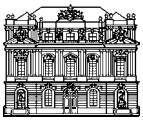
Michael Nentwich

# cyberscience

## Research in the Age of the Internet

Chapter 4

## CYBERSCIENCE AND THE SPATIAL DIMENSION



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# DETAILED LIST OF CONTENTS

"(E)lectronic communication is entirely decoupled from the co-ordinate system of physical space. E-mail interaction allows for transforming distance in physical space into 'closeness' (that is accessibility)."
(Merz 1998, 323)

# 4 CYBERSCIENCE AND THE SPATIAL DIMENSION

Part Three of this study is devoted to an in-depth discussion of six areas of potential and actual change in academia. Its first chapter deals with the potential of ICT to remove the restricting geographic component of scholarly working structures.

As I have defined cyberscience in relation to activities in a new kind of space, namely cyberspace (cf. 1.1), the use of networked computers has obviously the potential to affect spatiality in academia. Scholars may break free from spatial limitations to a considerable extent. The resources in the scholars' offices may be used even if the researcher is not present physically (telework). Online access to remote digital libraries with E-journals and access to various online databases may reduce the need to have a real library close by. So-called "extended research groups" may co-operate in a virtual environment (e.g. in a virtual laboratory or "collaboratory") while meeting at best occasionally. Groupware applications may support this joint research and virtual or E-conferences may take place on a larger scale.[482]

By diminishing the importance of space, cyberscience may have a considerable impact on the way research will be done in the not-so-distant future: multi-authorship may increase; the oral scientific discourse might be replaced by written procedures; scientific communities may be more fragmented, i.e. specialised, but interconnected world-wide; research infrastructure requirements may shift; and the positioning of more peripheral research may alter due to this development.

My guiding question in this chapter will therefore be the following: To what extent and with which qualitative consequences will the path to cyberscience affect the "geography", i.e. the spatial structure of academia? This analysis will, however, also touch upon a number of related questions, for instance effects on time and on social structures. The present chapter has three main parts: First, I will present the elements of the prospective new spatial layout of academia (4.1). Second, I will discuss a number of key issues on the path towards this new geography (4.2). Finally, the consequences for science and research will be analysed (4.3).

## 4.1 Elements of a new spatial layout of academia

As already noted, cyberscience potentially affects various constitutive aspects of how academia is organised. Based on my literature survey and Internet enquiry, I distinguish the following five main elements: (1) telework, digital libraries and remote information

[482] Thagard (1997b) describes a typical "day in the live of a cyberscientist" using all the elements listed here.

retrieval; (2) virtual seminars and conferences; (3) distant co-operation among researchers; (4) extended research groups, virtual institutes and collaboratories; and finally (5) the Internet as a new research tool.

### 1. Telework, digital libraries and remote information retrieval

The most striking feature of the new work environment is its "neutrality" vis-à-vis space: CMC allows for remote access to all kinds of resources. Data stored in remote databases can be retrieved for local computation or local data may be sent to a remote computer for analysis. Mailings with other researchers, with the research administration as well as with funding agencies, and finally with the general public may be handled electronically. Academic publications may not only be searched through bibliographic databases but, increasingly, also downloaded in full text for local on-screen reading or printing. If not available online, they may be ordered through a new form of inter-library loan called digital document delivery. Furthermore, all sorts of dynamic (constantly updated and improved) encyclopaedias and dictionaries can be accessed remotely. In many respects, researchers do not have to leave their computer desks any more (wherever they may be located – in the office, at home or "on the road"). Resources are available through LANs and the Internet, through online databases and archives of all sorts, as well as through digital or virtual libraries (cf. in particular sections 2.3.3 and 2.3.4). "Wired" researchers are constantly shifting between phases of in-office and of tele-work.

### 2. Discourse among non-present researchers: virtual seminars and conferences

ICT not only enable remote access to all sorts of data (people-to-machine communication), but also communication between researchers (people-to-people; cf. 2.4.2 and 2.4.4.4). Indeed there are already a number of virtual academic conferences,[483] often based on either E-mail, discussion lists[484], newsgroups or audio/video tools. Such conferences can be synchronous like traditional meetings where all participants are online at the same time. Or they may be asynchronous, that is the participants "tune in" whenever they have time available. In the latter case, a conference homepage or a "list archive" with all contributions made so far will be available. Contributions may be both presentations, video sequences of speeches, full papers, short comments etc. A good architecture for virtual academic discourse may be a co-ordinated system consisting of newsgroups and discussion forums, together with a central homepage of the respective programme, specific project presentations and a virtual archive with search-engine (Winiwarter 2000). In one model, virtual conferences may also be combined with face-to-face meetings. The physical meeting is preceded by an extended virtual phase during which the presentations take place and questions of fact are settled. During the physical meeting, discussion on open points and interpretation may take place.

[483] See the DSEJ for a comprehensive list of "E-conferences" (<Cyberlink=180>).

[484] For instance, Harasim/Winkelmans (1990) studied an "international online educational research workshop", which was an organised two-month-and-a-half-long E-mail group discussion with the possibility to up and download files from a central server. This server also handled the communication (termed "computer conferencing" by these authors) with a view to finding out about computer-mediated scholarly collaboration. Mills (1998) also describes a case study of using the Internet for scholarly discussion. Gresham (1994, 44ff.) surveyed a number of discussion groups in a qualitative manner. Hert (1997) analysed the social dynamics of a particular discussion in an E-mail list.

### 3. Distant co-operation among researchers

This may take various forms: Co-authors may be co-ordinated via ("multi-bilateral") E-mail (Rost 1996a). E-lists play an important role here, as collaborators have a common forum. Research-related notes as well as any organisational business can be shared and discussed. Some projects sustain even several E-lists for different aspects of the co-operation. Increasingly, also groupware is used which allows sharing files easily via a virtual "shared workplace" to which all participants have access (cf. 2.4.7). E-conferencing tools may equally be part of the digital co-operation infrastructure. Regular virtual meetings may be held to analyse the progress of the project, to discuss difficult issues and to chat about social issues. During the meetings, "desktop sharing" may imitate the conference table with a view to exchange notes and drawings like on a flip chart or to work together on a shared document, e.g. a project report or co-authored paper. A common project homepage may be both a window to the academic world outside the co-operation and a source of information for the collaborators with regard to the progress of the project.

### 4. Non-local research institutionalisation: extended research groups – virtual institutes – collaboratories

The new means of communication do not only trigger telework and distance co-operation on a case-by-case basis, but these elements may also become institutionalised. On the basis of groupware, remote control, shared database technology etc. (cf. 2.3.4, 2.3.7 and 2.4.7), there are a number of forms:

*Extended research groups* "do science at a distance"; they are "very large, unified, cohesive and highly co-operative research groups that is geographically dispersed yet co-ordinated as though they were at one location and working under the direction of a single director" (Carley/Wendt 1991, 407; Walsh/Roselle 1999, 52).[485] As opposed to earlier multi-institutional co-ordinated groups, the following potential advantages have been listed inter alia: democratic division of labor; communication of new ideas before they are fully worked out; unified perspective on what direction to move the research front (Carley/Wendt 1991, 407). I shall look into these effects in more detail in 4.3.1.2.

A *disembedded laboratory* among the collaborators is "the network of electronic connections through which news, results, ideas and tools (e.g. computer software) is exchanged" (Merz 1997, 250, writing about theoretical physics). In such a virtual environment, the accessibility among collaborators via E-mail replaces the co-presence of local co-operations. They are "disembedded" because these collaborative practices are at least temporarily 'taken out' of a local (physical) context and hence rely on electronic connections.

*Virtual laboratory or "collaboratory"* is a term derived by combining the words 'collaboration' and 'laboratory'. Initially, the notion of virtual laboratories or collaboratories was developed in the context of and confined to scientific laboratory tasks. It is all about remote controlled instruments and virtual instruments and the like (see OECD 1998, 209ff.). They "provide the access to equipment, colleagues and databases that are traditionally part of the laboratory organisation of science, without regard to geography" (Walsh/

[485] The prime example for extended research groups is CERN where the WWW was created with a view to facilitate collaboration of larger research groups (comprising even hundreds of distributed researchers). Another well-known example is the development of Linux through online collaboration of thousands of programmers across the globe (further examples: Walsh/Roselle 1999, 52).

Roselle 1999, 53). A collaboratory is "a computer-supported system that allows scientists to work with each other, facilities, and databases without regard to geographical location" (Finholt/Olson 1997, 28) or, in the words of Lederberg/Uncapher (quoted by Finholt/Olson 1997, 29), the "combination of technology, tools and infrastructure that allow scientists to work with remote facilities and each other as if they were co-located". An early US report (CSTB 1993) defines it as "an environment in which all of a scientist's instruments and information are virtually local, regardless of their actual locations". The virtual environment of the collaboratory supports all types of interaction – people-to-people, people-to-machine and machine-to-machine (cf. 1.2.1).

*Virtual or online institutes* are, similar to collaboratories in the sciences, the institutionalisation of distant co-operation in those disciplines not organised around laboratories.[486] All cyber-technologies of data sharing and virtual meeting are available in an institute-like organisational form. They "are a sort of meta-structure, similar to universities, under whose umbrella multiple forms of academic interaction may be combined" (Orthmann/Näcke 1999, 4, transl. MN). Some see the more structured virtual departments as the likely development of some of the invisible colleges of interlinked specialists which are wide-open and practically unmanageable (Noam 1995, 248).

### 5. Extending scope of research: The Internet as a new research tool

Yet in one further dimension, the Internet is overcoming traditional spatial limitations, namely as a research tool:

In the social sciences, E-mail or WWW forms can be used as a research tool for social scientists making *interviews or surveys* with the advantages of easy access to world-wide samples, of low administration costs (both financially and temporarily) and of its unobtrusiveness and 'friendliness' to respondents. E-mail, as an interview tool, avoids the conventional constraints of spatial and temporal proximity between interviewer and respondent and offers, at the same time, the remarkable practical advantage of providing 'ready-transcribed' data (Selwyn/Robson 1998).[487]

*Shared databases* (cf. 2.3.4) are another new tool: Scientists in different countries may combine local data sets and create global databases which can be used to answer questions that depend on collecting data from across the globe (Walsh/Roselle 1999, 60; see also Thagard 1997b). Knowledge bases on the web may become the nucleus of distributed collaboratories (Euzenat 1998).

[486] Virtual institutes may, however, not be restricted to the social sciences and the humanities. The Sea of Cortez oceanographic experiment is an early example of a virtual research institute which linked a number of research institutes together with a view to simulate and co-ordinate the remote robot in the sea (reported by Grötschel/Lügger 1996, 14f.) The Resilience Alliance (<Cyberlink=489>) is a collaborative project, an "institute-without-walls" (Holling 1999) devoted to conservation ecology. The members of the group use online community software (CommunityZero) to engage in debates and co-operative projects.

[487] A constraint is equally obvious: "its, as yet, limited and biased population of users (in terms of age, income, gender and race)" (Selwyn/Robson 1998). The other disadvantage mentioned by these authors, namely that "ensuring respondents' anonymity is virtually impossible" is not valid any more. Today, the invitation to participate in a survey is sent by E-mail, but the questionnaire is filled out anonymously on the web as direct input to the survey database. It is now technically possible to make sure both that only those invited to participate actually fill in the form (by a personalised access code) and that the survey databases do not store the individual code alongside the data, but only for the purpose of knowing who has not yet responded and should be "chased".

*Distributed computing* (cf. 2.2.1) equally reduces space to a negligible variable, thus creating virtual worldwide computing facilities.

ELEMENTS OF THE NEW SPATIAL LAYOUT

- Telework, digital libraries and remote information retrieval
- Discourse among non-present researchers:
  Virtual seminars and conferences
- Distant co-operation among researchers
- Non-local research institutionalisation:
  extended research groups, virtual institutes, collaboratories
- Extending scope of research:
  the Internet as a new research tool
  (interviews/surveys, shared databases, distributed computing)

*Overview 4-1: Elements of the new spatial layout*

As these five elements are already presented to some degree today, I hypothesise that they will also be in some combination in the evolving spatial layout of cyberscience.[488] In the next step, I shall look at the factors influencing this combination.

## 4.2 Key issues on the path to the new spatial layout of academia

Neither the advent of ICT, nor the development of specifically academic applications alone will bring about a "space-less" academia or an academia independent from space. Therefore, I will analyse and discuss various factors influencing the path to cyberscience.

### 4.2.1 On the suitability of E-mail for academic communication

> "As a medium for facilitating collaboration, e-mail is seen as a next-best substitute for face-to-face interaction."
> (Walsh/Bayma 1996, 349)

As we have seen in 3.3.1, E-mail is used very widely in academia already: it has become the standard communication tool among scientists. Why is this so? E-mail has a number of properties which make it ideally suited for academic communication: asynchronity, speed, written character and permanency.

*Asynchronity:* Due to its asynchronous nature, communication via E-mail is often a good alternative as compared to the telephone: communication may be sustained although the communication partners are not communicating at the same time. E-mail and (E-

[488] I shall point at differences between the various academic fields where appropriate.

mail-based) newsgroup discussion eliminates the need for geographic or temporal synchronization (Lewenstein 1995, 125). In detail, the asynchronous nature means:

- E-mail can be used not only for long distances, but also locally. Asynchronity is equally advantageous if communicating with external colleagues and among the members of the same research group, accommodated in the same building. Both might be travelling or temporarily out of office, giving lectures or having a coffee break. When it comes to non-local colleagues, a further reason for not being able to reach somebody in a synchronous timeframe is that s/he may be located in a much different time-zone.
- Some argue that growing E-mail and other online contacts may interrupt the normal flow of work (thoughts etc.) (e.g. Scheidl 1999, 100). However, one may turn off the E-mail programme more easily than the phone (as secretaries as filters are rather rare in academia). Hence, the moment of taking the message may be chosen freely. Even if available for synchronous communication at present, one is not forced to do so and hence not necessarily distracted from one's present work. Theoretical physicists, for instance, while "doing physics" (instead of "talking physics") prefer E-mail communication with a view to safeguard their independence, their rhythm of work (Merz 1997, 254). "In a disembedded collaboration, the collaborators (and the work they perform) become partially invisible to each other. This 'partial invisibility' is used as a tool." (Merz 1998, 325) Asynchronity allows for logging on at convenient times – which may be surprisingly often evening and night hours as well as Sundays (Harasim/Winkelmans 1990, 398f., see in particular their figures 6 and 7).
- Answers may be given a second (or third) thought and do not have to be spontaneous as is the case in a face-to-face situation (Mills 1998). This is equally important in communication about research issues[489] and when socialising.[490] In addition, those whose mother tongue is not English have, in an E-mail conversation, the possibility to consult dictionaries before answering. This is a real advantage if compared to the spontaneous face-to-face situation.
- Asynchronity also gives synchronicity a new spin: E-mail allows participants to 'talk' simultaneously, which is impossible or insensible in an oral setting. Although simultaneous speech hampers somehow the flow and coherence of discussion, the advantage of this may be that one does not have to wait for another to finish with the danger of forgetting parts of the argument in one's mind. Furthermore, although most E-conferences via E-mail lists are scheduled for longer periods, it may prove useful to "meet virtually" in a particular timeframe, meaning to be online at the same time (synchronous), but to communicate in an asynchronous mode.
- E-mail based, asynchronous communication may continue for a longer period because not all participants have to be brought together at one particular point in time at the exclusion of other activities (Walsh/Roselle 1999, 57, quoting a number of other studies; Mills 1998). In asynchronous communication it is possible to fully discuss a subject, as time restraints – a typical feature of face-to-face discussions – are virtually non-existent. In this sense, face-to-face meetings may be seen as less effective if com-

[489] Similar arguments apply with regard to videotapes or files of lectures and presentations which can be looked at asynchronously. As Kling/Covi argue "people watching a videotape may privately replay sections to enhance their comprehension, while in a face-to-face meeting they may have to ask questions (that might also embarrass the speaker or questioner)" (1995).

[490] This is, however, something to be learnt still. Often E-mail is used very spontaneously, perhaps even quicker and without much reflection on the possible consequences. The difference to a spoken dialogue is that an E-mail is persistent and cannot easily be "taken back".

pared to a continued exchange via E-mail because of the generally short duration and limited interaction opportunities of the former (Harasim/Winkelmans 1990, 397). Continuity and interdependence among messages can be signalled by quoting and referring to previous messages (e.g. Hert 1997, 345). Her interviewees told Merz that the specific properties of theoretical physics work favour phases of separated, "trans-local" work and, hence, E-mail communication – though not optimal – is a good tool to facilitate continuity (Merz 1997, 254).

*Speed*: Obviously, E-mail is a fast medium if compared to traditional or "snail mail" and even the fax. This is particularly helpful in long-distance communication. E-mail can, however, also be used as a speedy alternative or add-on to other forms of communication. In contrast to (slow) formal publication, E-mail conferences promise "to restore the speed of scholarly communication to a rate much closer to the speed of thought" (Harnad 1991, 48). Through E-mailing something approaching a 'real time' dialogue can be carried on, as messages and replies reach the other almost instantaneously. Since messages can also be saved for later reading or a delayed response, E-mail interaction "combines the promptness of phone calls with the temporal flexibility of s-mail (snail mail)" (Merz 1998, 323). Also proliferation is speeded up (Mills 1998, 2, calls this a "snowball effect"): Once something is posted on an E-list, it can very easily be sent (forwarded) all around the world and end up in places not originally envisioned.

*Written character:* As with asynchronity, non-native-speakers of the language used in the communication prefer written communication to oral communication (OECD 1998, 196). Furthermore, written messages allow time to formulate answers more thoughtfully before responding. This is, however, not always needed. For instance, Stichweh (1989, 23f.) suggests that for informal communication purposes (e.g. giving feedback on a manuscript) an immediate phone call of half an hour seems ideal. This would offer the opportunity to adapt one's arguments to the reaction of the other immediately whereas, in general, there would be no time for a similar detailed written elaboration. This argument rests, however, on the assumption that both partners have indeed a time-slot available at the same time (immediately after the one giving feedback has read the paper). Otherwise, one cannot but write down at least in short the ideas that one had during the lecture.[491]

*Permanency* of the written record helps to overcome the fluidity of spoken communication. E-mails can be stored, either locally by each communication partner or centrally in the archive of the E-list. In other words, a "discourse memory" remains available. Unlike spoken intervention, reference can be made to an earlier statement in written form. Discourse memory enables concrete and detailed reference to arguments previously tabled. In this context, Stichweh (1989, 36) created the German notion "unendlichkeitsfähig" (~ "apt for infinity") meaning that nothing gets lost and interruptions are neutral for the discourse. One can even say that the "elusive and ephemeral nature of information in verbal networks is overcome" (Gresham 1994, 47). A written record as generated by intensive E-mail use is particularly helpful when communicating complex ideas because each of the collaborators can review the documents at length at a later time, and does not have to rely on sketchy notes or memory (Walsh/Maloney 2002, 20). However, fluidity can also be an advantage in some contexts. For instance for brainstorming, the vari-

[491] Furthermore, Stichweh could not include the perspective of interactive videoconferencing over the Internet with simultaneous document exchange etc. which might turn out to be a better means of communication than the old telephone (as well as E-mail).

ous preliminary thoughts and ideas do not need to be made permanent, to the contrary. Mills lists among the possible causes for a low level of participation in E-lists that "writing something down – even for e-mail – has a feeling of permanence which may inhibit a certain level of communication" (1998, 4).

SIGNIFICANT PROPERTIES OF E-MAIL
- Asynchronity
- Speed
- Written character
- Permanency

*Overview 4-2: Significant properties of E-mail*

To sum up, looking at these significant properties of E-mail communication, it comes as no surprise that E-mail has taken over large proportions of communication among academics. In particular, distant bilateral communication (with a remote collaborator) is increasingly done via E-mail because of the advantages of asynchronity. But even local bilateral (with a colleague) and local multilateral (among a group) communication benefits from the written and asynchron character and the speed of E-mail. It is mainly the possibility of easy record keeping (permanency) together with the synchronous-asynchronous duality of the medium, which make E-mail-based lists attractive for extended E-conferencing.

## 4.2.2 Prospects of virtual seminars and conferences

Asynchronous E-mail lists, as discussed in the previous section (4.2.1), are but one way of "meeting" virtually. As we have seen in 2.4.4.4, there are various ways to hold virtual seminars, workshops of conferences (video and/or conferencing, with or without desktop sharing, E-lists, MOOs, asynchronous/synchronous etc.). In this section, I shall look at the functions of seminars and conferences with a view to finding out whether or not these functions can be fulfilled in a virtual environment. I do not divide sections for the various formats but discuss the differences where appropriate.

### 4.2.2.1 Functions of scholarly conferences

The following functions of academic seminars, workshops and conferences may be distinguished:

1. They are quasi experiments in the humanities and social sciences: a paper is tested against the arguments of the audience; one function is therefore: *quality control*;
2. They serve as an instrument of *transmission* of knowledge and ideas to the participants as a (i) market for ideas and as (ii) instruction for students;
3. They are a node in the scientific *networks*, a facilitator of renewing and establishing new relations within the network, in particular before and after the seminar or during a conference;

4. They are instruments of institutional or associational *social management*: participants get socialised in the group; paper-givers are being "initiated"; seminars may even serve as an instrument of enforcing discipline in a group;
5. They help *generate new ideas* and arguments by way of collective brainstorming and reflexive arguing.

In what way can we envisage that these functions may be fulfilled in an electronic way?

ad (1) *Quality control:* This is probably the function which is easiest to transfer to the electronic environment. In the context of E-journals, there are already promising experiences with this type of quality control (see chapter 8). For instance, Hert reports of participants of the E-mail discussion he studied who said that their main goal was "to get their opinions across, to test the reactions elicited, and to get people used to these opinions" (1997, 352). Hert concludes that the "forum was used mostly by people to express, or at least to experiment with, their disagreement concerning some part of the heterogeneous [particular scientific] community" (ibid., 355).

There is even potential for improvement on real seminars. The usual disadvantage of time constraints is less important in an electronic environment as there may be both a synchronous and an asynchronous part of the conference. Hence, lively debates do not have to be stopped because a coffee break is needed or because time is over – as they can continue in asynchronous mode. By contrast, debates may continue in cyberspace. In addition, in an asynchronous virtual seminar, the advantage of a written "discourse memory" fully apply (see above 4.2.1). A written record enables much more thorough analysis of the meat of arguments thrown into the discussion. If organised properly and supported by sophisticated software, another advantage applies, namely "threading". The various related contributions (threads) may be separated more easily both during the debate and afterwards. Whereas in the real world no particular argument can be pursued up to the point "where nothing is left to say", virtual seminars, as a matter of principle, are not restricted in a similar way.[492]

ad (2) *Knowledge transmission:* In the context of E-teaching, it is certainly hotly debated whether knowledge can be transmitted equally effective in a virtual setting. The written format requires special skills, both on the part of the presenter and the receiver of the information. When it comes to video-conferencing, the quality of the equipment is certainly paramount (see 4.2.3 below). The virtual environment may give the opportunity to follow a lecture in asynchronous mode, thereby having the choice to replay particular sections to enhance comprehension (Kling/Covi 1995).[489] The exchange of ideas is probably done more easily in a less formal setting, but some type of formalism is inevitable in a written procedure.

ad (3) *Network node:* In principle, academics can "meet" in cyberspace and networking is possible. Renewing contacts in a virtual setting is certainly easier than establishing new contacts. There is the strong argument that first time contacts are more promising if face-to-face. In the literature and also among the interviewees for this study, there is a general sense that the seminars and congresses are very important for sustaining academic networks (Fröhlich 1996a, 22; Riggs/et al. 1998).[493] However, there are some hints

[492] In practice, threading is often difficult and needs very disciplined list-members. See for instance the attempt to draft guidelines by the German chapter of ISKO for their discussion list "wiss-org" (Deutsche Sektion ISKO 1999).

[493] I shall come back to this issue in 4.2.4 below when I discuss the importance of informal activities in academia.

that virtual conferencing may play an important role in network building. Freeman (1984) discusses in-depth how a (relatively primitive) E-mail-based conference system impacted on the formation of a sub-discipline. He noted that the "whole of the scientific enterprise depends on effective communication among people working in an area"; particularly "in the early stages of the emergence of a new speciality, progress requires communication in order to establish the sorts of norms and consenses that define both problem and approach." (ibid., 203)

ad (4) *Social management:* Virtual seminars would certainly need some time to be able to become ritualised and fulfil the same function as face-to-face seminars. As long as they are something very new and not a tradition, they cannot serve the same purpose. I hold, however, that there is no convincing reason why they should not do so, in the long run. If discipline is indeed a problem, it might be enforced in an electronic environment, too.

ad (5) *Idea generator:* In the context of his discussion of a vivid E-mail discussion list debate, Hert notes that the properties and opportunities of the medium, i.e. the possibility to compose one's message by 'cutting & pasting' previous messages as well as marking and indenting original text, enables the participants to use the discursive context. The "medium is then a resource for negotiating different interpretations of some messages" (1997, 345). Hert speaks of the "collective appropriation" of the messages sent during an E-mail debate:

> "Unlike traditional written texts, these forms of writing show the process of constructing arguments in interaction with some of the recipients of those arguments. The debate is rewritten as it moves along, and one's texts are mixed with others' to become somehow the position emerging from the electronic discussion." (ibid., 350)

This is not to say that E-mail discussions will lead to consensus. Rather they may contribute to make points of dissent "more explicit to the general audience than is possible in a scholarly paper" (ibid., 354), simply because an author cannot know all points of dissent in advance. In addition, the asynchronous nature of E-lists also allows participants to throw in quick ideas without waiting for one's turn – as necessary in a face-to-face situation. This might perhaps even help to generate and record ideas.

To summarise, most of the functions of conferences and seminars may be fulfilled in a virtual setting, too. In some cases, it will take some time until the results become satisfactory. It is, however, not yet clear whether the more socially oriented, informal functions can be fulfilled. This will be discussed in 4.2.4.

#### 4.2.2.2 Organisational and technical aspects of E-conferencing

Although there is a long-standing tradition of conference and seminar organisation in academia, there is no doubt that many such events do not satisfy all wishes, many of them are sub-optimal, perhaps even a waste of time. There may be technical (e.g. bad loudspeakers, bad light conditions) or organisational (e.g. bad timing, bad chairing/moderating) or content-related problems (e.g. low-quality or unrelated papers). Nonetheless, researchers have become used to these shortcomings. In a virtual setting, these problems are bound to stay and there will be even new sources of dissatisfaction, but also new hope for more structured communication (as described above).

To begin with the *technical* side, more things can go wrong: for instance, network connections may break down or have bandwidth problems or the conferencing software may be difficult to use. Hence, "the importance of highly motivated NETMEETING 'champions'

in getting groups over initial learning curves" (Finholt 2001, 22) cannot be denied. After all, "collaboration is about lots of things besides the division of labor, like reassurance in the face of technical panic" (Eaves 1998, 3). In the literature, you find many descriptions of the problems of E-conferencing (e.g. Mills 1998). The software often does not support what is needed for smooth conferencing. For instance, inappropriate tools to structure (to "thread") themes may "contribute to a sense of information overload among participants" and may even complicate the process of organizing the discussions for moderating and subsequent text-production activities (Harasim/Winkelmans 1990, 398). We have to distinguish, however, between restrictions due to technological shortcomings and to the way people use the technology. For instance, if there is no human list moderator, it is difficult to have meaningful subject headers for sorting and structuring the debate because people normally use the reply function. Mills ponders whether "to impose even a moderate amount of structure on a medium which, by its nature, is somewhat chaotic, and on academics and others who want to formulate their own questions and points for critique – regardless of initial suggestions – inhibits free-flowing discussions" (ibid., 4). One may, however, argue that, as soon as the technology becomes more widespread and sophisticated, the learning curve will not have to be started over and over again, but coping with this peculiar virtual setting will become business-as-usual. Furthermore, unlike in a traditional conference setting, record keeping and threading may help to organise more structured seminars.

On the *organisational* side, the well-known problem of initiating discussion re-emerges in the virtual world in aggravated form. While in a face-to-face situation, there are a few social tricks to bring about reactions by participants,[494] these tricks would not work in an E-conference. How then is "traffic" (which is the jargon word for the amount of written contributions to an E-list) generated – how do discussions get going? If the conference is organised by means of (yet another) discussion list, the effect may be that people feel less inclined to participate actively. To counter this phenomenon, Mills proposes "to push the workshop analogy", that is, to help participants to realise that "even though they have not gathered in one place for a weekend with all expenses paid, they are still engaged in the same type of scholarly activity" (ibid., 4). The role of the session chair, the "moderator" or "list owner", may be even more important in a virtual setting (Harasim/Winkelmans 1990, 391). It may be more difficult to get a discussion going and to sustain the momentum (Mills 1998, 3). Obviously, this is also a matter of practice and evolving habits.

I agree with the CSTB conclusions that "(a)lthough technology will never cause the unwilling to collaborate, it can facilitate collaboration among those who are motivated and can make it more attractive to others" (CSTB 1993, 1). Hence, another organisational aspect is the setting of incentives to engage in this new form of conferencing and collaborating. Increased institutional recognition of online work may favour the professional adoption of computer conferencing (Harasim/Winkelmans 1990, 404).[495] Whereas ICT allows the scholar to conduct many existing tasks more effectively and to undertake entirely new activities, "at the moment the time requirements are assumed by the individual as add-on costs" (ibid.). That is, they do it in addition to their standard duties without getting due credit for it. From their survey among the participants of some E-con-

[494] The panel chair may, for instance, directly address a participant and look directly and provocatively in his/her eyes.

[495] On institutional policies, see 11.3.

ferences, Harasim/Winkelmans (1990, 402) add as a further incentive that the group should have "a specific task to accomplish, a deadline to meet".

Furthermore, the context in which CMC is introduced is "an important mediating factor" in explaining their effects (Walsh/Roselle 1999, 67) as well as their perspectives. The characteristics of the collaboration (long term vs. short term; group vs. individual) as well as pre-existing attitudes of participants towards that collaboration (Walsh/Roselle 1999, 67) play a role not only in general, but also with a view to successfully carrying out virtual workshops. The general insight that the introduction of new technologies may be most successful where they are built on existent social arrangements is certainly of relevance in this context here, as well.

### 4.2.3 Can multimedia eventually replace face-to-face?

Earlier research focussing on E-mail only concludes that, in general, face-to-face is paramount to establish strong enough ties for a working relationship sustained by E-mail (e.g. Carley/Wendt 1991, 435; Stichweh 1989, 39). In particular between collaborators who do not know each other well, if communication is carried out via E-mail, misunderstandings are likely to occur and are harder to detect. This is, as Merz argues, "because the 'nuances' to the messages get lost and the questioning look of the other remains invisible" (1998, 324; 1997, 253). In general, however, E-mail is seen "as a next-best substitute for face-to-face interaction" (Walsh/Roselle 1999, 55) allowing collaborators to continue "after laying the groundwork in person". There is evidence that would-be-collaborators emphasise the importance of establishing common understandings of the research problem offline, that is, through intensive, face-to-face interaction before going online. It is also known from interviewing that E-mail suffers from a lack of tacit communication (Selwyn/Robson 1998). Based on his research on USENET newsgroups, Lewenstein (1995, 144) summarises the argument that CMC will not replace traditional face-to-face interaction:

> "Although CMC allows discussions about technical issues to take place in forums that break the bonds of time and space, they do not allow researchers to acquire efficiently all the information (including judgements about veracity, thoroughness, and group opinion) that go into making scientific judgements. These judgements are fundamentally social decisions that require access to a greater scope of information than can be transmitted via CMC."

As indicated in the introductory sentence to this section, most observers commenting on the importance of face-to-face in academia argue against the background of very limited communication channels, in particular of E-mail. Indeed, written communication will never be able to transmit the whole array of tacit information known from face-to-face. However, even though nearly all first experiences with E-conferencing beyond E-lists reported in the literature[496] and by my interviewees[497] have been a mixed blessing, we should not underrate the technological potential of these new tools (cf. 2.4.4.4 and 2.4.7). It is, however, conceivable that there will soon be powerful tools for synchronously con-

[496] Finholt (2001, 26), for instance, argues that "when tasks are tightly coupled, that is, dependent on frequent interaction and feedback among collaborators, contemporary communication technologies – such as e-mail, video and audio conferencing, and groupware (...) – do not provide an adequate substitute for co-location".

[497] Cf. also 0.3.4.3 for this author's experiences with E-conferencing.

necting researchers, providing for near-perfect transmission of real-time (live) high-resolution video pictures of facial expressions. I venture the prediction that researchers will soon be able to apprehend the questioning or doubtful look of their collaborators in the virtual setting, too. This seems to be a possible future not yet taken into account in the face-to-face versus virtual meetings discussion.

In any case, the fact that electronic communication media are "poorer" or selective will be true for quite some time still and will perhaps never improve beyond a certain point, hence always will fall short of real face-to-face communication. However, this selectivity has two mutually dependent consequences. On the one hand, selectivity means that some aspects will not be transmitted. There is the danger that aspects important for mutual understanding may be missed. On the other hand, selectivity may lead to concentration in the sense that the communication partners are not distracted by other (tacit) and perhaps irrelevant information.

The crucial question is how much information is needed for functioning academic communication? Why should the communication of some "real-life information" (e.g. smell, distance to communication partner) be essential in an academic conversation? It is not primarily about dealing and negotiating a contract (where mutual trust and the way someone says something may be crucial)[498], but ideally about the exchange of ideas and arguments. Convincing another researcher in a conversation should not be due to factors other than intra-scientific ones. However, this argument refers to an ideal speech situation (Habermas) which is unlikely to be ever the case in the real world. We have to acknowledge that discourse is not interest-free, not neutral, but also serves social purposes of particular actors (in particular with regard to one's career).[499]

As it seems that in many circumstances, there is no alternative to distant collaboration,[500] the issue is not whether or not to meet virtually, but how to provide for a useful technical and social environment for this new reality. It seems clear that changing the circumstances for collaboration may undermine the effectiveness of the collaborative process by introducing new demands due to loss of a common physical setting (Finholt 2001, 25). Under what circumstances can virtual meetings be successful? One result of the research on collaboratories is that, in a virtual context, participants have to be explicit about information that is normally tacit when co-located (ibid., 26). From a technical point of view, the challenge for collaboratory developers is to produce "tools and applications that compensate for the absence of shared setting" (ibid., 26).[501]

[498] See, however, below in 4.2.5.

[499] By the way, this is equally true for face-to-face communication, which depends, for instance, heavily on the capabilities of the speakers (the rhetoric qualities; the quality of supporting material such as overhead slides and other media) and the level of attentiveness of the listeners (depending on the length of the speech; the quantity of information delivered/presented etc.). In other words: face-to-face communication has also limitations (Gresham 1994, 47).

[500] Financial means in international projects often do not allow for very frequent meetings at one spot. And even if they would, there would still be interim phases where a quick meeting would be necessary, but impractical to organise at short notice. International co-operative research is, however, increasing in share due to the respective funding policies of both many national and, in particular, international bodies.

[501] This might, however, be no panacea. Carley/Wendt claim that "(e)ven new graphic capabilities and expert interfaces that allow presorting of mail, however, are unlikely to result in more diffusion of primary information through E-mail unless they are accompanied by technologies for adequate information security and by development of policies for recognizing scientific contributions that are initially communicated electronically." (1991, 436)

Another claim could be that people meeting in a virtual setting should not expect first time contacts to always be successful (see 4.2.5 below). However, for some kinds of contacts, it is not really necessary to know each other in person, e.g. if the purpose is only exchange of technical information. There are examples where people have never met in person but would certainly describe their relationship as close and efficient.

Ultimately, this may lead us to the conclusion that cyberspace will never fully substitute or replace but rather supplement the traditional face-to-face system. The latter always remains an option in reserve when partial, indirect, virtual means fail (Eaves 1998, 2). It seems that both forms of communicating, face-to-face like the virtual, are not good for everything. Although E-mail is in many cases preferable because it is "more efficient, more forgiving, less fraught", there may be, as a last resort, "no virtual stand-in for meeting in person" (ibid., 5).

The main issue is that distant collaborators may lose their common understanding of the cause or their common ground over time, that is "the shared cognitive understanding that allows collaborators to successfully coordinate their effort to accomplish joint work" (Finholt 2001, 26). Misapprehensions may arise but, at the same time, remain unnoticed in "an illusion of understanding" (Eaves 1998, 6). The experience with collaboratories to date indicates the enormous difficulty of supporting complex group work in virtual settings. There are considerable problems "at the tricky intersection of technology with individual and group behavior" (Finholt 2001, 25).

In sum, I hold that we are only at the very beginning of a slow evolution. We may both expect ever more sophisticated technological tools and new organisational solutions that facilitate distant co-operation in academia. Even though the experience gathered so far is still limited and often based on outdated technologies, it seems convincing to argue that face-to-face meetings will still play an important role. Often they will serve as a last resort, if the collaborators feel that their common understanding is fading away and needs to be reinstated. In order to prevent the basis of collaboration from deteriorating in such a way, it may be useful to schedule face-to-face meetings regularly from the outset.

### 4.2.4 Informal research activities: the importance of the "Café"

In the preceding sections, I have already touched a number of issues making it clear that science and research is not only about developing and exchanging new knowledge. Research is not taking place in ideal, socially neutral settings, but is highly "loaded" with "context". For instance, a seminar or conference is not only about presenting and discussing research results but perhaps equally important, about networking and social management. Furthermore, we have seen that whether E-conferencing will become a viable alternative to face-to-face interaction, not only depends on the technical implementation but also on the organisational setting. In this section, I shall add yet another aspect: research is not only done in formal settings (like seminars) or in the tranquillity of the individual researcher's office. Informal meetings and exchange play an important role, too. In psychology, 'informal' is not 'uninformative' (Scheidl 1999, 100). We have to distinguish between

- *work-related topics* like the exchange of ideas, spontaneous brainstorming, filtering of news[502] and undirected discussion, and
- *social exchange*, that is conflict management, contacting, scheduling of meetings, a good working atmosphere, as well as gossip.

With regard to the work-related topics, the telling example of theoretical physicists has been analysed by Merz (1997, 246f.; 1998, 317). She distinguishes between 'doing physics' and 'talking physics'. Both phases alternate constantly during a project. 'Talking physics' is most important in order to substantiate ideas and subjects, establishing collaborations etc. "Above all, the workplace of a theoretician is a social place. It is the place of encounters with colleagues." (1997, 246, transl. MN) This is particularly important since theoreticians define their subjects themselves – like most social scientists and humanist scholars do. Merz argues that this is different, for instance, for biologists since their subjects, apparatus and collaborators are predetermined by the local context of the biology laboratory. Merz found that "for the communication in the phases of 'doing physics', the exchange of E-mails is better suited" (ibid., 252, transl. MN).[503] By contrast, 'talking physics', i.e. chatting is more difficult or even impossible via E-mail, as some physicists claim. There is no virtual counterpart (chat room, newsgroup) of the (real) 'Café' in which physics problems are being discussed frequently, at least not in theoretical physics (ibid., 256). "As the casual chats witnessed in a café heavily rely on the customers' visibility amongst each other, the only 'version of the café' for theorists at CERN is the actual cafeteria." (1998, 326f.) Merz observes that, "in phases where talking physics is essential, collaborators preferably meet face to face". However, even if there is no often frequented, general virtual meeting point, there is at least invisible bi- or trilateral exchange of a talking character, e.g. for continuing discussions triggered in a face-to-face meeting (1998, 326). Although, theoretical physicists use E-mail very frequently, the latter form of communication is "private" in the sense of "bilateral" or "trilateral", but invisible to outsiders, that is not in public E-lists. It seems likely that these findings also apply to other fields. Phases of informal reflection and exchange usually alter with a focussed mode of research. In the more text-oriented disciplines, "doing" would be "writing it up" while "talking" is more related to earlier phases of a project.

The "Café" in academia is not necessarily a real café. Being a synonym for an informal locale where you can meet fellow researchers, it may equally be the common room, the canteen or the library, as Atkinson proposes. He believes that virtual libraries will not replace traditional libraries altogether even if they become more and more digitised. Atkinson argues that the main purpose of the library as a geographical place would rather be to serve as a location for students and faculty to gather and to interact as groups with information objects. As a result, "the distinction between the library and the classroom must necessarily begin(s) to blur" (2000, 65). Another such locale has already been mentioned in 4.2.2. Conferences are not likely to be replaced completely by digital discussion forums and the like since the most important part are the session breaks and evenings where the "relevant" conversations take place (Fröhlich 1996a, 22).[504] This is also a matter of size. Kling/Covi (1995) submit that "the informal give and take between speakers

[502] „The filtering provided by local and informal communication is an important part of the process of finding scientific information." (OECD 1998, 198)

[503] However, "they attempt to meet face to face when writing up the results" (Merz 1998, 317f.).

[504] He adds that also the reward character of congress tourism should not be overlooked when assessing the interest in these events.

and listeners becomes more difficult (in contrast with the smaller face-to-face seminar)" if the audience scales up in size, or moves out in space and time. Hence, virtual settings have a disadvantage here.

While acknowledging the importance of the "Café", we may still ask whether cyberscience has good alternatives which make it possible that, in the longer run, at least some functions of the "Café" may shift from face-to-face to cyberspace.

E-lists may be such an alternative forum. Although a moderated newsgroup may be a useful forum for asking technical questions, its real mission could be that it is "more like a coffee hour conversation in a commons room than a serious publishing venture" (Odlyzko 1994, 24). Whether contributing to E-lists ("skywriting") may indeed be a new form of publication in the age of cyberscience, will be discussed in 7.2.4.4 and 8.4.2. The point of interest here is that both work-related and social exchange may take place in virtual form.

Apart from E-lists, groupware may also be designed to enable dispersed members of a group to exchange ideas in a shared workspace. There is also software available to support brainstorming in the cyberspace, both in synchronous and asynchronous forms (see 0.3.4.4 and 2.4.7). There is not enough experience yet to tell for sure whether brainstorming is intrinsically linked to the face-to-face situation. The use of such instruments is certainly helpful in some circumstances (namely in very structured and organised groups with a common goal). Groupware may, however, "be resisted if it interferes with the subtle and complex social dynamics that are common to groups" (Grudin 1994). Furthermore, it seems impossible that these tools would be able to replace spontaneous face-to-face meetings. An important feature of the latter is that they happen unscheduled and often bilaterally. Researchers do not tell everything that crosses their minds to everyone in a more or less open space. They carefully chose with whom to talk about what. This is true for both research-related issues and social exchange. Unlike an informal conversation in a café, an E-list or a groupware space is a more or less open space with a "memory", that is, a communication record remaining visible to all members having access to that space. Therefore, although groupware supports teamwork, informal exchange of thoughts may suffer. This makes it less likely that cyberspace will be used for all informal research activities.

However, even if virtual exchange takes place, it may not be enough: A sense of community may be indispensable for the academic discourse (Orthmann/Näcke 1999, 2). This sense of community changes when a "virtual scientific community" is to be built up. Pure virtual interaction may, nevertheless, lead to community building, hence an alternative to the standard social environment. At least one study showed that interpersonal ties among scientists can be formed through CMC (Freeman 1984; see also Goltzsch 1997, 96ff.). Although there is not much experience in science and research so far, there seem to be abundant examples of virtual communities outside the academic realm, such as in MOO/MUD environments and in chat spaces. Note, however, that this is often about games or very private interaction. It is quite likely that different rules apply in a professional environment.

Nonetheless, it might be useful to consider this perspective when organising E-conferencing. It has been proposed that two kinds of conference "spaces" should be organised: one for conducting the specified task(s), another for informal support activities (providing technical assistance) and for the purpose of socializing, which is deemed to contribute to a sense of community and connectivity among the participants (Harasim/Winkelmans 1990, 402). Others remain sceptical and argue that congresses cannot be re-

placed even though the extensive use of the Internet may simplify procedures and enhance contacts among members of any association. It seems likely that the face-to-face conferences will further Internet use between them (Riggs et al. 1998).

My overall conclusion is that the "Cafés" in academia – i.e. locales for informal meeting and exchange – are and remain important. We could expect with Merz (1997, 261) that the function of face-to-face conferences, at least in those disciplines where E-preprint archives play an important role, will shift from semi-formalised exchange of information in the form of speeches towards a stronger role for informal interaction. Most likely, there will be partial counter-parts in the virtual world, which may be able to fulfil some of the functions of the real "Café", such as informal information exchange and gossip trading. I remain sceptical, however, with regard to the potential of genuine community building with a view to conflict resolution and sustaining an excellent working atmosphere in research groups. In any case, the beneficial impact of the "real-world Café" on the smooth and efficient progress of research may be reinforced by the use of cyber-tools. Contacts made "offline" can be continued "online", work started face-to-face may be pursued efficiently via E-mail until the next meeting.

### 4.2.5 Establishing virtual contacts

On the one hand, there can be no doubt that the availability of institutional and individual homepages as well as of academic E-mail directories facilitates considerably the practical establishment of a contact with another researcher with whom you have not personally been in contact yet. In many cases, the attempt to reach someone through E-mail will be successful. In particular if you want to put forward a professional question, ask for a referee report or extend an invitation to a conference or a meeting. Indeed, the average researcher today gets many such requests from people around the world through E-mail (cf. 3.3.1).

On the other hand, it seems that making contacts with a view to exchange ideas or collaborate is more promising on a face-to-face basis, even if those once established relationships are pursued via ICT later on (Hert 1997, 331). Furthermore, knowing people from face-to-face contacts influences the likelihood of co-operation. Face-to-face contact was found critical in starting a scientific relationship (Finholt/Olson 1997, 35).[505] Once the contact is established, researchers do not see a necessity to meet again before starting a new collaboration if they already know each other from previous successful occasions (Merz 1997, 252). In this case they only meet irregularly and communicate almost exclusively via E-mail. Personal trust seems crucial here. As it is a very important feature of human interaction and the worldwide Net is rather impersonal, less considerate communication may be the result. "Whenever the direct contact between men is a necessary condition (as with the conclusion of agreements), then the well-known, familiar cognitive mental attitude plays a role." (Dunbar 1998, 261)[506] The decision to enter a collaborative relationship certainly falls within the group of (more or less formal) "agreements". Deliberating the fundamental concept of a project (including task distribution) falls within the same category.

[505] Note that establishing a collaborative project should not be considered the same as implementing the working relationship, i.e. to carry out the separable parts of a research enterprise. The latter might often be done via CMC with more or less regular personal meetings.

[506] Translation back from German by MN.

However, even though this general rule is certainly valid, there are nevertheless exceptions in practice. Merz reports that in rare cases, theoretical physicists who never met before decide to collaborate via E-mail (1997, 252). Other examples may be found in the framework of EU research. It is very likely that a significant proportion of the partners in EU-wide collaborative research projects do not meet in person while preparing an application. This is due to, first, the condition for such applications that research teams have to be composed from many different countries and, second, that there is often high time pressure (due to relatively short time lags between the invitation to tender and the deadline). Depending on the individual character of the would-be collaborators, the personal experiences with the medium and the general culture within the specific research community, it may well be that two or more people engage in co-operation without ever having met before. The increasing institutional and personal information available in the WWW (including full academic records as well as even photographs) contributes to filling at least some knowledge gaps due to the lack of personal acquaintance.

These considerations support the conclusion that, at least in the medium run, a completely virtual academia is not likely to emerge since, with respect to the establishment of contacts, institutionalised meeting points in the real world will be necessary. Whether it will be possible to bring about an online multimedia infrastructure able to imitate these real places and to fulfil all researchers' needs has to remain open (see, however, the above discussion on multimedia in 4.2.3). What is probably more likely is a continued presence of both virtual and face-to-face settings in academia with the latter's share diminishing.

## 4.3 Impact assessment of the new spatiality

Having outlined the elements of this emerging spatial layout and having discussed the key issues involved in this core development of cyberscience, I am now in a position to analyse the consequences for academia. This analysis will be subdivided into five major sections. First I shall have a look at how collaboration is changing (4.3.1). Here, both a steady increase and new forms or patterns of (remote) collaboration are to be detected. Second, I shall assess how the new tools impact on academic efficiency, both at the individual level and for academia as a whole (4.3.2). The observation that the new tools promote an academic communication culture even more based on the written word than hitherto, is the focus of the third section (4.3.3). Fourth, the consequences of the spatial changes for the academic infrastructure will be discussed (4.3.4). Finally, I focus on the impact of the new spatial layout on the virtual reconstitution of scientific communities (4.3.5).

## 4.3.1 Distant collaboration

> "It should not be assumed that these transformations necessarily represent progress. That is, collaboratories may not make scientific collaborations better or easier. However, it is reasonable to assume that collaboratories will make scientific collaborations qualitatively different and that use of collaboratories will introduce a new set of trade-offs and constraints in scientific work."
> (Finholt/Olson 1997, 33)

ICT enables regular, not only occasional distant collaboration. What does this mean for academia? In a first step, I shall ponder the relationship between the availability of the new tools for distant co-operation and the increase of collaboration in academia worldwide (4.3.1.1). In a second step, I shall analyse the new patterns of co-operation (4.3.1.2). Finally, I shall discuss whether academia, as a whole, becomes more "communicative" or whether the individual researchers become more isolated in front of their screens (4.3.1.3).

### 4.3.1.1 Increase of collaboration

A number of studies show that collaboration has been increasing over the last decades. For instance, scientometric[507] data document the increase in multi-authored papers, in particular in the natural sciences (e.g. Price 1986 (1963); Thagard 1997a). It was found that the number of international collaboration papers approximately doubled whereas at the same time, there was a nine-fold increase in the number of publications by large international collaborations (Walsh/Maloney 2002, 3). Furthermore, the percentage of papers published with authors from more than one country significantly increased (Walsh/Roselle 1999, 54, Table 3, on the basis of a survey of empirical studies). For instance in theoretical physics, "trans-local" co-operation is increasing (Merz 1997, 248f.; 1998), physics projects have proliferated that require the resources and expertise of multiple teams of researchers (Chompalov/Shrum 1999). Similar observations could certainly be made in other fields, too. Scientific work is thus increasingly geographically distributed.

As we have seen in the previous sections of this chapter, cyberscience provides for a number of services essential for collaboration at distance. In particular, fast communication, resource sharing, version control and other groupware functionalities allow sustaining co-operation without meeting face-to-face. In essence, CMC reduces the need for co-workers to be co-located. Before the advent of the cyberscience tools, remote collaboration was very cumbersome and possible rather inefficient and was only done when it was indispensable because of the subject matter. For instance, the huge financial means involved in high-energy physics led to international co-operation long before the advent of the Internet. This is not only true for the natural sciences. In the social sciences, for instance, comparative work over many countries was (and is) only feasible in multinational teams. Cyberscience now provides the infrastructure to make collaborative work at distance feasible at all and also on a larger scale – regardless of it being absolutely essential. According to Cohen (1995, quoted by Walsh/Roselle 1999, 53) there is indeed a significant correlation between CMC use and co-authoring.

[507] Scientometrics is professionally engaged in measuring scientific output (for a recent overview on the challenges of scientometrics, see Leydesdorff 2001).

When asked for their opinion whether "E-mail, websites and groupware applications lead to more collaborative work" the interviewees for this study were almost univocal in their assessment that, indeed, this is the case. Only a handful of my experts (from philosophy, physics, history and sociology) raised some doubts. In philosophy, there is not much collaboration anyway; in physics, it seems that there was always a high level of collaboration; the historians claimed that this is not automatic, in particular as competition is currently increasing; finally, sociologists would have preferred speaking of factors enabling or facilitating collaboration and doubted whether it actually takes place more often today.

As already voiced in the interviews, there is the strong argument that, after all, CMC has not caused these changes. The Internet may be seen as just the latest technology to play a role in promoting the growth in collaboration. Arguably, this trend started long before the Internet had been thought of (Odlyzko 2000). The Internet has, however, provided the infrastructure that allowed the international collaborations to occur at any significant level (Walsh/Roselle 1999, 56). There are also other reasons for increase of distant collaboration, in particular the growing geographical mobility (Merz 1997, 248f.)[508], but the opportunities of electronic communication support and facilitate this development considerably. There is the hypothesis that the increasing average number of authors per publication over the last few years may be due to the incorporation of geographically remote colleagues in mainly local projects (ibid., 253). Years of travel are common in many fields. Walsh/Bayma (1996, 347) found that there is an increase in research group size and in remote collaborations and note that even when not crediting the CMC networks with creating larger-sized groups, scientists cited their importance in facilitating them. The US report on the national collaboratories (CSTB 1993, 5f.) argues that both the exponential growth of "information to be accessed, stored, analysed and understood" (which can no longer be mastered by individuals) and the complexity of many research areas (which led increasingly to interdisciplinary research) drive the demand for information technology in science and research. Similarly, Walsh/Maloney explain the increase of collaborations by "a combination of the increasing scale of scientific problems, changes in funding patterns, and perhaps an overall increase in the number of scientists, as well as the availability of Internet-related technologies" (2002, 3). Speaking of funding patterns, there may be political reasons for the promotion of international co-operation by research funds. The prime examples are the European Union framework programmes. With a view to fostering EU research, these programmes tie funding to a significant number of teams of distinct member states of the EU working together. As the national research funds are increasingly replaced by EU funding there can be no doubt that this is a strong incentive to EU-wide collaboration. If funding is tied, the opportunities provided by the Internet that enable such international collaborations to be run easily are only a secondary reason to start them in the first place.

My conclusion then is that multi-authorship and the increase of distant collaboration is not unilaterally caused by CMC, but that the latter contributes to and favours the former to a large extent. Present day research obviously "needs" collaboration. There are a number of other reasons which favour the recent increase in transnational co-operations, among them funding policies, growing mobility, the increase of the overall number

[508] Merz (1998, 316) illustrates the connection between geographical mobility and more co-operation by quoting a particle physicist stating that during the postdoc years, before a researcher obtains a permanent position, s/he "accumulates collaborators".

of researchers and of their specialisation, and, last but not least, content-related reasons. There is, however, no doubt that many recent collaborative projects were started because the ICT infrastructure was at hand and promised to secure their smooth and efficient operation. Had this new infrastructure not been at hand and had there not been another overwhelming reason to start the collaboration (e.g. tied funding), perhaps many would not have happened at all.

#### 4.3.1.2 New collaboration patterns in cyberspace

Collaboration is not only increasing, but collaborative patterns themselves are changing. Walsh/Roselle claim that the prior empirical work on the effects of the Internet on science would suggest that scientific work is changing in profound ways. According to these authors "the most significant change may be the transformation of collaboration patterns" (1999, 71). Finholt who has studied a number of virtual laboratories submits that the transformations from laboratories to collaboratories, from physical to virtual co-operation, from the national or local workplace to a global one do not necessarily represent "progress". In his view, however, "it is reasonable to assume that collaboratories will make scientific collaborations qualitatively different and that use of collaboratories will introduce a new set of trade-offs and constraints in scientific work" (1997, 33). There are even more radical claims. Scholarly "skywriting" – that is the participation in electronic discussion and newsgroups as well as in open peer commenting in innovative E-journals (cf. 7.2.4.4) – may be so collaborative, to the point that it will even be "depersonalised, with ideas propagating and permuting on the net in directions over which their originators would be unable (and indeed perhaps unwilling) to claim proprietorship" (Harnad 1990, 4).

Others are more prudent in claiming profound changes. For instance, the 1998 report for the OECD concludes as follows:

> "For the most part, collaborative arrangements have not yet been revolutionised. ICT-based communication has been adopted in a way that reproduces local social relations and research practices. Thus, while the social structure has changed somewhat owing to ICT use, the reorganisation seems largely limited to changing (expanding) participation, with only minor changes in the content of participation. The existing work organisation is reproduced over a wider geographic area and ICT-based communication serves as the link formerly served by face-to-face communication in local collaborations." (1998, 197)

What a profound change actually is, is certainly up to debate. However, at least the following significant novelties can be distinguished:

*Increasing personal networks*: The number of individuals with whom a researcher can interact is expanded. This provides "greater access to potential collaborators and pathways for diffusing ideas" (Lewenstein 1995, 125).

*Enabling larger groups of researchers to collaborate*: The new tools provide for an environment which can, potentially, be used to organise collaboration among a much larger group of researchers than hitherto. The US report on collaboratories (CSTB 1993, 7) rightly notes that, "when too many human minds try to collaborate meaningfully, the requirements for communication become overwhelming". Cyberscience attempts to facilitate the necessary robust communication among scientists. To be sure, it involves not only technical considerations such as access to useful computer facilities, networks and data sets. Furthermore social considerations play an important role. For instance, the collaborative environment has to account for "differing academic traditions, approaches to and priorities in research, and budget constraints" (ibid.).

*Increasing collaborative continuity*: Thanks to E-mail and other cyber-tools, two authors originally working together at one spot may more easily continue their collaboration after one of them has moved to another job (Starbuck 1999, 189). This may also be true on a larger scale. E-lists are a perfect device to sustain the sense of community among a group of researchers between their rare face-to-face meetings.

*Better match of competencies*: Collaboration patterns may become "more mediated by substantive fit, rather than geographic or personal linkages" (Walsh/Bayma 1996, 349). In other words, the composition of teams in terms of members' competencies may be optimised due to the new opportunities to find researchers with highly specific matching or complementary skills. There is also the argument that due to increased communication we may expect increased attachment to the research group and the discipline. Apart from the psychological effect on the individual level (overcoming the sense of isolation), this in turn might lead to increased commitment (Walsh/Roselle 1999, 59) and hence to overall better group performance in the research.

The experts interviewed for the present study have been asked for their opinion on the following statement: "Collaboration patterns may become more mediated by substantive fit, i.e. competence-oriented selection, rather than geographic or personal linkages." The majority of the interviewees agreed with this statement. Only the philosophers are rather not expecting that substantive fit will play more of a role than local contacts for future co-operations. Less convinced about this effect are furthermore the interviewees from the medical sciences and from anthropology. Many pointed at their observation that this effect is not only caused by the new opportunities provided by the Internet (e.g. financial incentives; longstanding tradition to have more external than internal contacts in some fields; etc.). All in all, while agreeing in principle, many underlined that personal acquaintance will remain as important as ever and that the Internet is only one factor pushing in this direction.

*Specialisation*: Related to the previous point, there is the argument that the possibility of becoming involved in world-wide co-operations may favour the trend to more specialisation as the very specific skills and expertise can be made fruitful despite the lack of local projects in need of them. The experts for this study were asked about their opinion on this argument. A potential specialisation effect is only expected in political science and philosophy and to some extent in law, language studies and sociology while in all other disciplines, the answers were negative or split. Many pointed at a general "meandering" between specialisation and generalisation in their fields, while they were rather doubtful whether the former could be attributed to CMC. It has been argued by a number of my interviewees that specialisation would be more due to the increasing complexity and internationality of their fields as well as personal career path decisions. Furthermore, teaching obligations tend to discourage too much specialisation.

*New forms of collaboration*: Collaboration in the age of cyberscience may take the form of co-operative activities to build shared data or knowledge bases. In some fields, academics already contribute and have access to common databases, often managed by international networks (e.g. HUGO[509]). Increasingly, filling and structuring E-archives and databases has also become the content of whole research projects.[510] Others may follow suit, like the "International Network for Integrated Social Science" (Bainbridge 1999,

[509] <Cyberlink=408>.

[510] A prime example is CEEC (<Cyberlink=566>).

131)[511]. Even more advanced would be what I shall call "hyperbases" or "knowledge bases" in 6.3. As already noted, researchers – like many others – tend to behave strategically when it comes to sharing information and, hence, co-operatively. The question is whether the Internet is about to create environments in which there are more incentives to co-operate than before.

*Standardisation of working habits*: Groupware software may lead to standardisation of working habits (Scheidl 1999, 101). The idea is that the technology (groupware, database interfaces) would force its users to accept the same work flow, that is to follow similar patterns, to perform the same steps in the same order, to search for the identical elements etc. This may simply mean co-ordination of workflows or standardisation. In some circumstances the latter could certainly have a positive impact on the research, in others it may hamper creativity.

*Intensification of communication*: While the traditional means of communication have been comparatively cumbersome (slow or needing simultaneity – see 4.2.1 above), the cyber-means are easy-to-use and may increase the frequency of communication among distant collaborators (see below 4.3.1.3).

*Different split of work?* Further studies are needed to assess how researchers engaged in disembedded collaborations share, exchange and divide problems and objects and whether collaborators split up or parallel the work among them. "Are the rhythm and sequencing of these actions different when performed in an embedded or instead a disembedded locale?" (Merz 1998, 327)

NEW COLLABORATION PATTERNS

- Increase in personal networks
- Collaboration among larger groups of researchers
- Increase in collaborative continuity
- Better match of competencies
- Specialisation
- New forms of collaboration (shared knowledge bases)
- Standardisation of working habits
- Intensification of communication
- Different split of work?

*Overview 4-3: New collaboration patterns*

Taken together, these nine bullets lead me to the conclusion that the new tools indeed have the potential to create qualitatively different patterns of distant collaboration in cyberspace. It will accommodate for more researchers involved and, at the same time, allow researchers to have larger networks of potential collaborators. Furthermore, competencies of co-workers may match better and their workflows may be co-ordinated in a different way, perhaps even become standardised.

[511] The Network is intended to create the so-called "netlab" facility, which would be a "transdisciplinary, Internet-based collaboratory that will provide social and behavioural scientists at all institutions with the databases, software and hardware tools, and other resources to conduct worldwide research that integrates experimental, survey, geographic and economic methodologies on a much larger scale than previously possible" (Bainbridge 1999, 131).

#### 4.3.1.3 More communication vs. increasing isolation

On the one hand, there is evidence that CMC leads to more communication, at least among collaborators, but perhaps also in academia as a whole. On the other hand, CMC is often related to more isolation of the individual screen-workers.

##### More communication

One of the effects of CMC on collaborative patterns seems to be an increased frequency of communication among remote collaborators: "Rather than extended isolation punctuated by periodic, intensive face-to-face meetings, CMC collaborations can maintain a high level of contact among the remote collaborators." (Walsh/Bayma 1996, 350ff.) In particular, CMC facilitates the same types of checking in and updating for remote collaborations that are common in local collaborations (ibid., 353). That CMC leads to an increase in the amount of communication performed during a research project has been confirmed by a later survey of the empirical studies (Walsh/Roselle 1999, 57). E-mail both increases the number of interpersonal interactions and allows for deeper, more extended interactions among colleagues. However, this "serves primarily to enhance existing relationships; links to other groups or organizations are not increased" (Lewenstein 1995, 125). By contrast, outside closer working relationships like, for instance, E-lists, the frequency of communication is quite varied (Matzat 2000).

For sure, communication in local co-operations is certainly more intense from the outset than in remote ones. However, even with regard to the former, an increase of project-related written notes is likely due to local use of E-mail. In any case, there is a huge difference in communication among remote collaborators before and after the advent of CMC.

##### Isolation

There is this well-known result from research on telework environments, which goes as follows: Working alone with only the computer screen as a "communication partner" may lead to isolation in the long run. However, ICT does not only enable "people-to-machine" communication (e.g. searching in remote databases)[512], but also "people-to-people" communication, i.e. with fellow researchers. This communication is, so far, not very often face-to-face (with video), and always mediated. Nevertheless, it is communication. Furthermore, as we have seen above, there is even more communication among researchers, at least in electronic form. Hence isolation (in the sense of less contacts to and less communication with fellow researchers) is rather unlikely, quite to the contrary.

The sort of communication practised in cyberspace is, however, different than that in traditional circumstances. For instance, there is the hypothesis that CMC may create a more "instrumental and barren collegiality" (Walsh/Roselle 1999, 59), that is a social situation with less time 'wasted' in pleasantries, more targeted, more task-related. At least among theoretical physicists, E-mail interactions are being illustrated as rather "target-oriented" and allowing for omitting polite formulas (Merz 1997, 252). The "lone wolves" among the researchers who prefer to work rather alone without much contact to

[512] Note, however, that even "impersonal" databases may be somewhat personalised with the help of "avatars", i.e. computer-animated characters with a special (personalised) profile helping the user to find his/her way through the information on offer. "People-to-machine" communication transforms itself into a communication with a "pseudo" person at the other end.

colleagues may even find cyberscience much more agreeable, as they can now access the 'real' world only through the computer screen. Furthermore, some of the communication among researchers may shift from the real world to cyberspace even if there might be no need for this shift in practical terms. For instance, many physicists obtain copies of the papers of their own colleagues (that is from the same institution) through the E-pre-print server instead of directly from authors (Odlyzko 1994). In this case, the communication has shifted and became much more indirect.

We may approach the "isolation" argument from another angle: the standard situation in a research institution may be that most people work on different subjects and are hence isolated with regard to their speciality even among their local colleagues. As readers "individualize their knowledge background (...) they are no longer able to find topics for common discussion" (Geser 1996, 11). However, the CMC-induced emergence of highly specialised worldwide communities may even contribute to overcoming this sense of isolation (cf. 4.3.5.2).

Finally, we can even turn the isolation argument upside down: The separation of collaborators in physical space may be a safeguard "against the isolation of the collaboration from the rest of the scientific community" as it encourages each collaborator to also contact other colleagues (Merz 1998, 325).

In sum, I argue that ICT-based communication may simultaneously integrate and isolate individuals. The result could be a work environment where the individual is linked to more colleagues. The links, however, could be "more instrumental or less satisfying" (OECD 1998, 197). Proliferation of isolation is, however, rather unlikely as communication is increasing on a general level.

## 4.3.2 Enhanced efficiency

> "The fusion of computers and electronic communications has the potential to dramatically enhance the output and productivity of U.S. researchers."
> (CSTB 1993)

Spatiality can be seen as a limiting factor for efficiency: researchers need to go to the library and wait for the ordered book, they have to travel to a colleague with a view to cooperate etc. All this is, in principle, now also possible from the desktop. ICT can increase time efficiency and it can save money, e.g. for travelling.

Productivity may be defined "as the ratio of outputs to inputs, or more generally as the ratio of benefits to costs" (Massy/Zemsky 1995, 5f.). According to these authors, productivity can be improved by either doing more with more ("producing significantly greater benefits, encompassing quality as well as quantity, at modestly greater unit cost"), by doing less with less ("spending significantly less money while limiting benefits reductions to modest levels"), by doing more with less ("producing greater benefits while spending less money") or by doing more with the same ("improving quality at the same unit cost"). In principle, academia could become more productive in all of these dimensions. However, as we deal with incommensurable entities ("research", "knowledge", "information"), it will be impossible to quantitatively measure productivity in a satisfying way. In particular, the route to simply count publications per head per year is rather

doubtful[513] and will therefore not be taken here.[514] In addition, comparative social experiments are impossible (cf. 0.3.4). Rather I strive to describe qualitative changes in the process – changes that will arguably lead to more efficient task performing.[515]

It is certainly "too early for a definite answer" (OECD 1998, 224), but I shall look at the available evidence and arguments from both an individual (below 4.3.2.1) and a systemic viewpoint (below 4.3.2.2). Evidence from the empirical literature and from my own interviews will be included.

#### 4.3.2.1 Productivity of the researchers

In many respects the work of academics has been affected by CMC. In the following, I shall look at a number of them in a systematic way. For sure, thinking will not be accelerated. However, research is not only about generating novel ideas. There is much organisational, repetitive and information gathering work involved, too. In many cases these "secondary routines" account for the majority of a researcher's time. It is this area in which we will have to look for productivity gains in academic work on the individual level.

First, not only is the *information* available increasing, it is also much easier to *access* it (literally from the researcher's desk). Research tasks that used to take days or weeks may now be a matter of minutes (e.g. accessing the full text of an article or finding a particular quote in it) or even of seconds (e.g. finding a translation of a key term in an online dictionary). The OECD report comes to the conclusion that "ICT has increased researchers' ability to access information by supplying them with increasingly powerful tools at decreasing cost, thus enabling new ways of working" and has, on the whole, "significantly improved the efficiency of information-based work" (OECD 1998, 199). It is in particular the way the new information space is structured, the convenience of electronic links which can be followed in an instant, that may "prove to be orders of magnitude more productive for the user than hyperlinks in print" (Hitchcock et al. 1997c, 2).[516] In particular in the text-oriented disciplines, the availability of full-text resources is highly appreciated.[517]

Second, *authoring* of academic (hyper)texts may become more efficient since instead of summarising or reviewing already well established knowledge, one may link to previously published modules, e.g. with respect to standard methodology, previous research,

[513] While there are many interesting results from scientometric studies, the voices of the critics are still overwhelming. One of the most significant criticisms is the difficulty to account for redundant or parallel publications (slightly different titles with largely the same content and additional language versions). See, for instance, Fröhlich (1999) for an overview.

[514] This is, however, what Walsh/Maloney (2002) partially attempted. They concluded that "the relation between email use and the productivity of collaborations (multi-authored papers) was generally positive, though it was not significant statistically when we controlled for the social structure of the collaboration".

[515] Productivity can be seen as one measurement for efficiency. While in purely economic terms, productivity is linked to measurable in- and outputs, efficiency can equally be used for qualitative considerations. However, as the rather broad definition by Massy/Zensky indicates, in practice the two terms "productivity" and "efficiency" may be used synonymously. That is what I shall do here, too.

[516] By contrast, concluding their critique of hypertext enthusiasm, McHoul/Roe (1996, 9) write: "Everyday life continues pretty much as it always has: perhaps a little faster, that's all."

[517] For a discussion of the "information overload" argument, see 2.2.2.2 and below (eighth paragraph).

experimental set-up (if the same as in previous experiments) etc. Thus, the author may concentrate on the specifics of his/her findings (while the reader is free to follow the links to the more general introductions etc.).

Third, access to information is only one side of the coin. One empirical study (Riehm 1996) seems to show that there is still another side because *digital information* may be *used in a different way*. This study found that, while the choice of medium had little influence on the ability to reproduce the contents correctly, the electronic version is reported to be used for a significantly longer period of time than the printed version, and is less systematic. Riehm's conclusion was that "the popular belief that electronic information systems, in particular hypertexts, are generally more efficient was not confirmed." (ibid.) It is, however, doubtful whether these conclusions would hold true for a great variety of electronic information resources. The study was carried out before 1996, hence at a time when the WWW was still in its infancy. It is fair to say that since then, the user interface to digital resources has greatly improved. Furthermore, training and experience will certainly have an influence on how to use digital resources. It is therefore likely that Riehm's experiments, if repeated today on a broader basis, would lead to different results.

A related aspect is the use of discussion lists and newsgroups to search for information. One of the reasons for the success of this type of communication seems the low cost of responding in terms of time and effort. However, "the low cost of entry may also lead to a low cost of error" (Lewenstein 1995, 140) since many messages consist of corrections to previous messages (cf. also Hert 1997, 329). Error is, however, also possible in a non-digital setting, with the difference that in E-lists many others are somehow silently supervising what is being written.

Fourth, E-mail and other ICT tools certainly impact on the efficiency in *contacting and co-operating with people*, in particular among groups of researchers, but also in establishing first-time contacts or in renewing relationships. While E-mail use certainly presupposes strict time management because it can be overwhelming and too time-consuming (see the example of Odlyzko 1994, 18), the asynchronity of E-mail has proven to be very advantageous, when compared to the telephone. As soon as there are no media discontinuities any more, academic work may "be more efficient and lead to important competitive advantages" (Mittler 1996, 76, transl. MN; sceptical Leskien 1996). As the physical setting in which work occurs may be a key to successful co-ordination of joint intellectual activity, "(c)hanging the circumstances (...) may undermine the effectiveness of the collaborative process by introducing new demands that result from loss of physical setting" (Finholt/Olson 1997, 33). While under 'normal' conditions, tacitly shared information would be taken for granted, the need to communicate this in a cyber-environment respectively the loss of these tacit cues "may mean that collaboratory users are at greater risk of losing common ground" (ibid.) and hence be less efficient due to misunderstandings and the need for extra time of communication (cf. also 4.2.3).

Fifth, we have to acknowledge *technology-related costs*, e.g. the time spent on learning how to master the technology. Unfortunately, it seems that this is not at all a one-time-investment but a continuous process without end, as software and hardware keep changing at short intervals. Furthermore, there are also a number of problems, e.g. network reliability, stability of the computer hard- and software, incompatibilities between different file formats which all sometimes lead to frustrating additional work etc. (cf. already 2.6).

Sixth, much of the *work* which was *outsourced* in the days of the old typewriter, in particular the formatting of articles, is now increasingly done by the researchers themselves and not by the publishing houses any more (cf. 5.4.1). There may be a number of

academics who do this quickly and easily in their intellectual "wait loops", but others seem to spend considerable time on this new and demanding task, thus having fewer resources for the genuine intellectual work.

Seventh, productivity gains may *differ from individual to individual*. It was found that "those who make the most use of computer networks also tend to be the most productive" (Walsh/Bayma 1996, 345). By contrast, for some highly productive researchers (who habitually write using crash processes, preparing articles/documents within two or three days of a deadline), an "electronic workshop that develops a product over several weeks or months was stressful for those not accustomed to longer production timelines" (Harasim/Winkelmans 1990, 401).

Eighth, the sheer amount of information available at each scientist's desk may also be overwhelming (*information overload*). This has three distinct aspects:

(1) While it seems reasonable to argue, as I will do below (10.2.2), that more comprehensive input might lead to at least different, perhaps even better results, there is also the *filtering or selection problem*. "(M)anaging the wealth of information remains cumbersome" (Harasim/Winkelmans 1990, 398) because "the flood of (redundant) information (and thereby an increase in information frustration)" (Fröhlich 1996b, 10) is increasing. For instance, E-mail discussion lists not only transport important but also great amounts of trivial and irrelevant information and produce problems of information overload (Gresham 1994, 46). However, E-mail discussion lists may also facilitate information management because peer exchange manages information overload "by serving as a 'peer filter' of professional information resources" (Harasim/Winkelmans 1990, 398). A qualitative content analysis of the contributions to the cold fusion newsgroup (Lewenstein 1995, 138ff.) revealed that some 30 percent of the volume of the net was pure "noise", defined as inherent technological issues (like long headers, accidentally posted messages etc.) and "blather" and off-topic comments. However, even about 55 percent of all postings fell within his group "big ideas" (Carley/Wendt 1991, 415), i.e. primary or basic information, including technical speculation, original data, arguments about non-technical implications etc. The overall conclusion from the cold fusion case was that the impact was largely confined to issues of awareness and information gathering, but certainly influenced the process by which researchers made judgements about the research area. Hence the E-lists "were part of the process by which social consensus – knowledge – was produced" (Lewenstein 1995, 141). However, electronic bulletin boards, as completely 'public' forums, hardly "serve the needs of the active research community" (ibid., 143) and are, therefore, not likely to "replace traditional face-to-face interaction" (ibid., 144). We may expect that the more restricted E-lists will be assessed differently.

The "noise" (Gresham 1994) was always part of the invisible college as an informal information system. But there are means (to be learned first, for sure) to overcome the problem of information overload (e.g. receiving digests of E-mail discussions which allow quickly skimming of messages). In Harnad's words: "It is in fact easier to filter electronic mail than it is to filter real mail and phone calls (yet we never considered turning our back on the latter because of potential overload)." (1990, 3) Other technological fixes may be knowbots, "intelligent" databases or adequate system tools to thread themes within E-lists. However, it cannot be denied that even the configuring and managing of these tools will cost time. At the end of the day, it is not only a technical problem, but also an organisational issue, both at the individual and the organisational level: E-lists could be heavily moderated, mail filtering should be applied, expert query languages (cf. 2.3.4.2) should be learned etc.

(2) Furthermore, too much inter-linked information may also lead to *distraction* ('surfing around'). This is not to say that distraction and browsing may not lead to new and surprising insights, but it seems fair to say that there is a certain tendency of the new medium to seduce researchers to manage their time inefficiently. Many argue that the Internet fosters duplication and that hyperlinks now take one in circle which leads to unproductive hours spent in front of screens (e.g. Rosenthal 1998). In response to these fears, I may, on the one hand, point at the many initiatives to pre-select information (link collections, academic portals etc.) with a view to more focussed time management. On the other hand, surfing around may also be inspiring and favouring creative thoughts. Similar to the user of a library who finds something interesting next to the volume s/he was originally looking for (serendipity effect), undirected browsing the web may be productive, too.

(3) We have to doubt whether electronic means will enable human beings to overcome the *natural restrictions of our cognitive apparatus* to cope with more than a limited number of people (Dunbar 1998, 251f.). Therefore, even if the electronic environment makes us think that there are a dozen people meeting, we are not able to have more than three of them in our head. Furthermore, E-conference participants have to have *multi-tasking* capabilities – something that leads to problems of awareness, for instance not knowing who was who, and not knowing who was present at remote locations.[518]

Ninth, a move from the traditional scholarly communication system to a system based on E-publishing, in particular, has various impacts on faculty time: On the one hand, E-publication and digital retrieving is faster, therefore faculty time may be saved. On the other hand, *self-publishing* takes valuable time from research. Faculty time, both as teachers and researchers, can be considered the most valuable resource in the university. Therefore, time diverted from those activities to prepare and publish their own manuscripts and time spent to search for materials that are no longer available through well-established channels – these times "are all costs, true costs, using the scarcest resources of the academy" (Day 1998, 2).

PRODUCTIVITY OF RESEARCHERS
+ Better access to ever more information
+ Re-use of modules in hypertext authoring
+ Different use of digital information
+ Easier contact and co-operation
± Self-publishing activities
± Additional (outsourced) work
– Technology-related costs
– Information overload
  – Filtering and selection problem
  – Distraction
  – Natural restrictions of cognitive apparatus
• Individual differences

*Overview 4-4: Aspects related to productivity of researchers*

[518] On this see Finholt (2001, 22) who studied the use of a tool like NETMEETING. These conclusions correspond to the experiences of the present author with E-conferencing (see 0.3.4.3).

Given these various and partially contradicting answers to my question whether ICT will lead to more productive individual researchers, it is difficult to come up with an overall assessment. What I can say at this point is that ICT will have both positive and negative aspects on the productivity of the researchers. The advantages in information access and as regards communicating at distance seem, however, to outweigh negative side effects. For the latter, it seems that it depends to a large degree on individual learning and experience whether a researcher profits altogether, in particular as regards overcoming information overload. Technology plays a role, as it should be possible to solve or avoid some of the new problems. Technology is, however, no panacea. Organisational measures will have to be added.

#### 4.3.2.2 Productivity of the academic system

In general economic theory, it is all but clear whether information technology actually enhances productivity (Zerdick et al. 1999, 127). This is known under the label of the "productivity paradox" in earlier economic literature, which points out that computers and IT did not increase productivity. However, this seems to be contradicted by more recent studies. It was found out that an increase in productivity (of about 0.25 to 0.5 %) is only measurable with a time lag of about ten years, due to various transformation costs after implementation (in particular organisational and individual learning).[519] As academia was one of the first sectors to opt for ICT on a broad basis, it is not unlikely that we shall find a number of specific arguments suggesting that research as a whole has become more productive through the use of ICT.

To begin with, the individual researchers' gains in efficiency as discussed in the previous section will add up to an overall increase in productivity of the academic system. Furthermore, I find the following nine potentials:

(1) As we have already argued above in the context of increased co-operation (cf. 4.3.1.2), CMC use may allow for a more efficient *division of labour*. The market for specialised scientific contributions increases and becomes more transparent. Hence, project leaders may be more successful in finding the right specialist for the research task.

(2) Second, we may expect *economies of scope*. In general economic terms, such effects arise when it is possible to share components and to use the same facilities and personnel to produce several products. In a collaboratory, different research groups share, for instance, commonly filled databases to produce different research outcomes. Furthermore, the OECD report (1998, 225) points at the possibility of such effects if ICT breaks down barriers between sciences, as multi/interdisciplinary work may produce new results (cf. 10.2.5).

(3) Third, we may find *economies of scale*. Such effects arise when it is possible to spread fixed costs (e.g. regarding equipment) over a higher (or better quality) output. There is an efficiency-enhancing potential of sharing scarce resources, like for instance computer power (e.g. distributive computing) or experimental instruments which can be used remotely (NRENAISSANCE Committee et al. 1994, 113; OECD 1998, 225).

[519] The turning point in economical literature on the impact of IT on economic growth is the paper by Oliner/Sichel (2000) based on new data of the US economy. They estimate that the use of information technology and the production of computers accounted for about two-thirds of the 1 percentage point step-up in productivity growth between the first and second halves of the decade. Mellander et al. (2001) further develop this idea with Swedish data by establishing a relationship between IT and human capital (i.e. education of the work force).

(4) Furthermore, the *unnecessary duplication* of research may be *avoided*. The OECD report estimates "that over 10 per cent of all research performed in the hard sciences each year had already been done" and concludes that "(p)roviding electronic access to this data source might improve scientists' productivity by enabling them to focus on the appropriate issues" (ibid., 204). This is certainly not only true for the natural sciences, but equally applicable in the social sciences and humanities. Note that scholarly text production is not always redundant even if the main results are not new but already included in a previous publication. There are various "publics" even within academia justifying parallel publication. However, it is conceivable that in a fully digital publication system, "purely quantitative" publishing strategies may be cut down.

(5) Fifth, there is the potential for *time reductions* for certain scientific tasks, "primarily computing, communication, data collection, and the execution of certain experiments" (OECD 1998, 224f.) which may help reduce costs. This report acknowledges, however, that the evidence remained limited and that the impacts may also differ substantially among disciplines. (See already my discussion of efficiency gains by individual researchers, above 4.3.2.1).

CMC may have an impact on the necessary time to finalise projects. At least if compared to traditional international projects with no use of CMC, it seems likely that projects may become shorter due to the enhanced speed of communication and the fact that it is easier to have ad hoc (cyber-)meetings. Hence, projects may increasingly be completed on schedule (Bishop 1994, quoted by Walsh/Roselle 1999, 66).

This was also discussed under the label "*the project that never sleeps"* (OECD 1998, 197; similarly Merz 1997, 251). While asynchronous CMC may help overcome chronological time dispersion (due to time zones), dispersion may even be seen as an advantage since collaborators may shift the research tasks back and forth (Walsh/Roselle 1999, 58). At least in some particular situations, this may enhance time efficiency: each time a researcher comes back to the office in the morning s/he may continue working on the common text or other work unit on which the remote colleagues have worked since s/he left office the day before (see e.g. Starbuck 1999, 189).

The large majority of the interviewees for this study, when asked whether "the use of E-mail, E-prints, video-conferencing and E-journals accelerates the research process", answered positively. Some mentioned one or the other concern already discussed above (e.g. the filtering problem). Hence, the disciplinary differences are not overwhelmingly important. However, some differences can be detected. In the case of the anthropologists, the most important part of their activities is field research, which cannot be reduced through Internet research or E-mail, but has to take place in the field. Others (in particular mathematicians, philosophers and linguists) noted that the gains could only be marginal, as time for thinking cannot be reduced by CMC. Acceleration was reported to be very important for papyrologists using their decentral online databases.

(6) Although there is not yet convincing evidence that synchronous E-conferencing is about to replace traditional conferencing with high *travel costs*, such a potential cannot be denied.[520] As we have discussed above, despite of my conclusion that multimedia will not replace face-to-face in the medium run (cf. 4.2.3) and that informal contacts, preferably face-to-face remain important (cf. 4.2.4), there is some room for virtual seminars (cf. 4.2.2). As I can neither predict the technological progress to be made in this respect nor estimate the future travel budgets for project workshops, it is impossible to say how big

[520] The potential is further increased by fears of terrorism, infectious diseases etc.

the impact of E-conferencing will actually be. The only figure in the calculation of net profits that seems predictable is the cost for the E-conferencing infrastructure: it will probably be included in standard equipment.

(7) Increased attachment to the research group and the discipline, increased *job satisfaction* and commitment due to increased density of communication in remote collaborations (Walsh/Bayma 1996, 353) may be a qualitative factor to assess efficiency to be considered, too.

(8) By contrast, it seems not likely that there will be much room for reductions of *supporting personnel* in academia without endangering the overall output of the science system. In particular, librarians are all but superfluous in the digital era, as they will have multiple tasks (see 5.3). As there is not much secretarial staff in academia anyway, this will not be an area of economies. However, researchers perform ever more traditional secretarial tasks themselves (cf. 5.4.1 and 5.1). If we include the publishing industry in the "academic system" this would perhaps be an area of major job cuts (discussed in 9.1.3).

(9) Finally, widespread use of groupware software and database interfaces may lead to standardisation of working habits (Scheidl 1999, 101). In this context, Rost (1998d) speaks of the industrialisation of academic production. The idea is that the technology would force its users to follow similar patterns, perform the same steps in the same order, search for the identical elements etc. As standardisation is generally linked to efficiency gains, this may also lead to more productivity of the science system.[521]

There are also some caveats about the positive effects on productivity and efficiency of the science system:

- In the context of higher education, it has been argued that so far, "most IT-based academic productivity improvements have involved doing more with more" (Massy/Zemsky 1995, 6), hence the net gains might not be too important.
- The OECD warns that ICT might not be as good in the diffusion of non-codified knowledge which is, however, crucial in some respects (1998, 225). ICT use may involve considerable learning costs and thus reduce the potential gains in science productivity. The OECD report concludes that ICT is unlikely to reverse the overall trend of cost increases: "To some extent, ICT may simply be reinforcing patterns that were already emerging, such as joint research and the globalisation of research." (ibid.)
- The "Ortega hypothesis" (Cole/Cole 1972) that the pace of science is primarily driven by those at the top of their field suggests that expanding the participation of those at peripheral institutions through ICT should have little impact on the pace of science (Walsh/Roselle 1999, 67). This refers to the discussion of so-called peripherality effects (see below 4.3.4.3) meaning that institutions at the periphery of science would gain from improved access to resources at the centre.
- A constituent characteristic of scientific communication can be said that academics tend to withhold information (Fröhlich 1996a, 23f. who gives a number of examples and presents theoretical considerations). If this assessment holds, CMC – that is, tools to communicate information – will hardly lead to a more efficient scientific practise.
- The interviewees for this study were split in their reactions to the statement "Electronic publishing leads to more output in terms of more publications." Only the historians agreed to it unanimously, whereas all others were split. The overall tendency was "rather yes", but most experts pointed at the uncertainties about the future refereeing system. If it settles comparable to the present system practised in the paper world, no

[521] Note that, on the other hand, this may have a negative effect on creativity.

more output is to be expected (cf. 8.2.4.2). Many noted, however, that self-publishing will lead, at least in the short run, to more publications. It could be argued, however, that this will not lead to more output as such, but only to more visible output because many working papers and other drafts remained inaccessible in the past and are now available over the Internet.

The majority of the interviewees for this study reacted positively to the statement "ICT use increases efficiency." While the interviewees were split in language studies, philosophy and anthropology, all others felt that the Internet increases, overall, the efficiency of research production. Many voiced, however, some of the arguments discussed above and pointed at adverse effects, too. In particular, they pointed at technical problems, individual experiences and the non-structure of the WWW or restricted the effect to the information-gathering phase only.

**PRODUCTIVITY OF THE ACADEMIC SYSTEM**

| | |
|---|---|
| + Division of labour | + Job satisfaction increase |
| + Economies of scope | + Supporting personnel reductions |
| + Economies of scale (sharing scarce resources) | ± Doing more with more? |
| + Avoiding unnecessary duplication | ± Disadvantage for non-codified knowledge |
| + Time reductions | – Ortega hypothesis |
| + Travel costs reductions | – Culture of withholding information |
| | – More low-quality publications |

*Overview 4-5: Aspects related to the productivity of the academic system*

In sum, I have presented, on the one hand, a number of arguments indicating some potential for efficiency gains of the academic system due to ICT. On the other hand, there are a number of specific reasons why this system might react differently than the economic system (for which there is increasing evidence for productivity gains). Given the impossibility to measure academic output reliably and in any useful categories, it will, however, be impossible to say with certainty whether or not the new spatial layout in the era of cyberscience will improve efficiency on both the individual and the systemic level. Nonetheless, there are some strong indications to that effect.

### 4.3.3 Written culture

E-mail is about to supersede all other means of communication among scholars. In some respects, this is not only true for distant contacts, but also for local ones. As we have already discussed in 4.2.1, the asynchronous nature of this medium is equally advantageous within the same research institute. While "corridor conversation" or "jour fixe" meetings were traditionally the main channels for communication of departmental affairs, today circular E-mails have often taken over nowadays. Participation in discussion lists and newsgroups gives the opportunity not only to get in contact with other researchers without face-to-face meetings but also to work together on concrete research questions. Groupware is also mainly based on written contributions. Despite webcam and audio equipment, even most virtual conferencing models provide for extended written

stages of the conference (synchronous/asynchronous). Also the E-pre-print archives promulgate the written culture (Merz 1997, 261): Traditionally, conferences were the place of presenting research results for the first time – in spoken language. With the advent of the E-archives, this function is gone because every researcher is well advised to upload his/her results as soon as possible in written form and not to wait until the next conference.[522]

Taken together, cyberscience may mean that written discourse is gaining ground if compared to face-to-face spoken communication among researchers. Maybe the development of new technologies (human-machine-interfaces which enable speech-to-text conversion, cf. 2.3.8) will facilitate (respectively alter) the phenomenon described above. However, even if it will not be necessary to type in one's contribution to a written discussion because the computer translates the participants' voices (and the computer could perhaps even read out any answers[523]), such a discourse would arguably, nevertheless, retain the properties of an asynchronous, written discourse. Voice is then just another interface, but what is being said is input to a written debate.[524]

This shift to another dominant discourse medium entails a number of qualitative changes. We have already discussed that E-mail in particular is well suited for academic discourse, not least because of its written and potentially permanent character (cf. 4.2.1): the availability of a discourse memory, no time constraints for finishing discourse as well as the "second thought" argument have already been listed. Further possibly positive effects are:

- If academics communicate textually, their contributions are more easily judged by their content than by the physical characteristics or appearance of the poster/speaker (Gresham 1994, 47). This may have a positive influence on the self-confidence of participants.[525]
- As the medium enforces written text and "imposes that concrete statements be made" (Merz 1998, 324), collaborators are led to focus on the essential questions to be resolved without becoming distracted by other interesting ideas. Hence, written communication may not only speed up work, but also lead to more focussed discourse. A related observation can be made based on the study of online debates in E-lists. The dynamic of an on-line debate (what can be said and how) is affected by the electronic medium because these interactions are text based (Hert 1997, 330f.) In particular, participants rewrite their own texts as well as the messages of others. This manipulation of the texts can be said to enable participants to reappropriate the discussion whereby two styles of appropration can be distinguished: "a power-driven strategy of imposing a particular view on the debate" and "a tactical takeover of opportunities to participate, emerging out of the context of the discussion."

[522] A parallel development may be observed with regard to teaching: distance education and E-teaching is often text-based as opposed to traditional face-to-face lectures; students increasingly take advantage of communicating with their teachers via E-mail instead of coming to see them in their office hours (cf. 5.2).

[523] See 2.3.8.

[524] Kircz goes one step further and predicts that "(a)lthough language will remain the essential transfer mechanism for knowledge exchange, non-linguistic communication will regain some of the prominence lost since the written language enabled scientific communications to emerge, independent of place and time." He concludes, "text will play a less prominent role in the future" (Kircz 2001, 7)." However, what Kircz means by "non-linguistic communication" are mainly multimedia elements.

[525] See also 5.5 for an in-depth discussion of possible democratising effects of ICT.

- In a face-to-face setting, what a moderator can do to steer discourse ("facilitating") reaches its natural limits pretty fast, in particular if a larger group is involved. By contrast, the parallel methods in written discussions are developing and look promising (cf. 4.2.2.2).
- The textual basis of computer conferencing is likely to foster the reflective and analytical cognitive skills associated with the task of expressing ideas in written form (Gresham 1994, 48). As much of the formal academic communication is in written form anyway, more training to improve writing skills may be advantageous.
- Language barriers may be diminished. First, as scientific communities have become increasingly international, English has become the lingua franca in worldwide scholarly communication. Second, the written format is an advantage for those who are not natives in the communication language as it gives them more time (cf. 4.2.1). Third, the digital format of written communication lends itself to automatic translation (cf. 2.4.9). With regard to the E-print archive in the biomedical sector, it has been discussed that such a free archive would contribute to the reduction of language barriers by freely providing reports in a format suitable for automated translation (Varmus/ et al. 1999).

We have already discussed that written communication is limited insofar as it cannot transmit facial expression and gestures etc. (cf. 4.2.3), and that the written medium hinders interactiveness and spontaneity (cf. 4.2.4). Another point of debate was whether it would lead to physical isolation of scientists (cf. 4.3.1.3). Two possibly negative consequences of an increase of written communication are discussed in the literature:

- If communication takes place to a large extent in written form, we might witness an atrophy of articulation skills in spoken language. Instead, written articulation skills are favoured. In many cases, E-mail writing is, however, not the same as letter writing. There may be a general shift from "readability" to 're-oralisation' of knowledge (in German: 'Reoralisierung', Frühwald 1998, 313), i.e. a sort of 'spoken script'. Descriptive language may wither away. Written E-mail discourse could hence create a hybrid form of communication, a mixture of text and speech, which can be shown by use of Yates' lexical density measurement (Gresham 1994, 47, quoting Yates 1993). "Orality" may be one of the effects of computers on traditional writing (Ferris 2002). Also "scholarly skywriting" (Harnad) is something between speech and traditional text. The optimum medium for scholarly communication would neither be paper (being too slow) nor spontaneous speech (being too fast), but: "the reflection and discipline of refereed Skywriting may well be optimal, a form of scholarly interaction that was not possible before the PostGutenberg era" (Harnad 1995, 4).
- For criticism, however, the written form may be inadequate (Stichweh 1989, 24). Generalising this idea, there are some topics where a brief oral conversation might be more adequate, whereas a written procedure might be rather clumsy. This is, however, not really a negative consequence as the format (oral/written) may be chosen freely (the telephone will certainly not disappear).

To conclude, I hold that cyberscience will be characterised, at least in the medium run, by an increase of written discourse. At the same time, academic writing is, in part, changing its character. It gets more speech-like, in some respect more informal, perhaps more efficient (e.g. with regard to the social component of communication). As Woolley puts it, E-mail conferencing "turns writing into a many-to-many medium" (1998, 10) whereas one-to-many writing does not lose ground, as formal publishing in (E-)journals is still increasing.

### 4.3.4 Academic infrastructure in the future

The various elements of the new spatial layout also affect the academic infrastructure as a whole. Looking at the totality of the cyberscience developments taking place at the moment, we may assume that the scientific infrastructure may be less characterised by well-equipped libraries with large archives, seminar rooms and the close location to an international airport. Rather broadband and reliable access to the virtual information space via state-of-the-art multimedia desktop (or mobile) computers will be salient.

In this section, I shall focus not on the implications of the new spatial layout for university and research institute's budgets[526] but on three special aspects: on the future of the university (4.3.4.1) and the library (4.3.4.2), as well as on overall implications of worldwide ICT use, which is the issue known under the label of "digital divide" (4.3.4.3).

#### 4.3.4.1 The future of the university

> "(W)hile new communications technologies are likely to strengthen research, they will also weaken the traditional major institutions of learning, the universities."
> (Noam 1995, 247)

The university as a teaching institution is not at the heart of this study. However, as the provider of vital infrastructure for probably the majority of researchers, the alma mater comes, nevertheless, into focus here.[527] Note that there are a large number of contributions in the literature dealing with the future of the university as an institution, including a variety of scenarios. It is impossible to present all of them here,[528] but I shall discuss a selection, focussing on ICT-induced changes.

First, ICT reinforces and enables at the same time a forceful trend, namely *globalisation*.[529] ICT-based teaching and learning makes the educational market more "perfect" in economic terms: In the traditional setting, this market was split as information was not transparent and worldwide mobility was low. Now in the information society, all universities are potentially in competition. Mobility, although increasing, is less of an issue as education can now be delivered to each home. Transparency is greatly enhanced as all programmes and courses on offer worldwide can be retrieved and compared. Furthermore, if one combines campuses and connects them electronically, a considerable number of courses offered on each campus become redundant (Abeles 1998, 604).

Second, one of the possible outcomes of this global competition might be that students individually select courses from all over the world (under the condition that the appropriate organisational measures were taken). Higher education "is now in the global, competitive, market place. It is now a client driven environment where individuals are able to choose what they wish to acquire rather than accepting the dictates of institutions" (Abeles 1998, 606). In analogy to Negroponte's "The Daily Me" (an individualised digital newspaper), Skolnik coins the term "The Me University" signifying the potential opportunity for students to combine courses from all over the world, thus creating one's own

[526] See 11.2.

[527] With regard to the changing role of researchers as teachers, see 5.2.

[528] A most recent addition to this bulk of literature is the edited volume Dutton/Loader (2002) which combines 22 most topical papers.

[529] See e.g. Sommer (1998); Inayatullah (1998); Manicas (1998, 653f.); Encarnaço et al. (1998); Ronzheimer, 1998 #879]; Abeles (1998, 609).

"university". This creation could either be done on an individual level, or through "intermediary agencies which would scan, assess, certify, combine, and package courseware from a variety of sources" (1998, 641). The *virtual university* is born, but it is not necessarily only virtual. For instance, De Alva outlines a strategy for his university, the large University of Phoenix, which emphasises online information portals (1999, 57). These web portals would provide remote educational content and may be created by "online enablers" to which the universities outsource this task. The importance of these portals and online enablers in the transformation of the traditional academy "cannot be overestimated" (ibid.). This also means that the students may "replace or supplement their alma mater's courses with courses or learning experiences derived from any other accredited institution, corporate university, or relevant database." (ibid.) For this future teaching market, standardised and commercialised products (Noam 1995, 249) are being developed. In some scenarios on the learning environment for the second half of this decade, a shift form a campus-centric to a consumer-centric model of higher education is expected (Twigg/Oblinger 1996, 8f.; Skolnik 1998).

A related aspect is that ICT hence offers economies of scale and mass customisation which adds up to a "modern industrial revolution" (Massy/Zemsky 1995 2; compare also Rost 1998d). Equally, framing the impact of ICT on universities in terms of 'standardisation', Agre fears that if the market philosophy prevailed – and hence every student would pick and choose from courses delivered all over the world – it would not be possible any more to get a coherent education. But he also acknowledges that the "great opportunity, then, is to use networked information technologies to connect the places of university teaching with other places in the world" (Agre 1999).

A third trend induced by ICT is that *new and attractive formats of teaching* are enabled. For instance, multimedia might play an important role (e.g. Müller-Böling/Küchler 1998), and so will all forms of distant education. All of them will require an institutional answer to be delivered in a professional way. These new alternative teaching tools are not only attractive – although probably not "superior to face-to-face teaching (though the latter is often romanticized)" (Noam 1995, 248) but they can be provided at dramatically lower costs. Therefore, it seems that the present low-tech lecture system will hardly survive unaltered. Both the small and the very large universities already have lots of online courses on offer.[530]

Fourth, as education can probably not be successfully delivered at distance only, the universities will have to find a *new balance between local and distant modules* of their programmes. Perhaps, the future university "will be a combination of local nodes and global networks [where] training can be relegated to the distant educational networks, but the education of the young is hardly possible in the absence of close and intimate educational interaction, mentoring, and modelling" (Tehranian 1996, 445). In her scenario of higher education in the year 2030, Nicholson (1998) predicts two novel formats: 'experience camps' that provide study and social service experiences for a relatively small group of students and 'advanced learning networks' as vast distance learning enterprises without campuses. Noam addresses this issue by noting that there are "fundamental forces at work" which "are the consequence of a reversal in the historic direction of information flow. In the past, people came to the information, which was stored at the university. In the future, the information will come to the people, wherever they are. What then is the role of the university?" (1995, 249) His answer is that "the strength of the fu-

[530] See e.g. Spiewak (2001) for the large private Phoenix University; cf. also De Alva (1999, 53).

ture physical university lies less in pure information and more in college as a community; less in wholesale lecture, and more in individual tutorial; less in Cyber-U, and more in Goodbye-Mr.-Chips College." (ibid.)

A fifth important trend, triggered not least by the opportunities offered through ICT are the so-called "*mega-universities*" which are those with enrolments of over 100,000 students which have no campus and use a variety of delivery vehicles from "snail mail" to two-way video delivered by satellite (Abeles 1998, 604). In this sense, the advantage of physical proximity of scholars in universities "declines steeply" because "the invisible (off-campus) colleges raise in importance due to increasing specialisation and the opportunities of CMC" (Noam 1995, 249).

Finally, ICT favours a *split between basic and advanced knowledge*. The trend towards E-universities is not and cannot be equally strong in all fields. In the areas of "codified knowledge and algorithmic skills" (Massy/Zemsky 1995, 3), IT-based courses will be more successful than "those concerned with questions of meaning and value, of culture and philosophy" (ibid., 4). Basic knowledge will be more easily taught in some electronic form than advanced cutting-edge knowledge or interpretative and critical thinking.

THE FUTURE OF THE UNIVERSITY
- Globalisation – global competition
- Virtualisation
- Standardisation
- Multimedia and E-teaching
- Local vs. distant modules of education
- Mega-universities
- Basic vs. advanced knowledge

*Overview 4-6: ICT-enabled and/or reinforced changes for the university*

Given these trends, I agree with Cornford who observes that the application of ICT "is generating a myriad of demands for re-institutionalisation of the university" (1999). Researchers as teachers will not remain untouched by these developments (see 5.2). Equally, research at universities will find a changing environment. In particular, a split into research and teaching universities may be the consequence of this restructuring.

#### 4.3.4.2 New information infrastructure: digital libraries

> "It seems clear that among all of the properties [of libraries], physical location is the least likely to survive in a digital library."
> (Harter 1996b, 4)

As we have seen in 2.3.4, the future information infrastructure will have various forms. Based on databases, archives, link collections and full text servers, we shall probably see the spreading of digital and virtual libraries.

The traditional libraries aim at providing researchers with whatever is needed. Researchers have to go to the library and get what they want. Most research units have their own specialised library, which often parallels the holdings of similar collections elsewhere.

In the case of university libraries and other large libraries, these redundancies are particularly obvious. This multi-centred spatial institutional model of library may, in the networked world, no longer persist. Large domain-based libraries are likely to emerge that serve all users within an entire nation (or even at a supra-national level) within a specific discipline or subject domain (Owen 1997). A single centre may succeed the multi-centre model. While the parallel holding of identical items was useful and necessary in the pre-digital world, in essence a single copy[531] of a digital resource may serve a whole academic sub-discipline, as long as access rights are distributed widely[532].

As the WWW with its typical hyperlink structure lends itself to distribution, the new "central" libraries and academic databases are, however, most likely to be of a decentral nature: what is central is the access point (the "portal"),[533] but the holdings may be distributed. Virtual libraries are, in general, of a distributed nature. Given the financial difficulties of many academic libraries (cf. 9.1.3.2), specialisation and co-operation may be the key to overcoming the current crisis. MathNet, PhysNet, SocioNet and the like are typical examples of this trend towards resource sharing and access providing on a de-central basis. Similarly, projects like the DAS (Distributed Sequence Annotation System) in biology are decentralised systems. In the case of DAS, there is a reference server with basic structural genome information, various other annotation servers around the world and a Napster-like[534] browsing and exchange system (Rötzer 2001).

When it comes to digital resources provided by commercial publishers, however, the new world-wide (virtual) library consortia will have to negotiate with the publishers to license the particular digital items for world-wide use. Different models are conceivable (cf. 9.1.2). It is, however, also possible – as I argue in 9.1.3.4 – that academic publishing will not be outsourced to the private sector any longer, but taken care of by academia itself. In the latter case, a worldwide exchange system on the basis of mutuality may be established.

*In sum*, we observe a tendency towards central access to distributed resources, managed in a co-operative way. Traditional physical libraries will lose ground, as more and more publications will be on offer in digital form. For some time, this will be parallel to print, but sooner or later, central printing will be ceased for the majority of academic publications (cf. 7.3.1). Division of labour between libraries may be crucial as no single library can fulfil all needs of local academics, but large consortia with each participating library having a unique specialisation may be able to do so. Libraries may become virtual libraries for most of what they offer their users, but stay a traditional and/or digital library for only a small fraction of the knowledge available.

[531] This is not to deny that it may be useful to have several copies with a view to guarantee accessibility in a distributed system and for archiving purposes (see 2.5).

[532] This is not something to be taken for granted given the development of digital rights management systems (DRM), cf. 9.2.1.

[533] Note that the central portal may have several mirror sites which make it, strictly speaking, again multi-centred.

[534] Napster is (was) a highly decentralised system of sharing digital music files. The files were stored locally on individual PCs; the Napster software managed decentral exchange via a sophisticated system of meta-data (only the latter are stored at a central server).

#### 4.3.4.3 Digital unity? Perspectives for peripheral research

> "In a world brimming with new knowledge and new ways to find it, there have appeared pockets of information poverty and local hardship."
> (Walker 1998)

Sketching the academic world, we could draw two different maps. One would look similar to the geographical maps we are used to, that is distance would be measured in kilometres or miles, size in terms of researchers based at each unit. The other would be partly overlapping, but look quite different. Distance between the various research units would be measured in terms of academic exchange and co-operation, size in terms of closeness to the core of a discipline, that is how many contributions to the most advanced fields (the "edge" or "frontier" science) in the sub-disciplines has been made. Peripheral research could be defined in both maps. In the first, the core is where most research institutes are. For many disciplines, there would be centres in the US, Europe and Japan. Peripheral institutes in this traditional spatial sense would be located in developing countries or on remote islands (like e.g. New Zealand). Looking at the second map, we would realise that there are also many non-top institutions in the regions mentioned first, right next door to the top institutes, and a few core institutions also in geographically more remote areas.

Both types of peripheral research institutions are disadvantaged vis-à-vis the central and top institutions. They have less access to "central" facilities such as top libraries, appealing conference venues, academic networks etc. The "levelling potential" (Finholt/Olson 1997) or "peripherality" (Matzat 1999) hypothesis now says that cyberscience and in particular the ongoing liberation from spatial limitations through ICT, may help peripheral institutions to reduce their distance from the centre. If the most important ingredient to research under cyberscience conditions is a networked PC, then the location of that PC is of less importance as long as it is connected to the Internet. As the Internet is spreading rapidly to almost all countries, even researchers in developing countries will have access to communication that they do not have through print (LaPorte et al. 1995). In contrast to the buzzword of "digital divide", meaning the new cleavage between those who have access to the digital world and those who have not, one may speak of "digital unity" as the prospective final stadium according to the peripherality thesis.

As worldwide access to the academic networks is still in its infancy, it is certainly too early to come to final conclusions. However, many authors have addressed directly or indirectly the peripherality issue and contributed a variety of arguments that can be grouped in four "levels": (1) cost reductions, (2) the relationship between access to (formal) information and peripherality; (3) positive empirical effects; and (4) counter-productive effects.

(1) On a first level, cost reductions speak in favour of the peripherality thesis. It is cheaper to provide high-quality access to the electronic research networks (virtual libraries, E-mail, databases etc.) than to establish a high-quality infrastructure on the spot (Morton 1997, 5; Ginsparg 1996, 3). Telecommunication connection fees as well as equipment costs are still dropping (cf. Varmus/et al. 1999).

We need, however, to account for the rising costs of access to some databases, E-journals and the like which may counter-balance this advantage. For example, Lexis Nexis[535]

[535] <Cyberlink=442>.

is a huge, but very costly database (Tehranian 1996, 442). The same is true for OVID[536] and other bibliographic databases, and certainly for access to the large collections of full-text E-journals of the commercial publishers, such as Elsevier. While rich institutions like the German Max Planck Society or the US Ivy League universities can easily afford to provide their scholars access from each workplace, even most universities in Western Europe cannot. "Will this vast Internet library – with holdings exceeding those of all but a few of the world's libraries – be surrounded by toll gates charging substantial fees for access to this knowledge?" (Walker 1998; similarly Harnad 1997)[537]

At least in the short and medium run, central institutions again seem to have an advantage by pooling in order to increase their market power on the demand side; peripheral institutions are normally not connected to these networks but this might change. In the long run, however, E-publications seem to be cheaper than their paper predecessors (see 9.1.1) which should help peripheral, low-budget institutions – not to catch up (because the distance between central and peripheral institutions may remain the same), but to get at last access to all basic material.

Note that due to the fact that providing such infrastructure is not cheap, it is possible that access to the new resources will be restricted to those at elite institutions (cf. Walsh/Roselle 1999, 67, quoting Rice 1994). Today, it is not the geographical location that counts but rather the equipment with appropriate technical infrastructure. For institutes with deficient computer equipment or where access to the Internet has to be established through expensive telephone connections via modem, "the synchronisation of research in privileged locations does not necessarily imply a participating role in this (seemingly) globalisation" (Merz 1997, 260).

There is still another important limiting factor for overall cost reductions. Not everything is online yet. Initiatives like JSTOR[538], which retro-digitise old journals or the ACLS history E-book project,[539] are still rare. Hence peripheral institutions do not only have the problem of accessing the full text databases, but still also the offline material. As Johnston (1998, 17) notes that "(a)lthough some 1000 library catalogues can now be searched on the Internet, knowing 100 locations of a book will not produce it." Given the "half-time" of research results (which is, for sure, different in each discipline), this problem will partly diminish over time if the current trend to offer most publications (also) in digital format persists and even intensifies (the problem of access, however, may persist).

(2) On a second level, another point to consider is related to the overall question of whether access to high-quality information alone makes a top or central institution. Is it not as much the close contact to other top researchers, the buzz in the corridors or the tea-room conversations? If you are at the big institutions you have access to oral information, to seminars, you can talk to the person (Walsh/Bayma 1996; 1999, 64). The filtering and pointing provided by this local informal communication is an important part of the process of scientific information search (Walsh/Roselle 1999, 64). In the section on the importance of the Café (4.2.4) I came to a similar conclusion: as research is also an informal process, participating in it is essential.

[536] <Cyberlink=704>.

[537] There are already a number of examples of initiatives providing access either unlimited for free (like BioMedCentral <Cyberlink=226>) or at least for a low fee restricted to low income countries (e.g. HINARI for health journals, <Cyberlink=908>).

[538] <Cyberlink=322>.

[539] <Cyberlink=246>.

It is doubtful whether E-lists could do the trick. One important effect of them is "to prevent discrete items of information from coalescing into stable knowledge supported by a social consensus" (Lewenstein 1995, 129). There is empirical evidence that individuals were not able, in practice, to discriminate among information based on its source and date. Furthermore, how one accesses information affects how one responds to new information; differential access implies differential evaluation. These observations lead to the conclusion that "(d)espite the normative description of science as an arena of fully open communication, the new communication technologies exacerbate the practical problem of some groups of people having more access to information than other people" (ibid., 130).

(3) On a third level, we may actually look for concrete, empirically demonstrable peripherality effects. CMC may help to include peripheral research institutes and their staff in collaborations. There is already some empirical evidence pointing in this direction. For instance, scientists in New Zealand "made heavy use of the Internet to obtain more ready access to research communities North America and Europe" (Walsh/Roselle 1999, 55). Other examples can be found with regard to the EU research framework programme as regards the necessary inclusion of research teams from as many EU member states as possible – something most easily feasible through CMC (the alternative would be to increase travel budgets). E-pre-print servers have made the latest results much more widely available and diminished the importance of various small 'in' groups (Odlyzko 1994; Merz 1997, 258). Ginsparg concludes that "the reality is that less developed countries are already better off than they were before" (1996, 3). He mentions the example of researchers in Eastern Europe, South America or the Far East who frequently report how lost they would be without CMC and "how they can finally participate in the ongoing research loop" (ibid.).

Hence, CMC may lead to increased participation by less prestigious institutions, rather than to a restructuring of the status hierarchy, i.e. more researchers are included at the bottom while the work of those at the top is not transformed. The result is not a levelling of science but an expansion of science (Walsh/Bayma 1996, 355; 1999, 62f.). By contrast, Finholt/Olsen (1997, 34) put forward three sets of arguments to sustain their claim that "important forces will tend to move collaboratories in the direction of exclusivity and selection": first, the availability of a means for contact between two scientists does not guarantee that contact will occur (invisible colleges); second, if intellectual property rights play a role (e.g. in chemistry), sharing of information in collaboratories is less likely to occur; and third, face-to-face contact appears, at least initially, to be required.

In the context of empirical studies of E-lists, Matzat (1999; 2001) detects "peripherality" effects: In some respects, the peripheral researchers profit from CMC in general and participation in Internet discussion groups in particular through attaining some information benefits. Their research work becomes more visible to others and they become more aware of others' output. These "contact and information benefits" are, however, not sustainable. While Matzat's conclusions are well-founded in extensive empirical research, Gresham, by contrast, mainly draws from unsystematic anecdotal evidence and found that "not only geographical, but other barriers to access were overcome via e-conferencing" (1994, 45): breaking into the old-style invisible colleges was one of them.

(4) On a fourth level, we may also approach the issue from the opposite angle, that is not by asking whether ICT will bring advantages for peripheral institutions, but by asking whether or not participating in cyberscience may even be disastrous (both for individuals as much as for institutes). What would be the effects of digital divide in acade-

mia? It is conceivable that, for a "technophobic" scholar lacking connections to a major institution, the Internet widens the gap between this scholar and the rest of the intellectual world (Fuller 1998, 123; similarly Walsh/Bayma 1996, 348). By contrast, the major researchers and research centers "still benefit from a variety of advantages, some of which are reinforced by the use of the networks" (ibid., 359).

This is an important point: Even if peripheral research is profiting from cyberscience this does not necessarily lead to closing the gap between the core and the periphery, hence to true peripherality effects. If the core is gaining as much or perhaps even more, the gap still persists and may even be widened. Indeed, as (mainly) the core uses CMC to sustain the traditional networks and exchange relations, it is rather unlikely that peripheral research would enter the scene unnoticed. Hence, probably the same tacit rules as ever may decide on access to the network and to the important information.

There is another aspect, equally speaking in favour of the thesis that the divide will rather be reinforced than levelled down: There is a danger in non-elites' use of collaboratories to foster links merely among one another. While collaboratories may be critical for scientists at smaller institutions where they may have few local colleagues, this may, at the same time, lead to a concentration of non-elites who are marginalized in their larger, more traditional scientific communities (Finholt 2001, 30).[540]

*So, are we on the path to digital unity?* Will the peripheral institutes profit more than the centre so that the gap narrows down? What we can say for sure is that they will profit in absolute terms, in particular from better and easier access to published information. Whether the gap is narrowing down (that is, whether they will also profit in relative terms) is an open question and cannot be answered empirically as we lack both reliable measurements and comparative data. Furthermore, the future of the licensing system is not yet settled. The crucial issue is whether access to databases and digital libraries will be restricted to local users. If this were the case, peripherality effects would be low. As regards the informal channels of research, it is even more unlikely that CMC will change much. As we have seen (in 4.2.4), these are often bound to physical locales and hardly paralleled in the virtual arena. Hence, there will be only low peripherality effects on a general level. However, we may expect effects on an individual level (see below 5.5).

### 4.3.5 The virtual re-constitution of scientific communities

As the communication and collaboration patterns change, the characteristics and structures of scientific communities are changing, too. They "go online" or "become virtual". Researchers belonging to such a community may know each other, but not in person. They may exchange information and chat without ever meeting. New social structures emerge. New social dynamics are to be expected:

> "There is definitely not a simple reproduction of a given pattern in a new medium while people get used to that medium. We can consider here a more creative activity of appropriating this medium to fit the style of discourse used by academics. Social realities are created dynamically through interactions. (...) (W)hen participants exchange messages, they take advantage of the medium in

[540] Some voices are even more fundamental. For instance, Abeles writes: "Add to the oppressive balance of payments at the country level, and the increasing pressures from modern culture over electronic media the incursion of intellectual memes into academic institutions. This leads to the modification of long half-life knowledge. De facto, intellectual colonial rule is reintroduced." (1998, 609)

different ways to influence social realities. (...) (T)he members of electronic groups creatively exploit the features of the system to create emergent social dynamics." (Hert 1997, 332)

In this section, I concentrate on four specific, but related aspects of these new dynamics. I shall first look at the transformation of the so-called invisible colleges (4.3.5.1), second, at the increasing internationalisation of the scientific communities at large (4.3.5.2), then at the destiny of specialities (4.3.5.3) and finally at the synchronisation hypothesis (4.3.5.4).

### 4.3.5.1 Transforming invisible colleges

The term "invisible colleges" coined by Price (1986 (1963)) and further developed by Crane (1972) designates the informal collectives of closely interacting scientists, generally limited to a size that can be handled by interpersonal relationships. Already in 1994, Gresham (1994) observed a shift from the traditional invisible college to what he called "cyberspace colleges" as a new form of the informal research network (Gresham quotes Tracy 1980 coining the term "electronic college", ibid., 39). Gresham, however, does not predict a replacement of the traditional invisible college, but rather "the emergence of a new form of informal network in cyberspace existing alongside" the old forms. Note that Gresham and the other older literature talk mainly about processes of written communication, not about audio and video E-conferencing. From the observed uses of E-lists, which include many social activities, Gresham concludes that they impact on the formation of invisible colleges (1994, 44f.). One effect of increased communication among remote collaborators may be "an increased attachment to the research group and the discipline" (Walsh/Bayma 1996, 353). The network is able "to keep weak ties active" (ibid.). This may be equally applicable for invisible colleges, independent of present collaborative projects.

Gresham was quite optimistic that the virtual college will overcome the present handicaps of effective invisible colleges (mainly travel expenses and limitations of time and space) and that "elitism of the old scholarly networks will be overcome" (1994, 46). Also, the OECD report argues that improved communication "may contribute to an increase in the size of professional networks" (1998, 195; Walsh/Roselle 1999) and hence to opening the closed circles. This is, however, rather unlikely as we have seen in the previous section (4.3.4.3). It is common wisdom that the informal communication through which invisible colleges are maintained involves much personal contact (Lewenstein 1995, 125). E-mail seems not to stimulate new relationships but instead to enhance "the impact of strong invisible college and proximity ties" (Carley/Wendt 1991, 435).

As invisible colleges are at the core of all specialities, Freeman's (1984) discussion of the impact of CMC on the social structure of an emerging scientific speciality (social networks studies) is of relevance, here too. He comes to the conclusion that the early (E-mail-based) computer conference facility had indeed an impact on its participants. He argues that long-term proximity would be necessary for the development of a new scientific paradigm. Freeman then asks: "In judging whether a computer may be substituted for proximity, then, the question is whether the computer can provide persons with opportunities to learn about each other as well as to 'meet'." (ibid., 217) His empirical data on how well people know each other at different stages of the evolution of this speciality (which included a period of heavy CMC use) lets him carefully conclude that the "computer, it seems, can perhaps take the place of protracted face-to-face interaction and provide the sort of social structure out of which a scientific speciality can grow" (ibid., 201 and 220).

We may then conclude with Walsh/Roselle that the new media "both transform and reinforce the existing structure of communication within a community" (1999, 64). It reinforces by providing for new channels of communication. It transforms by setting incentives to shorten communication intervals. The old invisible colleges will persist, but will increasingly communicate in cyberspace. Invisible colleges completely outside cyberspace will vanish. The establishment of new such colleges will be favoured, as it is easier to sustain the ties knit during collaborative projects.

#### 4.3.5.2 Building international scientific communities

Beyond the (closer) invisible colleges, the (larger) scientific communities are equally affected by ICT use. While it is nearly impossible to concentrate all or at least the majority of researchers in a particular sub-discipline at one spot, cyberscience applications make it possible to pool both the "inner core" and further interested researchers without actually displacing the persons. Websites and E-lists can promote international networks and favour the integration of disciplines.

Hence, a sense of being part of a worldwide community is possible. In the "global village" of cyberscience, one encounters the relevant scientific community anytime online (Stichweh 1989, 8, 16). CMC may be fit to stabilise scientific communities through communication (ibid., 37). Obviously, there is a high demand for technologies which allow the continuation of relatively intensive intellectual exchange and co-operation in common research projects even after the termination of simultaneous presence at one spot (ibid., 40). In other words, while the medium does not create the community, it is rather a preexisting community taking advantage of the medium (namely scholarly E-lists) (Hert 1997, 333). One can speak of the participants' "community awareness" (ibid., 335, transl. MN) while writing their postings, because what one says in the list can be considered as addressed to the whole community.

Previously national scholarly associations "have gone international" in the age of cyberscience. For instance, the US Academy of Management's membership has become more and more international: extrapolating the current trend leads to 50 % international members in 2007 (Starbuck 1999, 187). One major reason, according to this author, is the Internet that facilitates knitting contacts around the globe. In some respect, therefore, the Internet contributes to a growing together of different, previously independent intellectual traditions and hence perhaps to new solutions (ibid., 190).

In conclusion, we observe that scientific communities have increasingly become worldwide communities with a highly improved communication infrastructure.

#### 4.3.5.3 Sub-field fragmentation?

On the one hand, there was (at least until quite recently) a constant growth in the number of researchers working in ever-smaller specialities (to keep the size of the audience for the results somewhat constant). These researchers are located, however, in departments which have not grown much meaning that researchers have become increasingly dispersed (Odlyzko 1994, 7). On the other hand, large distances, the lack of travel money and slow communication infrastructure were, until recently, not a favourable environment for building up specialised international scientific communities. As we have discussed, cyberscience makes contacts, virtual meetings, information exchange and co-operation much easier among those – in most cases – very few experts in one's own limited specialisation around the globe. While so far personal contacts were limited to the rare

occasions of international conferences and one only took notice of each other via publications in international journals, there is now the potential of continuing communication and of collaborating more easily. E-mail is "used to keep the connections built up during these contacts from atrophying" (Walsh/Roselle 1999, 62). This leads to what may be called a "globalisation of the fields" with tight links among dispersed scientists leading "to a more closely knit international community of scholars" (ibid., 56). Furthermore, while scientific exchange with colleagues in one's own home institution is still important, it is not always satisfactory due to different specialisations. In the age of cyberscience, researchers may directly communicate with other specialists in their own tiny "sub-sub-field". They "use their limited communication time to interact only with those in their speciality (anywhere in the world)" (ibid., 57).

Some have chosen to call the consequences of this development – researchers using their limited communication time to interact only with those in their speciality (anywhere in the world) – the "balkanisation of science" (van Alstyne/Brynjolfsson 1997b; Walsh/Roselle 1999). This means a fragmentation of research specialities even within sub-disciplines as opposed to the "global village" metaphor of unified sub-disciplines. In addition, there is only limited communication among these fragments. I will not continue to use this, in my eyes, rather insensitive notion but will speak instead of "sub-field fragmentation".[541]

It is still too early to say whether this potential will be realised. The proliferation of highly specialised E-lists is certainly a hint in this direction. Analysing their survey among over 300 scientists from four disciplines, Walsh/Maloney (2002) found, however, no evidence that E-mail led to fragmentation. Perhaps, these fragmented specialities are not stable but highly dynamic so that it is difficult to detect them. In the words of Bates, we are in the presence of "countless loosely knit and continuously shifting networks of individual researchers" (1994, 3). In addition, we have to take into consideration that the closer the topics of individual researchers, the more competition there should be between them. Hence, it will depend on the competitive or non-competitive overall character of the field whether such tiny sub-specialities will be formed and sustained on a worldwide scale.

In their study in information economics on the integrative or disintegrative effect of IT on electronic communities, van Alstyne/Brynjolfsson (1997a) measured information integration and developed a model of individual knowledge profiles and community affiliation. They show that an emerging global village represents only one outcome from a range of possibilities. Improved communications, access and filtering technologies could also fragment intellectual and social interactions; hence separation in virtual space can divide special interest groups. They forward two main arguments: First, the limited human capacity for processing information (bounded rationality) may lead to specialisation. Although IT eliminates geographical constraints on interaction, the amount of data one can absorb is bounded, regardless of how fast it can be accessed. Their second argument is that IT enables the satisfaction of preferences notwithstanding spatial limitations. Due to improved long-distance communications and filtering technology, people can opt for more focussed contacts. In a shorter paper, Alstyne/Brynjolfsson (1997b) apply their previous considerations on science in particular and argue that sub-field fragmentation is possible but not inevitable. Whether we will see fragmentation or integration "hinges on

[541] Geser (1996, 7) speaks of the possible "decay of broader 'scientific communities'" which will be replaced by networks of "extremely specialized new professionals that offer their outstanding, but narrowly focussed knowledge worldwide through electronic channels".

individual preferences and factors such as whether the pressure to publish at the frontier of one's own discipline is low enough to permit time for exploration in others".

On the positive side of this development, we may count that this enhanced communication among specialists contributes to a more satisfactory dialogue among knowledgeable colleagues. Eventually, this may lead to advances in research. The virtual sub-subfields may also help overcome the sense of isolation that stems from (in some disciplines) irregular hours and from concentration on a highly specialised endeavour that even local colleagues may have little interest in (Walsh/Roselle 1999, 59).

The potential downside of researchers forming work groups with remote colleagues is that their face-to-face interactions with their local colleagues may be replaced by computer-mediated interactions with remote colleagues (Walsh/Roselle 1999, 57). In this, one may see the danger of reducing the chances that ideas from one discipline cross-fertilise other fields (cf. also OECD 1998, 197).

Summing up, I hold that CMC will potentially lead to the establishment of very specialised, hence tiny and worldwide, yet dynamic and constantly shifting groups or "minicolleges" whose members communicate much more among them than with outsiders. This could reinforce the trend to ever more specialities and eventually lead to a high degree of sub-field fragmentation. The boundaries of the new fragments may not be defined by broad thematic area and space (e.g. the specialised "working parties" or "research groups" within national scholarly associations) but by a specific thematic focus, regardless of national or regional boundaries.

#### 4.3.5.4 Worldwide synchronisation/co-ordination of research?

Closely related to the above discussed building and restructuring of invisible colleges and scientific communities is the hypothesis that ICT may lead to a synchronisation of worldwide research activities. E-publishing and Internet databases that are accessible from everywhere lead to a level-playing field for all researchers since everyone can more easily be "up-to-date" and informed of ongoing projects and recent findings worldwide. As will be discussed below in 6.4.4.2 under the label "enhanced connectivity", the perspective of academic knowledge representation in hypertext format will contribute to this co-ordination and synchronisation effect. This hypothesis is similar, but less far-reaching than the peripherality thesis (discussed above 4.3.4.3): it is not argued that peripheral research will be able to come closer to the centre, but that all research, whether peripheral or central, might be better co-ordinated. It will be less likely that individual researchers or research groups focus on exactly the same problems with the same methodology, the same theoretical background etc. without at least knowing about each other.

The advent of E-pre-print archives made the distinction between "direct" (personal contact with author), "indirect" (via libraries and mailing lists) and "no" access to pre-prints, and hence the state-of-the-art, lapsed (Merz 1997, 259f.). Consequently, all researchers have access to the same information at the same time, at least in principle. Hence E-preprint archives synchronise research. This synchronising effect also leads to acceleration: since there is now a universal "time stamp" system (the registration date and time in the archive), a research group has to fear uploading its paper later than a competing group working in the same field. While in the days before E-archives there was still a realistic chance that both groups would be credited for their results (cf. 8.2.4.4), this is now less likely, because the slower group was, at least in principle, able to take notice of the winning group's results (ibid., 260).

There are also counter-movements. For instance, some researchers deplore that the possibility of immediate Internet publishing and communication creates "a bandwagon in which once-isolated scientists rush to become part of the latest trend. In the resulting stampede, all but a few promising avenues are quickly abandoned" (Glanz 2001). There is a sort of "social pressure against marching to a different drummer" (ibid.). Hence, some proposed to cherish more isolation (instead of co-operation), but this was not really thought to be realistic.

When confronted with the synchronisation hypothesis, most of my interviewees agreed to it, except for the sociologists and some experts in the humanities (papyrology, philosophy, history and anthropology). Some argued that "islands" of less co-ordinated research will certainly survive and doubts were raised as to truly universal access as a pre-condition (cost, infrastructure).

In conclusion, such an effect is likely, though it will probably not be universal in scope (not all fields will be affected alike). There is a chance that every researcher will be in a position to relate his/her own research to what has already been done and what is actually under way worldwide. The academic "clocks" will be more synchronised than before the advent of the Internet-based communication network.

## 4.4 On balance: De-materialisation of research?

In this chapter, I have shown that on the path to cyberscience the spatial layout of academia is changing profoundly. An overall conclusion is that space, that is the geographical distance between researchers and between them and their facilities (offices, resources, libraries etc.), diminishes in importance. Other dimensions are increasingly essential in shaping the circumstances in which research takes place. Among them are the reliability of the infrastructure, the conditions of access to specific resources, new organisational structures that slowly seize the new opportunities and the significant properties of the new cyber-tools. This is not to say that the traditional material basis will not play any role any longer. By contrast, proximity to specific locales in the real world as well as to the "core" researchers in a field will still be an important feature in many respects. In particular, when it comes to informal research activities, the new media can only partially fulfil what is needed by academics. The "Café" as a meeting place cannot be opened in cyberspace without losing much of its character. Furthermore, meetings in person will retain an important function when it comes to initial contact, to "contracting" – that is agreeing on the terms of a collaborative project – and to conflict resolution. Nonetheless, I expect that CMC tools will become a regular part of all scholars' daily routine very soon. Quick cyber-meetings to discuss a research issue that came up in a collaborative project are likely to replace phone calls or lengthy E-mail exchanges. Asynchronous E-conferencing will be used to complement face-to-face meetings with a view to overcoming time restrictions and to avoiding the loss of an important thread of argument. Distance co-operation based on E-mail will increasingly be enhanced by shared workspaces, such as file repositories and common databases. Access to written resources will largely shift to cyberspace, as very specialised and near comprehensive digital or virtual libraries will be on offer and accessible worldwide.

While these considerations support the conclusion that, at least in the medium run, a completely virtual academia is not likely to emerge, the impact of this gradual shift to

cyberspace activities on academia should not be underrated. In the preceding sections, I concluded the following: We have to expect a further increase of distant collaboration. Furthermore, the cyber-tools have the potential of creating qualitatively different patterns of distant collaboration. For instance, more researchers will be involved, researchers' networks will be larger, collaborations may last for longer and workflows may change. While communication among remote collaborators will increase and perhaps be of a more instrumental character, the danger of isolated researchers in front of their computer screens seems unjustified. ICT will have both positive and negative consequences for the productivity of the researchers. The advantages in information access and as regards communicating at distance seem, however, to outweigh negative side effects, in particular if we account for learning and experience. There are a number of arguments indicating some potential for efficiency gains of the academic system due to ICT. However, it will be impossible to say with certainty whether or not the new spatial layout in the era of cyberscience will improve overall productivity for various reasons. Cyberscience will be characterised, at least in the medium run, by an increase of written discourse. At the same time, academic writing is, in part, changing its character. Further important effects are to be observed with regard to the infrastructure of academia. In particular, there are many demands for a profound change as regards the traditional university. Equally, traditional physical libraries will lose ground. Peripheral institutes will profit from the diminishing importance of space. It is, however, uncertain if this will narrow down the gap between them and the top-institutions. In particular as regards the informal channels of research, it is rather unlikely that CMC will change much in favour of peripheral institutes, hence there will be no "digital unity effect". Furthermore, the new media both transform and reinforce the existing structure of communication within a community. The traditional invisible colleges will persist, but will increasingly communicate in cyberspace and the emergence of new such colleges will be favoured. Scientific communities will become increasingly worldwide communities with a highly improved communication infrastructure. In addition, the establishment of very specialised, hence tiny and yet worldwide, dynamic and constantly shifting mini-colleges whose members communicate much more among themselves than with outsiders is likely.

So, where does all this lead us? If we define as "material" the dedicated offices, books, libraries and conference facilities and as "immaterial" everything which flows among researchers in the form of bits and bytes, the notion of "de-materialisation" surely depicts an overall trend. However, the importance of physical locales seems not to go away soon. Furthermore, much of what researchers do is only marginally touched by these changes in the spatial layout, in particular laboratory work and thinking itself. Therefore, the future of academia is by no means complete "de-materialisation", but will be characterised by a new balance of both material and immaterial elements.