THE TRIPLE HELIX
A global forum for science in society

Guide to Writing for The Triple Helix (Cambridge University Chapter)

The Triple Helix is a network of student-run scientific societies across 19 universities worldwide. The primary activity of chapters societies is to (each!) produce an academic journal, *The Science in Society Review*, for publishing articles by undergraduates, which are reviewed by academics in the relevant field. The Cambridge chapter is also unique in producing a supplement for the work of graduate students. In addition some chapters put on scientific events such as panel debates. If you open an issue of the journal you'll notice that there are two main sections: one for articles written by Cambridge students, and another containing selected articles from other TTH chapters across the world. We submit the best articles from Cambridge to an international pool, so other chapters can choose to reprint your article elsewhere; we believe this is the only opportunity offered by a Cambridge Society for undergraduates to have their work internationally published in a thoroughly edited and reviewed academic journal.

Choosing a topic

Topics for articles should address an aspect of the science-society relationship. This can be done from one of two perspectives:

1. **Consider how a particular area of science affects society**: some recent articles have looked at agricultural technology, infant cognition, medical uses of viruses, etc.

2. **Assess how society affects science**. For example consider how society influences research and the applications of that research, or how science education and the legal regulation of science shape its development. Examples of recent articles in this vein have been on the development of science education in Africa, or the regulation of high-caffeine drinks marketed at young people.

It's also possible to combine these approaches, which can result in the most interesting articles.

The style in which articles are to be written is that typical of scholarly writing. As with all serious academic writing statements should please be backed up by citation and conclusions drawn from the available evidence with an appropriate degree of certainty; some speculation is permissible if it is made clear that you are speculating. It's also essential to ensure your article doesn't become a promotion for a specific product, service, research group, company, etc; all articles need to be impartial and

balanced. The best way to understand the style of *The Science in Society Review* is to read past articles, all available on our website: [www.camtriplehelix.com/journal].

Article length

Articles are 1,200 – 1,500 words (excluding references), this will usually fill 2 pages of the journal.

Citation

The style of citation should be the Vancouver style. Many excellent guides to using the style are already freely available (such as [www.library.uq.edu.au/training/citation/vancouv.pdf], [www.imperial.ac.uk/workspace/library/Public/Vancouver_referencing.pdf]), so citation style will not be covered in detail here. Briefly, whenever you make a statement that is not a thought generated by yourself (or a piece of your own original research), the source of the statement must be acknowledged (however statements considered to be general knowledge - e.g. the structure of DNA is double-helical - do not require referencing). This is achieved by placing a square-bracketed number after the statement, along with placing information about the source in a numbered reference list at the end of the article. The original source of the statement must be used, not secondary sources which themselves include the referenced statement. An example of a typical end-reference for a scientific paper is:

> [9] "Butcher A, Baker NM, Candlestick-Maker Y. Novel courtship behaviour in a species of small African shrew. J Imagin Sci. 2009; 9:145-234"

Similar methods of end-referencing exist for citing books, webpages and the like; again refer to the excellent extant guides. Journal abbreviations should please be those given in the 'Index Medicus' (which we will provide you with).

As an example to illustrate good practice in scientific writing take the excerpt below from a previous *SiSR* piece on the subject of 'fourth generation' nuclear reactors:

> *Anthropogenic climate change is a present reality [1]. Any proposed solution must be politically tenable. If we insist that people give up items they have used for decades, there will be no public will for change. If we insist that growth in developed countries slows, there will be no political will for change. If we insist that other nations do not industrialise, there will be no global will for change.*
>
> *To have a 3 in 4 chance of avoiding 2 C of warming, we must cut CO2 emissions to 0.48 tonnes per person-year by 2050 [1]. The current global mean is 4.4 tonnes per person-year; the UK and US emit 8.3 and 17.7 tonnes per person-year respectively [2]. Indispensible processes currently emit too much CO2. Steel, cement and fertiliser production emit 0.58 tonnes per person-year [3]. Human-caused deforestation and forest fires emit 0.85 tonnes per person-year [3]. Ignoring fertilisers, agriculture emits 0.84 tonnes per person-year [3]. We must optimise every aspect of energy use for minimal emissions.*
>
> *...*

> *Electricity is produced as required, so we need clean means of producing heat and electricity. Disregarding existing fossil fuelled plants, we have renewables, carbon capture and storage plants, and nuclear power. The UK has an abundance of renewable resources, but consumes an abundance of energy. MacKay [5] gives a numerate summary; disregarding any public dissent and devoting a majority of the UK's surface and seas to wind, photovoltaics, solar thermal, wave, tide and biocrops would not produce enough energy. Most of these renewables work less well at a global scale, as the UK has exceptional sites for many renewables. ...*

Information which the author obtained from research is referenced, while his own points remain unreferenced. The style is such that the author proves an argument from scientific data, and 'sensationalism' is absent. A small selection of exemplary previous *SiSR* articles will be provided along with this document as further examples of the style we're looking for.

Please **do not use EndNote** for citation. For technical reasons we require that all references are done manually.

Lastly, please don't be intimidated! Writing in academic style is easy once the conventions are understood; your editor and the *SiSR* staff are on-hand with advice.

Considering your audience

The audience for *The Science in Society Review* typically ranges from first-year undergraduate students to senior academics in virtually every field. Anyone with an interest in science and its place in society should be able to understand and enjoy your article. Keeping this in mind, ensure that you clearly introduce and define any specialist terminology. A student of astrophysics may have next to no knowledge of ecology, and *vice versa*; you need to take this into account. Be sure to introduce technical terms as they arise. Very basic terms (e.g. genome, acid, black hole), do not need to be defined extensively as there simply isn't the space. However, less common terms (e.g. ribozyme, arene, quantum indeterminacy), do need to be clearly defined or your article will become inaccessible. If you clearly define your terms then 'dumbing down' can be avoided while keeping your article readable. Your editor will be able to guide you as to which terms need defining and which do not.

Structuring your article

This is an extremely brief guide to structuring your article, which will be different for every article depending on the topic. Here are some **very** general pointers that can fit almost all articles, but please don't feel the need to follow this structure to the letter:

1. A good way to start is a short scene-setting paragraph, which introduces your topic and signposts why it is going to be an interesting and important article – 'the bigger picture', if you will.

2. Consider (if relevant) any traditional views or arguments that you are going to respond to in

your article. This is because the reader may not have specialist knowledge, and needs to be brought quickly and briefly up to speed.

3. Develop the main content of your article: the new information or argument you are presenting. Define specialist terms and acronyms the first time you use them. Ensure you present a balanced argument. If there are people who disagree with your argument, cite them and explain why you believe your argument is better than theirs (this will greatly strengthen your position).

4. Assess any problems with your argument: what are the limitations of the topic you're considering? Be modest and realistic – your article doesn't have to claim anything earth shattering. Modesty is infinitely preferable to exaggeration.

5. Conclude. Pull out to the larger picture to gain some perspective and to remind your audience why your topic is interesting and important. Signpost that you've addressed everything you set out to address.

This is by no means the only way to structure a good article; if you find yourself preferring another one then feel free to experiment with what suits your subject matter best. Lastly, read widely around your chosen topic to include as much new information and as many interesting perspectives as possible.

The editing and reviewing processes

You will be assigned an editor, who will read through your article and make suggestions for improvement. These suggestions may include pointers on punctuation, grammar, citation, structure, tone, balance, and overall direction of your article. Don't be concerned if you get your first draft back with dozens of comments: no one writes the perfect article first time, and our best articles go through many rounds of editing. Our rigorous editing process will ensure your work is in its best possible condition for publication.

Please bear in mind that your editor's suggestions are not set in stone. It is possible that you may disagree with them on a particular point. In this instance, try to explain your position to them. If after this you still disagree on a particular point, email the Editors-in-Chief, (eic@camtriplehelix.com) who will help you and your editor reach an agreement.

When both you and your editor are happy with your article, it will be read by a senior member of the Literary Team, who may make some small adjustments. Your article will then be reviewed anonymously by two academics in the relevant field, and their comments and suggestions will be sent back to you. When you have acted on their advice, your article will be ready for print!

Deadlines for the various stages of the editing process will be sent to you by email.

Practically Carbon Free

Jonathan Lee

Anthropogenic climate change is a present reality [1]. Any proposed solution must be politically tenable. If we insist that people give up items they have used for decades, there will be no public will for change. If we insist that growth in developed countries slows, there will be no political will for change. If we insist that other nations do not industrialise, there will be no global will for change.

To have a 3 in 4 chance of avoiding 2 °C of warming, we must cut CO_2 emissions to 0.48 tonnes per person-year by 2050 [1]. The current global mean is 4.4 tonnes per person-year; the UK and US emit 8.3 and 17.7 tonnes per person-year respectively [2]. Indispensible processes currently emit too much CO_2. Steel, cement and fertiliser production emit 0.58 tonnes per person-year [3]. Human caused deforestation and forest fires emit 0.85 tonnes per person-year [3]. Ignoring fertilisers, agriculture emits 0.84 tonnes per person-year [3]. We must optimise every aspect of energy use for minimal emissions.

> **“Most of these renewables work less well at a global scale as the UK really does have an abundance of sources”**

To produce our energy needs whilst emitting less CO_2, we need to understand how energy is used and moved. We use 3 main types of energy: local heating, transport, and electricity. Heat can normally be produced from electricity or fuels. In some industrial use, hydrocarbons are required for speed of heating or chemical properties.

For transport, we could use electric vehicles, storing energy in batteries. Unfortunately, global lithium reserves are small. US trucks alone would consume 170% of global Lithium production. Global battery powered transport requires that the world give up private vehicles. Even given enough lithium, it takes around 15 years to replace all vehicles. It is not clear that we have this much time. We could use Hydrogen as fuel, but this requires vehicle replacement and either high pressure or cryogenic storage. Storage is dangerous in private vehicles, and rules out aviation. It is not clear that we can rely on the body politic to give them up.

More reasonable alternatives are methanol and dimethylether. These replace diesel and petrol, both chemically and in ease of storage. Fisher-Tropsch synthesis allows these fuels and methane to be produced from CO_2, hydrogen and heat. Amine gas scrubbing allows CO_2 to be removed from the atmosphere given waste heat. Hydrogen is currently produced from natural gas. The main alternatives are electrolysis and the Sulphur-Iodine process. Electricity is very low entropy, and so thermodynamics constrains electrical generation to around 40% efficiency. Electrolysis is worse overall. The Sulphur-Iodine process is closer to 65% efficient overall [4]. Ultimately, solar thermal or nuclear power would be needed to actually produce heat. This would allow us to use hydrocarbons to store and transport energy, and use existing infrastructure at point of use.

Electricity is produced as required, so we need clean means of producing heat and electricity. Disregarding existing fossil fuelled plants, we have renewables, carbon capture and storage plants, and nuclear power. The UK has an abundance of renewable resources, but consumes an abundance of energy. MacKay [5] gives a numerate summary; disregarding any public dissent and devoting a majority of the UK's surface and seas to wind, photovoltaics, solar thermal, wave, tide and biocrops would not produce enough energy. Most of these renewables work less well at a global scale, as the UK has exceptional sites for many renewables.

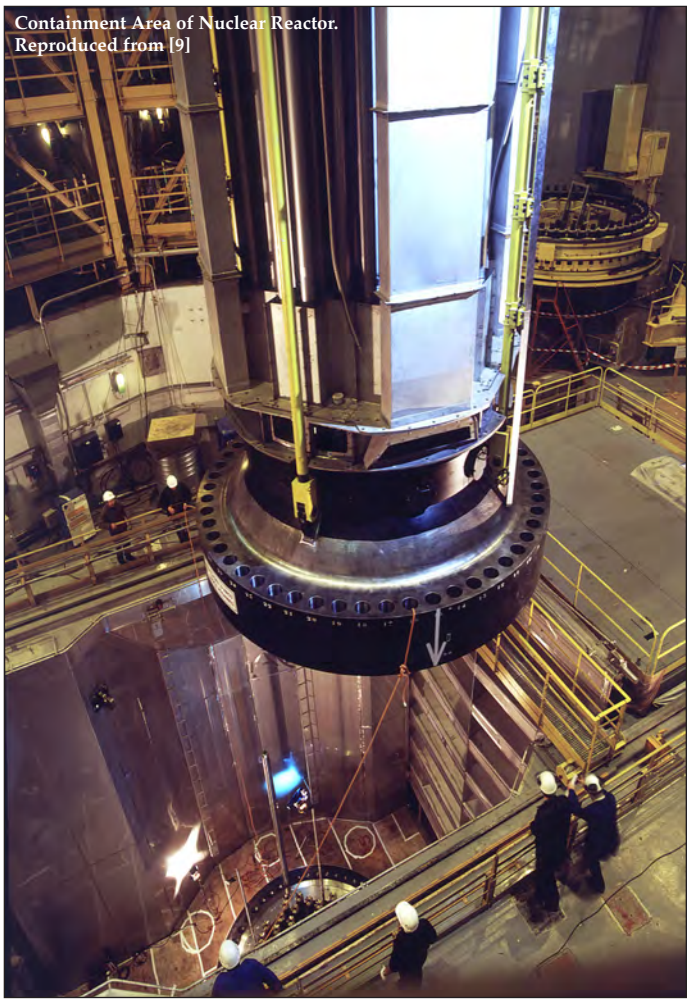
Another problem is the stability of electrical supply. Wind has the best statistical data, as it has the largest scale. In 2004 wind generated between 0.2% and 38% of German electricity on a day to day basis [7]. On their 7GW network, 8 hour predictions and actual supply differed by much as 6GW [7]. In the 2006 California heatwave, wind generation dropped to 4% of capacity for 10 days [6]. Electrical grids must balance supply and demand to avoid blackouts or melting their cables. Germany manages by importing and exporting from the French nuclear grid. At a national scale, renewables are unreliable. Generation capable of backing up all renewables at short notice is required.

Some propose carbon capture and storage. In practice, CCS has net emissions of 10-15% of normal fossil fuels, which is too high. CCS is more expensive than nuclear and has greater emissions. There is also the issue of finding stable geological stores. The emissions have far greater volume than the fuels burnt, and finding suitable large stable structures that are gas-tight is difficult.

> **“At present, enriched 235U or the 238U-239P cycle are commonly used; both cause proliferation concerns.”**

The remaining source is nuclear. Reactors can produce electricity and heat for hydrogen production. We want a reactor that has sound engineering, scales globally and is politically tenable. For this, society demands better waste properties, better safety and no risk of proliferation.

Coolant choice, canonically water, is a fundamental design driver. Unpressurised water boils too readily; interactions between pressure, temperature and boiling are the constraint leading to reactors that are sensitive to human error or natural disaster. High temperature steam is highly reactive, and so water cooled plants are limited to around 650°C. One known alternative is a mixture of unreactive metal fluorides. These are liquid between 400°C and 1400°C, and so high



Containment Area of Nuclear Reactor. Reproduced from [9]

temperature reactors can be unpressurised. If spilt, the salts solidify and so are easily contained. High temperature also makes hydrogen production efficient.

Fuel choice has proliferation and waste implications. At present, enriched ^{235}U or the ^{238}U-^{239}Plutonium cycle are commonly used; both cause proliferation concerns. However, Indian reactors use the more common ^{232}Thorium, first turning it into ^{233}U. ^{232}U impurities are easy to detect and prevent weapons using ^{233}U without enrichment. Natural Thorium is pure ^{232}Th, so no enrichment or reprocessing is legitimate. The conversion process consumes neutrons, reducing the number leaving the core by a factor of 5-10. The neutrons used are low energy and thus less penetrating. As a result, decommissioning and maintenance are far easier. Long lived waste can be formed by repeat neutron absorption without fission. With ^{233}U as fuel, any nucleus gets 3 chances to fission before becoming waste. Other fuel's cycles give fewer chances, and so the ^{232}Th-^{233}U cycle produces less long term waste.

Put together, we get the Liquid Fluoride Thorium Reactor (LFTR), a proposed Generation IV reactor. The fuel is dissolved in molten fluoride salt, and so gravity can move the fuel to specialised storage tanks if anything appears wrong. The reactor is passively safe; as the reactor heats up, thermal expansion in the salt reduces the amount of fuel in the reactor, reducing heat output. Furthermore, it is easy to remove fission products [8], which in turn reduces the formation of long lived waste. As a result, the "high-level" waste from an LFTR is less active than natural rocks after 300 years.

LFTRs are safer, have better waste and are harder to abuse. LFTRs passively shut down before reaching excessive temperatures. There is no potential for physical explosions in the reactor. If there is a leak, the material freezes and is contained. The smaller quantity of waste is less active. There is no excuse for enrichment or reprocessing, preventing proliferation. Thorium itself is plentiful; LFTRs produce 10 times more energy from the thorium in coal than is obtained by burning the coal [8]. Thorium can be economically extracted from granite [8]. Experimental LFTRs have been in operation since the 1960s, developed initially for aircraft where plutonium production was not desirable.

> **"Experimental LFTRs have been in operation since the 1960s. They are safe and can be exported"**

A wider plan can now be formulated. LFTRs are safe and can be exported. They use common fuel, securing energy supply. They can drive the Sulphur-Iodine process, Amine CO_2 extraction and Fisher-Tropsch synthesis. They can produce electricity. Hence we can achieve negligible net emissions without replacing our existing infrastructure. Producing hydrogen and electricity together also allows the electrical generation to be changed rapidly by balancing it out with hydrogen production. Hence the electrical grid can be made more responsive, and so traditional renewables can be used.

There are ways of reducing global emissions as required. The scope and politics of this problem are not well appreciated by the public. The canonical "environmental" line is renewables without CCS or nuclear. This fails to produce enough energy or be politically tenable. Politicians have made token local changes, but UK emissions must fall by about 90%, and we must find a global solution. Politicians and environmental advocates need to engage in numerate public discussion. One approach has been outlined above. It might not be ideal, but we must implement something soon. Reality will not wait. ■

Jonathan Lee is a fourth year student studying Mathematics at Trinity College.

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Your Genes Belong To Us

Gengshi Chen

Genae Girard, a 39-year-old woman living in the US, had to pay a staggering $3200 for a single genetic test for the BRCA gene associated with breast and ovarian cancer, only to find that she was unable to request a second opinion upon receiving the positive test result. After consulting with doctors, Ms Girard was advised to have her ovaries surgically removed in order to diminish the 60% risk of developing ovarian cancer indicated by the genetic test. Because Myriad Genetics, which holds a patent on the BRCA genes, is the only laboratory to provide the genetic test, Ms Girard had to undergo the life-changing surgery without knowing for certain whether it was absolutely necessary [1].

Ms Girard is only one of tens of thousands of women in this situation, left with no choice but to accept the outcome of a single indeterministic genetic test result, which in addition is subject to human errors in the test laboratory. Other companies are unable to provide an alternative method of diagnosis because the gene in question is protected under patent laws [2]. Currently 20% of human genes are "owned" by individual biotechnology companies and research labs, making it illegal for others to carry out diagnosis and therapy, and limiting research using those genes [1,3].

The underlying principles of patents are to promote openness of publically beneficial findings, and to reward investors for the capital endowed in innovating and developing a product. In return for disclosing the details of an invention and paying a maintenance fee, the patentee receives a 20-year monopoly over the patented product or process [4]. This argument has an appreciable value when considering inventions such as Tetra Pak® or SuperGlue. However, is the patenting of human genes a step too far? Do gene patents deprive the public of cost-effective health care, and what impact do they have on research in public institutions and competing companies?

> **"DNA … should be treated as the physical embodiment of … nature"**

The history of the British patent system as we know it today started in the 19th century, when the granting of patents became independent of the crown and turned into a regulatory matter for the state. With the passage of the Patent act in 1977, patent rights became an integrated part of British law.

It is worth noting that patents are country-specific, and the laws regulating them vary from country to country [4]. Generally, US patent laws are more liberal in the consideration of patentable matters than the European equivalent, allowing more gene patents to be approved [5]. The European Patents Office (EPO), an intergovernmental patent approval organisation, has 3 main criteria for the patentability of an invention: it has to be new, be susceptible to industrial application and involve an inventive step. In addition, the Biotech Patent Directive adopted in 1998 by the EPO contains further criteria and restrictions to clarify the patentability of biotechnological matters [6].

The association of BRCA1 with breast and ovarian cancer was discovered in 1994 by Mark Skolnick, founder of Myriad Genetics. He patented the gene and was granted a monopoly for the use of the gene in genetic testing, gene therapy, protein replacement therapy and the screening of drugs for cancer therapy [7]. In 1995, BRCA2, a related gene, was discovered and the patent rights were purchased by Myriad Genetics. The patents have allowed Myriad to, in effect, control the research and genetics testing of the BRCA genes in the US [8]. The BRCA1 and BRCA2 patents were approved by the EPO in 2001 and 2003 respectively, but cover a more restricted scope of rights than the US patents [1,9].

A law suit filed by the American Civil Liberties Union (ACLU) resulted in the invalidation of the BRCA gene patents in March 2010 at the US District Court for the Southern District of New York. The court decision taken by Judge Sweet was based on the argument that the isolated DNA is not markedly different from the natural state and that "DNA … should be treated as the physical embodiment of … nature". In other words, although DNA is a chemical molecule, it should not simply be treated as other chemical compounds, since it also carries information and knowledge, which is not patentable. This is the first time an American court has found it unlawful to patent genes, a decision which could lead to the invalidation of 18.5% of the current patents of human genes [5,8].

Opponents to human gene patenting are concerned in principle by the action of owning genes – DNA is intrinsic and not an invention. The patents monopolise the gene test market and inhibit competition-derived reduction of health care costs. The revenue of Myriad Genetics in 2009 was $326 million, most of which came from their BRACAnalysis gene test [8]. Another problem arising from the nature of the monopolised market is that patients are prevented from receiving a second opinion on their test results. The intellectual property rights allow the patent holder to deny licensing the usage of the gene for the development of alternative diagnostic tests, in order to retain their monopoly of the test market. Critics also argue that the current patent system (especially in the US) is unfair, because it allows a gene to be patented before a working product has been developed. Moreover, even if only a single function of a gene is understood at the time of patenting, the patent may cover all other functions of the gene yet to be discovered. This is something that has become increasingly significant as we discover the complexity of gene function and regulation [4].

One of the main arguments against gene patenting is that it stifles research, prevents scientific advances and stops the development of new therapies. To limit the extent of this effect, there are research exemption rules in the patent laws of many European countries and in the US, which allow "pure" research to use patented genes without the need for a licence [10]. Hundreds of research papers on patented genes such as the BRCA genes prove that the concept works; researchers are making use of the exemption rule [8]. To further reduce the research dampening effect, some biotechnology companies provide subsidised licensing to research labs [11]. In a statement by Myriad Genetics, the company said, "It is important for us to point out that research activities with the patented technologies are not limited in any way by Myriad and are encouraged through subsidised costs for testing from the company to researchers." Although this might encourage research on patented genes in non-profit labs, it is unlikely that competitors are using these free licences, since new products developed with the gene may be under the protection of the existing patent, allowing Myriad to claim royalties on their research [12]. Other organisations, such as the not-for-profit Cancer Research UK, take a similar approach by granting free licences to all reputable research labs, and in doing so preventing research on the gene in question from becoming stagnant [11].

> **"A major problem with ending gene patenting is the risk of increased secrecy"**

On the other side of the debate are supporters of gene patenting, who argue that patents are needed to provide an incentive for capitalists to invest in research. Due to the long process between the initial discovery of a gene and the commercialisation of the final diagnostic or therapeutic product, gene patenting is needed in addition to product patenting in order to drive initial research. A major problem with ending gene patenting is the risk of increased secrecy in the pharmaceutical and biotechnology industries as well as in academia, which would hinder research and result in wasteful research duplications. Gene patenting allows academics to publish their research openly, enabling further development [8,13].

The controversy of human gene patenting has been difficult to solve, partly due to the complexity of genetic material in terms of its function and regulation. New findings are constantly revealed, making it difficult for the law and ethics to keep up to speed with patentability criteria and case law. All gene sequence patents were granted prior to the completion of the first draft of the human genome project in 2000 by which time all human genome sequences became publically available [14]. The 20-year validity of patents means that the last gene sequence patent is going to expire in 2020, effectively solving the dilemma [8]. However, scientific advances continuously generate new uses and applications of already sequenced genes, such as genetic tests and drug screen targets, which may well be patentable. The scientific society and the general public should continue the debate in order to influence the way EPO and other patent offices are building up case law for the patentability of human genes, striving to achieve a balance between the incentive to invest in research, scientific progress and fair health care services. ■

Gengshi Chen is a second year student studying Natural Sciences at Selwyn College.

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