

# **Information gathering behaviour among academic researchers in different disciplines: ancient historians and research chemists**

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## Abstract

Since the mid-1990s the use of electronic resources has transformed information gathering for academic research, but has affected subjects in different ways and to different degrees. Where previously finding information in all subjects was based around libraries, researchers in many subjects do not now physically go to libraries, but have convenient access to vast amounts of information from their desktops. In other subjects electronic resources have been embraced, but visits to libraries are as important as ever and continue to form the basis of research projects with researchers regularly travelling abroad to use particular collections.

For this study in depth investigations were conducted in two substantially dissimilar subjects, chemistry and ancient history, so that differences between them could be highlighted and light shed on developments in academia generally. Surveys were conducted with groups of six researchers from each subject, using detailed semi-structured interviews. All interviewees were asked the same set of questions and were encouraged to give their opinions on relevant issues so as to yield qualitative information about their behaviour and attitudes.

The investigation found that the information gathering behaviour of chemists and ancient historians has become more different, rather than more similar, with the explosion of the use of electronic resources. Reasons for this include different methodologies, finances, the composition of research groups, working patterns and cultures within each subject. Searching techniques are significant because without them electronic information would not be retrievable and because they illustrate differences in information needs. There are important continuities in information behaviour, such as the importance of personal contacts.

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# 1. Introduction

## Background

It would be difficult to overstate the effects that electronic resources have had and are having on academic information gathering and scholarly communication. For example, in contrast to the hours traditionally spent searching for material in libraries, a recent report by the Research Information Network found that "academic researchers have recently become so accustomed to getting resources directly on their desktop from anywhere in the world, that dissatisfaction when something isn't available is now the normal reaction".<sup>1</sup>

A post-doctoral research associate in chemistry, who was interviewed for this study, explained that, as a postgraduate student, he was taught that 'an hour in the library saves ten hours in the lab'. Whereas he has virtually no need to physically make the trip to the library these days, researchers in ancient history confirmed that use of libraries continues to form the basis for their research projects and even, to some extent, of their professional credibility.

The information gathering behaviour of researchers in at least some disciplines has become more different, rather than more similar. Researchers have always had specific methods for carrying out and communicating their research, presenting different challenges for the academic librarian. Recent decades have seen an explosion in the use of electronic resources and consequent dropping off of visits to libraries in some fields, but not in others.

The term electronic resources (e-resources) may be taken to refer to online journals,

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<sup>1</sup> Research Information Network, 2006 p.11

databases and searching tools used to for retrieval. Bibliographic databases are the standard method for finding articles in academic journals, though full text databases, which include the full text of all articles listed, are widely used in some fields. E-books are slowly gaining in importance, but have not taken off as e-journals have, mainly because of the unwillingness on the part of publishers to make this content available electronically due to their belief that there was no pricing model that would make it worth their while to do so.

The benefits of this increased use of e-resources include faster, easier access to greater amounts of scholarly information, the ability to retrieve highly specific pieces of information and access these resources from anywhere in the world. It is perhaps not surprising that a survey of researchers at top Irish universities found that most researchers see a high quality e-resources service as a necessity, rather than a luxury, and that some said the loss of such a service would be a “disaster” that would lead directly to the best researchers leaving the country.<sup>2</sup>

### **Outline of research questions**

This study set itself the task of carrying out an investigation into the changing patterns of information gathering behaviour of academic researchers in different disciplines and the ways in which these have changed in recent years. The research questions are:

- What are the important similarities and differences in how the use of e-resources has progressed in different academic disciplines?
- How important are libraries to researchers in different disciplines?
- What is the role of culture in the utilisation of e-resources in different

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<sup>2</sup> Irish Research eLibrary, 2007 p.45-46

subjects?

- What is the significance of group work and interdisciplinary work in the utilisation of e-resources?
- Is face-to-face communication decreasing in importance with the increasing amount of information available on the desktop?
- Does searching behaviour differ between disciplines?

This study is based on detailed investigations in two strongly contrasting fields; ancient history, which is a text-based humanities discipline, and chemistry, which is a large, rapidly expanding scientific field. Ancient history researchers were interviewed primarily from Manchester University and chemistry researchers were interviewed from a group at Imperial College London. For convenience the latter group, which is part of the Imperial College Chemistry Department, are referred to as chemistry researchers, even though some of them are from different backgrounds and might not regard themselves formally as chemists.

A number of aspects of information gathering behaviour in the two disciplines are investigated; firstly the starting point is the changing use of electronic resources and libraries themselves. The investigation is not concerned with the details of research projects themselves, but with information gathering behaviour and use of libraries and other information resources. A decade ago information gathering in chemistry and ancient history were both library based, they have developed differently so that now ancient history is, but chemistry is not. An examination is made into reasons for this divergence in development and the likely course of development in the future. Searching techniques are examined and their importance is discussed, principally because they are necessary for large volumes of electronic content to be utilised.

Secondly, this investigation examines the extent to which these differences in use of



electronic resources are dictated by the methodology required for research and to what extent they can be attributed to cultures embedded within different fields. For example, text-based disciplines, such as the classics, have traditionally based their research around libraries, often travelling long distances to use particular collections. On the other hand, in other disciplines, information may have more credibility if it is accessed in the most up to date format, which can be taken to mean an electronic format.

Thirdly, this study argues that the extent to which research is carried out by teams, rather than individual researchers acting alone is a major factor in how information is gathered and disseminated. The rise of interdisciplinary and cross institutional research are also having and will continue to have a major impact on the way researchers work.

Finally, this study shows that the statement at the beginning of the section, which emphasises the expectation that researchers are to be able to gather all the information they need from their desktop, can be misleading. Informal sources of information such as word of mouth communication and networking remain vital and are perhaps becoming more important. There are important continuities in research fields that have in some respects been transformed, for example, researchers who rarely visit a physical library find that informal discussions and communication within their institution are critical to their work, especially given the interdisciplinary nature of research projects in some academic fields these days.

## **2. Literature review**

There is a wealth of literature on the subjects of the traditional information gathering and research processes in different disciplines and how these are changing. Investigations have tended to focus on case studies within disciplines or on surveys of academia as a whole, rather than on comparisons between changes in different fields, but some major studies have recently been carried out by the Research Information Network (RIN) and also sponsored by the Joint Information Services Committee. Culture within a discipline is naturally difficult to systematically pin down, but valuable progress towards this has been made by Whitley, Covi, Fry and Talja.

### **Quantitative user surveys**

In the time since of studying users has been important for libraries, they have found that the only way to get a proper picture of users' behaviour and needs is to conduct large scale user surveys. These are expensive and time consuming, but they are invaluable for directing a library service. They are also extremely useful for looking at behaviour of academic researchers because they allow us to make comparisons across subjects areas based on hard evidence. In recent years system generated statistics have been able to provide a vast amount of information; the challenge is to make this information usable and there have been some excellent attempts at this.

The University of Washington Library has been carrying out large-scale user surveys on a triennial cycle since 1992.<sup>3</sup> Taking this as their model, the library of the University of Illinois conducted a three year study running from 2004 to 2006, with

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<sup>3</sup> Hiller, 2002

another cycle commencing the following year.<sup>4</sup> Given their size and high response rates, these surveys provide crucial evidence on information gathering.

The surveys at the universities of Illinois and Washington both found conclusively that researchers in the sciences had progressed much further in their use of electronic resources, especially in comparison with those in the arts and humanities. In 2001 the University of Washington found that 79% of researchers in the Faculty of Humanities and Social Sciences rated books as "very important", but that just 25% in the Faculty of Health Sciences did.<sup>5</sup> The University of Illinois Library found that among graduate and professional students 79% in the arts and humanities visited the library in person at least once a week, whereas for those in the sciences the figure was 39%.<sup>6</sup> While the use of e-resources is less dominant in the humanities, the report for the Joint Information Services Committee found that e-mail newsletters were most popular in the arts and humanities and social sciences.<sup>7</sup>

The 2006 report for by the Research Information Network (RIN) highlights some differences that can be important in forming cultures within fields. It found that almost all researches in arts and humanities were working alone, whereas in the social sciences they were almost evenly split between working alone and in teams and in the sciences a majority were working in teams.<sup>8</sup> In the life sciences the majority were researching in multidisciplinary areas, whereas in the physical sciences the majority were working in subject specific areas.

The report by the RIN stresses the importance of colleagues and other researchers in the information gathering process and quotes a number of researchers directly, the

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<sup>4</sup> Chrzastowski and Joseph, 2006

<sup>5</sup> Hiller, 2002

<sup>6</sup> Chrzastowski and Joseph, 2006

<sup>7</sup> Rightscom, 2005

<sup>8</sup> Research Information Network, 2006 p.83 - 85

vast majority of who said that personal contacts were very important to their work.<sup>9</sup> Thus it would be mistaken to think of the scientific researcher's vital skill set as being IT focused; people skills are as crucial as they have always been.

The Irish Research e-Library (IReL) is a consortium project providing an e-resources package to seven major interdisciplinary Irish university institutions.<sup>10</sup> Since it is government funded, detailed analysis of the use made of resources it is providing is vital. The IReL Impact Survey, which was researched and published in 2007 gives detailed, quantitative survey data on the behaviour and value attached to electronic resources by researchers in different subject areas. The survey collected responses to 28 separate questions from over 2000 academic researchers. Because the research is so recent and detailed it provides an invaluable source for examining the use made of electronic resources by academic researchers across a range of disciplines in a range of top institutions.

A strong majority of respondents to its survey (86% to 7%) said that the provision of IReL's service is a necessity, rather than a luxury and some said that discontinuation of it would be a major blow to Ireland's technological competitiveness.<sup>11</sup> When asked the purposes for which they used IReL services by far the most common use was for literature searching (78%), followed by selecting a journal for publication (47%) and current awareness (43%).<sup>12</sup> There is clear evidence of divergence between different subject areas: while 61% of researchers in the sciences said that they no longer need to consult the paper copies of journals provided electronically by IReL, only 34% of researchers in the humanities agreed.<sup>13</sup> Reasons for preferring electronic copies were that they are faster and easier to use, that they are easy to print and that many people

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<sup>9</sup> Research Information Network, 2006 p.95 - 96

<sup>10</sup> Irish Research eLibrary, 2007

<sup>11</sup> Irish Research eLibrary, 2007 p.8 and p.45

<sup>12</sup> Irish Research eLibrary, 2007 p. 37

<sup>13</sup> Irish Research eLibrary, 2007 p. 34

can access them at the same time.<sup>14</sup> The main reasons for preferring paper copies were that they facilitate “the wonders of serendipity in terms of finding new articles” and that they make browsing easier.<sup>15</sup>

Borrego and Urbano used log analysis to study the use of electronic journals by the Chemistry Department of the University of Barcelona.<sup>16</sup> Their most important finding is that a small number of users consume the majority of information used and a greater range of sources are used when information is obtained electronically than when it is obtained in paper form. The study demonstrates that there is potential for studying user behaviour using log analysis, but that they should perhaps be used in conjunction with user survey in order to yield conclusions that are generally applicable.

## **Qualitative and theoretical studies**

Elaine Lally’s paper gives a useful overview of developments from perspective of a researcher in the ‘interdisciplinary “new humanities”’.<sup>17</sup> She explains that, due to the use of online resources, academic subjects are not distinct in the way that they used to be and research projects are increasingly interdisciplinary and collaborative across institutions. While Lally says that this is so “particularly in the humanities and social sciences”,<sup>18</sup> the RIN report stressed the importance of this development for the sciences; in any case the rise of interdisciplinary work is of vital importance for researchers in many fields.<sup>19</sup> The amount of published research material is now so vast that it is impossible, and perhaps undesirable, for a researcher to keep abreast with it

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<sup>14</sup> Irish Research eLibrary, 2007 p. 35

<sup>15</sup> Irish Research eLibrary, 2007 p. 36

<sup>16</sup> Borrego and Urbano, 2007

<sup>17</sup> Lally, 2001

<sup>18</sup> Lally, 2001

<sup>19</sup> Research Information Network, 2007a p.40

all and this can lead to a sense of confusion among researchers. Lally also explains how scholarly communities are taking on new forms; where traditionally they tended to be based around an institution or working within a well-defined field, now they are often based around a project, a web site or around e-mail discussion lists. Like academic disciplines, they tend to be less concrete and more inclined to arise with circumstances than they were in the past.

Lisa M. Covi conducted a study where 124 researchers, from four different disciplines were interviewed in detail.<sup>20</sup> The interviews show major differences between attitudes of researchers in the different disciplines. They show how for researchers in the sciences (molecular biology in her case study) getting credit for discoveries is a major concern, in view of the pace of developments, the possibility that others are researching in the same area and competition for funding.<sup>21</sup> For scientists, then, selecting the right area for research, keeping up with any similar research and publishing findings quickly are major concerns which have spurred the use of online resources.

Covi uses the concept of 'material mastery' to explain the different information gathering behaviour in different fields and at the same time to challenge the idea that if a resource is available then researchers will use it.<sup>22</sup> She argues that "digital library use depends on more than just materials use skills; they require a match with discipline-specific skills which arise from work characteristics" and that we should consider "discipline-specific patterns of working with materials as work practices embedded in social processes".<sup>23</sup>

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<sup>20</sup> Covi, 1999 p.298

<sup>21</sup> Covi, 1999

<sup>22</sup> Covi, 1999

<sup>23</sup> Covi, 1999 p.295 and p.312

Richard Whitley's book, *The Intellectual and social organization of the sciences*, is an important theoretical work to the development of e-resources, specifically because of the 'social organisation', i.e. culture, which plays an important part in change within a field. Whitley uses the two concepts of 'mutual dependence', meaning "the extent to which a field is dependent upon knowledge produced in other fields", and task uncertainty, meaning "the degree to which task outcomes and research processes are predictable, visible and clearly related to general goals".<sup>24</sup> Thus, because the sciences have a high mutual dependence and a low task uncertainty they tend to have a stable, single paradigm, results are easy to discern and agree upon and findings can be quickly and effectively communicated.

Because Whitley's work does not specifically discuss developments in e-resources, Fry and Talja's paper "extends" his theory of organisation and culture to explain different information gathering behaviour in this respect.<sup>25</sup> They carried out seven separate case studies in traditional and newer disciplines in the sciences, the social sciences and the arts and humanities. Fry and Talja found conditions in subjects to be significantly different, to the point that "communication systems designed for one discipline can prove inappropriate for, and even harmful to, another."<sup>26</sup> They highlight the role of culture in this, explaining that "the focus on disciplinary cultures as the factor explaining differences helps us to reach a closer understanding of what lies at the heart of the shaping of the networked environment."<sup>27</sup>

Unsworth, reflecting on current information gathering in the humanities, highlights some other major continuities.<sup>28</sup> He says that browsing lists of documents, many of which may not be relevant, is useful as the unsearched for sources can often be a vital

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<sup>24</sup> Fry and Talja, 2007 p.118

<sup>25</sup> Fry and Talja, 2007

<sup>26</sup> Fry and Talja, 2007 p.131

<sup>27</sup> Fry and Talja, 2007 p.131

<sup>28</sup> Unsworth, 2000

part of the discovery process. This is the electronic equivalent of browsing bookshelves in a library and according to Unsworth it is as useful as it always has been for researchers in the humanities. This may be supported by the point made in the IReL Impact Survey that paper journals, which tend to be preferred by humanities researchers, are easier to browse and make serendipitous connections.

Traditional libraries are highly valued by research communities and can arouse feelings of loyalty. Pommerantz and Marchionini's paper, 'The Digital library as place' is a theoretical study about electronic libraries of the future that makes comparisons with physical libraries.<sup>29</sup> They take as their starting point the fact that "libraries serve more than physical need". They argue that a library will and should, at least in a conceptual sense, constitute a space, and serve the needs of a community.

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<sup>29</sup> Pommerantz and Marchionini, 2006



### 3. Methodology

This study is part exploratory and part explanatory. Exploratory because it sets itself a number of what Robert Yin terms ‘what?’ questions: ‘what similarities are there between the way that chemists and ancient historians carry out research?’, ‘what is the role of culture in the utilisation of e-resources in different subjects?’<sup>30</sup> It is explanatory because it addresses what Yin calls ‘why?’ questions, primarily ‘why has information gathering behaviour developed differently in chemistry and ancient history in the last decade?’

The intention behind this study is to discover qualitative information about the changing use of libraries and e-resources by academic researchers. Given that the study is on a small scale, the most practical way to do this is to carry out detailed investigations into two different disciplines and make comparisons between them. Another possibility would have been to investigate disciplines that are similar or related, but this would have reduced the likelihood of discovering significant differences between them or that these differences would have a relevance to academic research generally. The disciplines selected were chemistry, a well established, fast developing scientific field, and ancient history, a fairly traditional, text-based humanities discipline.

By investigating just two disciplines that are very different there was a risk that much of what was discovered would not be capable of being generalised to academia as a whole. The results and conclusion are, in fact, relevant to academic research in general and contain much that is instructive of the progress of e-resources and libraries, in ways that a study covering many disciplines could not be.

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<sup>30</sup> Yin, 1994 p. 3-6

The issues being investigated and the focus on two specific disciplines lead to the strategy of conducting surveys of a number of people working in them. This enabled information to be collected about the actual behaviour of researchers in those disciplines and about their attitudes and experiences they have had. In order to carry out this kind of survey successfully it was decided that the best technique would be to carry out face to face semi structured interviews. It was important to conduct the interviews face-to-face so that interviewees would feel comfortable and could hold good quality discussions and give their views. The questionnaire needed to be semi-structured in order that the same principle questions of each interviewee whilst also gaining opinions and attitudes from them. It was not necessary for the survey to be particularly large in terms of the number of subjects interviewed, since it was qualitative, rather than quantitative information that was sought.

## **Interviews**

The core of the study is the two in depth investigations, with a group of research chemists and a group of ancient historians. These included field visits and draw on interviews conducted with six academic researchers in each group. The interviewees include PhD students, post-doctoral researchers and lecturers of various levels of seniority. Interviews were semi-structured, with interviewees being asked the same 24 questions to ensure consistency and encouraged to give their opinions. This allowed for the interviewer to follow up interesting issues with further questions. The questions were designed to provide information on behaviour and attitudes regarding the following issues: resources used, the importance attached to different information resources, sophistication of searching and the importance attached to it, the significance of group work and interdisciplinary research for information gathering,

the importance of discussions with colleagues and personal contacts, culture within disciplines and expectations of information resource use. The questionnaire can be found in the appendix to this study. Questions 1–3 deal with use of libraries, 4–9 with information gathering from both print and electronic sources, 10-13 with use of electronic sources, 14 and 15 with searching, 16 and 17 with communication with colleagues, 18-21 with group and interdisciplinary work and questions with 22–24 deal with opinions culture within disciplines.

The interviews provided qualitative information about the changes and continuities in research. Intelligent interpretation of this information was crucial and every care has been taken to bring out meaningful patterns but not to draw conclusions that are not thoroughly supported by evidence. At twelve, the number of researchers interviewed does not lend itself to statistical analysis, but is sufficient to allow a certain amount of quantitative discovery. However, the principal strength of this study is the value of the qualitative information. The heterogeneity of the researchers interviewed and their contrasting disciplines provides qualitative insights into developments in academic communication and information gathering.

A piece of research that is based on a similar methodology to this current study is “Material master: situating digital library use in university research practices”, by Lisa M. Covi. For this 1999 study Covi interviewed in detail over 120 researchers, a relatively small number, from four different disciplines at eight American universities.<sup>31</sup> She did not attempt to draw quantitative data from the evidence she had collected, but used it qualitatively to illuminate aspects of the way research is done. In places statements are quoted directly or at other times paraphrased or summarised to illustrate a point. Covi argues that the evidence supports using her theory of ‘material mastery’ to explain different information gathering behaviour between disciplines.

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<sup>31</sup> Covi, 1999 p.298

Her methodology of interpreting statements taken from researchers in interviews to construct models for their behaviour are generally convincing and so form the basis of this current study.

## **Sampling**

The groups selected for interviews were chosen because their strong heterogeneity provides a useful contrast. Preliminary discussions indicated that researchers in chemistry and in ancient history represent almost opposite ends of the spectrum in terms of their information gathering behaviour and their use of e-resources in particular. They make for interesting contrasts because of definite differences in methodology, culture and in the volume of work being done in those disciplines. Despite these peculiarities, the findings that are illuminated in the two case studies are broadly applicable to other disciplines within the humanities and the sciences.

The two groups were selected in part for their convenience: they were both available and willing to be interviewed, each group being known to the interviewer through a main contact. The chemists are part of a group at Imperial College London and the ancient historians are all at the University of Manchester, except for one who is based at Birkbeck College, University of London. One of those interviewed as part of the ancient history group is the Academic Liaison Librarian for Classics and Ancient History at the University of Manchester as well as being a published author on Roman history in his own right. His opinions were particularly valuable since he was able to give the views both of a librarian providing resources for researchers and of an academic using those resources for research.

## 4. Findings

### 4.1 Chemistry

#### Background to the discipline

There are several basic features of the way research is done in the sciences, including chemistry, that are worth examining. The first is that researchers almost always work in groups. When drawing up questions to ask interviewees for this study it was made clear to this author that to ask members of the chemistry group whether they had any experience of doing research alone would be nonsensical for the simple reason that research is so rarely done that way in the sciences. The chemistry interviewees are all working in a group of about twenty researchers including PhD students, post doctoral researchers and a professor.

Research in the sciences is becoming increasingly interdisciplinary, both in terms of the areas being investigated and the membership of research groups; the group interviewed in this study includes chemists, biologists, biochemists, and medicinal chemists. This is part of a more general process where distinctions between disciplines have become blurred; where once they were separate entities, areas of crossover are increasing in number and importance. Hence 38% of researchers in the sciences are working in interdisciplinary areas.<sup>32</sup> Elaine Lally reflected on a time when “well-defined named disciplines gave definition to the range of literature that was relevant to any particular field of study”, however “the internet has changed all

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<sup>32</sup> Research Information Network, 2007a p.40

this. ... technological change has had most impact in the science based disciplines”.<sup>33</sup> Collaborative research projects across institutions are becoming more common, partly because the development of e-mail and other electronic communication has made it more practical and partly because certain areas have become so specialised as to require the small numbers of experts in them to collaborate.

Chemistry, like other sciences is a broad and rapidly expanding discipline. The 2001 Research Assessment Exercise found that there were 1300.2 full time equivalent staff doing chemistry research at UK universities,<sup>34</sup> but this does not include those doing research for PhDs or working in private industry, for example for pharmaceutical firms. Scientific knowledge is progressing at an astounding rate and new sub-fields are continuously being opened up. This raises issues regarding the amount of the subject that researchers can be familiar with and it is certainly the case that there are many areas they will not have such a thorough knowledge of. Due to the growth in interdisciplinary research, researchers are regularly required to become experts in areas that are outside their formal education. As an illustration of this, a researcher contributing to a discussion organised by the Research Information Network explained that scientists need to read more now than they did twenty years ago.<sup>35</sup>

Information finding in chemistry may be said to be ‘content based’. Unlike some humanities subjects the source of the information is not important, but it must be current and, it must be from reputable, peer reviewed journals. Summaries of the information are just as good as the information in its original form and can be preferred in some instances, as the popularity of review articles in medical and other sciences demonstrates.

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<sup>33</sup> Lally, 2001

<sup>34</sup> Research Assessment Exercise website

<sup>35</sup> Research Information Network, 2007b, ‘Presentations Bose’ slide 6

In contrast to the humanities, scientific researchers are relatively unburdened by teaching duties. Of the researchers interviewed, only one was involved in teaching and this was for only a few hours per week as cover for another member of staff. Generally speaking, only senior researcher scientists do significant amounts of lecturing, leaving most researchers free to focus entirely on their research. Those researchers who do teach are most likely to be tutoring or giving laboratory demonstrations for postgraduate students; a researcher with a full schedule of undergraduate teaching is rare. It has, in fact, become more common in the sciences for the two functions to be separated, with teaching and research posts being advertised separately.

### **Background to the group of interviewees**

The group, which is based in the Chemistry Department of Imperial College London, is carrying out research in the fields of chemical biology and medicinal chemistry. As such it is an interdisciplinary group with expertise spanning the entire subject, from molecular cell biology to synthetic organic chemistry. It consists of approximately twenty researchers, including two principal investigators, two post doctoral research associates and a number of PhD students. Of the six interviewees, two were post doctoral research associates and four were PhD students.

### **Major issues in information gathering behaviour**

The most striking point about information gathering behaviour in chemistry is the use made of electronic journals, online databases and other electronic resources. Specialist

information, typically in journal articles, is continually required by researchers, whether they are searching background literature or investigating specific issues with experiments they are carrying out. Information may be required to provide a general background and for specific enquiries, in which case it needs to be in depth and highly specific. What is needed, then, is the kind of information found in articles in scientific journals. Imperial College Library subscribes to many hundreds of scientific journals, both in print and electronic format, resulting in availability of an enormous archive of historic literature and thousands of new articles every month. The challenge for the researchers is to find the articles with the information they need whilst expending as little time and energy as possible. Virtually all of this kind of information that could ever be required is now available from the researcher's desktop, to a degree that it was not even three or four years ago.

Corresponding to the increased use of electronic resources is a drop off in visits to the library itself. Although the research group is based less than a hundred metres from Imperial College Library, they very rarely have occasion to go there. Some had never been there; the most common response was that they went once or twice per year. The most common reason was to find a journal that was not available electronically, perhaps because it was too old or was too obscure to have been digitised.

The changes described have occurred very recently; one post doctoral research associate described making regular visits to the library as a student less than a decade ago. One PhD student said that two years ago, as a postgraduate student, the first port of call for her group when finding information had been the library, where now it is the desktop.

All the researchers interviewed spend a large portion, up to 50%, of their time finding information related to their research. This information is searched for and



disseminated via the researcher's desktop. The need for research information varies a great deal depending on the stage that a project is at. It is most heavily used during the early stages when the subject is being explored as a large amount of literature must be surveyed during this period. Later, when the focus is on experiments in the laboratory, a smaller amount of information is needed, but it will need to be very specific to deal with issues arising from the lab work.

The interviewees are aware that their electronic resources are nearly all provided by the library. Therefore one might make the distinction that while researchers rely on the library's services as much as ever, they hardly use its physical space or stock at all.

The scientists interviewed for Lisa M. Covi's study, who were molecular biologists, reported being under pressure to publish their results as soon as possible to ensure that they get credit for them. This is not an issue for the group at Imperial College London; although they are under pressure to publish material, there is not specific timing pressure. One of the group confirmed that in other scientific disciplines which are developing faster and which are generally more competitive, there could well be pressure for the timing of publications.

## **Searching behaviour**

There are some features of online searching by scientific researchers that are worth examining because this represents an innovation that facilitates the surge in electronic resources generally. The techniques and tools used for searching need to be sophisticated because of the amount of information that is out there on databases, in journals and on the internet and because of the specificity that researchers require.

The vast majority of research related information that researchers need is in scientific journal articles retrievable on databases. There are two main ways for searching these; the first is the text based search string used for searching the majority of databases. The most commonly used databases of this type are ISI Web of Science, which covers almost all scientific topics, and PubMed, which is more specifically useful for medical and biological topics. The choice of database used depends on the subject being researched and also on the background of the researcher, since most researchers tend to stick with the resources they are comfortable with. Of the two post doctoral research associates, for example, the one from the biochemistry background predominantly uses PubMed, while the one from the chemistry background tends to use Web of Science or SciFinder.

The researchers are able to search competently and all are able use long, specific search strings and to go through the process of broadening and narrowing their searches. Often, though, it is not necessary to do this as their subject terms are sufficiently specific that little refinement is needed. Half of the interviewees regularly use Boolean operators when searching and half do not.

The second method for finding useful information on databases is diagrammatic searching. SciFinder is a tool which allows the chemical abstracts database of the American Chemical Society to be searched using diagrams representing molecular structures. It is not the only such system, for example Beilstein has been developed in Germany, but it the one that is heavily used by the researchers at Imperial College. To use SciFinder one draws a molecular structure using the SciFinder software and uses this as a search term. This is possible because every item on the American Society of Chemistry's database of abstracts has been catalogued with diagrammatic

representations of the formulas involved. It is also possible to search for particular reactions on SciFinder and figures 1 and 2 show how this is done.

The searching that SciFinder allows is important for several reasons; firstly it provides a means of diagrammatic searching in a subject which can be very visual and where words often are not sufficient to represent issues. In this respect SciFinder performs a function that was not in any way possible prior to the growth of electronic resources generally. Secondly it responds to the demands placed on searching tools by the sheer volume of electronic material that is available for researchers in the sciences. Thirdly, it allows a higher degree of specificity than text based searching alone, which is important in an area that is expanding rapidly and in which new sub-fields continue to develop. These kinds of searching techniques make the expansion of e-resources practical; without them there would be a huge amount of digital information but no way to effectively retrieve and thus utilise it.

All the researchers also make extensive use of internet search engines, which can provide them with source of information when they need basic information on new topics and may also provide them with ideas when they are having trouble finding relevant information. This is especially useful when using college computers because when an article is found that is available in full text through one of the college's subscriptions the searcher can click on the link and be taken straight to the full article. Thus a search engine like Google Scholar is effectively used to search all sources for full text articles.

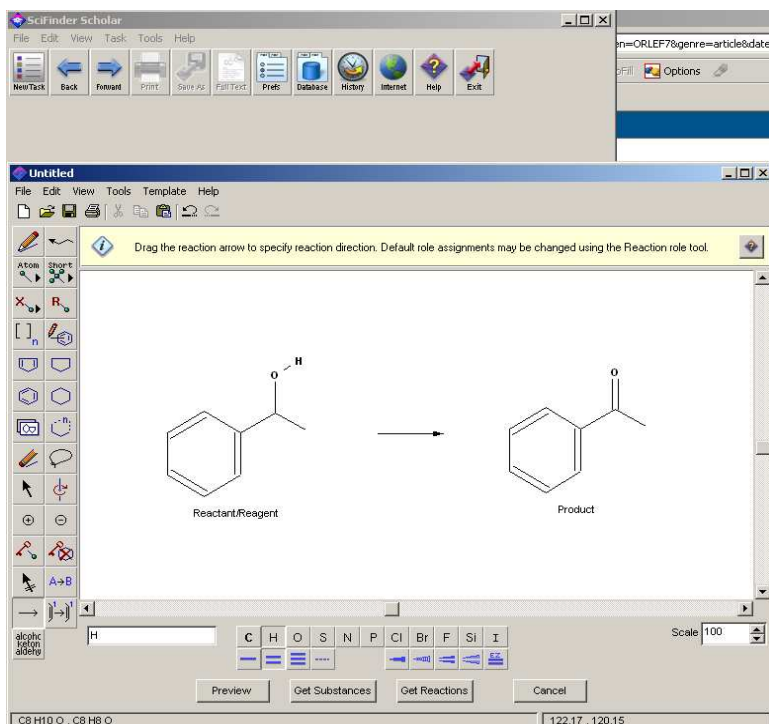


Fig. 1. A search is constructed using the drawing tools on the left of the box<sup>36</sup>.

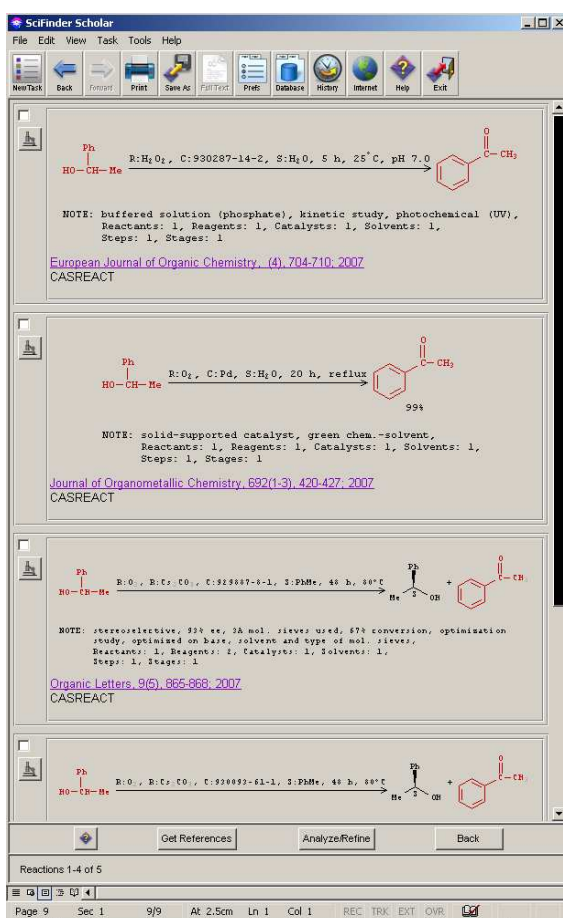


Fig. 2. Results are returned showing articles incorporating the reaction<sup>37</sup>.

<sup>36</sup> SciFinder

## **Keeping abreast of new developments**

Keeping up-to-date with new developments in their field, which may not be directly related to research they are currently carrying out, is vitally important to scientific researchers. Some estimated that they spent 20% of their time, the equivalent of one day a week, doing this, although for others, particularly PhD students, spending time on this is a luxury which they can afford only irregularly. The importance given to keeping abreast of new developments is partly a reflection of the rate at which knowledge is expanding. While this makes it impossible for one individual to read every relevant publication or to know about everything that is going on in their subject, it is important to be aware of major developments.

Given the time constraints and the volume of material, reviewing new literature can only be done via electronic sources; using print materials would be more time consuming in any case, but electronic sources can be searched for particular words and allow news to be delivered to researchers in convenient forms like RSS feeds and e-mail alerts. Of the researchers interviewed all keep up with new developments in their field purely via electronic media and one gave her main means of doing this as a quintessentially modern format, namely podcasts. For all the increased efficiency of using electronic sources to keep up with new developments, one post doctoral research associate sounded a cautionary note. He pointed out that the electronic resources that give such a high levels of specificity in current awareness mean that researchers are not browsing journals and keeping aware of general new scientific developments which could be invaluable to them.

A further, collaborative, means of keeping up with new developments are 'lit talks' that are given periodically by members of the group. Researchers select a piece of

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<sup>37</sup> SciFinder

new research of general interest and give a presentation on it to the rest of the group. These can be useful because they allow the task of keeping up with new development to be done collaboratively and via discussions and because they give insights into the different areas of other members of the group.

## **The significance of working in groups**

During the interviews the majority of chemists said, when asked, that working in a group has an effect on the way they get information and there is no doubt that this is the case. As they said, information and new ways of working flow quickly between group members. Physically most members of the groups have desks in the same room and are therefore working in close proximity to each other every day.

All of the researchers regularly discuss their work with their colleagues and there are many projects going on in the group. This situation tells us that working in the group is likely to increase researchers' general awareness of the subject and is an important information resources in itself. One researcher commented that her interests were broader as a result of the group that she works in.

Another researcher agreed, but said that it was not the size of the group that was important but the quality of the discussions that take place and the variety in backgrounds and research interests of its members. This opinion was based on the fact that she also spends some of her time in another group which does research purely in biology and she found working with the interdisciplinary group to be more informative.

Group work, particularly if it is interdisciplinary, represents an information resource in itself for researchers. It also encourages the use of a diverse range of resources, for example several of the researchers mentioned websites that they have shared with each other. The physical proximity of researchers means that they are aware of how others are working and what resources they are using. The possibility for a researcher to become seriously out of touch with information resources that are being used does not really exist; they will always know about new information tools and will have the opportunity to discuss them with colleagues

### **Culture within the subject**

When looking at how new opportunities are responded to it is always relevant to look at the culture of the groups involved. Interviewees explained that there are not particular information finding resources that they are expected to use. A comprehensive bibliography is expected for any piece of research and many sources are, for practical reasons, now only available at Imperial College electronically.

Chemistry is a subject that has largely made a transition to using digital information sources. This makes it different from newer subjects such as computer science which have never been entirely paper-based and whose information sources were 'born digital'. Scholarly communication in chemistry, therefore, is predominantly digital, but its patterns and culture reflect those of a few decades ago when it was paper based, for example with peer reviewed journals being the custodians of information on new research and researchers having to wait for new volumes.

## 4.2 Ancient historians

### Background to the discipline

Of the notable features of academics involved in ancient history, some are common to the humanities in general, while others are peculiar to ancient history. One feature that is common to nearly all disciplines in the humanities is that research tends to be carried out by individuals, rather than by groups. This in part is due to the nature of the materials being investigated; archives are searched, documents are interpreted, and arguments made by single researchers without any need for a team to share the workload. It is the norm throughout the humanities for research papers to have only one named author, unlike the sciences and the social sciences where it is not unusual for a paper to have five or six named authors. Of the researchers interviewed for this study, most had at some point worked with other researchers for limited periods of time on, specific projects, such as conferences and particular publications.

Interdisciplinary work is of little importance for research in ancient history. Some of the interviewees had worked on projects with academics from other disciplines, for example one was working with a specialist archaeological illustrator for a publication, while another, who specialised in Roman social history, had once worked on a project with some modern demographers. In this kind of interdisciplinary research there is little cross over between the disciplines, with each researcher sticking to their own area. Thus the demographers focussed on their part of the project, while the ancient historian focused on his. It can be said, then, that group work and interdisciplinary work, while they do exist for ancient historians, do not significantly affect their information needs or their information gathering behaviour.



The vast majority of researchers in the humanities have a busy teaching schedule. In this study even the PhD student regularly gives seminars and tutorials, something that would be unheard of in the sciences. This affects their research behaviour in so far as it means that they are focussed on research for only part of the year. When questioned about many of their information finding habits it was common for there to be two answers; one for term time, when they concentrate on teaching, and one for outside of term time, when they concentrate on research.

Ancient history is a relatively small subject area, both in terms of the number of people working in it and the amount of research being done. The 2001 Research Assessment Exercise found that there were the equivalent of 346.5 full time staff working in all of the classics, ancient history, Byzantine and modern Greek studies departments in UK universities, as compared to 858.8 in Sociology and 1300.2 in chemistry.<sup>38</sup>

One feature of ancient history research that is common to other humanities disciplines, but to a much lesser degree, is the level of specialism of some researchers. Some work in areas on which only a handful of other people are actively working. One of the interviewees, for example, is researching the Roman military in northern Britain. This is a subject so small that he might reasonably expect to read all new academic publications and be personally acquainted with all other researchers. Naturally he will also need to keep up with new developments regarding Roman history generally.

While the new research being done in ancient history is undoubtedly important, the pace of the expansion of knowledge could be reasonably said to be slow relative to

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<sup>38</sup> Research Assessment Exercise website

that in other subjects. In terms of new developments that researchers need to know about, there are very few of the new discoveries that periodically occur in the sciences, nor are there new areas of study opening up, as happens in the social sciences. Occasionally new archaeological evidence comes to light, or modern statistical methods may throw new light on social issues in the ancient world. Of more significance may be new perspectives on old issues; for example a researcher would certainly need to know about a work on how nineteenth century conceptions of race affect our views of ancient Greece.<sup>39</sup>

One thing that sets ancient history apart from the vast majority of other subjects is the extent to which knowledge is ‘text based’. Research is done by studying ancient texts, inscriptions or artefacts, and developing interpretations and arguments from them. For a fairly basic level of study this means that certain well-known texts need to be read. For example, someone studying ancient Greek political or military history is expected to have read Thucydides’ *History of the Peloponnesian War*, a summary will not do: the actual text in its entirety needs to be read. When doing research knowledge comes from studying texts, which may be obscure and, as we shall see, researchers are prepared to make sacrifices to consult them. Other text based subjects include philosophy, English literature and, to some extent, modern history. Naturally, these subjects have traditionally been based around libraries, both for research and for teaching purposes.

## **Background to the interviewees**

Of the six ancient history researchers who were interviewed, four work at the Ancient History department of Manchester University, one is the Academic Liaison Librarian

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<sup>39</sup> Bernal, 1991

for Classics and Ancient History at Manchester University Library and is a published author on Roman Britain and the other works at Birkbeck College at the University of London. All except for the librarian are involved in teaching; one of them is a professor, one is a PhD student and the others are lecturers. Their specialisms cover social, political, cultural and military history of ancient Greece and the ancient Roman world. Four of the interviewees specialise primarily in ancient Greece and two primarily in the ancient Roman world, although there was no significant difference between the behaviour and the attitudes of the researchers depending on their specialisms. As we shall see, they collaborate at times, but none of them could be said to constitute a team in the way that scientific researchers do.

### **Major issues in information gathering behaviour**

The number of visits made to libraries is quite variable, both between individual researchers and between times of the academic year. This, however, belies the importance attached to libraries as institutions and their central role in research done. Emphasising the effects of their teaching schedule, interviewees stated that they visit a library between once a fortnight and three times a week during term time and between every day and once a week outside of term time.

Researchers are quite prepared to travel long distances to use libraries and archives with special collections. Several of them have regularly used the libraries of the British School at Athens and the American School of Classical Studies at Athens and in some cases this had been the primary or only reason for making a trip. Most of the researchers often find it necessary to travel to specialist libraries within the UK, such as the British Library and the Institute of Classical Studies in London and the Bodleian in Oxford. They try to combine these visits with other things they need to

do, but often even if they had not other purpose for their trip it would ultimately be necessary for their research.

The central role traditionally played by print material in libraries and archives in ancient history is partly a reflection of the text based nature of the subject. It is also a result of the culture within the subject, which one interviewee described as 'bibliophile'. The methodology in the discipline, which is part of its strength, will be returned to later. In any case, the way researchers work has changed in recent years.

### **Increasing use of electronic resources**

There are three main types of electronic resources that have increased the speed and efficiency with which ancient history research is done; firstly electronic journals which make information immediately available on the desktop. Secondly, online databases have made it possible to find information in a fraction of the time it could previously have been found, if at all. Thirdly, the digitisation of materials in specialist libraries and archives has limited the amount to which travelling long distances to access resources is necessary.

The use of electronic journals and online databases for searching has changed work that is being done in ancient history. The Ancient History Liaison Librarian and Manchester University confirmed that they have switched their subscriptions for many journals from the print edition to the electronic edition only. This means that academics are using those journals entirely from their desktops and are saving themselves time in doing so.

Specialist online databases have made certain information much more readily available than it would be without them, if it could be found at all without them. The Oxford Dictionary of National Biography online and the National Archives online are examples of resources that provide instant access to extremely useful information. The fact that the electronic versions are keyword searchable makes them even more valuable. Other vitally useful searching tools include the Thesaurus Linguae Graecae,<sup>40</sup> which searches ancient Greek texts, and the index of the Packard Humanities Institute,<sup>41</sup> which searches inscriptions. Between them these allow researchers to search for any word or phrase from ancient Greek literature and inscriptions, whether obscure or well known and locate it in context.

An increasing amount of material at the kind of specialist libraries that ancient historians travel to is being digitised and made available online. This is happening slowly and unevenly; for example, while the American School of Classical Studies at Athens has a major project to make large parts of its collection available to remote users,<sup>42</sup> the British School at Athens has no comparable plans for its collection.<sup>43</sup> There can be problems with digitised versions of documents; one researcher, for example, complained out that the Packard Humanities Index does not include physical descriptions for its inscriptions, so if they are central to a research project then one may need to go and study the originals first hand.

The picture that emerges is that more commonly used material is largely already available online, but more obscure material is not. Researchers largely agreed that for producing original research it will always be necessary to travel to special libraries and archives, but that for non-original research, like commentaries and editing work, the material they need will be available online. The effect of electronic resources on

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<sup>40</sup> Thesaurus Linguae Graecae website

<sup>41</sup> The Packard Humanities Institute website

<sup>42</sup> The American School of Classical Studies at Athens website

<sup>43</sup> The British School at Athens website

ancient historians has been quantitative, rather than qualitative; certain work has become faster and more efficient, but the way things are done has not changed.

## **Searching and browsing**

The searching behaviour of ancient historians is a little different from that of researchers in many other subjects and this is largely because of the nature of the subject. When searches are performed they tend to be fairly simple; most of the researchers interviewed never use Boolean operators. Often keywords, especially in Latin or Greek are sufficient to retrieve the desired results. More important is the fact that researchers have much less need to perform searches at all than do their equivalents in other subjects. They normally know the item they are looking for before they run a search so there is little need for sophisticated searching strategies. If they are looking for an item that they found as a reference, which is very common, then they already have full details of it. This is partly a result of the relatively small size of the subject. Unlike some of the sciences, a single researcher may be able to keep track of the main developments and authors in a given area.

There is some variation in the amount of time spent on and the methods used for keeping up with new developments in the field. Some researchers do this using entirely electronic sources, while others use entirely print materials. The majority said that one way they keep up is by reading book reviews. This is something that was not mentioned at all by the groups of chemistry researchers who were also interviewed; for them the volume of publications is too great to try to read about each new book. In ancient history the volume of publications is far more manageable and highly advanced searching is not vitally important for these researchers.

Some of the researchers said that they can find it useful to browse the books on library shelves, although they do not do any kind of electronic equivalent of this. This kind of browsing can be productive partly because, as discussed, the subject area is relatively small and partly because it is the kind of subject where useful connections may be found by the human searcher in seemingly unconnected sources. This use of resources requires time on the part of the researcher and is particularly suited to print material. The strategy of browsing, then, remains much more popular among ancient historians than it does among researchers in most other subjects.

### **Issues with non-Roman fonts**

As we have seen, the uptake of electronic resources by ancient historians has been relatively slow and this is largely due to the nature of the subject and its methodology. The role of culture within the subject will be looked at later. One major factor that has made use of e-resources problematic in the past is the issue of Greek fonts. This used to be an issue for any institution in the English speaking world. A piece of software was used that allowed users to represent Greek letters using a coding system.<sup>44</sup> In the last year or so this whole issue has now been essentially cleared up by the use of Unicode for all fonts.

The issue of fonts meant that in the 1990s and early 2000s, while other subjects were becoming highly electronic and online in their resources, ancient history remained predominantly print based in its information sources and its scholarly communication. It has left some of the researchers who were interviewed with the belief that there subject is not suited to the electronic format and therefore that it will always be based around print material.

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<sup>44</sup> Silver Mountain Software website

## **The significance of working individually**

The interviewees had different views about the effects of their working primarily alone, but the majority agreed that it is a major factor in the way new resources develop and are utilised, certainly as compared to the dynamic among researchers working in groups. The survey of researchers showed that new ideas and new information spread more slowly among staff working as individuals rather than as a team. This is especially so where, as we have seen in ancient history, the field is not progressing particularly fast and researchers have the option of working as they always have done. Researchers occasionally work in groups for specific projects and these are usually with other ancient historians, hence the influence of others on their working styles is limited and the influence of others from outside their field is very small. Some of the researchers stated that the e-resources that they regularly use are things that they had found for themselves, while current students are shown how to use them and researchers in groups would share new resources and techniques between each other.

One researcher commented that working individually makes the behaviour of ancient historians “more predictable” as they tend to follow the same patterns throughout their careers. Another researcher explained that they can get “isolated”, but that this was not the case in the department at Manchester University because the staff are “young” and “collegial”, which is good for general motivation. He said that he did have experience of other ancient history departments which were not generally as friendly and staff becoming isolated and de-motivated could be an issue. Another researcher went so far as to say that working alone “introduces the risk of becoming blinkered” to new resources.



It is clear that the researchers who were interviewed had developed their skills with the information resources of their subject to an extremely high degree. They also each have an excellent command of their own subject areas, in which there are few other researchers working. With a high degree of expertise in such specialised areas, individuals working in their own way do not feel a great need to take on new ways of working and the uptake of new information resources is relatively slow.

### **Culture within the subject**

There are important methodological and technological reasons why the use of electronic resources is less widespread in ancient history than in many other academic subjects. The use of new technology is always shaped by individuals and communities and the uses they put it to.

There is an expectation on ancient historians doing research that they will travel to the part of the world they are studying to examine relevant items first hand. This is so even where the events in question took place over two millennia ago and relevant sources are available electronically. One of the interviewees explained that she and another researcher had “been gossiping about a particular colleague who does Greek History and yet he’s never been to Athens”, and that this is “frowned upon”.

The willingness of researchers to travel long distances to refer to specific material show how central the written word is to their projects. One interviewee described this preoccupation as a “fetish”, but also pointed out that some electronic resources have certainly been embraced. Electronic resources are being in used in such a way as to make traditional, bibliophile ways of doing things more efficient, rather than having significantly changed those ways of doing research.

## **5. Discussion and analysis**

### **5.1 Comparison between the two groups of researchers**

It is worth considering the similarities and differences between the two groups of researchers since some are more important than others. A decade ago information gathering in both subjects was library based and developments in the last decade have strongly diverged. Chemistry researchers use online database and e-journals to gather information from their desktops. Ancient historians, on the other hand, make use of these resources, but continue to use libraries as the focus for research and teaching and are prepared to go to some lengths to use them. It might be surmised that in chemistry it is expected that information will come to the researcher, while in ancient history researchers still often expect to go to the information.

It is tempting to ascribe difference in development to the fact that ancient history is essentially text based, whereas knowledge information gathering in chemistry is content based. However, this does not explain the issue, because ancient texts can be digitised and made remotely available just as scientific journals can, so there are further factors to be explored.

The two subjects operate on vastly different scales; chemistry has over four times as many full time staff in universities as ancient history and related subjects do and this

is without including chemistry researchers working in industry.<sup>45</sup> Levels of funding and the volume of publications are similarly much greater in chemistry. The pace at which knowledge is growing in the two subjects is extremely different. New knowledge in chemistry is expanding very quickly, certainly too quickly for one researcher to keep up with everything. In ancient history, while genuine new discoveries are extremely rare, there are periodically new arguments and interpretations that researchers must keep up to date with. These, however, are on a scale that an individual researcher in a particular area can reasonably keep up with.

One result of the difference in size of the subjects and in the rate at which knowledge in them is growing is that their researchers have very different searching needs. All of the chemists have a real need for sophisticated searching in order to find the material that they require. This includes the ability to search using diagrams of molecular structures as search terms. Without these kinds of searching techniques the expansion of e-resources would be in vain for the chemists; they would have a huge volume of information at their disposal, but would be unable to retrieve the items they require. The searching behaviour of the ancient historians stands in contrast to that of the chemists; in fact the most striking issue here is that many of them have little need to run searches at all. They usually know exactly what it is they are looking for since they usually find their sources in references in other articles. Their fields are usually small enough that they can keep track of major new publications themselves.

There are very different human dynamics between research projects in chemistry and in ancient history; firstly because chemistry research is done in groups, whereas ancient history research is overwhelmingly done by individuals. Where ancient historians do carry out research in groups, they are small – usually of two or three people and on specific projects for limited time periods. The majority of researchers

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<sup>45</sup> Research Assessment Exercise website

interviewed from both groups believed that this is an important influence on their behaviour.

Secondly, the groups that chemists work in are often interdisciplinary; hence a typical chemistry research project will receive input from a number of researchers from different scientific backgrounds, while the typical ancient history research project receives significant input from one researcher working alone.

Thirdly, while very few chemistry researchers teach, all except a few ancient historians spend a large proportion of their time involved in teaching and at certain times of year devote all their time to it. The picture that emerges is of ancient historians working alone and spending a lot of their time teaching, while chemists work in groups, devoted entirely to research projects which are often interdisciplinary. These patterns are important because they help foster the culture and attitudes within the subjects.

There are, of course, many other relevant factors in such a major development as the use of electronic resources. One of these is the technical issues with Greek fonts. This has now been effectively solved, but it did represent an impediment to the digitisation of scholarly communication in ancient history. One might consider, though, that chemistry researchers, with a more enthusiastic attitude to new technology and with the aid of the pharmaceutical industry, have been able to represent and run searches on molecular structures for a decade. It seems to be more than technical factors that made use of the Greek alphabet problematic until about a year ago.

One suspects that one of the most significant factors in the relatively slow uptake of electronic resources in ancient history is an attachment to established ways of doing things and to valuing particular aspects of the research process, namely field work.

This signifies the role of culture with academic communities, which is a subject that warrants further investigation.

## 5.2 The role of cultures within disciplines

Communities that live or work together invariably have their own ways of doing things and their own view of themselves. This constitutes a culture and it is important here because it determines how change is responded to. Crucially, small groups, such as the team of chemists at Imperial College London, also have their own group culture.

All of the ancient history researchers interviewed stated quite definitely that their subject has a culture of using libraries. The methodology of the subject attaches great importance to use of original sources, which are their point of contact with the ancient world. There is an expectation that researchers will consult these sources, which often means travelling long distances to them, in order for their research to have credibility. The development of new technology has raised the possibility of original sources being accessed electronically, as digital representations of original documents. These possibilities have not been fully realised, one impediment is that, for largely financial reasons, there is a lack of material that has been digitised. Another reason is the cultural factor; that researchers conceive of the research project being always done in the accepted form. Hence, one researcher's view that ancient historians make a "fetish" of using paper material in libraries and archives. Another example of this attitude is the complaint from a small number of researchers made to the Ancient History Librarian at the University of Manchester that resources were being lost when journal subscriptions were switched from print to electronic copies.

Chemistry researchers are taught to search through literature relevant to their research; missing out an important piece of information could cause severe problems in a research project. It is not considered important what means are used for accessing

these sources of information and interviewees felt that the choice of resources that can be accessed from their desktops is purely a practical one. Researchers who were interviewed stated quite definitely that chemistry did have a culture of library use prior to the development of e-resources, but were more equivocal on whether it does now.

From the above it could be suggested that chemistry does not have a distinctive culture in the sense that ancient history has. However, there are a number of important features that relate to the collaborative and interdisciplinary nature of a lot of work and these are exhibited well by the group at Imperial College London. While virtually all scientific researchers work in groups, not all groups work in close cooperation, nor do they all include members from different backgrounds, as the group in this study does. Within the group there is a culture of collaborating and sharing information with others and an acceptance that the way they work is open to change. There could be seen to be a focus on information sources that are quick to use and are in the most up-to-date format. Unlike the small minority of ancient history researchers who complained to their librarian about the loss of print journal subscriptions, the chemistry researchers would certainly complain if they now had to go to the library to access journals.

Lisa M. Covi argues for the importance of skills that researchers acquire and the concept of ‘material mastery’ when looking at changes in academic disciplines.<sup>46</sup> She argues that “digital library use depends on more than general material use skills; they require a match with discipline-specific skills which arise from work characteristics.”<sup>47</sup> This idea seems to explain some of the idiosyncrasies of the development of e-resources in both chemistry and ancient history; both have distinctive work characteristics which give rise to highly developed discipline-specific

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<sup>46</sup> Covi, 1999

<sup>47</sup> Covi, 1999 p. 295

skills which have influenced their responses to new technologies that have become available.

Covi's paper is highly relevant because it places a strong emphasis on the social aspects of different behaviour of in researchers in different disciplines, something the evidence in this current study certainly supports. However, while Covi explains these primarily as functions of the different methodologies in each subject, the attitudes of some of the researchers interviewed shows that there are a variety of other factors, that there is such a thing as culture and that it is a major factor. The interviews show that a culture, having become embedded in a community can take on a power of its own, regardless of how it came to be established.

Fry and Talja's paper, which develops Whitley's concepts of 'task uncertainty' and 'mutual dependence' in academic disciplines, supports the importance of the role of culture in the development of e-resources.<sup>48</sup> Ancient history has a low 'mutual dependence', because it is relatively independent of research done in other fields, and a high 'task uncertainty', because research is within less clearly defined parameters than in other subjects and its goals can be conceived in a variety of ways. Thus researchers tend to pursue separate interests and work individually or in loose groups, procedures may vary between researchers, writing styles tend to be narrative and research projects are 'topic oriented', rather than 'tools oriented'.<sup>49</sup> Research in chemistry, on the other hand, has a high 'mutual dependence', because it is always related to the findings of other research, and a low 'task uncertainty', because it has goals that are clear, predictable and related to general research goals. Thus the discipline has a single, stable paradigm, there is little attempt to address wider audiences, research tends to be 'tools oriented', is in done by closely coordinated

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<sup>48</sup> Fry and Talja, 2007

<sup>49</sup> Fry and Talja, 2007 p.118 - 120



groups and can be communicated with short esoteric language and symbols.<sup>50</sup> As Fry and Talja note these features help to build cultures within disciplines and are able to conclude that Whitley's theory enables them to "treat communication fora and a field's cultural identity as mutually shaping and inseparable."<sup>51</sup>

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<sup>50</sup> Fry and Talja, 2007 p.118 - 120

<sup>51</sup> Fry and Talja, 2007 p.131

## 5.3 Financial factors

An issue was not specifically raised by any of the researchers interviewed but that must be significant in implementing any new change is money. While ancient history departments are not specifically under-funded, institutions in the discipline certainly have fewer resources to develop new technologies than do those in the sciences and this has almost certainly been a factor in the uptake of electronic resources. For example, the British School at Athens does not have a programme underway to digitise its collection and make it remotely available,<sup>52</sup> whereas the American School of Classical studies, with a different source of funding does.<sup>53</sup>

The funding of university chemistry departments varies a great deal depending on their success in government Research Assessment Exercises and on their connections with industry. The chemistry department at Imperial College London is well funded, with staff salaries being higher than at other institutions, even in London. While certain chemistry departments may be under funded, chemistry as a field is well resourced, both by government and by industry and has money available to invest in new developments. It is almost certain that an internationally important resource, such as the collection of the British School at Athens represents, would be digitised and made available remotely if it were in chemistry.

Some of the tools used by chemists were developed in large part for use by commercial and industrial researchers. SciFinder has many commercial uses, such as the ability to search through information in patents, which are hardly ever used by academic researchers. In the UK industrial chemistry is dominated by the

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<sup>52</sup> The British School at Athens website

<sup>53</sup> The American School of Classical Studies at Athens website

pharmaceutical industry, which is able to invest in the latest products for information management and, both directly and indirectly, provides much of the funding for chemistry research in universities.

## 5.4 Importance of personal contact

Personal contacts and face to face communication are vitally important resources for all academic researchers and their significance has changed somewhat in ways that illustrate changes in information gathering behaviour. To discuss the importance of personal contacts might be felt to be stating the obvious in a sector that operates around social networks, but the differences in the behaviour of researchers in different disciplines makes such a discussion very worthwhile.

All researchers interviewed agreed that they regularly discuss issues in their research with their colleagues and that this can be very important. The stated reasons for doing this, however, differed between the two groups. The single most commonly given reason by the group of ancient historians was for finding pieces of information that they were unable to remember, such as an author's name or a historical source. This was followed secondly by consulting a colleague when doing research in an area where they have expertise and then thirdly by discussing a list of sources for a particular topic.

For researchers in the chemistry group the only important reason for discussions with a colleague was when doing work in an area where they have expertise. This has different implications to the ancient historians discussing issues with colleagues who have expertise in that area, mainly because the chemistry group is interdisciplinary and so they have more widely differing backgrounds than the ancient historians. Unlike the ancient historians, the chemists regularly work outside their own specialist areas. In situations where, for example, a researcher from a pure chemistry background needs some simple biological information, there is no shame in discussing even fairly basic issues with a colleague and this can be very useful. The

interdisciplinary research group may be seen, ideally as a group of experts who work together, helping and consulting with each other

Several chemistry researchers commented that these kind of discussions are good for the team. None of the ancient historians referred to this, nor would they because, as discussed earlier, they don't do research as a team, but as individuals. It would seem, then, that since the chemists work in a large, interdisciplinary team, personal communication is a necessity, whereas for the ancient historians it is more of a luxury.

It is also worth noting that the scientific researchers did not mention discussions with colleagues for important pieces of information that they could not remember or for lists of sources in a particular field, as the ancient historians did. The sophistication of the searching used by the chemistry group should mean that being unable to remember specific information is rarer and can be solved when it does occur. Using particular sources is not so important in chemistry, since it is not a text based subject, but even here researchers generally feel that their searching can retrieve all relevant literature.

While for the modern scientific researcher the availability of resources on the desktop has all but eliminated the need to visit the library, they have not decreased the importance of personal contacts and face to face discussions as an information resource. These have, if anything, become even more important as research and the teams doing it have become increasingly interdisciplinary. This makes communication skills and a cooperative atmosphere among staff important for good information gathering.

One of the post doctoral research associates explained that in some research groups that work in only one field, each member might be working relatively independently

and so “interpersonal skills wouldn’t really be important at all”. These skills were something that were specifically looked for when he applied for his post. Thus the image of the researcher dependent on their computer for information is a false one; their work is social and communicative. As research becomes more interdisciplinary, this can be expected to become more accentuated, at least in subjects where collaborative research is the norm.

## **5.5 Likely future developments**

In the mid 1990s information gathering for chemistry and ancient history, like academic research as a whole, was library based. Research in many subjects has been transformed in the period since then, while research in other subjects, such as ancient history, has not. There are a number of reasons for thinking that over the next few years the use of e-resources in ancient history will change the way that information is gathered, as they have done in other subjects. However, there are also some quite convincing reasons for thinking that it will not transform the subject and that the expected norms for finding information will remain broadly the same.

### **Issues in ancient history**

The problem with using Greek fonts on computers did present an impediment to the use of e-resources by ancient historians. Until around a year ago it was necessary for researchers to use a code to enter the Greek alphabet on the computers. This issue has been solved and the Greek alphabet can now be used on British computers without any problems. It remains to be seen whether this will lead researchers to make greater use of e-resources or help to change the attitude that the subject is better suited to paper based communication. It was only an issue for research into ancient Greece; for research into the Roman world the problem did not arise. The information gathering behaviour of those doing research into ancient Rome was not significantly different from those researching ancient Greece, so it seems likely that the removal of this obstacle will not have a major impact on the ancient history.

Texts that ancient historians use are being digitised and, in fact, all commonly used texts are already available to researchers online. The Thesaurus Linguae Graecae, provided by the University of California, Irvine, supplies a subscription service that “has already collected and digitized most literary texts written in Greek from Homer to the fall of Byzantium in AD 1453. Its goal is to create a comprehensive digital library of Greek literature from antiquity to the present era”.<sup>54</sup> The Packard Humanities Institute provides a similar service for ancient Greek inscriptions.<sup>55</sup> The fact that the full text of all items in these databases is searchable adds enormously to their usability. Thus the researchers have much less need to travel to their research material than previously.

However, digitisation has only been completed on more commonly used material and in the opinion of most of the researchers interviewed the kind of texts and inscriptions used in their research are never likely to be digitised. Material that is available on online databases is of the kind is used for researching editorials, commentaries and for teaching purposes. For carrying out original research a much wider range of material is needed, much of which is kept in libraries overseas. Researchers believe that these resources will never be digitised quite simply because it will never be worth anyone’s while to do it; the collections are not especially heavily used, there is little significant financial backing for projects in the field of ancient history and the current system, where researchers travel to the collections they need, works.

Another reason why increased digitisation of resources is unlikely to change entirely the way that ancient historians work is the desire to connect with their sources first hand. Historical knowledge derives from sources, so it is important to know those sources as well as possible; the researchers interviewed felt that a digital representation cannot compare to the document or artefact itself. This is especially so

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<sup>54</sup> Thesaurus Linguae Graecae website

<sup>55</sup> The Packard Humanities Institute website



when, as is sometimes the case, digital documents do not give all the required information, for example they may give a physical description that is incomplete.

The expected norm for information gathering and research in ancient history will continue to be, as it has been, that the researcher will visit collections, often in distant libraries and archives, in order to consult historical sources first hand. The means for finding information on resources will be made vastly more efficient by the use of bibliographic databases and online catalogues. Information gathering for work that is not entirely original, such as commentaries and editing work will become far quicker and more efficient as more important documents are digitised and made available online. Original research, on the other hand, is always likely to require visits to remote collections.

## **Issues in chemistry**

The information gathering behaviour of chemistry researchers has changed a great deal in a short period of time. There are some new pieces of technology that are starting to make an appearance among researchers, although they are highly unlikely that behaviour will revolutionise to the degree that it has over the last decade.

Electronic lab books and logging systems for use when researching and recording experiments are already common in industrial chemistry, but so far have not become popular among academic researchers. Their biggest advantage for industrial chemistry is the audit trail that is made available for the company which makes it possible to examine all aspects of any piece of research. This is a huge advantage, both for scientific and for legal reasons. Another advantage is that research becomes available to other researchers in the organisation, potentially making information gathering

faster and more efficient in cases where an issue has previously been touched on within the organisation. These kinds of software tools have not taken off among researchers in academia, largely because universities have not made them the norm, but if fully utilised they have the potential to further increase the efficiency of information gathering.

### **The future of information gathering in academic research**

Interdisciplinary and collaborative research projects are increasing in importance in the sciences, whereas they have not been so significant in the humanities. The difference is mainly due to the way that scientific knowledge is progressing which leads, in some cases, to distinctions between subjects becoming blurred. These days some areas of scientific research do not fall neatly within traditional subject boundaries, whereas almost all research in the humanities can be placed within a recognised discipline. These factors will continue to affect information gathering behaviour. Researchers working in areas that are evolving and where there are many collaborative projects are more inclined to utilise new technologies and are more in need of the speed of access that e-resources provide.

Looking towards the future, one of the post doctoral research associates from Imperial College, who was interviewed, noted that the electronic documents they use still mimic paper documents in their format. In time, he felt, electronic documents may come to resemble websites, incorporating sound, moving images and links to other documents. For all the changes that have recently taken place in the flow of information in academic research, the dust really has not settled yet. Documents mimic those of the pre-digital age, as perhaps do cultures and organisational structures. These seem likely to change as discussion becomes based around online

resources like web forums, rather than university departments and physical proximities.

## **6. Conclusions**

### **Review of major findings**

Returning to the research questions that were originally set, a few significant points of conclusion and suggestions for future research can be made. On the broad question of the major similarities in information gathering in different subjects, it is clear that ancient history and chemistry have become more different since the impact of electronic resources began to be felt in the mid-1990s. As with practically all academic disciplines information gathering was based around libraries, meaning that for very obscure information travel to far away libraries or use of inter-library loans was required. This has now changed in all subjects, but while in some the change has been qualitative, with the way things are done being transformed, in others it has been quantitative, with the same things being done, but more efficiently.

For all the changes in information gathering in academia there are some very important continuities. Finding information, particularly in text-based humanities subjects, is based around use of libraries and researchers place a high value on these. Researchers in scientific subjects rarely visit libraries these days but their information finding is entirely dependent on e-resources provided by their institutions' libraries. Personal contacts and face-to-face communication and remain as important as ever and may well be becoming more important with the increase in interdisciplinary and cross-institutional research.

Methodologies, finances and working patterns, particularly whether research is done primarily in groups or individually, all are important factors in the development on e-

resources within disciplines. Culture also plays an important role; all communities have a culture of some kind and this largely defines how they react to change. Thus some ancient historians have felt that their subject is not well suited to the digital format and have seen switching journals from print to electronic subscription as a loss of resources.

The searching behaviour of researchers varies a great deal in ways that are illuminating. Given the volume of publications in their area, scientific researchers need to use sophisticated techniques to retrieve the information they require. To do this they use techniques, such as searching with diagrams of molecular structures and searching the full text of articles, that were not available in any way when they were using print resources. Researchers in the humanities are far more likely to know exactly what they are searching for and often have got complete details of the item from a citation; hence they have comparatively little need to run searches at all.

How information gathering in the humanities will develop in the future is not entirely clear, but in ancient history it seems likely that it will continue to be focused around libraries with original research often requiring visits to collections abroad. In chemistry there are further developments in e-resources that are anticipated, but they will certainly not be as revolutionary as those of the last decade. Perhaps more important is the possibility that culture and organisational structures will evolve to reflect new ways of working.

## **Reflections on research conducted**

The process of carrying out research for this project was successful, both in terms of the quality of the findings and the logistics of completing the surveys within the

allotted time. In large part this was due to good practical organisation and good fortune with contacts among researchers. The interviews were arranged with the principle contacts from each group and important issues were discussed with them at length to ensure that questions were as relevant possible. Consequently results were produced that give meaningful information about changes in information gathering behaviour. The interviews were able to be carried out on a small number of people in a comparatively short space of time; the chemists were all interviewed in one day while the ancient historians were interviewed over four separate days. By comparison, completing interviews with subjects in several different locations or questionnaire distributed by e-mail could have dragged on for weeks.

The method of carrying out detailed investigations of two widely different subject areas was broadly successful. While the results do not necessarily tell us about research in all academic subjects, with interpretation they provide a lot of information about the humanities and the sciences and this is instructive about academic research in general. Some of what was found from interviews was expected, such as the sharp decline in library visits among scientists and the general reasons for this, while some was not, such as the revealing differences in searching behaviour.

## **Further research**

Librarians are now able to easily obtain much more accurate and detailed usage statistics for electronic resources, than was possible in the past. In 1999 Covi wrote that “it is impossible to determine simply from access logs how a subset of users in a particular discipline uses [electronic resources]”.<sup>56</sup> The situation has changed enormously: it now varies according to the way users log into electronic libraries, but

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<sup>56</sup> Covi, 1999 p.93

in some cases a high level of granularity is available regarding what types of users have used what resources.

When researching this current paper the researcher was able to view usage statistics for a major London University detailing the exact number of times a particular electronic resources has been used by each type of user (e.g. taught postgraduate, staff, visiting staff etc.) and by the department to which they belong.<sup>57</sup> These statistics were not used for this current study partly because at that time they were only able to provide information for a one month period and partly because that university does not have ancient history or chemistry departments.

Borrego and Urbano's article shows that there is a lot useful discovery to be made using the kind of detailed usage statistics that are becoming available at from many digital libraries.<sup>58</sup> Their article, though, does not include any input from researchers themselves and does not really tell us about their needs. A study focussing on a small number of subject areas in detail and incorporating usage statistics as well as the views of researchers would potentially be a very important piece of work.

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<sup>57</sup> I would like to thank Lucy Clifford, the Systems and Database Support Manager at City University for making this information available.

<sup>58</sup> Borrego and Urbano, 2007

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## **Use of libraries and electronic resources for information gathering: survey questions**

**Name:**

**Job/ specialism:**

1. How often do you use the library?
2. For what purposes do you use the library?
3. Have you used any libraries outside the UK in the last year? Which ones?
4. How much time in total, on average, do you spend per week on searching for information relating to your research (including time spent in libraries, searching databases, searching the internet, asking colleagues who may be able to give specific information etc.) For example, less than one hour, 3 – 4 hours etc.
5. How much time, on average, do you spend per week on keeping abreast with new developments in your field?
6. What are your main sources for doing this? (For example print journals, online journals using RSS feed, informal discussions with colleagues).
7. Rank the following sources of information in terms of their usefulness to you when searching for material:
  - Library catalogue
  - online databases
  - internet search engines
  - discussions with colleagues

8. How do you decide whether to read an article? For example title, abstract etc.
9. Rank the following sources of information in terms of their usefulness to you:
- print materials (books and journals)
  - online journals
  - online databases (such as Web of Knowledge etc.)
  - discussions with colleagues
10. What databases do you use most often? Why?
11. What search engine(s) do you use?
12. If you fail to get the information you need, why is this most likely to happen?  
For example:
- The information does not exist / is not publicly available
  - Databases not subscribed to by the college
  - books / journals not available in the library
  - lack of information from colleagues
  - Unable to search the internet effectively
  - Lack of time
13. What currently unavailable information services would you like to see provided in the future?

### **Chance discoveries**

14. When searching databases, library catalogues or using search engines, do you make very specific searches, with long search strings or do you use relatively simple searches? When would you use either kind of searching?  
Do you use Boolean operators?
15. Do you ever browse information without knowing exactly what you are looking for? Is this useful?

16. In what circumstances do you ask a colleague for information? Is this generally useful? If not, why not?

17. Have there been any occasions when information from a colleague has been vital for a piece of research?

**Inter-disciplinary research**

18. What researchers from other disciplines have you worked with in the past year?

19. What size group are you currently working in?

20. Have you ever A) carried out research alone [chemists] B) carried out research in a team [ancient historians]?

21. Do you think this affects your information gathering behaviour?

**Culture within disciplines**

22. Do you think your subject has a culture of using libraries?

23. What kind of information resources are researchers taught to use in your subject?

24. What information resources would a good research project in your subject be expected to use? Would a project lack credibility if certain resources were or were not used?