

Communicating Science

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A Practical Guide

 Springer

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*To the memory of Lewis Thomas (1913–1993),
who set an example to all of us
as scientist, communicator and humanist.*

PREFACE

Many years in the making, this book aims at improving the skills as communicators of my fellow-scientists. Advancement of knowledge is synonymous with diffusion of results, first within the scientific community and then to the public at large. Accordingly, the book has two main parts, corresponding to these two constituencies, with their widely different needs. A third, smaller section is devoted to informing decision-makers. I have attempted a rather comprehensive coverage.

Readers whose native language is not English – which incidentally is also my case – may find the book useful. While this is not a manual on speaking and writing English – there are plenty of those around – they may find it educative nevertheless.

In the vast majority of cases, I have first-hand experience of what I write about. In addition, I have consulted a recognized expert on each topic.

Each of the main parts is subdivided into two sections, Guidelines and Genres. The segments are set in alphabetical order within each of those subsections. Hence, the table of contents serves at the same time as an index. Within each segment, a few cross-references remind the reader of related subject matter in other parts of the book. Inevitably, there are repetitions, for which I apologize. A brief bibliography of some useful articles and books is provided.

It is my pleasure to thank for their precious advice, which has markedly improved this manual, my friends and colleagues: Philip Ball, Alex Bellos, Jim Bennett, Wesley T. Borden, John Hedley Brooke, Gregory L. Diskant, Roald Hoffmann, Jamie C. Kassler, Joseph B. Lambert, Robert L. Lichter, Annette Lykknes, Jozef Michl, Peter J. T. Morris, Guy Ourisson, Philippe Perez, Daniel Raichvarg, Christopher Ritter, William Roberts, Edward T. Samulski, Jeffrey Seeman, Peter Stang, Mel Usselman, Laura van Dam, Stephen J. Weininger.

I was gratified by the impressive professionalism of Dr. Marion Hertel and her colleagues at Springer, in Heidelberg.

My thanks go, last but not least, to my wife Valerie. She has gratified me with her skillful and imaginative editing of the individual pieces, making them both leaner and tastier.

CONTENTS

PART I

ADDRESSING PEERS

GUIDELINES

Abstract	2
Acknowledgements	3
Acronyms	4
Active or passive voice?	5
Bibliography	6
Body language	7
Conclusion	9
Electronic publishing	10
E-mailing	12
Erudition	13
Figures and captions	15
Free access	16
Ideographic vs. nomothetic	18
Illustration	19
Index	24
Introduction	25
I or We?	26
Irony	28
Neologisms and Eponymy	29
Notes	31
Opening paragraph	32
Organizing your material	33
Paragraph	36
Scholarship	38
Sentences	40
Signers	42
Speech delivery	43
Subtitles	45
Taking the floor	46
Title	48

Understatement	49
Verbs	50
Visuals (for a lecture)	52
Vocabulary	53
Website	55
Wit	56

GENRES

After-dinner speech	60
Book chapter	61
Book Proposal	62
Conference presentation	64
Editing proofs	65
E-mail	67
Editing	68
Editing a book	70
Editing a magazine	72
Editing for a journal	73
Editing a journal	74
Editorial	77
Informal discussion	77
Internet	79
Keynote lecture	80
Lecture	82
Lecture series	84
Letter for publication / Op-ed piece	86
Magazine article	87
Monograph	89
Obituary	91
Panel, roundtable discussion	92
Phone call	94
Poster	95
Presentation to a visitor	97
Progress report	98
Recommendation letter	100
Referee report	101
Research proposal	103

Research talk	104
Review article	106
Seminar	107
Slides and transparencies	109
State-of-the-art review	112
Teleconference	113
Visuals (for a lecture)	115
Writing a book review	116

PART II

THE GENERAL PUBLIC

GUIDELINES

Anecdotal	120
Avoid translation	121
Body language	123
Building a story	124
Conclusion	125
Dealing with an acquisitions editor	127
Didactic or narrative?	128
Illustration	129
Irony (In addressing the public)	131
Opening paragraph	132
Organizing your material	134
Personalizing	136
Respect	137
Rhetoric	138
Seduction	140
Speech delivery	141
Taking the floor	143
Telling a story	144
Thematic variations	145
The necessary reconstruction	147
Title of a book	149
Title of a story	150
Vocabulary (in pieces written for the general public)	152

GENRES

Autobiography	156
Biography	158
Blurb	160
Capsule biography	162
Children's books	163
College textbook	165
History of science book	166
Journalist interview	168
Magazine article	171
Natural history vignette	172
Newspaper story	173
Play	175
Poetry	177
Press release	178
Primary school textbook	179
Public reading	181
Radio interview	182
Science news	184
Science popularization book	185
Scientific exhibition	189
Secondary school textbook	190
TV show	192
Web site	195

PART III

DECISION MAKERS

GENRES

Briefing	198
Conference report	200
Consultant report	201
Expert testimony	203

PART I

ADDRESSING PEERS

GUIDELINES

ABSTRACT

An abstract is like the face of a person. It can tell one what to expect. It should give the gist of the paper in a short paragraph. Besides being a summary, it has another purpose. A showpiece, it beckons the reader into the paper. You do not want to compose an abstract so well devised the prospective reader after glancing at it will decide to skip the paper. But even worse, you want to avoid writing an abstract so discouraging as to turn the reader away from both the abstract and the paper itself.

Don't compose an unreadable abstract. This would seem to go without saying. An opening sentence such as »*Fragments of polyketide synthase (PKS) genes were amplified from complementary DNA (cDNA) of the fusarin C producing filamentous fungi *Fusarium moniliforme* and *Fusarium venenatum* by using degenerate oligonucleotides designed to select for fungal PKS C-methyltransferase (CmeT) domains*« is impossible: Too technical, too dense, too complicated a syntax, heavy with **acronyms**.

Let's start with translating and breaking down this sentence. How about, instead, »*Two species of filamentous fungi produce fusarin. Their complementary DNA serve to amplify fragments of polyketide synthase genes. We use for this purpose degenerate oligonucleotides, designed to select for the desired methyltransferase domains.*« Moreover, since the **title** of the paper starts with »Fusarin C Biosynthesis«, don't repeat it. The desired meaning of the above sentence is »*We have prepared oligonucleotide PCR primers selective for fungal polyketide synthase genes.*« Why not start the abstract thus?

Think of an abstract as a shop window. It requires elegance and attractiveness. The latter ought to be a reflection of the quality of the work, of the novelty of its approach, of the importance of its results. The former is exclusively a matter of word-craft, of style. It is not enough to whip out an abstract in five minutes, either before writing the paper or after having done so. A good abstract might be hours in the making. To invest time assembling such a jewel is not out of whack.

How can it be done? Write as if you were penning a postcard to a friend: use simple sentences, don't get technical and utter a clean message in a maximum of 50 to 100 words.

Incapable of such a feat? In that case, take a printout of your completed paper and underline a dozen sentences you feel epitomize the work. Paste them together and tie them together with transitions. Now, edit this paragraph. Be merciless. Try to reduce it by a third. You should now have the

first draft of your abstract. It only remains to turn it from decent into artful English. Do not hesitate to resort to a dictionary of synonyms and to use other tools such as a style manual. Read your abstract aloud, a crucial test. It will make you jettison multisyllabic unpronounceable words. It will make you focus on the genuine achievements of the paper. It will make you grab your reader by the sleeve: »*come inside, Mister, I have something truly marvellous I'd like to show you*«. This is the message from a well-designed abstract.

REFERENCE: K. K. Landes (1951) *Scrutiny of the abstract*.1. AAPG Bulletin, 35(7):1660; (1966) *Scrutiny of the abstract*.2. AAPG Bulletin 50:1992.

Whom to thank? 

ACKNOWLEDGEMENTS

This appears an almost perfunctory and ancillary part of a publication. Such a perception is misleading.

This segment is worthy of your full attention. Failing to thank someone for assistance does not speak highly of your accuracy and care – two essential qualities in a scientist.

Which brings up the question: whom to thank? The answer could not be simpler: anyone who is not listed among the authors and who nevertheless has somehow helped or contributed. The criterion for authors, covered elsewhere in this book, is very simply that any of the co-authors ought to be able to present and defend the paper, as a whole or in part.

How then should this segment be presented and written? There is no prescribed format. Nevertheless, I shall suggest one. Why not take model on the Acknowledgement section of nonfiction books? It is often prepared and written with great care. The author uses this opportunity to recapitulate the history of the book and to set it on the record. By doing likewise with your text, you will be able not only to thank all the relevant parties, but also to put together a piece of writing which, in the future, historians may turn to as a source of valuable information.

REFERENCE: R. A. Day (1994) *How to write and publish a scientific paper*. 4th edn, Oryx Press, Phoenix AZ.

They are eyesores. 

ACRONYMS

The TA is BI. This assertion, which could be construed as stating the sexual preferences of a teaching assistant (TA), is meant here as »the topic of acronyms is a bothersome issue«. One of the many problems with acronyms is the multiple meanings many of them have. Of course, within the confines of a single publication, addressed primarily to a group of specialists, such ambiguities vanish.

Acronyms are necessary due to the need for brevity. Long names of chemicals beg to be shortened. Thus monopyrrolotetrathiafulvalene (29 letters, far from a record) is shortened into MPTTF, with only five. Some such chemical acronyms have entered common language. Examples include DNA, RNA, TNT, DDT, ... Names of commonly-used laboratory tools and techniques are also turned into acronyms. Fourier-transform infrared spectrometry becomes FTIR (four instead of 37 letters), atomic-force microscopy is AFM and a superconducting quantum-interference device is a SQUID.

This last example illustrates a consequence of acronyms entering the scientific lingua franca. A naïve student using the SQUID and who continually hears it referred to as such may never learn what the acronym stands for. To him, the acronym is an opaque screen. He does not know the real composite name hiding behind, hence he may never find out how the contraption works. Is it such a hot idea for a user not to understand how an instrument works?

But acronyms have some redeeming value, too. Their very existence points to the pressure for efficient communication within the scientific community. Indeed, acronyms help to network research scientists worldwide. Often, an in-house abbreviation within a single research group transfers into common scientific language.

Another nice aspect of acronyms is their testifying to the playfulness of scientists. Play is an essential component of science. To make-up an acronym, a wordplay, belongs to such an attitude.

Do's and don't's? My first rule is to try and stick to a maximum of three letters in a non-punning acronym, such as DNA or TNT. One of the reasons is that, in a language such as English, it is difficult to pronounce more than three consecutive consonants. If you need more letters, then you should make sure that you have enough of a balance between vowels and consonants for easy pronunciation. A common trick is to tailor the acronym to an already existing word, as exemplified by SQUID. Quite a

few scientists have had a field day turning loaded words into acronyms, such as PENIS standing for an algorithm used in nuclear magnetic resonance (NMR for short). Make sure that, whenever an acronym first appears in a publication, it is flanked with its translation. But make as little use of acronyms as possible. They clutter a text, they hinder the flow of reading, they are eyesores and tongue-twisters, they are a necessary evil.

REFERENCE: K. T. Hanson (1995) *The art of writing for publication*, Allyn & Bacon, Needham, MA.

switch from the passive to the active 

ACTIVE OR PASSIVE VOICE?

This question is a dilemma only because the conventional way of writing scientific papers heavily favors the latter. But first, let's give a look at a few samples of such writing.

»*The characteristics of ... have been suggested so far to be the result of cooperative phenomena.*« The timidity in this sentence reflects a very real and respectable uncertainty, in attribution of a cause to scientific results. It stems from the difficulty of interpretation, which can never be certain and which, therefore, has to be muted. But there is a fine line between such prudence and downright obfuscation. One wishes the author of this paper had stuck his neck out and written for instance »*Cooperative phenomena account for the characteristics of ...*«. If this were too strong an assertion, it could be qualified: »*Cooperative phenomena account, at least in our view, for the characteristics of ...*«.

Another example: »*This work was motivated by previous demonstrations that ...*«. This opening statement aims at identifying a historical continuity, the study we are about to read did not arise in a void, it followed upon earlier work. Why not write instead »*We base this work on previous demonstrations that ...*«, which requires only a rephrasing from the passive to the active voice? Notice that, not only did I turn the sentence from passive to active, but I also moved it from the past tense to the present.

The habit of using the past tense is another feature in writings by scientists. When colleagues pen this sentence: »*Support effects have been attributed to co-reactant activation sites ...*«, thus referring to an opinion

which they might wish to challenge, why don't they write instead »*Do co-reactant activation sites truly produce support effects?*«

Sometimes, the combination of a switch from the passive to the active, together with dispensing with unnecessary words, works quite nicely: »It was demonstrated that this surface provides the best efficiency for ...« thus easily becomes »This surface is most efficient at ...«.

Turning to the passive voice is second nature to scientists. This is their way of playing possum. It is a diversion tactic against possible criticism of their work by referees and peers. They qualify their statements making them innocuous in the hope of deflecting any challenge. In so doing, assertions lose their edge, the writing becomes moot and the reader's attention wanders.

REFERENCE: M. Young (1989) *The technical writer's handbook*, University Science Books, Mill Valley, CA.

your paper has three constituencies 

BIBLIOGRAPHY

Why is a good bibliography essential? It demonstrates your seriousness as a scientist. What is a good bibliography? It displays honestly and conscientiously the foundations of your work. The phrase »scholarly apparatus« is synonymous with a bibliography: the end part of your paper is a testimony to your **scholarship**. Your results may be trusted, you are also a scholar to be respected. You know what you are writing about, you know your place in the science world, you read what others have published in the field.

The goal of a list of references is not one-upmanship. Avoid being vain, because it will invite ridicule and scorn, as if you were wearing a flashy suit with a gaudy tie and outrageous multicolored shoes. Refer only to those of your earlier publications truly critical to the understanding of the present work. Nor is the sole purpose of a bibliography to ingratiate yourself with the most influential among your peers, those most likely to be called upon to serve as reviewers or referees.

Your paper has three constituencies among its readership. Your peers make up only one. No less important are the young scientists, those start-

ing in the profession, the graduate students. Make your paper helpful to them. Select for their didactic value three papers, or book titles, for inclusion at the very beginning of your list of references. The third constituency you ought to keep in mind is that of present and future science historians. They need to configure the network of scientists active in a field. Inclusion of not only your friends but your enemies, is a must. You want your paper to have lasting value? Then, rather than omitting any but the most recent references, those published during the last couple of years, provide a decent time line.

At the risk of stating the obvious, the first requirement for a bibliography is total reliability. Check and recheck against the original publication in the journal, the spelling of the names, the volume and page numbers. You will be surprised by the number of errors which can and do occur in transcription.

If you have simply lifted your bibliography from another paper, such errors will also broadcast to the world the cardinal sin of a copy-and-paste job – this is plagiarism. It is actionable. If you do not have access to a library and thus are unable to read publications in your field, ask for the cooperation of a colleague elsewhere, operating under wealthier circumstances. He or she will be happy to give such help to a fellow-scientist.

A way to check whether you have provided a fine bibliography is to be prepared to give, at the drop of a hat, a summary of each cited paper.

REFERENCE: J.S. Dodd (ed) (1997) *The ACS style guide*. American Chemical Society, Washington DC.

It suggests availability. 

BODY LANGUAGE

We scientists may be polyglots, able to read and write, and even speak several languages. We have some mastery of the language of mathematical equations. We are fluent in the language of the scientific discipline we have specialized in. But there is one particular language at which, as a rule, we are poor. That is body language.

The stereotypes are aired on movies, on television and in cartoons. While they exaggerate, they carry some truth. The bespectacled scien-

tist is seen as an unattractive middle-age male who looks rigid, boring and uncompromising. He is visibly not at ease. His body lacks grace and charm. He cannot dance.

Counter those stereotypes. You love your science. Show it, express your enthusiasm bodily. Be dynamic whenever you are engaged in any form of science communication. Instead of standing stiffly behind a lectern or while pointing at an image on a screen, move about the room. Get close to the listeners, make eye contact with them individually. Meet people with an engaging smile. To smile is to grant a welcome. It suggests availability. It tells people without words that you are open and more than willing to share your knowledge and worldview.

The way you dress sends, not a single signal, a whole alphabet. This is too obvious to elaborate upon. Look at yourself in the mirror, ask a family member to help you in selecting your attire (attire as in »attraction, to be attractive«). The way you hold yourself, your involuntary gestures – a leg moving rhythmically, a tic with your hand, your furrowing your eyebrows, etc. – all assume significance and can be detrimental to your message.


You can improve in those sectors by regular physical exercise such as walking, swimming, tennis or gymnastics. An instructor or personal trainer in physical exercise surely would help. Likewise, consulting a physical therapist. Better yet, you could hire a coach who specializes in preparing public speakers. This person can also help you greatly by monitoring your voice, controlling its pitch and volume, and directing it at specific parts of your audience, making it carry drive and feeling. What your voice will express, your body will also start to follow. The voice can lead the rest of the body in expressiveness.

Starting with your hands. They are your most precious auxiliary. You can learn to make better use of them, in the following way. Stand in front of a mirror and read aloud, for instance a **paragraph** from a newspaper. Now repeat the performance and make sure to use your hands, in order to highlight points and create emphasis. Do this for a couple of minutes twice a day for a week. You should notice an improvement, your hands now accompany your speech. The second week, replace the newspaper with one of your own texts.

A final point: talking with your hands, more generally using body language will help you to act out the invisible. Your work involves characters and forces, perhaps at the microscopic level, perhaps in the astronomical range, in any case outside normal perception. It will help your listeners if you convey your mental image of such actors in your work with a little

gesturing. A little: remain somewhat restrained and discreet, and you will be all the more convincing.

REFERENCE: D.B. Givens (2005) *The nonverbal dictionary of gestures, signs & body language cues*. Center for Nonverbal Studies Press, Spokane WA.

Wrapping-up your story 

CONCLUSION

When a letter is written, it goes into an envelope. When the mail arrives, we can usually tell from the mere aspect of the envelope, whether it contains a bill to be paid or a letter from a dear friend. The conclusion to an article published in a scientific periodical has this same feature, it qualifies the paper as to its type, its merits and its lasting value. Keep it in mind when drafting a conclusion, do not treat it as perfunctory. Do not make it a study in conformity, nor a repeat of the **abstract** of your paper. Wrapping-up your story is a significant component of your publication.

A good conclusion should be eloquent and it should remain modest. Eloquent, because you want to leave your readers on an upbeat, so that they hold a good impression. And yet modest, do not regale yourself with what you have just accomplished: how pioneering, how outstanding an achievement! Blowing your own horn is a turn-off.

The optimal length of a conclusion is a couple of paragraphs, no more than a page overall, i.e., about 1,500 characters at most. And what are, or should be its ingredients? The Discussion part of the paper will have already critically examined the foundations of the work, the key assumptions made, the quality of the experiments, the statistical significance of the measurements, ..., so there is no need to reiterate this in the Conclusion. Towards the end of it, readers should find a one-sentence summary of the work, couched in a neutral, objective manner – remember to avoid one-upmanship, it stinks. Readers need such a sentence to reassure and perhaps convince themselves they have grasped the essence of what you had been telling them.

Bringing a scientific publication to its conclusion need not resemble the closing of a door, for two reasons: any scientific contribution is open-ended, moreover it is open to criticism and controversy too. You wish to

craft your conclusive sentences accordingly. Why not devote them, instead of burning incense to your own immortal glory, to a forward, prospective look?

Thus I recommend that your conclusion consist predominantly of statements about possible or probable extensions of the study which has just been reported upon. It will help you, in any case, to clarify in your mind what this future task consists of, whether you intend to do it or not. It will give your readers the sentiment that you are behaving responsibly, that you have an authorial attitude towards your work, worthy of respect. The clarity with which you will set your results in context, within the evolution of the discipline, more than within the narrower framework of your own evolving research, is a marker of a fine, thoughtful conclusion.

REFERENCE: M. Alley (1996) *The craft of scientific writing*. 3rd edn, Springer, New York.

favor nonprofit organizations ↘

ELECTRONIC PUBLISHING

*A*re we witnessing the demise of printed journals, with the transition to electronic publishing? Broadcasting science on the World Wide Web has many advantages. It is less costly, at least in principle. It spares considerable numbers of trees from being turned into paper pulp. Each page appears exactly as it was formatted, from use of software such as the Acrobat pdf. Bypassing printers accelerates publication. Moreover, closeness to e-mailing amounts to a return to the origins: in historical terms, science journals originated with private correspondences between natural philosophers, during the seventeenth century.

Those are all assets. But there are issues too, which need addressing. Free access has been a universal rule for the **Internet**. While consistent with the scientific ethic, which encourages the widest discussion and criticism, it runs somewhat counter to the need of the publishers, including professional societies. These want to make a profit, enough of it in any case to support electronic publishing. One can only hope that the Internet phenomenon will favor nonprofit organizations with respect to commercial publishers. This may well turn out to be a vain hope. Indeed, one should recognize a pivotal consideration. The editorial process bears

the major portion of the cost of publication – an invariant in going from traditional to electronic publishing.

One might argue indeed that the main issue of electronic publishing is editorial control. Academic publishing has thrived, over several centuries, by certifying a paper's validity in a number of ways, not only peer review but also prestige of the journal, and the whole scholarly process, from recording an observation in a laboratory notebook to having one's paper see the light of publication.

In the Age of the Internet, peer-review is made somewhat easier and faster by technology. It is essential that the quality control it ensures retains its excellence and be not debased. Scholarly values are inherently conservative, which may hinder at times the spread of revolutionary new ideas. Adherence to them may also stifle participation from developing countries to the advancement of knowledge. Editorial control is necessary at all stages of scientific communication, in order to ensure maximum discussion of the contents of each paper, while protecting its authors from *ad hominem* attacks and from gratuitous controversy, merely for the sake of being contentious.

The Web brings with it a facility, the electronic library. In the near future, each scientific paper will carry a bibliography of so many links, each of which will offer a virtual entry into a subset of the literature. I deem most promising this new dimension of publishing. With the appropriate technology, it ought to vastly decrease the amount of unnecessary duplication of effort and results.

The Web also carries with it a patchwork organization. It is segmented into discussion groups, centers of interest, ..., i.e., into a collection of highly specialized niches. This is worrisome. Science needs interdisciplinarity, it also needs for its sociology to include cores of people who are generalists, not specialists. Thus, I encourage you to publish in hyperspace in the less rather than in the more specialized journals. Otherwise, self-selecting of the readership into groups of narrow specialists may give the kiss of death to science. Even a cursory look at science history shows that real progress has always been both unpredictable and on the margins, rather than occurring in the mainstream.

I shall merely mention the issue of copyright, since fighting unauthorized copying and piracy conceivably will make effective use of technological tools. A more worrisome issue, I believe, is the archival: no worldwide agency is presently empowered and funded to preserve all the material which appears on the Net, electronic publications in particular. Yet,

scholarly work demands being preserved, and even the more so in the absence of current interest.

Moreover, rapid technological change ensures that supports for the data have an effective lifetime measured in just a few years. The example of floppy disks, Zip disks, CDs and DVDs, comes to mind. Fortunately, for the last 30 years or so, migration of digital documents from a machine, an operating system or an application program has been the preservation method of choice. It may well be so ingrained by now into our mental habits as to become a universal rule for archival safeguarding.

REFERENCE: G. P. Schneider, J. Evans and K. T. Pinard (2005) *The Internet illustrated introductory*. 4th edn, Course Technology, Boston MA.

harbinger of scientific collaborations ↘

E-MAILING

E-mail is easy, too easy. To e-mail indiscriminately, in mass, is to abuse the recipients, thus also drowning information in noise. The ability to dash off a note to a correspondent from anywhere, by typing on a keyboard, is a dream come true.

The greatest asset of e-mail is arguably its informality. In the office, e-mail has become the choice mode of communication among coworkers, using an intranet web. It has supplemented, to some extent has replaced conversations at the bench, in the instruments room, in the halls or next to the coffee machine.

To turn from local use to the global, e-mail allows one to reach out across the oceans, with no hindrance from the differing time zone – a superiority over phone or fax. This asset has been turned into habit, one wakes up in the morning to a detailed answer. It is such a nice and easy way to exchange information that it is a harbinger of scientific collaborations. I wrote a whole book in collaboration this way, trading chapters (or rather scenes in a play) by e-mail. The two of us did not need to get together at all. Nevertheless, we went through a baker's dozen of revisions.

Beware of the disadvantages of the informality. Those include the shapelessness of quite a few messages, the misspellings, the abuse of abbreviations and of cyberspeak. They blemish the appearance. The contents of a message suffer also from flippancy, if not from downright vulgarity.

E-mail can stoop to the level of a graffito scribbled on lavatory tiles. This need not be, but is too often the case.

E-mail suffers also, not so much in principle but in practice, from the lack of a permanent record. We exchange a large amount of correspondence and it vanishes into thin air. Usually, after a few weeks, months or years, instead of being archived, it is deleted from a personal computer. The loss is definitive. It is grievous, at least to librarians and to historians.

Which serves to emphasize that any message has to be significant, in order to rise from the noise, let alone endure. At the time of writing (autumn 2004), the signal-to-noise ratio for e-mail is of the order of one in ten. For one significant message, we receive on the average about ten pieces of garbage – known as spam in cyberspace. Avoid like the plague spamming your colleagues, or giving them impression of being deluged (by you!) with information they can do without. In that category: militant political propaganda, commercial advertising, newspaper clippings passed on, cartoons and jokes, ... This is my recommendation, resist proselytism, i.e., curb the impulse to widely circulate unsolicited files to people on an e-mail list, who belong to the circle of your professional acquaintances.

A positive recommendation now, as forceful as the warning just uttered. A good use of e-mail will hone your personal expression. Make it a genuine voice-mail: it is ideal for transmission of your own voice, with its idiosyncrasies, its mannerisms, its most endearing features. E-mail is or can be a written transcription of speech. In-between text and speech, it can become a close approximation to speech, this is up to you.

Truly, e-mail is speech: all the more reason to keep it articulate, direct and clean.

REFERENCE: J.v.Emden (2001) *Effective communication for science and technology*. Palgrave Macmillan, London.

a keen awareness 

ERUDITION

Some people may be surprised to find this word and notion discussed here. To them, erudition evokes old dusty volumes molding on library shelves, an arcane or disused knowledge absolutely antinomic to living, throbbing science. The two main reasons for their myopia are the