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"A SCIENTIST'S SURVIVAL KIT"

by Giovanni Carrada

2006

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Foreword

As much of the ongoing research is funded with public money, it is evident the need to inform the public about the main research results, so as to allow interested people to follow the ongoing developments and to form their own opinion on the basis of sound, science-based facts and data.

Fortunately, more and more events are organised on communicating science such as that held in Brussels on 14 and 15 November 2005. The European Commission publishes and freely distributes a number of brochures, movies, leaflets and other materials on European research for different age ranges. Science journalists are increasingly reporting about research and schools and science museums are multiplying their initiatives.

Probably, scientists and researchers can also still improve their skills and practice in interfacing with the media, elaborating and presenting information in a way that non initiated persons can easily and rapidly understand.

With the intention of providing a service to those scientists and researchers, we are glad to publish and freely distribute the English edition of this Survival Kit written by the journalist Giovanni Carrada, whose original publication has been supported by Italy's National Permanent Conference of Deans from the Faculties of Science and Technology. We are thankful to professor Enrico Predazzi, President of the Conference for his kind permission to distribute this Survival Kit to a broad and international audience.

INDEX

TO WORK!

SUGGESTED READING PREFACE

The publication of this science communication primer was strongly encouraged and promoted by the Permanent National Conference of Deans from the Faculties of Science and Technologies.

The Conference is worried about the cultural, social and economic underdevelopment which awaits a Country in which there exists an increasingly negative perception of science and basic research is contracting dangerously.

Fortunately, the alarm sent out by the Conference seems to have reached all or nearly all the country's science policy-makers, and opportune measures are being studied, where they do not yet exist.

One of the aspects neglected by these measures, however, is an adequate maximization of the scientist's work. If citizens do not know or appreciate what is being done in research institutes and laboratories, it is unlikely that science will find the support and talents it needs to continue to develop.

Unfortunately, even we scientists often underestimate this activity and tend to see it, in fact, as a marginal detail.

We have learned how to work in research and in the laboratory, but not how to work in the world of the media. Indeed, our internal communication practices differ greatly from science coverage for general audiences. But today we can no longer ignore what the public knows, or thinks it knows outside our institutes or laboratories.

For this reason, it is important that increasingly more scientists accept the author's invitation to "learn another job as well", or at least to have an idea of what it entails. Not everyone, naturally, will discover a particular talent for speaking directly to the public, but it will be useful to everyone, in any case, to learn to work better with the media. This is the objective of Giovanni Carrada's book. The pages which follow describe how the world of communications today works from the inside, including many tricks of the trade, while keeping in mind the scientist's point of view, interests, difficulties and values. This book is not a collection of pre-packaged advice, rather, it introduces the reader to the complex and sophisticated processes of science and technology communication, so that the reader will be able to apply them.

For this reason, before examining the more practical aspects, the book opens with a reflection on how and why the relationship between science and society is changing. It then proceeds with the underlying concepts of public communication, and finally it discusses everything that needs to be done before getting down to work, in the planning stage.

Most likely, the reader will find more surprises in this part of the book, since these first three chapters provide the information which will help him to begin thinking like a communicator.

The second part, on the other hand,

is dedicated to science communication practices, for scientists who want to take this job on personally as well as for those who work with journalists or other communication professionals. It is a true mineload of useful information and suggestions for scientists that want or have to make themselves heard in the noisy world of today. In other words, this manual is for the scientist who wants to survive in the sea of the media which very often too easily distorts, or even portrays the exact opposite of, what research has sweated to achieve.

Perhaps, the strong point of this work, however, is represented by its clarity of intent and expression. The no frills language is clear and precise while the examples are pertinent; its reasoning is well supported and the tone even-tempered and thoughtful. It is organized in conceptually solid paragraphs which are logically connected, allowing the reader to capture the key concepts of communicating science in the first, rapid reading. The quotations cited at the beginning of each chapter are extremely appropriate, and are not simply decoration. On the contrary they summarise the main points which follow and draw the reader in.

Every section of the book is arranged so that the reader will not waste precious time, as the author knows how much time is worth. For this reason, the bibliography also offers essential specifically-targeted, easily accessible studies.

The book is so easy to read and fluent that as the title itself reveals it can be taken as a survival kit; yet, in reality, the covert soul of a potential scientist and science communicator is felt. The sincere enthusiasm in this book is clearly rooted in professional experience which fully recognises the importance of science-citizen interaction.

This work, far from being exclusively designed for the scientific world, should be, I believe, used as a basic text for every course of study in Communication Sciences. If communication is not a gift, or at least not completely, and can therefore be learned, this survival kit seems to be a good starting point.

Enrico Predazzi

President of the National Permanent Conference of Deans of the Faculties of Science and Technologies

Dean of the Facoltà di Scienze MFN dell'Università di Torino

To Paola and little Giulio and Pietro

INTRODUCTION

A NEW JOB TO LEARN

A man who wants the truth becomes a scientist.
A man that wants to let his subjectivity free may become a writer.
But what should a man do who wants something in-between?

Robert Musil

In 1992, the astronomer Carl Sagan, protagonist of countless public appearances, as well as the author of twenty books translated worldwide, an enormously successful television series and a Hollywood film, was denied membership to the National Academy of Sciences. In fact he was not able to raise the required two-thirds vote from its members. Director of the Laboratory of Planetary Studies at Cornell University, Sagan had distinguished himself for the calculation of the greenhouse effect on Venus, for his studies on the surface of Mars and on the oceans of Titan, Saturn's large moon. Too many colleagues turned up their noses at his tireless activity in spreading scientific news, which had made him, perhaps the most famous scientist in the United States, and one of the most vibrant defenders of science in the world.
Two years later the National Academy of Sciences reconsidered its vote, honouring him with the Public Welfare Medal. Sagan had brilliantly challenged two important prejudices which besiege scientists that choose to communicate with the general public: the idea that scientists who do are distracted from their "real" work – research – and the idea that scientists are not able to express themselves clearly, as if their mental universe were so far from the common man that at the very least they need a "translator".

Openings and closings

There have always been scientists dedicated to disseminating their own work, the first being Galileo, who the Church never forgave for his choice to write in vulgate rather than in the more obscure Latin. Over the years, however, their willingness to do so has changed. The Nineteenth century was one of the most propitious, especially in England. Beginning in 1826, and for over twenty years, Michael Faraday described the latest developments in science every Friday evening, during extremely crowded lectures held at the Royal Institution.
Yet, in the first few decades of the Twentieth century scientists' enthusiasm for popularising science was already greatly declining. In 1938 Lancelot Hogben, afraid of jeopardizing his upcoming nomination as a Fellow of the Royal Society, asked his colleague, Hyman Levy to pretend to be the author of his book Mathematics for the Million, a popular work which became an international bestseller. Only in the 1980s was there a large scale resurgence of public engagement with the world of research. This was no coincidence, as we will see in the next chapter.

Today, however, most of the best popular books on science are not created by "translators", but by

scientists. Just think of Richard Dawkins, Antonio Damasio, Stephen Hawking, Edward O. Wilson, Jared Diamond or Luigi Luca Cavalli Sforza.

Even outside of the star system, increasingly more scientists are deciding to try out this new job. In fact, everyone, to different degrees and with different roles, may be asked to discuss or comment on his or her own research or research in their field. The reasons are varied many: s(he)may need to respond to a journalist's request, intervene on a debated issue, assist with an exhibit or a television show, present a degree, speak with lobbies or spokespeople for interest groups, present their own activities to industry, local institutions or other possible financers, or simply collaborate effectively with the press office of their own institution.

A new climate

Not many years after Carl Sagan's rejection, the situation changed. Today, in fact, scientific institutions themselves, like the English Royal Society and the French Académie des Science, the Australian Commonwealth Scientific and Industrial Research Organisation as well the American Association for the Advancement of Science, are all inviting their members to discuss their own work. It is no longer branded as a waste of time, but rather, in some cases public engagement is now indicated as an "obligation". Some of these institutions, such as the American National Science Foundation and the British Research Council have produced guidelines on communication, and many have created press offices or have hired a communication officer, promoting initiatives of every type including educational websites, documentaries, science shows and volunteer service in research. Some, such as the American Society for Neuroscience, have even formed a staff of professionals dedicated to assisting scientists in communications with the general public.

More and more frequently, some basic training in communication is considered necessary for those who work or are about to undertake a career in research. In Great Britain, for example, most of the Research Councils offer their Ph.D. students a few days of training in communications and the media, while proper courses are offered by universities, such as The University College in London. In the United States the American Association for the Advancement of Science and the Scientists' Institute for Public Information are the organizations which usually see to this.
Why is there such renewed enthusiasm?

WHY ENGAGE IN SCIENCE COMMUNICATIONS?

Today communicating is considered a strategic function by the majority of organizations which interact in our social system. It identifies them, justifies them, allows them to gain consensus and to work to achieve the objectives that all systems have: to survive, to protect themselves, to obtain resources, and to grow.
Annamaria Testa

First and foremost: Satisfaction

The vast majority of scientists will agree that, spoken or unspoken, it is absolutely natural to desire the dissemination of research, be it one's own or from one's field of study. It is rewarding to go outside the confines (human too) of one's specialization and share one's own passions with others: managing to do so can be a source of great personal satisfaction. Whatever the reason for deciding to communicate, if you are not able to transmit your own passion it will be very difficult to obtain good results. Konrad Lorenz was so popular because of his extraordinary ability to get his readers involved in the adventure of ethology, and the same is true for all the great scientist-communicators.
In addition to spreading knowledge, telling science stories helps convey the value of a scientific way of thinking and a rational attitude to problems, even to those which have nothing to do with science. Historically, one of science's most important cultural contributions was its example as "good training for democracy". In fact, it was also through science that the West learned to defend its own reasons with rationality and an assessment of reality, distrust towards established moral and cultural authorities, tolerance for others' ideas and the belief that everyone can contribute to the progress of knowledge.

Communicating with other scientists

Paradoxically, public communication can also help inform other scientists of your own activities, overcoming the barriers which separate different disciplinary fields. Progress in science and technology are, in fact, so rapid and numerous that in general scientists are only able to keep themselves updated in a highly specialized niche area of knowledge. All scientists, in other words, are part of the general public when something that lies outside of their field is discussed.
In the United States, competition for coverage in an important newspaper, like The New York Times, has been very strong, since it was discovered that it helps to become better known even amongst colleagues.
Some preliminary data cited in Nature even indicate how scientific works that were covered by newspapers were later cited more frequently in specialized publications.
Furthermore, new fields were announced and in some way even defined with respect to the others, in books for non peer audiences, as occurred in the mid Nineties with the studies on consciousness and earlier with cosmology.
Acquiring familiarity with the techniques of public communication of science may, finally, be useful in teaching. In fact, there is no reason to make a subject more difficult than necessary.
Even if (contrary to what happens in public communications) students have freely chosen to study a subject and have a precise reason for studying it, the ability to interest them and keep their attention alive, while helping them to save cognitive energy, can become precious in any type of lesson or presentation.

Often, however, the communication of science has other purposes, which are, perhaps, less noble but not less important.
More than an end, in these cases, the dissemination of scientific culture becomes a means. Being able to effectively express yourself, means being able to effectively persuade others and send out messages with clear objectives in sight.

But above all it is important for science

If many scientists end up enthusiastic about disseminating science, it is also because they have had to make a virtue of necessity. The great paradox of science today is, in fact, that while it is a hegemonic culture – few others are able to change our way of living, pro-

ducing, working and thinking so profoundly and quickly – science literacy remains low.
With rare exceptions, such as South Korea and Finland, international surveys show almost unanimously that citizens lack scientific knowledge, even in the most developed countries. This shortcoming is even more serious given the continual growth of knowledge and its practical applications. At the Lisbon Conference in 2000 the European government leaders pledged to make the Union "the most competitive knowledge-based society and economy" by 2010. As a result, the poor understanding of science by young people has become subject of public debate in Europe. Disregarded in the past, the results of international enquiries on the level of student preparation, such as PISA (Programme fro International Student Assessment by the OECD), are now published by important daily newspapers. In addition, occasions for friction between science and society continue to multiply due to the influence of new technologies, the choices new advances force us to make or the impact new knowledge has on the beliefs and values at the base of our identities, culture and ways of thinking.

The new necessity to communicate with the general public actually shows how successful science is: the more you know and know how to do, the more opportunities there are to encounter (sometime even to clash with) different social stakeholders or different points of view.

Thus, if until recently communicating with society was an optional, today it has become a necessity. And no one, in the scientific world, can afford to ignore this. In fact, you cannot expect someone else, for example an "enlightened" politician, to defend the interests of science. In the last few years the relationships between science and society have begun to change radically. In this regard some have spoken of a transition from "academic" science to "post-academic" science.
The important decisions which involve scientists' work are no longer made by the scientific community alone or by some office in a state department. More and more often they are the result of a complex negotiation with a number of social groups: national and local politicians, private companies and their associations, lobbies or special interest groups, "moral authorities" and the media. Often such decisions are also presented to the general public, whose opinions are later reflected in the way the media and politicians behave.
If one simply considers research on cancer or AIDS, human space missions, biotechnology or genetic screening, the growing weight (for better or worse) which extra-scientific opinions have on the decisions related to research priorities becomes obvious. Because scientific research is ever more often the true cultural, social and economic driver, the quality of science communication has become essential to democracy and progress. On the one hand then, it is necessary to avoid a technocratic drift, which would mean shielding the true decisions from public scrutiny behind a media smokescreen. This operation, in truth, would most likely boomerang in the short run, as past experience has taught. On the other hand, it is necessary to avoid the opposite, populist drift, in which an expert opinion is much less important than the political game and the inevitable irrationality of the mass media. Not just this. It is also important to prevent the birth of a subclass, scientifically speaking, made up of people who know nothing at all about the progress of the techno-sciences, and cannot understand how the modern world works, and are therefore unable to participate in the life of a technological society.

The general objective of an effective policy for science communication is to (re-)construct a climate of reciprocal knowledge and trust between science and society, establishing an authentically open and not just "cosmetic" dialogue with the public.

Visibility, consensus, trust

The first objective, from this point of view, is to obtain visibility. In fact, it is difficult to make yourself heard if you are not "visible"; or rather, if you are not recognised as someone important and entitled to speak by the general public or specific stakeholders. Naturally, visibility must be positive; namely, it must be associated with social consensus regarding its very existence and activity, which can play on an entire range of motivations, from the usefulness of one's own research to national pride. More than ever, obtaining or protecting your financing is tied to this consensus. Social support is, in fact, a prerequisite for political support. Just think, for example, of the role public mobilisation played in determining the financial contributions for the research and treatment of two important illnesses with very different incidence like AIDS and breast cancer, or for cancer research and research on cardiovascular diseases, which in actual fact represent the number one cause of death in western countries. And there are other examples as well.

Social consensus is not automatically created, based on how good the cause is objectively, but it needs to be actively pursued with effective communication.

It was no coincidence that a few years of an intense communication campaign was necessary to "sell" the Human Genome Project. Initially the campaign involved periodicals for the scientific community and then gradually included popular magazines which baptised the human genome "the book of life".
When, in the first half of the Nineties, the Finnish government gave the ok to a decade-long 13.5% annual increase in spending for research, the decision was made possible by the construction of a widespread and profound social consensus in the country. The ultimate example is Telethon's financial contribution to research for rare genetic diseases. Telethon is a series of national charities professionally managed, that collect donations for dozens of millions of euro with single annual televised events.
Without social consensus, not even lobbying is enough: as the GMO experience has shown, politics must follow the electorates orientation, no matter how unreasonable it may be. Consensus, not necessarily of an entire social body, becomes, in fact, even more important when the objective is difficult to reach. When the decision is controversial, and it may be so for various reasons, the final decision is always political. And political decisions are not always rational. In some issues, which can be defined "ideological", the freedom of research itself may be in question. But they are not necessarily lost causes. A referendum campaign which intended to prohibit any type of research in biotechnology was defeated in Switzerland in 1998, because scientists made an all out effort to inform the general public, and learned to use the same instruments of public communication as their adversaries.
Finally, there are times when it is essential to make a scientifically based voice heard loud and clear, such as when irrationality risks exploding, in situations like the SARS epidemic, an earthquake or the umpteenth new "cure" for cancer. The fundamental objective is, however, to establish with society, or key members of it, a deeper and more solid relationship based on trust. Only on this basis, tested over time, will the inevitable gap be bridged; even if to some degree there will always be a difference between those who hold very complex knowledge and all the rest.

THE ADVANTAGE OF BEING A SCIENTIST

Nothing shocks me. I am a scientist.
Indiana Jones

The combined pressures to publish and find resources for research do not make the life of a scientist easy. Even without the added task of learning a new job.
Many may not feel particularly talented as communicators. And perhaps they are not. Basically, they have chosen a completely different career. Many others may not like this job, perhaps because they feel as if they have to "dirty their hands" in some way. Others may not like the idea of adding their personal contribution to the general information overload.
Communicating with the general public is, in fact, not without risks, as we will see further on when we examine some of its ethical aspects. There is an actual risk that even in important choices the better communicator's position will prevail, and notthe one held by the scientist with better arguments. Moreover, a scientist may be appreciated more if (s)he is telegenic rather than for the impact factor of their publications.
The need for public communication, however, remains.

The mechanisms which have created the escalation of volume and communicative hyperboles in every sector of society now apply to science as well. And the price for not communicating, or communicating poorly, is becoming higher every day. Today those who are not (well) represented in the public arena risk losing their say, resources, trust and at times even freedom.
There is nothing exceptional in all of this. All great social actors have had to take this same road, and science is beginning to take it up at least a generation late, compared to, for example, the private sector. And this is a road that you cannot turn back on. Why not, then, delegate public communication to professionals? As in all organizations, in science, communication is inevitably being handled more and more often by professionals, and it should be that way. However, the active involvement of scientists remains indispensable, because they are always the first link in the chain of communication.
Every choice made at the beginning of the chain will influence everything that happens subsequently, for better or worse. Professionals, such as the press officer, must, in any case, be informed and guided.
Moreover, because of the very specific nature of science compared to other sectors, it is often difficult for a non expert to have as good a command of the subject as the scientist doing the work, or to see all its implications, even in the long term.
The scientist, in other words, is the person best equipped to correctly posit the communication, and at times to do it themselves. Most international reports have, in fact, underlined that the general public views being a scientist as an asset, compared to the journalist. Their credibility is higher simply because (s)he is are the one who creates the knowledge and does not simply pass it on second hand.

If it is true that the consequences of science and technology are too important to leave in the hands of scientists alone, it is also true that the relationship between science and society is too important to simply leave in the hands of non scientists.

At times, to speak with a foreigner it is better to learn their language rather than to use an interpreter, and then perhaps complain if you do not understand each other.

WHAT IS IN THIS BOOK

The best effect of any book is
that it excites the reader to self-activity.
Thomas Carlyle

The purpose of this book is to help those who work in the world of research to communicate the contents and importance of their own work or the work in their field. In fact, it provides the essentials for public communication in science and technology for scientists who wish to take this task on in person as well as for those who choose to use the media or professionals. In this last case a scientist risks limiting his role to checking the correctness of the content and wasting precious opportunities, or worse dictating wrong choices.

The idea is to take a look at what lays behind the work of professional communicators, like journalists, who understand how to address the public at large, and learn to use their skills to the benefit of science.

This volume is a collection and summary of reflections and experiences from the last few years, not only in the field of public communication of science and technology, but also in the social sciences and the wider world of professional communications; in addition, naturally, to the author's own experiences.

But, can you learn to communicate? The good news is that the rules to communicate effectively are few and simple. The bad news is that it is not easy or natural to apply them. To some degree, in fact, communicating is a repeatedly new process, and the most suitable application of the rules needs to be identified case by case, using your creativity, which is, as we all know, is a curious mix of rationality and subjectivity. A book, moreover, may not be the best means to transmit practical knowledge: it is better to demonstrate something and then have it done, just as we do in the laboratory.

The following pages, however, do offer an good way to begin, or to reorder and enrich what has already been learned from past errors or intuition.

This book is arranged "from general theories to small tricks of the trade", in the sense that it begins with a more general and theoretical framework and, little by little, moves on to more practical and functional information. A simple manual of practical advice, similar to the ones already available internationally, would not be enough, in fact, to get an idea of how complex and sophisticated the processes of communication are, especially if the subject is science or technology.

Let us take a look, then, at the book.

Chapter 1 helps understand how and why the relationships between science and society are changing and how long-standing difficulties have been addressed. In particular the crisis of the main approach used until recently, the so called Public Understanding of Science, is examined. Is it really true that everything would be resolved if citizens simply had access to more scientific knowledge? This subject is then developed using the results of reports and surveys, in addition to the most important analyses of how knowledge and opinions on science are shaped, and ends with the new models of communication between the world of research and society.

Chapter 2 discusses the basic principles and concepts of communicating science to the general public, which are (almost) the opposite of those used for peer audiences. It begins with the need to compete for attention in a world in which everyone is forced to raise their voice louder and louder: excellent reasoning is not enough and an emotionally flat communication does not "make the grade". Nor is it enough to "translate" into a simpler language, which presumes, in any case, that the reasons (obvious and less obvious) why the public finds science difficult are clear. It is necessary to create stories which contain and possibly embody the facts and arguments that must be presented to the public.

Planning is the subject of Chapter 3. Public communication cannot be improvised, and the most serious errors, in fact, are those made at the beginning. Planning means thinking carefully about a number of elements: objectives, audience, the subject's limitations and opportuni-

ties and messages to transmit. And if the task is an uphill battle and involves more than one contribution, it is necessary to devise an informational campaign.
Chapter 4 deals with communicating in person, as the author, and thus above all how to transform what you want to explain in something the public is willing to listen to. Three elements are examined in detail: what a good science story is and how to find and construct it; how to be convincing, applying the classic techniques to science and technology as well as a few specific solutions. Finally the ideas and the tools to explain, or rather to make a difficult topic easy are discussed. In addition, attention is given to the quality of writing, a basic skill necessary for every type of medium, as well as to the opportunities and dangers of pictures.
Chapter 5 deals with communicating through journalists, or rather how to use the media to reach the target audience. Success means recognising and overcoming the differences between your professional background and the journalists' experience, but also distinguishing between the various types of journalists. A special topic discussed is how to access the media as well as how to answer their requests. The chapter closes with how to learn to work with journalists and the importance of establishing good personal relationships with them.
Chapter 6 is dedicated to the choice of the most suitable media for one's own objectives and possibilities. The main media are examined in relation to science: their characteristics, diffusion, audience, suitable topics, key advice and how to access them.

Given the wide range of topics dealt with, but also considering the value of the reader's time, this book is inevitably a synthesis which, to make the reading easier, has avoided notes and quotations. For this reason a practical bibliography has been added to facilitate a more detailed study of the subjects dealt with in each chapter: documents which can be downloaded from Internet, which are fortunately numerous in this sector, have been given more attention than books and articles.

THANKS

Having worked with Piero Angela for over ten years has taught me almost everything I know about science and technology communication. In addition to many "tricks of the trade", Piero Angela has shown me that science can be explained clearly while respecting both science and the public.
Precious advice and suggestions were offered by my friends, Romeo Bassoli, Massimiano Bucchi, Rossella Castelnuovo, Emmanuele A. Jannini and Elisa Manacorda.
Finally, a special thanks to Prof. Enrico Predazzi, president of the National Conference of Deans from the Faculties of Sciences, who from the very start believed in the idea of a "survival kit" to help our scientists explain science and make its reasons heard.

LEAVING THE IVORY TOWER

Science and society: just like a marriage

Today's scientists are no longer constrained simply by the laws of nature, as was generally the case in the past, but also by the laws (and attitudes) of the land.
Norman Augustine

Once upon a time there was an era in which, when science spoke, citizens took off their hats and listened to the Word, in silence. It was the era of The World of Tomorrow, the 1939 New York fair, the era when the Atomium in Bruxelles was built in 1958, the era when man landed on the moon in 1969. In those days people believed what the doctor, physicist or agronomist said.

That period, a long honeymoon with science, is over.
At the end of the Sixties, the term "scientific" began to take on negative connotations, evoking more doubts than certainties. In the collective imagination the promise to continue to improve life for all began to lose ground to negative icons called "DDT", "Chernobyl" or "Talidomide".

In 2000, the Science Museum of London conducted an in-depth market survey for a promotional campaign. One of the most important findings revealed that its name needed changing: the most negative element indicated by the focus group, and that the authors of the survey agreed had to be removed, was the word science itself. At least science is not alone.
As with every important group, from the government to the Catholic Church, science and technology too had to abandon the safe port of a sacred social role, to face the open sea of distrust, controversy and public assessment or, to use a more fashionable word, accountability. It became necessary to account for their choices, not only to the general public, but also to the same institutions which had previously supported them unconditionally (probably because of the long-lasting upshot of their victorious role in the Second World War first, and later the Cold War).

The new climate has resulted in very different consequences. For example, English high energy physicists lost out, when a few years ago they received the following request from Her Majesty's Minister of Scientific Research: "In thirty lines explain why British taxpayers should invest a substantial part of their resources in Higgs' Boson research". What those physicists wrote is not known, but they did not convince the minister. Proposition 71 had more luck, winning the referendum held in California on 2 November 2004 to resume research on embryonic stem cells and grant financing for three billion dollars (financing is uncountable) in that state alone. Thanks to the people's voice, California will likely become the most advanced centre in the world for this type of research too.

Even if every metaphor has its limits, the best way to understand the relationship between science and society is perhaps to compare it to a marriage.

Just like a married couple, science and society look for and need each other, and are joined by an unwritten, but no less binding contract. Society needs science as its driver for social, economic and political success, while science lives off the resources, talents and freedom that the society makes available.

In the good old days (even if they were not as good as memory would have them) the partnership between science and society resembled old fashioned marriages. We were all poorer, but at least the husband (alias science) was "the head of the house", or at least he could exercise a certain amount of authority. Then, when his authority was questioned, the marriage itself underwent a crisis. The most important The couple's complaints represent its most important symptom.

If we listen to science, it tells us that society does not understand it, that it is not interested in scientific results and does not understand how science works. It does not pay attention to those questions science knows the most about and exaggerates its (few) errors, while taking for granted its (immense) benefits.

Society does not take it into consideration often enough and cuts off its life supplies; in short, society shows little or no gratitude.
If, on the other hand we listen to society, it tells us that science causes problems that it does not know how to solve. It caters to governments, the military or multinationals, not to the interests of the common person whose taxes pay for research. It does not want to explain what it does to anyone, even if it seems clear that it is pursuing the most futile curiosities. It is a world in the shadows, out of control. It does not explain itself (perhaps even intentionally).

As in a true marriage, the first step to solve a crisis is to understand the other's reasons, whether they are right or wrong, because dialogue begins with these. Understanding the other's point of view and explaining your own means knowing how to communicate. Until today, however, a different approach has been used.

The rise and fall of the Public Understanding of Science

Our most urgent and direct message must be
to the scientists themselves:
learn to communicate with the public, be willing to do so
and consider it your duty to do so.
The Royal Society Report on
the Public Understanding of Science, 1985

To simplify (but not too much), the scientific community's reaction to this crisis gave birth to the idea that it was society that had to understand science and that everything would be fine if only citizens had greater scientific knowledge.
The idea behind the vast majority of communication activities was the so called Public Understanding of Science. This expression became a label for every type of initiative (books, articles, exhibitions, museums, events) launched by the scientific community for the general public, and an explicit objective for programmes, committees, foundations, agencies, scientific associations and institutions in every developed country.
The Public Understanding of Science has been a kind of "standard model" of the interpretation of relationships between science, technology and society. According to its basic premise, known in the specialist literature as the "deficit model", the root of public controversies on science or technology is the fact that citizens lack an understanding of scientific knowledge, theories and methods. Thus, if these were translated from specialist terminology into more popular language, the controversies would automatically resolve themselves. In this model, science and society are

considered “two social bodies separated by a sort of semi-permeable membrane which allows the flow of information (dissemination) and actions (technological innovation) from science into society, but it does not permit flows in the opposite direction”.

As far as communication is concerned, the public is considered a basically homogeneous and passive audience for the “pure” knowledge produced by scientists, who are the source of the flow of information, and to some degree the censor as well. The choice of what knowledge ought to be given is therefore based on the presumed cultural and cognitive gaps in the public, rather than on their questions, interests and skills.

The Public Understanding of Science model recognises, of course, one important part of the problem. With rare exceptions, a vast number of surveys in almost all developed countries have actually found low levels of scientific literacy in the population.

But is this really the most important statistic? If citizens knew more about molecular biology, would they really be less diffident about genetically modified foods?

At the end of the Nineties, this rather simplistic approach to relationships between science and society, and therefore, to the communication of science, began to show clear signs of its shortcomings. The strongest signals were felt in Great Britain, the very country that in 1985 launched the “movement” with the famous Bodmer Report and that had invested more than others, even through a special financial organization, the CoPUS (Committee for the Public Understanding of Science). In 2000 the important report “Science and Society” prepared by the Chamber of Lords, with the help of important fact-finding surveys, recognised that despite the efforts made the British population not only continued to be scientifically illiterate, but the much hoped for appreciation had changed into an aversion to research. And if Great Britain is crying, the other nations are not laughing.

Unfortunately (or luckily) things are much more complicated.

In truth, it would be enough to consider the nature itself of communication processes to understand that a one way relationship could not work. This does not mean downplaying the value of specialized knowledge, but simply that it is necessary to be realistic. Choices and opinions, no matter how right, cannot be imposed in a democratic society: no one would accept them and the attempt to do it would almost surely backfire.

A consensus must be created about the choices to be made, just as in a marriage. But there are also more specific reasons. First of all, what does it mean to understand or know science? Does it mean knowing many scientific facts? Many theories? Scientific methods? Or how science functions as an institution? And in each field, what is the acceptable level of knowledge, and for which types of audiences? No one has managed to give a convincing answer to these questions yet.

Moreover, the idea of transforming citizens into little molecular biologists or little statisticians is much more difficult than can be imagined. For at least three reasons.

The first is that they would need to know too much. To get a real idea of the possible risks of electromagnetic fields, for example, it would be necessary to be familiar with the nature of electromagnetic radiation, its interactions with living cells, and the epidemiological research on them. Yet how many areas of expertise should our poor citizens have to master?

The second is the so called paradox of specialization: as the quantity of knowledge produced increases, or is at the least revised (two things which are happening at a terrifying speed), the possibility for a single individual to master it is reduced.

In society the basis of shared knowledge can only diminish: if, on the whole knowledge is growing, then contemporarily the individual experience of ignorance can also grow.

The third reason is the lack of sufficient motivation. How many people are willing to invest the time and effort necessary to get a good scientific education? What incentives would they need? To get an idea, just think what it would be like to ask a scientist “to become literate” in another subject of great social relevance, such as law.

Would (s)he be really willing to delve into the technicalities of criminal procedure or administrative justice that are essential for a really informed opinion? Outside of our professional niche, we are all “public”.

In some cases, then, the most frequently discussed science is the one with fewer certainties. Just think, for example, of climate change. If the scientific community itself has not yet reached a consensus on the subject, what sense does the Public Understanding of Science make?

The idea of changing citizens into little scientists could also turn out to be useless. If we look at survey results, it is clear that there is not a clear correlation between the level of scientific literacy and attitudes and opinions on science. In the United States, for example, there is a generally more positive attitude than in Europe, despite the lower level of scientific literacy. Generally speaking, more informed people tend to have stronger opinions for or against a particular innovation: this is the result, for example, of two important enquiries conducted in Great Britain and Italy on transgenic foods.

It is difficult to make forecasts. Attitudes and opinions are in fact the product of complex processes that depend on individual mental models, which in addition to factual elements include emotions, ethical considerations, prior knowledge and value judgements. These are all things which cannot be modified with a simple addition of a little more information. To begin with then, an effective communication requires a Scientific Understanding of the Public.

Communicating Science is, then, something a bit more sophisticated, in which psychological, and especially emotional concerns play an important part. Could this be where the problem lies? Has the flame of love gone out in this marriage, at least in the heart of society?

Do people care about science and scientists?

The end of our foundation is the knowledge of causes, and secret motions of things; and the enlarging of the bounds of human Empire, to the effecting of all things possible.
Francis Bacon

There is something profoundly disturbing, something desired but also feared, something that has always been implicit in Bacon's project but that, the closer it comes to being achieved, the less attractive it is.
Jon Turney

The idea of not being loved in the outside world is fairly widespread in the scientific community. And just like in real marriages, it is usually taken out on a third party, that in this case is not another person, and not even a mother-in-law, but typically journalists, envied for their unjustly earned power over the public's mind, and thus, community-made-decisions.

Scientists are actually top on the list in the results of surveys on social consensus and the credibility of the various professional categories, such as the Eurobarometer reports and the Science Indicators from the National Science Foundation.

According to the 2001 Eurobarometer report on science and technology, the three most highly esteemed professions in Europe are medical doctors, scientists and engineers, while journalists, entrepreneurs and politicians are at the bottom of the list. The balance between the benefits and the negative consequences of science and technology is also considered positive.

Some problems, however, do exist. Indeed, the same report reveals that 42.8% of Europeans agree with the statement "scientists are responsible for the bad use of their discoveries by others" while 80.3% agrees with the idea that "the authorities should formally oblige scientists to observe ethical norms".

Feelings toward science reveal a fundamental ambivalence between fascination and fear. And where there is ambivalence, not much is needed for a positive perception to become negative.

This ambivalence is a more general problem of modern society, an era of continual changes, which present promises as well as threats. As the cultural historian Marshal Bearman wrote, "Modernity is refreshing and exhausting, full of energy and terrifying. Above all it is open. To be modern means living in an environment which promises adventure, power, joy as well as the growth and transformation of ourselves and the world. At the same time, it threatens to destroy everything that we have, everything that we know."

Ambivalence is more explicit for technology, in which we recognise the possible benefits, but also the ability to knock down age old limits and dissolve acquired categories. Care must be given, then, to restrain the temptation to magnify the "power" of science: moderation, in addition to being usually more correct, is, in any case, more advisable than technocratic optimism which is still, in part, in fashion.

Other psychological mechanisms are also at work. They are as simple as they are powerful. One of these is the tendency to become more alarmed than necessary when faced with something new, rather than risk not seeing potential danger. According to a study conducted in Germany, people are four times as more likely to react negatively than positively to a new scientific development. This type of "instinctive rationality" is responsible for the greater attention given to negative information, and may explain our propensity to take the benefits of science for granted and exaggerate its errors or the fears it stirs.

Another psychological mechanism is an instinctive distrust towards those who hold knowledge that we do not have; it tends to always create a barrier between the expert (and more generally, those who have received a scientific education) and the others.

From this point of view, the fact that the new "objects" of science, from DNA to nanotechnologies, are invisible and outside the reach of common knowledge and common sense does not help. Consequently they are more mysterious and may arouse distrust or even simple disinterest.

It is also for this reason that science museums now have a limited impact and are visited almost exclusively by children. If it was once easy to understand how a steam engine works, perhaps with the help of a cutaway or a mechanical model, today we can open a cell phone and observe it for hours without even

beginning to understand how it works. It is not surprising, then, that the highly polluting coal had better press than high frequency electromagnetic waves receive today. The media magnify all these worries.
The ambivalent feelings towards science and technology oscillate, then, between fascination and fear, but the crossover point in this emotional couple is different depending on the cultural milieu. Today, science probably stirs more fascination in Asia and the United States than in Europe, and much more than in the Arab states.
To return to our metaphor, the relationships between science and society now resemble a modern marriage, in which there are more arguments (and more separations) because the partners are equal. For this reason, The Public Understanding of Science has begun to be an "unadvisable" expression and it is now preferable to talk about engagement, bi-directionality, involving communication, debate, but above all dialogue.
If science and society want to get along they must learn to communicate more and better. No one says that it is easy, but it is the price to pay in a mature democratic society. Some examples, like Finland, California and some Asian nations, let us hope that the price can be transformed into opportunity. For both partners, of course.

Dialogue with society

Before talking, you must listen.
To make yourself understood,
you must first understand.
Annamaria Testa

Today society no longer signs blank checks for anyone, not even for science. Exactly like a married person, citizens expect to be consulted (and informed) before a decision is made. In fact it should always be made together. This is true for any decision; whether to have a mammogram done, to build an incinerator or even a dump for nuclear waste.
As events such as the controversial project for the Italian national disposal site for radioactive waste at Scanzano have taught us, you cannot simply decide, announce and then defend your decision, because this will eventually mean abandoning the project. What is needed today are clear programmes for public consultation, during which the problem is not explained just from a technical point of view. Citizens, on the contrary, need to be heard and then given answers which take into consideration their requests, uncertainties and the values at stake. It is even possible that a different technical solution may be found. Just consider what happened before the approval of the law which regulates the experimentation on embryonic cells in Great Britain: parliamentary debate began only after two years of informing and consulting all the main social players involved.
This new way of making decisions about technology is really only one sign of the wider crisis of the old contract between science and society. Yesterday, society interpreted it more or less this way: "I will support you and you will provide the benefits; but you do it, I trust you completely".
Today, however, society wants to know at least who you are and what you do, and a web site which clearly and comprehensively explains this is the least to be expected. At the same time, it also wants you to explain it to children, perhaps with exhibits or a television programme, and to offer a useful service for adults, for example practical health information, just as the large American biomedical research centres do. Furthermore, if the research produces potentially risky technologies or raises ethical questions, society wants to be able to have its say, but it especially wants to be reassured that the scientists feel responsible towards society, and not only towards science, and that they are more concerned about the public than other groups, like industry.

Even if implicit, the new contract between science and society increasingly more often determines what can or cannot be done in the laboratory. In almost every field, scientists must now explain the meaning and aims of the research they intend to carry out. And if they are unable to do so, or they encounter other types of issues, for example bioethical, they may see the necessary financing or the very permission to continue certain types of research denied. In this new context, your own spaces need to be negotiated, and to negotiate you must communicate, which means knowing each other and exchanging ideas.

The communication of science is no longer simple dissemination, but rather a process in which different players produce knowledge, messages, attitudes and new practices accepted by all. Science plays a fundamental role, but in this process many may want to have a say, including the media, institutions, environmentalists, associations of people with various diseases, as well as citizens' committees. And they are often right. In order to remain an authorative voice, science has to keep socie-

ty's trust, which is obtained through reciprocal understanding and not with simple statements of facts, no matter how incontrovertible they are, let alone statements of authority. As in a marriage, trust must be earned with effort and is easily lost; a one night stand, and it is over. Both science institutions and individual scientists shoulder this responsibility.

The consequences of one person's negative behaviour, especially if the others do not strongly and publicly disassociate themselves from them, have repercussions on the entire community.

In order to create a climate of faith and trust there must be channels of communication which are always open and scientists must be willing to communicate. Instead of asking only "what do people need to know", we should ask "what do people think they need to know", "what will be the effect on people of what I want to say ", "What do they know, or think they already know". Indeed, if communication is to be successful we need to deal with reality, but also with the perception of this reality held by the people you want to communicate with.

How knowledge and opinions of science are shaped

There is no great invention,
from fire to flying,
which has not been hailed as an insult to some god.
John B.S. Haldane

The photograph of a cow which is being given a shot of hormones may arouse an animals' rights activist's indignation and worry about its possible effects on a mother's health. On the contrary, it may make a farmer happy because of the increased productivity it represents.

They are not mental experiments, but a test actually carried out by a German scientist on a group of citizens. Whatever is communicated never ends up on a tabula rasa, as the more orthodox approach of the Public Understanding of Science holds, but interacts with everything people know or think they know on the subject, with their convictions and feelings, their distrust, the way they are used to getting information and their personal experiences.

For scientists to base themselves on their own attitudes, shaped by scientific facts and their own field of studies, is particularly misleading. Their attitudes are the result of the special mental training provided by their scientific education. Each one of us, in real life, almost never weighs the pros and cons of a position with the utmost impartiality, looking for the most logical and rational explanation. Rather, we make a pretty quick evaluation based on our personal experience and opinions, as well as the social and cultural context we live in. In particular, we tend to select those elements which confirm what we already think and disregard or rationalize the others.

Thus, the ground where our message is going to be planted cannot be ignored, since their interaction determines whether a message is ignored, distorted, misunderstood or otherwise understood and accepted. In other words, you need a realistic model of the public you are addressing.

The public of science is still unfamiliar. Despite the enormous cultural, social and economic impact of science, there is nothing similar to the sophisticated surveys made for the advertising market to draw from. Understanding what happens when a scientific theory or facts become common knowledge and opinion is, however, a task some sociologists, social psychologists, anthropologists, cultural historians, and cognitive scientists have ventured upon. Even if there is no model which describes the shaping of popular versions of science, a few interesting mechanisms have been clarified.

The starting point of many analyses is that information, scientific or related to scientific facts, arrives piecemeal, usually from very different sources and lacking an interpretative framework, either because this framework is not provided, or because it is too complex. Our mind, however, literally abhors scraps of information, the lack of meaning and significance, and an image of the world is reconstructed using the scraps available, unifying them with ties which are often arbitrary and irrational, filling in the blanks with what we have. It is a bit like the way vision works. In other words, our mind actively tries to build meaningful structures where there are none, making use of the knowledge, concepts and devices we already possess.

The appropriation of a scientific theory or facts is not at all passive, but rather it is an active process guided by our common sense which tries to respond to specific demands.

In its most popularised version, for example, an old theory on the cerebral hemispheres often divides the brain into a "warm" right hemisphere, tied to emotions and sociality, and a "cold" left hemisphere, rational and "evil", though it is just one way to respond to the very human need to classify individuals using typologies, like "artists" or "engineers".
The most frequent aim of these reconstructions, however, is to build a bridge between a new development and what is already known or believed, or rather, to make the unfamiliar familiar by reducing it to a more ordinary image. The "laziness" of the mind also plays a role in this, since it usually looks for shortcuts that allow us to economise on our own cognitive energy. Every scientist knows how much effort and determination is needed to pay attention to the facts themselves and resist the temptation to read something into them that (s)he would like to see.
A scientific theory or a fact is thus transformed into social representations, that are not limited to reassuring, restoring a sense of continuity to one's own representation of the world, but concretely guide actions. Like filters, different representations lead to different interpretations of the same scientific facts, news or discoveries, channelling the reactions into the same number of directions. To every effect, the representations act as pre-judgements.
A very popular social representation is the "naturalness" (which equals genuineness and safety) of traditional foods compared to those produced industrially. This representation was established at the end of the Sixties in a specific cultural context and after various episodes of bad business by the food industry, because of the legitimate desire to know what ends up on our plates. It has ended up influencing our relationship with all foods, leaving little room to examine each case specifically.
Basing his ideas on prejudices (pre-judgements), of course, is exactly what every scientist tries not to do in his work. Yet, the scientist who disregards the importance of this in the field of public communications makes a big mistake.

Not knowing what the social representations in play are or ignoring them can lead to misunderstandings, and therefore, to ineffective communication at best, and a damaging message at worst.
The social representation "resists", in fact, the expert's mindset because it is based on other elements and other ways of thinking that can also be very strong.

Communicating risk is perhaps the field in which social representations count the most. In this context the scientist's voice easily loses its privileged role and becomes just one of the various points of view on the issue. This is not a value judgement, but simply an observation. Unfortunately, this is what often happens: therefore, it is necessary to be aware of it and keep it in mind.

The perception of risks

It happens, that for a common vice of nature, that we conceive greater trust or stronger terror for the things we have not seen and that are hidden and unknown.
Julius Caesar

There are very few technologies that do not present any risk, however small. Yet the acceptance of a technology depends less on a statistical estimation of a risk, than on a personal decision based on the risk perceived and the advantages it seems to offer.
The evaluation is never completely objective, therefore a citizen's evaluation may also be very different from the expert's assessment expressed in probabilistic terms. For example, people worry much less about car accidents than plane crashes, more about the so called "electromagnetic pollution" than the damage caused by smoking. Psychologists' studies have revealed that the degree of control individuals feel they have over the phenomenon highly influences their opinion of the expert's probabilistic estimates.
In the Anglo-Saxon world the risk society perceives is often represented as the product of hazard (the risk as evaluated by scientists) and outrage (the degree to which the citizens react). Outrage cannot be explained, as the scientific community often tends to, exclusively by the general public's lack of technical knowledge or the exaggerated alarm and distorted facts the media have transmitted. In fact cultural, moral and often even political components contribute to this factor. The issue of GMOs, from this point of view, is truly paradigmatic. Transgenic foods arouse, at least in Europe, extremely strong and widespread outrage despite the extensive scrutiny they have been given and a decade of consumption without the minimal negative consequence in a good part of the rest of the world. The situation is the result

of many different elements; for one there is a pre-existing social representation of foods. Then there is the so called "symbolic short circuit between food traditions deposited in history, artificiality and transgression of the natural order", as well as political and economic interests tied to the protection of European agriculture from international competition. There are founded concerns for the regulation of intellectual ownership in the field of genetics, not to mention the story of Frankenstein, an extremely powerful myth of contemporary popular culture of science and technology, where a creature, fruit of an illicit interference in the mechanisms of life, escapes his creator's control. Because of these factors, any type of public debate on the topic must take place on this playing field, a strongly rooted framework which does not lend itself to a rational and reasonable discussion of the subject. It is in this setting that another social representation has been able to grow, which is less powerful but not less foolish: the no risk guarantee for any new activity or technology, of the so called "precaution principle", at least in its more restrictive interpretations. The role of the media in all this is important, but different in part from what is commonly believed. It is true, in fact that the media love this subject because it is interesting and captures attention, even if nothing has actually occurred yet. And it is true that they sometimes distort the facts. Various studies have, however, suggested that what actually happens is that the media do not tell people what to think, but what to think about. In other words, they decide what the public should be exposed to or not. And that is not all.

It also seems as if people's attitudes to scientific risks become more negative simply because they are frequently discussed, regardless of whether the risk is emphasized or, to the contrary, reassessed.

The evaluation of the risk is a personal issue and eventually depends on the acceptability of the risk in one's own world, in addition to the amount of trust (again) in the social players that are in charge of keeping this risk under control. Communication, then, must explain the probabilistic size of the risk in understandable terms, and if necessary reassure. But it should never be limited to giving the nude and crude facts. On the contrary, the risk needs to be placed in a context, illustrating the causes, effects, implications and interests in play, and if there are any, the benefits which accompany the risk, answering any questions and expectations the general public may have.

All these elements, in fact, come together in the social representations that are not necessarily a death warrant.

Be part of the game

In modern democratic conditions,
science like any other player in the public arena ignores
public attitudes and values at its peril.
"Science and Society" Report
Chamber of Lords, 2000

The perception of risks, just like the shaping of other social representations of science and technology, is formed during public debate which can occur anywhere, but mainly in the media. It is here that the boundaries are negotiated as to what is accepted by society and what is not, which risks to accept and which to refuse. Moreover, it is here that the credibility of science (its knowledge, its methods, its objectives) must be won.

The first condition for effective participation is to know and understand the playing field. If a simple exposition of the facts and arguments is not sufficient, before making the first move it is necessary to clearly identify: the participants, the points of view, feelings and interests involved, favourable influences as well as the obstacles that need removing and those which can be sidestepped.

As Jon Turney, one of the most perceptive scholars in the social representation of science and technology, wrote: If we want to understand the origins of the vocabulary used today to talk about science, we not only need to trace the internal development of science, but also the history of science in popular culture, beginning with the culture today. And since most communication takes place in the media, this needs to be studied carefully.

In order to know the playing field it is not necessary to examine the work of scientific journalists, who generally reflect a vision of the world which is not unlike that scientists themselves, but television, daily newspapers, movies illustrated women's magazines, interest groups' web sites, science fiction: it is more important to look at what "lay" jour-

nalists and other professionals are saying (even unconsciously) about social representations since they are the most truthful interpreters of the common way of thinking.

This is how the negative social representations can be caught in time, and perhaps acted on immediately, before they solidify and cause damage. This is the case, for example, of the rising wave against nanotechnologies, which really emerged from futurology sold as science by Eric Drexler, the author of Engines of Creation, by Michael Crichton in his novel Prey, and in the famous interview of Bill Joy, the late scientific director of Sun Microsystems for Wired magazine: is there anything better than swarms of undetectable androids about in the world to reawaken the ghost of Frankenstein? This might even crack a smile, considering that nanotechnologies is one of the most matter-of-fact and useful sectors in material sciences, if the situation were not quite so similar to the GMO issue raised a few years back. At that time too the alarm was sounded in good faith, although it turned out to be unfounded, and the innovations, which affected daily life, were also invisible and did not offer obvious benefits to the consumer. The initial demands for "strict" regulation of the nanotechnological sector, if indeed it makes sense to talk about it in such a heterogeneous field, have already made themselves heard.

In these cases the situation can be averted and the playing field can be changed in time. We all tend, in fact, to prefer information that confirms the opinions we already have. Information on new topics, or topics perceived as such, very strongly influence attitudes. Everything that is said thereafter will have to take the first impression into consideration. Politicians are very familiar with this game: for this reason they always try make themselves heard on popular issues.

There are no infallible recipes, however, for effective involvement in public debates. Each case is different. As we will see in Chapter three, the right recipe needs to be found case by case, by analysing the topic and context of the communication.

There is not one valid recipe for each of the many possible circumstances. Scientists are the ones who must learn to communicate with the public, each in their own context.

Whatever the recipe chosen may be, one ingredient is indispensable: trust, which compensate for the knowledge that is inaccessible to a non peer audience. A case in point is the physician-patient relationship. This is the main path to a good relationship between science and society.

In all cases - and there are many - in which a true understanding of the science involved is illusionary, the only choice available to the public is between trusting or not trusting the experts.

Be careful, though. Even if the general public does trust the expert, its trust is no longer a total authorization and does not substitute dialogue. Rather it is the objective, reached after time, of good communication, or rather reciprocal knowledge and respect as well as credibility won on the field after continual availability. When trust in science weakens, in fact, the credibility of other players, from magicians to alternative forms of medicine grows stronger.

Communicating is an indispensable Sisyphean task

Now, here, I see.
It takes all the running you can do,
to keep in the same place.
Lewis Carrol

In the Odyssey, Homer describes the destiny that awaits Sisyphus, Aeolus's son, founder of the city of Corinth, and an extremely shrewd man. When it is his turn to descend into Tartarus, the gods condemn him to pushing an enormous boulder up a hill, which then rolls down the hill as soon as he nears the top, making him repeat this arduous task in eternity.

Public communication of science is also a never-ending "task". Indeed, every discovery, every application makes us review what we know or think we know, or at least change our usual way of doing things. It forces us to face new problems that we do not know how to solve, new choices to make, and new knowledge that we do not how to classify and interpret.

Yet, no one likes changing, at times not even scientists themselves. Communication of science helps, then, to continually re-construct the bridges between what we knew and what has just been discovered, continually up-dating the social representations in circulation.

Yet, from our point of view there are two ways to remain in the race.

The first is routine communication, an ever-open channel with society to be used to construct, over time,

the indispensable basis of reciprocal knowledge and trust.
This form of communication is carried out with updates, activities in schools, offering useful information and services for the media. We are talking about communicating through various social players, including the media, local institutions, interest groups or individuals.
The second is, instead, crisis communication, which is used for expressing opinions on issues at hand.

It should be very clear: without routine communication, crisis communication is of no use. If the public that you want to convince do not know you, do not think you have ever offered anything useful, or have never been able to test out their trust in you, they will not listen.

Having said this, we can begin to address the basic concepts of the public communication of science.

THE ABCs OF COMMUNICATING WITH THE PUBLIC

From peer to peer to public communication

A different language is a different view of life.
Gustave Flaubert

When the sophisticated Atlantic Monthly magazine published The Double Helix in two episodes at the beginning of 1968, it stirred both the readers' admiration and a small hornet's nest of issues. Whatever did James D. Watson want to do with his adventure of how the structure of DNA was discovered? Did he want to flatter himself, slander his ex-competitors, tell a science story, or get rich from an unscrupulous business deal?
What critics were actually reprimanding the Nobel winner for was the simple fact that a scientist, indeed, a great scientist, had written a book that was not only fascinating, but even enjoyable.
What a difference there was, in fact, between the book, which eventually became a classic, and the two small concise pages in the 25 April 1953 issue of Nature with which Watson himself and Francis Crick opened the era of molecular biology. Watson had simply understood earlier than other colleagues that communicating with society is something completely different from communicating within one's own professional circle: it is not a simplified version, nor a "translation", and not even a simpler way of teaching.

Unfortunately, the kind of communication scientists are used to using is very far from what should be used to communicate with the rest of society: while science works with hypotheses and empirical observations, the general public tend to believe stories which ring true.

Learning to write a scientific paper is part of every scientist's training. Since the Nineteenth Century, the norms for writing up research have been very clear. They were created for communicating data and arguments as quickly and effectively as possible. In its prescribed form, with the sections arranged in a fixed order, from the abstract to the bibliography, the scientific paper is organized so as to leave as few ambiguities as possible in: the language is impersonal and lacking in narration; its syntax is simplified; its semantics rigid. The language is highly specialized and extremely concise and there are no digressions or figures of speech.
Unfortunately, however, the very reasons why an article is written this way are the same that make scientific literature practically illegible outside of specialist circles.
Public communication has different requirements; it follows different norms; and above all, it takes place in a different context. Most of the problems which occur during an exchange of ideas with society arise when these differences are not taken into consideration.

Competing for attention

Just like the fighter plane that breaks
the sound barrier, a concept today
must have an aerodynamic shape
to overcome the barrier of the excess of information.
The thrust of the hyperbole is not, in itself, necessarily enough.
There must also be the ability
to penetrate found only in the elementary concepts,
summarized in a slogan.
Giuliano da Empoli

The first big difference, and one that is often underestimated, is that communication among experts implies the readers' complete attention, since they are already interested in the information because they need it. On the contrary, non expert readers (or listeners, viewers, visitors) usually do not have any particular reason to pay attention to what is being said. They do not have to listen. Their attention must be won, otherwise any effort made becomes useless.

It is not the public that must take interest in science, but science that must try to make itself interesting to the public.

If today there is a much valued commodity, this is people's attention.
Many are competing for this attention, and they are usually well-equipped: businesses, politicians as well as lobby groups for small and large interests are all in search of visibility and consensus. In a knowledge-based society and economy not only science needs to communicate more. Even beyond the commercial needs, today there is much more information to support every type of product or service than there was in the past. Yet the more people talking, the easier it is for individual voices to get lost.
Competition is therefore strong and is becoming increasingly more difficult: we are transforming ourselves into a society overloaded with information.
What does this mean, practically speaking? On the one hand, the means and opportunities for information are multiplying and now include almost any type of event, created or sponsored by a great variety of groups.
On the other hand, it is necessary to yell louder than ever in order to be heard. Messages are more and more often shouted and simplified, in forms which are shorter or faster than ever before, in the hope that at least something will catch the public's attention and "filter through". Just flip through the magazines from a few years ago or watch an old television programme again and you will see.
Competition begins in a newsroom where scientific news is also expected to be "sexier" than ever. Not even important international scientific magazines are completely immune to this trend: in the race to be talked about, they too sometimes make a mistake, like the famous incident of the "memory of water", in a 1989 issue of Nature when a result which was apparently extraordinary soon after proved to be a sham.
The difference between peer and public communication is at the root of almost all the strong points, as the discoverer of the double helix understood, but also all the defects that popularisation of science might have, like sensationalism. Yet it cannot be disregarded if effective communication is to take place.

The rule of thumb is that something becomes news if the public finds it new, but above all, interesting. For this reason it must touch a fundamental human need, or a subject which has already caught public attention.

The piece of news that "filters through" is the one that most easily strikes the strongest chords, which involve our health, economic development, wonder, national pride, fear and so forth. Just look at how much attention climatology has received since we have begun to worry about global warming. If what we want to talk about does not strike one of these chords, a tie can be found – an excuse, an honest one – to bring it up. These days even science and technology need the skills of the spin doctor, the specialist who knows how to turn news into something more appealing.
To explain a new development in geophysics, for example, it is always better to try and link it to earthquakes or volcanoes. The classic trick to get a scientific congress in the news is to save a piece of good

news for the occasion. The articles' headlines will carry only that piece of news, but many articles will also talk about the congress. The secret, then, is to start off with matters and motivations which already hold public interest, and then little by little perhaps lead the discussion to other areas.

The importance of a result, however big it is, may not be enough to make it news. Knowing how to communicate means, first of all, knowing how to transform what you want to say into what the public wants to know, creating (or recreating) the reason, which exists naturally among colleagues, to learn about it.

Only a few manage to escape an apparently relentless drift towards increasingly louder and potentially misleading forms of communication. Marketing experts call these people "gatekeepers" (the gate to people's attention), for they have, in fact, gained the authority and social position to strongly influence the public's choices. Bombarded with information, each one of us, in fact, tends to delegate the choices in specific areas of knowledge to someone else.

The gatekeeper is, thus, a filter that acts as a guarantee for some types of information. Today there are gatekeepers for vacations, computers, wines and fashion. Editorialists of large newspapers are gatekeepers. In science they are the important popularizers or Nobel prize winners, famous people that do not need to shout to make themselves heard. Institutions like NASA can become gatekeepers too, as long as they work effectively to build up their image and credibility over time.

The power of emotions

Whatever the sun may be, it is certainly not a ball of flaming gas.
D.H. Lawrence

Communication among scientists is neutral and lacking in emotions. Thus, only the facts speak, motivate and convince, not the person presenting them, nor the hope that the theory is right, and not even fascination they hold.

In public communication, on the other hand, the quality of the discussion or data is not enough. The same data that for scientists are another piece to add to a well-known picture of knowledge (and emotions), for the public is only an isolated fragment of information, with almost no meaning. While Watson and Crick only needed a short, dry article in Nature to capture the scientific community, that for years had been anxiously awaiting the solution to the DNA puzzle and perfectly understood its value (for science as well as its discoverers), in order to grab the public's attention the Double Helix was needed, a book which recreated everything behind that research, including the urgency of the two young scholars' "mad pursuit", pressed by the competition of many and much more qualified colleagues. In other words, it was a person who talked about it. All scientists know very well how important passion is for their work, but they also know it must be set aside when it is time to evaluate the results. Yet when communicating with the public it would be wrong to wear this mask of detachment. This very show of neutrality may be necessary to avert falling too deeply in love with hypotheses which could turn out to be wrong, or when presenting results to colleagues, but in time, it has been costly to the scientist's public image, since it still carries connotations of reserve and coldness.

Indeed today it is crucial to make one's topics appealing, and if possible spectacular or even sensational (of course within acceptable and ethical limits); there is no longer room for scientists who are disoriented by or even scorn the idea of popularising their research.

If confronting the facts of reality is the common denominator of all types of scientific enterprise, arousing emotions is the common denominator of all forms of communication.

In public communication emotions are not a cheap trick to raise attention, let alone something manipulative (as long as it is intellectually honest). To be sure, gaining public confidence and creating positive feelings can be more persuasive than indisputable facts.

The first step in any public communication is, therefore, to identify which emotions will win over the public. An emotionally flat communication, in fact, "does not filter through", or is immediately forgotten.

This simple fact, already taught by the ancient orators, has been, indeed, rediscovered by the neurosciences, which have re-evaluated the role feelings and emotions play on our cognitive abilities.

There are infinite ways to lend emotions to a topic, some noble and others base. The best way to choose is to identify your own emotions as a scientist, and then find the closest possible link with your audience: the feelings of wonder at how nature works, intellectual curiosity, the search for answers to important existential questions or world problems, the pleasure of working in

special areas and so forth. The Holy Grail, from this point of view represents the reversal of man's "disenchantment with the world" by science, so despised by the Romantic poets.
Allowing your own passion to transpire will also help to make that fundamental transition from "communicating something", typical of communication among experts to "communicating with someone". One aspect of communication which is often neglected, in fact, is that information is not exchanged in abstract terms, but within a relationship between speaker and listener, in which the emotional factor highly influences the ability to recognise, evaluate, and possibly even retain the information presented.
For this reason a scientific work may also have many authors, while a book or a popular article has only one.

Effective communication has two legs. The first is rationality, that in the planning stage helps to identify the opportunities, but above all the limitations of communication. The second is the ability to construct, as in any literary text, a dialogue with the public, imagining for a moment what the reaction may be to what is said and consequently adapting it to the answer.

The quality of communication depends greatly on the quality of the relationship which is established with the audience. As in friendship and marriages, the better you know each other, the more respect there is, the better you will get along.

The power of storytelling

It is not the voice that directs the story: it is the ears.
Italo Calvino

While the scientific article was invented only once, stories have always been told in all human civilizations. The human mind seems to be specially made for creating stories, which represent the most natural way to receive information. The mental images created by stories are precious cognitive references since they organize our experiences and make them coherent.
A story which captures our attention "forces" us to read or listen to it until the very end. A story is also an important memory aid; in science we can recall Fleming's mould, Newton's apple or the snake in Kekulé's dream. It is no coincidence that in English journalism an article is called a story.

Whatever the means, the format, the aim and the content, communicating science to the public means knowing how to turn it into a story.

If we examine popularisation that works, we rarely find anything that resembles a textbook or a scientific work simply translated into simpler language. Concealed to different degrees we always find a story, or a fact, a concept or a way of reasoning disguised as stories. This is true for an article, but also for a television programme, a book, a documentary or a lecture.
Science stories have much in common with the language of journalism. In a story, there is an adventure, with the characters' deeds, the time of action and a place, that even it its simplest form must therefore include the famous "5 Ws" of English journalism: Who, what, where, why and when, to which we can add the H of how. The narrator is as close to the reader as (s)he is to the characters and, unlike the scientist, shuns abstraction. As the old journalistic saying goes: " Explain ideas with facts and facts with people".
Choosing what goes into a story does not depend on the need to be thorough and exact, but on how the contents work in the narrative structure, which then acts as a filter against the temptation to tell it all. At the same time, however, the context of the news – usually absent in a scientific report – is recovered, by adding the basic concepts in play, the history of the discipline's internal development and the explanation of its possible ties with the reader's personal experience.
The need to involve the reader or the spectator means destroying the prescribed form of a scientific work. Instead of the usual sections, there is, what in journalist jargon is called the "inverted pyramid", since the assumptions (the base of the pyramid) are the last thing to think about: the opening line needs to capture the audience's emotions, then the heart of the story is told, and only later are the details given, beginning with the most important. When the details become less important, they can be cut. The story does not necessarily have to reflect the order and reality of events, but there may be digressions, explanations, flashbacks, analogies, metaphors and so on.
The text is no longer impersonal, strictly in the third person narrative and with a wide use of impersonal and passive forms, but it becomes spoken language, which carefully follows the imaginary route and mental rhythm of the listener. The

discourse must flow smoothly without any snags, because it is also meant to be read (or listened to) just once.
No science story, however exciting and readable, is, however effective if it does not manage to also clearly explain what it is talking about. It has been said that the moment of comprehension is to knowledge what an orgasm is to sex. This is what distinguishes it from journalism (effective journalism, which is not necessary the best) and other forms of public communication.

Why is science "difficult"?

Science often explains the familiar
in terms of the unfamiliar.
Lewis Wolpert

Communication among scientists includes almost everything necessary to make it difficult, not only for non scientists, but often for those who are not specialists in the field. Even when scientists try to speak clearly, however, they do not always explain themselves well.
Indeed, science is often difficult, or at least complex, in itself, and it is not necessarily true that it can be made easy or readable like the article in an illustrated magazine or a televised news report. In any case, much can be done. You do not need a natural gift for clarity, as long as you understand what might make science difficult. Some reasons are almost obvious.

Language

Science thrives on specialized language, from mathematics to the various specialist terminologies, in which many words do not even have a direct translation, but refer to concepts or entire processes that can be very complex: just think of "genetic expression", "tectonic" or "inflation". Communication requires, on the contrary, the use of a shared language. Thus technical terms should be avoided, and when it is impossible to pass them up, their meaning should always be explained, even when it might seem banal, as, for example, when we talk about "DNA". The same thing can be said for concepts.
Our mind also has a difficult time handling dimensions, like nanometres or billions of years, that are very different from the measurements used that can be encountered in daily life: this is a problem that can be solved with appropriate analogies.

Maps

Science is a network of knowledge that is connected on various levels of complexity, and thus it is difficult to understand a topic without knowing the basics. Moreover, scientists hold the map of their own discipline, but the public does not. Even if in public communication there is usually little space to outline the bases of a topic, you cannot presume the public has the same motivation that a university student has to know them: at least those principles crucial to understanding the message need to be included. No more than this, however: a good rule of thumb is to explain one thing at a time.

Explaining means accompanying someone from what (s)he already knows to what (s)he does not know yet. Thus, an explanation is always a line of reasoning as well, naturally suitable to your audience's level of understanding.

A lack of meaning

In order to understand, you must also want to understand, and believe you can.
The first problem is that science often deals with objects and phenomena that are far, or at least seem to be far, from real life experiences. Before explaining, these need then to be put into a context that highlights their connection with the public's experiences and motivations. If you want to talk about the life of a star, you might begin by explaining that the atoms that make up our body have not always existed, but were moulded in a thermonuclear oven inside a large star.
The fact that scientists have a mental map of their topic, and are also used to looking at their theme in minutia, often makes for an account in which details tend to prevail over the wider vision of the problem, and therefore over the more general meaning of the topic, which is taken for granted. Indeed, finding a meaning, its relevance or applicability is one of the problems in the communication of scientific topics.
For this reason it is hard to get excited about the structure of organic molecules, while cosmology, which provides answers to questions that man has always asked, is so popular.
Finally, the lack of interest and desire to understand rooted in bad

scholastic memories can never be underestimated. These memories also account for the sense of inadequacy people experience when they approach science. A small demonstration that science is not so difficult to understand would help to overcome this psychological barrier: perhaps an initial simple line of reasoning could be used even if it is not closely related to the main theme. In other words, it is a matter of breaking the ice, just as science museums and science centres do with informal styles of education.

The unnatural nature of science

Science seems "difficult" for less obvious reasons as well.
The main reason is that, although practicing science may seem like the most natural thing in the world, science is actually a profoundly unnatural way of learning. As Lewis Wolpert, the embryologist who headed the British Committee for The Public Understanding of Science, emphasized: science implies a special way of thinking that is unnatural for two main reasons. In the first place, the world is not built on a basis of common sense. This means that "natural" thought – common ordinary good senses – will never help to understand the nature of science. With a few rare exceptions, scientific ideas are counter-intuitive: they cannot be acquired by simply examining phenomena and they often have little in common with daily life. In the second place, doing science requires a conscious awareness of the traps of "natural" thought: common sense is inclined to error when it is applied to problems which need sound and quantitative thinking. The explanations suggested by common sense are extremely unreliable.
Our mind is, in fact, Aristotelian, not Galilean: for this reason becoming a scientist requires training in a different way of thinking, and not only the simple acquisition of knowledge. If this were not true, we would have understood earlier simple phenomena like motion or blood circulation, which have always been just under our nose. In cases in which understanding requires thinking like a scientist, it is important to warn the public of this specific difficulty, guiding them through this different way of seeing things.

Identifying the audience's problems

Generally speaking, it is always necessary, to remember that while communication is, first and foremost, a dialogue – which at times is imaginary– with an audience, any explanation needs to be preceded by an understanding of the difficulties the audience may encounter.
Compared to journalists, or at least professional communicators, scientists have the great advantage of knowing the subject well, but the great disadvantage that it is not as easy for them to understand what the public might find difficult.
On the contrary, journalists, as non experts, are aided by their own experience and easily recognise these difficulties. A skilled communicator does not take anything for granted and saves readers, viewers or listeners the problems (s)he has already had her/himself, and perhaps even conveys the same, fresh enthusiasm for what (s)he has just learned.
If scientists want to make themselves understood, then they must make a greater effort to become an observer of their own topic from the outside, as we will see in greater detail in the next chapter. Given the large asymmetry that exists between scientists and their audience, they need to carefully watch their level, time and ways of explaining.

The imperative of being clear

It is very important, in this regard, that everybody understands. Once the segment of the public you want to address is identified, it makes no sense to explain yourself only to a part of it, and forget about the rest. Every communication is actually made up of a communication in the strict sense of the word, which involves the contents, and in a meta-communication which involves the relationship established between the speaker and listener, and that transmits the emotional spirit of the communication itself.

Not making yourself understood is worse than not being understood. It means, in fact, communicating your disinterest in the public as well as the low opinion you have of their ability. Whoever uses complicated language, perhaps because (s)he believes this will make him more credible, runs the risk of seeming detached and offensive.

Ethics in science communication

If one tells the truth, then sooner or later one will be found out.
Oscar Wilde

The prescribed form for drafting a scientific paper helps to eliminate, to a large degree, those shady areas which might hide missing or shaky data, a logically weak point in the line of reasoning or an unclear experimental procedure.
On the contrary, in public communication, if the large asymmetry in the knowledge held between the expert and non expert is added to the techniques applied (narration, emotion, rhetoric devices, partial explanations) the potential for deception or manipulation is enormous.
In short, scientific research's great influence implies just as great a responsibility. The more science touches everyday life of society with greater speed and less mediation, the less scientists can disregard the ethical implications of their research and communication.

In order to open a channel for dialogue with public opinion, trust is necessary. But trust is easy to loose and difficult to gain – or, worse, gain back – and the positive or negative consequences of scientists' communication are often reflected on their professional circle, if not on the entire scientific community.

In this case too, there exists a more obvious and a less obvious ethic.
The first rule is to respect the factual truth. A precise account, complete and honest, should be ready to clarify how the results were obtained, how reliable they are, whether they agree with other studies, what credit is due to other scientists, and if others disagree and why.
Moreover, results should not be emphasized more than is rightful: a public that has been disappointed once, will be sceptical forever. One of the key features of science is its temporary nature, which is even truer for the frontiers of science: if this is the case, it is better to acknowledge this fact immediately, so that those who are reading or listening are aware of the nature of the information received.
Results that are popularised should have already undergone a peer-review. There is no easier way to lose public confidence than to announce something that is then challenged or rejected shortly afterwards. This already happens frequently enough for physiological reasons. Nor should the appeal to public opinion be exploited as a substitute for the scientific community's consensus. Respect for factual truth alone may, however, not be enough, because you can be guilty of omission.
The possible negative consequences of your research should not be disregarded. Discovering the genetic basis for the predisposition of an illness, for example, opens the door to improved prevention, but also to potential discrimination. The fact that the balance may be positive overall does not mean, in fact, that negative aspects do not exist. Their omission might, indeed, be brought to light by someone else, creating serious damage to your credibility.
Another error is the omission of other options, when there is not just one to choose from. In other words, you should not offer one option, the one we are convinced of, as the only possible choice; not even in good faith. This situation is more common in medicine and in the choices of technologies: consider, for example, the pros and con of the various sources of energy.
It can also be considered omission when you do not dissociate yourself, publicly as well, from a colleague that has behaved inappropriately, accepting the attitude that "there is honour among thieves". As soon as the unprofessional conduct is discovered, people will note your silence and lump you together.
Finally, possible conflicts of interest should be declared. The increasing intertwining of public and private research will offer more opportunities for the mask of scientific objectivity to hide interests which have not been or cannot be revealed. Never underestimate, though, the public's discernment of which sources of information can be trusted and which cannot.
Since ethics is a question of values, the ethics of public communication has a dimension which is less obvious, but perhaps more fundamental.
While it may be true that scientific knowledge does not have a moral dimension of its own, the methods used to obtain it and its possible applications do. It is true that scientists sometimes lose or cannot have control over how their results are applied, yet there is nothing worse than an attitude in scientists who rid themselves of this problem by appealing to the "pureness" of their research. On the contrary, scientists should not only declare the values at the root of their work, but also be ready to divulge the social implications of their work as well the work of others, and their own opinion, positive or negative. Who is more entitled to do so? What better opportunity is there to communicate that scientists are responsible citizens?
As many considerations made in other fields have underlined, you cannot be convincing (or be so for a long time) if you are not genuinely convinced that you need to work

ethically and consequently do so, especially at the institutional level. In other words, if there is no substance there is no effort great enough in public relations to conceal your limits. In an open society, in which you are examined under the microscopes of many, there is no way to keep possible flaws hidden. Thus, you must first examine your own values compared to the society's values, and the respect owed to its citizens; only then can you begin to think about constructing visibility and credibility, which represent the most precious assets for the individual scientist as well as for the community (s)he belongs to.

Never, never try to manipulate your public, not even for a good reason. If people realize what you have done, they will feel humiliated, and where health or safety are concerned, this can mean wiping out your credibility for who knows how long. A policy made to exploit your credibility is a sure recipe for disaster.

The first objective of a scientist's public communication policy is to earn a reputation as a credible speaker. As remarked by Hans Peter Peters, an expert on the problems between science and society: "It is always better to inform and explain your reasoning as honestly, clearly and completely as possible. Even if we will not convince our readers or listeners, at least we will have given them the impression that we respect them. This too can play a part in forming their opinions, since information does not stand alone. At times, the perception of honesty can obtain more than the information itself".

PLANNING YOUR COMMUNICATION

Starting off on the right foot

It sounded an excellent plan, no doubt, and very neatly and simply arranged; the only difficulty was, that she had not the smallest idea how to set about it.
Lewis Carroll

From NASA on down, many scientific institutions have their own strategy for communication. No communication, in fact, should be improvised, least of all science communication. Let us immediately clear the field of one misunderstanding: the idea that communication is only intuition and creative impulse.
Natural talents are rare.
In any professional communication, subjectivity and the strike of genius enter into play only later, after careful analysis has clarified its objectives, constraints and opportunities. Even in advertising, a field that from the outside seems like a kingdom of free reigning creativity, the creative pair (copy and graphic designer) start work only after a long and often extremely sophisticated analysis by the marketing team has defined the constraints to work within.
Think first: putting together intuition and planning, which follows a precise sequences of stages and verification, is a valuable rule at all levels, whether it be for a single contribution (an article for a magazine, a school visit to a laboratory, a radio interview or a book), or, even more importantly, for the planning of an information campaign. In this way, you can at least protect yourself from the most common errors.

The most common errors

The first is that you cannot make yourself heard. This occurs when you are unable to access a channel of communication, because no newspaper shows interest in your topic, but also when you turn to the wrong people, perhaps because you have used a channel which does not reach the audience you are interested in.
You can also manage to talk to the right audience, but without being understood. Comprehension in a crucial aim when you talk about science, unlike, for example when you talk about politics or literary criticism. This error might even backfire.
You can also be clear but not interesting, usually because the content or reasoning selected represent priorities for you as a scientist or the institution you belong to, but not for the public. This category includes information on congresses or expensive experimental apparatus, or in any case, what scientists hold citizens should know. Today, however, as in many other sectors the consumer is the focus of attention: communication must therefore be, first and foremost, a service offered by those who do research to citizens, and not to themselves.
There are also content errors, like suggesting the wrong message or contradicting earlier statements, thus irritating or alienating somebody.
Even when these errors have been avoided, a more subtle, but not less serious error may remain: the lack of an objective.

Rarely the scientific community is able to distinguish between the understanding of science and the appreciation of science and its benefits, as if making citizens little experts means automatically gaining their support.

The choice of one of the many things that can be discussed or one of the various points of view on a topic must, in other words, help to reach the objective. If for example I want to convince you of the usefulness of a new, very expensive accelerator, talking about the spinoffs of fundamental physics or describing a chapter in the history of the research, appealing to national pride, might be more useful than the fascination offered by the theories of everything or Higgs's boson theory. The opposite choice will be made, of course, for a class visit to a laboratory.

Think first

All the stages in the process of communication are important. In this chapter we talk about planning, that is everything that takes place before getting down to work, namely before writing an article, contacting a journalist, commissioning a contribution, organizing an information campaign, etc. In fact, there is almost never just one way to talk about something and the choice must be based on careful consideration of five essential elements:

- **audience**
- **constraints**
- **opportunities**
- **message**

Only later will the concrete opportunities, or rather the resources, ability and access to the media, be considered. Here you will find a check list of "filters" which the idea or initial need should go through.
There is no better way to evaluate your planning than jotting down a concept, which is a single page listing and justifying the choices made. This is a tool widely used to check if everything is coherent and convincing.
These elements, chosen with rationality but also with a pinch of creativity, should produce a story. But we will deal with this point in the next chapter.

Clarify your aims

Our plans fail because
they do not have an objective.
If one does not know
to which port one is sailing,
no wind is favourable.
Seneca

The first question to ask may seem banal, but in reality it is crucial because everything depends upon its answer: "Why am I doing this?". The decision to communicate too often expresses only the desire to come out of isolation or obscurity by doing something

Defining you objectives means deciding which category of people you want to address and what type of change you want to obtain in them.

It is no coincidence that the first and most delicate task of a communication consultant is to help clients clarify their ideas on these two points.

Who do I want to address?

When asked this question, many still answer "the interested general public" usually meaning the educated audience. Now, apart from the fact that there are actually very few educated people, and that they may not be the ones who have to be interested in us, and that we need to force ourselves to interest them, this attitude clashes with one of the basic principles of every communication.

Communication which has something good for everyone has almost always something bad for everyone. And it is more difficult.

The public, in fact, are heterogeneous in sex, age, socio-economic level, interests, needs, background knowledge and cognitive abilities. For a series of reasons which concern the transformations that our society is undergoing, the public tend to be increasingly divided into cultural "tribes". As advertising experts know very well, communication functions best for each segment of the public, when it is cut to size: each audience needs the, message, means and language which work best .
Today, there are truly few generalist media (actually, a few TV channels and they are more expensive and difficult to access, while usually specialized media (scientific magazines for example), which are easier to reach, are a way to enter the cultural market, gain attention and eventually approach other more important and influential channels.
If necessary, it is better, then, to multiply and diversify your contributions, packaging them for a homogeneous segment, whether it is for schools, policy-makers, the local community or journalists.
More often than you can imagine, there is no need to speak to everyone. It is important, in fact, to speak to your stakeholders, the people that may be interested in your research or the organization that has produced it. Since the list is generally potentially very long, priori-

ties should be established. Who do I most need to communicate with?

What change do I want to obtain?

Once your public have been identified, it is necessary to clarify the change you want to obtain. Usually, the objectives of a communication are part of one of these categories:

- **the exchange of information**
- **visibility/awareness**
- **dialogue**
- **persuasion**

When you say you would like the public to know or understand something, which is the most common objective in technical or scientific fields, what is "this something" exactly (this needs changing).. The problem in this case is to be realistic and not give in to the temptation to explain everything. Unless you are writing an entire book, you should concentrate on just one element. The most obvious choice would be to concentrate on a fact, which in some cases, for example when you talk about risks and safety, cannot be avoided. You might, however, prefer to discuss a concept, which is often necessary in human genetics, since facts about molecular biology are often too complex. Or you might explain the meaning of a research project, as is often done in fundamental physics, in which both the facts and concepts require too much background knowledge and impracticable languages.
In the other cases the scientific explanation, always present, must be useful in achieving the objectives pursued.
The communication from a centre of volcanology, for example, might focus on various subject matters: you might explain to the local community, (familiar with its behaviour, that someone is always monitoring the volcano; tourists might be interested in the fascination this large and spectacular natural phenomenon holds; the media might want to know what types of forecasts can be made and how reliable they are; politicians may be interested in the fact that the centre's annual budget represents a small fraction of what the forecasts can help save should an eruption occur.
Thus, the choice of the fact, concept or meaning will depend upon the interests, expectations, needs and possible fears of that particular segment of the public.

Know your own audience

When an ear grows sharper, it becomes an eye.
Rumi,
Persian poet and mystic
from the XIII century.

The secret of Piero Angela, the journalist that "invented" scientific popularisation for Italian television and its well-recognised leader for 25 years, is an extraordinary sensitivity for his audience, whose interests, tastes, cultural level and reactions he knows perfectly.
His audience, however, are different from those which watch other television programmes, including science programmes.

Knowing the people you are addressing is one of the first rules of communication. No words can always be clear or persuasive. Clear or persuasive words exist only for a specific audience, which you must have a reliable model of.

Once your audience have been identified, you should be able to answer at least three questions:

- **Who are they?**
- **What do they already know about the topic?**
- **What do they think about it?**

When doing this, the researcher has the opposite problem from the journalist. While the journalist must learn the scientific knowledge, the researcher needs to learn the "lay knowledge", including which media their audience receives their information from. This information can be found personally, or if possible, in the press and through specific surveys. In fact, very few studies on the publics of science exist, except for the fields of biotechnology and information technology. Even if the stakes are just as high, there exists nothing similar to the very sophisticated surveys used in advertising.
Identifying a segment of the public means understanding how complex your explanation can be, as well as what their expectations, motivations and interests are. Different means are better for reaching different audiences; for example adults might prefer TV; teenagers, Internet; children, museums and exhibitions; and the establishment, influential newspapers. To know a specific public means choosing the right media for

them and the testimonials they consider the most credible and listen to.
It is easy to assess what the public already know about the topic: usually they will know very little. Every one of us can be compared to a curious fourteen year old, more or less, in those fields that are outside our professional field. The topic itself can be of help here. It is more likely, for example that the public know what happens during a heart attack, which is often explained by the media, than how chemical bonds work. The exception is the subgroup with particular interests, like people with a particular disease, who are particularly motivated and used to getting information from the Internet, or other sources.
The next step is to understand what our public want to know. Above all we must consider their interests, concerns and hopes, along with the most popular topics of public debate. Subjects tied to energy saving, for example, are of interest when the cost of oil goes up, and only to the people who actually pay the energy bills. In effect, it is always necessary to begin your discussion with preexisting interests and only later introduce new and important information.
It is more difficult to understand what ideas the public have about the topic, or rather what its public image is. A media analysis does in fact help, but it is not conclusive. A more refined analysis is necessary, if possible with special surveys and focus groups, but meetings can also be useful. In order to find the right topic for a conference on homeopathy, for example, it might be more important to know what is appreciated most in homeopaths and their approach to the patient, rather than to get information on studies that disprove their effectiveness. In other words, it is necessary to learn to listen and carry out some cultural and social analyses.
A simple exam of the media does not provide an understanding of what is at stake and where the public stand. Are they opinions or simple frills on the surface of awareness, easily changed? Or are they attitudes, stronger sympathies, hidden below the surface? Or are they values, large public movements, as strong as they are slow to change?
If you decide to (or if you can) go along with the popular public stance, so much the better, because you will find some extremely useful allies. But if you decide (because you have to) to go against them, you will need to be very aware of your position and use more care in your presentation. In these cases, the best thing is to calmly analyse the reasons behind the positions you do not share, listening more to the public than to your colleagues, trying to understand how they have come to these conclusions using cultural analysis or a history of the controversy.
The most serious error that can be made is to demonstrate that you are not familiar with public opinion, or even worse, do not respect it, in an attempt to force your point of view on them because you know more than they do. Rather, it is important to be open and willing to an exchange of ideas, and only later, calmly explain your position.

Assess constraints and opportunities

The ideas of new opportunities
do not just wait around to be discovered.
These ideas have to be produced.
Edward de Bono

Whatever topic you want to discuss has constraints to consider and opportunities to exploit, and they may not be easy to identify, especially if you are involved in the minutiae of the problem. Considerable personal knowledge and investment do not help, in fact, to see the subject from the outside Seeing through the public's eyes, is, however, essential during the planning phase as well as in assessing what has been done.
Let us forget, then, that our topic is the simplest and most interesting in the world and try to asses it objectively from different points of views, exploring all the possibilities.

Is it news?

Everything that is news has a built-in appeal, just like everything that has to do with popular issues. Often, in science, the news in itself, is not as important as the maturation of a line of research. In this case a curious piece of news might represent the opportunity to talk about the rest as well.
The detachment of a particularly large iceberg might represent the opportunity to talk about climate warming at high latitudes, and perhaps the activity of a national laboratory in Antarctica. For the same reason those researches can be linked to a subject of current events.
A recent blackout can be, on the contrary, the opportunity to talk about topics tied to new sources of energy, while the death of a celebrity, the starting point for a discussion of your own research on the disease which (s)he suffered from.

Fascination or surprise

Can your topic make the imagination fly?
The popularisation of science has always used fascination and surprise; just think of the relative weight carried by topics like space, dinosaurs, human evolution and animal behaviour.
Even if not all subjects stir the imagination, many lost causes may be salvaged to some degree by "parasiting" more popular subjects: the microfauna of the soil becomes a miniature savannah; material sciences, modern day alchemy; a result in the field of cosmology, a fruit of Einstein's theories.

The size of the natural public

How many people are potentially interested in the subject?
Niche subjects are always more difficult to sell than subjects which touch a large number of people.
A result, small as it may be, in the treatment of breast or lung cancer receives greater publicity than the definite cure for medullary carcinoma of the thyroid, which is extremely rare. A study on global warming in Italy will attract more attention than another on the growth rings in Alpine fir trees. While it may be true that scientists naturally tend to overestimate the potential interest their own sector holds, they should not commit the error of underestimating it either. Sometimes a little bit of imagination will help find a particular point of view that can make it interesting to a wider audience. An electronic nose, for example, can be seen in another light if it can help discover explosives in bags at the airport or used for the quality control of foods.

Importance

Why do we need it? What will change after this discovery?
The more a result influences our way of living, the more interest it arouses.

The outbreak of a new infectious disease, even if few people have caught it, stirs more interest than a parasitosis that has run havoc in agriculture. An asteroid which passes close to the Earth receives more attention than another that crashes on Jupiter. A mathematical model applicable to the fluctuations in the stock market attracts more attention than the birth of an entire new branch of mathematics. In this case too, if the topic handled does not seem immediately useful, it can be worthwhile making an effort to find an application or a consequence that it might have, perhaps in the future. Generally speaking, the public appreciate concrete benefits, and more than anything else they appreciate whatever might benefit our health. Just look at the warm welcome biotechnological products in medicine received compared to those in agriculture and food industry.

Expectations

And what happens now?
Every discovery or new application opens a brand new scenario, and interest will be higher where the expectations tied to it, good or bad, are important.
Cloning the sheep Dolly, for example, raised as many strong negative expectations as the announcement of "cold fusion" produced positive ones. Without bothering with events of this size, important expectations can be created by the perfecting of a new genetic test, the discovery of new planets outside our solar system, the raising of spermatozoa in the laboratory or a new agriculture variety. When dealing with a topic, it is also important to carefully explore the considerations, especially extra-scientific, that the public could make.

Emotional significance

What emotions can it arouse?
Emotions and feelings are the indispensable salt for every communication, because they the spark the reader's or listener's interest.

The discovery of a 1 meter tall hominid that lived up to eighteen thousand years ago on an island in Indonesia was, for example, linked, even in Nature, to the possibility that the famous yeti found in the Himalayas might also be more than just the fruit of the imagination. Many results in robotics receive disproportionate coverage compared to their actual import because of the fears and hopes tied to the development of robots.
When a topic seems to be, however, wanting in emotional charge, this should be sought, naturally without exaggerating. It may be found, for example in the circumstances in which it was discovered, in the connection to a particular celebrity or even, in an exciting hypothesis, even if it has not yet been explored. The discovery of prions, before mad cow disease made them famous, gained fame, largely because they were found during the study of their transmission during a ritual in a New Guinea tribe, whose members ate their dead relatives' brain.

Contextualization

How pertinent is it to every day life?
Many studies in psychology have shown that the closer a topic is to our world, the stronger our interest is: that is why medicine takes the lion's share in the popularisation of science.
When, on the contrary, the topic seems remote, the initial step is to understand how to relate it to something the public consider relevant. When you want to discuss the study of solar neutrinos, it would be best to explain that we live under a continual shower of these particles.
If you talk about macromolecular design, it would be worthwhile recalling that the origin and cure of many diseases depend on their structure.

Comprehensibility

Can it be easily understood?
If a topic is not understood, then nothing is gained from the communication.
Many topics, like chemistry, the

theory of the superstrings and most of mathematics, remain almost completely excluded from popularisation simply because they are too difficult. In these cases, after considering the instruments which can be used to make the topic clearer (we will talk about this in the next chapter) it can be helpful to avoid concentrating on the explanation of the facts, verifying whether it might be easier to explain the concepts, or the meaning of the research or only its application.

Spectacularity

Does it lend itself to a spectacular show?
Images can be extraordinary promoters of a scientific topic. Just think of ethology, made popular by television documentaries, or space exploration, made familiar with the help of enormous numbers of photographs, films and cartoon animation made available for free for decades by NASA. The availability of good images is essential if you want to offer a topic to illustrated magazines and television, and often it is the deciding factor in whether they choose to cover it. The topic then becomes a so called photo opportunity, that is, an excuse to show pictures. For this reason there are increasingly more scientific laboratories or institutions that produce or have produced visual documentation of their activities, and make it available to the media.

Service

Which service can be offered to the public?
Communication should not be simply the opportunity to explain to the public what interests a scientist. Every time it is possible, you should make the effort to also offer the public something that lasts and that is considered useful, interesting or that they can tell family and friends about, even if it is only marginally tied to the main topic.
If for example you talk about genetically transmitted deafness, it is useful to give information on new instruments to discover it at birth. If you talk about the importance of flavonoids in a healthy diet, it is right to give nutritional advice about eating fruit and vegetables. In addition to an opportunity to spread important knowledge, it is a way to thank the public for their attention.

Choose your message

The greatest book is not the one whose message engraves itself on the brain - but the one whose vital impact opens up other viewpoints.
Romain Rolland

After your aims have been clarified, your audience identified and the topic's constraints and opportunities analysed, it is necessary to focus on the message. The message is the extreme synthesis of what you want to communicate, or rather the essential core of the contents or line of reasoning that should, in any case, be learned and remembered by the receiver: everything, in the communication, must contribute to getting it through to the public. The message is almost never as obvious as it is in the communication. Indeed it guides it like the north star: it helps to give focus to an interview, it is the nut of the question that you want a journalist to address immediately, it is the first input that you give a press office or whoever has to produce a communication for us.
In order to be effective, the message must take account of the objectives, but above all, the public's needs, and it should be summed up in just one sentence. "Ninety percent of the research on rare genetic diseases was conducted by Institute X and helped to discover the cause of the most serious and widespread non genetic diseases", could be the message for a fund-raising campaign for research. Whereas "The new polymer is the first worldwide which can substitute silk and will renew the national textile industry", might be the gist of the announcement for a new patent.
Careful attention should be given to possible incomprehension or misunderstandings.
A message must be brief and clear, but not generic. "The catalogue of historic earthquakes will help to classify the Italian territory more precisely in terms of seismic danger, thus preventing damage produced by earthquakes more effectively" is better than "The catalogue of historic earthquakes is a fundamental contribution, the pride of European seismology".
Focusing on a message is essential especially when using "fast" and ambiguous means, that leave limited space to reflection, like the radio or television; because it is that morsel that will remain in the heads of an audience which is often distracted.
In defining the message it is important to make an effort to go beyond the initial hypotheses that come to mind, remembering above all who you are addressing. If for example we want to promote a university's degree courses in science, different publics are sensitive to different messages. A government or a banking foundation might be asked to contribute because "the graduates in the field of science are important to eco-

nomic development". If we are addressing young prospective students you can appeal to the fact that " a science degree opens the door to a fascinating world and can be the gateway to an international career". Whereas their parents might want to know that "it is not true that you cannot find a good job with a science degree". If there is more than one group being addressed, it will be necessary to weigh and balance these messages.
Wherever possible, the message should first be tested and if necessary adapted, and subsequently its impact should be assessed.
The aims chosen, the public being addressed, the topic's constraints and opportunities, and the message are the elements to put together when you move on to the actual drafting of any communication.
The subject in the next chapter is communicating in person, while the chapter that follows deals with communicating through journalists. Before dealing with them, however, it is necessary to consider the existence of at least one other aspect of planning.

When communicating is an uphill battle

Victorious warriors win first and then go to war,
while defeated warriors go to war first
and then seek to win.
Sun Tzu

Not always can you announce the discovery of a simple cure with no side effects for a terrifying disease, or a new source of clean and cheap energy, or the intention to carry out a research project at no cost, whose benefits are clear to all and have no bioethical and environmental contraindications. In the real world, things are almost always more difficult.
Very often, public communication of science helps to face complex situations, but at times the work is all uphill. This is what happens with topics like GMOs, the chemical or nuclear industry, or simply basic research in fields that may seem esoteric.
In these cases a single contribution is not enough and a more complex and concerted effort is needed. Generally speaking, it is more expensive and usually extended over time and requires a more sophisticated approach: when tactics are not enough, you need a strategy.
Having a strategy means, first and foremost, knowing how to identify all stakeholders with interests in the issue, and being able to interpret the complex relationships that tie them together: particular segments of the public, policy-makers, non government organizations, the media, the scientific community and opinion leaders.
It is then necessary to analyse the public images circulating within the social body, to measure public opinion with special surveys or other instruments and reconstruct why and what caused these problems.
On these bases, then, it is important to form alliances with groups that have our same interests, such as particular industrial associations or associations for the sick, environmentalist organisations or political forces. Together a course should be traced and agreed upon to create knowledge and awareness about the topic, or to change the existing perception of it.
Finally it is necessary to ensure the financing to be able to carry it out.
There are no recipes or simple check lists to create and implement a strategy of this type, which goes far beyond the single scientist's possibilities, if for no other reason than the fact that in the field of science such previous experiences are few, even at the international level. Nor can a simple survival kit deal with these problems. Yet it is important to know they exist.

The ten laws of human communication

Before getting down to work, it might be useful to check the planning of your communication in the light of a small Decalogue that recalls a few psychological truths (from Hugh Mackay, Why don't people listen?, 1994).

1 *It's not what our message does to the listener, but what the listener does with the message, that determines our success as communicators.*

2 *Listeners generally interpret messages in ways which make them feel comfortable and secure.*

3 *When people's attitudes are attacked head-on, they are likely to defend those attitudes and, in the process, to reinforce them.*

4 *People pay the most attention to messages which are relevant to their own circumstances and point of view.*

5 *People who feel insecure in a relationship are unlikely to be good listeners.*

6 *People are more ready to listen to us if we also listen to them.*

7 *People are more likely to change in response to a combination of new experience and communication than in response to communication alone.*

8 *People are more likely to support a change which affects them if they are consulted before the change is made.*

9 *The message in what is said will be interpreted in the light of how, when, where and by whom it is said.*

10 *Lack of self-knowledge and an unwillingness to resolve our own internal conflicts make it harder for us to communicate with* other people.

TELLING A SCIENCE STORY

Telling a story, or rather getting read

Always do what you are afraid to do.
Ralph Waldo Emerson

If we run through the list of international bestsellers from the last few years the science books we find are usually stories.
It is a lot more difficult for an essay, in the strict sense of the word, to meet with success. In Oliver Sack's stories, for example, the oddities of the human mind are investigated by neuropsychology with stories of real people, stories in which every scientific discourse apparently disappears. The writings that made Stephen Jay Gould famous are often inspired by real events or famous people. Stephen Hawking explained the frontiers of astrophysics in A Brief History of Time. Indeed a trend in publishing which has become extremely popular and particularly successful, uses science stories to talk about entire branches of learning. Fermat's Last Theorem by Simon Singh represents perhaps the most famous case.
A story can be found anywhere, in documentaries, on television shows and radio programmes as well as in magazine articles. It may be only one of the ingredients used, perhaps as a device to catch the audience's attention right from the start. The exceptions are relatively rare, however, at least in successful communication, and are usually found in those areas in which the communication reports on socially useful information, like information for people with a particular disease or information on risks.
Public communication should never be a simple list of information, like an instruction manual, even if it is translated into simpler language. Our mind, faced with new information, always looks for a meaning, an underlying theme to latch onto. At the very least, the line of reasoning presented should be introduced with an opening question, followed by an exposition of facts and then a discussion and answers. The most effective solution, however, consists in "disguising" the line of reasoning inside a story. This story acts as the audience's guide through the thick forest of unfamiliar subjects, so that they will not feel lost, and will actually encourage them to continue onward.

Turning a scientific discussion into a story means making a discussion that is not natural, natural; making the abstract concrete, or rather, turning what the author wants to say into what the audience prefers to hear.

WHAT IS A STORY

A story is a type of substitute experience that draws the reader, or the listener, into a situation which (s)he would never have experienced otherwise. For this reason we find certain recurrent elements developed (and not simply cited):

- characters we get to know and can identify with, including some good and perhaps even some bad (a researcher, a group of sick people, an animal population, a cyclone, a photon inside the Sun…)

- the driving force behind the way a character behaves which appeals to public interest (revealing a mystery of nature, solving an environmental problem, saving someone, predicting a natural phenomenon)

- the setting (a laboratory, an exotic forest, the upper atmosphere, a coral reef…)

- the time period (today, Galileo' era, twenty years from now when we will have landed on Mars…)

- the action which takes place over time, or rather the structure which organizes the whole story

How to find a story

The choice of a story, from the many that can be constructed around the same topic, should be based on your audience, the medium, the space available and your objectives.

At times the story will choose itself, in a manner of speaking. In order to explain what gene therapy is, for example, you might tell the story of a child affected by a serious autoimmune disease, beginning with the discovery of the disease up to its cure.

At times the choice is less banal. In this way, physics in the twentieth century could become a Biography of Physics; the developments in evolutionary biology might fill the history of the research carried out by the Grants, a married couple that for decades on the Galapagos islands have traced the evolution of Darwin's chaffinches as it has occurred; while the climax towards the explosion of Krakatoa might provide the idea for a large fresco on the progress of geophysics and the impact of geophysical phenomena on the biosphere and human life.

If you are not able to find a suitable story right away, the best thing to do is take the elements identified during your planning, beginning with what you found in assessing your topic, and find a narrative map which can put them together. You could begin with the most promising element and then make sure the others fit in coherently.

To talk about the carbon cycle in nature, for example, if the most appealing idea seems to be the link between the worlds of living and non living things, you might try the trick Primo Levi used in his famous story Carbonio. In this story he describes the element's biogeochemical cycle through the adventures of a single carbon atom in rocks, the atmosphere, plants, animals and men.

During this stage it is necessary to find the right images. In most stories that work, certain standard figures or devices can be found; very often they can also be used to tell science stories. One of these is the struggle to overcome apparently undefeatable obstacles, another is the countdown towards a dreaded event, or perhaps there might be a contest between dishonest opponents, the misunderstandings of others, the "crossing of the desert" etc. In Primo Levi's story the theme is a journey and the return home. At the beginning of the story the atom is freed from a calcareous rock and after thousands of adventu-

res returns to form another one. These images are especially useful at the beginning of the story, where it is important to establish a relationship with the reader, and at the end of the story, where they help to reinforce its emotional aspect.
Once a satisfactory storyline is outlined, it is necessary to verify that it is coherent with the objectives set and the message chosen. Primo Levi's journey of a single atom of carbon may be suitable to describe the importance of carbon in the biosphere, but not in a discussion on climatic changes: in this case it would be better to follow a group of carbon atoms, in which only a few manage to return "home" to a rock, while others are forced to remain in a purgatory called atmosphere, as molecules of carbon dioxide. A good science story, in addition to transmitting information and stirring emotions, should then make its public fly higher, offer an important interpretation or communicate the meaning of the topic. To continue our example, it must explain that a thousand different strands, visible and invisible, join the biosphere to non-living components of the planet. The story, in other words, should simplify the complexity of topic to a "legitimate" level, without sacrificing its conceptual depth.
The story, finally, must be easily told in the space and time available, which is usually limited.

HOW TO CONSTRUCT A STORY

A GOOD IDEA IS ONLY THE BEGINNING, BECAUSE THE STORY NEEDS TO BE CONSTRUCTED. THE FIRST STEP IS TO MAKE AN OUTLINE. PROFESSIONAL WRITERS KNOW WELL THAT WRITING WHAT YOU HAVE TO SAY IN ONE SITTING IS ALMOST ALWAYS A UTOPIA, AND THIS IS TRUE FOR BOTH LONG AS WELL AS SHORT TEXTS. IN FACT, OFTEN THE MORE CONCISE THE TEXT NEEDS TO BE, THE MORE DIFFICULT IT IS TO WRITE. THE OUTLINE SHOULD DEFINE THE PHASES IN THE STORY, ASSIGNING EACH PART A PURPOSE AND ARRANGING THE NECESSARY MATERIAL IN THIS ORDER. WITH THE HELP OF THIS GUIDE, WRITING BECOMES MUCH EASIER.

There are no rules to construct a story, which is the result of personal planning, but some advice could be useful.
For a start, it is necessary to find a point of view which stirs an emotion, or at least is already of public interest. In order to talk about sharks, for example, it is better to begin with the fears that they might arouse, even if the objective is, in fact, to show that these fears are unfounded. The public need to be accompanied step by step to this conclusion. In order to discuss the molecular bases of some heart diseases it is better to begin with the sudden death on a playing field of a famous footballer, than with the ionic channels in heart cells. Capturing your audience's attention must be done at the start, otherwise the public are lost before you have even begun.
Be careful though. Do not play all your best cards at the beginning because the narrative path needs to be paved with golden coins. New and interesting information acts like bait drawing the audience to the conclusion, where it would be fitting for them to find a few surprises. For example, you might show that the study of these rare heart diseases could lead to a cure for heart diseases which could touch anyone of us. After the opening, a brief and clear account of the facts would be appropriate to clarify what you want to discuss. In our example, we describe how a heart is made, how the electric signal which orders the contraction is emitted, how the heart cells are connected and coordinated. Then the narration itself begins.
A story that works is not a simple series of facts placed in order. On the contrary, it is the result of a selection of events that lead to something significant. The narration that "captures", then, is not sequential, but consequential. It needs a plot, which is nothing more than a construction of events meant to produce a particular effect on the audience. In our case this effect is the explanation of a phenomenon; thus, the plot follows the various physiological mechanisms which ensure the normal functioning of the heart pump, highlighting the weak points which might give out after problems in the ionic channels, but which can also be protected if these problems are discovered in time. If there is not much space – or time – available (thus almost always) it is better to follow just one line, without sidetracking which makes the reader or viewer go back and forward, because they will get lost easily. Unlike what happens in fiction, in which digressions and flashbacks are commonly used, in science communication the story contains a line of reasoning, that the public should follow effortlessly in only one direction. To conclude, it is usually worth going back to the initial question or situation, thus closing the narrative circle. If the story opens with a question, the end must contain the answer. The finale should also leave the public with something, usually a clarification of the message you decided on in the planning stage, because the last thing read or listened to is normally what is most easily recalled, and what will continue to echo in their minds.

CONTROL

Just like an evaluation of the topic is carried out during planning, the outline needs to be checked by putting yourself in your public's shoes. This is the only way to verify if the narration flows, if there are any gaps or incongruences, if there are times in which the attention fails, or on the contrary, is too heavy, anticipating emotions and reactions stirred by each passage and consequently, adjusting them.

Arguing, or rather persuading

People are generally better persuaded by the reasons which they have themselves discovered than by those which have come in to the mind of others.
Blaise Pascal

The power of a story that rings true is very strong, because it helps the mind "to see" something that is occurring, and we all tend to believe what we see, even if only in our imagination. Yet, it is not necessarily true that this is enough to convince.
Often persuasive arguments are needed that do not necessarily coincide with the nude facts, which are what is found in scientific papers. This is true simply because the public do not know everything that an expert in the area knows. Thus, it is necessary to learn to weave not only a line of reasoning around a story, but also a convincing argument, or more specifically, instructions for interpreting the facts and correlations in the argument, which clarify.
If for example you discuss introducing a gene into a plant with molecular biology techniques, it might be useful to clarify for those who are not familiar with the improvement of cultivated varieties, that genetic modification is much more limited, precise and better known than modifications carried out with traditional techniques.
In one word, it is important to use a bit of rhetoric. This art does not always get good press, particularly among scientists, but in some circumstances it is simply naïve to disregard its basic principles. If applied with honesty, in fact, it can make the communication much more effective.

Thinking about the public

Convincing is not only a problem of technique. As the ancients already theorized, it first requires taking your public into consideration.
The first fairly obvious condition to be persuasive is, in fact, adopting the type of argument that your particular public are more inclined to accept, and appeal to the motivations most important to them. If, for example, you want to persuasively promote the opportunities offered by the use of GMOs in agriculture, it would be more convincing to talk to farmers about why these products can help the competitiveness of their farms, also in the long term; to consumers about why genetic engineering can safeguard local products by protecting them in the least invasive way from parasites; to politicians about why the rest of the world is using them.
The second and less obvious condition is to establish the right type of relationship, because this will influence how the information given is received. To affirm, for example that "any serious scientist will tell you that no genetically modified food is harmful to your health" is one of the best ways to irritate your listener. Persuading means, in fact, deciding not to impose a power based relationship and recognising your public's ability to understand and decide for themselves. In other words, it means respecting them.
Moreover, it also means respecting their opinions. When you argue a point, in fact, you admit that at least in principle there are other possibilities. To begin by saying that "opposition to GMOs" is based on irrationality, or unmentionable interests" denies that there are any others: your own thesis, when you are talking to a sceptical audience, must be demonstrated.

How to construct a line of reasoning

A solid line of reasoning is important, and should include elements which need to be identified or defined carefully:

- the thesis, or rather what you want to convince your public of ("Tests for approval have successfully demonstrated that GMOs do not pose health risks");

- the arguments, or rather the statements underlying the thesis (the approval procedures make it possible to exclude with certainty the problems feared.");

- the proof, or rather the factual data which supports the arguments ("in ten years, although GMOs have been consumed by hundreds of millions of people, not even a stomach-ache has been reported");

- the premises, that are the explicit statements at the basis of the entire argument ("all plants we cultivate are the result of genetic modification, including radical modifications, brought about on the wild progenitor plants for thousands of years");

- the assumptions, statements or circumstances that are not even mentioned since it is presumed that the public already agrees with you on them ("we all want products that are safe for our health");

The actual construction of your line of reasoning with the help of these elements can be carried out with various methods. The classic method based on Latin rhetoric is usually the most effective and can be suitable in extremely different circumstances. This includes the following sections:

- exordium: the introduction used to win over the public and explain why the speaker is important for the topic;

- narratio: the exposition of the facts which introduce the topic;

- confirmatio: the exposition of the arguments and the proof in their favour;

- refutatio: the exposition of the arguments against the opposing thesis;

- peroratio: the explanation of the conclusions' meaning for the public and the declaration of what you expect the public to do or think.

As you can see, the classic rhetoric model is not very different from the prescribed format for a scientific paper. A persuasive communication based on an argumentative construction uses, in fact, what psychologists call a "central path".
This path requires the listener to pay attention, reflect carefully on the information provided, relate and integrate the information with what (s)he already knows and elaborate a new assessment. In other words, it requires a certain amount of cognitive energy.
The problem is that in a society characterised by information overload we cannot think carefully about every message that reaches us, and very often the spaces available are very brief, as in a TV interview for the news. In this case you can use "shortcuts", or rather what psychologists call a "peripheral path". In this instance, force of persuasion will not be left only to arguments pertinent to the thesis, but will also depend on the attractiveness or the charisma of the speaker (a well know scientist or a Nobel prize winner, for example), the surprise offered by a partial datum (soya and kiwi cause allergies, not GMOs") or even to a few witty words.
Other tools of persuasion can be added to the classical ones, and are often effective when talking about science.

The counterintuitive result

Catching the public by surprise can destabilise the public's assumptions and help to open the door to new information, thus creating a new cognitive equilibrium. In food information, for example, popular fads and clichés, like the importance of iron in spinach the dissociated diet, that pasta makes you fat or fruit should be eaten with the peel, can be disproved. (these cannot really be considered fads because they have been considered "true" by generations of mothers)
This tool works well when the topic is not particularly controversial. Otherwise it could turn out to be counterproductive, for it may trigger confrontational feelings.

Comparisons

For the same reason you can also make a comparison with a similar situation, usually in another country. In order to convince your public of the importance of earthquake-proof buildings you can talk about the different consequences that earthquakes of equal strength have on Turkey and Japan, perhaps comparing two equal-size earthquakes that actually occurred. The idea in this case is to help understand how many things we take for granted that we should not (like "earthquakes kill", while "it is the house which collapses that kills").

The use of data

Few but well chosen data can change the premises of the discussion themselves. Showing, for example, how the number of animals used in experimentation has declined over the years, is better proof than many statements of principle that researchers want to avoid useless suffering and use alternative methods whenever possible.

The ace in the hole

A few significant cases can say more than an entire discourse.

When discussing the importance of animal experimentation, you can talk about how the discovery of insulin used to control diabetes would not have been possible without experimentation on dogs.
Or, to demonstrate the importance of curiosity-driven research, you might explain that the computer is the result of studies of pure logic by Alan Turing. And again, on the home page of the website for the Society of Neuroscience there is a link to a page called "Brain research success stories", explicitly dedicated to those stories able to persuade the public and policy makers of the need to increase federal financing of biomedicine.

Forecasts for the future

A story told is something in some way real, and an extrapolation of something that already exists acquires the flavour of certainty.
To persuade your public of the potential of stem cell research you can help them to see how different the future will be for a person diagnosed with diabetes or Parkinson's disease in twenty years, when regenerative medicine will have achieved the hoped for advances. This can be an extremely useful tool as long as your extrapolations are not too farfetched.

Changing the premises

Sometimes it is not easy to understand why the public have such a distorted idea of a subject, but once the reason has been discovered you hold the key to changing that idea.
The lack of appeal in the study of materials science, for example, is in good part owed to the very prosaic and sectoral image that outsiders may have. To disprove the prejudice surrounding this discipline it might be sufficient to associate it with creativity and explain how the wide-ranging use of advanced materials means that graduates in this field will have the opportunity to pursue their own individual interests.

Opening up to the other side's reasons

If the public have different ideas on a topic, these should be recognised, and if possible appreciated. On the more controversial issues in particular it is better not to set off useless opposition. On the contrary whenever possible you should try to be receptive to the adversary's opinions.
Take for example a television programme dedicated to the centennial of the birth of Giulio Natta, an Italian chemist who won the Noble prize in 1963 for the discovery of some of the most frequently used plastics today. In addition to talking about the social value of the introduction of plastics and the thousands of benefits that they brought at all levels, it also cited some of the problems tied to the production of waste. This fact created some ill feelings in one of Natta's biographers but gave credibility to the programme, thus avoiding any accusation of partiality (for "polluting chemicals").
In the same way, when speaking about homeopathy it is better to discuss the importance of a good relationship with the patient, something usually highly appreciated in homeopaths, with the hope that the same relationship might characterise the relationships with allopathic doctors, who can also offer effective therapies.

Playing on positive feelings

Sounding an alarm, playing on fear or widespread criticism is often counterproductive. The idea of a dead end situation may tempt you to dismiss the problem, or in any case, put off any type of engagement with the public.
Optimism of the will is almost always more effective than pessimism of reason.
The success of Italian television reporting on science and society grew decisively when it stopped discussing only the negative side of things. The new reports, in fact, use success stories to discuss more general topics, including the importance of high tech companies, university startup and the value of basic research. Only at the end of each report does a short data-filled file explain that the success story was really a happy island in a sea of troubles.

Method is more important than the result

At times, understanding how science works can be even more convincing than the results achieved. This might be the case, for example, in a comparison of science with the pseudo sciences and the paranormal, in which showing how a scientist searches for the truth is more useful than tying to disprove, time and time again, the thousands of statements which continue to represent themselves on extrasensory perceptions or UFOs.
Teaching the public to use scepticism regularly, rather than explaining why a certain phenomenon is impossible, is like teaching someone to fish rather than providing the fish.

Control

Just as you checked the story, controlling your line of reasoning requires you to put yourself in your audience's shoes; this time you want to look for weak points in your reasoning, foreseeable perplexities which you did not account for or gaps in your logic.

Explaining, or rather making what is difficult easy

Everything should be made as simple as possible, but not simpler.
Albert Einstein

There exists a threshold of difficulty below which the mental machine does not turn on, and another above which it gets stuck.
Piero Angela

An explanation is the lowest common denominator of any type of science communication and the first measuring stick it is judged by.
In communicating with the public, then, the pleasure of understanding must be second to the pleasure of the explanation, because the public should not feel as if they have to do homework, otherwise, they will give up.
It is not easy to be clear. If describing and convincing require a good amount of intuition, explaining primarily requires practice. A series of suggestions and the knowledge of a few tools, however, help avoid reinventing the wheel.

Clear ideas

The first condition is to clarify your ideas: it is not possible to be clear if you do not think clearly, if the meaning of the topic, in addition to its technical contents, is not clear.
If there exists one small secret in the popularisation of science, it consists in identifying one interpretation. This should be single unifying idea that is obviously suitable for your aims and public, and can act as a filter for the information so that the entire discourse revolves around this interpretation. Talking about the life of the stars, for example, can mean concentrating on the importance of their mass in predicting their destiny while omitting other considerations.

How much should be explained?
It is necessary to explain everything that helps to understand the topic or to make the message convincing, but nothing more. You should resist the temptation to talk about as many things as possible. Your public's most limited resource, after their attention, is the their cognitive energy.

How much should I simplify?

It is important to offer your audience a mental challenge that they can handle; therefore it usually needs to be relatively simple.
Every time you engage in scientific popularisation, in fact, to some degree a compromise needs to be made, thus losing a part of the topic's complexity or depth.
To understand how much you need to simplify, you can weigh the costs of simplification against its benefits: if further simplification means distorting the message, then you should go no further. If however, precision and thoroughness means that the message will be lost or the public will lose interest, greater simplification is needed. Often it is preferable for the public to grasp the overall meaning of the discourse, rather than only parts of its contents completely.
As a rule, you can adjust your information by thinking about what type of specialist knowledge you would understand in a field that is different from your own, perhaps outside the scientific world.

Developing a line of reasoning

Presenting a line of reasoning, even in story form, is one way to tell the public that what follows needs consideration, and that they will need to pay a bit more attention than usual, or in any case focus a little bit differently. The line of reasoning will be the foundation that supports your explanation, but compared to what is usually presented to colleagues, there will have to be enormous differences.

Points of reference

The main difference is that when talking to a non peer audience it is necessary to reconstruct an overview of the topic, an absolute must for the public. And to do this you need to begin with familiar examples, since it is easier to understand something that you have a mental picture of. In other words, it is a matter of providing the public with a map they can use to orient themselves with.
The first type of map is used to identify the position of the topic in the territory represented by scientific knowledge of the world. Let us imagine we must explain the meaning of a sexual signal in the female body like the 2:3 ratio between the waist and hip measurements, an indicator of a good ability to reproduce since it is the result of an excellent hormonal balance. In this case it is better to remind your audience first that we are the product of an evolutionary process that rewards those characteristics which assure the highest number of offspring. And then that there are other characteristics to be selected including psychological features like personal preferences, especially the ones tied to the choice of a partner.
Those who do not have these underlying concepts in mind might find the idea of choosing something

based on an unconscious element almost absurd.
Similarly, the public might need a real map if you are talking about an object that is not familiar, usually because it is invisible.
If for example you discuss the human genome, not everyone knows exactly where it is and what role it plays. It would be a good idea, then, to recall straight away that our body is made of thousands of billions of cells, and that each one holds the nucleus of a genome couple, that is a bit like its "instruction manual".
Every map must therefore begin with something familiar. From this point you can circle in on the subject until you have reached the core of your explanation.

Warnings

At times the place you bring the public to is particularly unusual, difficult, or in any case far from the everyday world. In these cases it is better to warn them, presenting the topic as an adventure into a strange and fascinating land. This may be necessary when you explain how new particles are created with the help of an accelerator, thanks to the transformation of energy into matter: here you can show how Einstein's famous formula works, E=mc2. You ask the public for a small act of faith, because nobody ever notices this type of transformation in their daily life; but to be sure no doubts remain you remind them that the inverse transformation is the one which occurs during the explosion of an atomic bomb.

Terms and concepts

Technical terms should be avoided whenever possible. Any communication, in fact, must use shared codes. The terms coined to allow specialists to communicate more quickly and "economically" are useful to them and those training to become like them, for example, university students. Yet, in general, they are only obstacles that cause us to give up, even if they are accompanied by a definition. Mitochondria are "the cell's power plants", but it is not always necessary to use their name. The criterion to decide whether or not to use a technical term is its usefulness, or rather if it needs to be used often or if the public will have to use it again.
To avoid creating problems for your audience it is always better to explain terms and concepts, even if it may seem banal to do so, because they often reflect semi-knowledge that is not well understood. Among these we can include, for example, "DNA", "natural selection", "scientific theory", "immune system": never take anything for granted.
For the same reason it is advisable never (or almost never) to use mathematics, which is almost completely absent from popular books in this field.
The most important concepts of the explanation, then, should be repeated if necessary, to be sure that they are understood. Repetita iuvant.

Examples

In general, concrete things are more easily communicated than abstractions. For this reason, as soon as it is possible, examples should be provided: a prediction of Etna's eruption helps to understand how a volcano is monitored. A demonstrative case makes it possible, in fact, to "see" a general concept, that you come to or return to, by extrapolations, similarities or differences. Multiple cases can help, but be careful: one example explains, two divide, three contextualise, but four are already an inventory list.

Dimensions

In science often such large or such small dimensions are used that it is difficult for our mind to conceive of them. Two hundred million years, 1 nanometre, 10 megapascals, are almost abstractions for a person who is not used to these units of measurement. If you put two or three of these in a row in a talk, you will irreparably disorient your reader or listener. Thus it is necessary to use this type of data with parsimony, aided perhaps by an analogy.
To explain the size of a molecule of DNA, for example, you can explain that, if it were enlarged 100 million times its atoms would be as big as a golf ball and that the human genome would be 80,000 kilometres long, about twice the length of the Earth's meridian.

Metaphors

A very important tool for explaining is the metaphor, the rhetorical figure which replaces a word or expression with another that offers an intuitive analogy.
It becomes particularly useful when describing phenomena that cannot be described with terms or examples relative to daily life experiences. When explaining research on the prevention of new blood vessel formation in tumours, for example, you can talk about "cutting off supplies". Nuclear particles become "small balls". The co-evolution between prey and predator is described as an "arms race".
A metaphor can also help to provide an interpretation of the topic. In a television story on physiology and pathology in different age groups, sexual organs were compared to an all-terrain vehicle (youth), a salon car (adults) and a vintage car (the elderly), to explain how they do their job over a lifetime, highlighting however, their changing ability to face surprises.
The power of a metaphor lies in its ability to provide an image: it is more natural than an abstraction and makes it possible to achieve the closest possible idea of something. In general, metaphors are extremely important social representations because, like bridges, they make it possible to insert new ideas into the cognitive world of society; for this reason they have even won a place even inside mainstream science (just consider "The hypothesis of the Red Queen" or the "selfish gene" in

evolutionary biology). As such, they are, however, very frequently responsible for the distortion or trivialization of the facts of reality.
Therefore, after it has been used to introduce a subject, a metaphor should be dismantled thoroughly, cleaning it up and refining it, in order to attain (or at least get closer to) a more correct explanation. Thus, atoms stop being little balls and genes lose every moral connotation.

Discoveries

A particularly effective strategy, which is easily combined with narration, is to take the public through the phases leading up to a discovery. In order to explain that matter is made up of atoms and molecules you can start with Dalton and end up at the atoms "photographed" by the tunnel effect microscope, using Einstein's explanation of Brownian motion. In this case the author is a "facilitator" who provides the right elements, one by one, so the public can reach their conclusions by themselves.
This tool is very effective for various reasons. First of all it induces the public to put themselves in the scientist's shoes so they understand the way (s)he works and thinks, but most importantly it gets them involved.
Thus, the discovery of something stimulates a trust in their own abilities to understand, and helps them to learn to stop waiting for others to give solutions. In addition, since the public must use the information that they are given each time, it becomes easier for them to digest and remember it.

Experiments

When something hard to believe is at stake an experiment can be a useful resource; it can be real or only mental.
In the first case a real experience is provided: for instance, Scientific American ran an article on hypnosis, supplementing the experiment with the story and photos (and a video on the web site) of a session of hypnosis that some magazine editorial staff members participated in.
In the second case the experiments are mental, similar to Einstein's lift experiment, Schrödinger's cat or Maxwell's little devil. They make it possible to observe an invisible phenomenon from a privileged point of view, concrete and without the ambiguities of metaphor.

Controls

Verifying the effectiveness of an explanation is usually, for a researcher, more difficult that judging whether (s)he has successfully described the topic or persuaded the audience. There is a tendency, when you speak or write on a subject that you know very well, to assume that others know what you know about the topic. Furthermore you do not have the experience with "lay" problems that journalists have.
Nothing is more important in this case than knowing how to put yourself in somebody else's shoes and checking your work again to see if there are any grey areas. Nothing should be taken for granted. It is necessary to review your work, trying to foresee any problems the public might find, and trying to be still clearer.

The text: short, clear and effective

The less we know, the longer our explanations are.
Ezra Pound

Whatever the medium you use, the quality of the text is always extremely important. A poorly written text can, in fact, thwart all the energy poured into the work. Ever since the expression "knowledge-based society and economy" stopped being a slogan and turned into a true description of reality, all sectors of communication have begun to appreciate this, and consequently professional writing has become a subject taught in universities.

A good text does not uselessly overwork the reader, it provides its contents naturally and has a distinct "personality", for it establishes a relationship with the reader.

Here below we summarise a few general rules for good writing that we all know but do not always remember to use.

Brevity

The longer a text is, the more it abuses of a scarce resource, the reader's time, lowering the odds that the latter will read it all the way through, but also that (s)he will begin reading it at all. As a rule, the probability for any document to be read and understood is directly proportional to its brevity.
Today, most spaces and formats call for brevity, reflecting the public's new habits.
The fact that every communication becomes faster can penalise the exposition of complex topics like scientific topics, but brevity and concentration also force the author to be clear, pruning the text of excess words and digressions that might hide or confuse the messages. During revision you should not

hesitate to cut: most texts improve after a good trimming.
The other side of the coin is that, contrary to what you might think, the effort needed to write (like the need for good planning and a good outline) is inversely proportional to the space available.

Clarity

Just as for an explanation, the first secret of clarity is simplicity: when choosing between two expressions, it is better to choose the simpler one, the one that uses fewer words, discarding the longer and more involved ones.
Here are a few suggestions for simplifying a text.

- Begin sentences with the subject and verb and leave the subordinate clauses to the right side. A clear sentence can also be very long, as long as the subject and verb announce the theme and meaning immediately.

- Observe the "rule of closeness": keep together subject, verb and direct object; the noun and the adjective; the preposition and its object. Do not separate them with useless parentheses, forcing the reader to go up and down to put the sentence together. If there is a lot of information to give, do not try to use just one sentence. Put parenthetical clauses at the opening or closing, or break up the sentence using adverbs to tie the sentences together.

- Avoid clusters of relative clauses. There should never be two "that" or "which" in the same sentence: use a nice full stop and begin a new sentence.

- More emphasis is given to the beginning and the end of a sentence. Thus, place the most important things you have to say there.

- Repetition of key words helps to attract attention to the most relevant elements.

- One piece of information for each paragraph. The paragraph is more incisive if the first sentence states the information, and those that follow explain it.

- The rhythm of a text is largely created by varying sentence length. Long sentences carry the reader more quickly to its comprehension and for this reason they must be perfect in readability, fluency and clarity. Brief sentences create pauses.

- When the subject and the line of reasoning become complicated, short words and paragraphs should help. A sentence that most people can read easily has at most twenty five words. Slowing down the rhythm of the information, in fact, helps comprehension. If the sentence is short, the reader will read more slowly and will take the time necessary to think, digest, compare and learn.

- The presentation is also important: avoid long and monotonous texts and provide visual variety to the page. Use as many titles, subtitles, paragraphs and lists as possible: breaking up the text helps the reader.

- Choose words and expressions carefully: always select words and expressions that are short, precise, concrete, familiar to the reader, avoiding jargon, incomprehensible abbreviations and pointless foreign words.

Effectiveness
A text is effective if it adheres to the contents naturally, and successfully engages the reader or listener directly and personally. For this reason, in addition to practice, empathy with the reader or the listener is particularly valuable. Thus, here are a few suggestions:

- While you are still thinking about your text, try to "portray it" as a story and put it on in your mind. This is the first way to write it.

- Give your text a real "voice", lively and clearly identifiable. Whoever is reading must have the impression that you are speaking to them directly, with a language (s)he recognises. To be sure, re-read it aloud.

- Talk, whenever possible, in the first person (do not use impersonal forms), perhaps using the "we" to eliminate the distinction between the reader and author, put yourself in their place.

- Always choose verbs rather than nouns, use them in the active voice and include lots of gerunds and infinitives, filled with power, action and energy.

- Be careful with adverbs, that very often dilute the meaning of the verb and prevent it from expressing its strength completely.

ß Check punctuation, which organises the text and gives it meaning: listen to what you are writing and check how it sounds.

- Try to play with words, even in very serious texts and articles. Choose common, everyday words for contexts where they are not usually used. This is a good rule of thumb especially when writing in and for sectors characterised by jargon and technical words, like science and technology to be precise.

- Avoid clichés and overused expressions, like "from the infinitely large to the infinitely small". As the English writer George Orwell suggested, do not ever use a metaphor, a simile or another rhetorical figure that is ordinarily found in publishing. The reader feels as if (s)he has already read or heard it and therefore pays less attention, when (s)he does not stop reading entirely.

- Do not be afraid to use repetitions intelligently but sparingly to emphasise your messages and increase their impact. Repetition can cause monotony, but if it is dosed correctly it is an important tool for strengthening and highlighting key words at key points.

- The reader must feel as if (s)he is sliding naturally from sentence to sentence. Make sure, then, that one sentence flows into the next. Connectors and transitional phrases – despite, and yet, but, in the same way, however, then, thus, in fact, therefore – are what join your sentences together and function as signs which show us where we are going; they are what makes a group of sentences a coherent and convincing discourse.

- Telling is not enough, it is also necessary to show. The "ladder of abstraction" should be climbed quickly upwards and downwards: at the bottom there are objects and things; at the top, ideas and concepts.

- When the subject is serious use a light tone, or if possible, humour. When it is not, go ahead and exaggerate especially when talking about science, which is usually associated with heavy ideas.

- Never underestimate the usefulness of titles, subtitles and headers; this so called "paratext" helps readers understand how a discourse is arranged.

Control

To revise a text means exchanging the writer's for the editor's hat: the text is usually read aloud. Your ears, in fact, are more sensitive than your eyes to contorted or disconnected transitions, a pace that is too slow or too quick, errors, misplaced words, excessively long sentences and irritating repetitions. The text should be re-read at least twice, the first time immediately after writing it, and the second time after letting the text sit for a while, which also helps to overcome any aversion you may feel towards picking it up again.

The use of pictures

A photographic image is a message with no code.
Roland Barthes

The fact that ours is a "civilization of images" is not simply a cliché. There is an ever increasing number of pictures, fixed or moving, requested for every type of science communication, so that at times the pictures themselves become the opportunity to talk about a subject.

Pictures attract attention and stir emotions instantly; they can help to tell and explain why with less description or even hold a metaphoric value, creating synergy with the written text. For this reason it is true that "a picture is worth a thousand words".

Even if a picture may hold extraordinary power to communicate, their use must follow various rules and requires special attention. Unlike written language, a picture does not tie the speaker to the listener with well codified meanings. In other words, it can be ambiguous.

In the video of a microchip manufacturing company, for example, you can see technicians at work in a white room and wearing suits that even cover their heads, hands and feet. Yet it is never said that those clothes protect the chips from human contamination, and not vice versa. For a lay person those suits evoke the need of protection from something harmful: as a result, instead of transmitting the idea of technological excellence, the video communicated the idea, counterproductive and damaging to the company's image, that in that factory dangerous material was being handled.

Pictures communicate without any mediation, and do so always and in any case by stimulating our interpretation. The outcome of this interpretation depends, however, on who, when, where and in what context it is observed. Before using pictures, then, it is important to reflect not only on their beauty, effectiveness and comprehensibility, but also on the meanings that the public you are addressing might attribute to them.

USING JOURNALISTS

Journalists and scientists: two different cultures

Journalists are ignorant?
If we were scholars we certainly would not be doing this job.
Natalia Aspesi

To be in the media

In April 1992 NASA's satellite CoBE (Cosmic Background Explorer), practically unknown to the general public, sent pictures to Earth of small irregularities in the cosmic background radiation dating back to the Big Bang. These represent the earliest signs of the future organization of the galaxies in the universe and a long awaited confirmation that the universe began with a Big Bang. Despite its scientific value, there was little hope that this news might make its way into the media. George Smoot, a researcher from Berkeley, did something that perhaps none of his colleagues were willing to do. Talking to journalists, Smoot declared that watching the images transmitted by CoBE was "like observing the face of God". He sensed that a catchy phrase would be able to speak to the imagination of all those who might otherwise not be able to understand the news, and he won over the global scene. An English journalist even wrote that "The annoying thing is that besides being one of the greatest astrophycists he's also modest, charming, funny and nice. Worse still, he's handsome."

If you want to communicate with society, you have to be in the media, first of all in newspapers, on the radio and television. Not only are the media extraordinarily effective in reaching an extremely large number of people, but they are also in the arena where most of the social negotiation of knowledge and opinions takes place. In fact, it is in the newspaper or on the radio and television that public images, consensus and credibility of various social groups – science included - is made or destroyed.

Contact with business and political and interest group stakeholders is made through the media as well. For politicians, in particular, science-related themes, discoveries or problems become "real" only when they appear in a newspaper, because they develop into a potential subject of political debate to be used for or against them.

Gaining space in the media is not always easy and in general requires investments in terms of time, effort and resources that cannot be ignored. The return on these investments is often long term and almost always difficult to measure. The simplest way to access the media is the press review, but it is also important to know how to evaluate the effectiveness of the articles published or the radio-television coverage aired, not only the quantity.

The point is not to communicate with the media, but to use the media to communicate with certain categories of people: the media are the means, not the end.

Scientists vs. journalists

Journalists are your way into the media. Not only do they know how to pick out the right words and arguments, but their professional experience has also made them experts at listening to society, and consequently identifying its interests, opinions, moods and values. For this very reason they should be considered as potential, extraordinary allies, rather than intermediaries that must be put up with, or even worse simple targets of cutting remarks. Even if it is not always easy to work with them.

Scientists generally view journalists as people who do not understand the nature and value of science and for this reason they do not dedicate their attention to it, or they distort it, normally in an attempt to make it more sensational.

From their point of view, journalists accuse scientists of not being clear, and often they do not believe that scientists or their work might be of interest to readers or viewers.

It is necessary to learn to accept journalists for what they are and find acceptable compromises with their way of seeing things. Journalists also have good reasons for what they do.

To do this successfully it is important to clearly understand how the

interests, goals, values and routines of researchers and journalists differ.

- Journalists, like public opinion, expect science to give answers and certainties, while science chiefly produces doubts and questions that it tries to answer.

- The first thing journalists look for in a story is an emotion, while scientists attempt to see things as neutrally as possible. At times what the scientist sees as sensationalism is really sensationalism, at others it is only the spices needed "to sell" the story.

- Journalists look for results, even if they are only partial or temporary and at least potentially sensational. Scientists, on the other hand, rarely leave the laboratory shouting "Eureka!" and prefer to tread carefully.

- Journalists love writing about single scientists that have made a revolutionary discovery, while scientists see science as a cumulative and co-operative enterprise. Even Newton admitted standing "on the shoulders of giants".

- Journalists look for controversy; scientists, consensus. While the latter think that being precise means speaking with just one authoritative voice, journalists think that diverse voices (even better is they disagree) give a more complete picture, and are, in fact, used to reporting opinions that they do not agree with.

- Journalists are always in a hurry because they have very tight deadlines and have to remain within the space given to them, whether they are words in a text or minutes in a transmission, and in any case they have to bring a result home. On the contrary, scientists work at the rate imposed by the nature of the research, that can have (and often has) negative outcomes.

The main aim scientists have is to produce new knowledge about the natural world, and their success is measured by the approval they receive from other scientists.
The main aim journalists have is, on the contrary, to entertain and inform, and their success is predominantly measured by the number of copies sold or audience share.

The media, in fact, are above all economic enterprises, and the news they report is what sells the most.

What is a "good" piece of news?

We expect some new disaster
with each newspaper we read.
Abraham Lincoln

Scientists and journalists often have very different opinions on how important a fact is. If you want to communicate through the media, then, you should identify what might make a news item valuable to a journalist. In the newsroom, much is based on the perception or "instinct" developed with experience and handed down from generation to generation, but some studies have attempted to identify the components of a "good" piece of news more precisely. Here are the main ones:

Threshold

First of all, there is a size threshold. Something "big" must really be big, or at least look so. "A small earthquake tremor in Sicily" does not make for much news, while "Thousands of people seek safety from an earthquake in Sicily" is a little better.
Where journalists tend to magnify, scientists tend to tone down: this is fine for academic environments, but it does not help with the media.

Meaningfulness, relevance, and consonance

To the public, good news also has meaningfulness, relevance and consonance. It must have a meaning in relation to what they know; it must be pertinent and possibly not contradict what they already know or think. A new measure of Hubble's constant, for example, is a problem that the general public does not know or understand; it has no impact on their life, and perhaps contrasts with their religious convictions. A title like "Cellular phone waves are hazardous to your health" responds to the requirements: it refers to something very familiar, raises a problem that concerns owners of cellular phones, thus all of us, and is in tune with the climate of suspicion surrounding new technologies. But "Chocolate stimulates because it contains antidepressive substances" also works well. The journalist's slant on the applications or consequences of a discovery is what will make a particular piece of news relevant.

Co-option

The co-option is a tie between a piece of news and an important event of the moment. Political disagreements between Europe and the United States can transform the race between American and European scientists to find a vaccine against AIDS, or the technological challenges of the new Galileo satellite navigation system, into news. Even news of a natural clonation in the animal or plant world can secure a short article, since Dolly the sheep has brought the theme of clonation into the limelight.

Frequency, unexpectedness and continuity

Another value appreciated by journalists is frequency, which allows them to prepare themselves to cover an event beforehand– just as they do with sports every Monday. This happens rarely in scientific fields: by definition, discoveries are not predictable. In the same way, the possible continuity of a news item is appreciated; meaning that it will be discussed for a while. An example might be the so-called "mad cow disease" or climatic changes. Thus, for the journalist it is worth investing time to collect more information or find the right contacts.

Competition

The opportunity of reporting news exclusively, thus reporting a scoop, is cause for professional pride in a newsroom, but scientists and scientific institutions are not accustomed to providing exclusive news (or they are not yet, since it is beginning to be required by some large scientific magazines).

Nothing is better than bad news

In a newsroom very good news is welcome ("a wonder drug against colon cancer found"), but even more so is very bad news ("the Earth was skimmed by a large asteroid"). The most common scientific news, unfortunately, is moderately good.

Reliability

Fortunately, however, scientific news is very often reliable. Journalists only need, in fact, to cite the fact that the news was published in Nature or the New England Journal of Medicine, or that it was announced by this scientist or that university, to have a clear conscience. This is a real advantage compared to other fields.

The power of fame

One last important component in "good" news is the fact that it can be linked to an important or famous place or a person, a celebrity. For this reason the awarding of Nobel prizes always makes the news, even if the research the prize is awarded for usually dates back to many years before.

Many factors come into play in deciding what makes the news.

The most important have to do with public demand, rather than the desires, advantages, or the possible ignorance of journalists.
Before contacting a journalist it is important, then, to consider carefully how to present your news, trying to make the most of it using the criteria listed above. In other words, it is a matter of adding a bit of spin, something that can attract attention to it. If an interplanetary probe is exploring Europe, Jupiter's famous moon, it is better to underline that there is water there, and therefore there could also be life.

Not all journalists are alike

Being a journalist is always better than working.
Luigi Barzini

There are science journalists…

How easy it is to overcome the cultural gap depends on the type of journalist you are working with. In fact, two categories of information professionals work on science and technology.

The first are science journalists. In addition to knowing more science, they are more concerned about their reputations in the scientific community and are more willing to invest time and effort to study their topic and avoid errors. They usually have more time to complete an assignment. Therefore, they can research the subject, think about it, check what they have written or have it checked. Since they often have a science degree and sometimes a brief experience in research, they speak the same language and share the same values as the scientist. They are natural allies and feel as if they are "on science's side".

Science journalists are the ideal channel for routine communication with society. Working with them is easier, but if (as often happens) they work for specialized magazines, pages or shows, they may also be of limited use. With rare exceptions, they are not the ones, in fact, who have access to the most influential media.

… plain journalist…

The second category includes newspaper reporters, editors or editors-in-chief who normally work on other types of news, like the daily news, politics or foreign news, but occasionally have to deal with scientific topics. They are people who work in a hurry, with very little time for research or controls, especially if they are employed in press agencies and daily newspapers. They almost never have a scientific background and they feel like foreigners in the world of science, or can even be suspicious of it.
In normal situations, the result might be the simple publication of some howler to smile at. At times, however, a science-based story becomes so important that it captures the front page of daily newspapers and the opening of the TV news. This is the case, for example, of debates on the use of embryonic stem cells or "mad cow" disease.
When this happens, science journalists are often brushed aside, and the story is handed to other reporters, may oversimplify the issue and transform it into a controversy between two opposite points of view, giving the scientific community's opinions the same weight as minority or other stakeholders' opinionsThey are convinced that this is the way to give a more balanced view or simply that the difference of opinion sells better.
Working with plain journalists is more difficult because the cultural gap is wider, but it is very important: getting to know each other and gaining mutual support and respect in times of "peace" can be precious in a crisis situation.

… and the journalists that really count

Finally, there is a particularly valuable category of directors and editorialists, whose voices are extremely well-liked and accepted (whether inside or out of the headlines): access to them is the Holy Grail of communication through journalists.

How to access the media

Wooing the press is an exercise roughly akin
to picnicking with a tiger.
You might enjoy the meal,
but the tiger always eats last.
Maureen Dowd

If the media are the means and not the end, the first step is to choose the right ones, namely, the most popular and listened to by the public you want to address. They should be the most suitable for transmitting your message. The second is understanding which ones are most accessible. Generally speaking, in fact, there are two large categories of media: those in which competition for the space available is high (influential press, the radio and above all television) and those that never know how to fill their spaces (thematic television channels or news channels, Internet sites, local newspapers and specialized periodicals). The first group reaches large numbers of people, but is difficult to access. The second reaches a more limited public, but is useful to hone your skills for more ambitious goals.

Before making a move of any kind it is a good idea to read papers or magazines, watch television programmes and listen to the radio. What are the topics they like dealing with? How are they presented? Who works on them? What are their opinions? At this point you can ask yourself how a story is "sold".

The press release

If you do not have a contact with a journalist yet, or if you want to publish your news widely, the first tool is a press release, a brief presentation of the news sent by fax or email. A press release is inexpensive but also of limited value. Newsrooms, in fact, are flooded with press releases of every type and the competition for the attention of a journalist, who may have only a handful of seconds for each news item, is ferocious.

A press release must convince the journalist that your piece of news is important, and to do so you have twenty to thirty lines available to you. Actually you have fewer: usually, if the first paragraph does not grab their attention, the press release ends up in the waste paper basket, and the journalist will move on to the next.

For this reason, how you arrange the information in a press release is exactly the opposite of what you do in

a scientific paper. First comes the conclusion, namely, the news with all the essential information, beginning with the most important, then the aim of the research and finally the results and implications. Separately, at the bottom, you can put in information that may be useful to understanding the context of the topic.

The text should be arranged in paragraphs and blocks, and each one should discuss one point, using graphics that make for quick easy reading (titles in capital letters, short synopses in italics, key words in bold).

The text must be concrete and specific with no flights of the imagination, because the journalist will see to that.

The embargo, the date before which the news cannot be published, should go at the top of the press release, while at the bottom you must not forget to put your own address, telephone number and email and possibly a web site where more detailed information can be found.

An email or a telephone call can help to prepare the interest and attention of a journalist you are particularly interested in.

In some countries the scientific community has created programmes for scientific news based on the web, with daily releases. The most famous is Eurekalert (www.eurekalert.org) managed by the American Association for the Advancement of Science.

Face to face meetings

At times it is better not to remain behind an anonymous press release and to organize a meeting. It can take place in a café or a bar, or at a press conference or during a visit to the laboratory. A meeting is an opportunity to establish a personal relationship, but it is necessary to have something really important to say (and/or show) because time is a scarce resource for journalists as well.

If you do not have truly big news in hand, or it is difficult to explain its importance clearly beforehand, it would be a good idea to at least think of an experience you could offer journalists: the opportunity to interview an important person, a visit to a laboratory with really special instruments, an outing to a volcano, an excursion on an oceanography ship, a glimpse through a telescope. What is important is that you do not invite them to see or hear something that might interest a scientist but which holds little interest for them. Be careful, then, with congresses: they are so boring for non specialists that an invitation might well backfire.

Press agent

Working with the press requires a lot of time, effort and many many telephone calls and emails, in addition to a particular talent that not all scientists can be expected to have. For this reason, this task is left more and more often to a press agent, or a public relations officer. Having a person responsible for media relations has many advantages: economy of scale on time and resources, continuous attention and a coherent media strategy, construction of a laboratory "brand", creation of a media relations network, greater visibility on the outside for all lines of research, not only those led by the most media savvy people.

The success of this professional figure depends on the person's competency and quality, naturally, but also on the constraints (s)he has been given.

A press agent is, in fact, useful when acting as a "facilitator" and not as a censor (as sometimes happens) of the relationships between journalists and scientists. Their role, in addition to producing and distributing press releases and other material for the press, is to identify the most promising stories and guide journalists to the people or figures they want to speak with. (S)he should not be, then, a spokesperson, because journalists may hold that (s)he is not sufficiently knowledgeable on the topic or not qualified for an interview or a comment; in other words, that (s)he is not a substitute for the real thing, the scientist.

Materials for the media

Once you have managed to attract a journalist's attention, you must be ready to give them more. The secret is "make his work as easy as possible" by collecting or preparing specially made materials which will help to evaluate a topic and then to write the piece or prepare the report. You should include details, arguments, and simple effective examples, well written articles for non peer audiences, press reviews, photographs with captions, ready to use Video News Releases or unedited footage (B-rolls).The scientist should of course be willing to be interviewed.

How to answer the media's requests

Facing the press is more difficult than bathing a leper.
Mother Teresa of Calcutta

Scientists are often contacted by journalists with requests for explanations, comments, or interviews.

A journalist's request is an opportunity, not a bother: remember that you are not doing them a favour, but you are using the media to reach the public.

If that telephone call is to turn into an article, a report or at least an interview, and hopefully a good long-term personal relationship, a few tricks can be useful.

Always keep the door open

Always be ready for every type of request, even impromptus. An interview is usually made by telephone, but if you think it is more appropriate, invite the journalist for a personal meeting.

Are you the right person?

If you have been contacted by a journalist, be sure you are the right person to answer their questions based on your competency and not on your position in your institution's hierarchy. If you are not the right person, suggest the name of a more competent colleague. Often, however, journalists do not have much time to close a news item: if you can be of help, clarify your position, but help them.

Who is the journalist?

When you are contacted, get information on the publication (s)he works for and try to understand if this will influence the way your work or comments will be presented. If necessary, consult your colleagues.

Be prepared

Even if you are the world's highest authority on the subject, take time to prepare for the interview. When the journalist calls, try to understand their approach to the topic and what questions you will be asked. Then think about how to present the results of your research. What is new or unexpected? What impact might this have on this particular public? What are the wider implications of your work, for example, from an ethical point of view? Can you offer any strange, funny, and perhaps personal anecdotes?

Work within their time constraints

Journalists always have little time. If they say they have an hour to finish a piece, it is usually true. Try then to answer their requests as soon as possible, putting aside other possible commitments. If you offer to find information, make sure you can get it for the journalist in time.

Keep it simple

The journalist and their readers probably know very little about your field. Explain your work, or comment on the work of others as simply as possible and with the easiest words you can use, as if you were with a friend. If you must use a technical term, explain its meaning. Also try to use as few numbers and statistics as possible. The more you use, the more likely you will be misunderstood, badly cited or not understood at all. In these cases, even if it means being less precise, it is better to use a good analogy.

Help the journalist to help you

Just as you need to convince the journalist about the importance of a news piece, the journalist needs to convince their director or editor-in-chief of the same thing. They are the people who decide. Help the journalist, then, to grasp the heart and meaning of the news, because this is what (s)he will need in the newsroom.

Be careful with verbatim quotes

There usually is not enough time to go over a piece before it is printed or aired, but you can insist on checking your answers that are reported as quotes, especially if this has been made clear from the very beginning.
A request for your opinion on somebody else's work or any other delicate question should be answered "off the records" or "with the recorder off", and only for journalists that you know and trust. Generally speaking it is better not to give a journalist a "no comment" answer, but you should not feel obliged to give an answer you might be sorry about later, either.

Expect errors

You are just going to have to accept it: journalists often make mistakes. We all make them, so just imagine those who are not very familiar with the subject. If it is a matter of minor mistakes, you can let them go. In other cases it is worthwhile explaining them, as politely as possible. A few errors in

good faith should not, then, compromise your relationship with a journalist. If they were deliberate, however, it would be a good idea to avoid this journalist and publication in the future.

Understand the journalist's constraints

Do not get upset with the journalist if the title of the piece you worked on together has got little to do with the contents. In fact, the author of a piece has no control over what appears in the newspaper. It is the editor-in-chief who decides on the paging, possible cuts, pictures and title. Perhaps (s)he did not understand it well or decided to give it a little bit more "life" to make it more appealing to the readers.

Trust their judgement

To write ten, a good journalist needs to know one hundred. If you do not find all the details you explained and held essential in the piece or report, do not be surprised. The journalist knows much better than you how many details the readers or viewers are able to digest. The journalist wants your ideas, not your data.

Afterwards, always say thank you

After the article or report has come out, always thank the journalist and, unless it was a disaster, pay them your compliments. Just like ascientist, (s)he too puts their best into their work.

Working together

If you have an apple and I have an apple
and we exchange these apples
then you and I will still each have one apple.
But if you have an idea and I have an idea
and we exchange these ideas,
then each of us will have two ideas.
George Bernard Shaw

Two complementary figures

Science communication can be particularly effective if the scientist and the journalist manage to overcome their mutual distrust and the cultural barriers that divide them, and co-operate.

Their competencies are, in fact, perfectly complementary, as long as there is mutual respect for each other's role. The scientist should be responsible for the contents and the journalist the communication's format, while the selection of the contents and the choice of the message can be made together. Of course, this is more easily said than done.

The journalist must accept the role of the amateur and give up a bit of control over the texts. On the contrary, the researcher must accept the journalist's way of arranging the work and agree to introduce changes only for the sake of greater accuracy.

The easiest formula for co-operating is a final review of texts, to assure that factual errors have not been overlooked. A good journalist should always agree to this: content accuracy is the last effort (s)he needs to make, but it is the first obligation (s)he has to their reader or viewer.

The importance of personal relationships

Co-operation will be much greater and more productive if you work together from the very beginning. For this to happen it is necessary to have a good personal relationship.

Few things can improve how science is covered and portrayed in the media as routine working partnerships between single scientists and journalists who know and trust each other.

A good personal relationship develops out of shared interests first, and then from the fact that you get along. Let us take a look, then, at public communication of science from a journalist's point of view.

The world of science, even just in the more popular sectors, is too large for journalists, even specialized journalists, to figure out by themselves. Covering science is much more difficult than covering sports, politics or the daily news. Journalists are always looking for new interesting stories, details, checks and opinions. Even if the

Internet facilitates their work, they often have to look for the classic needle in the haystack, and nothing can substitute a person's answer to a specific question, that begins perhaps with a very particular point of view or requires a value judgement. Asking a scientist is much more simple, useful and gratifying than questioning a database. Often it is actually irreplaceable.

The right scientist can solve a journalists' problem in a few moments. That is why a network of contacts in the world of research is one of every science journalist's professional assets.

On the other hand, and rightly so, journalists do not want to be told what to write, because they have no intention of becoming a tool in someone else's hands, nor do they know what to do with the scientist point of view as it is. Journalists need an "honest" person who knows how to see things from their point of view as well.

Thus, many journalists look for scientists in wide disciplinary sectors whom they can consult when necessary. This science consultant is the person who journalists can call directly because they know them, they know that their judgement is reliable and (s)he is on their side.

In exchange for this privileged position a scientist's work or sector will receive greater visibility, and (s)he is given the opportunity to influence the way certain topics are reported or to express their opinion during an emergency.

As long as they do not act like unethical know-it-alls, colleagues who become media experts are not necessarily motivated by personal vanity or guilty of grandstanding. The overall image of scientific enterprise almost always has something to gain from them.

Consequently, contact with journalists needs to be cultivated by offering the help requested and informing them of new developments in advance. There also need to be periodic meetings, however, and you need to keep track of their work, trying to understand their interests and necessities, by understanding how they work. This all requires time, because each one has a great deal to learn.

In addition to being useful, working together can also be very gratifying for both, and at times it represents the beginning of a researcher's career as a science communicator.(S)he may turn into a writer or a journalist, but sometimes (s)he may even take on the very valuable role of columnist.

KNOWING THE MEDIA

Choosing the right medium

The medium is the message.
Marshall McLuhan

When, in 1624, Galileo decided to set out his reasons and began writing the Dialogue Concerning the Two Chief World Systems he was aware of the problems that this work might cause him with the Church. However, he did not have to choose which means of communication to use, nor fear that his message might go unnoticed. The few hundred copies of the book published by Ladini, a typographer in Florence, assured that this purpose was achieved remarkably well.

But, what about today? Is an interview with the Corriere della Sera (or Le Monde, Frankfurter Allegemeine, El Pais, or The Times) better than an article in Scientific American? Should you choose a television story or a book? The cover of an important weekly magazine or an exhibition in a science museum? A press agency take or an article on a most popular webzine? The news on the morning radio show or a press conference with a related event?

In any case, this question constitutes the first step forward. The contents are often given so much attention that the choice of the medium is neglected, and yet this choice represents a key decision.

The media are much more than simple technologies for the transmission of information. There is no need to bother Marshall McLuhan, the famous Canadian media expert who maintains that every message becomes something different depending on the medium used. Just glance around and you will realize the profound differences between one medium and another.

Daily newspapers reach an adult public. Science museums are particularly popular among children; web sites reach small tribes of people with very specific interests. Television is watched by almost everyone, and even a science programme can talk to a few million viewers, while it might be expected that a book, at best, be read by a few thousand people. On the other hand, if we examine the quantity of information transmitted, the relationship between books and TV is inverted, while on the web the number of details can be chosen by the user.

Different languages are used for different media. The radio, for example, uses only words, while an exhibition speaks mainly through its objects. This explains why, among other things, each medium lends itself more to certain topics and less to others. It is much easier to talk about ethology on television than on an Internet site, and the opposite can be said about human genetics. It is much more straightforward to show the personality of a scientist on the radio than in a museum, while a simple experiment from classic physics is better demonstrated by a museum exhibit. What influences the choice of subjects is also the size of the public. On television you deal with subjects that can really interest everyone, while on the web you can talk about any topic, even if there are only a few people in the whole world interested in it.

In selecting a medium time becomes an important factor as well as the way it is used. The radio is listened to in the morning and television is watched in the evening. Daily newspapers are skimmed and read quickly, specialized periodicals are give more time and attention. On television, entertainment is the main objective; on the web, information; in a museum, experiences and feelings.
Communication times also vary. A press agency or a web site run a piece of news in just a few minutes; a weekly, in a few days; an exhibition, in a few months; and a museum, a few years.

Other differences?

Functions and values in the public arena differ from one medium to another. TV news and daily newspapers influence public opinion, while web sites and conferences make it possible to feel it out. It is a lot more simple to appear in a popular science magazine than on television, while the Internet is infinitely more accessible than the cinema (but Carl Sagan managed to do even that!).
A television interview takes much less personal time and energy than writing a book, while updating a web site requires greater continual effort than a lecture given every once in a while. On the other hand, not everyone is gifted with the same personal abilities. A beautiful voice is helpful on the radio; on television, a captivating face; for a daily newspaper or a non peer magazine, a brilliant writing style.
Finally, costs vary from one medium to another. It is very different to give an interview, distribute an electronic newsletter or publish a house organ. It is very different to call a journalist-friend or have a press office work for you. There is a big difference between writing a book or setting up an exhibit. There is a big difference between hosting a television crew in the laboratory or producing a video on your own.
If the media are means and not ends, before using them it is necessary to be familiar with at least their main characteristics.

Television

Television – unlike other communication tools that preceded it – destroys more knowledge and more understanding than it transmits.
Giovanni Sartori

Television is the only means which can potentially speak to everyone. In an era in which the media tend to follow the tastes and interests of increasingly narrow segments of the public, television has, in fact, remained a truly generalist medium. It is the only one that can bring science closer to those that do not know it, and therefore, would not go looking for it elsewhere. This is especially true for each one of those citizens for whom it represents the only means of access to the world and culture.

This medium, however, has distinctive characteristics that do not always mix well with science.

Television uses more images than words to communicate, because the former tend to prevail over the latter. Contrary to words, which can be put together and taken apart as one likes, giving them the exact meaning desired, images can be very strong and carry different meanings for different people, and they are not always tailor-made. Thus, because it is so dependant upon images, television lends itself to telling facts, more than explaining concepts.

This is not all. On television very few words can be used: in five minutes, the average length of a report on a specialized programme, you can use the same number or words that you would use in a brief newspaper article. The length of a TV news spot is actually measured in tens of seconds.

Television communication also tends to be elusive. The limited number of words available requires an extremely succinct synthesis of the topic. This leaves the mind little time to understand and absorb, discourages the repetition of concepts and rarely includes an introduction to the topic or background information. Television also has short time periods and an increasingly fast pace, and it is not possible to go back if something is missed, as you would when reading a book or a newspaper article. Furthermore, viewers are often distracted: a family member's remark can be enough to sidetrack their attention so they miss something forever.

In addition, television is used and perceived essentially as a form of entertainment, and the audience's willingness to apply themselves and follow a rather complex explanation is usually very limited.

In fact, science on television is limited to explaining only a few fundamentals and the meaning of the topic. You do not learn from television, at least in the full meaning of the word. On the other hand, television can be extraordinarily effective in stimulating interests and the desire to learn, directing the public towards other means like magazines or books.

The lion's share in science television programming is dedicated, naturally, to natural history and health, and this leads us to television's great constraints.

The first is the constraint set by pictures: no pictures, no story, as they say in America. Even if a bit of creativity can work miracles, on television you usually have to talk about what you can see and that possibly also has a good visual presentation. Consequently animal behaviour, volcanoes and space exploration do well, while chemistry, molecular biology or nanotechnologies do badly. Do not even mention mathematics! Unfortunately, a good part of contemporary science cannot be made directly visible because it deals with invisible things. Computer graphics can help, but they are expensive, become boring quickly and may not really be helpful.

Even if well represented, the synthesis of proteins or crashes between particles, for example, do not speak for themselves. Even pictures of laboratories all look alike these days, and they do not make for a great show.

Thus, before suggesting a topic it is necessary to make sure that it can be made visible, perhaps by getting pictures directly or through your network of international contacts.

The second restriction is that on television you usually can talk about things which naturally interest a wide audience, while it is unlikely that you will find space for niche subjects. Television production requires, in fact, large resources and the programme can generate large incomes through commercials, proportional to the number of viewers. Thus competition with other types of programming is very high. This means that the topics dealt with and the level of explanation must appeal to a wide number of people: television always looks for the least common denominator among its potential viewers.

Television is one of the most difficult means to access, if for no other reason than the very limited number of spaces available: there are only a few hours of programming a week,

at least in the free-to-air channels. Many more spaces are opening up on satellite theme television channels which are gaining ground. The problem is that compared to the free-to-air channels, which are more popular and financed by commercials, they have less money available, and just like specialized periodicals they are not meant for everyone, but only for people who are already interested in the topic.

Appearing on television may be intimidating, and if you do more than a brief interview it requires personal talents (having a natural screen presence) that are not particularly common. Before you go on air, it would be a good idea to try and understand what type of programme it is and what objectives it has set. A science programme and a talk show are two completely different situations. And, is the interview live or recorded? What questions will be asked? Who are the other guests? Usually the host wants to keep the tension high during the programme, and if the subject is controversial (s)he might even choose to set a researcher against a real quack as if they had the same qualifications.

Answers on television are always very brief, just long enough to highlight a few key points. Therefore, it is better to be prepared and not open up the discussion. In front of the television camera, finally, you must move as little as possible, speak slowly and avoid technical terminology, extremely complex concepts and numbers, as much as possible.

The radio

An equal must talk to an equal, a free citizen to a free citizen,
a thinking brain to a thinking brain.
The radio contributor must not present himself
as a teacher to the radio listener, nor as a pedagogue,
much less a judge or a prophet,
but as an informer, a pleasant interlocutor, a friend.
Carlo Emilio Gadda

In contrast to television, radio is the kingdom of the pure word, not covered by music or background noises, but highlighted.

Radio communication is direct, hot, stimulating, and if necessary also in-depth. The radio evokes, stimulates the imagination, induces listeners to listen more closely. It is also a medium that uses few intermediaries between the scientist and the public. People come out directly: the opportunity for personal and direct contact makes the radio the best place to show who you really are and disprove the stereotypes of the scientist that gets on a high horse and starts explaining the “arcane worlds” to the ignorant, and of the crazy scientist, a genius but basically a bit pathetic.

Television’s younger sister, the radio is often underestimated. In the newspapers, for example, you never read about it, but it is really listened to frequently, especially by young people, and because it does not interfere with other activities, like driving, but it provides a background.
As for topics, the radio allows for a much wider choice than television, because words are much more versatile than pictures. Certainly, visually spectacular topics, like tigers and typhoons, inevitably loose something of their appeal, but in return it can also deal with more conceptual subjects, without having to refer to some “fact”.

Even if the choice of news must satisfy the normal journalistic criteria, there is also room for slightly niche areas. Since it costs less and is less profitable, radio is influenced less by the number of listeners and it is possible to fly higher, satisfy particular groups of listeners or carry out experiments that are prohibited on TV. Of course, the topics have to be interesting. If one distinctive criterion exists for choosing the news, it is the need for something to discuss or reflect on with the host and listeners, rather than a simple explanation of the topic.

Researchers almost always have access to the radio through interviews; at times it is the newsroom that asks for the interview, at others it is the researcher who sends in a proposal or calls directly.

A radio interview is simpler compared to a television interview because it is usually on the phone, and it requires fewer personal talents since it is easier to speak on the phone from home or the laboratory than in front of a camera.

A nice voice is important, but not too much. Rather, it is useful to be synthetic, appear spontaneous and know how to transmit your own passion for the topic. In general, it is better to speak off the cuff, guided by the host’s questions, possibly just preparing a starter to break the ice with the host and listeners. The opening

should be clear and captivating, state synthetically what you will talk about and then throw out some problematic element or mystery that will be developed during the interview.

Each time you talk, you should be brief, at most 20 to 30 seconds, then give the floor to the host (who will otherwise have to take it himself) for another question. Since the listener's attention may be discontinuous, perhaps because (s)he may be doing something else, you should repeat the most important points more than once.

In front of a microphone (or the telephone receiver) you need to pronounce the words clearly. Uncertainties and small slips of the tongue, if corrected well, can, in any case, add to the spontaneity of the interview. The important thing is not to mumble, or worse, remain silent: five seconds of silence and listeners will think their radio is broken.

The generalist press

To be completely frank, despite my horror for the press, I would really like to rise out of my tomb every ten years or so and go buy a few newspapers.
Luis Buñuel

To talk about the press means talking about a boundless world, diversified and not sufficiently studied. Even if true investigations on the subject are lacking, it is not far from the truth to say that the generalist press deals with science infrequently and badly. It is also very difficult to access.

This can be explained by the evolution of editorial processes developed over the last fifteen to twenty years. Since the use of wired news, and fax or email for the transmission of press releases, newspapers no longer look for the news but the news pours in on them, and there are increasingly more pieces to choose from.

The first consequence is that scientific news has to face strong competition. In large newspapers, in fact, there can be thousands of number of news items to choose from every day, between wired news and press releases.

The second consequence is that newspapers have a diminishing number of internal experts, such as the science editors who had the contacts and knowledge to find and judge the news. Today the most frequent figure is the desk-reporter who re-writes the news provided by agencies or press releases. This news is then selected by a hierarchical organization of managing editors, feature directors, assistant directors that are usually just as badly informed in sectoral knowledge.

Not only is there less available knowledge provided by specialists, science included, but specialist voices are also disappearing from the selection process. Specialised journalists, like science journalists, are now almost completely external figures who depend on the decisions made by those who work inside the newspaper.

In this way the normal criteria for selection are biased, and emotions and a herd mentality tend to prevail. If yesterday a newspaper asked "what have the others not written?"; today the first question risks being "what have the others written about that we have not?".

Furthermore, recently the influence marketing has on a newspaper's orientation has grown. For marketing people the importance and even the interest of the news often count less than page layout, the type of topic to run and especially the reader profile which can be sold to advertisers, the real clients in the publishing business. Insurance advertisers, for example, typically want the newspaper to talk about health. But who might be interested in mathematics, biodiversity or fundamental physics?
In short, it is very difficult to access daily newspapers and generalist magazines if you can only count on your efforts, for example sending a press release. It is hard to guess what might interest a journalist, it is difficult to get a hold of them, and even if you do, it is difficult to strike the right note. Things improve in less popular press, like local newspapers.

In practice, in order to appear in the most important newspapers it is almost indispensable to have a press office in the hands of good professionals. It is these people's job to know what is behind the choices made by various newspapers and to nurse the contacts with key people inside the newsrooms. Today, in fact, the institutions present in the most influential

The specialized press

A true journalist explains what (s)he does not know very well.
Leo Longanesi

media are those which are equipped with a good press office.

Deciding whether it is worthwhile or not to invest in such an office essentially depends on your objectives. Being in the large daily newspapers and national weeklies makes you more visible to policy makers, both public and private; they receive the press reviews. If you have other objectives, for example creating a relationship with a local community or making citizens more aware of a certain topic, other routes may be simpler.
Magazines with wide circulation dedicated to scientific dissemination are a phenomenon that exploded in the Nineties in several countries. The readers are prevalently male and young, with variations depending on the different publications. Usually they are read carefully and thoroughly, unlike daily newspapers.

The criteria for topic selection are similar to those used for daily newspapers, magazines and television, but the choice is broader and more "relaxed", with a minority share also for the hard sciences, often completely absent in other media. Being illustrated monthlies, one important criterion for selection is the availability of eye-catching pictures, both photographs and drawings.
Ample space is available in these magazines, and since almost only science and technology are discussed competition with other news is not as high.
Thus it is realistic to consider sending press releases or true proposals to the newsroom without resorting to professional intermediaries. In fact, various researchers write regularly for some of these publications, but they must obviously abide by the editorial policy and norms. More often the scientist acts as a consultant or the interviewed expert. Perhaps this role offers less personal satisfaction, but it is surely simpler and less tiring.

Books

All of the books in the world contain no more information
than is broadcast as video in a single large American city in a single year.
Not all bits have equal value.
Carl Sagan

Obviously there is no need to present the book, which from way back has been the least short-lived, and the most influential means for knowledge dissemination. It is also the most suitable for passing on information and lines of reasoning. It can also lead to medium to long term visibility, especially as opposed to the other media.

It is no coincidence that it is the first means of communications to come to mind. The decision to write a book must, however, be well thought out. It involves an enormous investment of time (including evenings, weekends, vacations) and self-discipline. The moments of doubt and discouragement cannot be counted. And such a large effort is rarely rewarded with a similar size result.

Books talk to a minority of people; a minority that surely counts, but it is usually very small.
Books are also very difficult to promote.

Among novelties and re-publications, tens of thousands of titles are published every year in a typical western country, a mass which it is extremely difficult to emerge from, and in which it is easy to perish, even if only due to an oversight. In fact, publishers have resources to promote only a small number of the books they publish. The others are handed over to fate. Competition also takes place within a sales circuit, usually in small bookstores. Even if science essays have a long shelf life, a book can remain in distribution for a few weeks only, and then it is gone. If the publisher, the holder of the rights, believes that a new edition is not reasonable, the author's work is literally nullified.

Naturally, these caveats are not meant to discourage an author, but only to make them think well before making the crucial decision.

The first question to ask, then, is if the topic is worth a book. Is it important? Does it deal with a particularly active frontier in research like astrophysics or human genetics? Does it examine the areas at the centre of public debate like stem cells or hereditary intelligence? Is the subject of personal interest, like psychology or medicine? Are there captivating stories of people to tell, to bring the discussion alive? And above all, is there really something new to say?

If the answer is yes, are there already other similar books? Bookshelves and catalogues are full of duplicates, so it is better to make a market survey first.

If the outcome of these examinations is positive, you can prepare a proposal for the publisher. First of all this includes a concept, or rather the development of the idea from an editorial point of view, with a discussion of the topic, the approach and the public interested in the book, which demonstrates the opportunities it represents. A good concept manages to reduce the book's topic and reason of being to a simple and clear idea. Moreover, the story and characters need to be identified (a book for dissemination is not a manual!), and a summary and possibly even a sample chapter should be included.

Before convincing the publisher, the proposal is useful to the author, so (s)he can begin to understand the size of the undertaking and thoroughly verify whether it is truly what (s)he wants to do. If the publisher has accepted the proposal and believes in it, then (s)he should be willing to invest in the idea, and it might be possible to reduce the work by sharing the writing with a professional writer, usually a journalist, who takes over writing the draft. A four-handed book (not always all printed on the cover), is fairly widespread in the Anglo Saxon world, and allows each of the two authors to take advantage of their own competencies, but requires team spirit and good mutual understanding. If mutual understanding and trust are not created, the job might well end with a quarrel.

Finally, when the book is completed, it is necessary to be ready to promote it with presentations, interviews, calling all possible contacts in the media. Without this final effort, the book may end up in premature oblivion.

Science museums and exhibitions

If the young people themselves see science as something for children, it is not surprising if puberty seems to be the main enemy of the Public Understanding of Science. Science centres, made to encourage and involve people in science, might actually lay the foundation for a total and deliberate rejection of science by young people as soon as they find out about more attractive choices.
Neil Cossons

Over the last twenty years more science museums have been opened worldwide than ever before, including these so called science centres.These are collections of interactive exhibits that illustrate the basic principles and mechanisms of science and technology, and unlike other museums they have little or no room for the conservation of objects from the past. In the United States, for example, from 1970 to 2000 six hundred museums and science centres were opened, and in the nineties alone five billion dollars were spent. This infatuation, however, has struck the entire western world. In an era of indirect or even virtual experiences, citizens are increasingly hungry for the direct, concrete, personal and "special" experiences that only these places or events seem able to provide.

Although some large historic institutions still show signs of the past, science museums have come a long way since the end of the Nineteenth century, set up as universal fairs that brought in millions of people and exhibited (to celebrate them) almost exclusively the important industrial inventions like the locomotive engine, airplanes, turbines or reconstructions of mines.

The turning point was marked by the inauguration, in 1969, of the Exploratorium in San Francisco, which opened the era of the science centre. Over time, museums also adapted to the new hands-on philosophy, and many different media can be found there: objects to look at, interactive exhibits, films, theatri-

cal productions, projections, laboratories, animation and most importantly, activities, from lectures to role playing.

In short, for each subject the most suitable means is used.

During this development, however, these organizations basically lost the adult public. Today, between 80 and 90% of the visitors are made up of school children and families with children. On average, 44%, almost half of the visitors is under fourteen years of age. More specifically science museums and science centres are having enormous problems attracting teenagers and adults without children. In terms of its contents, a museum or an exhibit poses still more restrictions than television.

An examination of which subjects are dealt with in science museums and science centres confirms the impression of any visitor: in these places the great majority of exhibition space is dedicated to classical physics or a selection of a few technological areas. A few projects are offered on astronomy, earth science, perception psychology, in addition of course to natural history collections.

Perhaps what is missing is more noticeable than what there is. Little or nothing deals with the most important advances in science and technology from the last one hundred years. Very few exhibits are dedicated to nuclear physics, molecular biology or cosmology, just to cite a few examples in the pure sciences. If we look at technologies, it is difficult not to note the absence of (except for, as usual, a few rare exceptions) microelectronics and recombinant DNA, telecommunication systems, industrial agriculture and new materials technologies.

Furthermore, at least in terms of exhibitions, there are problems in presenting the major debates that have emerged over the last hundred years on the relationship between science and society. In this regard it is surprising to note the difference between the subjects which are most successfully dealt with in museums and the subjects which dominate the pages of newspapers and popular magazines and television programmes dedicated to science.

The reason for all this can be found in the medium's strong constraints. An exhibition must speak through its objects, not through words. "Three dimensional books", with dozens of pages on wall panels and objects that substitute photographs, are of no use, although some museums still use them.

Visitors do not necessarily enjoy intellectually gratifying or emotional experiences. Young visitors walk through these places, packed with information and experiences quickly, like adults reading a daily newspaper. And they will stop at an exhibit for reasons which are often very different from those imagined by the person who planned the exhibition.

If and when they stop to look at something more carefully, it is usually for about thirty seconds. Half their time is typically spent at the café, restaurant and bookshop.

In addition, it is extremely difficult to assess how educationally effective museums and exhibitions are. Generally, except for guided tours, few facts and theories are learned in these places.

Finally, access barriers to these places are very high. A museum, a science centre or an exhibition are very expensive and need to involve public administrations, foundations or large private sponsors. You have to pay for the use of the building space, the display, but in particular, the management . Because of the maintenance and activity expenses, management costs tend to increase with the number of visitors. It is important to resist the temptation of doing it on your own, because they are complex and sophisticated objects from all points of view, from the planning to the realization. Even if the ideas often come from and are guided by scientists, the collaboration of specific professionals is absolutely indispensable.

Why then are museums and science centres so successful? The main reason is that the visit provides a strong emotional experience, chiefly meant to provide a mental map of the topic and stimulate interest in it. The true function of science in an exhibition is to fascinate, and therefore to direct people towards other media, such as books, or a greater personal commitment to studying science at school.

The Internet

I had (and still have) a dream that the web could be
less of a television channel and more
of an interactive sea of shared knowledge.
I imagine it immersing us as a warm, friendly environment
made of the things we and our friends have seen,
heard, believe or have figured out.
I would like it to bring our friends and colleagues closer,
in that by working on this knowledge together
we can come to better understandings.
Tim Berners-Lee

The last to arrive, and not yet the most popular, the Internet is, however, the most quickly growing medium in importance. This is true because it is a ripening means, and we are probably far from having explored all the opportunities it has to offer.

It seems to have everything required to become the paradise of communication, without most of the restrictions set by traditional media. Everyone can publish on it, thanks to its technical simplicity, the low cost of the hardware, the zero cost distribution and printing, and because there is space for everyone.

Its contents can remain in the archives. Today's newspaper will be used to wrap up fish in 24 hours, while a document on the Internet can remain available for as long as you want it to. In the same way, the Internet is accessible to everyone, as long as they are connected to the web. It is not necessary to go out and look for it or buy it somewhere, because it arrives directly at home or the office. Moreover, most of the contents is free.

For these reasons it works well when you want to reach many people or small communities united by the same interest.

Family access to the Internet, also with broad-band connection, is already very high. Although its use for the moment is still rather rudimental – limited to searching for information, games or sex – in the future it will become more widespread and sophisticated just like other communication technologies did in the past.

The problem is that being on the web is not enough in itself to be seen. Most sites are, in fact, visited by very few people, or just once in a while, perhaps by chance. Mortality on the web is very high. A site must be well made and constantly updated, offer interesting contents or useful services, but most importantly it must be linked to other sites. The higher the distance is in terms of intermediary links to the most frequently visited sites – that 25% of sites that makes up the superconnected heart of the web globally – the lower the probability that someone will end up there. Despite all these considerations, the potential is truly enormous. At the moment, science on the Internet means various things. The main uses are online versions of paper newspapers, free or subscription, the webzine (magazines only online) and institutional sites for research institutes and newsletters. The last two instruments are the most important for a researcher.

Every university, research institute or large company now has a web site. Too often, however, at least in Europe, its contents and services are almost exclusively for internal use only. An extremely precious channel of communication with society is therefore not being used. Just take a look on the web and you will see that in the United States all these institutions offer their citizens every type of useful resource, updated and certified. For any health problem, for example, you can consult the site offered by the National Institutes of Health, for questions on the weather the site by the National Oceanic and Atmospheric Administration, just for curiosity about space, NASA's site. Similar services, although on a smaller scale, are also offered by smaller organizations. There are probably few more effective ways and that are easily available, to make yourself heard by society, for routine communications that we have seen are the basis for a good relationship.
Finally, for those people who are more interested and request it, there is the plain and simple newsletter, a bit more than an email sent periodically to the addressee: the simplest and most economic way to keep people informed.

TO WORK!

AS THE SAYING GOES, THERE'S MANY A SLIP 'TWIXT THE CUP AND THE LIP'.

READING A BRIEF MANUAL WILL CERTAINLY NOT BE ENOUGH TO TURN A SCIENTIST INTO A SCIENCE COMMUNICATOR, BUT I HOPE THAT I MANAGED AT LEAST TO PROVIDE THE MAIN STEPS: WHY TO MAKE THIS CHANGE, WHICH CHANGES TO MAKE IN YOUR HABITUAL WAY OF THINKING AND DOING, HOW TO PLAN YOUR COMMUNICATION, HOW TO DO IT AS AN AUTHOR OR WITH A JOURNALIST, HOW TO CHOOSE THE MOST SUITABLE MEDIUM.

NOW YOU HAVE TO GET TO KNOW AND ANALYSE THE BEST EXAMPLES, TRY AND TRY AGAIN, AND THEN EVALUATE WHAT YOU HAVE DONE, AND SEE IF IT REALLY WORKS. AS WITH ANYTHING ELSE. IF, HOWEVER, THERE IS ONE SECRET, IN THIS JOB, IT IS TO CULTIVATE THE HABIT OF PUTTING YOURSELF IN YOUR AUDIENCE'S SHOES, EVEN WITH YOUR IMAGINATION. HOW? BY LEARNING TO SEE THROUGH THEIR EYES, REASONING WITH THEIR HEAD, BELIEVING OR DOUBTING WITH THEIR JUDGEMENT, FLYING WITH THEIR IMAGINATION. COMMUNICATING, I WOULD LIKE TO RECALL JUST ONCE MORE, IS ESTABLISHING A RELATIONSHIP. YOU CANNOT DO WELL IF YOU DO NOT LET YOURSELF BECOME INVOLVED. IN THIS, COMMUNICATING IS DIFFERENT FROM ANYTHING ELSE. EVEN FROM SCIENCE.

SUGGESTED READING

Solid bases

Jane Gregory e Steve Miller, Science in Public:
Communication, Culture and Credibility, Basic Books, 1998

Deborah Blum, Mary Knudson,
A Field Guide for Science Writers, Oxford University Press, 1997

Online Resources

Office of Science and Technology, Going Public,
An Introduction to Communicating Science, Engineering and Technology
http://www.dti.gov.uk/ost/ostbusiness/puset/g_public.htm

English Biotechnology and Biological Sciences Research Council, Communicating with the Public:
http://www.bbsrc.ac.uk/tools/download/communicating_notes/ Welcome.html

Lars Lindberg Christensen
A Hands-On Guide to Science Communication, aimed at public information officers, 2003
http://www.eso.org/~lchriste/scicomm/

People Science & Policy Ltd e Taylor Nelson Sofres Research Councils UK,
Dialogue with the Public: Practical Guidelines, 2002
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European Research, A Guide to Successful Communications, 2004
http://europa.eu.int/comm/research/science-society/sciencecommunication/
index_en.htm

To Know Science is to Love it? Observations from Public Understanding of Science Research
http://www.copus.org.uk/pubs_guides_toknowscience.html

Now for the Science Bit! Concentrate Communicating science:
http://www.riverpath.com/library/science/science_bit.asp

An e-Guide to Science Communication:
http://www.scidev.net/ms/sci_comm/

Communicating Science News. A Guide for Public Information Officers, Scientists and Physicians
http://www.nasw.org/csn/

To keep updated

Public Understanding of Science, the main international academic publication dedicated to the relationships between science and society and the communication of science:
http://pus.sagepub.com/

The international portal dedicated to resources on every aspect of communications between science and society:
http://psci-com.org.uk/

European Commission

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