicion of having close ties with Bolsonaro and the federal government. The President and his sons were the first to promote the "game-changer" PDF, and there are leaked videos of scientists and medical doctors working together with Prevent Senior and President Bolsonaro to promote the COVID kit, in an attempt to convey to the populace the notion that the pandemic was under control and there was no need for mitigation and preventive measures that would "hurt the economy."

Another case in Brazil is the use of proxalutamide, a male hormone blocker, as a COVID-19 treatment. This involved another private healthcare operator, the Samel group. Proxalutamide is a drug still under study for prostate cancer, and its use is not authorized by Brazil's regulatory agency Anvisa. Nonetheless, it was used in clinical trials, which in turn, have also not been authorized by the Brazilian Board of Ethics in Research (CONEP). A group of Brazilian researchers conducted clinical trials with the drug, with suspicious results that did not go unnoticed by the international scientific community. "Too good to be true" was the ironic remark in Science. Besides having no ethical clearance to run the trials, the group failed to inform CONEP of the elevated number of deaths during the trial, which would have been reason to halt it. The study protocol also differed from the one deposited at the website Clinical Trials. O Globo, one of Brazil's largest newspapers, published a series of reports and articles on proxalutamide, but a judge deemed them prejudicial and censored them.

UNESCO declares that the proxalutamide case in Brazil, if the details known so far are to be confirmed, is one of the most serious violations of human rights of patients in the history of Latin America. Patients were not informed that they were part of a trial, and neither were families.

As we know from the horror movies, the only way to kill a zombie is to destroy its brain—before it devours ours. The same is true for zombie science. As scientists, science communicators, and citizens, we need to recognize this distortion of science and take aim at its methods before it has another chance to distort, harm, and kill.

For reflection/discussion:

- Explain in your own words what exactly 'zombie science' is. How has it distorted science?
- In your opinion, how might this distortion of science influence the perception of science and the role of science in society? Consider this from the perspectives of different stakeholders stated in the article. What about the level of trust between these stakeholders and scientists?
- In the final paragraph, the authors conclude that 'we need to recognise this distortion of science and take aims at its methods' (lines 123-124). Given the severity of this issue, in what ways can the methods of 'zombie science' be addressed fully?
- How might appropriate regulations and/or limits imposed on scientific research help to address this trust deficit that may arise between society and science?

Related Cambridge/RI essay questions:

1. To what extent should politicians have a say in scientific research? (RI Y6 CT 2021)
2. 'Non-scientists should have little say in how scientific developments are managed.' What is your view? (RI Y6 Common Essay Assignment 2020)
3. Is our trust in science misplaced? (RI Y6 Timed Practice 2020)
4. 'Our job as scientists is to find the truth.' How far do you agree that this view accurately reflects the role of scientists today? (RI Y5 Promo 2018)

Reading 18: How Covid-19 is driving the evolution of Industry 5.0 **EU 5**

Dan Gamota | Forbes | 28 December 2020

This reading will help you to:
- Understand how technological revolutions can be driven by global health crises.
- Evaluate the factors that drive the 5th Industrial Revolution.

The ripple effect of Covid-19 continues to impact how we work, learn, live and play. As the pandemic persists, companies of all sizes have responded with surprising speed and agility to maintain operations, despite the ongoing threat of massive disruption. With nearly all business travel halted or stalled for more than eight months, people have discovered new ways to coordinate, collaborate and communicate with colleagues, customers and partners. Employees, who once flew around the world regularly to visit customers or train remote workers at global manufacturing facilities, have been grounded.

While it may sound counterintuitive, Covid-19's travel bans actually have helped ignite innovation. After all, necessity is the mother of invention, so people around the world have found new ways to engage, connect and complete their work. In turn, the emerging processes spearheaded by resilient leaders are championing new use cases for existing technologies. According to a recent article from IEEE Transmitter, global collaboration in 2020 has advanced on a scale that will be studied for decades. Digital tools and immersive experiences, bolstered by augmented reality (AR) and virtual reality (VR) as well as at-a-distance collaboration tools, are gaining rapid adoption while accelerating us along the path to Industry 5.0.

The Fifth Industrial Revolution is evolving from a concentration on the digital experience to one where humans are back in charge. The results will combine the skill and speed of automation with humans' critical and creative thinking. As such, Industry 5.0 represents the ultimate partnership between intelligent humans and smart manufacturing machines. While Industry 4.0 marks an era of automation, artificial intelligence, the Internet of Things (IoT) and autonomous actions without human intervention, Industry 5.0 puts the focus on people.

The Best AI Is Invisible

This is an important evolutionary step, not a major revolutionary one. Throughout the past eight months, we've seen countless examples of how people are stress-testing technologies because of the need to connect from afar. New use cases are continually emerging — from the widespread use of AR/VR to support remote immersive experiences to the National Basketball Association working with Microsoft to debut virtual viewing technology.

The convergence of human cognition and artificial intelligence is poised to produce a slew of new use cases in the near future. The possibilities are plentiful when we contemplate what is possible when people and collaborative robots, virtual assistants, digital twins and avatars work side-by-side or enjoy truly immersive experiences in ways not fully imagined before Covid-19.

The Biggest Accelerant: People

While technology adoption has received a major uptick in 2020, the biggest accelerant I have witnessed is how people have stepped up to fix problems, learn new technologies and maintain business operations. Without the benefit of fly-in teams to troubleshoot new technology deployment

hiccups or address line-down escalations to resolve broken manufacturing processes, individuals and teams have achieved fast-growth trajectories of their own.

Since they could not rely on other people to fix their problems, they came up with successful solutions. As a result, they became better problem-solvers, more innovative thinkers and more productive teams. In short order, the students became professors. And the dialogue has changed from the plaintive "How do I fix this?" to the definitive "I have some ideas on how to make this process work better."

The ability to take greater ownership and apply more innovative thinking will serve us all well during Industry 5.0, especially in balancing automation with increased demands for personalization and customization. In this next industrial era, smarter manufacturing machines will be used to reduce costs and drive efficiencies, so experts can be freed to truly tailor the products consumers want most.

Looking ahead, it is important to realize that Industry 5.0 will open doors to new ways of making products without losing sight of the craftsmanship that only experts can deliver. This reminds me of the awe I felt watching highly qualified RF engineers tune filter systems used in communications base stations. The demonstration of an automated tuning system has been elusive. It is almost impossible to replace these individuals who tune sophisticated RF equipment with the innate skills and dexterity typically reserved for extremely proficient piano tuners.

The Virtual Age Has Arrived

A recent Deloitte blog stated that Covid-19 has heralded the start of the Virtual Age, which is tectonic enough to qualify as the Fifth Industrial Revolution. With it comes a re-imagining of work, workforces and workplaces. In the near future, corporate America may no longer be defined by physical offices and gleaming headquarters. Several industry leaders, including Google, Zillow, Uber, Twitter, Reuters, Facebook, Square and others, announced extensions of their work-from-home policies. While Twitter's plans preceded the pandemic by two years, the company's decision to offer workers flexibility and autonomy may represent the ideal model for the future.

There will be many more lessons to be learned from Covid-19 that can be applied to the future of work and our foray into Industry 5.0. Now more than ever, we need to be open to applying these learnings while giving creative people ample freedom to put their human touch on how smart machines operate. In the long run, we'll all produce better outcomes while finely calibrating technology road maps to produce breakthrough products that benefit everyone in our ever-changing world.

For reflection/discussion:

- What are some key characteristics of the Virtual Age proposed by the author? How do these characteristics differ from Industry 4.0? Justify your reasons with research.
- What are some key industries or particular social groups/communities in Singapore that might be affected by these developments?
- How ready is your own society prepared to deal with challenges related to Industry 5.0?

Related Cambridge/RI essay questions:

1. In an age of rapid technological advancement, is a single career for life realistic? (Cambridge 2018)
2. How far can scientific or technological developments be a solution to global problems? (RI Y5 CT1, 2018)
3. Is there any point in trying to predict future trends? (Cambridge 2013)
4. To what extent has technology had a negative impact on the skill levels of the people? (Cambridge 2010)

SECTION D: SCIENCE AND TECHNOLOGY – DISRUPTIONS AND DANGERS

Reading 19: With the metaverse, are social recluses still a problem? **EU 4, 5, 8**

Extracted from With new technologies and the metaverse, are social recluses and hikikomori still a problem? | Leo Lewis | Todayonline | 10 November 2021

This reading will help you to:

- Learn about the characteristics of the metaverse and its application in real world contexts.
- Consider the wider implications of the metaverse on groups of previously socially isolated people who are forming increasingly vibrant online communities

Since the concept of the hikikomori recluse was first introduced by a psychiatrist in Japan nearly a quarter century ago, it has encapsulated a range of terrors about society, technology and the young. In its early stages, the phenomenon of individuals withdrawing into their bedrooms for months or years at a stretch was considered a peculiarly Japanese problem. Theories linked it with the nation's perceived societal and economic woes.

A 2006 book, Shutting Out the Sun, deemed it the pathology of a "lost" generation created in the aftermath of the 1980s bubble. A combination of Cabinet Office studies in 2015 and 2018 suggested that Japan may have more than a million 15- to 64-year-olds living as hikikomori in its broadest definition.

In 2019 the psychiatrist who coined the term all those years ago warned that the real number may be far higher. Yet neither the cause nor the symptoms of this issue were uniquely Japanese. As the concept was probed in greater academic, medical and socio-economic depth, it was found to exist plentifully in many other countries, especially Asian ones.

In South Korea, Singapore, China, Hong Kong and elsewhere, it was ascribed different names, root causes, risk factors and possible treatments. But the fundamental worry – that these people (mostly men) were vanes of an ill wind — was consistent. As was the idea that there was something fundamentally sinister about the confected, virtual worlds many hikikomori inhabited compared with the real world lived in by the rest of us.

China's referring to the hikikomori as "unproductive youth" captured both the contempt and disquiet that their withdrawal engendered. Looming over all of it, of course, is the idea that reclusion has been disproportionately aided and abetted by technology. In particular, the increasingly seductive and inescapable worlds created online and by ecommerce.

A 2017 regional symposium and subsequent paper concluded that increased internet use, online gaming and the consequent rise of certain addictions could play an important part in the rising rates of social withdrawal. "Online food delivery and shopping platforms that provide resources and services to the doorstep may further facilitate... disengagement," the authors added, implicitly adding Uber Eats to its long list of societal menaces.

So far, so grim. Yet on to this largely pessimistic scene has arrived the metaverse, and Mark Zuckerberg's bubbly peddling of the unimaginable fun and fulfilment we will all have in these new virtual worlds just as soon as technology allows it.

There are near infinite possible lines of speculation of where the metaverse may be heading — some sensible, some hucksterish[2]. To take one at random: After the creation of an immersive metaverse, how long might it be before a virtual trip to a ski resort or beach is sold or consumed as the low-carbon, morally correct choice?

Perhaps. But to some the dangers are already clear. Within two days of Zuckerberg's online explanations, the China Institutes of Contemporary International Relations — arguably the country's most influential think-tank and affiliated with the Ministry of State Security — roared out of the blocks with a substantial position paper on the subject.

Among the many strands it pulls at, the CICIR paper (which cites Nintendo's whimsical Animal Crossing game as an early example of an immersive virtual world) foresees huge implications for the balance of geopolitical power and a "new round of reshuffling". It sees, in Mr Zuckerberg's early discussion of the issue, the risk of the United States using these giants as a channel for greater influence.

It also cites Japan's "strong sense of crisis" towards the meta universe, confirming that China has been closely watching the experiences of its neighbour for lessons in what and what not to do. The Chinese paper does not explicitly mention the hikikomori, but refers to the possibility of the metaverse luring young people into a realm of "digital drugs" and long, irretrievable periods out of touch with people in the real world. Whatever emerges here, it feels like a moment where some perceptions of reclusion might inflect.

Is a withdrawal from the outside still problematic if it takes the individual to a place more widely accepted as desirable, with a vibrant society of its own? In some future light, might the hikikomori be deemed less the sad victims of society and technology gone awry and more the brave colonists of a prairie in which everyone will soon want their homestead?

For reflection/discussion:

- Lewis suggests that 'there was something fundamentally sinister about the confected, virtual worlds many hikikomori inhabited' (lines 17-18). Yet, this phenomenon 'was found to exist plentifully in many other countries' (line 13), suggesting that there is something appealing about such virtual worlds. What do you think the inhabitants of virtual worlds gain or hope to gain? What do they stand to lose even as they spend a large portion of their lives in such online realms?
- Lewis reveals that the kind of self-imposed social isolation the hikikomori represents is particularly common in 'Asian [countries]' (line 13). Can you suggest reasons why this may be so? What are some characteristics common or inherent in Asian societies that may predispose their people towards self-imposed social isolation?
- Given the link between 'increasingly seductive and inescapable worlds created online and by ecommerce' (line 22) and 'social withdrawal' (line 25) and 'disengagement' (line 26), should societies continue to support the development of expansive virtual worlds like the metaverse, as well as online services like food delivery and ecommerce platforms? Why or why not? What considerations may be useful in allowing us to evaluate the tradeoffs, or in other words, weigh the pros against the cons meaningfully?
- Chinese researchers have identified the development of online, immersive environments as potentially altering 'the balance of geopolitical power' (line 41). Whose responsibility should it be for overseeing the development of new technology and managing the adoption of technological advancements – scientists, technology business giants, or governments? Justify your answer.
- In the end of his article, Lewis asks the question of whether 'the hikikomori [would] be deemed less the sad victims of society and technology gone awry and more the brave colonists of a prairie

[2] A huckster is someone who sells or advertises something in an aggressive, dishonest, or annoying way

in which everyone will soon want their homestead' (lines 66-68). What sort of change in mindset in societies, particularly in Singapore, do you think is required for the latter scenario to materialise?

- What specific technological advancements from the past can you think of that societies also struggled to accept initially? What would it take for people to come to accept, even embrace new technologies?

Related Cambridge/RI essay questions:

1. Examine the view that the scientist is concerned only with knowledge, not morality. (Cambridge 2020)
2. How far is science fiction becoming fact? (Cambridge 2015)
3. To what extent can the regulation of scientific or technological developments be justified? (Cambridge 2014)
4. 'Science gathers knowledge faster than society gathers wisdom.' Do you agree? (RI Y6 CT2 2013)
5. 'Technology has failed to simplify our lives.' To what extent is this true? (RI Y5 Promo 2012)
6. Does technology facilitate crime? (RI Y6 CT1 2011)

SECTION D: SCIENCE AND TECHNOLOGY – DISRUPTIONS AND DANGERS

Reading 20: As tech disrupts our jobs, it's not too late to turn pain into gain **EU 4 and 5**

Guy Ryder | World Economic Forum | 22 October 2018

This reading will help you to:

- Understand the massive potential of welcoming disruptive technology into the workplace
- Offer solutions to the threat of obsolescence posed by such technology

The World Economic Forum's Future of Jobs Report 2018 gives some cause for encouragement. The business perspective on how technology will affect growth and job creation is becoming more positive, the survey results show. The new reality of technology in the world of work – the so-called Fourth Industrial Revolution – is already here. While countries are feeling the effects in different ways, at different speeds and to different extents, it is already clear that many jobs are disappearing or being redesigned. This raises new economic, legal, ethical and social considerations.

One such issue is ensuring that the workforce has the skills needed to support new technologies. Our research shows that the digital divide between developed and developing countries is becoming more acute and is the result not only of business cost-benefit decisions but also of workforce capabilities. By capabilities, I mean not just the higher-level technical and vocational skills needed to design, operate and maintain digital infrastructure, but also basic skills and ICT proficiency. The message is that skills matter, if we want to use technology to decrease, not increase, inequalities. So far, this wave of technological change has not brought about an overall reduction in employment, as the Forum's report confirms. While the change has affected certain sectors and occupations negatively, it is generating many new jobs in others, both directly and indirectly.

However, we need to prepare for the replacement of a broader range of tasks, thanks to the rapid development of machines capable of learning, known as artificial intelligence (AI). Service sector jobs such as business administration, transport and healthcare, which have so far experienced little disruption, may see job profiles and opportunities shift significantly.

Yet automation in these sectors, correctly applied, could bring significant benefits to both developed and developing countries. Those with intermediate and lower skill levels may be able to obtain improved conditions in production and work, while in developed economies, AI may allow productivity growth to pick up again.

But let's be clear that we are talking about potential benefits here. What we will actually see depends on how the transition for workers and companies is managed. Workers will need to learn new skills or undergo retraining, with a particular focus on 'soft', social and interpersonal skills. If workers can adapt quickly, a productivity revival could generate more jobs, in both existing and new occupations, and absorb the rising number of labour market entrants, especially in developing countries.

Not only could this transformation contribute to higher wages and living standards, but it could do so in ways that are 'green'. New technologies offer win-win possibilities for reducing use of energy and resources, while offering substantial productivity and competitiveness gains.

So, what is the magic mix of skills the workforce needs to exploit the technological revolution? It includes basic technical, analytical and ICT skills, of course, but these are almost the icing on the cake. Underpinning them should be strong cognitive skills, such as literacy and numeracy. These enable the most important attribute of all – an aptitude for lifelong learning.

A range of core employability skills should be added, such as creativity, problem-solving and critical thinking. Interpersonal and communication skills, as well as emotional skills and the ability to assess and take risks, and manage stress and change, will become more important. They will need more attention from education systems, because they give humans a comparative advantage over machines.

It follows that our enthusiasm for adopting technology must be accompanied by a similar enthusiasm for quality education systems, from the earliest years. If we equip our children with the appropriate package of skills, they will not only be able to cope with this Fourth Industrial Revolution but will be ready for the Fifth and Sixth too. The era of front-loading skills for a single qualification that defines a career path at the start of a working life is over. Training systems will need to be flexible, allowing workers to continue learning throughout their careers. This lifelong learning approach has to be backed by incentives for learning with innovative financing (for example through individual learning accounts, credits and tax breaks) and co-funded by the private and public sectors.

Lifelong learning implies that each worker will experience a broader range of jobs than in the past. The resulting increase in job transitions will require a range of adaptation strategies and supports, including new forms of income security through social protection, and reformed career guidance and job matching service.

Just as importantly, when it comes to getting skills right for the jobs of the future, social dialogue and private-public partnerships between all those involved in the world of work – employers' organizations, trade unions, and education and training designers and providers – will be crucial.

A shift to lifelong learning is essential if we are to harness technology for our benefit, rather than allowing ourselves to be swept along by the tide. At the same time, if all and not the few are to benefit, we need to re-examine and renew our concept of the social contract, so that we have the foundations on which technology can shape a better future.

For reflection/discussion:

- Do you think that technological disruption in the workplace carries more upsides than downsides?
- Ryder stresses the importance of 'lifelong learning' (line 35) in helping to circumvent the massive impacts of technology disruption in the workplace. Is such an ethos present in your society? How do we see it manifest?
- Identify and evaluate the tradeoffs involved in societies choosing to embrace disruptions.
- List down five professions that you have your eye on in the future. Now, research into whether these professions are threatened by the existence of disruptive technology, and if so, how.

Related Cambridge/RI essay questions:

1. In an age of rapid technological advancement, is a single career for life realistic? (Cambridge 2018)
2. To what extent does technology make us more skilful? (RI Y6 CT2 2016)
3. 'Technology has failed to simplify our lives.' To what extent is this true? (RI Y5 Promo 2012)
4. Consider the view that most work these days could, and should, be done from home. (Cambridge 2011)

SECTION D: SCIENCE AND TECHNOLOGY – DISRUPTIONS AND DANGERS

Reading 21: Is artificial intelligence making big tech too big? **EU 4, 8, 9**

The Economist | 23 Jun 2024

When ChatGPT took everyone by storm in November 2022, it was Openai, the startup behind it, that seized the business world's attention. But, as usual, big tech is back on the front foot. Nvidia, maker of accelerator chips that are at the core of generative artificial intelligence (ai), is now duelling with Microsoft, a tech giant of longer standing, to be the world's most valuable company. Like Microsoft, it is investing in a diverse ecosystem of startups that it hopes will strengthen its lead. Predictably, given the "techlash" mindset of the regulatory authorities, both firms are high on the watch list of antitrust agencies.

Don't roll your eyes. The trustbusters may have infamously overreached in recent years in their attempts to cut big firms down to size. Yet for years big-tech incumbents in Silicon Valley and elsewhere have shown just as infamous a tendency to strut imperiously across their digital domains. What is intriguing is the speed at which the antitrust authorities are operating. Historically, such investigations have tended to be labyrinthine. It took 40 years for the Supreme Court to order E.I. Du Pont de Nemours, a large American chemical firm, to divest its anticompetitive stake in General Motors, which it first started to acquire in 1917 when gm was a fledgling carmaker. The Federal Trade Commission (FTC), an American antitrust agency, is still embroiled in a battle with Meta, a social-media giant, to unwind Facebook's acquisitions of Instagram and WhatsApp, done 12 and ten years ago, respectively.

This time, rather than waiting until deals are done and markets are stitched up, the preference is to be nimble. It is now the trustbusters who are trying to move fast and break things.

Broadly speaking, the authorities have two areas of concern. The first is whether the world's biggest firms are trying to tie businesses into their products in anticompetitive ways. The second is about control: are some of the biggest generative-ai investments poorly disguised acquisitions intended to sidestep antitrust consideration? Nvidia is under scrutiny on the first count. It has recently fallen under the gaze of America's Department of Justice, which is understood to be investigating allegations that it locks users of its graphics processing units (GPUs) into its software, and that a scarcity of GPUs is the result of anticompetitive conduct. Nvidia declined to comment.

The attention on Microsoft is more over the second category. The FTC has launched a market inquiry of the software-provider's $13bn investment in Openai, which gives it a 49% share of the profits. It is also investigating Microsoft's hiring in March of most of the staff of Inflection, a rival to Openai (the most significant hire was Mustafa Suleyman, Inflection's co-founder, who sits on the board of *The Economist*'s parent company). Microsoft also declined to comment. The FTC has other big-tech firms under the spotlight, too. It is looking at investments by Alphabet and Amazon in Anthropic, another maker of large language models (LLMs).

Inevitably, there is little public information concerning this antitrust scrutiny. Yet Britain's Competition and Markets Authority, a regulatory agency that is also probing the two Microsoft deals, has recently published a study of LLMs (it refers to them by their alternative name, foundation models) that illustrates the main concerns. The biggest one, it says, is the potential role of a few tech giants to shape the market in anticompetitive ways. It notes that Alphabet, Amazon, Apple, Meta, Microsoft and Nvidia have forged more than 90 partnerships with LLMs since 2019, mostly by taking minority stakes. It expresses concerns that they may exert leverage on the modelmakers through supply of critical

inputs, such as computing power and data, as well as controlling access to consumers via their platforms. It also notes that some of the deals may have been structured to avoid merger scrutiny.

In America, the government's concerns are similar. But the trustbusters are not just looking at LLMs. They have their eyes on the whole caboodle—from the gpus at the bottom to consumer applications at the top of the generative-ai "stack". The FTC's investigation of Microsoft's Inflection deal is yet another type. The agency is probing whether Microsoft failed to supply the correct merger paperwork when it hired most of Inflection's employees and paid for a non-exclusive licence to its technology. In other words, it suspects it was an acquisition in disguise aimed at avoiding an antitrust review. For Microsoft, it was not an acquisition at all. What is left of Inflection remains an independent company.

This is all tricky terrain. Building LLMs is capital-intensive, like drilling for oil. The requirements for computing power, digital information and human expertise is such that model-builders justifiably turn to tech giants for support. Big tech has the balance-sheets, data and cloud infrastructure to help, as well as providing a seal of approval. Moreover, it is hard to assert that a tech giant has an exclusive hold over any generative-AI startup when so much polyamory is taking place. Satya Nadella, Microsoft's boss, once asserted with regard to Openai that his firm was "below them, above them, around them". That sounded suspiciously like monogamy. When Openai recently announced a partnership with Apple, a Microsoft rival, Mr Nadella was miffed.

The other type of competition

It is tough political territory as well. If intervention is too heavy-handed, China hawks will accuse the trustbusters of suffocating American innovation in favour of its strategic rival. Yet there is room, at the very least, for a light touch. Generative ai will cause big technological upheaval, though in what ways is still unclear. If the incumbents are left to their own devices, they will surely use their imperial might to try to bend it to their advantage. Regulators have a duty to prevent them quashing competition. So by all means move fast. Just don't break things too badly.

For reflection/discussion:

- How should regulatory authorities balance the need to foster innovation with the responsibility to prevent monopolistic practices?
- How might consumers be affected by the consolidation of power among a few tech giants in the AI industry?
- How do investments by big tech firms in AI startups influence the overall progress of the technology sector?
- In what ways might the pursuit of progress by tech giants conflict with the principles of fair competition?
- How can regulators ensure that the rapid pace of technological advancement does not outstrip their ability to enforce antitrust laws?

Related Cambridge/RI essay questions:

1. To what extent can the regulation of scientific or technological developments be justified? (Cambridge 2014)
2. How far is it acceptable for technology to be used only for financial benefit? (Cambridge 2012)
3. How far should technological developments be regulated? (RI Y5 Promo 2016)
4. How far should we embrace the increasing use of technology in the world today? (RI Y5 Timed Practice 2020)

Reading 22: What happens when police use AI to predict and prevent crime? **EU 5 and 6**

Hope Reese | JSTOR Daily | 23 February 2022

This reading will help you to:

- Identify how bias is embedded in AI systems and its repercussions.
- Evaluate the wider implications of the "accountability gap" created by the lack of human oversight in AI systems.

Bias in law enforcement has long been a problem in America. The killing of George Floyd, an unarmed Black man, by Minneapolis police officers in May 2020 most recently brought attention to this fact—sparking waves of protest across the country, and highlighting the ways in which those who are meant to "serve and protect" us do not serve all members of society equally.

With the dawn of artificial intelligence (AI), a slew of new machine learning tools promise to help protect us—quickly and precisely tracking those who may commit a crime before it happens—through data. Past information about crime can be used as material for machine learning algorithms to make predictions about future crimes, and police departments are allocating resources towards prevention based on these predictions. The tools themselves, however, present a problem: The data being used to "teach" the software systems is embedded with bias, and only serves to reinforce inequality.

Here's how: Black people are more likely than white people to be reported for a crime—whether the reporter is white or Black. This leads to Black neighborhoods being marked as "high risk" at a disproportionate rate. Using data as a tool for policing is not new—it's been going on since the 1990s, in an effort to help departments decide which communities are at "high risk." If they know where the most crime happens, the thinking went, police could put more resources into policing a given area.

However, the logic is faulty: If more police are dispatched to a certain neighborhood, it clearly follows that "more" crime will appear here. Essentially, it's a feedback loop, which provides a skewed version of where crime is actually taking place. (Another issue at hand is the allocation of police resources rather than social services. There is much debate, for instance, about whether the role of police in certain poor, Black neighborhoods also tends to create a "police state" environment, in which citizens do not feel safe, and there are strong arguments that more funding for mental health or other social services would better serve these communities). When machine learning algorithms are fed this "data" to train their predictive systems, they replicate this bias, reinforcing false ideas about which neighborhoods are more "high risk."

Another problem with the thinking is that it relies on past information. While our past may give us a clue into future behavior, it does not take into consideration the concept of and potential for rehabilitation, and has the effect of reinforcing negative views, and continuing to punish those who have already paid their debt.

Police departments across the globe are using these software programs to pinpoint crime. While there are dozens of American tech companies selling this type of software to law enforcement agencies, one particular startup, Voyager Labs, is collecting social media information—including Facebook posts, emojis, friends–and analyzing them to make connections, even cross-referencing this information with private data, to create a "holistic" profile that can be used to find people who pose "risks."

Inaccuracy and Bias Embedded in AI Systems

Automated-policing approaches are often inaccurate. A 2018 trial conducted by the London Metropolitan Police used facial recognition to identify 104 previously unknown people who were suspected of committing crimes. Only 2 of the 104 were accurate. “From the moment a police officer wrongly identifies a suspect until the moment the officer realizes their error, significant coercive action can take place: the suspect can be arrested, brought to a police station and detained. It can be terrifying, with irreversible consequences, including human rights violations,” Edward Santow writes in The Australian Quarterly.

Additionally, facial recognition systems have also demonstrated bias against people of color. In an egregious example, Facebook’s facial recognition algorithm labeled Black people “primates”—which it recently told the BBC “was clearly an unacceptable error.”

Lack of Human Oversight in Automated Processes

Automated systems remove human oversight. As law enforcement agencies increasingly rely on these deep learning tools, the tools themselves take on an authority, and their predictions are often unquestioned. This has resulted in what Kate Crawford and Jason Schultz, in their report “AI Systems as State Actors” call an “accountability gap,” which “may result in both state and private human employees having less knowledge or direct involvement in the specific decisions that cause harm.”

The tools themselves could come from various sources—created “in-house” by government agencies, developed by contractors, or even donated, Crawford and Schultz point out. And with these various configurations, there is little information on who should be accountable when the systems fail.

A new project by Columbia University, in tandem with the AI Now Institute and the New York University School of Law’s Center on Race, Inequality, and the Law, and the Electronic Frontier Foundation, was recently begun “to conduct an examination of current United States courtroom litigation where the use of algorithms by government was central to the rights and liberties at issue in the case.” In this report, the researchers focused on cases in which AI is currently being used in law enforcement: in the areas of Medicaid and disability benefits, public teacher evaluations, and criminal risk assessments. In these cases, the researchers looked at how the AI systems were used by humans. The authors concluded:

These AI systems were implemented without meaningful training, support, or oversight, and without any specific protections for recipients. This was due in part to the fact that they were adopted to produce cost savings and standardization under a monolithic technology-procurement model, which rarely takes constitutional liability concerns into account.

The focus of the algorithms were biased—in an effort to cut budgets, they targeted those who would be more likely to need support. “Thus, an algorithmic system itself, optimized to cut costs without consideration of legal or policy concerns, created the core constitutional problems that ultimately decided the lawsuits.” Like “traveling sales representatives,” the authors remarked, these automated tools would take information from one location to another, applying it to new populations, increasing the potential for bias to skew the results. “As AI systems rely more on deep learning, potentially becoming more autonomous and inscrutable, the accountability gap for constitutional violations threatens to become broader and deeper.”

This raises the question: How should we hold the software companies themselves accountable? When automated systems are given free rein, and human oversight becomes obsolete, should tech companies assume responsibility for how their products are used? The law is still unclear on this issue.

"When challenged, many state governments have disclaimed any knowledge or ability to understand, explain, or remedy problems created by AI systems that they have procured from third parties," Crawford and Schultz argue. "The general position has been "we cannot be responsible for something we don't understand." This means that algorithmic systems are contributing to the process of government decision making without any mechanisms of accountability or liability." A failure to address this accountability gap should mean a halt in the use of these tools.

The Surveillance State

For all of the glaring human rights problems in automated policing in America, we live in a country in which the idea of police protection is baked into our Constitution. In governments that do not have this kind of protection, automated policing technology can be used for ill purposes. In China, for instance, facial recognition is used for purchases and in traffic regulation, surveillance images are stored. "China sells its facial recognition technology to authoritarian governments who wish to track their own citizens. This Chinese tech is relatively inexpensive to acquire, being employed furtively, without public detection or uproar," writes Maria Stefania Cataleta in a report for East-West Center.

Thankfully, some law enforcement agencies are taking these concerns seriously. In September 2021, for instance, the Toronto Police Services Board, announced it would be drafting a policy to govern the use of AI technology. Damning reports on the Chicago police department have led it to suspend its use of predictive policing as well. All law enforcement agencies should take this issue seriously—it could mean the difference between putting an innocent or guilty person behind bars.

<u>For reflection/discussion</u>:

- In what ways has the use of AI systems resulted in an 'accountability gap' (line 49)?
- Do you think it is possible to overcome this 'accountability gap'? Why and how?
- Are there areas of human decision-making that you believe should never be delegated to AI systems, no matter how advanced the latter are? Why or why not?
- The Singapore government has also been developing AI tools and patrol robots to support the police force. Use research to find out more about these initiatives. Has enough been done to mitigate the drawbacks of AI?

<u>Related Cambridge/RI essay questions</u>:

5. Is modern technology a benefit or a threat to democracy? (Cambridge 2020)
6. How far is science fiction becoming fact? (Cambridge 2017)
7. Is modern technology a benefit or threat to our safety? (RI Y6 Prelims 2021)
8. 'Artificial intelligence creates more problems than benefits.' Discuss. (RI Y6 Prelim 2019)

Reading 23: Why are the Japanese more receptive to robots? **EU 5, 8, 9**

Adapted from Robots for Ageing Societies: A View From Japan | Miyako Takagi | Heinrich Boll Stiftung | 17 April 2023

This reading will help you to:

- Understand the factors that enhance Japanese society's receptivity towards robots
- Consider the benefits and applications involving the use of robots, even in areas that societies may not currently accept the use of robots

On 1 October 2021, the total population of Japan was 125.5 million. The population aged 65 and over was 36.21 million, accounting for 28.9% of the total population (ageing rate) . By sex, the population aged 65 and over consisted of 15.72 million males and 20.49 million females, with a male-to-female ratio of approximately 3:4.

Recent trends have shown an increase in the number of men and women aged 65 and over living alone. In 1980, men and women aged 65 and over accounted for 4.3% and 11.2% of the population respectively, but by 2020, among the one-person households with the member being 65 years old or over, men accounted for 15.0% and women 22.1% of Japan's total population of 126.15 million.

The biggest problem in an ageing society is the increase in the number of dementia patients. The number of people over 65 years old with dementia in Japan was estimated to be about 6 million in 2020, and it is predicted that about seven million people (about one in five elderly people) will have dementia by 2025. Mild Cognitive Impairment (MCI) is a condition in which memory loss is neither normal nor dementia, although it does not interfere with daily living. About half of those with MCI will transition to dementia within five years, and it is believed that starting preventive activities at this stage can delay the onset of dementia.

Engaging in interactions such as having conversations has a significant effect on dementia prevention. However, the frequency of conversation for single elderly men is considerably lower than that for single elderly women. Owing to Japan's company-centric culture, most men struggle with building new relationships after retirement, and hence fewer conversation partners. Also adding to the strain is the chronic shortage of caregivers who can visit elderly people at their homes to assist them with daily living and strike conversations. How, then, should the Japanese society support the elderly who live alone?

Human–Robot Partnership

Robots that can communicate with humans through conversations and movement can be found in restaurants and electronics stores across the country nowadays. Whereas for households, Aibo, a dog-type robot that was redesigned in 2018, and Paro, a baby seal, are some of the common models.

Aibo, which looks like a digital gadget, has built-in communication with a cloud software that realises the character and intelligence of a pet. The more you see it, the more it learns about you and recognises your face; and the more gently you treat it, the more affectionate it becomes. The first model of AIBO, sold from 1999 to 2006, costed Japan yen (JPY) 250,000 (USD 2,380). It was so popular that the first 3,000 units ordered were sold out within 20 minutes, and a total of about 150,000 units were shipped. The current model of Aibo sold more than 20,000 units over the first six months since its launch in January 2018.

The release of new communication robots is no longer a rare occasion these days. LOVOT, one of the most popular communication robots developed by GROOVE X Corporation, is more than just a cuddly, lovable figure. Its 360-degree hemispheric and temperature cameras allow it to keep an eye on the entire room and quickly find out where its owner is. The behaviour of a LOVOT is not programmed in a fixed manner, but processed by deep learning and other machine learning methods to create real-time movement. The conversational humanoid records and accumulates information on people's behaviours and tastes during conversations, so as to deepen its understanding and convey topics and information of interest at the perfect moment. In addition, it replies around 0.4 seconds after the other person finishes speaking, allowing for smooth conversation.

Different Attitude toward Robots in Japan and the West

From a global point of view, Japan is undoubtably a pioneer of communication robots. With most of the suppliers from Japan, communication robots are mainly found in the domestic market. In fact, a one-month survey conducted in December 2019 suggested that Japanese of all ages and both sexes seemed to accept communication robots as a comfortable conversation partner. Among the 1155 respondents in their 20s to 60s, 40% were male and 60% were female. In the question “Would you like to use a communication robot when you are in a hospital or medical facility?”, 17.2% answered “Yes, I would like to use a communication robot” and 36.6% said “Somewhat I would like to use a communication robot”, meaning over half of the respondents were open to the option. As for the reasons for wanting to use a communication robot, 55.1% respondents said they wanted “to relieve loneliness”, 53.9% hoped “to relieve free time”, and 44.5% had the “prevention of dementia” on mind.

Why has the communication robot boom not occurred outside Japan? This difference may be attributed to the differences in the popular understanding of robots in Japan and Western countries. The word “robot” is derived from the Czech word Robota, which meant “forced labour” and was used to classify peasants who were obliged to do forced labor under the feudal system. A common view of the West is that robots should be subservient to humans, who are in the constant fear of a robot uprising. The “three laws of robotics” devised by science-fiction writer Isaac Asimov already in 1942 have pervaded the genre as well as popular culture. They prohibit robot injury to humans and establish robots’ obedience to human instructions and protection of human existence.” Such rules have taken firm root and continue to dominate popular imagination, despite the rapid development and much wider application of robotics technology over the past decades.

In Japan, by contrast, popular culture has long cultivated the idea that humans and robots could coexist in harmony. In the 1960s, Osamu Tezuka’s Astro Boy was animated for television, after which Japanese children have since been gripped by the weekly episodes of a story where robots work with humans to defeat social evils. Another much-loved character is Doraemon – a robotic cat who lives in a Japanese family’s house and shares meals daily as equal friends – has been enjoying its popularity since the 1970s. The generations who watch Astro Boy and Doraemon from a young age recognise robots as their friends, a conception that may be passed on to the future.

Robots and Ageing: Different Strategies

On 30 May 2022, the New York State Office on Aging (NYSOFA) announced plans to distribute communication robots to more than 800 seniors across the state, with the mission to maximise the ability of seniors to receive non-medical support services and to age well and independently in their communities. The Pew Research Center reported that more than a quarter of adults over the age of 60 live alone in the United States, which was picked up by Fortune magazine and entitled the article “New York is turning into Japan by giving robots to old people as companions”. ElliQ, the

communication robot distributed by NYSOFA, was developed by an Israeli company with approximately USD12 million in funding from the Toyota Research Institute, Inc. (TRI). Unlike Japanese robots, it is not humanoid in shape. The robot body is made of two parts, and only the upper part can nod and rotate, a concept rather similar to a smart speaker. The main difference between Amazon Echo and ElliQ is that the former does not talk to people actively or at all – unlike most communication robots developed in Japan.

The living arrangements of the elderly in Japan and the US are consistent with countries with relatively developed economies, where people tend to have fewer children and live longer beyond their childbearing years.

NYSOFA's efforts to launch EliQ aim to address the growing social isolation of older adults in the US. Efforts to quantify the cost of loneliness have shown that for Americans aged 65 or above, social isolation costs the government approximately USD7 billion annually in additional health care costs. Lonely elderly people are more likely to suffer from health problems such as depression and heart disease and longer hospital stay.

In Japan, the eight million born during the baby boom after World War II will be aged 75 or over in 2025, sparking fears for social consequences. In view of the increase of MCI patients from 2.56 million in 2000 to 6.69 million in 2019, the surge is likely to persist well beyond 2025 and the MHLW estimated that 2.43 million care workers would be needed by then. In 2017, care workers were added to the foreign technical training programme, which was expected to significantly increase the number of foreign care workers, but even now it is not sufficient. Furthermore, the current depreciation of the Japanese Yen is accelerating the outflow of foreign workers.

Under these circumstances, the use of communication robots to care for the elderly is believed to be the one and only solution, and hence the shift of Japan's national policy to focus on promoting the use of nursing care robots. If nursing-care robots, including communication humanoids, are utilised under the cooperation of the public and private sectors, a solution to the healthcare worker shortage may not be as far away as it is assumed after all.

For reflection/discussion:

- Summarise the key differences in terms of how Western and Japanese cultures perceive robots. Apart from the effects of popular culture, what other reasons can you think of for why the Japanese are more receptive to robots than Western societies? Do you think that Japanese attitudes towards technology in general is similarly positive? Given how commonplace technology already is in Japanese cities, what positive impact might there on how the Japanese perceive new, cutting-edge technologies?
- In your opinion, are Singaporeans' attitudes towards new technology more aligned with Western societies, or with Japan? Why or why not?
- Do you think robots should be a used as an alternative for actual human interactions, especially in working with the issues relating to the elderly? Why or why not? What are some considerations that might be more unique to Singapore?

Related Cambridge/RI essay questions:

1. Is modern technology a benefit or a threat to democracy? (Cambridge 2020)
2. How far is science fiction becoming fact? (Cambridge 2017)
3. Will technology completely replace the role of humans in the future? (RI Y6 Prelims 2022)
4. Is modern technology a benefit or threat to our safety? (RI Y6 Prelims 2021)

Reading 24: Industrial Revolution 5.0 – driven by sustainability **EU 4, 5, 7**

Paval Bhattar | Spoon Agency | 18 Jan 2022

This reading will help you to:
- Understand the key drivers of sustainable developments in technology in the modern world.
- Examine the contexts in balancing sustainability with profit and productivity.

With climate change mitigation emerging as a top priority, it is time to usher in a new Industrial Revolution, one where men, machines, innovation, productivity, and profitability are driven by the common purpose of increasing sustainability.

The climate crisis and the COVID pandemic are changing the way we produce, consume, work, live and interact with each other and our surroundings. Digitalisation, AI, robotics, the Internet of things (IoT) and the Industrial Internet of Things (IIoT), Augmented Reality (AR), Virtual Reality (VR), and blockchain technologies are already pushing human achievement and possibilities to new heights.

As we innovate further and break new ground, every field of human endeavour is under pressure to go green. Electric Vehicles (EVs) are making sustainable transportation commercially viable. Capital is chasing ground-breaking and innovative green ideas. Further, all business stakeholders, including consumers, governments, citizens, partners, and investors, are demanding care for the environment as part of products and services.

"A rich stew of new technologies, materials, design methods, financial techniques, business models, smart policies, and aggressive investments could in this decade revitalise, relocate, or displace some of the world's most powerful industries," declares Amory Levins, co-founder of the Rocky Mountain Institute, an organisation dedicated to enabling the transition to clean energy, in a recent report.

The writing is on the wall. The next industrial revolution could very well be one driven by sustainability. A revolution that leads people to consider the environment and focus on doing more with less. The future will hinge on the world being able to rethink, reuse, recycle, regenerate, and share resources, as well as treat natural resources as precious commodities.

"Being closer to nature and biodiversity will be a very important part of the next industrial revolution," explains Meri Ventola, Director of Technology at UPM Biochemicals. "We will be moving away from the heavy consumption of today into the traditional way of doing things so that we are really recycling and reusing the materials in an efficient way."

She should know. At UPM, wood's incredible versatility has been unleashed to create a slew of innovations that promise to quench the world's thirst for raw materials in a sustainable and renewable fashion. For instance, the company has already developed biofuels that produce about 80 % less greenhouse gas emissions than fossil diesel while their range of biochemicals is being used to replace fossil-based chemicals in many products.

Heralds of change

The rise of such radical innovations is a trademark feature of previous industrial revolutions, heralding seismic shifts in human society.

For instance, the first industrial revolution was sparked by the invention of the steam engine and the spinning jenny, which gave us factories, railways, power looms and textile mills – giving humanity the

means to influence our environment in a way unlike ever before. The second industrial revolution gave the world telephones, telegraph, railroads, electric power, gas, petroleum, engines, modern ships, rubber, bicycles, and automobiles – allowing for maximum utilisation of our environment.

In rapid succession, the third and the fourth industrial revolutions redefined automation and gave us the Internet, connectivity, mobile phones, renewable energy, and electric vehicles (EVs) – innovations that allowed the world to take stock of exactly how it is using the planet's natural resources. And now, the fifth industrial revolution stands poised to give people the power further take responsibility for the environment and their impact on it.

"I've got solar on my roof in my home here outside Toronto, Canada. I've got a Tesla in the garage. Theoretically, I'm a net-zero driver because I'm not really burning any resources," says futurist Jim Carroll. "This fundamentally changes everything in terms of what we think sustainability is," he adds.

Accelerating the sustainable revolution

Carroll's mention of a car is almost prophetic. According to the World Economic Forum, the automotive industry is on the brink of driving the next process and technology-driven industrial revolution with a circular economy template that other global industries could follow.

Recently, 60 automakers, research institutions, NGOs, suppliers and international organisations committed to the 'The Circular Cars Initiative' (CCI) to facilitate the transition towards a circular economy.

Many automakers like Daimler (Mercedes-Benz) and Renault are already using recycled materials in their vehicle production. Others, like Ford which pioneered the concept of doing more with less, are turning plastic waste into a secondary raw material, reusing waste powder from 3D printers for injection-moulding vehicle parts, using discarded carpet in moulded engine components and recycling tyres in dash panel extensions.

Ford is also using plant-based materials like soy-based foam, wheat straw, rice hulls, cellulose, and coffee chaff to improve production efficiency, support vehicle weight reductions and avoid the use of fossil-fuel-based plastics.

It's important to know that most of these circular economy initiatives have been executed as collaborations. So, why would the mighty not go alone?

"Collaboration is the only way forward. Nobody can actually do things alone. Stakeholders who have the money and capability need to put all their efforts into today's new technologies, allowing us to make progress in the right direction," explains Ventola.

The age of mass customisation

3D printing is at the top of the list of emerging technologies that will help us in the future. It is an efficient, affordable and, most importantly, sustainable way to have closed-loop manufacturing processes that repurpose, reuse and recycle waste materials.

For instance, carmaker Renault plans to use 3D printing to recycle and retrofit vehicles in what it calls, 'Europe's first circular economy Re-Factory'. Several other car manufacturers are following suit.

Many companies around the world have also started using 3D printing to reduce their carbon footprint and integrate waste into materials, in order to become more efficient and environmentally friendly. 3D printing is also being used in healthcare (bionic limbs, etc.), pharmaceuticals, cosmetics and food items.

"The industrial IOT, 3D printing and advanced scientific materials are taking us from a world of mass production to mass customisation, where we can manufacture products for a market of one. This really changes everything and perhaps the biggest potential impact comes from 3D printing," predicts Carroll.

Mercedes-Benz provided a good example of this last year when it offered its 3D printing services expertise to produce medical equipment during the COVID crisis. The flexibility offered by 3D printing is all the more important when you consider the different materials that it can use to create new products.

A revolution in material science

Industrial Revolution 5.0 will be as much about materials as it is about mettle. Carroll estimates that by 2025 there will be 5 billion known chemical substances compared to just 19 million today. What impact will these substances have on manufacturing?

"It means opportunities for innovation," says Carroll passionately. "Years ago, it was the discovery of one single new chemical substance that permitted Apple to miniaturise the hard drive for the first edition of the iPod. In other words, one single new chemical substance led to the birth of a multi-billion-dollar industry. And that's one substance out of 5 billion, meaning there is so much opportunity from new material science."

The potential is enormous, but so is the responsibility to learn from past industrial revolutions. Care must be taken to ensure that these raw materials are sourced sustainably and is a part of the circular economy. The forest industry has a key role to play in this regard.

Through the practice of sustainable forest management principles, the forestry industry has succeeded in creating an ever-renewable and sustainable resource through wood-based products.

For example, nanocellulose, a gel-like substance refined from wood pulp, is hoped to replace harmful metals and plastics in batteries and sensors, as well as smart packaging – where it could be used both as an electrical and protective component. Wood by-products, such as UPM's Renewable Functional Fillers (RFF), are being used to replace carbon black and precipitated silica in various end-uses of rubber and plastics applications, such as hoses, sealings and automotive weather strips.

"We test various technologies and manufacture materials for application development," explains Ventola. "In the fourth industrial revolution, the share of fossil-based chemicals is still huge compared to biochemicals. But this will change. We need to change it. At UPM, our work helps provide us with the knowledge that provides the basis for identifying new areas where we can grow. We even have a satellite made from wood launching off this year. I am very excited about other such possibilities the future will bring.

As the world races to enter a new industrial age, it is clear that the sky is no limit. Are you ready for Industrial Revolution 5.0?

For reflection/discussion:

- What are some areas needed for sustainable development as described in the reading?
- How realistic are some of these desired outcomes when they are tied to profit and productivity demanded by business sectors and other consumers today?
- What do the ideas listed here say about the relationship between scientific discovery, technological innovation and social change?

Related Cambridge/RI essay questions:

1. How far should profit be the aim of scientific or technological developments? (RI Y5 Promos 2022)
2. Is modern technology a benefit or threat to our safety? (RI Y6 Prelims 2021)
3. To what extent are young people in your society prepared for a world that is constantly changing? (RI Y6 Prelim 2019)
4. 'Human need, rather than profit, should always be the main concern of scientific research.' Discuss. (Cambridge 2016)
5. Is there any point in trying to predict future trends? (Cambridge 2013)

SECTION E: TECHNOLOGY AND SUSTAINABILITY

Reading 25: The case for making low-tech 'dumb' cities instead of 'smart' ones **EU 4 and 5**

Amy Fleming | Guardian | 15 January 2020

This reading will help you to:

- Understand concepts in 'low-tech' alternatives to developing smart cities today.
- Recognise some embedded assumptions and values in scientific discovery and technological advancement.

Ever since smartphones hooked us with their limitless possibilities and dopamine hits, mayors and city bureaucrats can't get enough of the notion of smart-washing their cities. It makes them sound dynamic and attractive to business. What's not to love about whizzkids streamlining your responsibilities for running services, optimising efficiency and keeping citizens safe into a bunch of fun apps?

There's no concrete definition of a smart city, but high-tech versions promise to use cameras and sensors to monitor everyone and everything, from bins to bridges, and use the resulting data to help the city run smoothly. One high-profile proposal by Google's sister company, Sidewalk Labs, to give 12 acres of Toronto a smart makeover is facing a massive backlash. In September, an independent report called the plans "frustratingly abstract"; in turn US tech investor Roger McNamee warned Google can't be trusted with such data, calling the project "surveillance capitalism".

There are practical considerations, too, as Shoshanna Saxe of the University of Toronto has highlighted. Smart cities, she wrote in the New York Times in July, "will be exceedingly complex to manage, with all sorts of unpredictable vulnerabilities". Tech products age fast: what happens when the sensors fail? And can cities afford expensive new teams of tech staff, as well as keeping the ground workers they'll still need? "If smart data identifies a road that needs paving," she writes, "it still needs people to show up with asphalt and a steamroller."

Saxe pithily calls for redirecting some of our energy toward building “excellent dumb cities.” She’s not anti-technology, it’s just that she thinks smart cities may be unnecessary. “For many of our challenges, we don’t need new technologies or new ideas; we need the will, foresight and courage to use the best of the old ideas,” she says.

Saxe is right. In fact, she could go further. There’s old, and then there’s old – and for urban landscapes increasingly vulnerable to floods, adverse weather, carbon overload, choking pollution and an unhealthy disconnect between humans and nature, there’s a strong case for looking beyond old technologies to ancient technologies.

It is eminently possible to weave ancient knowledge of how to live symbiotically with nature into how we shape the cities of the future, before this wisdom is lost forever. We can rewild our urban landscapes, and apply low-tech ecological solutions to drainage, wastewater processing, flood survival, local agriculture and pollution that have worked for indigenous peoples for thousands of years, with no need for electronic sensors, computer servers or extra IT support.

This month, Julia Watson, a lecturer in urban design at Harvard and Columbia Universities, launched her book Lo-Tek: Design by Radical Indigenism, with publisher Taschen. It’s the result of more than 20 years of travelling to research the original smart settlements, through an architect’s lens. She visited the Ma’dan people in Iraq, who weave buildings and floating islands from reeds; the Zuni people in New Mexico, who create “waffle gardens” to capture, store and manipulate water for desert crop farming; and the subak rice terraces of Bali. Watson walked the living tree-root bridges that can withstand adverse weather better than any human-made structure, and that allow the Khasi hill tribe in Northern India to travel between villages during the monsoon floods.

“There are so many different ways you can rewild cities,” says Watson – and it’s not just a case of plonking an ancient system in a city, but rather adapting complex ecosystems for different types of places with their own unique requirements. Take a current proposal she is working on for the high-rise city of Shenzhen on the Pearl River estuary by Hong Kong. It was once a fishing village, then a textile town, “and it just skyrocketed,” says Watson. “All of the fishponds and polders and dykes and wetlands that absorb all the water in that delta landscape are being erased. So the city is developing in a way that’s erasing the indigenous resilience in the landscape.”

But you don’t have to erase to go forwards, she says. “You can leapfrog and embed local intelligence, using a nature-based traditional Chinese technology that’s climate resilient, ecologically resilient and culturally resilient. And we can make beautiful urban spaces with them as well.” Kongjian Yu, a design professor at Peking University, agrees with this philosophy. Known as the “sponge cities” architect, Yu creates urban landscapes in China that passively absorb rainwater, using permeable pavements, green roofs and terraced wetland parks that flood during monsoon. If wetlands are situated upriver of the buildings, they will flood before the water reaches the city proper.

The parks have brought fish and birds back to cities, says Yu, “and people love it.” The projects, he says, “are performing well, and many of them have been tested for over 10 years, and can certainly be replicable in other parts of the world.” In fact, this month he has visited Bangladesh, ironically, “helping their ‘smart city’ project,” where he has convinced “the minister in charge that nature is smart, and our ancient wisdom tells us how to live with nature in a smart way.”

Copenhagen, too, has opted for a dumb – or, as local planners call it, “a green and blue” – solution to their increasing flood risks: namely, a series of parks that can become lakes during storms. The city estimated they would cost a third less than building levees and new sewers, and come with the added ecological benefits of rewilding. An abandoned military site was cleaned up in 2010 and rewilded into

a nature reserve and common for grazing animals, the Amager Nature Centre – a vast park with not only happy people meandering and cycling around but insects, protected amphibians, rare birds and deer.

But dumb cities can be even smarter than that. Not only can functioning wetlands defend cities against floods and restore nature, they can clean wastewater. And they can do it more efficiently than sewage-treatment works – all while absorbing a whole lot of carbon, nitrogen, sulphur and methane, and creating a fishing industry and fertile farmland. No water, energy, treatment chemicals or fish feed required. The world's largest such system, in east Kolkata in India, involves the city's sewage feeding the fish. It saves the city approximately $22m (£17m) a year in running costs for a waste treatment plant. The water can be used for irrigation, saving a further £500,000 in water and fertiliser costs. And it enables much of the city's food to be grown locally.

Or, as waters rise globally, we can learn from Makoko, the incredible city-on-stilts in Lagos that is home to 80,000 residents. Its "floating school" – sustainable and solar-fuelled – has captured the world's imagination. Rotterdam has already introduced a floating forest and farm, and is developing plans for a sustainable floating city.

The Eastgate building in Harare has no air-conditioning or heating, yet stays regulated all year round using a design inspired by indigenous Zimbabwean masonry and termite mounds. As for dumb transport, there can be no doubt that walking or cycling are superior to car travel over short urban distances: zero pollution, zero carbon emissions, free exercise.

And there's a dumb solution to the spread of air conditioning, one of the greatest urban energy guzzlers: more plants. A study in Madison, Wisconsin found that urban temperatures can be 5% cooler with 40% tree cover. Green roofs with high vegetation density can cool buildings by up to 60%. Or you could just think like a bug: architects are mimicking the natural cooling airflows of termite burrows. Mick Pearce's 350,000 sq ft Eastgate Centre in Zimbabwe's capital, Harare, completed in the 1990s, is still held up as a paragon of dumb air conditioning: all it needs are fans, and uses a tenth of the energy of the buildings next door.

A few token green walls and trees won't do it. Watson calls for a focus on permaculture: self-sustaining ecosystems. There are hundreds of nature-based technologies that have never been explored. For example, Watson envisions stunning urban uses for the living root bridges of the Khasi hill tribe: "They could be grown to reduce the urban heat island effect by increasing canopy cover along streets, with roots trained into trusses that integrate with the architecture of the street – in essence, removing the distinction between tree and building." They could even retain their original use during seasonal floods – living, physical bridges over the water. In April, Greta Thunberg and Guardian columnist George Monbiot made a rallying video calling for more trees and wetlands and plant cover to tackle the climate crisis. Cities can be part of this push. The idea of smart cities is born of what Watson describes as "the same human superiority-complex that thinks nature should be controlled". What's missing is symbiosis. "Life on Earth is based upon symbiosis," Watson says. She suggests we replace the saying "survival of the fittest" with "survival of the most symbiotic". Not as catchy, perhaps. But smarter.

For reflection/discussion:

- Based on lines 6-17, what are some of the limitations of new technologies that make them less appealing, especially when compared to 'old' technology?
- How should governments balance the desire for technological advancement in cities with the need to maintain essential human labour?
- Fleming claims that 'for many challenges, we don't need new technologies or new ideas' (lines 19-20). To what extent do you agree with her statement?

- From lines 39-64, Fleming lists "different ways [to] rewild cities" (line 39). In what ways is the absence of technology 'smart'?
- In what ways might integrating ancient technologies with modern urban planning offer a balanced approach to city development?
- Fleming argues that 'the idea of smart cities is born of…the same human superiority-complex that thinks nature should be controlled' (lines 96-97). Explain this concept in your own words.
- Consider Singapore. Given our aspirations to be a Smart Nation, how realistic and desirable are the ideas proposed in this article? Why or why not?
- How can urban planners ensure that the implementation of smart technologies does not lead to unforeseen vulnerabilities in city infrastructure?

Further Reading

Powering the Smart Factory with the Internet of Things
Discusses the opportunities for the smart factory that the Internet of Things offers, from reshaping every aspect of product development and delivery, from the plant floor to the value chain.
https://www.theatlantic.com/sponsored/vmware-2017/iot-manufacturing/1751/

A Future Where Everything Becomes a Computer Is as Creepy as You Feared
Discusses the privacy threats that arise from the internet of things.
https://www.nytimes.com/2018/10/10/technology/future-internet-of-things.html

How can privacy survive in the era of the internet of things?
Discusses the privacy threat from the internet of things and how to return the right to privacy to the individual.
https://www.theguardian.com/technology/2015/apr/07/how-can-privacy-survive-the-internet-of-things

The internet of things – who wins, who loses?
Discusses third party stakeholders that benefit from loT and perpetuate the threat to privacy.
https://www.theguardian.com/technology/2015/aug/14/internet-of-things-winners-and-losers-privacy-autonomy-capitalism

Smart City Initiatives: Singapore
Understand how Singapore is transforming itself into a smart city.
https://mobility.here.com/learn/smart-city-initiatives/singapore-smart-city-holistic-transformation

Related Cambridge/RI essay questions:

1. 'We cannot trust science to provide an effective answer to our environmental concerns.' Discuss. (RI Y6 Common Test 2022)
2. 'Technology is advancing too fast.' Is this a fair comment? (RI Y5 Promo 2020)
3. How far should we embrace the increasing use of technology in the world today? (RI Y5 Timed Practice 2020)
4. 'Science is Man's best hope for creating a better world.' How far would you agree? (RI Y6 CT2 2018)
5. 'Science creates more problems than it seeks to solve.' Comment. (RI Y5 CT 2016)
6. Does technology always make life better? (RI Y5 CT1 2013)

Reading 26: Can lab-grown burgers help stop climate change

Spencer Bokat-Lindell | New York Times | 14 October 2021

EU 7 and 8

This reading will help you to:

- Gain an understanding of dietary science and how they influence consumption patterns in an age of climate change.
- Understand the reasons that drive innovation in food science and challenges in sustaining these measures.

Humanity's love of eating animals should worry you, even if humans are the only animals you care about. Meat and dairy production is responsible for 14.5 percent of the planet's greenhouse gas emissions, with about two-thirds of those coming from cattle. To keep global warming below two degrees Celsius above preindustrial levels, the limit established by the Paris climate accord, the World Resource Institute says much of the wealthy world needs to cut its beef and lamb consumption by 40 percent — and that's on the low end of such estimates.

Americans are among the top eaters of beef in the world, and persuading them to cut down on it or swap plant-based burgers for their steaks is a challenge.

Enter lab-grown — or, as some prefer, "cultured" or "cultivated" — meat: In the past few years, a small but fast-growing industry has sprung up with a mission to create meat from cell lines that doesn't just taste like meat but actually is meat. Last year, a restaurant in Singapore even put lab-grown chicken on its menu.

As the sector has bloomed, so too have predictions of its imminent usurpation of meat of the slaughter-requiring variety. But how close are we really to that future, and is it the one we should be aiming for in the first place? Here's what people are saying.

The urgency of reducing meat consumption

Vexing as the problem beef poses for climate change mitigation already is, it's going to get worse. That's because the world is getting richer, and when people get richer, they eat more meat. Since 1961, global meat production has more than quadrupled, to more than 340 million tons from 71 million tons. By 2050, the Food and Agriculture Organization estimates that global demand will reach 455 million tons. "The 7.8 billion of us on this planet cannot have a steak every night," Inger Andersen, executive director of the U.N. Environment Program, told The Times in April. "It doesn't compute." And climate change isn't the only issue at stake in the race to cut down on meat:

Pandemics: The increasing demand for animal protein is one of the major risk drivers of pandemic outbreaks, according to the United Nations. Another is the "intensification" of animal agriculture that the growing demand for meat requires: Animals are bred to be genetically similar and crowded together in huge facilities that promote viral transmission and mutation. Since 1940, agricultural intensification measures — dams, irrigation projects and factory farms — have been linked to more than 50 percent of zoonotic infectious diseases that have spread to humans.

Animal welfare: You don't have to believe that eating meat is per se immoral to object to the incalculable suffering factory farming inflicts on billions of animals — including human workers — every year.

Antibiotic resistance: About 65 percent of antibiotics in the United States are sold for use on farms, often just to prevent animals from getting sick. That's contributed to the rise of antibiotic-resistant diseases, which are already killing 700,000 people a year worldwide. By 2050, the number could rise to 10 million.

Food-borne illness: Lab-grown meat could reduce the threat of food-borne pathogens like E. coli and salmonella, which kill 420,000 people every year.

Why lab-grown meat isn't filling grocery stores just yet

As Vox's Kelsey Piper has reported, there are still a number of hurdles lab-grown meat has to overcome before reaching commercial viability:

Scaffolding: Growing ground beef is one thing, but replicating the structure and texture of a steak, say, requires shaping cultured cells into complex tissue — and researchers are still working out how to do that.

Scale: As Piper wrote, "it's not enough to be able to make one steak — you need to be able to make steaks at the same incredible scale that factory farms do." And at least for the moment, the economics and engineering challenges of building full-scale facilities are prohibitive.

Cost: Lab-grown meat is staggeringly expensive. In early 2019, the Israeli-based company Aleph Farms said it had driven the cost of producing a beef patty down to about $100 per pound. Eat Just, the company behind the Singaporean lab-grown chicken, initially said making a single nugget cost $50. For lab-grown meat to start replacing factory-farmed meat, all of these problems will have to be solved.

Should we launch a moonshot for affordable, lab-grown meat?

While other countries have thrown money behind alternative proteins, America's lab-grown meat industry has emerged without the support of the U.S. government, which spends $38 billion each year subsidizing the meat and dairy industry.

My colleague Ezra Klein believes that should change. In an April column, he noted that the Good Food Institute, a nonprofit that promotes the alternative protein industry, had asked the Biden administration for $2 billion in funding, half of it for research and half of it to set up a network of innovation centers. The institute estimates that with enough investment, by 2030, cultivated meat would be able to compete on cost with some conventional meats, requiring only $2.57 per pound to produce — a stunning reduction.

"I've never seen anything like this in terms of the volume of money being talked about and the opportunities to do something transformational," Representative Earl Blumenauer, an Oregon Democrat, told Klein. "It wouldn't take a lot of investment in alternative protein to take it to a whole different level. It'd be a rounding error in terms of the money going through Congress."

State involvement may be needed not only to accelerate innovation but also to ensure that innovation is widely shared. The international regime of intellectual property law that has governed the world's disastrously unequal vaccine rollout offers "a troubling preview of how other lifesaving technologies might be apportioned, including those needed to keep global warming below two degrees Celsius," the climate journalist Kate Aronoff writes. "Setting technology transfer as a baseline at this early stage of cellular agriculture's development could (optimistically speaking) set a precedent that discourages other sectors from using patents to charge exorbitant rents for everything from cultured salmon to clean energy."

But some say lab-grown meat won't be able to start displacing conventional meat in time — or perhaps ever. David Humbird, a Berkeley-trained chemical engineer who spent over two years researching a techno-economic assessment of lab-grown meat, believes the industry faces extreme, intractable technological challenges. In interviews with Joe Fassler of The Counter, he said it was "hard to find an angle that wasn't a ludicrous dead end."

Even the chief executive of Eat Just conceded that the challenges Humbird raised need to be reckoned with, leaving it "very uncertain" whether cultured meat can displace slaughtered meat in the next 30 years. In Fassler's telling, for cultured meat to be a meaningful climate solution would require several scientific breakthroughs worthy of many Nobel Prizes — and in the next 10 years, not 30.

A strong case can be made for the state to stake money on those breakthroughs, just as it did on vaccines for the coronavirus. But then again, conservative members of the Senate have fought to pare back the size of prospective climate spending, potentially forcing policy trade-offs that climate experts and activists would prefer not to make.

"The environmental ravages we face are vast, destabilizing, and encroaching on our real lives right now," Fassler writes. "The fires, the floods, are already at our door. In all this, it would be so good to know we have a silver bullet. But until solid, publicly accessible science proves otherwise, cultured meat is still a gamble — a final trip to the casino, when our luck long ago ran out. We should ask ourselves if that's a chance we want to take."

We could also just eat less meat

Perhaps, as Piper and Klein hope, lab-grown meat will eventually become more widely available, and even if its cost never reaches parity with that of factory-farmed meat, a meaningful amount of substitution will become possible.

But as Aronoff notes, diets need to change now, particularly in the West. And people generally exercise a degree of control over what they eat in a way they simply do not over how their electricity is generated. America's love of beef might seem intractable, but another beef-loving country, Brazil, has shown what the beginning of a national shift toward more climate-friendly diets might look like.

Although vegetarians and vegans have the smallest dietary carbon footprints, adopting a more climate-friendly diet doesn't require becoming one, as the Times food columnist Melissa Clark wrote in her meat-lover's guide to eating less meat. Following the World Resource Institute's recommendations, she started focusing more on chicken, pork and seafood (especially mollusks), which produce far fewer greenhouse gas emissions than beef and lamb, both of which she has relegated to special-occasion status.

"I like to loosely think of my approach as mindful meat-eating," she wrote. "Now, when I do simmer up a pot of beef short ribs (or smear cream cheese on my bagel, or go for sushi), I'm thoughtful and deliberate about it, which makes it taste even more delicious, seasoned with anticipation.

For reflection/discussion:

- The reading lists several reasons to support the development of lab-grown burgers. Which of the reasons cited is most convincing to you? What are you most doubtful about? Why do you think so?
- It is suggested that making lab-grown proteins more affordable could have 'transformational' (line 60) effects in terms of reducing human consumption of meat. How far do you agree with this? Might there be other factors that are as important as affordability, perhaps even more so?

- Are such modern developments in food science effective in tackling wider environmental and ethical issues surrounding the world today?
- Do you think certain societies may find it more difficult to consume lab-grown protein on a large scale? Why or why not?

Related Cambridge/RI essay questions:

1. 'Leading healthy lives is increasingly challenging in today's world. Discuss. (RI Y5 Promo 2019)
2. 'Human need, rather than profit, should always be the main concern of scientific research.' Discuss. (Cambridge 2016)
3. How effectively is public health promoted and managed in your society? (Cambridge 2015)
4. 'We should only fund scientific research that improves our quality of life.' Discuss. (RI Y6 CT1 2015)
5. 'Scientific research into health and diet is unreliable as it so often contradicts itself.' Is this a fair comment? (Cambridge 2013)

SECTION F: TECHNOLOGY AND INEQUALITY

Reading 27: Booster vaccine roll out a sure recipe for boosting inequality **EU 5 and 8**

Endy Bauni | Jakarta Post | 30 December 2021

This reading will help you to:

- Understand the underlying concerns associated with national vaccination programmes in a developing country.
- Examine how access to vaccines is driven not only by technological advancement but also political and economic factors

In the run-up to the National Games (PON) in October, the government worked hard to make sure that as many people as possible in Papua and West Papua provinces, hosts of the biennale event, get their Covid-19 vaccines. It never got anywhere near the published target of a 70 per cent vaccination rate. In the end, the vaccine roll out in the two easternmost provinces focused on three regencies and one city where the Games' venues were located. PON XX was still considered a huge success, held at a time when the nation was struggling to bring down Covid-19 infection rates. The vaccination program in the two provinces allowed many Papuans, as well as visitors who were already fully vaccinated, to watch their favourite sports and athletes fighting for the honour of their respective provinces.

Fast forward three months to now, both Papua and West Papua rank among the lowest-ranked provinces in the country when it comes to vaccination rates. Once the Games was over, apparently, Papuans were all but forgotten in the national vaccination program.

As of this weekend, the number of people in Papua who have received their first dose is 28 per cent of the target, and only 20 per cent have gotten their second, according to Health Ministry figures. West Papua is doing better, though is still well below the national level, with 52 per cent and 34 per cent, respectively, for the first and second injections. Aceh, Indonesia's westernmost province, and Maluku, also rank among the lowest four of all 34 provinces.

Yet the government has been touting Indonesia's national vaccination program as a success, with 156 million people receiving the first dose and 110 million their second, giving a vaccination rate of 75 per cent and 53 per cent for their first and second injections of the targeted 208 million people. So confident with this success that Indonesia is now ready to formally roll out a program for the third injection as a booster to strengthen the effectiveness of the first two doses, beginning in the new year.

As the government's own data shows, the benefits of the vaccination roll out have not been equally enjoyed across the nation. Jakarta tops the list in the vaccination rate, with 136 per cent of the target receiving their first dose and 123 per cent their second, while Bali comes second with 103 and 91 per cent, respectively.

This raises the question of whether the booster vaccine roll out would further increase the inequality that we are already seeing caused by the pandemic and the economic downturn. Much has been written about the widening gap during the pandemic, between the rich and poor, between rural and urban areas, and between Java and Bali on the one hand and the rest of the archipelago on the other.

When it comes to vaccines, understandably, priorities have been given to areas hardest hit by the Covid-19 virus, including Jakarta, and all provinces on Java and Bali. Giving them top priority was acceptable, just as it was acceptable to give Papuans priority in the runup to PON XX. But allowing a booster vaccine roll out when barely half of the nation have gotten their second injection raises moral and ethical questions. If the government claims that vaccination is the key to economic recovery, it follows that those who are already vaccinated are better positioned to recover, while those unvaccinated would be left behind and more exposed to the virus.

The World Health Organisation has appealed to rich countries to postpone booster vaccinations until at least 40 per cent of the population in all countries are vaccinated. Most countries ignored the WHO and are going ahead with their booster programs. Indonesia will begin next week. The WHO argues that given the limited availability of vaccines globally, giving booster vaccines would deprive poor countries of access to vaccines. It also warns that vaccine inequality would prolong the Covid-19 pandemic.

President Joko "Jokowi" Widodo spoke on behalf of developing countries when he made an impassionate plea for rich countries to help reduce vaccine inequality during a meeting with other leaders of the Group of 20 most wealthy countries in the world. At home, the President faces increasing pressure from those who have received both injections to roll out the booster program amid reports that the new Omicron variant could render the early vaccines ineffective without the third injection. Officially, booster vaccines have already been given to health workers, but unofficially and quietly, many people in Jakarta and Java have received their third jab. Shots have already been available at commercial rates rather than for free.

The national vaccination rate has not moved as rapidly as the government wished for various reasons, from the slow arrival of imported vaccines to the problems in distributing and administering the vaccines, as well resistance from people sceptical about the vaccine program. When rolled out in January, the government hoped to complete the vaccination program - meaning 208 million people getting both jabs - by the end of 2021. With the year about to close, we are only halfway to that target.

But is this a good enough reason for the government to begin rolling out booster vaccines? "Recover together, recover stronger"; Indonesia's motto of its G-20 presidency beginning in December would ring hollow unless we address the vaccine inequality at home. The booster vaccine policy would not only deprive many people, including those in Papua and Aceh, of their vaccine rights, it would also be

a sure recipe for boosting greater inequality, with all its social, economic and political consequences down the road.

For reflection/discussion:

- Identify the regions and provinces stated in the article. Go online and locate them on Indonesia's map. How is this exercise useful in helping you understand specific challenges in implementing vaccine roll-out programmes for a developing country?
- The author has listed several concerns related to vaccine rights and vaccine inequality. What does this tell you about the limitations of science as a state-sponsored enterprise?

Related Cambridge/RI essay questions:

1. 'Scientific advancement breeds complacency.' How far do you agree? (Cambridge 2021)
2. Now more than ever, scientific pursuits must be undertaken only to achieve practical ends.' Do you agree? (RI Y6 CT1 2018)
3. 'Science is Man's best hope for creating a better world.' How far would you agree? (RI Y6 CT2 2018)
4. How far can scientific or technological developments be a solution to global problems? (RI Y5 CT1 2018)
5. 'Technological advancement has worsened the problem of poverty.' Do you agree? (RI Y5 CT 2014)

SECTION F: TECHNOLOGY AND INEQUALITY

Reading 28: How to close the digital gap for the elderly **EU 4 and 5**

Ella Kidron and Vivian Yang | The Davos Agenda, World Economic Forum | 19 January 2021

This reading will help you to understand:

- The underlying reasons for widening digital gap for the elderly.
- The measures taken by tech companies to help the elderly overcome barriers to using smart technology.

Many young people have embraced the convenience of digital technologies such as online shopping, car hailing, digital payments, and telemedicine. But many elderly without a grasp of the latest knowledge are at risk of being left behind. Several news reports in China during the outbreak of COVID-19 put this issue in the spotlight: an elderly woman who wanted to pay for her medical insurance with cash was refused due to concerns that her cash might be carrying the virus. The woman, who had not set up mobile payment, was left alone in the service centre at a loss.

In another case, an elderly man without a phone was asked to get off the bus after failing to show the driver his health-status code via the app used at all public places in China. These incidents are stark reminders of the widening digital gap for the elderly.

China: an ageing population puts a spotlight on the digital divide

The challenge is not unique to China, but it is particularly pressing for the country given the rapid transformation of its massive population of 1.4 billion into an aging society. Around 2022, China is projected to become an "aged society" with 14% of the population above 65 years old – some 200 million people. It would typically take nearly a hundred years for many countries to reach this stage, while it will only have taken 21 years in China.

What's even more staggering is that by 2050, the number of Chinese elderly is estimated to reach 380 million, amounting to nearly 30% of the country's overall population. With just a small population of the elderly online, more needs to be done to provide access and guidance before the problem exacerbates with the rapidly rising aging population.

Pandemic pushes the elderly out of offline comfort zone

According to statistics from China's Ministry of Industry and Information Technology (MIIT), out of the 274 million mobile phone accounts of elderly users (those 60 years old and above) in China today, about 134 million are using smart phones to browse the internet. This means approximately 140 million still lack access to it.

The pandemic, however, has pushed a great number of elderly people online, in China and globally. The Chinese government issued plans in November last year to help elderly people overcome barriers to using smart technology. Meanwhile tech companies, such as e-commerce company JD.com, are stepping up their efforts to ease the transition. Here are three major trends in this arena:

1. Taking online in-store

Brick-and-mortar stores have started to arrange assistants in dedicated zones to help elderly customers make sense of everything from digital payments to robot services. These are all services that many young people, who grew up with the internet from an early age, take for granted – but they can also be learned.

At JD's omnichannel supermarket SEVEN FRESH, elderly customers are guided by staff to place grocery orders online, that are then delivered to their doorsteps at a specific time. Similarly, in JD's offline pharmacy, customers can sit on a sofa inside the store and wait to collect their medicine, pay for it with the help of in-store assistants, and walk away with professional healthcare advice.

"We are keen to use and benefit from these new technologies, but getting to grips with them is no easy task for us," said Ms Zhang, 78, an empty nester who tried to use a self-help health screening robot in a JD pharmacy store.

Her words speak to the difficulties many elderly people face. "By using this machine, I have not only experienced advanced technology, but also gained confidence," said Ms Zhang, after having mastered the robot. In terms of online services, many elderly customers shy away from voice systems or chatbots. In light of this, China's top three telecom operators recently announced a speed-dial system to transfer users above 65 directly to human service personnel.

Furthermore, upon the request of MIIT, adaptive versions of more than 150 apps and websites in China are being built, featuring simpler interfaces, fewer pop-up adds and more anti-fraud support.

2. From louder smartphones to voice-activated home appliances

Tailormade smartphones play an important role in easing elderly people's transition into the digital space. Phones with big buttons, larger font size and high-volume speakers have popped up recently. Last year, JD launched China's first 5G smartphone for the elderly in partnership with ZTE. The phone is equipped with services such as remote assistance, synchronised family photo sharing album and fast medical consultation services – handy for both the elderly and their children.

Importantly, it enables adult children to manage their elderly parents' phones from afar – something that is becoming more necessary as families are increasingly separated by the demands of work in a location far from home. (JD data found that 70% of elderly consumers believe children are indispensable in their care process and 68% want to spend more time with their children, but this is not always possible.)

Besides customised smartphones, JD and other companies are exploring a variety of ways to adopt advanced technologies to improve elderly people's lives. These include: voice-activated IoT home appliances for users with limited mobility; an AI-powered speech recognition system that can communicate in a variety of dialects; and a big-data based health management system that can provide more accurate health advice.

3. Enabling the elderly a good investment for brands

Training goes a long way to abating the fear surrounding new technology. Last year, JD organised classes for the elderly on how to use digital devices, starting with basics like downloading apps, and increasing in complexity to cover how to line up for a hospital appointment virtually, scan QR codes and use mobile payments.

This has economic benefits too. With more and more elderly finding their footing in the digital world, they are adding fuel to the already booming silver economy. During 2020, JD saw more elderly consumers start shopping online due to COVID-19; and they've kept up the habit since, appreciating the added convenience and plethora of choices. This has led the company to use big data to work on more products designed specifically for elderly consumers.

But it's about much more than just learning how to use the technology. With a better grasp of e-commerce, elderly parents are now turning around and making purchases for their children. Some are

even joining flash sales campaigns, participating in the highly popular new phenomenon of group buying, and even grabbing digital red envelopes.

And, in diverting themselves from loneliness, especially during the pandemic, they are turning to livestreaming, short videos and singing apps for entertainment. Behind these skills are newfound confidence, freedom and connection; the idea that they are "too old" or that "technology is just for young people" is simply a thing of the past.

For reflection/discussion:

- The authors raise examples of measures taken by tech companies to ease the digital transition in China. Do you see such initiatives in Singapore? How successful are they? What are some limitations or challenges in implementing them?
- The authors are rather optimistic about the elderly adopting technology. Do you have any reservations or concerns? In the case of Singapore, how confident are you that this can be effectively and fairly done? Base your reservations on specific characteristics of Singaporeans and Singapore society.
- In your opinion, should new technology always be embraced readily?
- Apart from the elderly, which other groups might be vulnerable when it comes to the take-up of new technologies? Why so?

Related Cambridge/RI essay questions:

1. How far should we embrace the increasing use of technology in the world today? (RI Y5 Timed Practice 2020)
2. 'Modern technology always improves the quality of people's lives.' Discuss. (RI Y6 Prelim 2016)
3. Are we overly dependent on digital technology? (RI Y5 CT1 2015)
4. 'Technology alienates people more than it serves to bring them together.' Discuss. (RI Y6 CT1 2013)

Further Reading

Japan's technology leads the way in caring for the elderly

Discusses how medical data and AI are combined to enhance the care provided for an aging population.

https://www.euronews.com/next/2019/10/29/japan-leads-the-way-with-elderly-care

SECTION F: TECHNOLOGY AND INEQUALITY

Reading 29: Technology's role in educational inequality
Visakh Madathil | Medium | 16 March 2019 [adapted]

EU 5, 6, 8

This reading will help you to understand:
- The negative impact of educational inequality
- How technology can create & worsen such inequality
- Conversely, how technology can help narrow such equality gaps

Education is riddled with inequality. In the same city, it is not uncommon to find schools with widely disparate instructional quality, equipment, and outcomes mere minutes away from each other. Rather than providing a solution to wealth inequality, education now reinforces it. Technology plays a role in creating this inequality in our classrooms, but it can also help overcome it.

Inequality in education is detrimental to society. It's proven that neighbourhoods where children are from play a vital role in future incomes, primarily because of educational outcomes[3].

Inequality in education increases inequality in society and widespread inequality is undesirable for everyone. Inequality undermines the effectiveness of our politics and institutions, expends national resources, and creates needless social animosity and division.

Education is crucial for economic development and bettering lives. Many stable, well-paying jobs demand decades' worth of education to merely qualify. With income inequality increasing and wage growth remaining stagnant, education plays a vital role in providing people with social mobility.

It is imperative that we can equip people with the tools and resources needed for a dynamic, technology driven economy. With automation and artificial intelligence threatening to be major labour force disruptors, it is important our classrooms can create prepared, critical thinking students. Addressing educational inequality is key to creating a more sustainable society.

Some ways how technology creates division

☹ *Online learning may not work*

A recent trend in educational technology (ed-tech) is the widespread adoption of online and "blended" (online and face-to-face) instruction. A report by the National Education Policy Center (NPEC) found that that students at virtual charter schools only graduate at a 20 percent rate and 77% of blended schools perform below state averages. California's Public Policy Institute discovered that community college students are 10 to 14% less likely to pass an online class compared to when they take it face-to-face.

Clearly, the effectiveness of online and blending learning is limited, yet ed-tech advocates and investors keep pushing the adoption of these technologies in low-income classrooms. Without acceptance that these styles of learning are flawed, real progress cannot be made. Until these learning methods are proven, their adoption will only help increase inequality, rather than help students.

☹ *Amplifies discrimination*

Many technology and data-driven tools (including in ed-tech) help reaffirm discriminatory practices. A study by Stanford's Institute for Economic Policy Research found "that instructors (i.e., professors at

[3] *For a fuller report: "The Opportunity Atlas – Mapping the Childhood Roots of Social Mobility", Raj Chetty et al., Jan 2020 [https://opportunityinsights.org/wp-content/uploads/2018/10/atlas_paper.pdf]*

selective universities) are 94% more likely to respond to a discussion forum post by a White male than by any other race-gender combination" after analysing 124 different Massively Open Online Courses (MOOCs). This shouldn't be a surprise, as we've been knowing about technology enabled discrimination in education for some time now — in 2014 the United States Department of Education issued guidance to address the "potentially … unlawful discrimination" that comes when educational resources are not improperly developed and utilized.

Predictive analytics tools promise to identify struggling students through various data points — including grades, test scores, race, gender, income, and age. These tools seem promising, but there's little evidence they even work — and there's rising concern they are counterproductive. There's no research to prove that these algorithms are actually effective and there is even less oversight and accountability to their uses. There is little being done to address the algorithm bias in our schools, but awareness is being built. Unfortunately, in the current state, ed-tech tools have amplified the discrimination they once promised to help solve.

☹ Exacerbates the digital divide

Classrooms in across the nation country have been flooded equipped with software, computers and high-speed internet. However, the technological disparity and literacy gap is increasing — and instructors often get caught in the middle of it.

A Education Week Research Center analysis found that instructors in lower income schools are less likely than their counterparts at higher income school to receive technology-integration training. Instructors often struggle to explain the technology tools in their own classrooms to their students, leading to thousands of students not being able to fully access resources.

Fluency with technology is important for students as they progress through their careers. It opens opportunity and knowledge and allows students to maximize educational opportunity. Instructors must be properly trained first before any gains are realized. Schools need to become properly prepared to embrace any technology they hope to adopt, but they current aren't.

Some ways technology can overcome division

☺ Immediately provides students with resources

Using internet connected devices, students can access the newest textbooks, instructional videos, and other content to bolster their studies. The internet and cloud can ensure that no school will have to use out-dated textbooks. With the rise of cheap and free online learning portals, it is easier than ever to learn and retrieve information. Digital learning can inspire a lifetime's worth of curiosity and learning, something that will be vital with widespread technological disruption on the horizon. It is about time we brought that opportunity to every student and classroom.

Faulty IT infrastructure needs to be addressed, but investment in bringing reliable networks to schools will ensure a prepared generation. Never again will students have to use old, outdated resources in their classrooms and never again will their learning have to be stifled.

☺ Supports multilingual classrooms

Over 9 percent of the 50 million public school students in the United States are English language learners (ELLs). These students participate in special programs to build proficiency in English that can be aided by technology. Translation tools, built using Natural Language Processing, can help students better their English skills. Text-to-Speech and Speech-to-Text software can allow students to practice either enunciation, while instructors can focus on assisting all students. Software can not only be used to help instructors improve communication with their students, but also to bolster English skills.

Software can help students practice their English skills without the supervision of a teacher, leaving instructors to focus on solving critical challenges for students.

☺Identifies & overcomes difficult concepts

Clever software already is helping students identify and overcome difficult concepts. If a student is studying biology, rather than sitting listening to a teacher lecture about genetics, the student can watch an engaging video online and then play a fun game to solidify concepts. Then, the student can take a quiz that narrows down on concepts the student struggles with and provides them with resources to further their understanding. Then, the instructors can learn about students' struggles and appropriately tailor lesson plans.

Already, software like Zearn, i-Ready, and LearnZillion are helping students across the US. These software tools will help save time and allow instructors to truly understand and meet the needs of their students. This also allows students to master concepts and avoid repeating courses — improving student retention and graduation rates. Software can, and will, help students learn more effectively when properly paired with instruction.

Technology is playing an ever increasing role in our lives — and that includes in the education of the next generation. It is clearing fuelling inequality, but it can also be used to bridge the gap between our wealthiest and poorest schools. However, it will take progressive public policy, rigorous oversight, and technologists dedicated to minimizing discrimination, to codify these changes. Nevertheless, the process needs to begin with thinking about the changes we want.

If we care about bettering lives, we will care about educational inequality. Knowing the causes of educational inequality is the initial step in solving it. Systemically addressing challenges in technology will go a long way in creating a more prosperous world for us all — after all, the future does depend upon it.

For reflection/discussion:

- With reference to the issues raised by Madathil, to what extent has the 2020 Covid-19 pandemic contributed to and/or exacerbated the 'digital divide' that this article refers to (lines 46-57)?
- With reference to Singapore, how far do you agree that technology has 'overcome division' in the ways Madathil describes (lines 59-84)? What significant challenges do you think Singapore face in ensuring that technology plays a positive role in educational inequality?
- How else might Singapore leverage on technology to further boost educational equality? What issues and obstacles might we face in doing so?

Related Cambridge/RI essay questions:

1. How far can scientific or technological developments be a solution to global problems? (RI Y5 CT1 2018)
2. To what extent can technology be a solution to social problems? (RI Y6 CT1 2015)
3. Technological advancement has worsened the problem of poverty.' Do you agree? (RI Y5 CT 2014)

Further Reading

"Coronavirus - School closures in Asia expose digital divide" (The Straits Times, 13 Mar 2020)
https://www.straitstimes.com/asia/se-asia/asia-school-closures-for-coronavirus-expose-digital-divide

SECTION F: TECHNOLOGY AND INEQUALITY

Reading 30: Technology can help equality of people with disabilities **EU 5, 6, 8**

Satria Ardianuari | The Jakarta Post | 25 July 2019

This reading will help you understand:

- Why it is important to help people with disabilities to integrate into society
- How assistive technology can help to reduce inequality for people with disabilities

The ability to perform basic activities of daily living is an essential need for every person. If for some reason the body functions and structures are disturbed, the ability may be reduced or even lost, resulting in what we call disability.

The 2016 national employment survey of Statistics Indonesia (BPS) estimates that 12.15 percent of Indonesia's population – or over 265 million people – have moderate to severe disability. The survey also reveals that 45.74 percent of individuals with disabilities have lower or no education whereas those without disability (87.31 percent of the total population) receive only primary education of averagely 6.5 years.

Disability often restricts participation and interaction in one's community. People with disability have lower educational attainment and fewer economic opportunities in addition to being marginalised and often even excluded from society. Therefore, participation in the labour market is significantly low for people with disabilities.

The 2016 Law on People with Disability was passed following ratification of the United Nations Convention on the Rights of People with Disabilities in 2011. The law entails Indonesia' commitment to the eradication of discrimination against people with disabilities and its active support and provision of services to this segment of the population. The new law also raises the principle that public programs be inclusive and accessible to people with disabilities.

How assistive tech can help

Another way to increase involvement in education and increase economic opportunities for people with disabilities is through the use of appropriate assistive technology. The Rehabilitation Engineering and Assistive Technology Society of North America states that assistive technology has been proven to assist people with disabilities, improving their quality of life. With the technology devices specifically tailored to meet the individual's needs, people with disabilities can improve and optimise their daily functioning, allowing them to become independent, self-sufficient and self-confident.

Depending on the disability and rehabilitation goals, assistive technology includes a wide range of technology devices. For example, individuals with mobility impairments can benefit from wheelchair seating systems, artificial limbs and/or support braces (prosthetics/orthotics) which increases independence. Students with hearing impairments can benefit from assistive listening devices or hearing aids. Those with speech impairments can benefit from text-to-speech output or augmentative communication devices.

Specialised computer software and adaptive hardware can equally help employees with cognitive disabilities complete their tasks. Assistive technology can also expand to adaptive driving, home or workstation modifications, all of which are specified according to the needs of each person with a disability. The ultimate goal is to assist their vocational and recreational activities in addition to helping daily routines.

However, access to assistive technology may still be a challenge. The national social economic survey (Susenas) confirms that people with disability throughout Indonesia mostly cannot access assistive technology despite some efforts. Although still inadequate, our government already provides some of the assistive technology devices through the national insurance systems. The national health insurance BPJS Kesehatan, for example, covers seven assistive technology devices at a considerably low price. Generally, the coverage is so small that a person needs to have additional insurance from local government agencies, self-funding or other sources. An employee who acquired a disability at work can benefit from the new provision of mobility devices and can claim insurance coverage from the national employment insurance (BPJS Ketenagakerjaan). The national employment insurance has also established the "return to work" programmes which provides employees with medicine and rehabilitation treatment following accidents or injuries.

Following the World Health Organization (WHO) guidelines, a number of public and private hospitals with rehabilitation centres, private companies and non-government organisations are supplying technologies for individuals with disabilities. Providers of assistive technology devices are promoting modalities that include prosthetics/orthotics, mobility aids, wheelchair and seating systems. Some devices have become commercially available over the counter such as hearing aids, speech output devices and mobility aids.

These assistive technology devices can help fulfil the life goals of people with disabilities particularly by allowing active participation and interaction in education and employment. Schools and employers should also be willing to adapt and accommodate the needs of their students and employees with disabilities. Moving forward, Indonesia's government and citizens should become advocates for individuals with disabilities by promoting inclusion and equality in every day aspects of life. Apart from ending stigma and discrimination against them, assistive technologies can become among the catalysts to help our country become truly inclusive for all.

For reflection/discussion:

- With reference to Ardianuari's ideas, summarise: (a) the *challenges* faced by individuals with disabilities; (b) the ways that assistive technology devices can *help improve* their lives.
- Ardianuari mentions that the Indonesian government 'provides some of the assistive technology devices through the national insurance systems' (lines 38-39). The Singapore government does so too: (a) Find out what assistive technology provisions are available here for the disabled; (b) Assess to what extent these current provisions are adequate.
- Besides such assistive technology with disabilities-specific applications, in what other ways can technology *in general* be used to better the quality of life for individuals with disabilities?

Related Cambridge/RI essay questions:

1. 'To be effective, schools must turn to technology.' How true is this of education today? (RI Y6 CT 2021)
2. 'The idea that science and technology will solve our problems is a delusion.' Discuss. (RI Y6 CT2 2017)
3. Assess the impact of technology on health in today's world. (RI Promo 2018)
4. Discuss how robotics contributes to the modern world. (RI Y6 CT2 2014)

Further Reading

New tech to help disabled people *(Laura Potier, The Guardian. 8 Sep 2019)*

Electrical stimulation

Nine years ago, David Mzee was left paralysed by a gymnastics accident and told he would never walk again. Last week, he competed in a charity run during which he walked 390 metres, thanks to an experimental treatment[4] that uses electrical stimulation of the spinal cord to rejuvenate dormant circuits in patients whose spinal breaks are not complete.

Helmet for the blind

Designed by the Chinese organisation CloudMinds [www.en.cloudminds.com/], Meta looks like a cycling helmet and uses sensors and cameras to map its environs, sending information to a cloud server to be processed by AI technology. The information can be communicated through speech, helping blind people and those with visual impairments to navigate streets, recognise objects and negotiate traffic lights and crossings.

Next-generation hearing aid

A cochlear implant might be nothing new, but researchers at Columbia University, New York, are working on a "cognitive hearing aid"[5], which monitors the brain activity of users to identify which voice the listener is focusing on. It then magnifies that audio while quietening surrounding noise, allowing for better hearing.

Bionic exoskeleton

Last week, American Lyle Fleming was able to walk for the first time in six years thanks to an exoskeleton[6] that has been described as a "legged Segway". Designed to help those with paralysis to stand and walk, a similar wearable robotic frame was approved in 2012 by the US Food and Drug Administration for physical rehabilitation, to be used with crutches or walkers. Future exoskeletons may replace wheelchairs, providing greater mobility and health benefits.

Giving voice to the speech-impaired

Scientists in the US, UK and China are working on prototypes of gloves that translate the hand movements of sign language into speech, allowing real-time verbal communication with people not proficient in sign language.

Further Watching

"The robot that gives humans a job" – Channel 4 Living, UK
https://www.youtube.com/watch?v=XPluc5BJNIE

[4] *Full article: "Paralysed men can stand and walk after electrical stimulation" – Ian Sample, The Guardian, 31 Oct 2018 [https://www.theguardian.com/science/2018/oct/31/paralysed-men-can-stand-and-walk-after-electrical-stimulation]*

[5] *Full article: "Cognitive hearing aid uses AI and brain waves to enhance voices" – Luke Dormehl, Digital Trends, 7 Aug 2017 [https://www.digitaltrends.com/cool-tech/cognitive-hearing-aid-columbia/]*

[6] *More about this tech: "Exoskeletons – Robotic structures making paralyzed people walk again", The Medical Futurist [https://medicalfuturist.com/exoskeleton-technology/]*