Concepts In Scientific Writing

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Contents

Dedicated to:

Benjamin Rory David Borsaru
Godson of the author.

Preface

A conventional guide to scientific writing will be concerned *inter alia* with such things as terminology, units and figures and diagrams. These are all necessary to good scientific writing. This book however is not so focused. It draws on history of science and on philosophy to give the reader sufficient background on these to provide him or her with ideas and insights which will be an aid to good writing. At the beginning of the book selected writings by Nobel Laureates are held up as examples, and this is followed by a discussion of logic, in the formal sense of that word in philosophy, as it relates to scientific writing. The matter of popularisation of science follows, and some eminent writers of 'popular science' are quoted from. Scientific etymology and the use of figures of speech follow. There is also a chapter on newspaper reporting of science.

A reader will sense a strong biographical component to the book. An expert scanning the research literature in his or her own field looks for familiar names amongst the authors, and a new scholar has to establish a reputation by publishing well received work. That is equivalent to saying that writ*ing* and writ*er* cannot be considered totally separately from each other. In a book like this one concerned with scientific writing as a discipline in itself, biographical details of writers whose work is being quoted from are wholly necessary. I originally thought of calling the book a 'guide' to scientific writing, but the title I have in fact used probably suits the book better.

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Clifford Jones.

Churchill, Victoria.

August 2015.

1 Examination of selected scripts from previous generations of scientists

The author's intention in this chapter is to select scripts by eminent scientists from up to about a century ago and analyse them for their structure and writing style. It was thought preferable to use work by scientists having achieved that ultimate accolade, a Nobel Prize. The Nobel Prize in physics for 1904 went to Lord Rayleigh (1842–1919) a.k.a. John William Strutt. The scope of his work was very wide and a collection of his papers published by Cambridge University Press is accessible online [1][1]. A portrait of Rayleigh forms Plate 1.1 below.

Plate 1.1. Lord Rayleigh. Image taken from [2].

The paper from the Rayleigh collection selected as the first paper to be examined is entitled 'On the dissipation of energy', and was first published in 1875. The wording of the title is of some interest. To entitle a scientific paper 'On [the topic of the paper]' is a practice which was prevalent long after 1875 and is still quite acceptable. 'On the dissipation of energy' occupies four pages of the journal in which it was originally published. It is not divided into sections, whereas a four-page published piece nowadays most likely would be. It does not have an abstract. The first paragraph of the paper reads thus:

> *The second law of thermodynamics, and the theory of dissipation founded upon it, has for some time been a favourite subject with mathematical physicists, but has not hitherto received full recognition from engineers and chemists, nor from the scientific public. And yet the question under what circumstances it is possible to obtain work from heat is of the first importance. Merely to know that when work is done by means of heat a so-called equivalent of heat disappears is a very small part of what it concerns us to recognise.*

This introduction is direct and informs a reader of the theme of what follows, and is general without being vague. A comment that a particular idea has received attention in some scientific circles but less so in others is often helpful and remains a common approach to introducing a discussion, and Rayleigh's following of that with an emphatic statement is very good style. In the next sentence he enlarges upon that in an effective and convincing way.

One can be confident that Rayleigh's use of the word would have been correct and precise, but 'dissipate' was later to become a rather overworked word. For example it has been used synonymously with 'disperse'; a news feature in 2015 reads 'Locals safe after toxic orange gas cloud dissipates over northern Spain' [3]. Later in his paper Rayleigh refers to 'unnecessary dissipation of heat'. A thermodynamicist in the 21st Century might have preferred to rephrase that 'avoidance of low efficiency'. Later still in his paper Rayleigh acknowledges that there is no synonym for the rather clumsy expression 'opposite of dissipation'. Nowadays that would be expressed not in terms of dissipation but, as in the example above, in terms of efficiency. 'Dissipate' in its verb or noun form occurs eleven times in the four-page article under discussion, signifying not repetition but the importance of the concept of 'dissipation' to the subject matter.

One or two very minor things in Rayleigh's paper might have attracted the notice of a modern proof-reader. In the paragraph already quoted in italics a case can be made that 'nor' should be 'or' and that commencement of a sentence with 'And' is better avoided, though these are points of pedantry. A little more serious is the description of movement of hot gases from a combustion process, in the third page of the paper: 'After a time the products of the combustion are passed into another passage….' 'Transferred into another passage' would obviously have been better.

A general point is that something a 'pedant' might have disapproved of sometimes becomes accepted practice simply by being widely followed. The most obvious example is splitting an infinitive, once strongly deprecated but now no longer seen as an offence against the English tongue [4]. It is debatable whether it was pedantry or simply delicacy which once precluded use of the terms 'male' and 'female' in the description of joints and connectors. Imagine a laboratory flask with an opening into which is slipped a stopper designed so as to have an outer diameter exactly matching the inner diameter of the opening. To have called the opening 'female' and the stopper 'male' would have been common enough in informal discussion thirty-five years ago and would have embarrassed no-one but such terminology would not at that time have featured in written documents. That taboo has long gone.

There are seventy-six papers by Rayleigh in the published collection [1], all of them having previously been published in journals, and these are of varying length. One of them – 'On the theory of resonance' – is over forty pages (note 'On' again) whilst some occupy only one or two pages and are effectively 'notes'. The volume also contains examination questions from the Cambridge Mathematical Tripos in Rayleigh's time. In present-day academia the setting of university examinations is a matter requiring the utmost attention to quality.

Lord Rayleigh's work is outside living memory. The famous work by Watson and Crick on DNA is within living memory, though certainly a long time ago: it was in 1962 that they along with M. Wilkins received the chemistry Nobel Prize. A publication by Watson and Crick in 'Nature', still a major science journal [5], in 1953 begins:

We wish to suggest a structure for the salt of deoxyribose nucleic acid (DNA).
This structure has novel features which are of considerable biological interest.

This very direct lead-in sets the tone for the remainder of the article, which is concise and free from verbiage. Every sentence contains necessary scientific detail. A short piece published in 'Nature' might be expected to have a conversational style, and this is reflected by frequent use of the first person plural in Watson and Crick's article as in the above quotation. One or two further examples follow.

We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid.
We have made the usual chemical assumptions….

The first person plural used sparingly in formal scientific reporting is acceptable. Sometimes in scientific writing the pronoun 'we' is used in a different sense, intending to unite the author(s) and reader in a vague sort of way. Repeated use of the first person plural in this way in the same piece of writing has sometimes attracted criticism from reviewers as being poor style. (See also comment on page 12.)

Watson and Crick go on to add that 'full details' of their work will be 'published elsewhere', so the piece in Nature has a directness, almost an urgency, which reporting of the 'full details' would not have. This has been described in a commentary on the article under discussion [6] as an 'expound later' approach. In the time of Watson and Crick this was necessary when, as in their case, independent work on the same topic was taking place elsewhere. In these times a publication once accepted can be made available online in a matter of days, so there is less justification for the 'expound later' approach. The 'urgency' referred to is also reflected in several single-sentence paragraphs, and reviewers have been known the describe such a style as being 'breathless'.

Description of the structure of DNA requires many highly specialised terms including 'fibre axis' and 'helical chain' and in the publication under discussion it has been assumed by the authors that readers will have a grasp of these. Equivalently and probably more realistically, it has been assumed that anyone who would benefit from reading the article will have a grasp of these. In a longer publication just how much guidance a reader will need in understanding established terms appertaining to the topic of the publication is a matter for judgement, and a citation of an earlier and possibly independent publication in which the necessary definitions are given is a way around this. Editors were often required, as business practice, to limit excessive background. That was when printing costs were high, a less important issue on today's journal publishing scene.

The paper by Watson and Crick analysed above was followed by another in the same journal the following month. It is entitled 'Genetical implications if the structure of deoxyribonucleic acid'. Why 'Genetical' and not the equivalent 'Genetic'. 'Genetical' is not wrong, although if Watson and Crick had drafted their paper in the days of word processors they might have found that the spell checker underlined it. A word likely to feature in any scientific report of a chemical nature is 'oxidation'. 'Oxidisation' is not wrong, though rarely encountered.

The second paper in Nature (which is not the 'publication elsewhere' promised in the earlier article) has the same 'expound later' character as its predecessor. The sentence below is from the penultimate paragraph:

> *For the moment, the general scheme we have proposed for the reproduction of deoxyribonucleic acid must be regarded as speculative. Even if it is incorrect, it is clear from what we have said that much remains to be discovered….*

The book so far has focused on the seminal writings of Nobel Laureates in science so that what might reasonably be seen as exemplary writings might be appreciated by a reader. This theme continues with examination of publications by Irving Langmuir, Nobel Laureate in chemistry 1932. There is one reason why inclusion of Langmuir is appropriate in a book on scientific writing. Some of his work is known to anyone who has studied chemistry even at first-year university level, through the Langmuir adsorption isotherm. Plate 1.2 below is a photograph of Langmuir.

The publication seen as being Langmuir's best is entitled 'The arrangement of electrons in atoms and molecules'. It was published in 1919. On inspecting the paper, which is sixty-six pages long, we first note that the title is both brief and general, and this is good practice. At the time of publication of the paper Langmuir was in the employment of General Electric, recorded on the paper as his affiliation.

The first paragraph of Langmuir's 1919 paper reads as follows.

Plate 1.2. Irving Langmuir. Photograph taken from [7].

The problem of the structure of atoms has been attacked mainly by physicists who have given little consideration to the chemical properties which must ultimately be explained by a theory of atomic structure. The vast store of knowledge of chemical properties and relationships, such as is summarized by the Periodic Table, should serve as a better foundation for a theory of atomic structure than the relatively meager experimental data along purely physical lines.

An obvious point to note is the US spelling of 'meagre'. In the first line 'attacked', though the meaning is clear enough, might not have been the best choice of word. (Even so James Clerk Maxwell, whose work was in the 19th century and features in a later part of this book, is on record as having used 'attack' in this sense.) The milder term 'approached mainly by physicists' would convey the same meaning. The paragraph has a critical tone, and one might take the view that a writer of the stature of Langmuir has the intrinsic authority so to write. Certainly the paragraph is free from 'personalisation': he does not identify the physicists the inadequacy of whose work he comments upon. Even so references in support of the views he expressed might have improved the paragraph. The next paragraph begins:

Kossel[1] and Lewis[2] have had marked success in attacking the problem in this way. The present paper aims to develop and somewhat modify these theories.

So we have 'attack' again! It is clear enough what is meant by 'in this way': from 'knowledge of chemical properties and relationships, such as is summarized by the Periodic Table'. Both references are from 1916 and the references are given as footnotes. Superscripting of the reference numbers is still common practice, and journals have their own conventions for that. Some require use of brackets: Kossel (1) and Lewis (2). Others would not use numerals at all, but would require 'Kossel (1916) and Lewis (1916)…'. 'To develop and somewhat modify' has about it just a suggestion of the split infinitive and, even allowing from transatlantic variations in the meaning of words, 'somewhat' is probably not the best choice here. Why not 'This paper aims to develop these theories and to modify them in some degree'?

In the paragraph under consideration Langmuir states the objectives of his paper clearly, and very early in the paper. In spite of its length the paper is not divided into sections, and this simply reflects the conventions of those times. It might also be relevant to the absence of a major introduction. On only the fourth page of a paper of sixty-six pages does Langmuir introduce his own 'postulates', preceding them by saying:

> *By a consideration of this equation* [*an equation immediately above*] *and principles of symmetry and by constant checking against the Periodic Table and the specific properties of elements I have been led to the postulates given below.*

Again the period of the paper has to be noted, and whilst use of the first person singular in a published paper was quite unexceptionable in 1919 it would be discouraged by editors nowadays. One would instead simply say 'the author' or perhaps 'the present author'. In fact in another of his papers, entitled 'The constitution and fundamental properties of solids and liquids and published in 1916', Langmuir does refer to himself throughout as 'the writer'. In the same paper he says:

> *We shall see that these ideas on tautomerism will prove of value in connection with a study of the constitution of liquids.*

This is an example of use of the first person plural discussed on page 9.

The 1965 Nobel Prize for chemistry went to R.B. Woodward whose photograph forms Plate 1.2 below.

Plate 1.2. R.B. Woodward. Image taken from [8].

There has been a book about Woodward [9], which in commenting on one passage from his writings uses the word 'beautiful'. The passage is reproduced below.

> *Our investigation now entered a phase which was tinged with melancholy. Our isothiazole ring had served admirably in every anticipated capacity and some others as well. With the obtention of* [*a tropolone*] *it had enabled us to construct the entire colchicine skeleton, with almost all the needed features properly in place, and throughout the process it and its concealed nitrogen atom have withstood chemical operations, variegated in nature and of no little severity. It mobilised its special directive and reactive capacities dutifully, and had not once obtruded a wilful and diverting reactivity of its own. Now it must discharge but one more responsibility – to permit itself gracefully to be dismantled not to be used again until someone might see another opportunity to adopt so useful a companion on another synthetic adventure. And perform this final act of grace it did.*

The above is taken from the Harvard Lecture Series and its most likely readership is graduate students. They would have been comfortable with such words as 'isothiozole', 'tropolone' and 'colchicine'. Before making general points on the above we examine certain words. 'Anticipate' has been used as a synonym for 'expect', a widespread practice which has not always met with acceptance. As the eminent expert in word usage Sir Bruce Fraser once said, if a couple anticipate marriage that does not mean that they expect to get married. Obtention is an obscure word, yet is simply the noun form of 'obtain'. 'Variegated' might have been as well expressed simply by 'varied'. 'Graciously' might have served its turn at least as well as 'gracefully'. It is emphasised that the above are points are of the nature of an analysis, not of criticism.

The passage above whilst superbly expressing the science also adorns it by its elegant personification of the isothiazole ring. That no doubt evoked 'beautiful' from an earlier commentator on the passage. Such a style is the prerogative of an expert having mastery of a subject to a degree where there is personal engagement. The same phenomenon on a lower plane is evidence of enthusiasm on the part of an author. It is good to be enthusiastic, but it is not good for a piece of scientific writing to be dominated by the author's keenness. Possibly subconsciously, Woodward would have wanted a reader of his work to sense an appeal of the science rather than an admiration of his writing style. Another way of saying that is that discipline is needed in writing. It is to the character Pygmalion in one of Ovid's works that the expression 'art of concealing art' is attributed. That means subjugation of an artist's proclivities to the enhancement of the quality of his or her creation, the 'discipline' referred to above. This point is touched on again in Chapter 6 when 'style' is discussed.

Personification in a much smaller degree than in the passage by Woodward is fairly common in scientific writing. It would not be seen as frivolous to state even in a formal report that a chemical reaction had to be 'coaxed' into taking place. An advanced text on superconductivity [10] says 'Every college student who works in a laboratory with liquid helium knows how temperamental equipment becomes at low temperatures', as if such equipment had a 'temperament'! This has been cited to make the point that personification to that extent in an otherwise formal piece of writing is not unacceptable. A writer wanting to avoid it might have said that at low temperatures equipment 'tends to malfunction' or 'becomes less reliable'.

The difference between the mild personification involved in the use of 'temperamental' and the much more effusive style of Woodward is one of degree. He attributes to isothiazole the quality of grace, surely a feature of its 'temperament'. As a further example of personification the present author can recall, on being informed of the ready response of a particular organic compound to acid, that one 'only had to show it the acid bottle'. That would be seen as lively style rather than as flippancy. Personification, along with other figures of speech, is discussed more fully in Chapter 6.

In the same year that Woodward received the Nobel Prize for chemistry another American, Richard Feynman, received the Nobel Prize for physics. His name is well known to students and professionals in his subject area on account of the 'Feynman Lectures on Physics' which have been in print without interruption since the mid 1960s. Plate 1.3 below shows a boxed set of the volumes.

Plate 1.3. Boxed set of the Feynman Lectures on Physics. Image taken from [11].

Before considering the lectures we shall look at some of the many quotes attributed to Feynman, accessible on [12]. One such quote is:

> *It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong.*

Obviously this is only so if the 'experiment' is reliable and if the 'theory' has been correctly applied to the experimental results. Feynman is on record as having said [13]:

> *Physics is like sex: sure, it may give some practical results, but that's not why we do it.*

Before criticising him for that we have to be aware that it was probably said to students, and a little innocent frivolity so often oils the wheels.

Another of Feynman's quotes is:

> *If I could explain it to the average person, I wouldn't have been worth the Nobel Prize.*

This leads to the notion of 'popularisation' of science concerning which much can be said. This leads further to the concept of 'haute vulgarisation', where 'vulgar' does not mean crude or antisocial but has its earlier meaning of simply 'ordinary'. Traces of this survive in primary school level mathematics. There are both 'vulgar fractions' and fractions having been adapted and made more suitable for subsequent incorporation into calculations as 'decimal fractions'. There is nothing coarse about vulgar fractions. The meaning of the term is that before the proliferation of numeracy they were the way the 'common people', the meaning of the Latin *vulgus*, conducted their monetary and trade calculations. That is why in countries including England and Australia it was not until well into living memory that the basic unit of currency had a decimal basis. Before 1971 there were 12 pennies to the shilling, 20 shillings to the pound and therefore 240 pennies to the pound. In dealing with such there is no advantage of decimal fractions over vulgar. Haute vulgarisation is the expression of scientific ideas in a form suitable for comprehension by the untrained, and Feynman's assertion at face value seems to be saying that in the case of his work that is impossible. Haute vulgarisation has a chapter to itself later in the book.

Turning to the Feynman lectures, we first note that the entire set is now accessible online free of charge courtesy of Caltech [14]. In Volume 1 the most basic mathematical operations – addition, subtraction, multiplication and division – are discussed. In the US the term 'math' tends to be used instead of 'maths', and that is evident in this part of the Feynman lectures. A point of interest is that he gives as an example of elementary division:

$$b = c/a$$

There are of course two equally correct ways of saying this:

$$b = c \div a$$

$$b = \frac{c}{a}$$

The second of the two above would be unlikely to be used in an advanced scientific report, and it would require that the writer came out of Microsoft Word into Microsoft Equation Editor. The third is no better and no worse than that quoted from Feynman. When numerator and denominator both contain multiple quantities use of the horizontal symbol for division might, to the eyes of an inexperienced reader, have a clarity advantage over the oblique symbol especially when units are included. The present author knows this from student feedback he has received over the years.

A number of passages from the Feynman Lectures will be examined, starting with one from the part on properties of matter.

We shall also find that the subject [properties of matter] can be attacked from a non-atomic point of view, and that there are many inter-relationships of the properties of substances. For instance, when we compress something, it heats; if we heat it, it expands. There is a relationship between these two facts which can be deduced independently of the machinery underneath. This subject is called thermodynamics.

So Feynman, in common with Langmuir and Maxwell, likes to 'attack' a problem! The above paragraph is a very helpful explanation of the significance of the laws of thermodynamics. What Feynman is saying is that predictions about the behaviour of matter, including those obtainable from the gas laws, can be also deduced from thermodynamics without any invocation of atoms, molecules or whatever. As stated with some emphasis by Einstein (another Nobel Laureate) [15] this is both the strength and the appeal of the Laws of Thermodynamics, and Feynman expresses that well in the discourse quoted from. The 'machinery underneath' is the atomic and molecular behaviour, and he emphasises that the properties of a substance can from thermodynamics be 'attacked' – 'evaluated' possibly better – without any model for that.

In a part of his lectures concerning atoms, Feynman says:

Because atomic behaviour is so unlike ordinary experience, it is very difficult to get used to and it appears peculiar and mysterious to everyone, both to the novice and to the experienced physicist. Even the experts do not understand it the way they would like to, and it is perfectly reasonable that they should not, because all of direct, human experience and of human intuition applies to large objects. We know how large objects will act, but things on a small scale just do not act that way. So we have to learn about them in a sort of abstract or imaginative fashion and not by connection with our direct experience.

The most important features of the above are its candour and the obvious intention that it will engender confidence in students. It could perhaps be expressed more succinctly as:

The behaviour of particles of atomic size is often highly counterintuitive and in its interpretation comparisons with ordinary sized objects will not avail.

That however is a little clinical and lacks the warmth of the significantly longer statement by Feynman. For 'warmth' to be sensed is an important factor in reader acceptance. Another way of putting that is that a reader likes to feel assured that the writer's heart is in the right place.

In the section on atomic nuclei Feynman says:

> *What are the nuclei made of, and how are they held together? It is found that the nuclei are held together by enormous forces. When these are released, the energy released is tremendous compared with chemical energy, in the same ratio as the atomic bomb explosion is to a TNT explosion, because, of course, the atomic bomb has to do with changes inside the nucleus, while the explosion of TNT has to do with the changes of the electrons on the outside of the atoms.*

This is easily understood, and the comparison with TNT is helpful. 'Has to do with' though colloquial is often a good alternative to 'relates to'. A point of detail is that to 'release a force' is not a helpful expression. In the matter under discussion the force is *overcome* and (as correctly stated) it is energy which is 'released'.

The Nobel Prize for chemistry the year before Woodward got it, that is in 1964, went to England's Dorothy Hodgkin for her work on X-ray Crystallography. Plate 1.4 below shows Hodgkin in the company of Linus Pauling, who received the Nobel Prize in chemistry in 1954 and also won a Nobel Peace Prize.

Plate 1.4. Dorothy Hodgkin with Linus Pauling, December 1957. Image taken from [16].

The following is taken from an article published by Dorothy Hodgkin in 1971 entitled 'Insulin molecules: the exact extent of our knowledge':

> *It seems extraordinary to know as much about insulin as we now know – the whereabouts of all the atoms in the molecule in space – and still to know so little about what it actually does that makes it so important in our lives.*

As the concluding statement in a review containing some difficult concepts, this is easily understood by someone having no scientific knowledge beyond a rudimentary idea of what an atom is. In the biography of Dorothy Hodgkin by Georgina Ferry it is commented upon that in a publication with three collaborators, a contribution to a monograph on penicillin, Hodgkin 'departs from the usual style of scientific writing in adopting a more narrative approach'. Ferry quotes the following passage as an example:

Throughout the whole of the X-ray crystallographic investigation of penicillin we have been working in a state of much greater ignorance of the chemical nature of the compounds we have had to study than is common in X-ray analysis. We have, at all stages of our examination, tried to make any deduction we could of chemical interest, and we have seen some of these confirmed and others not. For the future application of X-ray measurements in this type of problem our errors as well as our successes have been of importance….

The accuracy achieved in the present analysis is, in fact, much better than could have been anticipated at the beginning of the investigation; and it seems quite likely that in the future, under improved experimental conditions, a higher degree of precision might be reached.

The above touches on a point of high importance, the fact that an error can and often does contribute positively to an ultimate success. An incorrect way of doing something can be a pointer towards a better way of doing it, or a flawed idea can be the precursor to a sound one. This is more a point of scientific reasoning than of scientific writing but the two cannot of course be strictly demarcated. (See also discussion of Isaac Asimov in Chapter 3.)

Pauling was, as noted, a recipient of two Nobel Prizes, that for chemistry and that for peace. His capability as a writer and his standing as a scholar were such that once he developed an interest in something he had no difficulty in writing a text on it. And so he gave the world his book 'Vitamin C and the Common Cold', published in 1970 and translated into nine languages. A scientific writer will often need to compose something in a subject area outside the area of his or her basic training, and Pauling's foray into medicine was in some degree an example of that. It has to be pointed out that Pauling's ideas on vitamin C (a.k.a. ascorbic acid) have not met with total acceptance by the medical community (e.g. [17]) but it is with the style of his writing that this chapter is concerned. The below is taken from Pauling's book.

The mechanism of its [*vitamin C*] *effectiveness against viral infection, such as a common cold, is not yet known. I have, however, formulated the hypothesis (which has not yet been tested by experiment) that the effectiveness of ascorbic acid in providing protection against viral diseases results from its function in the synthesis and activity of interferon in preventing the entry of virus particles into the cells. The discovery of interferon was reported in 1957 by Isaacs and Lindenmann. It is a protein that is produced by cells infected by a virus and that has the property of spreading to neighboring cells and changing them in such a way as to enable them to resist infection. In this way the interferon ameliorates the disease.*

We note the US spelling of 'neighbouring', and more importantly that Pauling states where he is coming from in two ways: by informing a reader that the role of vitamin C in curing the common cold is not understood and by adding that his own ideas had not at the time he wrote the book been examined experimentally. His introduction to the interferon is suitable for the non-specialist audience at which the book is directed. There is more on this book in the next chapter.

This chapter then has taken a carefully selected passages from the works of Nobel Laureates and gleaned points from them of general interest in scientific writing. An interested reader can find many more online and, perhaps, apply to them the analytical approach taken in this chapter to identify features of interest in the writing style and prose structure. A few Nobel Laureates feature in Chapter 6 when the use of figures of speech is considered.

References.

[1] https://archive.org/stream/scientificpaper01raylgoog#page/n36/mode/2up

[2] http://www.nobelprize.org/nobel_prizes/physics/laureates/1904/strutt-bio.html

[3] http://inhabitat.com/locals-safe-after-toxic-orange-gas-cloud-dissipates-over-northern-spain/

[4] http://grammarist.com/grammar/split-infinitives/

[5] http://www.nature.com/nature/index.html

[6] http://www.exploratorium.edu/origins/coldspring/printit.html

[7] https://www.google.com.au/search?q=irving+langmuir&biw=1820&bih=833&source=lnms&tbm=isch&sa=X&ei=Dn2gVcFBgrCYBa-VraAG&sqi=2&ved=0CAYQ_AUoAQ#imgrc=Ekv38EXdQxficM%3A

[8] http://media-2.web.britannica.com/eb-media/16/8716-004-14B4E051.jpg

[9] Benfey O.T., Morris P.J.T. 'Robert Burns Woodward: Architect and Artist in the World of Molecules' Chemical Heritage Foundation (2001).

[10] Sheahen T. 'Introduction to High-Temperature Superconductivity' Springer (2006).

[11] https://www.google.com.au/search?q=feynman+lectures+in+physics&biw=1820&bih=833&source=lnms&tbm=isch&sa=X&ei=s-yiVa6wIqfFmAWj-Jww&sqi=2&ved=0CAcQ_AUoAg&dpr=1#imgrc=QSA3QvUyGjyYbM%3A

[12] http://www.brainyquote.com/quotes/authors/r/richard_p_feynman.html

[13] http://www.goodreads.com/quotes/117534-physics-is-like-sex-sure-it-may-give-some-practical

[14] http://www.feynmanlectures.caltech.edu/I_toc.html

[15] http://physics.stackexchange.com/questions/91017/why-are-the-laws-of-thermodynamics-supreme-among-the-laws-of-nature

[16] http://profiles.nlm.nih.gov/ps/retrieve/ResourceMetadata/MMBBMM

[17] http://www.quackwatch.com/01QuackeryRelatedTopics/pauling.html

2 Logic in scientific writing

Some formal background in logic is necessary as a lead-in to this chapter, including clarification of the word 'fallacy'. Fallacies are classified as being formal or informal and the distinction is important in science no less than in other fields of intellectual endeavour. A formal fallacy is intrinsic, and cannot possibly lead to a correct conclusion, and in the category of formal fallacy is what philosophers refer to by the self-explanatory term 'unwarranted assumption'. As an example, imagine that an environmental lobbyist states that in a particular geographical region there were 1000 deaths from asthma or bronchitis during the previous year and argues from that that there is inadequate control of industrial emissions. If it is then shown from records that the number of such deaths was much lower – say 100 at the most – the argument of the lobbyist collapses and he or she has perpetrated a formal fallacy. Formal fallacies in science and technology can be more subtle than in the above example. If a scientific report contains statements or arguments clearly inconsistent with fundamentals, and/or mathematical errors, there again there has been formal fallacy but close peer review might be necessary for such a fallacy to be uncovered.

On the other hand, an informal fallacy is due not to inherent incorrectness but to inadequate premises and might, with better and more persuasive premises, be transformed to a correct conclusion. One such [1] is the 'argument from tradition' a.k.a. *argumentum ad antiquitatem*, the view that something having been accepted for a long time must for that reason be correct. This as a principle is not an error, but whether in a particular case it leads to a correct conclusion or an incorrect one depends on the strength of the premises. An incorrect conclusion from weak premises is called an informal fallacy. This and other genres of possible informal fallacies are listed in the table below (there are many more). Examples of each follow.

Argumentum ad antiquitatem.	Appeal to tradition (see above). Relevant to invocation of the standards bodies.
Argumentum ad novitatem.	Appeal to novelty. An example given below.
Argumentum ad populum.	Appeal to a popular belief.
Argumentum ad ignorantiam.	Appeal to lack of positive evidence. Examples given below.
Argumentum ad consequentiam.	Appeal to the consequences. An example given below.
Argumentum ad verecundiam.	Lit. Appeal to reverence. Appeal to authority better. See comments and example below.
Argumentum ab auctoritate.	'To argue that the authority of the person asserting is proof of the assertion's truth' [6].
Argumentum ad Wikipediam.	Reliance on Wikipedia.
Argumentum ad experientiam.	Argument from general (not particular) experience.

In science reporting there is heavy reliance on the standards bodies. These include ISO whose HQ is in Geneva, ASTM International (formerly American Society for Testing and Materials, HQ in Philadelphia) and Standards Australia (HQ in Sydney). These often prescribe methods for particular scientific procedures and tests and they also issue standards for terminology. The latter is especially important in scientific writing.

The standard ASTM E284 is entitled 'Standard Terminology of Appearance'. It was originally published in 1966 but has been revised more than once since and the current version dates from 2013. The image below of the first page shows the layout used of such documents as well as the presence of the ASTM logo in the top left-hand corner. The standard in its most up-to-date form is drawn on in a paper on automobile paint published in a major journal in 2014, in which the fact that the standard uses the term 'orange peel' to describe an irregular surface is mentioned. *Argumentum ad antiquitatem* is being used in two ways here. One is that forty years elapsed between the first issue of the standard and the most recent, and there were several revisions over that time. Much more importantly, simply use of the name of ASTM is an 'appeal to tradition': ASTM have been issuing standards since the late 1890s (the very first appertained to metal used in the manufacture of rails for locomotives). Examples of citations of documents issued by standards bodies in scientific writing are multitudinous, all of them to some degree an example of *argumentum ad antiquitatem*.

Plate 1.1. Layout of the first page of ASTM E284: Standard Terminology of Appearance. Image taken from [2].

Argumentum ad novitatem is in some degree the opposite of *argumentum ad antiquitatem*, having the meaning that something should be accepted because it is new. A hypothetical example will be given. In an account of clinical trials involving the measurement of sugar in the urine of a cohort of patients the statement is made:

Measurement of sugar levels used not Benedict's reagent but the more recently developed glucose oxidase method.

There is the clear implication that newer is preferable, though probably not to the extent of fallacy. The above sentence on urine sugar levels if rephrased:

Measurement of sugar levels was by the widely used glucose oxidase method

would have an element of *argumentum ad populum*, which features in the following row of the table.

A particular example of *argumentum ad antiquitatem* likely to lead to fallacy, to which the author has drawn attention previously [3], is the matter of flash points of organic substances. There are fire protection reference books published by major bodies having gone into several editions in which flash points for numerous organic compounds are unreliable. A writer quoting an incorrect flash point from such a book would, in citing the book, be applying *argumentum ad antiquitatem* with questionable 'premises' and an informal fallacy would be the result.

Turning to *argumentum ad ignorantiam*, the legal principle of 'innocent until (or unless) proven guilty' is of course an example of this as is the verdict 'not proven' as an alternative to 'guilty' or 'not guilty'. Translated 'argument from ignorance' *argumentum ad ignorantiam* does not mean 'ignorance' in any derogatory sense but more 'arguing from the current limited state of knowledge'. One example from the scientific realm is not only pertinent at the present time but also controversial: some antagonists in the global warming debate have expressed the view that such evidence as there is for global warming, including the melting of the polar ice cap, cannot be proven to be due to rises in the carbon dioxide level of the atmosphere [4]. Conversely those who accept global warming on the basis of its wide reporting, and invest in protection from it, are exercising *argumentum ad populum*. More generally, those reporting scientific findings use the principle of *argumentum ad ignorantiam*, probably without realising they are doing so, when in support of a point they write something like:

No counter example is known to the authors

and provided that there *is* no counter example an informal fallacy will not ensue. *Argumentum ad consequentiam* means invoking observation more than analysis. Again a hypothetical example will be used. Waste water after cleansing enters a river, and in an environmental account it is reported:

No reduction in the fish population of the river was recorded during monitoring over a two-year period.

This is arguing from observation rather than from an inspection and evaluation of the cleansing plant. To say that *argumentum ad consequentiam* used in this sense means the same as 'the proof of the pudding is in the eating' would not be wide of the mark, and many would be more comfortable with the latter expression. Moving on to *argumentum ad verecundiam*, this can mean blind or uninformed appeal to authority. An example is Linus Pauling's book 'Vitamin C and the Common Cold', quoted from in the previous chapter. Its sales were very strong because people thought that a book written by such an eminent personage must be correct. A picture of the cover to the book forms Plate 2.2 below.

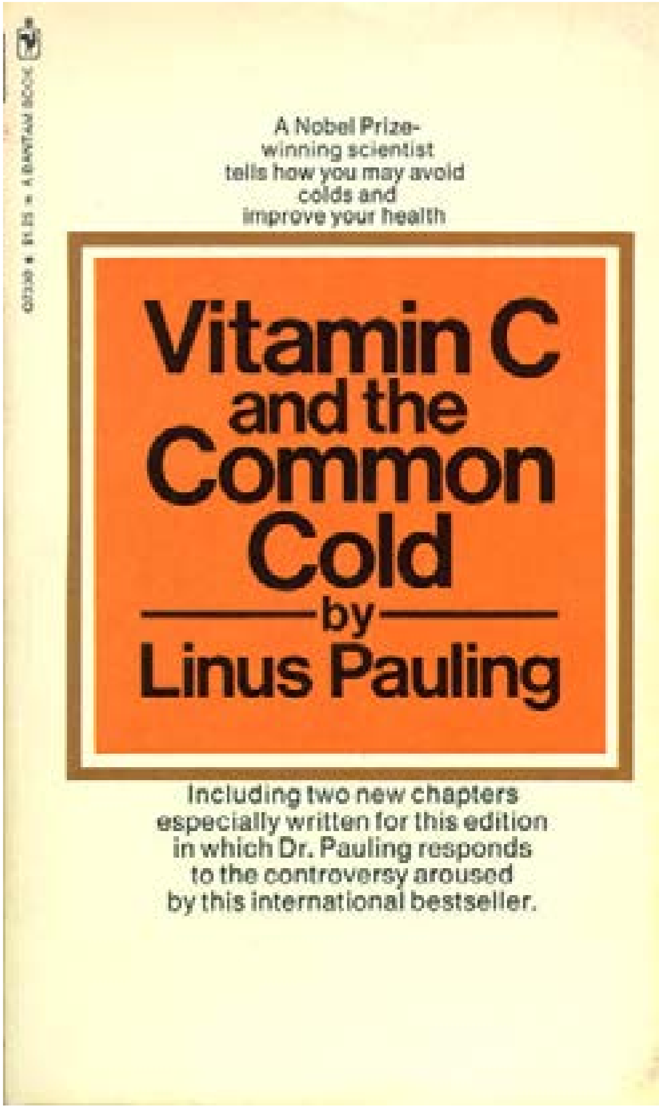


Plate 2.2. 'Vitamin C and the Common Cold' by Linus Pauling, an example of *argumentum ad verecundiam*. Image taken from [5].

An extremely common use of *argumentum ab auctoritate* is the term 'personal communication' in the references of a scientific publication. The citation will read 'X, Personal communication', so X's authority is being appealed to by the author, who has received unpublished information from X. Let it be noted that there have been difficulties with this, and some journals have required written permission from X for such a citation to be made.

There is an essence of *argumentum ab auctoritate* whenever an equation named after its originators is used. Simple examples are Boyle's law (Robert Boyle, 1627–1691) and Ohm's law (Georg Ohm, 1789–1854). That is even more so of scientists who have been immortalised in units, such as James Prescott Joule (1818–1889), who features at length later in the book. The Rayleigh (see previous chapter) is a unit in photometry. Michael Faraday (1791–1867), deservingly, scored twice in this regard: the Farad is a unit of electrical capacitance and the Faraday a unit in electrochemistry. (Faraday features in later parts of this book, as does Tesla after whom an electrical unit has been named.) And there are those whose names have been affixed to constants, such as the Boltzmann constant[2]. Perhaps the ultimate such accolade is the naming of a chemical element as in Lawrencium, symbol Lr, in honour of Ernest Lawrence (1901–1958). The naming of an element after Lise Meitner (1878–1968) is discussed in Chapter 5.

Moving to the next row of the table, an example of a mild form of *argumentum ab auctoritate* would be:

As a chemical kineticist I have reservations about the proposed reaction mechanism.

Here *argumentum ab auctoritate* leads to a correct conclusion provided that the grounds which the kineticist furnishes for the reservations – his or her 'premises' – are sound. If the premises are deemed after due consideration by other kineticists not to be sound there is an informal fallacy. If there is patent error of fact or of calculation there is descent into formal fallacy. So the whole gradation – an acceptable conclusion, an informal fallacy and a formal fallacy – can be extrapolated from this very simple example.

The next entry (which is slightly frivolous) *argumentum ad Wikipediam* obviously represents a fairly recently introduced term in a Latin guise. That is itself is not wrong. For example, those assigning names to newly discovered biological species frequently use a Latin idiom. The formal name of the Port Jackson shark, which inhabits waters of which Port Jackson in Sydney is a part, is *Heterodontus portusjacksoni*.

Argumentum ad experientiam might mean invocation of seniority, for example a science graduate of forty years' standing might for that reason be dismissive towards an idea expressed by someone having graduated much more recently. It can of course work in reverse: with an element of *argumentum ad novitatem* a younger scientist might, without having given them due thought, see the views of an older one as being dated. Either of these if not, in a particular instance, backed up by suitable premises is a source of informal fallacy.

Close attention to the principles outlined in this chapter is necessary in scientific writing. There is some conceptual overlap with the coverage of figures of speech in a later chapter.

References

[1] http://www.skepticalraptor.com/skepticalraptorblog.php/logical-fallacies/appeal-to-antiquity-or-tradition/

[2] https://www.google.com.au/search?q=ASTM+E284&biw=1820&bih=833&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMItKzc6o7cxgIVxmKmCh2zeA0S#imgrc=tO-VqEMlD5ds9M%3A

[3] Jones J.C. 'Hydrocarbon Process Safety: A Text for Students and Professionals' 2nd Edition Whittles Publishing, Caithness (2014).

[4] http://wattsupwiththat.com/2012/04/20/the-illogic-of-climate-hysteria/

[5] https://www.google.com.au/search?q=linus+pauling+vitamin+c+and+the+common+cold+book&biw=1820&bih=833&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMIhtLytZ7cxgIVpiGmCh2tPw01#imgrc=MN556lQd0-_PxM%3A

[6] http://www.escapistmagazine.com/forums/read/18.859644-Logical-Fallacies-and-You-How-to-be-properly-argumentative

3 Haute vulgarisation in Science

Music, drama and creative writing have been described in one of the most influential books of its kind of the 20th Century [1] as the 'garnered fruits of civilisation'. For these to be made widely accessible was the aim of their originators and is the duty of society. So it is with science, the appeal of which comes within the scope of the 'garnered fruits of civilisation'. As pointed out by A.R. Michaelis in an article in New Scientist in 1963, this was recognised as long ago as the 18th Century when a book on Newton's scientific discoveries, directed at a wide readership, was published by two French writers. Michael Faraday began his Christmas lectures for children at the Royal Institution in 1825. They continue to this day and are now broadcast. Michaelis, who uses the term 'haute vulgarisation' in his article, emphasises that those who first promoted it were scientists of the highest stature and acclaim, with the implication that haute vulgarisation is not an activity of the dilettante. 'Popularisation of science' properly understood should not be a derogatory term. A publication presenting scientific theories and developments in a way comprehensible to a general readership is sometimes called a vulgarising book. Of course, where science influences policy, as in innumerable ways it does, there is a need for popularisation to be held in balance with the need for the informed judgement of the trained expert.

In [2] it is stated, with reference to the Paris Academy of Sciences:

Unlike the Academy, which never had teaching or haute vulgarisation as one of its roles, most of the voluntary organisations were engaged in educational ventures from which they received both membership and financial backing.

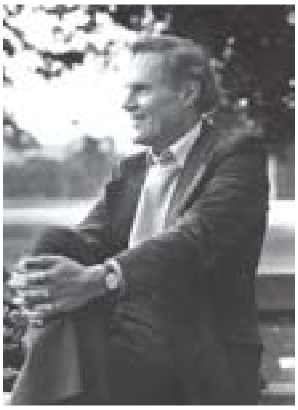
The voluntary organisations referred to were also termed *societes libre* and it is noted in [2] that they saw 'propagation' of science rather than its 'advancement' as their aim. This was at a period when, for example, Antoine-Laurent de Lavoisier was living in France and conducting his researches there. He was himself an elected Fellow of the Paris Academy of Sciences.

At that time haute vulgarisation was seen as being synonymous with pedagogy. By 1825 when the Christmas lectures came into being it was seen at least by some as scientific discourse directed at an audience who are not experts in the subject and are not aspiring to become experts. The periodical 'Scientific American' came into existence in 1845. In a very recent publication [3] this is identified expressly as being a medium for haute vulgarization. An important point to remember is that in haute vulgarisation as in any form of writing or literature, standards can be high or low. *Bibliotheque des sciences contemporaines*, published in France in the late 19th and early 20th Centuries is described [4] as containing 'excellent works in the haute vulgarisation of science'. Moving from France (which has featured twice in this chapter) to 19th/early 20th century Russia, reference [5] has this to say:

The very nature of its content made mathematics a comparatively secluded academic occupation; as a result mathematicians [in Russia during the period of interest] had very little to do with the growing haute vulgarisation of scientific thought and with the various public exhibitions.

Details of some noted popularisers of science are given in the table below, which is followed by comments.

Lancelot Hogben (1895–1975).  Image taken from [6].	Zoologist. Medical statistician. Fellow of the Royal Society (FRS). Two 'vulgarising books': 'Mathematics for the Million' (George Allen and Unwin, 1936) 'Science for the Citizen' (George Allen and Unwin, 1938) [8].
Louis Figuier (1819–1894).  Image taken from Wikipedia.	Trained in medicine. Expert in chemistry and physics. Publications include an annual volume of scientific advances from the previous year. Described in [10] as a 'master of haute vulgarisation'.

Peter Mason (1922–1987).  Image taken from [11].	Physicist. Books include: Genesis to Jupiter (Australian Broadcasting Commission, 1978). The Light Fantastic (Penguin Books, 1981). Blood and Iron (Penguin Books, 1984). Half Your Luck (Penguin Books, 1986, with B. Petty.)
Mary Somerville (1780–1872).  Image taken from [12].	Publications include: 'Mechanism of the Heavens' (1831), a translation of Laplace's 'Celestial Mechanics'. 'The Connection of the Physical Sciences' (1834). 'Physical Geography' (1848). 'On Molecular and Microscopic Science' (1869). Portrait courtesy Sommerville College, Oxford.
Julius Sumner Miller (1909–1987).  Image taken from [15].	Physicist. Books include: 'Quiz Questions in Physics' Horwitz-Martin, Australia (1967). 'Physics Fun and Demonstrations' Central Scientific Company (1968). 'Enchanting Questions for Enquiring Minds' Currey-O'Neil, Australia (1982). See also citations in the main text.

Edward Livingston Youmans (1821–1887).  Image from [18].	Founder in 1872 of 'Popular Science Monthly' (see Plate 3.1). His sister Eliza Ann Youmans (1826–1914) an assistant and collaborator. On his death succeeded as editor of 'Popular Science Monthly' by his brother William Jay Youmans (1838–1901).
Magnus Pyke (1908–1992).  Image taken from [21].	Broadcaster. Books include: 'About Chemistry' (Oliver and Boyd, 1959). 'Boundaries of Science' (Harrap, 1961). 'Nothing Like Science' (John Murray, 1957). 'The Science Century' (Walker and Co., 1967). Portrait courtesy A. Lee.
Lucy Hawking (1970–).  Pictured above with her father Stephen Hawking. Image taken from Wikipedia.	A trained linguist. A novelist and journlaist. Recipient of the 2008 Sapio Prize for Popularizing Science.

Isaac Asimov (1920–1992).  Image taken from [22].	Professor of Biochemistry at Boston University. Science fiction author. Popular science works include: 'Life and Energy' (Avon Books, 1962). 'The Intelligent Man's Guide to Science' (Basic Books, 1960). 'Understanding Physics' 3 volumes (Barnes and Noble, 1966). Many more!
William Whewell (1794–1866).  Image taken from [25].	Mathematician and philosopher. Works include: 'History of the Inductive Sciences' (1837) 'The Philosophy of the Inductive Sciences, Founded Upon Their History' (1840). An almost exact contemporary of Michael Faraday (1791–1867), with whom he held discussions. Portrait courtesy J. van Wyhe.

A review of 'Mathematics for the Millions' [7] published a few months after the book itself describes it as an attempt to 'popularise mathematical knowledge', the exact antithesis of attitude of the Russian mathematicians in the italicised statement above. In the introductory 'Author's confessions' to 'Science for the Citizen' Hogben states:

In the Victorian age big men of science like Faraday, T.H. Huxley, and Tyndall did not think it beneath their dignity to write about simple truths with the conviction that they could instruct their audiences.

That this was so of Faraday we have already seen in discussion of his Christmas lectures. John Tyndall FRS succeeded Faraday as Superintendent of the Royal Institution. Thomas Henry Huxley FRS gave lectures to 'working men', many of which were published [9]. By contrast Louis Figuier (following row) devoted his life to writing, in a highly productive and effective way. That Peter Mason (third row) had both broad interests and an informed social conscience is evidenced by his having once, in mid career, been a candidate for the Australian Parliament. His award-winning book 'Blood and Iron' is about the application of science to weaponry.

Mary Sommerville (nee Fairfax) was an outstandingly good writer and synthesist of information[3]. It is fairly clear from something she wrote in the preface to 'The Connection of the Physical Sciences' that she had a grasp of all of the developments by the time she wrote it in the scientifically heady days of the 1830s and knew what to expect by way of further developments. She wrote [13]:

The progress of modern science, especially in the last few years, has been remarkable for a tendency to simplify the laws of nature, and to unite detached branches by general principles…. As that of light and heat, such analogies have been pointed out as to justify the expectation that they will ultimately be referred to the same agent.

The 'same agent', which 'united' the 'detached branches' of heat and light was of course thermal radiation, the principles of which were formulated in the late 1870s.

In writing, disciplined imagination is important especially when, as is so often the case, knowledge comes from books (or in these times from the internet) and not from first-hand experience. There is a well-known anecdote – the author is unaware of its correctness – about a professor of Egyptology who had never been to Egypt. That the same is true is some of Somerville's writings is pointed out in a biography of her [14]. In her book 'Physical Geography' she says, with reference to the flora of the USA:

The autumnal tints of the forests of the middle States are beautiful and of endless variety; the dark leaves of the evergreen pine, the red foliage of the maple, the yellow beach, the scarlet oak, and purple Nyasa, with all their intermediate tints, ever changing with the light and distance, produce an effect at sunset that would astonish the natives of a country with a more sober-coloured fauna under a more cloudy sky.

As pointed out in [14], Somerville never went to the USA. (Her husband Dr. William Somerville, an army surgeon who had served in Canada, might well have done.) In her 'Physical Geography' book she gives equally vivid and picturesque accounts of many other geographical locations including the Amazon jungle. Was Somerville's work really 'haute vulgarisation'? It was probably in that spirit that she took on her translation of Laplace's work. Her later work in geography is much less dependent, if at all, on earlier sources.

Much more obviously in the category of haute vulgarisation is the work of Julius Sumner Miller (following row) whose endeavours were directed primarily at the young. He probably did not enhance his scientific reputation when he did a TV advertisement for Cadbury's chocolate in which a principle of elementary physics was invoked in a rather meaningless way. Sumner Miller's style was to pose the question 'Why is it so?' and in each case to furnish an answer (e.g. [16]). The questions he referred to as 'Millergrams'. Some quotes attributed to him reveal his attitude towards communicating science. For example [17]:

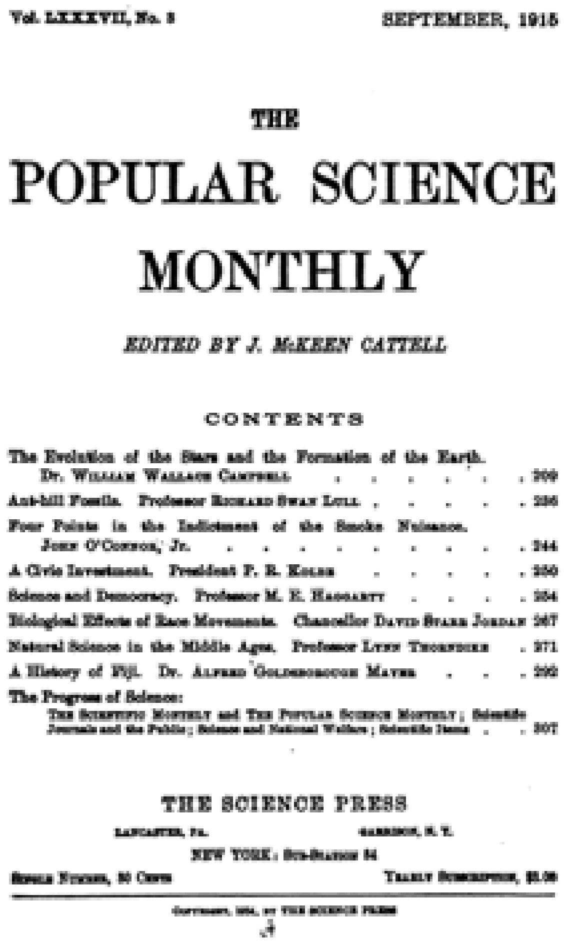
My view is this: We teach nothing. We do not teach physics nor do we teach students. (I take physics merely as an example.) What is the same thing: No one is taught anything! Here lies the folly of this business. We try to teach somebody nothing. This is a sorry endeavour for no one can be taught a thing. What we do, if we are successful, is to stir interest in the matter at hand, awaken enthusiasm for it, arouse a curiosity, kindle a feeling, fire up the imagination. To my own teachers who handled me in this way, I owe a great and lasting debt.

Most of this is fairly unexceptionable, especially if addressed to a young audience. Someone longer in the tooth might perceive superficiality, and in particular point out that enthusiasm sooner or later has to be followed by a sense of duty and commitment and that 'teaching' is fostering this as well as imparting knowledge. A student having been initiated into a subject will need to perceive that a disciplined approach to study is more important than any initial experience of enthusiasm. Multitudes would say from experience that enthusiasm becomes deeper and more satisfying with discipline, though it is not the intention of the present author to philosophise on that. It perhaps needs to be repeated that Sumner Miller's approach expressed in his statement above is directed at youngsters. Another of his utterances, featuring in his posthumously published autobiography, is:

My first TV series on demonstrations in physics – titled 'Why Is It So?' – were now seen and heard over the land. The mail was massive. The academics were a special triumph for me. They charged me with being superficial and trivial. If I had done what they wanted my programs would be as dull as their classes! I knew my purpose well and clear: to show how Nature behaves without cluttering its beauty with abtruse mathematics. Why cloud the charm of a Chladni plate with a Bessel function?

That has a confrontational style and, being in his autobiography as noted, was not directed at children. On his derogatory reference to mathematics just one comment will be made. Anyone who is a regular referee of journal articles in the physical sciences becomes aware that, in these times, wide availability of mathematical software tends to lead to graphs, charts and the like which, though having considerable eye appeal, do not relate at all clearly to the theme of the publication of which they supposed to be a part. This was less so in Sumner Miller's lifetime. It is surprising that he singles out Bessel functions for dishonourable mention, as these are not at all difficult to understand and to apply in routine calculations, for example on the conduction of heat.

'Popular Science Monthly' (next row) is still in production, 143 years after its creation in New York. In its early years it owed much to the Youmans family. Plate 3.1 shows the September 1915 issue. An obituary of Edward Livingston Youmans was published in the May 1890 issue of the monthly which he had created. In it clues are provided to his capability and influence. Like Henry Ford, whose life span overlapped with that of Youmans, he spent his formative years on a farm and lamented that so much farm work was done by hand which could, if the laws of physics were suitably applied, have been done with


Vol. LXXXVII, No. 3 SEPTEMBER, 1915

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MONTHLY

EDITED BY J. McKEEN CATTELL

CONTENTS

THE SCIENCE PRESS
LANCASTER, PA. GARRISON, N. Y.
NEW YORK: Sub-Station 84
Single Number, 30 Cents Yearly Subscription, $3.00

Plate 3.1. Contents page for Popular Science Monthly, September 1915 issue. Image taken from [19].

machinery. At the time Youmans was entering manhood eyesight difficulties diverted him from a career in law to one in writing for newspapers, with scientific study in his spare time. He prepared digests of scientific books of the time as newspaper articles, making him one of the earliest newspaper scientific correspondents. In 1851 he published his 'Class-Book of Chemistry', which went into several editions one of which (that from 1863) is, at the time of writing this book, accessible online [20]. The book is beautifully structured, having thirty chapters across the four parts of the book in a single volume. Someone scanning it is left with the impression that Youmans must have had as good a grasp of the subject across its several divisions as anyone alive at the time. His work was that of a communicator: the eyesight difficulties referred to earlier precluded his being an experimentalist. As with Margaret Somerville, the term haute vulgarisation possibly needs qualifying by a statement that Youmans' knowledge and insights were truly profound.

Magnus Pyke (following row) was in the tradition of Julius Sumner Miller and is remembered for his flamboyance in broadcasting. His more serious thinking is to be found in his books, and there is a point of contact in one of them with the views attributed above to Edward Livingston Youmans and Henry Ford that machinery would replace manual labour as a result of judicious application of science. In 'The Science Century', Pyke has this to say:

Instead of one seamstress making a shirt a number of women, each equipped with a sewing machine, made a part of the shirt and another woman assembled the various portions into the final finished garment….

The significance of the division of labour which justified the respect paid to it by nineteenth-century manufacturers was that it represented the beginnings of the application of scientific thinking to the organisation of industry….

The final development of this phase of science-stimulated factory management was introduced by Henry Ford in 1914….

and the final statement above refers to the first assembly line in car manufacture. Previously Ford and other manufacturers had produced cars one at a time in a 'static' workshop.

The endeavours at popularising science by Lucy Hawking (following row) have been directed at children. Isaac Asimov is a very well-known name in science, and his popular books are many. Earlier in this book it was stated that 'an incorrect way of doing something can be a pointer towards a better way of doing it, or a flawed idea can be the precursor to a sound one'. This is entirely equivalent to the below, attributed [23] to Asimov:

A subtle thought that is in error may yet give rise to fruitful inquiry that can establish truths of great value

though this view does not of course originate with him. A review of Asimov's 'Intelligent Man's Guide to Science' in the New York Times for 13th November 1960 [24] starts off by saying:

Some specialists in the humanities may shudder at the prospect, but it will not be long before ignorance of things scientific becomes as revealing a mark of cultural illiteracy as ignorance in Latin and Greek or nineteenth-century poetry was in times past. A decade or so ago, when the importance of communicating with the general public was not widely appreciated, scientists rarely bothered to prepare popular descriptions of their work. Today the situation has changed noticeably. In response to an increasing demand for more and better science education, many active investigators are making their first efforts to explain laboratory findings in terms that students and laymen can understand.

The reviewer J. Pfeiffer was himself a science writer. That the second sentence of his review is open to question is clear to anyone having read this chapter thus far. What he might have been getting at is that 'a decade or so ago', that is, between about 1945 and 1950, television was nowhere near as prevalent as it was later to become. (It is widely held that the Nixon-Kennedy contest of 1960 was the first US presidential campaign to have been 'fought on television'.) Pfeiffer's throwaway remark that 'scientists rarely bothered to prepare popular descriptions of their work' is also open to criticism: one need only think of the Christmas lectures at the Royal Institution described above. Is he on more solid ground with his contrast with the classics? At the time he wrote that the public were starting to be exposed to scientific terminology such as 'unsaturates' when shopping for food. They were being introduced to the term 'octane rating' when filling with gasoline. They were being informed about enzymes when watching ads for washing powder. Earlier they were exposed to 'classics' in their day-to-day lives, not least in church attendance with such things as the Nunc Dimittis and the Agnus Dei. And one's high school would have a motto in Latin such as 'Fides et Labore'. These perspectives, succession of the classical culture by the scientific, have been missed by Pfeiffer in his comments on Asimov's work.

Moving on to the following row, William Whewell's activity would have been about concurrent with that of Margaret Somerville. An important difference is that Whewell was rooted in his work by a post at Cambridge whereas Somerville worked outside formal structures, a reality imposed by the social conditions and conventions of her day. Edward Livingston Youmans, himself something of an outsider, also belongs to this period. Whewell is credited with having coined the word 'scientist' in the 1830s as a result of his involvement with the British Association for the Advancement of Science of which Charles Darwin was, at that time, secretary [26]. So to classify Whewell as being amongst other things a promoter of haute vulgarisation of science is altogether justifiable. One of the numerous words of wisdom in his 'Philosophy of the Inductive Sciences' is an assertion that a very early example of applied science was in astronomy: men and women 'applied' it to the concept of the calendar. Whewell expresses it thus:

A practical knowledge of astronomy such as enables them to reckon months and years is found among all nations [in recorded history] except the mere savages.

Ten examples of popular writers, ranging from several who reached the peak of their influence in the mid 19th Century to one who is in the prime of life at the present time, have been discussed and their work commented upon. The contemporary scientific writer can obviously benefit from study of their work and that of others like them.

References

[1] Huddleston T. 'Naught for your Comfort' Collins, London (1956).

[2] Hahn R. 'The Anatomy of a Scientific Institution: The Paris Academy of Sciences, 1666–1803' University of California Press (1971).

[3] McShane P. 'The Everlasting Joy of Being Human' Axial Publishing (2013).

[4] Paul H.W. 'From Knowledge to Power: The Rise of the Science Empire in France, 1860–1939' Cambridge University Press (2003).

[5] Vucinich A. 'Science in Russian Culture, 1861–1917' Stanford University Press (1970).

[6] https://www.google.com.au/search?q=lancelot+hogben&biw=1820&bih=784&source=lnms&tbm=isch&sa=X&sqi=2&ved=0CAYQ_AUoAWoVChMIyr6M86HhxgIVZ5SmCh1RjA3g#imgrc=B5ALM9h0oK11eM%3A

[7] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2985699/?page=1

[8] https://archive.org/stream/scienceforthecit032798mbp/scienceforthecit032798mbp_djvu.txt

[9] http://aleph0.clarku.edu/huxley/letters/65.html

[10] Cohen I.B. 'Revolution in Science' Harvard University Press (1985).

[11] http://www.asap.unimelb.edu.au/pubs/reports/1996/ar96_8a.htm

[12] http://www.nature.com/nature/journal/v432/n7017/full/432553a.html

[13] http://www.jstor.org/stable/213560?seq=4#page_scan_tab_contents

[14] Neeley K.A. 'Mary Somerville: Science, Illumination, and the Female Mind' Cambridge University Press (2001).

[15] https://www.google.com.au/search?q=julius+sumner+miller&biw=1820&bih=784&source=lnms&tbm=isch&sa=X&sqi=2&ved=0CAcQ_AUoAmoVChMI89L6wNrjxgIVxN-mCh10dgDb#imgrc=hSwqG-Wh_dO2RM%3A

[16] Sumner Miller J. 'Why It Is So?' ABC Books (1971).

[17] Sumner Miller J. 'What Science Teaching Needs' Junior College Journal, **38** (1967).

[18] https://www.google.com.au/search?q=edward+livingston+youmans&biw=1820&bih=784&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMI9JGyqKHmxgIVJS2mCh3nAQm1#imgrc=w2xPvtJMBlhZxM%3A

[19] https://commons.wikimedia.org/wiki/File:Popular_Science_Monthly_Sep_1915_cover.png

[20] https://archive.org/details/classbookofch00youm

[21] https://www.google.com.au/search?q=magnus+pyke&biw=1820&bih=784&source=lnms&tbm=isch&sa=X&sqi=2&ved=0CAYQ_AUoAWoVChMInYLUgKDoxgIVZZ6mCh37fA_Y&dpr=1#imgrc=pzbG7vBGHeqNdM%3A

[22] https://www.google.com.au/search?q=isaac+asimov&biw=1820&bih=784&source=lnms&tbm=isch&sa=X&sqi=2&ved=0CAYQ_AUoAWoVChMIyquugMPoxgIVAh2mCh3T2QOa#imgdii=q1Z3KCEdxq46zM%3A%3Bq1Z3KCEdxq46zM%3A%3BvH72LR2rerwsRM%3A&imgrc=q1Z3KCEdxq46zM%3A

[23] http://www.brainyquote.com/quotes/authors/i/isaac_asimov.html#FDwZdljG8F0sfGtQ.99

[24] https://www.nytimes.com/books/97/03/23/lifetimes/asi-r-guide.html

[25] https://www.google.com.au/search?q=william+whewell&biw=1820&bih=784&source=lnms&tbm=isch&sa=X&sqi=2&ved=0CAYQ_AUoAWoVChMIo-Pns9_oxgIVwi-mCh1tqgOe&dpr=1#imgrc=_Qpx11D289cu_M%3A

[26] http://www.encyclopedia.com/topic/William_Whewell.aspx

4 Origins of selected scientific words

The word 'science' itself was coined in the 14th Century [1]. There is a view that accurate use of a specialised word needs knowledge of its origin and etymology. In the table below frequently used words in physics are given and their origins discussed. This will be followed by tables for words in chemistry and in the biological sciences. Each table is followed by comments.

Physics

Temperature.	In the sense of 'degree of hotness', used by Galileo (1564–1642), by Robert Boyle (1627–1691) and by Robert Hooke (1635–1703).
Gravity.	Latin Gravitas, 'heavy'. [4]
Velocity.	Used in the English language since the early 15th Century. From Latin *velocitatem*, 'swiftness' or 'speed' [5].
Acceleration.	Entered the English language in the 16th Century. From Latin *accelerationem*, 'hasten' [8]. See also comments in the main text.
Dense.	Latin *densus*, 'thick, crowded, cloudy' [10].
Electricity.	Neo-Latin electricus, 'amber'. 'Electricity' first coined in 'Pseudodoxia Epidemica' by Sir Thomas Browne in 1646.
Mass.	Latin *massa*, 'kneaded dough, lump, that which adheres together like dough' [13].
Inertia.	Latin *inertia* 'unskillfulness, idleness' [14]. Used in the scientific sense by Johannes Kepler (1571–1630).
Radiation.	Latin *radiare* 'to beam, shine, gleam, make beaming' [16]. Scientific meaning from the mid 16th Century.
Spectrum.	Latin *spectrum* 'an appearance, image, apparition' [17]. Term in its scientific sense originates with Newton.
Convection.	Latin root, connected with 'convey'. Entered the English language in the 1620s. 'Convection current' in recorded use since 1868.

A student of physics having a bent for word usage and origin will expect that 'temperature' is linked to 'time' in such manifestations as 'temporal', and that the apparently satisfactory expression 'temporal dependence of the temperature' (meaning the temperature fluctuations at a particular site) will if taken at face value be meaningless. We are informed [2, 3] that there is no link between 'temperature' and 'temporal', but that 'temperature' *is* linked with the verb to 'temper'. Use of 'gravitas' in the non-scientific sense ('He made the utterance with such gravitas') is believed to have preceded its use to mean 'physically heavy', the first written example of which is dated 1692. The adjectival form does not extend to both: one would apply the word 'grave' to a very serious situation but not to a heavy object.

Isaac Newton's Philosophiæ Naturalis Principia Mathematica (often simply referred to as the *Principia*) was published in 1687 in Latin. Plate 4.1 shows the title page of the original text. An example of use of the term velocitatem in the *Principia* is the following, from Book 1:

*Sed & eodem argumento æque contendi posset nullam esse corporis ad certum locum pergentis **velocitatem** ultimam*

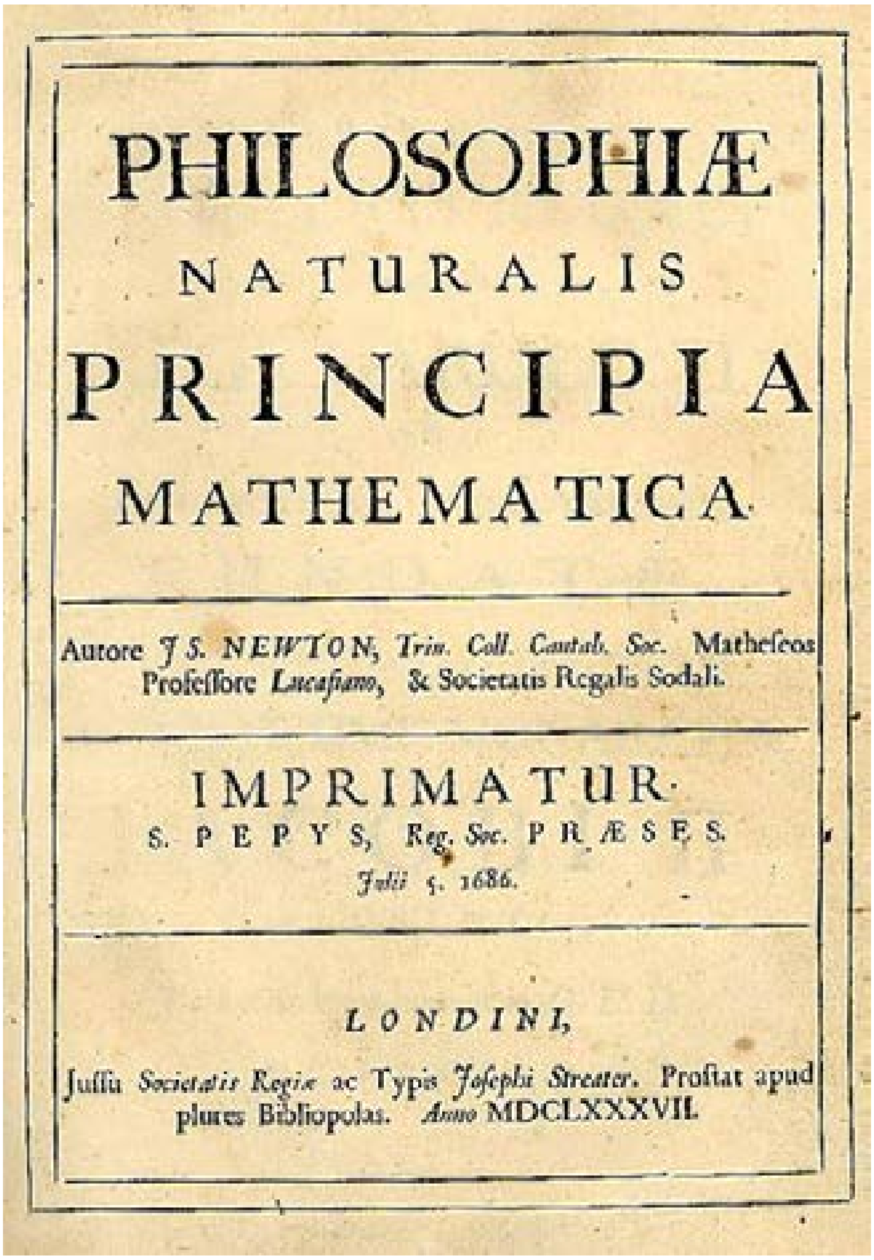
(present author's emphasis) which translates to [7]:

But by the same argument it may be alleged, that a body arriving at a certain place, and there stopping, has no ultimate velocity.

Moving on to 'acceleration', although this word appears in all recent forms of Newton's Second Law of Motion and is central to an understanding of it, it does not appear in the original expression of the Law in the *Principia* which reads [9]:

*Mutationem motus proportionalem esse **vi motrici impressae**, et fieri secundum lineam rectam qua vis illa imprimatur.*

The term emboldened translates to 'the motive force impressed' which is taken to mean the same as 'acceleration'. Moving on to 'density', by Isaac Newton's time this was used synonymously with 'specific gravity' [11]. Coining of the word 'electricity' was with reference to electrostatics, not electrical current. The usage referred to in 'Pseudodoxia Epidemica', the first time the word 'electricity' appeared in print, was [12]:


PHILOSOPHIÆ

NATURALIS

PRINCIPIA

MATHEMATICA

Autore J S. NEWTON, *Trin. Coll. Cantab. Soc.* Matheſeos Profeſſore *Lucaſiano*, & Societatis Regalis Sodali.

IMPRIMATUR.

S. PEPYS, *Reg. Soc.* PRÆSES.

Julii 5. 1686.

LONDINI,

Juſſu *Societatis Regiæ* ac Typis *Joſephi Streater.* Proſtat apud plures Bibliopolas. *Anno* MDCLXXXVII.

Plate 4.1. Title page of Newton's *Principia*. Image taken from [6].

'Crystall will calefie unto electricity; that is, a power to attract strawes and light bodies, and convert the needle freely placed'.

The spellings of 'crystal' and of 'straw' in the above are as in the original. It was written during the Stuart period at a time when Tudor English, the medium of William Shakespeare, was still prevalent. It is seen as the period when the English language was at its finest, its hey-day.

The Latin root of 'mass' is colourful. Newton used the word in its Latin form in his *Principia*, and it consequently entered English scientific vocabulary (1704 is sometimes given as the date for this). 'Inertia' is used in the *Principia* [15]: its earlier use by Kepler in astronomy is noted in the table.

In moving on to 'Radiation' we first note that it is linked to 'radius' and that that term did not have its meaning in geometry until the 1610s. It was Newton who split visible light into its constituent colours by means of a prism in work predating his *Principia*. Scientific usage of the word 'radiation' began in the previous century, possibly through the influence of Nicolaus Copernicus (1473–1543). The present author's conjecture would be that the term 'convection current' originated with Joseph Fourier (1768–1830).

The examples in the table have hopefully given the reader a grasp of the importance of Latin in scientific etymology and also of the influence of the investigators. A particular web site has been drawn on in several of the references and this a reader can go to for such investigations of his/her own. A table on chemistry follows.

Chemistry

Molecule.	Latin root, meaning 'extremely minute particle' [18]. Scientific usage from 1810, originated by A. Avogadro (1776–1856).
Pressure.	14th Century, 'suffering, anguish; act or fact of pressing on the mind or heart'. Scientific meaning since the 1650s. 'Pressurise' since the 1880s. [19].
Vacuum.	First usage in the English language in 1650 (in the period of Tudor English) in a philosophical treatise, not a scientific one.
Catalyst.	Term coined, with its current meaning, in 1835 by Jöns Jakob Berzelius (1779–1848) [21]. A loose link with 'analyst'.
Alkali.	Arabic root, used in the scientific sense since 1813 [22].
Litmus.	Probably related to 'lichen' [23].
Vapour.	In English usage since 14th Century with reference to water. French root [24].
Chromatography.	Term coined in circa 1903 by Mikhail Semyonovich Tsvet [25]. See also comments in the main text.
Ion.	Term originates with Michael Faraday (1791–1867).
Pipette.	'Pip[e]-*ette*', a small pipe.
Gel.	Coined in the mid nineteenth century by Thomas Graham (1805–1869). From Latin *gelu*, 'chill'.
Enthalpy.	Term coined by Heike Kamerlingh Onnes (1853–1926) [26].

The term 'molecular sciences' has become a synonym for 'chemistry'; certainly the two are often used interchangeably. There has been a tendency for chemistry departments in universities to become schools of molecular science, divided into departments of chemistry, biochemistry and so on. One example amongst many is Latrobe University in Melbourne. Fairly obviously 'pressure' as a scientific term originates with Evangelista Torricelli (1608–1647) who invented the mercury barometer [20]. It is noted in the table that 'vacuum' originally meant 'emptiness' or 'absence of anything'. It received its scientific meaning from Torricelli. Berzelius (following row) is also credited with originating the term 'protein' although it was not until much later, when knowledge of organic chemistry had advanced, that the term acquired the precise meaning it now has. He also, in 1833, coined 'polymer'. In noting that 'alkali' has an Arabic root, it has to be remembered that a word often has more than one origin and that these influence each other over the course of the centuries. There is also Latin input to the word 'alkali'. The concept of 'base' in chemistry, a related term to 'alkali', began with the French chemist Guillaume François Rouelle (1703–1770), who introduced the term in 1754. Litmus, the best known acid-base indicator, is made from dyes extracted from lichens hence the name, as explained in the table.

With reference to 'chromatography', the originator of the term put together *chroma* (colour) and *graphein* (writing or drawing) [25]. In his introduction of the term 'ion' Faraday was influenced by William Whewell. That the two men were contemporary and shared ideas is noted in a previous chapter. The root of 'pipette' (following row) is fairly clear, that of the term burette, a complementary piece of equipment, a little less so. 'Burette' is derived from the French 'buire' meaning 'vase'. The term enthalpy (final row) has a broadly Greek basis ('warm in').

So as with the table for selected words in physics, that for words in chemistry draws on linguistic and biographical details. The aim of both (and of that on biological terms which follows) is to encourage a reader to expand the list to terms of particular interest to him or her.

Biology

Cell.	Term in its biological sense coined by Robert Hooke (see above).
Cellulose.	Cellulose as a carbohydrate first isolated by Anselme Payen (1795–1878) who assigned it that name.
Enzyme.	Term coined (as 'enzym') by Wilhelm Kühne (1837–1900) [28].
Muscle.	Linked to 'mouse' [29].
Metabolism.	Term coined by Theodor Schwann (1810–1882) [30].
Species.	The term given its biological meaning by John Ray in 1586 [31]. See also comments in the main text.
Bacteria.	Term coined in 1838 by Christian Gottfried Ehrenberg (1795–1876) [32].
Spore.	Greek σπορά, 'seed'.
Gamete.	Term coined in 1878 by Eduard Strasburger (1844–1912) [33].
Gene.	Term coined in 1909 by Wilhelm Ludvig Johannsen (1857–1927) [34].

Insulin.	Coined in the early 20th Century. From the Latin *insula*, 'island'.

It was after examining tree bark with a microscope of his own devising that Hooke coined the term 'cell' in its biological sense. In Plate 4.2 below is an illustration he published in 1665 of the cellular structure of plants.

'Enzyme' is derived from Latin *zume*, 'leaven' so enzyme strictly means 'in leaven'. The muscle-mouse identity arises from the fact that the movement of a bicep muscle was likened to that of a mouse.

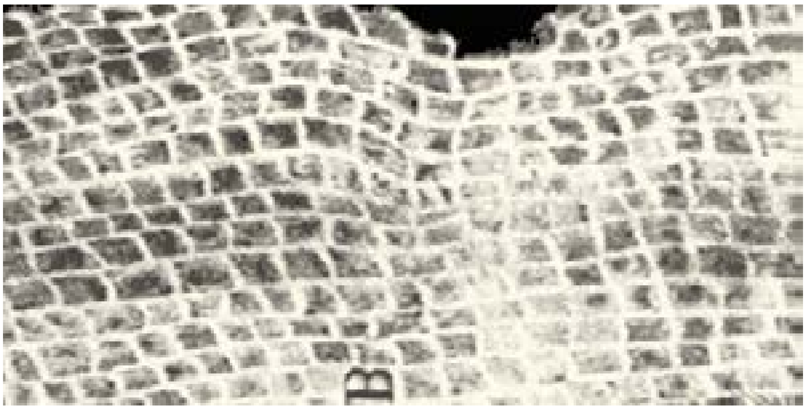


Plate 4.2. Drawing of plant cells published by Robert Hooke in 1665. Image taken from [27].

In coining 'metabolism', Schwann drew on Greek *metabole*, 'change', the meaning being chemical change. In his 'species concept' (a.k.a. the 'species problem') John Ray (next row) defined a species as:

a set of individuals who give rise through reproduction to new individuals similar to themselves

a definition from which no-one would dissent today. As stated in [31] it is reproductive continuity which characterises a species. Ray's terminology was to be used by Charles Darwin ('Origin of Species'), also a point noted in [31]. It was because of the rod-like shapes of the bacteria which he viewed under a microscope that Christian Gottfried Ehrenberg applied to them the Greek word βακτήριον meaning 'small staff'. In introducing the word gamete, Eduard Strasburger was using the Greek *gamein*, to marry. The origin of 'insulin' is a little puzzling at first consideration. It arises from the fact that insulin is secreted by the parts of the pancreas known as the islets of Langerhans. An islet is of course a small island, and anatomical use though basically figurative is now established nomenclature and means tissue distinct from nearby tissue [34].

A small representative selection of words in physics, chemistry and biology has been given. That there is overlap is obvious even on this scale, for example 'pressure' could equally well have been in the physics table and 'enzyme' in the chemistry one.

It often comes as a surprise that terms very much in the vocabulary of science and technology in the 21st Century originate long outside living memory. Moreover, the term 'software' was coined in its sense in computing by John Wilder Tukey (1915–2000) [35][4] in 1952. That is only within the 'memory' of the very elderly! Similarly the expression 'word processing' in the form in which it is now understood – an electronic means of composing and typing – can be traced back to 1964 [37].

References

[1] http://www.etymonline.com/index.php?term=science

[2] http://www.etymonline.com/index.php?term=temperature

[3] http://www.english-for-students.com/tempor.html

[4] http://english.stackexchange.com/questions/48469/which-usage-of-the-word-gravity-came-first

[5] http://www.etymonline.com/index.php?term=velocity

[6] http://www.library.usyd.edu.au/libraries/rare/modernity/newton3.html

[7] Ferraro G. 'Some mathematical aspects of Newton's Principia. Newton and the method of the last and ultimate ratios', Nov 2010, Campobasso, Italy. <halshs-00655601>

[8] http://www.etymonline.com/index.php?term=acceleration

[9] Silver B.L. 'The Ascent of Science' Oxford University Press (1998)

[10] http://www.etymonline.com/index.php?term=dense&allowed_in_frame=0

[11] Naess A. 'The Selected Works of Arne Naess' Springer (2007).

[12] Heathcote N.H. de V. 'The Early Meaning of Electricity: some Pseudodoxia Epidemica' Annals of Science **23** 261–275 (1967).

[13] http://www.etymonline.com/index.php?term=mass

[14] http://www.etymonline.com/index.php?term=inertia

[15] http://plato.stanford.edu/entries/newton-principia/

[16] http://www.etymonline.com/index.php?term=radiation

[17] http://www.etymonline.com/index.php?term=spectrum

[18] http://www.etymonline.com/index.php?term=molecule

[19] http://www.etymonline.com/index.php?term=pressure

[20] http://www.aps.org/publications/apsnews/201210/physicshistory.cfm

[21] http://www.newworldencyclopedia.org/entry/Catalyst

[22] http://www.etymonline.com/index.php?term=alkali

[23] http://www.etymonline.com/index.php?allowed_in_frame=0&search=lichen&searchmode=none

[24] http://www.etymonline.com/index.php?term=vapor

[25] http://science.jrank.org/pages/1462/Chromatography-development-chromatography.html

[26] Howard I.K. 'H Is for Enthalpy, Thanks to Heike Kamerlingh Onnes and Alfred W. Porter' Journal of Chemical Education **79** 697–698 (2002).

[27] http://www.famousscientists.org/robert-hooke/

[28] http://www.discoveriesinmedicine.com/Enz-Ho/Enzyme.html

[29] http://english.stackexchange.com/questions/42022/why-isnt-muscle-pronounced-muskle

[30] http://www.britannica.com/biography/Theodor-Schwann

[31] http://biomed.brown.edu/Courses/BIO48/20.SpeciesConcepts.HTML

[32] Rickard D. 'Pyrite: A Natural History of Fool's Gold' Oxford University Press (2015).

[33] http://todayinsci.com/J/Johannsen_Wilhelm/JohannsenWilhelm-Quotations.htm

[34] http://www.britannica.com/science/islets-of-Langerhans

[35] ://www.theguardian.com/notesandqueries/query/0,,-202099,00.html

[36] http://askville.amazon.com/coined-word-software/AnswerViewer.do?requestId=2180563

[37] Bazerman C. (Ed.) ‘Handbook of Research on Writing: History, Society, School, Individual, Text’ Lawrence Erlbaum Associates, NY (2009).

5 Newspapers and popular magazines

The book thus far has considered what might be called serious scientific writing, the composition of reports and articles by experts either for those already experts or for the uninitiated nevertheless wanting an expert's view. The press frequently have to report on scientific and technological matters. Often they consult external experts. A particular newspaper might have a science editor or a science correspondent. A distinction has to be made between coverage of a science topic for its interest and application of science to a news item. Also, a 'science article' might be concerned with scien*tist*. In this chapter selected writings from newspapers and magazines will be presented with comments. These will be divided into the physical sciences and the biological sciences, starting with the former.

Physical sciences

Publication details.	**Article title (in capitals) and selected quotations (in italics).**
New York Times, September 29th 1982. Attributed to Associated Press.	NEW ELEMENT CREATED BY WEST GERMAN PHYSICISTS. *The disclosure of element 109 was made Monday at an international physics conference inaugurating Michigan State University's new cyclotron laboratory.* *Only 92 elements are found in nature, but experiments like this one have, in the last few decades, resulted in the production of minute quantities of new elements.*
New York Times, January 18th 1913. Information from London via the Transatlantic cable.	NEW GAS DISCOVERED. *Sir Joseph Thomson FRS, Director of the famous Cavendish laboratories at Cambridge, made the announcement tonight* [*17th January*] *at the Royal Institution that he had discovered a new gas. It holds the same relationship to hydrogen that ozone does to oxygen, which means its chemical formula is* H_3. *He found this curious form of hydrogen hidden away in metals, especially iron, zinc, copper and lead.*
The Telegraph (UK), 5th October 2011.	NOBEL PRIZE FOR CHEMISTRY AWARDED TO QUASICRYSTALLINE DISCOVERY. *The work of Daniel Shechtman, the winner of the prize of 10 million Swedish crowns (£940,000), has opened the door for experiments in the use of the quasicrystals, which he discovered, in everything from diesel engines to frying pans.* *Prof. Shechtman found in 1982 that atoms in crystals could be packed in a pattern which did not repeat itself – recalling the intricate mosaics of Arab art and flying in the face of the accepted view that patterns had to be repetitious.*

Dominion Post (New Zealand), 11th December 2008.	RUTHERFORD'S LEGACY LIVES ON. *A century after Lord Ernest Rutherford received the Nobel Prize for chemistry, his work still shapes the scientific world, modern Kiwi scientists say. On December 10 1908 Lord Rutherford was recognised for his work on the disintegration of elements.* *Waikato radiocarbon dating laboratory director Alan Hogg said Lord Rutherford's success gave New Zealand scientists the confidence to achieve on the world stage. 'His experiments often required ingenuity that is typically Kiwi, and I personally have found great inspiration in his example.'*
The Age (Melbourne, Australia), 9th May 1995. Authored by A. Patton.	X-RAYS, SCANS, ULTRASOUNDS. *In recent years there has been an astonishing refinement in medical imaging techniques such as X-ray, ultrasound, magnetic resonance imaging (MRI) and nuclear scans. The result has been an immense improvement in diagnostic precision and, in turn, better management of many medical conditions.* *MRI (magnetic resonance imaging) is a comparatively new, non-X-ray technique that provides exceptional detail of structures such as the brain and spinal cord. The part of the body being investigated is positioned inside a magnetic field. Different types of tissue emit different radio signals, so an image can be generated by computer on to a screen.*
The Times (London), 21st July 2015. Authored by Ben Webster.	FOSSIL FUELS WILL MAKE CARBON DATING IMPOSSIBLE. *Fossil-fuel emissions could deprive archaeologists of one of their most powerful tools by making it impossible to use carbon dating to distinguish new materials from ancient artefacts, a study has found.* *Carbon released by burning fossil fuels is diluting radioactive carbon-14 and artificially raising the radiocarbon "age" of the atmosphere.* *If emissions continue rising at the current rate, by 2050 a new T-shirt could have the same radiocarbon date as a robe worn by William the Conqueror a thousand years earlier, scientists say.*
Sydney Morning Herald, 26th September 1991. Authored by Emma Tom.	HOME IS WHERE EVERYTHING IS DYING. …*everything in Chernobyl is dying. The air is bad and there are no leaves on the trees*… *They* [*survivors of Chernobyl*] *need everything as far as treating leukaemia goes*…
Newcastle Herald (NSW), 8th February 2013. Authored by Damon Cronshaw.	PLASTIC PERIL WORSENS. *Plastic, which amounts to 60 to 80 per cent of marine debris, is a particular concern.* *Hunter catchment authority coastal and marine officer Brian Hughes said: 'Whatever plastic products are produced, some people will do the wrong thing and a percentage of it will end up in the ocean.'*
New York Times, 9th July 2015. Authored by Julie Turkevitz.	DARK CLOUDS LIFT OVER DENVER, BUT EXPERTS WARN OF MORE TO COME. *An ugly and ominous dark cloud that has enveloped this city and much of eastern Colorado this week finally dissipated on Thursday*… *Hundreds of wildfires have churned across western Canada in recent weeks*…

'The Star (Malaysia)' 4th July 2015.	SWISS CUT PUBLIC TRANSPORT PRICES AMID OZONE SPIKE. *Regional authorities in Switzerland temporarily cut bus and train fares Saturday to encourage people to leave their cars at home, as a scorching heatwave sent ozone pollution levels soaring.* *In Geneva, all public transportation was available at reduced rates, the regional environment department said, adding that the lower prices would continue until the ozone levels were back to normal.* *The heat is driving an increase in pollution, with ground levels of health-hazardous ozone soaring well above the normal average of 120 microgrammes per cubic metre in several Swiss regions….*
Times of India, 24th July 2015.	PETER HIGGS GETS WORLD'S OLDEST SCIENTIFIC PRIZE. *Nobel Prize winner Peter Higgs has joined the ranks of Charles Darwin and Albert Einstein by winning the world's oldest scientific prize, the Royal Society's Copley Medal, for his pioneering work on the theory of the Higgs boson, which was discovered in 2012. Higgs, 86, received the Copley Medal for his fundamental contribution to particle physics with his theory explaining the origin of mass in elementary particles….* *The Copley medal was first awarded by the Royal Society in 1731, 170 years before the first Nobel Prize…*[*it*] *has most recently been awarded to eminent scientists such as physicist Stephen Hawking….*

With reference to the contents of the first row, it should be noted that element 109 was named Meitnerium, after Lise Meitner (1878–1968). Moving to the next row, local time in New York at the time Thomson made his announcement to the Royal Institution in London must have been early afternoon. The news found its way to the breakfast tables of New Yorkers less than 24 hours after its release in London. The chemical species reported by Thomson is known as triatomic hydrogen. Moving on the Daniel Shechtman and quasicrystals in the next row, the mention of 'diesel engines and frying pans' is presumably in recognition that the sort of structure he postulated is found in many alloys. The author of the piece in the Telegraph is also on perfectly solid ground in invoking the 'intricate mosaics of Arab art'. That these display the features of quasicrystals was noted in the press release by the Royal Swedish Academy of Sciences announcing award of the 2011 Nobel Prize for chemistry to Shechtman. So the writer was not in any way trivialising the scientific matter with such details. The adulatory account of Rutherford marking the centenary of his Nobel Prize (next row of the table) is good to see, and the mild jingoism is quite natural in view of the fact that New Zealand is a small country with correspondingly few such illustrious individuals in its history[5].

The statements quoted from the Age Newspaper (next row) will be discussed in turn. In the first sentence of first italicised statement, might 'medical examination techniques' be better? 'Imaging' suggests Magnetic Resonance Imaging (MRI) in particular. And might 'advancement' be an improvement over 'refinement'? More serious is the statement that 'Different types of tissue emit different radio signals…'. This is open to serious criticism. The basis of the magnetic resonance signal is radio frequency absorption – the opposite of emission – by certain atomic nuclei. The signal is 'generated' thus and not by any computer. The computer simply receives the signal and displays and records it. These comments are not meant to be an ungenerous attack on the newspaper article under review (even less on its author) but is given as an example of how errors of fact can slip into reporting of science at newspaper level. A reader of this book can read the full article by going to [1].

The matter of carbon dating and the possible jeopardy by release of carbon dioxide from fuel burning (next row) attracted major attention, having for example been on a BBC web site (which also contains the William the Conqueror comparison). What the 'Times' article might have pointed out is that carbon-14 in the atmosphere is formed by the effect of cosmic rays on nitrogen. A quantity of Carbon-14 decays to nil in time of the order of 50000 years, orders of magnitude less than the time for coal or oil formation from living materials. These fuels can therefore be taken to be free of Carbon-14 as, therefore, is carbon dioxide resulting from their combustion. So carbon dioxide free of Carbon-14 is constantly entering the atmosphere and this affects the Carbon-14 to Carbon-12 ratio of the atmosphere. Such detail if a little excessive for a journalistic account might have been expressed:

Fuels do not contain the Carbon-14 isotope, so carbon dioxide from them dilutes the atmospheric Carbon-14 level, which arises from the action of cosmic rays on nitrogen atoms.

The statements in the following row re Chernobyl are quotations made by a survivor, not of the composition of the author of the piece (although the decision to use them was of course hers). Note the irony of the title to the piece, suggestive of the saying 'Home is what you make it'. The following entry is from a regional newspaper: the problem to which it relates – plastic waste in the sea – is global. Sometimes in science journalism a numerical spin can be put on a point which increases its impact. This will be attempted here for the matter of plastic waste in the ocean.

An authoritative source [2] states that annually 8 million tonnes of plastic waste finish up in the oceans of the world. From the calculation in the appendix to this chapter the statement could be made:

This quantity of plastic if gathered and used as a fuel would be sufficient to sustain a power plant equivalent in output to the Robert W. Scherer Power Plant in Georgia, the largest coal-fired power plant in the US.

It would probably be sufficient to leave it at that, and an uninitiated reader of the newspaper, though benefiting from the perspective made, would perceive the impracticality of 'gathering' the plastic from the oceans. A scientifically trained reader might recognise that as some of the plastic waste would consist of PVC (polyvinyl chloride) there would be dioxins in the emissions from burning. These are the most harmful substances to human beings known. These and other points could feature in correspondence on the article or in a blog.

In the NY Times entry in the next row the word 'dissipate' is used in the way deprecated in the first chapter of this book. 'Churned' later in the quotation is a strange choice of word: 'spread across Canada' might have been far better. 'Churn' became a synonym for 'produce' in some applications. The publish-or-perish philosophy in academia was once said to lead to the 'churning out of publications'. But even this sense does not fit the quotation above.

The next row in the table deals with an example of a coverage in which an important detail is missing. A reader of the entire piece in the 'Star' would get the impression, unless he or she knew better, that ozone is emitted by vehicles. It is not! What is emitted by vehicles is unburnt hydrocarbon which once in the atmosphere is involved in the formation of ozone. The final row is concerned with the Higgs boson, the discoverer of which is feted in the article discussed. The chapter moves on to examples of press reporting of the biological sciences.

Biological sciences

Publication details.	**Article title (in capitals) and selected quotations (in italics).**
Times of India, July 23rd 2015.	5 LAKH TREES PLANTED AFTER FELLING BY DMRC: GOVT. *More than five lakh trees were planted from 2003 to 2015 to restore forest cover lost due to construction and expansion of Delhi Metro, the city government informed the Delhi high court on Wednesday.* *On April 15, HC had expressed alarm at the 'magnitude' of trees cut by Delhi Metro Rail Corporation (DMRC) for various projects, linking it to rise in air pollution. It had sought reports from the government on scale and locations of 'replantation'.*
The Guardian (UK), 5th August 2013. Authored by Helen Davidson.	CLIMATE CHANGE PUSING MARINE LIFE TOWARDS THE POLES, SAYS STUDY. *Rising ocean temperatures are rearranging the biological make-up of our oceans, pushing species towards the poles by 7 kms every year, as they chase the climates they can survive in, according to new research….* *'In general, the air is warming faster than the ocean because the air has greater capacity to absorb temperature. So we expected to see more rapid response on land than in the ocean….'*

Sydney Morning Herald, 30th October 2008. Authored by Jeremy Smith.	BIRD LIFE IS CHEAP ON OUR FREEWAYS. *I'm not opposed to planting natives [plants native to Australia] – I've planted scores myself – and many plant them specifically to attract birds. It works. Honeyeaters, lorikeets and silvereyes flit through those gardens in joy. But there is a place for everything and the edge of a freeway is not the place for native shrubs and their nectar-dripping flowers.* *When did you last see a small bird bouncing off your windscreen as you drove along the freeway? 'Not my fault,' you thought. 'It flew straight into the car. There was nothing I could have done.' True, but how many other cars have killed a bird this year? This week? It's hard to quantify the slaughter, because scavengers – cats, crows, foxes – soon clean up the victims, but it is substantial.*
New York Times, February 28th 1926.	LEAGUE IS ASKED TO SAVE FISH; MODERN MACHINERY SAID TO THREATEN DENIZENS OF THE SEVEN SEAS. *The League of Nations has been asked to call an international conference to find means to protect the fish of the Seven Seas because the world in the not distant future is likely to be threatened with a meat shortage. Meat, it is predicted, will become a delicacy while fish will either replace meat or have a much more important place on the menu of the average family.*
New York Times, January 16th 1897.	TOPICS OF THE TIMES. *Investigation conducted by a naturalist sent to Africa by the Royal Society of England has confirmed the belief that at no remote period, geologically speaking, Lake Tanganyika was a part of, or connected with, the sea. Some years ago jellyfish much like those in the neighboring ocean were found in its waters.*
Daily Mail (UK), 9th June 2010.	THE DUTCH ELM DISEASE: EXPERT BREEDS TREE THAT IS RESISTANT TO DEADLY BLIGHT. *As it swept through the British countryside, Dutch elm disease wiped out 25million trees. But among the few survivors was a specimen discovered 33 years ago by horticulturist Paul King, who decided to take some cuttings. And now, after years of painstaking research, he has developed a tree resistant to the infection.* http://www.dailymail.co.uk/sciencetech/article-1284637/The-Dutch-Elm-Disease-destroyer-Man-breeds-tree-resistant-deadly-blight.
Sydney Morning Herald, 24th December 2012. Authored by Heath Aston and Nicole Hasham.	HUNTING IN NATIONAL PARKS MAY INCREASE FERAL ANIMALS. *Hunting in national parks may increase the population of feral animals in certain areas, an internal state government report has warned.* *Carcasses and body parts from shot animals that will be left in the bush once hunting begins in March will provide a previously unavailable food source, according to a leaked draft risk assessment from the Office of Environment and Heritage.*
The Guardian, 23rd July 2015. Authored by R. Pielke.	IF WE DISCOVER EXTRATERRESTRIAL LIFE, WHAT HAPPENS NEXT? *Fifty years ago the era of robotic exploration of our solar system was just beginning. In July 1965 the Mariner IV probe sent back data showing that Mars did not have vegetation, much less canals crisscrossing the planet…* *Carl Sagan, astronomer and early rock star scientist, asked why the media was so quick to 'deduce a lifeless Mars'…*

The Independent, 28th July 2015.	EXPEDITION DISCOVERS 13 NEW SPECIES OF SPIDER ON A REMOTE AUSTRALIAN PENINISULA. *Thirteen new species of spider have been discovered in Australia by volunteers in one of the most remote parts of the country.* *These 13 new additions will be added to the over 40,000 described spider species documented on earth.* *The 10 day adventure was tough, but with the 13 new spider types to show for their work, including a brush-footed trapdoor spider and the newly named mouse spider, which lives in a stocking-shaped web, it seems the hard work was worth it.*
Newcastle Herald (NSW), 19th November 2014.	RARE MARSUPIAL FACING EXTINCTION. *Australia's northern hairy-nosed wombat is on the brink of extinction with only 126 of the marsupials left in the wild, according to a report launched at a major environmental conference in Sydney.* *It's one of some 138 Australian species facing extinction, according to the WWF Australia report released at the World Parks Congress….* *Under the international convention on biological diversity, Australia committed to making 17 per cent of its land and 10 per cent of marine areas ecologically representative and protected by 2020.*

A point of interest in the first row of the above table is use of lakh, meaning 10^5. So half a million trees were planted 'after felling by DMRC'. The two pairs of inverted commas in the quotation are surely superfluous. Moving to the next row, there is the small point that SI units in the form of their approved abbreviations should not be in plural form, so kms should be either km or (probably better for a newspaper report) kilometres. On reading the sentence a reader might wonder whether the article is concerned chiefly with global warming or with marine life. The next paragraph quoted above is also a quotation in the original article, not of the composition of the author of the article. The specific heat of air is ~1000 J $kg^{-1}K^{1}$, so a rise in temperature of 1 degree Celsius of 1 kilogram of air requires 1000 J. The specific heat of water is 4180 J $kg^{1}K^{-1}$ so a rise in temperature of 1 degree Celsius of 1 kilogram of water requires 4180 J. Unit amount of heat will have a greater temperature effect on air than on the same weight of water, which is what is presumably meant by the statement. 'Absorb temperature' is not the best expression: 'respond to absorbed heat by rising in temperature' would have been clearer.

The author of the piece in the Sydney Morning Herald (following row) has made what appears to be a good point about the folly of cultivating certain plants close to fast-moving traffic. The following one in the New York Times uses the term 'Seven Seas', which at that time was a figure of speech for the oceans of the world. 'Denizens of the Seven Seas' was fifty years later being expressed 'Harvest of the seas'. Instinctively if not strictly according to etymology 'menu' suggests a choice, so 'diet of the average family' might have been better, or perhaps 'the average family's daily fare'. The term 'Topics of the Times' as it relates to the New York Times (following row) continues into the 21st Century. The article on Dutch Elm disease contains an attractive photograph of the tree which, not having succumbed to the disease, was the basis of cultivation of progeny resistant to the disease. This tree is 200 years old, and as with the article on plastic waste a spin could have been put on this. If the tree is 200 years old it will have taken up about 5 tonnes of carbon dioxide from the atmosphere over its life span.

Moving to the next row, a feral animal (or just a 'feral') is of course a non-indigenous animal descended from a domesticated animal and having been born in the wild. Their threat to vulnerable living things, in particular certain birds, is a constant issue, and hunting of ferals with a licenced firearm and with permission of the landowner is legal in Australia (though criteria for classification as 'feral' varies from state to state as do the dates of the hunting season). The point at issue in the article under discussion is that this activity far from providing a service to community by controlling the feral population might have the reverse effect. Appearance of the article in a city newspaper is not surprising. Greater Sydney contains several national parks, including one at its southernmost edge. Perhaps more importantly urban sprawl means that many now live at or close to the interface of suburbia with 'the country', and intrusion of feral animals into private gardens is an issue there.

Carl Sagan, whose name appears in the next row, would have merited mention in Chapter 3 of this book as a populariser of science. The possibility of life on other planets has long exercised people's imaginations, and became the theme of fanciful books and movies. That its basis in reality has not been totally dismissed is evidenced by the fact that the Royal Society of London in 2010 published a volume entitled 'The detection of extra-terrestrial life and the consequences for science and society'. Those putting a religious dimension on it have quoted, in a by no means unintelligent way, from St. John's Gospel: 'I have other sheep that are not of this sheep pen. I must bring them also.' (John 10:16, New International Version). It is not any possible divine inspiration of this which is being invoked here. The penmanship, in the second half of the 1st Century AD, was human enough.

The discovery of a new species of plant or animal is always newsworthy, and that thirteen new species of spider were found in Cape York, Australia (following row), is remarkable. That the exploration was undertaken by volunteers is rightly emphasised. Of course, one would expect that the subsequent work by taxonomists – addition to the 40000 species of spider already classified – will be on a formal basis. That will be reported not in newspapers but in scientific journals and the professional methods of taxonomy will have to be applied to the satisfaction of reviewers. The entry in the following row makes begins with the threat to the survival of a particular marsupial and extends the discussion to to marsupials generally. This is not an example of the error of 'illicit transference' – argument from specific to general – which might have featured in Chapter 2, as no 'argument' is present in the article under discussion so it is only information which is extended (not transferred from a 'specific' theme to a general one).

In this chapter then points of interest have been drawn out of press articles on the physical sciences and on the biological sciences. A reader in turn will be able to apply the sort of analysis here to other such articles as with the previous chapters.

References

[1] http://newsstore.fairfax.com.au/apps/viewDocument.ac?page=1&sy=age&kw=magnetic+resonance&pb=all_ffx&dt=selectRange&dr=entire&so=relevance&sf=text&sf=headline&rc=20&rm=200&sp=nrm&clsPage=1&docID=news950509_0226_8260

[2] http://news.nationalgeographic.com/news/2015/02/150212-ocean-debris-plastic-garbage-patches-science/

Appendix to Chapter 5

Calculation.

The plastic will be assigned a calorific value of 35 MJ kg^{-1}.

On combustion, 8 million tonnes will release:

$$8 \times 10^9 \text{ kg} \times 35 \times 10^6 \text{ J kg}^{-1} = 2.8 \times 10^{17} \text{ J}$$

Electricity obtainable from this at 40% efficiency[6] = 1.1×10^{17} J.

This amount would be produced annually by generation at:

$$[1.1 \times 10^{17} \text{ J}/(24 \times 3600 \times 365)] \times 10^{-6} \text{ MW} = 3550 \text{ MW}.$$

The largest coal-fired power plant in the US – the Robert W. Scherer Power Plant in Georgia – has a capacity of almost exactly this (nominally 3520 MW [1]).

Reference

[1] http://gizmodo.com/5850299/americas-largest-coal-power-plant-burns-11-million-tons-of-bituminous-a-year

6 Use of figures of speech

The matter of personification in scientific writing was discussed in Chapter 1 with the writings of R.B. Woodward as an example. Synecdoche, often seen as a form of personification, is defined in [1] as 'a figure of speech in which a word or phrase that refers to a part of something is substituted to stand in for the whole' and gives 'all hands on deck' as a common example. Here 'hands' means 'sailors'. Another example as is 'the Crown' for 'the reigning monarch'. The statement:

The chemical element Roentgenium was a discovery of the GSI Helmholtz Centre

is correct factually and, as written, and an example of synecdoche.

Another example of synecdoche is substitution of reference to a container for the substance contained. It would be polite at an afternoon tea to ask a guest whether he or she would like 'another cup', and the guest having signified acceptance would not expect to be handed an empty cup. In his *Principia* (see Chapter 4) Newton describes an experiment, with far-reaching conclusions, in which a bucket of water is rotated. The set-up must have consisted of the bucket, the water, a suspension device (actually a rope) and a means of rotation. It is pointed out in [2] that this is frequently referred to simply as Newton's bucket experiment and that that is an example of synecdoche. It is in fact entirely analogous to 'another cup' above. An illustration of the experiment forms Figure 6.1 below.

Related to synecdoche is metonymy, and the two are not always easy to distinguish rigorously[7]. An example of metonymy is use of a place name alone to signify activity at the place: 'Hollywood' as a synonym for 'film industry' is an obvious (and widely quoted) example. A scientific one might be:

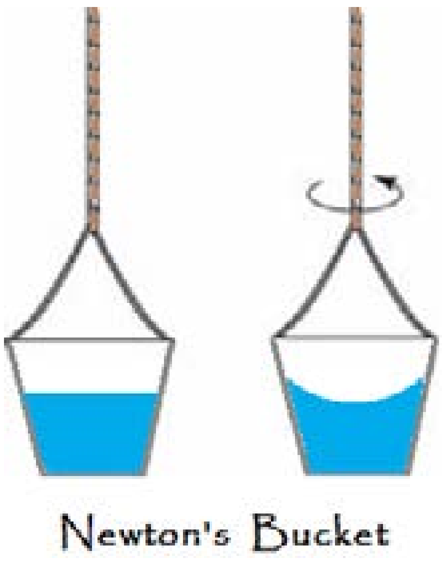


Figure 6.1. Taken from [3].

One looks to Detroit for up-to-date information on engine lubricants

when what is meant is of course is that Ford and General Motors at their respective R&D facilities in Detroit have such information. Detroit is often referred to as 'Motor City' [4], and to re-express the above as:

One looks to Motor City for up-to-date information on engine lubricants.

would be less of a metonym if at all as Detroit is identified as the scene of car manufacturing without reference to its general existence. The same fact could be expressed by the stylistic technique of hypophora [5] – the posing of a question followed by an answer to it – in the following way.

Where would one look for up-to-date information on engine lubricants? To Detroit.

The statement on atomic nuclei from the Feynamn lectures quoted on page 17 is also an example of hypophora. 'Tautology' in the sense of careless repetition is widely deprecated. Sometimes however tautology is inadvertent, and the most common example of this from general parlance is 'free gift' when a gift, by definition, is free [6]. It is also pointed out in [6] that whilst nobody would take exception to the term 'monsoon season' this too is strictly tautology as 'season' is etymologically encapsulated into 'monsoon'. Sometimes apparent tautology is necessary for there to be an unequivocal meaning. As a scientific example, the term 'intermolecular interactions' is widely used in chemistry and expresses a meaning which 'intermolecular actions' or 'molecular interactions' could not. For example, 'molecular interactions' might mean interactions between moving molecules and a stationary surface, for example a catalyst. Use of 'inter' twice in as many words, even though it means 'between molecules' in each case, is not at all incorrect in the expression under consideration, and the term 'tautology' if applied to it carries no negative suggestion. In this sense, consistently with the theme of this chapter, tautology is a style and not a defect.

Sometimes, as (again) referees of papers notice, mild tautology in the negative sense slips into scientific writing in statements such as 'instrumentational analysis by gas chromatography was performed'. Any gas chromatograph is a scientific instrument, so 'instrumentational' is superfluous and adds nothing to the meaning. Another example of such inattention in writing would be 'This design feature was found to be totally redundant.' Something is either redundant or it isn't, and 'totally redundant' is analogous to 'fatally drowned'. 'Quite redundant' is acceptable if it is taken to mean that there were no consequences from dispensing with it.

In moving on to adjunction as a figure of speech, what more authoritative source could one draw on than Abraham's Lincoln's Gettysburg address, which began with 'Four score and seven years ago, our forefathers brought forth on this continent a new nation'? It has been pointed out (e.g. [7]) that 'on this continent' is an 'adjunction', as it adds nothing to the meaning and is there only to enhance the style. The term 'new nation' later in the sentence does the work of 'on this continent' as more obviously does the fact that Lincoln is directing what he says to fellow-Americans. Even so, both the appeal and 'flow' of the sentence are the better for its inclusion. As a scientific analogue, imagine that a published research paper having, as is standard practice, the names and affiliations of the author(s) at its commencement, states:

The table below gives the results obtained in our investigations.

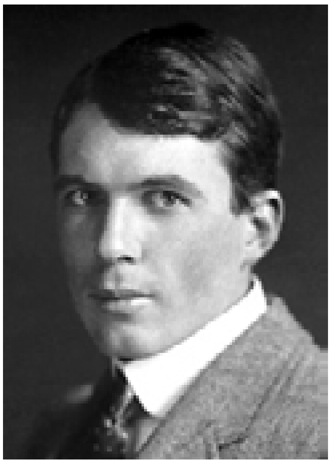
'In our investigations' is like Lincoln's 'on this continent': no reader needs to be informed of it, yet the sentence would not have 'flowed' as well without it. The figure of speech referred to as 'litotes' is defined [8] as 'consisting of an understatement in which an affirmative is expressed by negating its opposite', and 'no small problem' is given in [8] as an example. This is not as strongly figurative as, for example, a metaphor is, and probably features in scientific writing as much as in prose writing generally. A simple example would be:

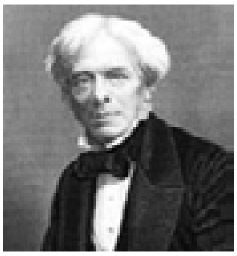
These findings could not be interpreted with ease.

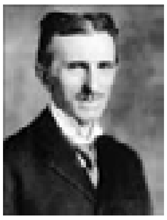
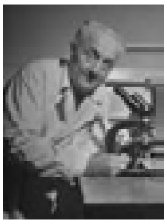
Below, selected writings of scientists sufficiently eminent to have earned a place in history are examined for examples of the use of figures of speech.

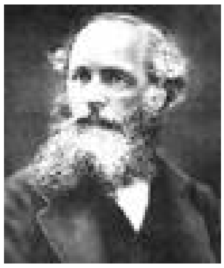
Writer, publication and notes (in italics).	**Expression selected for comment.**
Marie Curie 'Radium and Radioactivity' Century Magazine January 1904 pp. 461–466. http://cwp.library.ucla.edu/articles/curie.htm *'Century Magazine' was published in New York over the period 1881–1930. Madame Curie's original language was of course Polish.*	'…they [rays outside the visible region] do not possess the power of directly impressing our retina.'  Portrait of Madame Curie, taken from [9].

Ramsay W. 'Modern Chemistry' Aldine House (1900). https://archive.org/details/modernchemistry00ramsuoft *Sir William Ramsay (1852–1916), a Scot, obtained the Nobel Prize for Chemistry in 1904. He is most noted for his discovery of four of the inert gases.* Joule J.P. 'On some amalgams' Manchester Memoirs, circa 1883, reprinted in 'The Scientific Papers of James Prescott Joule', accessible on: https://archive.org/details/scientificpapers01joul	'…the interpretation of results of analyses presents a problem of no small difficulty. The work of F.W. Clarke of the US Geological Survey has contributed not a little to the solution of the problem.'  Portrait of W. Ramsay, taken from [10].
Joule's lifespan was 1818–1889. He was therefore too early for a Nobel Prize.	'Since it was believed that mercury refused to enter into combination with iron…'  Portrait of J.P. Joule, taken from [11].

Bragg W.L. 'Reminiscences of Fifty of Research' Journal of the Franklin Institute **284** 211–228 (1967). *W.L. (Sir Lawrence) Bragg, who was born in Australia, shared the 1915 Nobel Prize for physics with his father W.H. Bragg.*	'So I got it into my head that if X-rays were anything they were pulses.' 'Sommerfeld strongly opposed this [a proposed experiment], thinking it was a mad venture.' 'Then Knipping, just for the devil of it, tried putting the plate on the far side of the crystal.' 'Now, the final trick, and that will be the end of my painful story. This is what we call "staining"'.  Portrait of the young W.L. Bragg, taken from [12].
Sir Humphry Davy. 'Elements of Chemical Philosophy as Regards the Laws of Chemical Changes: Undecompounded Bodies and their Primary Combinations' Smith, Elder and Co., Cornhill (1840). *This edition of Davy's book is posthumous: he died in 1829. His brother John Davy assembled collections of Sir Humphry's work after his death.*	'…it [a compound of sulphur and chlorine] affects the eyes like the smoke of peat.'  Image of Sir Humphry Davy, taken from [13].

Michael Faraday, personal diary entry 15th November 1845. Quoted in: Day P. 'The Philosopher's Tree: A Selection of Michael Faraday's Writings' CRC Press (1999). *Comparison of dates in this and the above row shows that Faraday wrote this 16 years after the death of Davy, who had been a strong influence on him.*	'Now we find *all* matter subject to the dominion of electric forces, as they before were known to be gravity, electricity, cohesion.' (Italics in original.)  Michael Faraday towards the end of his life, taken from [14].

Nikola Tesla, writing in 'Liberty' February 1937. http://www.tfcbooks.com/tesla/1935-02-00.htm *The unit Tesla – kg s-2 A-1 – is named after Nikola Tesla. 'Liberty' is a religious magazine published in the US since 1906. Tesla once worked with (for?) Thomas Edison.*	'…we may reduce the frictional forces which impede progress, such as ignorance, insanity, and religious fanaticism.'  Photograph of Nikola Tesla, taken from [15].
Albert Szent-Györgyi (de Nagyrápolt) 'Oxidation, energy transfer, and vitamins' Nobel Lecture 11th December 1937. *Albert Szent-Györgyi (1893–1986) received the Nobel prize for Physiology or Medicine.*	'Energy from the sun's rays is trapped by green plants, and converted into a bound form, invested in a chemical reaction.' 'water, the mother of all life…' 'When I first ventured into this territory, the foundations had already been laid…' ' Suddenly the long-ignored hexuronic acid moved into the limelight…' '…this fruit [paprika] represented an unbelievably rich source of hexuronic acid, which, with Haworth, I re-baptized ascorbic acid.'  Photograph of Albert Szent-Györgyi, taken from [16].

H.S. Ruse (1905–1974). Informal letter on Edinburgh Mathematical Society note paper, 7th June 1936. *A photocopy of this letter is in the possession of the present author who was given it by Marit Hartveit[8], then a graduate student at the University of St. Andrews, in 2010.*	'Sorry to bother you with letter writing but it canna be helpit.'  Photograph of the young Harold Ruse, taken from [17].
The Scientific Papers of J. Clerk Maxwell (Niven W.D., Ed.) Dover Publications Inc., NY (1965). *The date given is that of an American reprint which is accessible online. The compilation by Niven of Maxwell's work was originally published in 1890.* *Maxwell lived from 1831 to 1879.*	'Although sulphur evidently would not answer for this purpose, phosphorus might…' (p. 57). 'The conjecture of a philosopher so familiar with nature may sometimes be more pregnant with truth than the best established experimental law discovered by empirical inquirers…' (p. 187). 'An important contribution to our stock of appropriate ideas and methods has lately been made by Mr R. B. Hayward…' (p. 250). 'When a pencil of rays is brought to a focus, the reduced path from the origin to the focus is the same for every ray of the pencil.' (p. 280). 'Such a consequence of a mathematical theory is very startling…' (p. 391).  Photograph of James Clerk Maxwell, taken from [19].

Madame Curie's statement in the first row of the table is figurative though difficult to classify as a simple metaphor, as it accurately describes what visible light does. It corresponds to 'impinge upon the ears' when the sense of hearing is meant. Madame Curie's statement is however classifiable as synecdoche, as vision involves more than just the action of the retina so the part is being used to mean the whole.

Sir William Ramsay's superb text 'Modern Chemistry' is not the sort of tome to which one would look for figures of speech. It is rigorous and precise and there is hardly a page which does not contain chemical formulae and structures. The statement quoted in the table contains two examples of litotes, though certainly to a moderate degree. Elsewhere in Ramsay's book there are suggestions of personification, as when a chemical compound 'claims' something. Interestingly, more than once in the book he uses the term 'throwing down' to describe formation of a precipitate. The expression might have begun as laboratory jargon. Joule's published works are similarly very advanced and free from casual or colloquial content. The present author had to search Joule's published work very closely to find any figurative expression at all, and eventually spotted the personification quoted. It is very similar to R.B. Woodward's account of 'coaxing' a chemical reaction, discussed in Chapter 1. If Joule had wanted to avoid personification he could have said that mercury resists combination with iron.

The paper by W.L. Bragg discussed in the next row (published only a few years before his death) has a very chatty style, being addressed to colleagues and associates. It is not a formal report of original work; Bragg had previously published very many such. The colloquialisms in the table are an arbitrary selection of many in the paper under consideration. If formal analysis of figures of speech is attempted, it can be noted that the use of 'mad' in the second quotation is hyperbole – exaggeration for means of emphasis – and in this case is hyperbole tinged with humour. 'For the devil of it' is an idiom, as is the expression to get something into one's head.

Sir Humphry Davy's simile on peat burning in the following row is interesting and possibly reflects his Cornish upbringing. That he drew on a homely example of that sort is itself a point of interest in analysis of his writing. Personification is unequivocal in Faraday's reference to the 'dominion' of electric forces. In the phrase quoted from Tesla's (largely biographical) article 'friction' alone might not have been seen as being strongly figurative. Nobody would have seen the expression 'political friction' as being so. His expanding the term to 'frictional forces' does make it a figure of speech. Simply 'the forces which impede progress' or 'the influences which impede progress' would have removed any trace of floridness, but that might not have been Tesla's aim in a piece directed at popular readership. There is of course nothing wrong with aspiring to a 'style' in writing and a good style adds interest to the content. Difficulties begin when attention to style is more evident than attention to content or when style is applied to disguise weak content. Whilst a writer of repute might well become recognisable by his or her style, a writer needs to avoid idiosyncrasy or eccentricity. Originality has to be held in balance with individualism: they are not of course the same. This is a return to a point made in Chapter 1.

The Nobel lecture by Albert Szent-Györgyi, whose mother tongue was Hungarian, is rich in figures of speech and some examples are given in the table. 'Invested' and 're-baptised' have an element both of metaphor and of personification. The next row of the table contains 'canna be helpit' in which H.S. Ruse adopts a Scottish style, 'adopts' because Ruse was not Scottish. The expression is reminiscent of Robert Burns' widely quoted words [18]:

Some hae meat and canna eat,
And some wad eat that want it,
But we hae meat and we can eat,
And sae the Lord be thankit.

Ruse, who on moving to Edinburgh from Oxford in 1927 immediately took to Scotland with all of the enthusiasm of young manhood, had no doubt attended 'Burns suppers' at which the above words by Burns would have been used as a form of grace.

On analysing the five statements by Clerk Maxwell in the final row, we note that the idea that sulphur would 'answer a purpose' is analogous to the 'refusal' of mercury to combine with iron in Joule's statement previously discussed. 'Pregnant with truth' is another figurative expression by Maxwell as is 'stock' of ideas and 'pencil' of rays. 'Startling' in the final statement is colloquial for the times and for Maxwell's otherwise very rigorous approach.

This chapter has hopefully equipped a reader to analyse scientific writing for figures of speech and, more importantly, to make effective use of them in new writing.

References

[1] http://www.literarydevices.com/synecdoche/

[2] Bunn J.H. 'The Natural Law of Cycles: Governing the Mobile Symmetries of Animals and Machines' Transaction Publishers (2014).

[3] https://www.google.com.au/search?q=newton's+bucket+experiment&biw=1820&bih=784&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMIrdmv2Zr_xgIVIVGmCh2UPgKp&dpr=1#imgrc=4Qw7mgkB8hUggM%3A

[4] https://answers.yahoo.com/question/index?qid=20090108052325AAsXzwa

[5] http://literarydevices.net/hypophora/

[6] http://askville.amazon.com/definition-tautology-current/AnswerViewer.do?requestId=50724616

[7] http://www.softschools.com/examples/grammar/adjunction_examples/148/

[8] http://www.thefreedictionary.com/litotes

[9] https://www.google.com.au/search?q=madame+curie&biw=1820&bih=784&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMIqpfow76BxwIVBiCmCh36bArs#imgdii=__dlFVoj3Ccd5M%3A%3B__dlFVoj3Ccd5M%3A%3BH_--XuUUO3B-xM%3A&imgrc=__dlFVoj3Ccd5M%3A

[10] https://www.google.com.au/search?q=sir+william+ramsay+noble+gases&biw=1820&bih=756&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMI-an69sqBxwIVop6mCh1B_gxq#imgrc=filgdycNPnAGIM%3A

[11] https://www.google.com.au/search?q=james+prescott+joule&biw=1820&bih=784&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMIw-ybt9SBxwIV4hemCh0_oACR&dpr=1#imgrc=krtTPycJPMDbTM%3A

[12] https://www.google.com.au/search?q=william+l+bragg&biw=1820&bih=784&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMI3NjKgeKBxwIVBl6mCh0ZmAwk#imgrc=FnVgiSx--4agBM%3A

[13] http://www.advameg.com/contact-oth.php

[14] https://www.google.com.au/search?q=michael+faraday&biw=1820&bih=784&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMIxPfP1faBxwIVJ1CmCh200QDW#imgrc=1vlw9VAH6YoegM%3A

[15] http://www.kerryr.net/pioneers/gallery/tesla.htm

[16] https://www.google.com.au/search?q=A+L+B+E+R+T+S+Z+E+N+T-+GY+%C3%96+R+G+Y+I&biw=1820&bih=784&source=lnms&tbm=isch&sa=X&ved=0CAcQ_AUoAmoVChMIle7rtvODxwIVSqeUCh0kNQ3S#imgdii=6E1SDaqAieaYJM%3A%3B6E1SDaqAieaYJM%3A%3Brx0XmMnwe_8LiM%3A&imgrc=6E1SDaqAieaYJM%3A

[17] http://www-history.mcs.st-andrews.ac.uk/history/Biographies/Ruse.html

[18] http://www.goodreads.com/quotes/22238-some-hae-meat-and-canna-eat-and-some-wad-eat

[19] https://www.google.com.au/search?q=james+clerk+maxwell&biw=1820&bih=784&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMI-t7Cm5yExwIVZlumCh1RKgWn#imgdii=XEI6PWc8x5PH0M%3A%3BXEI6PWc8x5PH0M%3A%3B45WE0PHnQZHWMM%3A&imgrc=XEI6PWc8x5PH0M%3A

Postscript

The point was made in the Preface that such details as conventions in layout and referencing in scientific articles can be found from numerous sources. Publishing generally has undergone radical changes over the last fifteen to twenty years since personal computers became so numerous. It is intended that this book will guide a scientist whose duties include frequent reporting in the techniques of writing as well as introducing him or her to scientific tradition. Whilst it might be difficult to imagine how the originators of that tradition would have adapted to the age of the internet a sense of continuity with them is vital for continued scholarly excellence. I hope (and intend) that this book will express that conviction.

Endnotes

1. The author has endeavoured to use in this chapter sources which a reader can access online.
2. It is a sad fact of the history of science that Ludwig Boltzmann, who was born in Vienna in 1844, committed suicide whilst on holiday in Italy in 1906.
3. Somerville College Oxford is named in her honour.
4. Though many web sources including that cited state that Tukey coined the term software (though he never claimed to have done), there have been suggestions that in fact someone else did so at about the same time [36].
5. Maurice Wilkins, who as noted on page 7 shared a Nobel Prize with Watson and Crick, was a New Zealander.
6. The efficiency expected if supercritical steam is used.
7. Above 'The Crown' is given as an example of synecdoche on the grounds that the monarch's ceremonial headgear – a 'part' of the monarch – is taken to mean the monarch him/herself. In some sources this usage is seen as metonymy on the basis that the crown is a *symbol* for the monarchy. See http://www.literarydevices.com/metonymy/
8. Her PhD thesis 'The Lesser Names – The Teachers of the Edinburgh Mathematical Society and other aspects of Scottish Mathematics 1867–1946' is accessible online.