Reading scientific papers for understanding: revisiting Watson and Crick

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The ability to use the research literature within a given field is a basic skill that students should acquire as part of their higher education studies. However, undergraduates need support in developing this skill. The use of concept maps as an aid to interrogating the literature is described here. This may help students to highlight key issues raised within a research paper, and may be used to demonstrate understanding to their tutors. An example is given by reference to the paper in which James Watson and Francis Crick suggest a structure for DNA. In this, annotated concept maps are used to highlight key issues from the paper from two perspectives: the race to describe the structure of DNA, and the biochemistry of the molecule.
Key words: Academic writing; Reading; Study skills.

Introduction

The 'traditional' peer-reviewed scientific paper (most often in hard copy, though increasingly in e-journals) still represents the 'gold standard' for the presentation of research findings within the sciences. Within higher education, it is normal for courses to be accompanied by, or even based on, the reading of research literature (eg. Janick-Buckner, 1997; Muench, 2000). The central point of this paper is that undergraduate students need support in this task.

When Janzen (1996) wrote, 'I write papers to be published rather than to be read,' he was probably representing the unspoken intentions of many authors. Writing with this aim in mind will result in papers that are crafted to satisfy the requirements of editors and reviewers. The result can be impenetrable text, laced with technical jargon that is only appreciated by 'those in the know'. Experts in the field will cope with papers of this type and will be able to place the paper within the context of related research. However, students of biology typically do not have such a sophisticated knowledge structure to activate and, therefore, 'fail to put the details of a paper together to create a coherent understanding of the text' (Brill *et al*, 2004). Students, therefore, need to acquire techniques that can help them to develop the skills required to make the most from their reading.

Concept mapping

The manipulation of material into another format may help students to construct their understanding of the information presented in a scientific paper. The conversion of dense text into a graphic interpretation (a concept map) is suggested here. Applications of concept maps have been described for a variety of uses in biological education (e.g. Kinchin, 2000), but the literature pays little attention to their use as a tool to help interpret scientific papers. Concept maps have their greatest influence on the person who constructs the map. Therefore, if students can be encouraged to produce concept maps of papers (or sections of papers) this will increase their focus on the reading activity and force them to make explicit the perceived links between ideas presented.

It is important for concept mapping to be introduced to students before using the technique to expand their understanding of biology. Learning biology and learning mapping techniques simultaneously would present students with a dual challenge, making it difficult for tutors to separate difficulties students may have with mapping from difficulties they may be having with the biology.

Guidelines for introducing concept mapping to students have been presented by various authors; some of the most accessible are given by Novak and Gowin (1984) and White and Gunstone (1992). I have found one of the best ways to introduce concept mapping is as a revision/summary tool at the end of a section of work. This allows students to experiment with mapping a topic with which they are already familiar. An overview of concept mapping and how it may be used within biological education is provided by Fisher *et al* (2000).

As an introduction to concept mapping to aid reading of the scientific literature, it may be helpful to guide students through a 'worked example'. This will show them how a page of dense text may be transformed into a relatively simple diagram. Concept maps of this sort could be presented with annotations to ask for justification or expansion of a particular point. Such a worked example is presented below by reference to a paper that most students of biology will be aware of, but few will have been moved to seek out from the shelves of their libraries.

Watson and Crick (1953)

To illustrate the use of concept mapping to help in the reading of a paper, I have chosen to look at the Nobel Prize-winning paper by Watson and Crick (1953) that announced the double helix structure of DNA. I have selected this paper for the following reasons:

- it is probably the most important paper of the twentieth century to be published in the field of biology
- it is of relevance to students from all branches of biology
- it is a short paper of around 900 words
- it is freely available to students as a pdf file from a number of locations on the internet[1]
- it is written in a style that is accessible to students of biology
- it raises many questions about scientific writing style - much of it is written in the active voice.

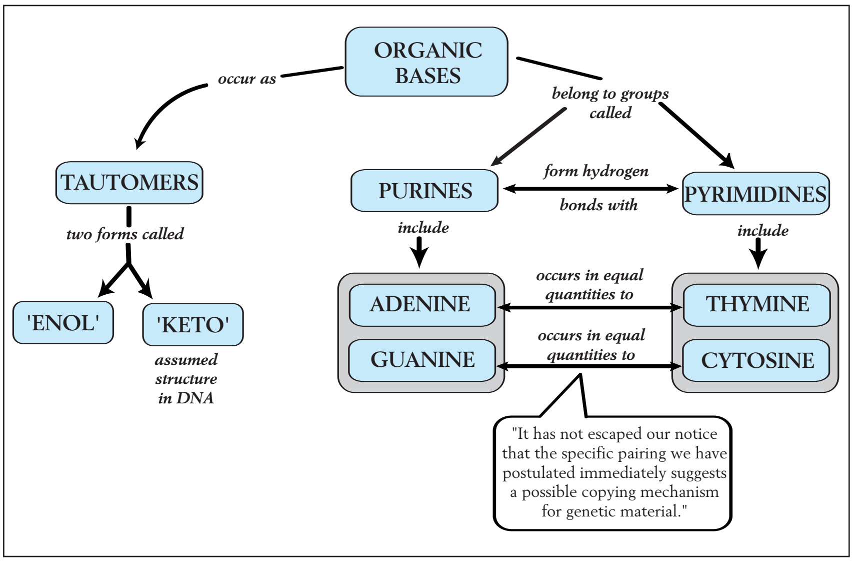

Figure 2*. A concept map of the central section of the paper by Watson and Crick (1953) in which the authors describe the 'novel feature' of their proposed structure of DNA – the role played by the organic bases. The map includes a single annotation with a quote from the original paper, to which students should be directed, and asked: 'How?'*

For students to read meaningfully, they have to be reading for a purpose that is well-defined and relevant (Davies and Greene, 1984). Students may be directed to read Watson and Crick (1953) as part of, for example, a course in the history of science or in molecular biology. Within these different contexts, students will be reading the paper from different perspectives and concentrating on different aspects.

The race to describe the structure

Watson and Crick were seemingly pipped at the post by Pauling and Corey (1953), who proposed a three-chain structure for DNA shortly before the publication of the paper under discussion. Given that Pauling was already an established figure, Watson and Crick felt obliged to explain why the three-chain structure was not workable, and devoted about one-fifth of their paper to this explanation. A concept map that is structured to emphasise the key differences between the two proposed structures (Figure 1) can help to focus on the problems associated with the three-chain structure.

The biochemistry

Understanding the biochemistry of DNA forms a part of most (if not all) courses in biology. The description of the 'manner in which the two chains are held together by the purine and pyrimidine bases' forms the bulk of the paper by Watson and Crick and is the essential aspect that indicates the significance of the two-chain structure. This is summarised in Figure 2.

Students often confuse the terminology associated with DNA structure: for example, by confusing purines with pyrimidines. Figure 2 is structured to emphasise the key points associated with complementary base pairing and is annotated with a quote from the paper to which students should be directed and simply asked: 'How?'

Conclusion

After students have been taken through a worked example of how concept mapping can illuminate the structure of a scientific paper, they should be encouraged to construct their own maps of key papers. Alternatively, further maps could be constructed around Watson and Crick (1953). For example, if students were given the following concept labels to link in – ROSALIND FRANKLIN, ERWIN CHARGAFF, MAURICE WILKINS – the map would look very different and would stimulate a very different discussion. Within this short paper, I have implied that concept mapping might be a solitary process, undertaken by students in isolation. However, there is growing evidence that (for some students, at least) a collaborative component to concept mapping activities may bring additional benefits (eg. Kinchin, *et al*,

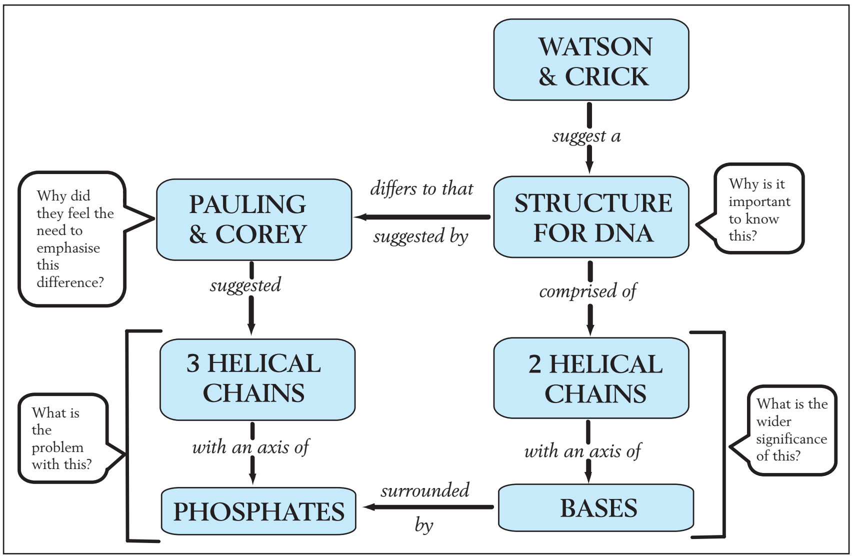

Figure 1*. A concept map of the first section of the paper by Watson and Crick (1953) in which the authors explain their objections to a three-chain structure for DNA proposed by Pauling and Corey (1953). The annotations provide focused questions to test student understanding.*

[1]A number of websites give access to a pdf version of Watson and Crick's paper. One of the most engaging can be found at: www.virtuallaboratory.net/firstSeries/WhatisScience/section_09.html

2005). Teachers should feel able to adapt and extend the activities suggested here to suit their students' particular needs.

In the first instance, students should be directed to relatively simple texts that contain clearly identifiable key points to be mapped. As they become more proficient at mapping, students should be directed to more demanding papers in which the arguments presented may be open to different interpretations. Whilst the approach described here clearly requires some time commitment to prepare materials and introduce them to students, I feel that the investment is worthwhile. I presume that lecturers who provide students with lists of further reading do intend for their students to read the texts listed and, in so doing, further their understanding of the subject. If (as has been suggested by Kinchin, 2004), A-level biology students are no longer engaging in 'reading around the subject', then the sudden expectation for them to be able this as undergraduates will be met with disappointment. The concept mapping technique described here can support their development as critical readers of the primary literature. To produce a concept map from a research paper requires the student to fully engage with the text. This is surely something to encourage.

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