Chapter 4--The Chemists

Description of the Department and the IPST

The Department of Chemistry and Biochemistry at UMD is divided into five units: Organic, Inorganic, Biochemical, Analytical-Nuclear-Environmental (ANE), and Physical Chemistry. I chose to interview six faculty members in subfields of chemistry that would be close to physics, namely physical chemistry which is similar to chemical physics and nuclear chemistry which is related to nuclear physics. Four of the chemists that I interviewed work in the Institute for Physical Science and Technology (IPST) at UMD. Their fields range from physical chemistry to chemical engineering, but they are all conversant with the culture and work habits of scientists in other closely related fields.

The IPST's mission is to sponsor interdisciplinary scientific research and education. The thirty-five faculty members who work there all have joint appointments with one of the other academic departments on campus, primarily Physics, Mathematics, Engineering, and the Department of Chemistry & Biochemistry. They are supported by a large staff of research scientists, postdoctoral research associates, research administrators and technicians. Researchers typically collaborate with many of the regional facilities including the Naval Research Laboratory and the Johns Hopkins Applied Physics Laboratory. The IPST also administers the Chemical Physics Program which draws faculty with backgrounds in both chemistry and physics. Although the Graduate Department of Chemistry & Biochemistry at UMD is not ranked among the top programs, the graduate program in Chemical Physics is ranked tenth nationwide (Gourman, 1996).

I selected the six interviewees from studying the webpages for the IPST and the Chemistry & Biochemistry Departments, searching specifically for chemists.[11] I contacted them using e-mail, and, in most cases, sent out the questions ahead of time (Appendix B). The interviews were taped.

Dr. John D. Weeks

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[11]The IPST homepage is available: http://www.ipst.umd.edu. The Chemistry homepage is available: http://www.chem.umd.edu.

Dr. John D. Weeks, a physical chemist and theoretician, has a joint appointment to the Chemistry & Biochemistry department and the IPST. He is a "Distinguished University Professor," an honor held by only 20 full professors at UMD. "I'm probably closer to a condensed matter physicist in some ways. I study surfaces and steps on surfaces which is part of physics, and I have another area of research which is liquids, and that's more traditional physical chemistry" (John D. Weeks, personal communication, January 21, 1999. All the quotes in the following section refer to his comments during the interview). He reads the Condmat Los Alamos archives if he has time, and admitted that he was behind in his reading of the formal literature as well. He has a physics graduate student who actually submits their manuscripts to the Condmat server. He has not submitted any e-prints to the chemical physics server at Los Alamos, because his physical chemistry graduate students do not know how to do it. "I want to encourage them to learn." He is not under any publication constraints, and his work does not involve patents. He just returned from a sabbatical at Berkeley, and he continues to collaborate with some chemists there. In the past five years he has published twenty-five articles, and he seeks publication mainly in *Physical Review Letters*, *Physical Review B* and the *Journal of Chemical Physics*, published by the American Institute of Physics. When I asked him why he chose the latter publication instead of the ACS journal called the *Journal of Physical Chemistry*, he explained that it had more to do with habit than anything else; "Up until a few years ago, if you were between fields, as I am, the *Journal of Chemical Physics* was <u>the</u> place to get published. It has a long, distinguished history and is widely circulated. In the last few years, the *Journal of Physical Chemistry* has improved. Some of my colleagues submit to that journal. I probably should consider them both."

When I asked about the differences between the terms, physical chemistry and chemical physics, Dr. Weeks began to talk about the different cultures of physics and chemistry in respect to publishing, commenting on the wide disparity between the ACS position prohibiting prepublication and the APS position that grants wide latitude to physicists. "I am much in favor of the physicist position on this. In addition to the archives, I post my preprints on my web page. For this reason, I usually don't publish in ACS journals. My collaborator at Berkeley, however, has selected an ACS journal for our current work. I still intend to put a LateX version of our

paper on my web site, and I don't think they can stop me." When I asked him why the e-print archives were not popular among chemists, he responded. "Physicists are much more trendy. When a field gets hot, a lot of them will work in that field, and then they'll go work in another field. Chemists tend to stick to their one little area for longer periods of time. There are plenty of problems to go around...Then in the bio area, competition would work against the concept of e-print archives. They don't even send preprints to one another. If there is the potential for commercial development, it puts a damper on sharing of ideas. The ACS policy position against electronic dissemination, which seems very bizarre from a physicist perspective, is also a factor."

If he needs to get a publication out quickly, he'll try *Physical Review Letters*. "Timeliness is not super important like it is in some fields. Most of the stuff that we do is not time sensitive, although you would like it to be quick." He consults the archives when he has some new topic; "If I think I have a new idea, I search Los Alamos just to see the latest things that have been done." Does he think that posting a preprint to the servers will establish priority for his research? "Well, probably not. It's out there, and it could happen. If you put it there too much before you submit it to the journal, you could be asking for trouble. We submit simultaneously." Reviewers do not refer to the e-print archives much, and the official position is that priority can only be established by the date of submission stamped on the manuscript by the publisher. You cannot assume that everyone is reading the archives in his field.

Dr. Weeks is straddling two cultures, and his inclination in disseminating research favors the physicist position. The technical content of his work, and the APS journals in which he gets published help explain his attitudes about the preprint servers. He is much closer to the theoretical physicists' position than to the habits of chemists.

Dr. Jason Williams

Dr. Jason Williams is a post doctoral research associate in physical chemistry. He does computational and theoretical chemistry working on studies of inelastic and reactive molecular collisions. His advisor has grants from NSF, and his work does not involve patents. In the past five years he has published four papers. He submits his work to *Molecular Physics*, a European publication, and the *Journal of Chemical Physics* put out by the American Institute of Physics

instead of the ACS's *Journal of Physical Chemistry* because his advisors have told him that it is more prestigious.

When I asked him about the e-print archives, he had never heard of them. In his previous experience as a researcher at U.C. Irvine, his advisor would send out about 10 or 15 hardcopy preprints to close colleagues. "It was a way of alerting others about our work" (Dr. Jason Williams, personal conversation, January 21, 1999. All quotes in the following section refer to his comments from this same interview). He has never submitted a paper electronically, although he uses e-mail and has created his own web page. Although he had a vague notion about the software called TeX, he uses Word for writing his papers. He liked the idea of the archives, but commented; "It's hard enough to keep up with the published literature. It's a struggle to keep some kind of currency in our field, because there's so much information." At this point in his career, he is most focused on the formal literature, because of the need to get publications on his resume.

Dr. Dev Thirumalai

Dr. Dev Thirumalai is a full professor with a joint appointment to the Department of Chemistry and Biochemistry and the IPST. He is a theoretician in physical chemistry. In the past, most of his work was in molecular collision dynamics, equilibrium and nonequilibrium quantum statistical mechanics, and spectroscopy in the condensed state. More recently his work has shifted to physical chemistry that is closer to biochemistry, specifically, the theory of complex systems like protein folding. Protein folding involves big biological molecules that have some special configuration or pattern to fold and twist in a particular way. Physical chemists have gotten interested in speculating how the molecule knows which way it should fold and take shape. It's become a very hot problem and there is big interest in this area.

His sponsor is the NSF, and he is not under any publication constraints. He collaborates with experimentalists at UMD and with scientists at other universities. In the past five years he has published over fifty papers. He sends his publications to the *Journal of Molecular Biology*, *Proceedings of the National Academy of Sciences*, and *Physical Review Letters*. When he thinks about submitting a paper that is really good, where timeliness is important, he has learned that it

is prudent to avoid *Nature* or *Science*. "Generally *Nature* and *Science* are hostile to theoreticians. Instead of waiting for a slow review with a high probability that it will be rejected, I generally submit it to *PRL* to avoid delay. It might seem like I'm chickening out by avoiding *Science*, but I don't want to lose six months." (Dr. Dev Thirumalai, personal communication, February 4, 1999. All quotes in the following section refer to his comments from this interview).

He reads the Los Alamos archives daily because he subscribes to a service that places all new Condmat papers on his e-mail. He only recently learned that it is possible to search the Los Alamos archives on the Internet by field, keyword, name or preprint number. His post doc submits their papers, so he was not able to comment on the technical difficulties of electronic submission. He used to write his papers in Scientific Word, but now has begun to use TeX. When I asked if he felt that a paper submitted to the archives could establish priority to those findings, he began to talk about the differences between physicists and biochemists.

"Physicists have always shared their preprints. The distinction between the preprint and the formal journal article is not crucial. The idea that matters most is when the information gets passed to you, not whether it's been refereed. When good people are writing articles, seldom do they make egregious mistakes, so that the paper will be wrong. It might be irrelevant, but rarely full of errors. Therefore, the Los Alamos archives are helpful. In this culture, you are expected to cite preprints, if they are relevant. What is important is the point at which the paper comes to your attention, not whether it has passed through peer review.

There is no tradition of sharing preprints in the biological sciences or in biochemistry. In my own case, I have never submitted a paper to Los Alamos working in biochemical areas like protein folding until after the paper has been formally accepted by the journal. It is actually the case that I am sufficiently afraid of my competitors stealing my ideas, and it has happened, so I won't do it. Electronic submissions are not used in biological or chemical journals. Papers sent for review are all in hard copy, as well. Even experimentalists who might be attempting to verify one of my theories, will not send preprints of their papers until after it has been published."

I asked him to explain why these communities are so different. "Biochemistry is intensely competitive, but some fields in physics are as well. Physicists, however, are less diverse. For example in condensed matter, if you are working on the Quantum Hall effect, and

you are a player, everybody knows who you are. If you have a new idea, you only need to consult about ten key people to find out if it's viable or really new. It's such a small community that if you plagiarize, everybody would know it. There are only a few journals where you could publish, and that's it. But in biochemistry or the biological world, there are so many journals and the community is extremely large and diverse. Someone could take your idea and very few people would even be aware of it. It would be very difficult to manage an electronic archive of unreferreed material in this kind of a community."

Currently, since his work is involved with biochemistry, Dr. Thirumalai feels it necessary to be more secretive and more careful about disseminating e-prints. "In terms of concrete problems I am moving away from chemical physics, but in spirit, I am more comfortable with the culture of sharing ideas." Since he is working in this new field, however, he is adopting the new rules, habits and expectations of that community.

Dr. Athanassios Z. Panagiotopoulos

Dr. Athanassios Z. Panagiotopoulos, a full professor, has a joint appointment with the Department of Chemical Engineering and the IPST. He is working in thermophysical properties. He is not under any publication constraints, working with grants from NSF and DOE. Some of his work in applied chemical thermodynamics may involve patents at a later time. He is a theoretician, but he collaborates extensively and intensively with experimentalists both locally and with people at Cornell. He has published about thirty papers in the last five years. He considers prestige and circulation to be the most important factors in selecting a journal. He submits most of his papers to the *Journal of Chemical Physics*, the *Journal of Physical Chemistry*, *Macromolecules*, and *Langmuir*. He tried recently to submit a few papers electronically to an ACS journal, but the results were "disastrous." Chemists still prefer to send hard copies of papers and manuscripts to be reviewed through the mail.

He subscribes to the Condmat e-print archives, and occasionally he will read them. He has in the past submitted papers to the Condmat archive that would be of interest to physicists, but he has stopped doing it. "I recently became aware of the policy of the ACS which refuses to accept manuscripts that have been widely disseminated on the archives. Additionally, the

community of scientists in which I now work, do not use the archives." (Dr. Athanassios Z. Panagiotopoulos, personal communication, February 5, 1999. All of the quotes in the following section refer to his comments during this same interview). When I asked him why chemists do not use the archives he responded, "All of my colleagues who are chemists and chemical engineers even now, do not have the technical expertise to use the archives. First of all, they all use Word, so that would prevent them from submitting their files using the required TeX software. In addition, it is more common among chemists and chemical engineers to be involved with work that may have commercial applications. They would be reluctant to use electronic preprint archives if it meant giving up intellectual property rights."

I asked if he stopped submitting to the archives out of concern that his ideas might be scooped by others. "I do not worry about that. I tend to be very liberal. I place my preprints on my personal website before they are accepted for publication." He continues to read the archives, searching for papers by people he knows and trusts. However, he now relies on his web page to share preprints. At conferences he will mention his webpage address to his audience. "I don't know if I will get in trouble from the ACS for this practice. I keep track in detail of the people and the Uniform Resource Locator (URL) addresses of those who are downloading my papers. Not the actual person, but you know the machine name of those users requesting my papers. I suspect that my papers get disseminated more widely through my webpage than those I submitted to the archives. Tracking the usage, on average, my papers are downloaded twenty times a month from my website."

Dr. Panagiotopoulos is familiar with the cultural mores of both physicists and chemists. His website has become a vehicle for sharing preprints and a way to circumvent the hard line taken by the ACS in regards to prepublication. He claims that his papers get more visibility from his personal website than they would on the archives. It is clearly a violation of the spirit of the ACS policy. In practice, it may be impractical and impossible for the ACS to enforce their policy if this practice becomes more prevalent among chemists.

Dr. Alice Mignerey

Dr. Alice Mignerey is a full professor in the ANE unit of the Chemistry Department, in

the field of experimental nuclear chemistry. Her experiments are conducted at the Brookhaven National Laboratory on a Relativistic Heavy Ion Collider (RHIC). She is part of the PHOBOS collaboration made up of 50 scientists. She spends most of her efforts in nuclear science at the present, but she also is interested in the development of applications of Accelerator Mass Spectrometry (AMS) in carbon dating of coastal aquifer systems of environmental interest. The RHIC experiments could be called nuclear physics or nuclear chemistry since they are so similar, while the AMS work is in the field of chemistry. Dr. Mignerey is another example of the growing number of scientists engaged in interdisciplinary work. She feels comfortable in both worlds, having done undergraduate work in physics and graduate work in chemistry. The term "nuclear science" was coined by Ernest Lawrence at Berkeley where the chemist, Glenn Seaborg also worked. "The tradition of the Manhatten Project was just as much chemists as it was physicists" (Dr. Alice Mignerey, personal communication, February 15, 1999. All quotes in this section refer to her comments during the interview).

Her work is sponsored by the DOE, and she is not under any publication constraints. She works through the hierarchy of a program advisory committee to get approval on proposed experiments and access to the accelerator. The time from the inception of a project, to the building of equipment, to running the experiment, to the analysis of data and, finally, to publication can take several years. In the past five years she has published about five papers. She sends most of her papers to *Physical Review C*, *Physical Review Letters*, *Nuclear Instruments and Methods* and W*ater Resources*. "Timeliness of publication is important if you have some late breaking news that you have to get out. You do a letter. It's hard to compress it into four pages. There's also the *Phys Rev Rapid Communication* which is a part of C. That has to be limited to a few pages as well, so if you have something more substantive, you have to go with *Phys.Rev C*. I actually fault a lot of my colleagues for publishing letters and never publishing the full paper. They never publish the details which is a cop out, if you ask me."

Dr. Mignerey does read the Los Alamos e-print archives, although she has never submitted a paper to them. She appreciates reading the theory papers there, and often consults them when she has a citation for a specific e-print. "We're a very closed society in our research field so usually there isn't a lot out there that we don't already know about. All the information

on the e-print archives has already been presented at a conference, meeting or workshop so we are not concerned about priority issues. I don't mind waiting for six months for my papers to be published, because everyone has talked about it at meetings and they know it is coming. It's not like this data has not seen the light of day. We talk about our data at meetings as soon as we can agree on something to talk about. We want the community to know what we're doing and get feedback from them. We're usually not breaking into a new field as much as some other areas of research. We've been in this field for years and we're just sort of evolving as the field evolves." They do not need to refer back to archival journals to get the background on an issue or to learn who is working on a given problem.

When I asked her if there were a limited number of problems that nuclear scientists could work on, she replied; "There are big picture problems that you could address from different angles, and accelerators are designed to address theories of the beginning of the universe, studying hot dense matter. The hard part is interpreting the background from what you are looking for. The other big problems are studying the structure of a neutron or a proton or quarks. Nothing can be measured from first principles anymore. You keep waiting for a theorist to come up with a new interesting thing to test. You have to rely on theoretical predictions to guide you." These communities are well aware of what each group is working on.

Before quoting material, she would prefer to see it in a refereed journal. She does not cite preprints, but she will cite a conference proceeding. "I will cite something that has been accepted for publication, however. Although a conference proceeding is not refereed, it has been presented before one's peers so it is in the open literature then." She has never sent out many preprints using a distribution list. "It's costly and wastes time." She still receives many piles of them in hard copy from others.

Dr. Mignerey admits that she has not taken the time to learn TeX. She writes her paper in Word and gets her students to convert the files and submit them. She relies on her students to create web pages for her. She is not enthusiastic about the trend toward moving all transactions to the digital environment, although she loves e-mail. She prefers reading and browsing the paper journal and hates to read things on a computer screen.

Dr. Sandra Greer

Dr. Sandra Greer is a full professor with a joint appointment to the Chemistry Dept. and the Department of Chemical Engineering. She is an experimentalist studying fluids undergoing equilibrium polymerization. She collaborates with a few scientists around the world who are working in her specialization. "People's research interests get so highly refined that it's not that likely to fine many working on the same problem at one institution (Dr. Sandra Greer, personal communication, February 15, 1999. All quotes in this section refer to this interview). She has been working in this area for ten years. Her work does not involve industry or patents, and her work is supported by government agencies. In the past five years she has published ten papers. She usually submits to the *Journal of Chemical Physics*, *Macromolecules*, and the *Journal of Physical Chemistry*. "Timeliness is very important. Deciding when to submit your work involves some ethical issues. First of all, you want to make sure it's right. On the other hand, if you sit on it too long, someone else will beat you. I rarely use *Phys. Rev. Letters*. There are ethical issues here. With these *Letters*, people rush into print and they are often wrong and inaccurate. Moreover, they are limited in length and so they don't give enough information for someone else to verify their work. And then they often fail to write up the full paper. I would rather spend time writing up the entire analysis with all the details. As a result I have fewer papers than many other people. I don't write things more than once....or try to get the least publishable unit out of some work."

Dr. Greer does not use the Los Alamos preprint archives and actually disapproves of them. "I would never submit to them. I have severe reservations about this electronic publishing. I'm afraid that the formal journals would refuse to review my paper, considering it already published on the archives." She is concerned about others stealing her work. "If you send your paper to a journal, then you have a submission date and you have some control over your intellectual property. If you send it to the archives then you are just giving it away. Anybody could just download it and send it off to a journal as their own." When I asked her why many physicists found them very useful she replied; "Physicists are big on *Letters*. They judge themselves by how many *Physical Review Letters* they have. They are big on getting things out fast."

She uses e-mail quite a bit when people are at a distance. However, with people on campus she prefers to talk to them. "If it's substantive material, I'm likely to call them on the telephone or walk over to talk to them because I like the give and take. I don't use preprint bulletin boards." She will send out hard copy preprints to about fifteen people that are working in her specialty. "These are people I know and trust." She uses WordPerfect to write her papers and submits either in hard copy, or she will send a paper on a disc, and send the figures by overnight mail. She does not have a personal web page. She thinks that physicists are more familiar with computers because traditionally they have always worked with instruments. Dr. Greer clearly identifies herself with chemists, distancing herself from habits endorsed by physicists.

Main Themes and Issues

Among this small group of chemists, there are four who occasionally read papers on the archives and one who formerly submitted articles to them, but has since stopped, as he migrated to a new specialty. Subtle differences in how the archives are used relates to the degree of acceptance and the scientist's perception of their usefulness. There is a big difference between a scientist who just peruses the abstracts occasionally and a scientist who consults them daily and submits papers to them frequently. Because I chose to interview chemists who work in subfields that are closely related to physics, I discovered that they use the same journals as physicists, and they feel comfortable classifying their work using the Physics and Astronomy Classification Scheme (PACS). The theoretical physical chemists (Weeks and Thirumalai) both felt that part of their work could be described as condensed matter physics. It is not surprising to find so many of these chemists using the archives. Larger samples of chemists are needed to positively assert that chemists who work in specialties that are closer to core fields within the discipline of chemistry do not use the e-print archives.

Another theme that emerges from these interviews is the new option of disseminating papers through personal webpages. With comprehensive search engines like Altavista and HotBot, a simple name search would effectively locate a scientist's current papers. The archival function that Ginsparg promises would not be satisfied, although authors would have more immediate control over their work. Effective use of personal webpages to disseminate papers

assumes that one's work and reputation are already established. Serendipitous discovery of new papers which is facilitated in using the e-print archives, would also be forfeited with personal websites.

Dr. Thirumalai and Dr. Panagiotopoulos present interesting examples of "migrants" who are moving from one specialty into another. "Before a migrant can fertilize a 'destination' specialty with concepts originated elsewhere, he or she must be able to communicate in the new vernacular" (Chubin, 1976, p. 466). To communicate well, migrants need to know not only the new vocabulary, but also the accepted norms and habits for disseminating research in their new group.

The final chapter includes analysis of the e-print phenomenon, addresses my original hypotheses and covers potential areas for future research.

CHAPTER 5- ANALYSIS AND CONCLUSION

Interviews with twelve UMD scientists, focusing on their attitudes and preferences for disseminating research, reveal a complex picture of the use of e-print archives. The impact and importance of these archives vary greatly among the twelve interviewees:

- Nine of the scientists have several papers that reside on one or more of the servers at Los Alamos, though only three have actually electronically submitted papers to them, on their own. Five of the physicists and four of the chemists feel that people in their specialty should at least be aware of the e-print archives.
- Only four of the twelve regularly consult them to read or download e-prints. Four, three of whom are aware of their existence, do not use them at all. The remaining four are in a middle category; of these, two are students who indicated that their mentors kept up with the papers on the archives, one merely consults them occasionally and one used them in the past.

The interviews with these scientists point to a variety of practices with several potential explanations for their response to the e-print archives. The sample of scientists is too small, however, to come to any definite conclusions whether these differences in the use of e-print archives stems from individual styles or from the norms of the subfield in which these scientists work. A larger survey of a representative sample of scientists stratified by subfield would be necessary to make more definitive statements. Nonetheless, we can attempt to interpret the practices of these twelve scientists, using the hypotheses developed in Chapter 1.

I begin with an examination of work styles, including technical expertise with computers. Next I discuss how status, including that of foreign and younger scientists, relates to usage of the archives. This is followed by a consideration of other social and cultural explanations including learned behaviors and historical patterns of work habits, perceptions of the importance of timeliness in publishing results, and how scientists perceive their audience and the size of their specialty. I then continue with some economic explanations, and finally, look at technical or

subject content as an explanatory factor to include the difference between experimentalists and theoreticians.

Technical Expertise

To begin, technical expertise with information technologies is an important explanatory factor. Anyone wishing to read e-prints must have Internet access, a recent version of one of the more popular browsers, and software to decompress files. This expertise divides the younger and the older scientists because often older scientists do not have as much experience with computers. To submit papers as well as to read them, scientists need a high-end computer and technical expertise to compile and convert files. In addition, scientists must know and use TeX if they want to use the Los Alamos site or have an assistant who can do so. While some nuclear and physical chemists use TeX, most chemists do not. "Nearly all of the manuscripts that the ACS accepts for publication are submitted electronically, typically in Microsoft's Word or Novell's WordPerfect, says Lorrin R. Garson, chief technology officer of ACS's Publications Division (Wilkinson, 1998, p. 14). The electronic submission that Garson refers to is the practice of sending a disc full of files to the publisher. This is much simpler than converting and compressing the files in order to send them electronically to the publisher.

The way work is organized and socially structured with all its underlying ideology and norms will affect how technology is incorporated into the fabric of daily practices. Computer use among all researchers is crucial in today's work environment. The use of electronic networks, particularly the use of e-mail among certain communities of scientists, has been linked to styles of work. Walsh & Bayma (1997), found that physicists are more likely to use e-mail than biologists and chemists because their collaborations with researchers around the globe require a great deal of coordination. Walsh & Bayma (1997) also found that physicists, who are more mobile, traveling back and forth to large laboratories, rely on e-mail to keep in touch with colleagues. Chemists, on the other hand, are less likely to rely so heavily on e-mail because they tend to work in local, independent groups. "Chemistry is mainly a bench science. Chemists work in labs with small teams of mostly graduate students and postdocs, and occasionally undergraduates. Research groups are usually in the 5-20-person range. But, the larger groups are often split into parallel experiments, with little need for tight coordination among them" (Walsh

& Bayma, 1997, p. 395).

I did not find a big discrepancy in the use of e-mail between the chemists and physicists at UMD. All of the physicists and chemists that I spoke with mentioned that they are collaborating with others around the world. E-mail is commonly used by all the physicists and chemists that I interviewed, although Dr. Greer did admit a preference for face-to-face communication rather than e-mail if a colleague were close by, within walking distance. Although computer usage for e-mail has become fully institutionalized, the use of e-mail does not require a facility with file compression, or navigating different operating systems and interfaces. Evidence indicates that physicists are ahead of chemists in their ability to submit papers electronically, use compression utilities to handle large graphics files and switch platforms, for example from a Unix environment to Windows. Physicists have incorporated the use of the Internet into their everyday work habits. Experiments with electronic peer review are already underway in the APS while the ACS is just beginning to study the possibilities (Wilkinson, 1998).

Among our sample, how scientists perceive their status in the field relates to their usage of e-print archives. Even though they might meet all of the technical requirements listed above, not all scientists choose to use them. Dr. Drake, for example, was the one senior physicist interviewed, who dismisses them. Although he does not come right out and admit that the technical barriers inhibit his use of the archives, he uses words like “ponderous” and “inconvenient” to describe his experience with them. If he felt sufficiently motivated to use the archives, he could clearly do so, perhaps with a little help from a colleague, but there is not sufficient incentive to make this happen. Since he is well established in his field, chair-elect for the division of plasma physicists of the APS, and well connected with scientists in his field, the “old boy” network is functioning well for him. In a sense, Dr. Drake is already on the distribution lists of those who are most crucial to his work, and he does not need the archives to get his work known. For young scientists who are not well connected, however, the archives provide a more evenhanded way to distribute information.

Dr. Yakovenko, who started his career in Russia and worked for a while in France before coming to America, expressed an appreciation for the open accessibility of the e-print archives for anyone in the world. Personal connections with leaders in a field and access to a large

research library are not as important to some communities of physicists today. With a computer connected to the Internet, they can read some of the most recent papers in their field, and feel connected with new developments. Arthur Smith reported that over half of the submissions to the APS e-print server were from foreign institutions, and Ginsparg's site is mirrored in locations around the globe, attesting to its popularity among researchers far and wide.

An editor of *Physical Review E* stated that European physicists, who cannot rely on overnight mail, have made the effort to learn TeX and conquer the technical expertise to submit electronically because it is the quickest way to get published. The group of researchers writing for this journal, who do everything electronically, are either scientists from outside the United States or young American scientists who are anxious to get published. "Those who most urgently want to get published will comply with everything" (Dr. Neal Abraham, personal communication, February 16, 1999). Unlike most American physicists who submit hardcopy papers for formal peer review in *Physical Review E*, physicists from other countries almost always submit electronically in the preferred RevteX format. Once the technical expertise is there, it is a simple step to simultaneously post them to the archives.

Social and Cultural Factors

What other social and cultural factors might explain current attitudes and practices concerning the e-print archives? By social and cultural factors, I mean the norms and values of a social unit, specifically the socialization that occurs in separate fields and subfields in science. As C.P. Snow (1971) outlined the differences between the two cultures of scientists and humanists, it is possible to also find cultural differences between specialties and sub-fields of scientists. "Of course there is sub-division within, say, the scientific culture. Theoretical physicists tend to talk only to each other, and, like so many Cabots, to God" (Snow, 1963, p. 55). While these boundaries may be artificial constructs that defy generalizations, certain habits and behaviors can be identified as unique to particular fields, while other behaviors are common to all scientists.

Many behaviors learned in graduate school are related to preferences about scholarly communication and publication. Educational institutions are one among several that often assume responsibility for socialization and pattern maintenance (Hess, 1997)

Apprentices

While young aspiring physical chemists and physicists prepare for graduate school, they begin to gravitate toward a speciality in the field. Depending upon their mentors, inclinations and skills, they will become either experimentalists or theoreticians. During the long apprenticeship period of graduate school and their years as "post-docs", young researchers must learn the mores, world views, and expectations of their particular group. Traweek (1988, p.82), in a study of the culture of high energy physicists, elaborates on the training process where traditions, behaviors and the culture of their group are learned: "They are learning to become meticulous, patient, and persistent, and these emotional qualities are crucial for doing good physics. They also are beginning to learn what is meant by 'good taste', 'good judgment', and 'creative work' in physics. They are receiving training in aesthetic judgments (catharsis, pride, satisfaction, pleasure)."

The interviews conducted at UMD corroborate this pattern of younger scientists learning behaviors from peers and elders. Young scientists must follow the advice and example of their mentors and project leaders in order to succeed. Within the network of their contacts, the modes and methods for communicating with those in their laboratory group, with outsiders, and competitors, must be learned. Dr. Cerne first learned about the e-print archives from his mentor, and Mr. Steinhauer was encouraged to learn how to submit manuscripts to them by his boss. Conversely, Dr. Williams remained in the dark as to their existence because no one around him uses them. The apprentices learn work habits and gradually figure out what is acceptable and expected of them. All the younger scientists I spoke with followed the advice and lead of their mentors in deciding to which journal they should submit manuscripts. Frequently they would be listed as co-authors with their mentors. This is how professional self-perception and their identity as scientists in relation to the world is learned.

It is clear, even from our small sample, that the selection and identification of one's audience is one of the key predictors whether someone will use the e-archives or not. As indicated earlier, an article written for a journal published by the American Chemical Society will not be sent to the archives as an e-print. If a researcher seeks publication in the ACS'

Journal of Physical Chemistry, that scientist is reaching out to an audience influenced by ACS rules on prepublication. Determining group identity and self-perception as part of functional unit within a specialty are all related to how and where researchers disseminate their papers. Because of this, technical content may be less important than the perceived audience for a particular manuscript. However, since the technical content of scientific papers follows the same community boundaries as norms of dissemination, it may be impossible to isolate technical content as an explanation for different practices in the use of the e-print archives.

Age factors

The acculturation process, by which the wisdom and customs of older scientists are passed down to newcomers, is reversed in one small way, in this instance. Because the e-print archives require a good background in computer technology, with an understanding of file compression and decompression techniques, the older generation of physicists often rely on the younger researchers to submit papers for them. It is the younger scientists who have to help their mentors with the technology. At the same time, however, it is more often the older, established members of the community who actually read the archives, along with the formal journals, to stay on top of their fields. The physicists who find them valuable are encouraging their students to use them. Dr. Weeks and Dr. Cohen both mentioned sharing the value of the e-print archives with their students. The mid-level and senior scientists that I interviewed learned about the existence of the archives, for the most part, through informal conversations with their peers.

The young scientists that I spoke with rely on their mentors to keep them informed. These apprentices do not consider that it is part of their job to be reading the literature. Relying on their senior scientists to keep current in their fields and write successful grant proposals, the young researchers are completely focused on their particular experimental task or theoretical calculation. Dr. Cerne, in the process of seeking a job in academia, tries to read *Science* each week, but he is most concerned with getting a number of publications accepted in formal established journals. Dr. Williams is also focused on completing papers in order to get published, and complains that he has no time to read journals. This is a worrisome finding, if true for many young students. They need to begin reading the literature in their field if they hope to succeed. Certainly, it is not just the younger scientists who admit to falling behind in keeping

up with the literature. Dr. Yakovenko, Dr. Baden, Dr. Weeks, and Dr. Drake all mentioned how hard it was to find time to read articles either on the e-print servers or in the formal journals. The interviews suggest that the scientists who make time to read manuscripts on the e-print archives are generally mid-level or older scientists, those who select research problems for their group. They are most highly motivated to keep up with the current literature in their field.

Early Dissemination and Timeliness

How scientists choose to disseminate their work and communicate with others depends, in part, upon the transmission of learned behaviors that is part of the culture of their particular group. Hess (1997), explains this cultural worldview as the total learned knowledge, beliefs, and practices, both conscious and unconscious, of a social unit. Young scientists learn what is required to succeed. For example, Traweek (1988) has highlighted the particle physicists fear of obsolescence in their work and impatience with any lag time in publishing results. They learn to disseminate and scan preprints to keep on top of a rapidly changing field, but oral communication is even more important than written: "Particle physics changes so rapidly that waiting to learn of interesting data, detector innovations, or new theoretical developments until they appear in the journals is regarded as exceedingly unwise. What is being talked about is the current, more advanced knowledge; what has been written is considered established, uncontested, and hence uninteresting" (p. 121). In this culture, archival journals are not very important. Informal communication is fundamental in the highly competitive atmosphere of high energy physics: "Talking is the way to get something done, to win extra computer or beamtime for one's group, to acquire a good postdoc, or to persuade other physicists of the significance of one's own research results." (p. 118) High energy physicists perceive themselves to be working on cutting edge science where Nobel Prizes can be earned in a matter of a few years with the discovery of a new elementary particle. With many researchers all focused on the grand unified theory of the universe, prompt dissemination of preprints is crucial. Clearly, part of this cultural worldview includes perceptions of time.

Perceptions of the importance of timeliness in disseminating information is something about which I asked all twelve scientists. They <u>all</u> asserted that it was very important when working in an area that was popular among many other researchers, where competition would be

likely. The trade-off in early dissemination, however, is the loss of quality control that journal peer review provides. This felt need to overcome the lag time imposed by the slow peer review process can not fully explain the pattern of use of the archives. Dr. Weeks, in fact, mentioned that physicists are "trendy," following hot topics and always seeking emerging fields. Dr. Weeks was the only physical chemist who admitted that most of his work was not time sensitive, yet he is one of the most enthusiastic users of the archives. His reasons for using them have more to do with a principled or philosophical desire to share ideas as soon as possible, using any means at hand. The interviewees all stated that waiting from two to six months was an acceptable lag time to wait for publication, but most wanted the process to be quick. All the physicists who regularly post their papers on the e-print archives are motivated in part by the timely dissemination that they afford. Dr. Cohen, in particular, mentioned that speed of dissemination was important. His delight at getting his work cited many times by others in the literature within three months of posting his papers is an indication of this. Concern for feedback was less of a motivating factor.

Dr. Drake, the plasma physicist who does not use the archives, nonetheless asserts that timely dissemination is important. As in all perceptions, this is a subjective notion. The subject areas covered by *Physical Review E* are statistical and computational physics, chaos and nonlinear dynamical systems, plasma physics, liquid crystals and classical fluids. The Los Alamos server set up for this community of scientists is labeled with the generic name--the Physics Archive. This server bundles together all of the subfields of physics where physicists have been slower to use and submit manuscripts to the archives. According to an editor of *Physical Review E,* this is traditionally not a rapid publication area where scientists feel they must urgently share their work (Dr. Neal Abraham, personal communication, February 16, 1999). The editorial board of each section of the *Physical Review* decides on their own policies that reflect current practices of their particular community. In the case of *Physical Review E,* their policy on content of articles states: "Authors are not held responsible for references to preprints, internal reports, results that have been reported only orally at meetings (even though an abstract may have been printed), or for papers that have appeared in publications not abstracted in

standard abstracting journals."[12] A large portion of scientists in this community do not consider the archives to be important. This statement does not appear in the policies for *Physical Review D.* This is direct evidence of differences in attitudes and behaviors about the e-print servers among subfields of physics.

Theoreticians vs. Experimentalists

Evidence indicates that theoreticians use the e-print archives more than experimentalists. Even though the seven theoreticians and five experimentalists that I interviewed exhibit a wide variety of behaviors relating to the archives, the theoreticians who currently use them do more than just consult and read papers. They are the ones who make sure their work is posted on the Los Alamos servers. The scientists who are the most avid proponents and users, including Dr. Yakovenko, Dr. Cohen, Dr. Weeks, and Dr. Thirumalai, are all theoreticians. The yearly statistics from the Los Alamos archives support this as well. The number of papers posted to HEP-TH (high energy physic-theory) in 1998 was 2,774 while the number posted to HEP-EX (high energy physics-experimentalist) in 1998 was only 407. Similarly, the number of papers posted to NUC-TH (nuclear-theory) in 1998 was 977 compared to 110 for the NUC-EX server.[13] I suspect the theoreticians are attracted to the space which the electronic archives creates for unfiltered dialogue and conversation through the exchange of papers. Less concerned with precise formulas and accurate measurements, theoreticians are hungry for ideas, and the archives provide a venue for sharing them.

Structure and Specialties

The e-print phenomenon provides a medium that supports the norm of communism. Storer (1966) found that the social-structural characteristics of a field had an impact upon how strictly the norm of communality was interpreted by scientists. In "hot" fields with rapid advances in knowledge, sharing would occur in informal communications as long as the community was small enough for people to know each other or know of each others' reputations.

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[12]Physical Review E editorial policies and practices are available on the WEB at http://publish.aps.org/PRE/polproce.html.

[13]Submission statistics for each server are located at http://xxx.lanl.gov.

"In such cases, where scientists tend to know one another as individuals, there should be less reluctance to divulge preliminary findings and hypotheses since priority is assured by personal knowledge rather than simply through publication" (Storer, 1966, p. 131). Dr. Thirumalai mentioned the difference in size and diversity of communities as having an impact on the use of the e-print archives. In physics, the numbers of scientists working in a given area of condensed matter for example, is small compared to the numbers of chemists likely to be working on a given problem. Dr. Thirumalai felt that the usefulness of preprint archives would decrease or would be unmanageable in competitive fields involving large numbers of scientists. It would be impossible to know each other's work or reputation, because the numbers would prevent it. Priority in this situation would need the imprimatur of an official publication.

According to Science and Engineering Indicators (1998, p. A-106), there are 111,400 employed chemists, excluding biochemists, while there are only 29,000 employed physicists and astronomers. These numbers however, reveal little about how many scientists specialize on particular problems. Paul Ginsparg started the e-print archives for a community of about 100 scientists all working on the same problem. The researcher's perception of the size of their specialty is something that needs further investigation. Dr. Thirumalai mentioned that one would only need to consult ten key people working in the specialty of the Quantum Hall Effect to find out if an idea were new. Doing a search of the e-print archives using the keywords "Quantum Hall Effect" pulls up 535 papers under that subject classification in 1997 and 671 papers in 1998. This seems to indicate a large and active research area. How do researchers perceive the size of their specialty and the notion of who the key people are in their subfield?

One of the factors looked at by Hargens (1988) to explain the substantial variation in rejection rates for scholarly journals across disciplines was the diffuseness or concentration of a field's journal system. I was struck by the fact that the physicists and the physical chemists interviewed all mentioned the five *Physical Review* publications or *Physical Review Letters* as the premier journals in their fields. The picture is different for chemists who publish in ACS journals. They have many more journals to choose from, with a more diffuse journal structure. Hargens (1988) found the average acceptance rate for manuscripts of *Physical Review* to be almost eighty percent. While all six physicists mentioned that it was harder and more

prestigious to get published in *Physical Review Letters*, they all had successfully published in one of the *Physical Review* publications. More research is needed to determine whether scientists are more willing to use the e-print archives if they are fairly confident that they can get published in the formal literature.

Sharing Preprints

All of the physicists, with one exception, and several of the physical chemists, especially Dr. Weeks and Dr. Thirumalai, emphasized their preference for early sharing of their findings. Dr. Cerne, one of the younger experimental scientists, was unique in mentioning that he wanted to keep control over his data until formal publication. Dr. Thirumalai, working in a competitive field, and Dr. Panagiotoupolos, fearing the edict of the ACS against pre-publication on the web, have stopped sharing preprints on the archives. The manner in which several of these physical chemists cope with a dichotomized world is fascinating.

Merton (1973) has written extensively about the ambivalence of scientists with respect to priority and recognition. The physical chemists that I interviewed exhibited a high degree of ambivalence relating to the two worlds that they inhabit. They split their work and their attitudes according to the audience that they address. They identify work that will be of interest to physicists, and thus be publishable in physics journals, as appropriate for the e-print servers. Work that is destined for chemical or biochemical journals is not disseminated until it has been formally accepted by a publisher. Dr. Weeks and Dr. Panagiotopoulus sometimes make an exception to this dichotomy by pre-publishing all of their work on their personal web pages, justifying it in their own minds as permissible, or at least unenforceable by the ACS. Creation of these personalized sets of resources on the Web has provided a means to circumvent the letter of the law. Further study needs to be done on scientist's use of personal web pages. How common is this practice? An examination of conference proceedings might be a place to start finding statistics on how many papers or abstracts list an accompanying website address. Dr. Thirumalai, who stated that he was most comfortable with the culture of physics that promotes the sharing of preprints, admitted that he took on the identity of biochemists by keeping secretive about his work in protein folding.

Garvey (1979) found that researchers were more likely to send out preprints if they had

worked in their areas of speciality longer and devoted more time to basic research. I did not find any connection between length of time in a specialization and the use of the e-print archives. There was some correlation, however, between those involved in applied research with patents pending and a decreased sharing of preprints. David Steinhauer's group that is involved in the invention of patentable microscopes, demonstrates a high level of ambivalence about this desire to share their papers, while worrying about intellectual property issues. They have organized a seminar on the topic of patents because they are concerned about the legal ramifications of publishing and the time limit for filing patents once a paper has been published. One member of the group commented that it was probably "stupid" to put some of their papers on the Condmat archive before investigating whether this constituted formal publication. However, this person defiantly defended the utility of the e-print archives, stating that he considered the material posted there a part of the physics literature (Anonymous personal communication, February 5, 1999).

Traditional practice has some explanatory credibility as well. We have unanimous corroboration by all the interviewed physicists and most of the physical chemists that, in the past, they distributed paper preprints to large numbers of scientists working in their area. The reason for this behavior by physicists must have developed from the desire to share papers promptly with their colleagues. What seems to have amounted to an extravagant expense in terms of duplicating costs and postal charges may have developed gradually. For example, the sizes of the groups working in the same area may have increased slowly enough so that it still seemed manageable to send papers to everyone. I did not ask the scientists if they first circulated their papers to one or two trusted colleagues, but for Chubin (1975), trusted assessorship is an important relationship that constitutes the informal social organization of science.

Historically, chemists have never shared large numbers of preprints with those working in their area. The chemists all mentioned sending out only ten to fifteen preprints, if that many. The most likely explanation for this parsimony is the potential for commercial development in many areas of chemistry which in turn fosters secrecy. "In chemistry and experimental biology, the increased market penetration makes more items in the researchers' worlds into commodoties, and this commodification extends into the information they produce" (Walsh & Bayma, 1996, p.

690). Distrust and caution about sharing ideas is probably more prevalent among chemists than among physicists. Whether that distrust is an artifact of edicts from the ACS or is otherwise imbedded in the culture of chemistry remains unclear. The ACS has actually put a number limit of fifty on this practice of distributing e-prints in today's electronic environment, and it has effectively limited the practice among chemists who use e-mail. (Wilkinson, 1998).

Economic Considerations

Economic considerations explain usage of the e-print archives. The important connection between formal publications and obtaining grants influences whether scientists will opt to disseminate papers on the e-print archives. If the ACS refuses to consider chemistry papers that have been distributed on the web, this is a complete showstopper. The importance of grants to sustain research will automatically make this economic factor override all other considerations. Dr. Panagiotopoulos, who works in applied chemistry mentioned that chemists working in areas that involve patents would be prohibited from any kind of pre-publication or dissemination of their work without first going through the university patent office. Although it is possible, according to the United States patent law, to file for a patent application up to one year after publishing, European law does not grant this year of leeway (Berman, 1994). Clearly, filing for the patent first is important for inventors. The economics of scientific publishing is also connected to the hardline stance of the ACS against electronic prepublication by authors out of fear of losing subscription revenues. The ACS reportedly counts on subscriptions for their journals and the Chemical Abstracts database for eighty percent of their budget.

In conclusion, this case study has revealed that the popularity and appreciation of the e-print archives among physicists and chemists is actually subfield specific. One hypothesis that emerges is that physicists and physical chemists who submit manuscripts to *Physical Review A, B, C, D* and *Physical Review Letters* are more likely to use the archives than physicists who write for *Physical Review E*. Chemists who hope to publish in ACS journals, which accounts for the major share of research chemists, are not likely to use the archives. Although discouraged from using the archives, some chemists circumvent this by disseminating their papers on personal websites. The interviews suggest that physicists take pride in their habit of openly sharing ideas with anyone willing to listen. It needs to be pointed out, however, that these ideals crumble

quickly in a competitive community.

Another hypothesis, supported by usage statistics, suggests that theoretical scientists use the e-print archives more than experimentalists. Scientists who enjoy searching the literature for the frontier of emerging fields are more likely to consult the archives than scientists who are focused on specific laboratory experiments. Further research is needed to explain why theoreticians are more likely to promote early dissemination of their papers. Is this phenomenon true for astronomers and mathematicians? Statistics from the APS e-print server suggest that submissions from foreign institutions accounts for about fifty percent of the papers on the servers. Further research is needed to determine if the situation is the same on the Los Alamos servers. More work needs to be done to pinpoint which foreign scientists are using the archives and how they use them.

This preliminary look suggests that behaviors and attitudes about the archives can be explained by a combination of social factors and structures, economic considerations and past historical practices. The apprenticeship relationship in graduate school where young scholars are initiated into the culture of their new profession is key to understanding current attitudes about electronic dissemination of e-prints. Self-identification, developed through interaction with peers and mentors, accounts for many of the assumptions, habits, and attitudes about appropriate methods for disseminating research. Evidence suggests that physicists working in the specialties of condensed matter or particle physics are more likely to share papers on the e-print archives. Because scientists adopt the mores of their own community, it can be expected that current practices will not change dramatically.

Publishers of scientific journals do not need to fear that the e-print archives will replace their position of preeminence for scholarly publication in the near future. The gatekeeping function of peer review, assisting in filtering out poor work, is crucial in today's world of information overload. Additionally, the reward structure tied to journal publication is deeply entrenched in academia. The e-print archives have provided a spur to scientific publishers to encourage the move toward electronic scholarly communication and electronic publication. The e-print servers have opened up one more avenue for disseminating research results that appeal to some communities of scientists.