Future for science journalism

WHY HISTORY, PHILISOPHY AND POLICY OF SCIENCE MATTER …

By Joost van Kasteren

Science and technology are major factors in shaping tomorrow's society. Research and innovation have been acknowledged as key factors in meeting the "Grand Challenges" of our time such as food security, energy supply, healthy aging, and mobility. Being key factors, public and its policy makers must be provided with the information that is necessary to call science and technology to account. Therefore there is a growing need for independent science journalism to interpret, explain and comment on the results of scientific research and technological development.

Because of the importance of science and technology it is important that science journalists show how science actually works. That goes beyond just articles about interesting developments in science but includes also information about the organization and funding of scientific research, the entanglement with industry and other interest groups and the way scientific results are used.

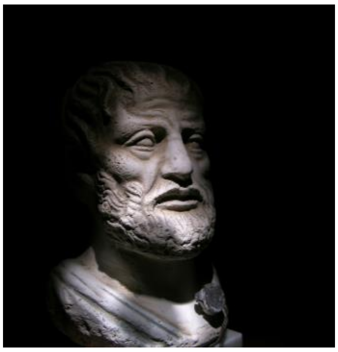
Until now, it is companies and bureaucrats that mainly exert the influence on science, but given the challenges society is facing, it is essential that civil society and citizens get a voice in setting the research agenda. Boring? No, it is a challenge, because society needs more than wonder to respect science and it is up to journalists to bring the critical scrutiny that is needed to integrate science in society. (Susan Watts in Nature, 10 April 2014).

Science journalists must be able to inform their audiences about scientific efforts and results from different perspectives - political, economical, social and moral perspective. Some knowledge of the history, philosophy and policy of science can help to question the implicit assumptions that most scientists and lots of other people take for granted. Instead of just ‘translating’ the achievements of science and technology, the future of science journalism lies in providing the information that the public and the politicians need to get a grip on the powers that shape their futures.

History of science

The history of science is often presented in quite an unhistorical way. The key ideas of a scientific discipline are presented in a logical order from the ‘scientific revolution’ of the 17th century onward. No mention is made of all the false theories that were once ‘en vogue’, the battles that have been fought between different schools of thought and of the political and religious influences that have shaped science and technology over the centuries. Still that kind of information is useful for science journalists (and others), because it gives another perspective on present-day science.

The Aristotelians and many ‘schools’ in the city of Athens in those days tried to explain reality from a few ‘first principles’. This led to concepts that sound a bit awkward to us nowadays like a stone is not falling but searching for its place in the natural order. Or the belief that all earthly bodies are composed of four elements: earth, fire, air and water. Still Aristoteles is seen as the first scientist, or rather natural philosopher, because of his studies in biology, astronomy and physics.



Aristotle Zhang Heng

By the way, the ancient Greeks were not the only ones that tried to explain reality. In China for instance Zhang Heng developed an extensive knowledge of astronomy (astrology in those days) and mechanics. He invented a kind of astrolabe, improved calculations for pi, documented 2500 stars and invented a seismometer with which he tried to predict earthquakes. And in the Middle East, in Mesopotamia and ancient Egypt, foundations were laid for modern day astronomy and arithmetic.

Still the scientific revolution and the accompanying modernization did not start in China or the Middle East, or in ancient Greece. It started around 1600 in Europe more specifically in Western Europe as society was opening up during the Renaissance when people developed several ways to understand reality.

The Ancient Greek philosophers played a big role in this revival. Their manuscripts had been saved – at least part of them - translated into Arabic and extended by Islam scholars at the height of the Islam Empire (750-1000). They were re-discovered when the Moors were driven out of Spain and gradually became known throughout Europe where they evolved further into modern science.

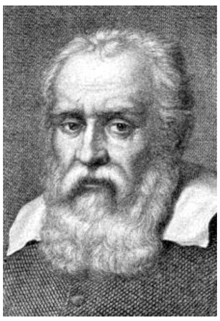
According to the Dutch historian of science Floris Cohen ("How modern science came into the world", Amsterdam 2010, free download) three very different and very separate modes of acquiring knowledge about nature came together at that time in Europe.

The *first* was the Athenian variety, which he calls the speculative part of Greek knowledge: scholars that tried to explain reality from a limited number of first principles like Aristotle. The famous French scientist Descartes turned Athenian variety into a natural philosophy of atomist origin.

The *second* form of knowledge is one he refers to as Alexandrian, named after the city in Egypt that was built by Alexander the Great. It seeks to explain or rather model the world in abstract mathematical terms and formulas. Joannes Kepler and later Galileo turned it into what Cohen calls a mathematization of nature, i.e. modelling the world, based on observations.

The *third* form of knowledge, unique for Europe, was based on an accurate description of natural phenomena for practical application. It had started in the 15th century with scholars like Paracelsus and artisans like Leonardo da Vinci who used their observations for developing new therapies in the case of Paracelsus and new ‘machines in the case of Da Vinci. Francis Bacon turned this form of knowledge into a fact-finding, practice-oriented mode of experimental science.

Descartes



Galileo

Bacon

The coming together of these three forms of knowledge led to what we now call the Scientific Revolution - or better perhaps - a period of transition, lasting forty years during which pre-scientific ways of understanding nature developed into more or less modern science. According to Cohen this transition was unique in the history of mankind. Although the Chinese and the Islamic civilization had been more advanced and more literate in earlier centuries the scientific revolution did not happen there.

Even in Europe it was not sure that modern science would survive and develop untill our day and age. Around 1640 Europe had been torn apart by wars fed by religious differences. Even innocent debates about for instance a question why ice floats on water could in no time become a religious dispute. It could have been a repetition of what happened in the Islamic Empire around 1050 when it turned to its religious core, during long lasting and heavy attacks from the Mongols.

Instead the scientific revolution gained momentum and the mechanical philosophy, for which the groundwork was laid by Galileo and Descartes, became the dominant scientific vision in the second half of the 17th century, thanks to figures like Christiaan Huygens and Robert Boyle and others. Its widespread acceptance, writes Samir Okasha in "Philosophy of Science: A Very Short Introduction", marked the final downfall of the Aristotelian worldview.

It culminated in the works of Isaac Newton and his masterpiece the Mathematical Principles of Natural Philosophy, published in 1687. It describes with great mathematical precision and rigour a dynamical and mechanical theory based upon three laws of motion and his principle of universal gravitation. By doing that he provided the framework for science for the next 200 years. His mode of explanation was extended to all kinds of phenomena beyond mechanics, like chemistry, thermodynamics, and electro-magnetism.

Although widely regarded as the founding father of modern science, Newton also practised alchemy. In fact he belonged to the pre-Newtonian world, writes James Gleick in his biography “Isaac Newton” (2003).

Alchemy was in its heyday and like his colleagues Newton worked in secrecy obscuring his writings with ciphers and anagrams. It would take another century or so before modern chemistry emerged from alchemy and based itself on the mode of explanation that Newton himself had developed for the physics of motion.

Many scientific disciplines emerged based on the mode of explanation by Isaac Newton. Still scientific development was not as straightforward as we might think. In chemistry for instance the phlogiston theory of Georg Ernst Stahl survived for a long time after it had been negated by Antoine Lavoisier, and even Newtonian mechanics survived for a long time the observation that the planet Mercurius’ orbit around the Sun did not fit the laws of motion and the principle of gravity.

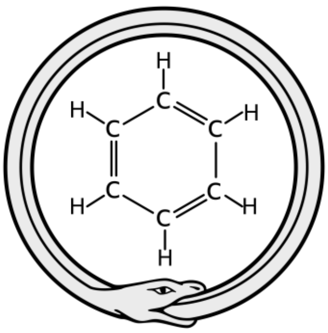
The above is only a very short introduction into the history of science. There are loads and loads of books and articles written about the subject, about science in general but also about scientific disciplines, scientists and inventions. The main lesson to be learned from them is that science and technology are the result of human activity with all the problems and shortcomings of the human condition. Which raises the question in what way do they differ from other forms of knowledge, something philosophers of science are still debating about.

Philosophy of science

According to Herman Koningsveld, a Dutch philosopher and author of the book “Het verschijnsel wetenschap” (The phenomenon science, not translated) the aim of science is to gather of true knowledge about reality i.e. the development of laws and theories that explain and predict natural and social phenomena. If I use a certain amount of force to push a ball, I can - under ideal conditions - predict what speed the ball will be rolling ten minutes from now.

There are more ways to acquire knowledge about the reality we live in: intuition for instance or experience or revelations like the Holy Books. Science distinguishes itself from these forms of knowledge by demanding that a law or theory (a theory is a coherent system of law-like relationships) must be justified by facts and by logical arguments. In other words: logic and facts determine whether a theory is accepted or rejected.

The above is not to say that scientists develop their hypotheses and theories through logical reasoning and then try to confirm them by collecting acts or doing cleverly designed experiments. Most researchers work capriciously and irrational and are often led by hunches. A classic example is the structure of benzene, which appeared to Friedrich Kekule in a dream in the form of a snake biting its own tail. But that is not the point. Science being based on logic and observed facts is a justification afterwards.



According to the standard model of science where many scientists adhere to, science is based on logic and observed facts and these observed facts are free from prejudice, beliefs and morals. Science is value free in the sense that external values, like moral values, are excluded.

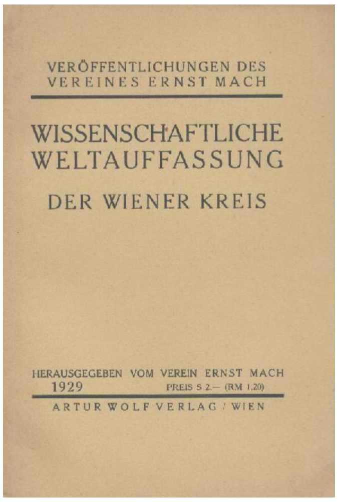
That means that we can also make a clear distinction between facts and decisions. Facts are facts and decisions are by definition value-laden. Political decision-making on science limits itself on the one side to create the conditions for science – money, people - and on the other hand to decide what to do with the results. On no way politicians or other people should interfere with the scientific process itself.

Intermezzo: LAW

Through induction a finite number of observations can be turned into an infinite collection of facts: a law. Laws can be deterministic like the law of Gay Lussac and Ohm's Law, or statistically. A simple example of the latter is that the chance to throw six with a dice is one in six. Laws are actually observed regularities. A theory describes the mechanism behind these regularities. For instance the gas laws of Gay-Lussac and Boyle finally found their place in the kinetic theory of gases. A theory not only explains the observed regularities (laws), but also provides the opportunity to formulate new laws and test them.

[End]

This standard model of science was first formulated in the late twenties in the manifesto of



the Vienna Circle, a group of philosophers and scientists that met weekly in one of the Stuben in Vienna. They called upon people not to be guided by dogmas and unverifiable truths of theologians and philosophers, but approach reality in an unbiased scientific way, based on facts and logic. The manifesto was in fact a call for emancipation. People were asked to liberate themselves from the shackles of ideology and faith.

Almost a century onward we live in a science-based society. Even the Church leaves truth claims about reality to science as was symbolized by the apologies of Pope John Paul II in 1992, for the condemnation of Galileo Galilei in 1633.

The standard model of science also lies at the basis of post-war science policy, first formulated by Vannevar Bush in his report ‘Science the endless frontier”. We will come to that in the next chapter on science policy.

Although a lot of people, including many scientists, still think along the lines of the Vienna Circle, the standard model has come under fire as early as the thirties. Its main critic was Karl Popper. In his famous “Logik der Forschung” (1935, English translation: The Logic of Scientific Discovery, 1959, free download) he aims his arrows on the concept of empirical knowledge that underlies the standard model. The suggestion that theory-free perception of facts leads to laws and theories is not true, he says. It is just the reverse.

Researchers formulate a theory in response to a problem that they are experiencing. Where the theory comes from is not important. It is often a speculation or an educated guess. The speculation or theory is then confronted with facts, either observed facts or results from experiments, designed to test the theory. If it passes the confrontation the theory is provisionally accepted. If not, it is dismissed. In Popper’s words: a theory must be falsifiable and the main task of a scientist is to design experiments to falsify i.e. dismiss the theory.

The so-called critical rationalism of Popper has two consequences for people that deal with science. The first one is that science does not automatically lead to The Truth, a correct description of reality. You can design different experiments to test it over and over again, so

you might come nearer to a correct description of reality, but one falsification and your theory has to be dismissed.

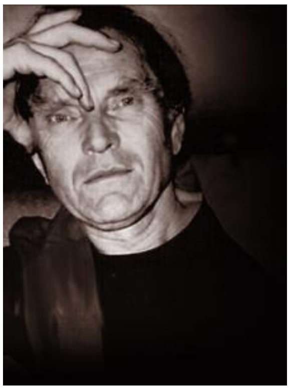
Let us say that I have a theory that all swans are white and I have tested it over again under different circumstances – in winter, in summer, in the north and in the south. The theory becomes stronger and stronger but alas… Just before I am to collect a big prize for my endeavours, someone produces a black swan that falsifies my theory.

In fact Popper says that the empirical basis of the standard model is not rock bottom, but quicksand. For us journalists – and others – it means that a certain amount of scepticism – not cynicism - is justified when scientist make predictions based on their theories.

The second consequence is that observed facts or results from experiments are - by definition - theory-laden. Or, put it another way: The theory functions like a searchlight or sometimes even just a straw; it shows only part of reality. Some parts come into the full light, while others remain in the dark. Another searchlight, a new theory, might shed light on the parts that stayed in the dark, overthrowing or at least changing the first theory.

An example: for quite a long time it was thought that global warming was mainly caused by anthropogenic emissions of carbon dioxide. Only quite recently there has been more attention for the role of changes in ocean currents in climate change, such as the Pacific and Atlantic Decadal Oscillation, leading to an interesting discussions about the contribution of mankind to climate change. Is it 97 per cent or just 50 per cent or even less?

In Popper's critical rationalism there are no objective facts. The observed facts are always dependent on the theory that is to be falsified. This can easily lead to relativism with regard to science in the sense that scientific facts are loaded with prejudices, beliefs, values, and / or determined by money, power or religion.



A representative of this relativism is the philosopher Paul Feyerabend who wrote a book “Against Method” (1975) in which he states that there is no “scientific” method, but lots of different ways to look at the world around us.

“There is no ‘scientific world-view’ just as there is no uniform enterprise ‘science’- except in the minds of metaphysicians, schoolmasters and politicians trying to make their nation competitive. Still, there are many things we can learn from the sciences. But we can also learn from the humanities, from religion and from the remnants of ancient traditions that survived the onslaught of Western Civilization.”

In fact that means that there is now way we can distinguish science from other forms of knowledge like religion or pseudo-science. Popper himself seriously tried to combat that kind of relativism. To be able to do that though, he had to invent the concept of undisputed background knowledge.

Each discipline, he reasoned, creates its own empirical basis: facts upon which everyone agrees. In astronomy, for example, the theory of the refraction of light is part of this undisputed background knowledge; it is outside the critical order of astronomical theories. The tacit understanding is that you do not question the observations with a telescope, solely because you criticize the theory of refraction.

However the line between this undisputed background knowledge and the acceptance of a set of theories within a scientific discipline is very thin. Challenging that set of theories, the so-called paradigm, might be difficult, as Thomas Kuhn described in his “Structure of Scientific Revolutions” (1962).

The development of a scientific discipline starts with a pre-paradigmatic period when there is no common platform. Instead there are several schools that keep themselves busy by continually debating the foundations of the discipline. At a certain point in time one of the schools takes the lead. Not because they have formulated the best theories, but because researchers have focused on practical problems and came up with solutions.

If they develop more and more solutions to practical questions, more and more researchers will join them. Eventually the pragmatic approach leads to a theoretical framework, and the

discipline enters into a period of 'normal science' as Kuhn calls it. The theoretical framework functions the frame of a jigsaw puzzle and researchers set out to find the missing pieces and put them together.

At a certain point in time it turns out that one or more pieces – odd observations - do not fit into the puzzle, like Mercurius' orbit that did not fit into Newtonian mechanics. According to Popper's critical rationalism this counts as a falsification that should lead to the dismissal of the theory.

In practice however such an anomaly, as it is called, will often been ignored. Sometimes even the researcher who came up with the non-fitting piece is sidelined or denounced as a troublemaker. Not on the basis of rational arguments and observed facts, but because the 'establishment' within the discipline fears to lose power, influence and funds. Or as Kuhn puts it: "The prevailing paradigm is immunized against facts that do not fit the theory".

Changes only begin when there are to many pieces that don't fit the jigsaw anymore and/or when the elder scientists retire and the younger ones take over. Thomas Kuhn calls this transition a period of revolutionary science when a new paradigm is created. As the term revolutionary implies this transition is not always based on undisputed facts and logical reasoning but bears more resemblance to a political struggle.

The question is what to do with the findings of the philosophy of science. Everyone should decide for himself or herself, of course, but personally I think the critical rationalism of Popper offers the best leads for the professional science journalist and communicator. It is a basis for a sceptical attitude toward science. It prevents you see the results of scientific research as the ultimate truth and teaches you not to base your judgements – or headlines like “Breakthrough in cancer research” – on a single research paper.

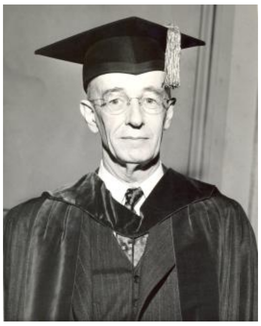
At the same time it provides opportunities for describing these results from different perspectives - economically, politically, socially, morally. The recognition that these observed facts are laden - even value-laden - opens up the possibility for a serious dialogue with society about the use of scientific research for solving societal challenges.

Although there is no real criterion to demarcate science from pseudo-science and other forms of knowledge I like to think that critical rationalism is also an antidote to the idea that science is an opinion like any other one, especially when it comes to controversial issues such as climate change, shale gas, nuclear power or genetic modification.

Every theory remains a theory, but as it has withstood several attempts at falsifying, it has more weight than just any other view. Moreover: Science might not lead us to the ultimate truth, but the scientific approach is a good way to expose untruths and that is always useful for a journalist.

Science policy

To understand something about science policy in our days we have to go back in time once more. Not as far as the days of ancient Greece, but to the period shortly before the end of World War II. The year 1944 is the starting point of science policy, as we know it today. In that year, President Roosevelt asked his Director of the Office of Scientific Research and Development, Vannevar Bush, to write a report on the role of science in peacetime.



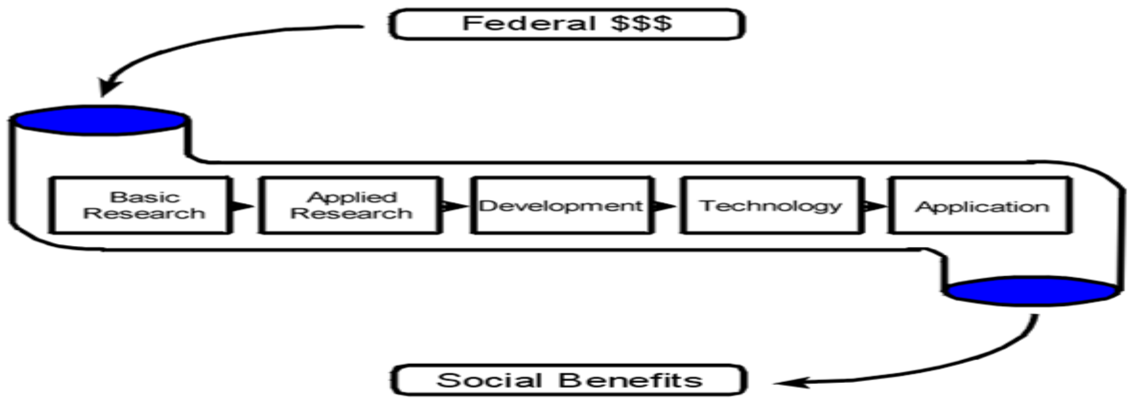
The Office had been established a few years earlier when the United States were drawn into the war by the attack on Pearl Harbour, to support the war effort. One of their projects was the Manhattan Project that would eventually lead to the atomic bomb.

Before Bush had finished his report Roosevelt had died and the United States had shown what an orchestrated scientific effort was capable of in Hiroshima and Nagasaki. Nevertheless, Bush published his report with the very American title “Science the endless frontier. He argued for a continued support for basic research, even in peacetime, without too much control by the government or other.

Basic research in Bush’ view was free research, curiosity-driven without even the suggestion of practical application. His view on science seems directly derived from the above-mentioned standard model of the Vienna Circle, which says that science is based on logic and unbiased observations. The essential characteristic of basic science being that it focuses on the understanding of nature and its laws.

According to Bush applied research invariably drives out pure research if the two are mixed. So he made a sharp distinction between research for understanding and research for use i.e. between basic and applied science. At the same time, however, he believed that basic research is the engine of technological progress.

The assumption that science is the engine of technological progress is a cornerstone of modern day science policy. It is based on the so-called linear model, which assumes that free basic research serves as a source of new discoveries. Applied researchers and engineers then convert these discoveries into technical inventions that can provide for all the needs of society. Basic scientists should not be bothered with questions about possible usefulness of social relevance of their research, but left in peace to follow their curiosity.



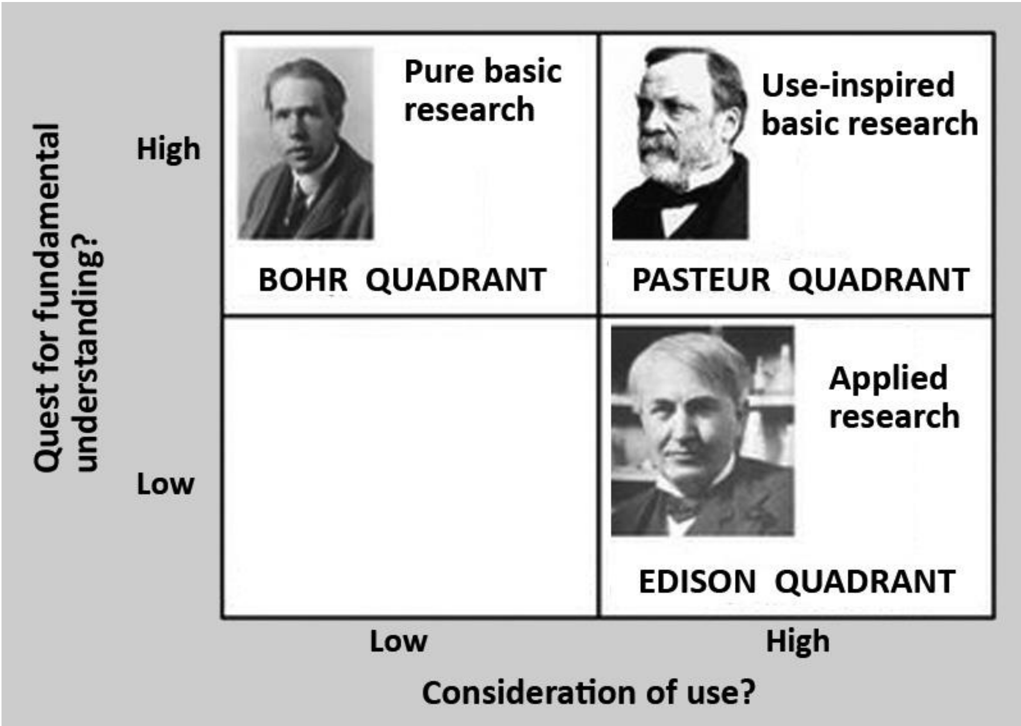
Many countries use this model to shape their science policy. In the Netherlands, for instance we have two funding organisations for public-financed research: one for applied sciences and technology and one for basic science. The last one was erected shortly after the war, based on the ideas of Vannevar Bush and – partly - funded by the Marshall Plan. Nowadays it also funds thematic research on environment or other problems, but a large part of the funding still goes into basic science.

Horizon 2020, the Framework program for research & innovation in the EU, also reserves a large part of its 10 billion budget, about one-third, for basic science. The European Research Council shares out the money using the criteria of quality of the research proposal and the track record of the scientist. For the European Commission curiosity-driven basic science is an important source for technological progress and economic growth.

Intermezzo

Actually, it is noteworthy that the sharp distinction between research for understanding and research for use, made by Vannevar Bush in the forties, has endured for so long. In the aftermath of the Paris Revolution of May 1968 – the seventies - the period that I myself was at university, we students laid siege to the ivory tower and fought for socially relevant research. Partly as a result of that some things changed. Thematic research programs were set up and scientists were and still are asked to indicate whether their proposal serves a social purpose, however far into the future. Under the Horizon 2020 program a large part of the budget will be spent on research into the Grand Societal Challenges - about one third - and to strengthen the competitiveness of European industry – also about one third. And even the European Research Council now has grants for 'Proof of Concept' to establish the innovation potential of ERC-funded frontier research projects. It shows that one of Bush' dogma's (applied research drives out basic research) has faded. But although things have changed, there is still little or no discussion about the linear model and its underlying division between basic and applied research, between understanding and use. Yet there is every reason to, because it does not fit with reality and therefore hinders the development of an adequate science policy.[End]

The linear model was criticised Donald E. Stokes in his book "Pasteur's Quadrant: basic science and technological innovation". He did so already in 1997, but his ideas are only now becoming more widely spread. He developed an alternative by not putting "use" and "understanding" as opposed to each other, but using them to make a quadrant with use on the horizontal and understanding on the vertical axis.



The quadrant provides four types of research:

Top left we find the research that is focused on fundamental understanding without regard for possible applications. An example is the quest of Niels Bohr to develop an atomic model. This type of research is the type of basic research that Vannevar Bush envisioned.

Bottom right, we see research that is not focused on fundamental understanding, but only on application. This quadrant Stokes connects with the name of Edison, also because he forbade his employees to follow their scientific curiosity. All activity in Menlo Park was solely aimed at commercially useful inventions.

Below left we find the investigation that neither aims for fundamental understanding, nor application. It is a type of research that is mainly descriptive. A typical representative would be Linnaeus, who developed a naming system for all living organisms. The data that come from this type of research often provide the raw material for basic science in Bohr's quadrant.

Top right finally we find research that is both focused on fundamental understanding and application, defying the sharp division of Vannevar Bush. Stokes calls it use-inspired basic science, and a typical representative is Louis Pasteur. His research falls into the category of basic science because of his efforts to understand microbial processes at the same time he kept his eye on potential applications by accurately controlling these processes.

The Stokes' quadrant seems to be much more helpful in figuring out what is going on in science and science policy than the linear model that is largely based on the idea of science built on logic and unbiased facts. Especially nowadays when the whole science system seems to be geared towards improving competitiveness and meeting the grand societal challenges. It would be nice to link Pasteur's Quadrant, as described by Stokes to the critical rationalism of Karl Popper but he does not mention him even once.

If anything recent developments in science and technology look more like a scientific revolution as described by Thomas Kuhn. Recently the European Commission published a background paper on Science 2.0. According to this document Science 2.0 is all about "a paradigm shift in the modus operandi of research and science, impacting the entire scientific process." This shift is mainly caused by the rise of digital technologies that are not only responsible for a huge increase in the volumes of data that are generated, but also make it possible to detect and research patterns in unstructured data, the so-called Big Data research.

Another development mentioned in the document is the enormous growth in the number of scientists. 'Every decade produces as many scientists as have lived before', the Background Document states, and that growth mainly occurs in China and India. The world now has about 6 million scientists, but in the next fifteen years alone there will be already in China 200 million graduates. Not that all of them are researchers.

These digital technologies in combination with the arrival of digital natives at universities and research institutes - young people who were born after 1990 and have grown up with social media - also lead to new forms of global cooperation, says the European Commission. They share all information ripe and green via social media, open access web magazines and other forms of data sharing.

An example of this is the Open Science Movement. It started in the USA but there are now several initiatives in Europe as well, like 'Hack your PhD', which has its origins in France. The 'open science' movement advocates a more transparent way of doing science, with lots of room for collaboration, not only with other scientists, but also with NGO's and citizens.

Although science is by definition open system, says one of the spokespersons, we see a number of developments that tarnish the fundamentals of science and innovation. Apart from the already mentioned pressure to publish and the growing entanglement with the business, he also mentions the growing number of patents, including software and biological materials and processes that were not patentable thirty years ago.

There are other signals to support the idea of a transition in science. In the Netherlands, for instance several scientists published a paper entitled “Science in Transition: Why science does not work as it should and what to do about it”. In it they put a strong emphasis on the perverse incentives that have crept into the science system. There is an enormous pressure to publish, while at the same time it is very hard for young researchers to get a job that lasts longer than two or three years.

Another issue they address is the growing entanglement between university and industry and the issue of independence and trust. Or as they put it in their position paper: Science produces not only knowledge but also careers, resulting in too many sloppy publications – if not even fraud.

Scientific publications are a reconstruction afterwards. They rarely describe what actually happened in the lab, but describe according to the mores of science the hypothesis to be tested, the materials and methods that have been used, the results that have been achieved and a discussion about the meaning of these results.

Because it is a reconstruction it also gives the opportunity to brush up the results of experiments, for instance by leaving out the 'outliers', data of an experiment that did not fit the hypothesis. Sometimes it turns even into downright fraud, for instance by making up data. Scientific journals try to prevent that kind of behaviour by asking authors for all their lab results and other information from the shop floor.

Economist "Trouble at the Lab"

The criticism does not come alone. Last year, as mentioned, the Economist published an extensive article on unreliable research titled "Trouble at the Lab" (Economist October 19th 2013). It showed among other things that a large part of the results of scientific research is not replicable. Replication research is not done very often either because there is no funding or you don't score points doing it. This leads to a situation where there is no cost in doing things wrong, but the cost is in getting your article published.

The acclaimed peer review that should prevent this kind of sloppiness is functioning much worse than scientists themselves and funding agencies dare to admit. Peer review itself is also under fire. It is an unpaid job and so it often has to be done in between other tasks. In very specialised fields the peers know each other which might lead to mutually scratching backs or – the opposite – turning down a paper and use the information for your own research. It happens because scientists are no superhuman beings, but have a career to think about too.

In general, science and scientists still enjoy pretty much respect as becomes clear from various surveys, but when it comes to specific topics such as the use of genetically modified crops, the extraction of shale gas or vaccination against HPV - or vaccination in general - then scientists are seen at best naive and at worst as lackeys of big business. Public debate on these and other issues in Europe often turn into a fruitless "dialogue between deaf' because the concerns of citizens are neglected by scientists.

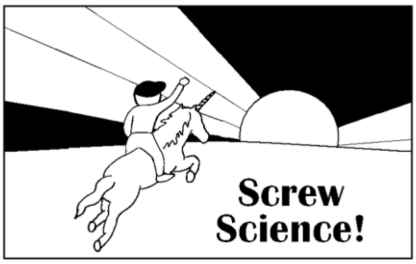
Conversely the results of scientific research are presented as the ultimate truth. A lot of scientists still adhere to the so-called deficit model, thinking that if we explain it once more the public will eventually understand what is going on and agree with us on the actions that are needed. The societal debates about genetic modification, climate change and shale gas (fracking) have shown that supplying a critical public with more information and better explanation is not enough. If anything it makes people even more convinced of their own 'unscientific' views.

Instead of suggesting that the science is settled and there is nothing to discuss because facts are facts, a better starting point would be to discuss the values behind the theory that has unveiled these facts. Instead of debating the facts you could have a dialogue on values to – at least – agree to disagree. Too often it happens that scientists accuse the public of using the wrong facts and/or the wrong interpretations. In short: that the public is just stupid and should leave science and the interpretation of scientific results to people who know what they talk about.

Intermezzo: HPV-vaccin

An example is the vaccination campaign against human papilloma virus (HPV) that causes cervical cancer. Hundreds may be even thousands of parents were in doubt about the efficacy of the vaccine and its possible side effects. These worries were probably induced and/or multiplied by the fact that they had to think about their 11- or 12-year old daughter as a sexual being. In droves they sought information from a variety of sources – Internet, friends, neighbours, physicians. Based on the results of that quest, quite a large percentage decided against vaccination. Mind you, the decision was not taken lightly; some might have even lost sleep on it. Yet scientists told them that they were stupid and backward if they did not have their daughter vaccinated. That does not sound like the start of a good dialogue. [End]

Restoring public trust in science and technology is important. Paraphrasing Churchill (on democracy) we could say that science might be the worst form of acquiring knowledge about our world, except for all those other forms that have been tried and failed. In his book "The March of Unreason" (2005) Dick Taverne, founder of Sense about Science, examines the public reaction against science and its implications for democracy.



Not only do we hold back technologies (like gmo, for instance) that could dramatically improve the lives of many poor people, we also risk strangling scientific creativity and technological innovation by irrational practices like organic agriculture, homeopathy and eco-fundamentalism. According to Taverne history shows that there is a close link between science and democracy, both being 'products' of the Age of Enlightenment.

So science policy should be aimed at stimulating a real dialogue between science and society, not just a dialogue between deaf. A prerequisite for that kind of dialogue is that scientists admit that the facts and theories they present are not certainties from here to eternity. As Popper already has shown almost 80 years ago even scientific observations are biased by theories how the world is working and hence are not free of values.

The dominant paradigm in nutritional science for instance is the prevention of diseases caused by too little or too much and too unhealthy food. Consequently people that are overweight are addressed like children that have to change their habits. As if they don't know what is going on. Wouldn't it be better, says Hedwig te Molder, professor of communications, to start a real dialogue about food that includes other values such as food as an important part of a good life, or as a social activity. Such a dialogue could lead to quite a different research agenda.

Anyway, it seems that the science and science policy, as established at the end of World War II are cracking in their seams. On the one hand because of developments within in the scientific community itself, such as the advent of digital technology, the exponentially growing output of publications and the pressure on researchers and on the classis system of peer review for judging research proposals and publications.

On the other hand there is a lot of external pressure on science. The combination of shrinking budgets and major societal challenges put an axe to the root of curiosity-driven basic science. Large companies such as Shell, Philips and Unilever already knew how to use a little private money to get a lot of publicly funded research done, but now small companies, and other organisations and citizens want to have their say in the formulation of the research agenda.

With all that is going on these are interesting times for science journalists who are willing to look beyond the weekly output of Nature, Science and The Lancet. I think there is need for describing and analyzing what is going on science, from the leg work in the lab and the pressures scientists have to deal with right up to the way decisions are made about research agenda's, funding and cooperation with industry and other partners.

At the same time there is an urgent need to describe and analyse what is going on in the relation between science and society. Is public trust eroding and if so why. And how can citizens get involved setting a research agenda to deal with the grand challenges we are faced with. So I think there is definitely a future for independent critical science journalism. In the next chapter I will discuss how we are going to grab that future.

The future of science journalism

Science journalism, like any other kind of journalism is in transition phase because the media landscape is changing dramatically. Thanks to the Internet independent science journalism is meeting with a lot of competition – for attention – from blogging scientists, press releases – often disguised as online news - from universities, research institutes, media centres and other kinds of free copy and footage. So the question arises whether science journalists still have a role to play or that they leave it to public relation officers and media-savvy scientists to inform the public about the things that are going on in science.

Before answering that question we have to go back in time a little bit (again) to the 60s and 70s when science journalism became a specialism. In those days the unwritten rule was that any reporter should be able to write any subject. The first generation mainly consisted of general reporters that got interested in science and technology mainly through writing about environmental issues.

Nowadays science journalism has become a specialism, like sports, business or policy journalism. There seems to be – in practice at least – a big difference between these specialisations. While our colleagues at the sports or political desk have no problem with analyzing, commenting and criticizing, science journalist tend to be very loyal to science and its practitioners.

A Dutch science journalist once compared his trade to that of a foreign correspondent, writing about the goings on in another country but always from the perspective of his audience in his home country. It is a kind of balancing act, because one the one hand the foreign correspondent has to have a great interest for what is going on in his host country. On the other hand he should always keep in mind that his information has to be useful or entertaining for the folks at home.

Looking at science journalism in that way I think we have been behaving like a foreign correspondent that has gone native, that our loyalty to science turns into a fascination, even a passion for science. That does not have to be a problem as long as we remember that our job as journalists is that of a critical controller of power.

It sometimes seems though that we behave more like cheerleaders of science than of watchdogs, as was the title of a series of articles in Nature on this very subject in 2009. In one of the articles of that series Tony Murcott describes a pattern that has arisen in science journalism:

"There is a rhythm to science news, easy to spot in the mainstream media and as familiar to every science journalist as breathing. It follows the publication cycles of the major peer-reviewed journals such as Science, The Lancet and Nature. As press releases describing research arrive in our inboxes they are scanned for stories, the most newsworthy picked, offered to the editors and then reported"

(Tony Murcott "Science journalism: Toppling the priesthood", Nature 25 June 2009)

Sometimes the main contributor to the story is telephoned or emailed to ask a few supplementary questions and sometimes even another researcher, who did not contribute to the story, is asked for his opinion. Still the whole subject is approached from the perspective of science, not from a broader perspective, which might make it more useful for the audience. As Murcott writes:

'*This is not exactly a description of a journalist – more that of a priest, taking information from a source of authority and communicating it to the congregation.*'

Of course there are lots of reasons and excuses for this attitude. As said, many a science journalist has a science background and tends to be loyal to his teachers and peers who are now working in science. Then there is the proverbial lack of time and the fact that we are dealing with complicated subjects we hardly understand ourselves.

It is also very tempting and nowadays even necessary for most freelancers to supplement their meagre income from newspapers and magazines, by writing press releases or background stories for universities, research institutes and companies. Others, working for TV or radio supplement their income with media trainings or presiding a symposium or other kind of meeting. If you don't want that, you either have to marry rich or live like a student for the rest of your life.

It may be a bit exaggerated but if this is the actual situation in science journalism, we have to ask ourselves what our added value is for our audience and – more specifically – for the chief editor and the publisher. If science journalists only take information from a source of authority and 'translate' it for their audience from the perspective of science, they are actually doing the same as the public relations officer writing a press release or the scientist writing a blog.

Eventually the publisher or chief editor might come to the conclusion that it is cheaper to use the press releases from research institutes, instead of paying a reporter to write more or less the same story. The more so if he realises that the same reporter writes press releases for that research institute to supplement his income. So chances are that if we stick to this type of science journalism (cheerleader) we are making ourselves obsolete.

To prevent that from happening we have to look more closely at our role of journalists. From a conversation with German professor Hans Peter Peters, specialised in public communication of science and technology, I learned that apart from being a watchdog, journalists are or should be able to write about their subject from different perspectives.

Writing about economy a journalist applies perspectives of politics, morals and/or everyday life. And writing about science you apply perspectives of politics, economics, education, morals and so on. In fact you do not apply criteria that are inherent to the system you write about, but you observe the science system from the logic of politics (= power) or economics (= money) or morals i.e. different societal areas.

By applying observational criteria that are external to science, the journalist can link the perspectives of these different subsystems. That produces two pictures: one on purpose, showing science in relation to politics, economics, morals and culture. And the other as an extra: the image of science as it is seen by society - from the outside.

The latter picture shows that good-quality independent science journalism is very much in the interest of science. Not to promote science or scientists but to describe how science is looked upon from the outside. As said, that mirror function is not something a science journalist consciously sets out to do. If he writes from the different societal perspectives it is created automatically.

The external selectivity, the application of observational criteria outside science, is typical for journalists. Science writers or science communicators can translate scientific subjects for a large public in many ways. They also have to anticipate on the interest of their audience but as secondary criteria.

A PR-officer from a university always keeps in mind the interest of the university. And a scientist who blogs, will always keep in mind the interest of his project or his career. Scientists and hired science writers can only simulate journalism, but cannot replace it, the most important difference being that a journalist has no stake in the subject he writes about. He is independent.

A journalist specialised in science reporting must be able to inform his their audiences about scientific efforts and results from different perspectives - political, economical, social, moral. At the same time he should be able to write about any subject – football, cosmetics - from a science angle.

At the Kavli Symposium on the future of science journalism that was held in February 2014, Dan Fagin from New York University suggested to try and define science journalism by establishing what competences science journalists need and what values they have.

Among the competences of science journalists the most important are science literacy and numeracy; use and evaluation of experts and expertise; use of evidence and argumentation and last but not least being able to present it all in a clear and involving way.

Among the values of science journalist are the obligation to independently depict reality to the best of his capabilities and knowledge; loyalty towards his audience; transparency; verification and providing context.

In short: in terms of competences he differs from other specialised and general reporters but his values are the same. On the other hand his competences are the same as those of other science communicators, but his values are different. A freelance science journalist working for both independent media and for sponsored media – like university magazines – should be aware of these differences and preferably be open about his different assignments and the different 'hats' he is wearing.

After having established what the added value of a science journalist is, we still can't be sure that there is a future for science journalism. For that we have to turn that added value into a business model: who is willing to pay for that added value?

From the above we can conclude that there obviously is an urgent need for independent science journalism. First of all for democracy: the public and the politicians need someone they can trust to be independent to inform and explain to them what is going on in science and technology and how that might influence their lives, jobs, neighbourhoods, in short the society they live and work in.
Secondly, science itself has to gain a lot from independent science journalism. Imagine a world without it where just blogging scientists and public relations officers inform the public about science and technology. By definition they will do that from the perspective of their institution or their research group. The majority of them will do that in a decent and responsible way, but there will always be who stretch their claims too far and present hypotheses as predictions.

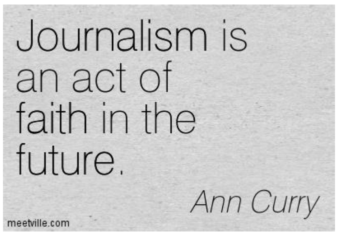
So instead of making ourselves more or less redundant by behaving like cheerleaders for science, we have to make clear that science and technology reporting is as much a cornerstone of any news medium as are economics, politics and sports. Not by obediently reproducing the press releases from scientific magazines and research institutes, but by analyzing and interpreting science and technology from the perspective of our audiences, like a real watchdog.

The first thing than is to convince editors and publishers that, instead of downsizing or even abolishing science desks as has been happening over de the last five or ten years, they should welcome science journalists, not only to write about science but also as players in multidisciplinary teams of journalists tackling an issue the importance of science and technology reporting.

Then there is still the problem that less and less people are willing to pay for information. That is not just a problem for science journalists, but for all kinds of journalists in the age of Internet. Like other journalists, science journalists will also have to find new ways to report about the things that are going on in their field and what that means for their audience.

There are already several promising initiatives, like The Correspondent in the Netherlands, where people take a subscription, not for a magazine but for in-depth articles from journalists. In the USA there are several websites, like Pro Publica and Inside Climate News that are sponsored by foundations. Another example is Norway where a website (forskning.no) is sponsored by so many universities and research institutes that it is actually independent.

To sum up I would say there is definitely a future for science journalism because in a democratic there is a need for unbiased reporting about developments in science and technology, including science policy and science funding. Science and technology are indeed too important to leave them to scientists and engineers. What is different today is that both the science and media landscape are changing fast and these changes affect our role as science journalists and the way we work. It is still much too early to predict what type of business models will survive these ongoing transitions.



That uncertainty might be frightening but it also means that new possibilities will arise for (science) journalism. You just have to explore them.

MORE INFORMATION

- http://undsci.berkeley.edu/article/intro_01
- https://www.youtube.com/watch?v=tP8teUgZcBY
- http://en.wikipedia.org/wiki/History_of_science
- http://www.oapen.org/search?identifier=406703 (Floris Cohen)
- http://www.wfsj.org/course/index-e.html