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What can history teach us about the prospects of a European Research Area?

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Preface

This report is the result of work carried out by the Centre for the Study of the Sciences and the Humanities at the University of Bergen, Norway. The work was commissioned by the European Commission's Joint Research Centre at Ispra, and as such this report is the final deliverable of our Service Contract 257218 with the EC-JRC. Throughout this work we have greatly benefited from continued academic discussions with Dr Andrea Saltelli at the EC-JRC. We also thank colleagues at the National Conference for History of Science in Norway (January 2013) for valuable comments on our presentation of the methodological principles informing the study. It should be emphasized, however, that the content of the report is solely our own and that we have enjoyed full academic freedom in the choice of content as well as style.

Four researchers at the Centre for the Study of the Sciences and the Humanities have participated in the creation of the report: Ragnar Fjelland, Silvio Funtowicz, Kjetil Rommetveit and Roger Strand. All four have taken part in the general process of creating the outline and composition of the report as well as the general study that informed it. All four have commented on various chapter drafts. As for the individual chapters, they have had different lead authors: Fjelland (Ch. 1, 3), Funtowicz (Ch. 10), Rommetveit (Ch. 4-6, 8, 11, 12.1) and Strand (Ch. 2, 7, 9, 12.2). We are grateful to Judith Ann Larsen for proofreading the manuscript. Strand is responsible for the final edit and the resulting inaccuracies or errors to the extent that such emerged in the process.

It is our belief that the history of science has a lot to offer to contemporary debates on research policy and on science in society. This is especially true when the history of science is not seen as independent from political, economic and cultural history – that is, when history is allowed to display how the different sectors of society are all entangled into each other and help shape each other. This calls for a historical sensitivity also for challenges, problems, conflicts and crises; and such a sensitivity appears to be timely in present-day Europe, where the word "crisis" is taking a predominant place on public and political scenes. In this report, we write about matters of conflict and controversy in the past and in the present. We believe that conflicts and controversies should be described sharply and candidly in order to be clearly understood and analysed. Consequently, parts of the report might appear as provocative in its content and style. If we have succeeded, this rather lengthy text will also be perceived as an interesting read.

Executive Summary

There are important lessons to be learned for research policy from the history, philosophy and sociology of science. Current European research policies make a number of assumptions about the role of scientific research and innovation in our economies and societies. They also make assumptions about the governability of scientific research by public management and quantitative tools such as research indicators. These assumptions have their history and they (often implicitly) rely on particular philosophical and political commitments. At the time of writing (2013) Europe is faced with serious economic and political challenges. Accordingly, it is a good time to rethink fundamental assumptions. With this purpose, this report displays and discusses some central features and principles of European history and philosophy of science.

In order to answer the question of what can history teach us about a European research initiative (for instance, the European Research Area – ERA), one has to understand the trajectory, co-evolution and changes that took Europe from the emergence of the European state and Modern science to the current European Union and Innovation research and techno-science. One should also reflect on the contradictions of this process, and ask if the current dominating trends are still faithful to the **Humanist tradition** that made of Europe an extraordinary and unique experience of diversity and universality.

The first step of our analysis is to identify a dominant set of uncritical beliefs about the nature of science and its role in society, in order to systematically test these beliefs against history. These beliefs include: Science delivers objective, universal and value-neutral truth (or approximate truth) about Nature if it is allowed to act according to its own method, undisturbed by Society. Nature consists of physical matter in a Cartesian space and of forces that act on matter according to universal and eternal laws. Scientific knowledge is an unquestionable Good because it enables us to understand, predict and control Nature, and develop technology to this end. Technological development is a main driver and indispensable requisite for economic development and growth in modern societies. Finally, in modern societies, public decisions should be founded on and legitimated by scientific facts, "Science speaking Truth to Power". This so-called "**received view**" appears to be implicitly assumed in our institutions of governance. However, all parts of the received view are to some extent empirically inadequate and philosophically problematic.

The received view is the result of philosophical and scientific traditions that can be traced in Europe back to Ancient Greece. However, to understand the peculiarities of the received view, as well as its strengths and shortcomings, it is useful to go 400 years back, to a Europe riddled by disaster and disruption during the Thirty Years' War (1618-1648). This is also the Europe of what later was called the Scientific Revolution, with René Descartes, Copernicus, Galileo Galilei, and many others. An important similarity between the heroes of the so-called Scientific Revolution is that they searched for certainty in the midst of chaos: a Europe of poverty and massive death and with eroding trust in theological and political authorities. This is the context in which Descartes turned to silent philosophical meditation to distinguish certain truth from falsity and illusion, and in which Galileo searches for laws of Nature under ideal conditions. Indeed, philosopher Stephen Toulmin (1922-2009) showed how the Scientific Revolution was quite different from the Renaissance. Where

Renaissance thinkers celebrated open discussion and difference in opinion, the natural philosophers of the 17th century desired unique, universal and unambiguous truth. For that purpose they developed a worldview: "The Book of Nature is written in the Language of Mathematics."

It would be a mistake to think that European history is a story of harmonious and respectful development of the different modern institutions: Science, Politics and Law, Humanities etc. All institutions and sectors have frequently had expansive ambitions at the expense of others. For example, the German mathematician and philosopher Gottfried Wilhelm Leibniz (1646-1716) followed in Descartes' footsteps and saw in his own calculus not only a tool for astronomy and other physical sciences, but also a basis for a more general idea of calculation whereby a "community of minds" could rationally achieve political unity of Europe. This idea of **rational decision-making** later developed into cost-benefit analysis and other methods for calculating what is the "best option".

Moreover, it is important to bear in mind how Modernity never was a set of fixed and established rules but rather an **ongoing experiment**, the experience of nature and society changing (in) history and as a consequence of human action. Science with its logics and laboratories is just one – albeit important – site for this experiment. Other such sites of prime importance and value for European history and identity were the humanities, politics and law.

The humanities, which developed expertise in interpretation, multiple perspectives and dissent, promoted the value of reason, diversity and tolerance. The (natural) sciences, which developed expertise in the reduction of uncertainty, promoted the value of rationality, uniformity and control. The best of European culture might be seen as the result of the continuous exchange and tension between these "two cultures". It is also important to note how the humanities in themselves are diverse across time and space. In the Renaissance, "studia humanitatis" was in contrast to the study of the divine. Only in the 19th century do the humanities become research-based academic disciplines that define themselves in contrast to natural science. As such, they were often deeply entangled in nation-building projects: Historians, archaeologists, literary scholars, philosophers and others helped identify and formulate the identity and qualities of European nations in their quest for independence, power and expansion. Later, in the 20th century, the same disciplines developed an ever more reflexive and self-critical understanding of their own relationship with the nation and the state.

Modern politics must also be understood in light of 17th century Europe, a Europe in which authorities are collapsing. On one hand, the Church gradually lost its claim to truth about worldly matters. Physics proved better than the Bible and Aristotle's writings. As for human affairs, religious conflicts led to disaster. Accordingly, we see the rise of new political thought about the State and its legitimate claim to power. The State becomes conceived as a human affair - a social contract between free men, for the benefit of all. It should justify itself with reasonable, transparent arguments and not by recourse to esoteric knowledge or a privileged relationship with God. The modern insistence on separating "is" from "ought" is created: Science can tell us what "is" in Nature, but what we ought to do, must be settled in culture and politics. Untamed culture and politics, however, seemed to release chaos and disaster. In a context where dissent and free argument seemed to easily develop into violence, mathematical clarity and unequivocal rules appeared attractive. Hence we find the birth of modern economics, by which issues of ownership, transaction, fairness, etc., could be solved with certainty and precision.

The history of the Scientific Revolution is also often told as one of increased mastery and control over Nature. Practical applicability of physical knowledge was important already for Galileo, Descartes and Newton. Other thinkers, however, stand out as the great ideologues of the social and economic benefits promised by science. We shall mention three: Francis Bacon (1561-1626), Marquis de Condorcet (1743-1794) and Vannevar Bush (1890-1974). Bacon formulated the basic belief that knowledge gives us power to act in the world to the benefit of our lives. Condorcet elaborated the utopia of a science-based society as one of welfare, equality, justice and happiness. Bush argued that scientific progress and a strong public funding of basic science are necessary conditions to sustain economic growth by the development of new products (or innovation in contemporary vocabulary). Most official research policies at the beginning of the 21st century can be seen to include echoes of these utopian thinkers.

Still, neither of these three appreciated the increasing centrality of biological thought in the development of modern capitalist societies. Since the beginning of the life sciences, their fundamental notions of change were deeply marked by political events. This was important for the ways in which biology, evolution and society came to be perceived. Nazism displayed among other things the most perverted form of biological and societal thought. On quite another level, however, biology has come to offer both central concepts and techniques for contemporary societies: Societies that are thought of in terms of never-ending development and evolution, in which stagnation is uniquely negative and for which biotechnology is a never-ending source of hope for progress.

The centrality of biology, biotechnology and innovation together with the increasing focus on environmental and ecological problems are our main cues to contemporary events and problems, as well as our suggestions for how to deal with some of these problems. Contemporary history, however, is a risky endeavour. Rather than “stating the truth”, we aim at clarifying assumptions in order to be able to challenge them and in that way offer new perspectives and possibilities for action.

This leads us to ask questions such as: What if the reliance on techno-science, co-evolving with emerging structures of power, has put us in a path-dependent cul-de-sac, where to do more of the same, but faster and more efficiently, becomes the only problem-strategy possible, increasing the democratic deficit and neo-authoritarian temptations?

Science and technology have become fused with industries and economies on global scales, and it is becoming increasingly clear how the received view is inadequate for capturing, articulating and dealing with the consequences of science, technology and industry. The sociologist Ulrich Beck made famous the notion of the Global Risk Society as one that increasingly becomes preoccupied with fending off and dealing with the unintended consequences of modernity’s progression: from pollution of the environment and changes to the climate system, over individualisation and loneliness in society, to threats towards privacy and massive surveillance through new digital technologies.

The received view conceived of the social contract between science and society as one based in a separation between the two. It is not clear what can replace it today. Furthermore, whereas the imperative of innovation is frequently hailed as a vade mecum for many of our times’ ills, this has not paid off so far. Science, technology and innovation do not necessarily work according to prescription, and especially not those of the linear model of innovation, which still today persists as the most powerful expression of what we have called the received view.

Whereas previous periods of stability and continuity within Western societies have tended to rely upon frameworks in which science has provided relatively stable sources or worldviews, today no such unity or wholeness singles itself out. The received view does not recognise this state of affairs, but covers it up. It is indeed difficult today to single out a stable bedrock of scientific findings upon which politicians, communities, individuals or industrialists may construct common projects. To some extent, it even makes sense to state that the sciences are internally incoherent, sometimes even contradicting each other, and that no straight and simple message can be singled out for that very reason. The received view, however, does not help us in this situation, since it prescribes certainty and unity of purpose (through science) where, in reality, this may be lacking.

There appear to be two dominant, partially conflicting grand narratives of the present. Both claim their basis in science, and both carry implicit or explicit political messages. The first, “Bios”, is the one of the necessary and sufficient role of innovation, growth, adaptation, evolution, and the centrality of new and emerging sciences and technologies such as life science and biotechnology. The second, “Geos”, is the one of the limits to growth, the limited supply of natural resources and the change in human behaviour and civilisation that is called for when global human impact has become a significant force onto ecosystems, material cycles and climate systems of the Earth.

The depth of the problems just described can be further outlined as follows: most of the institutions cherished by Europeans as the hallmark of the Enlightenment (science, representative democracy, the rule of law, the public sphere, etc.) were predicated on the logics and institutions of *Bios*: the paradigm of the necessary and sufficient role of innovation, growth, adaptation, evolution, and the centrality of new and emerging sciences and technologies such as life science and biotechnology. But in so doing they (unintentionally) ignored the limited amount of resources upon which they relied, and for a long time they lived happily ignorant (apparently) of the side-effects on the environment as well as to deep issues of global and local inequity and injustice. Today, main concerns are connected to how one might retain, safeguard and renew democracy and welfare in the face of economic downturn, increasing inequity, increasing social unrest and with the climate change disaster possibly just waiting to happen. Even as Europe attempts to address a number of issues relating to its material and natural basis of its subsistence, it must try and keep alive the ideas and practices of democracy, and of reasonable levels of welfare for its populations. Where better to look for solutions than to science, technology and innovation? Innovation, however, should be taken as something more and deeper than merely industrial products based on scientific research. We suggest the concept of “deep innovation”, characterised by at least three types of depth: First, profound attempts at dealing with the grand challenges themselves and not just the development of consumer products and services that somehow may claim to be related to the challenges. Second, profound novelty in the interlinkages between grand challenges. Third, a deep involvement of members of society in the development of new ideas and new solutions not just as passively receiving consumers, but as citizens who participate and through their involvement build new forms of agency.

We are thus ready to state some suggestions for concrete action. The idea that scientific knowledge should determine or prescribe the course of action is in itself part of the 17th century solutions that contemporary society has inherited as part of the problem. We propose the following ideas:

European Values: Return to Reason. The central piece of heritage from the European Renaissance is the humanist ideal of reasoned dialogue between reasonable persons who are aware of their own limitations and are curious to learn from others. This is to be contrasted with later beliefs in the certainty of rational calculations on the basis of scientific knowledge, and the irrationality of what is not science (politics, emotions, citizens). Scientists, analysts and other experts are still asked to improve their indicators and statistics to reduce uncertainty and provide a firm basis for evidence-based policies. From history and philosophy one can learn that for many complex issues there is no certitude to be had without falling into the strategic production of policy-based evidence rather than evidence-based policy. The duty of the expert would then be to insist on the *Return to Reason,* defy requests for hyper-precise information or advice and contribute to the criticism and discreditation of unfounded claims to certitude and rationality. In a return to reason, experts and policy-makers would frequently have to admit that they lack precise knowledge of matters at hand and that there is no way of knowing if the proposed course of action will be successful. This is likely to weaken hegemonic or privileged positions of power within the current framework.

European Values: Diversity and Tolerance. In the same heritage from the Renaissance, diversity of opinions and perspectives is considered a resource for understanding and living with complex issues and not as noise to be filtered away from singular truth. While this insight may be useful in many contexts and on many levels, we would like to suggest it also in the context of contemporary European research policies. Specifically, diversity of perspectives should be encouraged in order to challenge the hegemonic position of the Bios paradigm that is linked to a focus on industrial growth and competitiveness. Increased diversity and tolerance of such complementary perspectives might not be achieved without loosening the ties between research policies and industrial policies as well as between their respective proponents.

European Values: Universalism, Democracy and Public Knowledge. Equally central are the European values that are so closely linked to the scientific revolution and the development of modern science: Universalism, democracy and the public character of scientific knowledge in the service of the common good. If a return to reason would imply that elites admit the limitations of their knowledge and therefore the need for the citizenry to accept responsibility and commit to actively contributing to the future of society; and a celebration of diversity would imply a strengthening of other voices than those of industry, then democracy means that everybody is entitled to have their voice heard and universalism means that it is reasonable to listen to them. A logical first step on such a path could be the principle that the results of scientific research with public funding should be public knowledge. Public knowledge should have open access; however, it entails more. What is more, is discussed and developed in practical terms among theoreticians and practitioners of so-called “Open Science”, “Social Innovation”, “Post-Normal Science” and other concepts of public knowledge endeavours.

Grand Challenges and Deep Innovation. Assessments of the success of policies on grand challenges through deep innovation should include assessments of ultimate outcomes and not just proxies such as the development of consumer products and services that somehow may claim to be related to the challenges. Second, grounded in the original concept of innovation, we propose an emphasis on new interlinkages between the grand challenges. Third, and closely related to the three action points above, deep innovation would signify the deep involvement of members of society in the development of new ideas and new solutions not just as passively receiving consumers but as citizens who participate and through their involvement build new forms of agency. Deep involvement would mean that citizens and governments meet grand challenges also through what they *do* and not only through what they *buy.*

Reassessing the Present Function of the ERA. We would not be surprised if our suggestions described in the above bullet points will be rendered contrary and counter-productive to existing policy on the European Research Area as it is usually interpreted and understood. In that case, we propose that analysis is performed to understand why. The function of the ERA or any other institution or policy is not necessarily (only) the one purported by its dominant actors. This would entail the following tasks:

a) Critical analysis of commonsensical assumptions on the effectiveness of actual policies at the level of the European Union with regard to achieving an increased level of integration of research across European borders.

b) Critical analysis of commonsensical assumptions on the appropriateness of policy as such at the level of the European Union given the objective of integration of research across European borders.

c) Critical analysis of commonsensical assumptions about the appropriateness of the current policy objectives and their measures. Why exactly is it important and desirable to increase the level of integration of research across the borders of European member states, or across regions of Europe, etc.?

d) Sociological analysis of the effects, functions and purposes of the European Research Area policies. Sociology, contemporary history and social research in general have the difficult task of trying to get a deeper understanding of actual actions and events, beneath purported function and purpose. What is the evidence that European research policies indeed should be best understood and assessed as attempts at governing of complexity and thereby increasing rates of innovation and accordingly competitiveness and wealth?

Policy Indicators, Bios, Geos and European Values. Indicators (e.g. economic indicators) for research policies are constructs that aim at measuring human social activity. Any sound social science methodology would need to establish critical distance from the interpretational frame provided by the dominant actors themselves in order to avoid mere reproduction of dominant narratives.

Specifically, in a process of providing new understanding to escape the conceptual confinement of the Bios paradigm, it will be important to deconstruct currently used indicators to assess the extent to which they incorporate or reproduce Bios assumptions about growth, consumption and the unlimited availability of natural resources to be internalised, capitalised upon and put through the value chain and consumed. Similar questions could be raised for each of the grand challenges. Accordingly, one might conclude with the inappropriateness of a number of standard measures. The many attempts at constructing indicators appropriate for a Geos paradigm, such as CO_2 emission calculations, have proven that this is no trivial issue. This does not mean that there cannot be reasonable and useful Geos-informed indicators. Rather, it reminds us of the need for a Return to Reason: The problem is not so much the indicators in themselves but rather the status ascribed to them as guides or proxies to truth.

Consistent with the preceding points relating to general European values, our suggestion would be that public services could have three roles with regard to policy indicators. First, there is the work of criticism and deconstruction of indicators that are presented as value-neutral or otherwise unproblematic and in that way unduly contribute to hegemonies of power. Secondly, there is the creative work of constructing new indicators that relate directly to grand challenges, either in terms of ultimate outcomes (and not only their effects as seen from a Bios paradigm), or in terms of process (for instance measuring initiative and agency in civil society). Third, with philosopher of science Paul Feyerabend one could argue that state powers should take responsibility for the diversity of perspectives in knowledge production. For instance, in issues where there is political disagreement, one way to implement European values of diversity, tolerance and democracy would be to make sure that the political interlocutors all have public support in terms of information. It would not be the right way to try to provide value-neutral, paradigm-free indicators, because that is an illusion. Rather, it would mean to sustain a diversity of value-laden indicators, grounded in their respective interpretational frameworks, be they Bios, Geos or others.

1. The Purpose of the Report

There are important lessons to be learned for research policy from the history, philosophy and sociology of science. Current European research policies make a number of assumptions about the role of scientific research and innovation in our economies and societies. They also make assumptions about the governability of scientific research by public management and quantitative tools such as research indicators. These assumptions have their history and they (often implicitly) rely on particular philosophical and political commitments. At the time of writing (2013) Europe is faced with serious economic and political challenges. Accordingly, it is a good time to rethink fundamental assumptions. With this purpose, this report displays and discusses some central features and principles of European history and philosophy of science.

The purpose of this report is to describe and illustrate the relation between history and science; specifically what can history teach us about the rationale and prospects of an integrated and coherent European research effort.

History and science are not simple terms; they are complex and therefore ambiguous. In successive chapters we will try to provide the reader with a more precise idea of the meaning of both, selecting a number of episodes in European history. This in order to illustrate some conclusions that will be offered not as proofs but as suggestions for broader deliberations.

The European nations and Modern science emerged as a response to a critical historical situation. Both were based on ideals and values that were thought to be fundamental and universal**,** as an important part of the Humanist Renaissance program of the fifteenth century. The central problem was framed as follows: Granted that we are finite beings, and can never achieve certainty, how are we to act to make the best out of the present situation? Basic values were tolerance, humbleness, and recognition of different perspectives.

The transformations and developments that followed this Modern Europe were tremendous but also contradictory. They generated wealth and human rights but also misery and dislocation, all of them unevenly distributed. Cultural, political, economic, scientific and technological achievements in Europe were balanced by colonialism and worldwide exploitation.

Therefore, in order to answer the question of what can history teach us about a European research initiative (for instance, the European Research Area – ERA), we have to understand the trajectory, co-evolution and changes that took us from the emergence of the European state and Modern science to the current European Union and Innovation research and techno-science.

We have also to reflect on the contradictions of this process, and ask ourselves if the current dominating trends are still faithful to the Humanist tradition that made Europe an extraordinary and unique experience of diversity and universality.

2. The Received (and Inadequate) View of Science in Modern Society

One can identify a set of common beliefs about the nature of science and its role in society. These beliefs include: Science delivers objective, universal and value-neutral truth (or approximate truth) about Nature if it is allowed to act according to its own method, undisturbed by Society. Nature consists of physical matter in a Cartesian space and of forces that act on matter according to universal and eternal laws. Scientific knowledge is an unquestionable Good because it enables us to understand, predict and control Nature, and develop technology to this end. Technological development is a main driver and indispensable requisite for economic development and growth in modern societies. Finally, in modern societies, public decisions should be founded on and legitimated by scientific facts, "Science speaking Truth to Power". This so-called "received view" – "received" in the sense of being adopted without much independent critical evaluation – appears to be implicitly assumed in our institutions of governance. However, all parts of the received view are to some extent empirically inadequate and philosophically problematic.

In our science-based modern societies, and in particular in scientific institutions such as universities, research institutes and academies, one may be struck by a strange paradox:

On one hand, prominent scientists often underline the need for research-based knowledge in public decision-making. They may insist that decisions about CO_2 emissions, genetically modified organisms or tobacco regulation have to be well informed by the relevant expertise, for instance climate scientists, biologists and biotechnologists, and epidemiologists, respectively. Practitioners and stakeholders, say, car producers, car owners, farmers or the tobacco industry, might hold relevant knowledge, but their knowledge cannot replace scientific expertise. Indeed, knowledge claims from these stakeholders should be treated with scepticism exactly because they have a stake in the outcome of the decision.

On the other hand, the same prominent scientists often appear to find themselves qualified for making decisions or giving advice on research policies, e.g. funding, strategic choices or research organisation – decisions that may be public in nature and in which they as scientific practitioners clearly are stakeholders. Such scientists find their way into research councils, funding boards and public administration because their experience and success in science are recognised. Only rarely is it voiced that a physicist's or biologist's claim to expertise on decisions on the governance of science and technology is analogous to the tobacco farmer's expertise on the tobacco regulations. Only to a relatively small degree have the public institutions that deal with research policies and the governance of science and technology sought and recruited expertise from the research disciplines that specialise in science and technology as their subject of study: history, philosophy and sociology of science, science and technology studies (STS), science policy studies and others.

There are many explanations for this paradox, including those that simply point to the difference in cultural prestige and political power of a physics professor and a tobacco farmer, or that of the physics professor and the sociologist of science. A more profound explanation, however, is that relates to how Science is understood in Western culture. Scientists have described and understood their work as being fundamentally different from other professions in society. Science has been understood as being *outside and above of* society, and scientists have been seen as spokesmen of Truth and not of particular interests. This way of thinking has been consolidated in Europe over the centuries and it is deeply embedded in our public institutions.

This report is a contribution to advance the thinking about how to understand and govern the European Research Area. In order to achieve this goal, we will have to go beyond many of the usual cultural beliefs about science, held by scientists and citizens alike. This is because the research disciplines that actually study science and technology, have found these common cultural beliefs theoretically unsatisfactory and empirically inadequate. They are not research-based. For the sake of clarity, we provide a brief outline of these beliefs in this chapter before we criticise and go beyond them in the subsequent chapters. In this, we are not original at all – this approach has been quite frequent in academic work on these issues, and there is a plethora of concepts that refer to some or many such common cultural beliefs about science, for instance "grand narratives", "modern conceptions", "first (early) modernity", "positivist ideals", "the simple view", "the modern model", "the received view", etc. All of these concepts are used in various ways and not necessarily with a very precise definition. Here, we shall speak of the "received view" (even if that term is often used in a more narrow debate in analytical philosophy of science), because of its most general definition: A "received view" is a worldview that is passively received and adopted without much opposition or criticism by the one receiving it.

The received view about science and its role in the world is transmitted every day in science education and in popular culture. It goes more or less like the following:

The external world – or "Nature" – has an objective existence independent of man and Science and is able by the incremental accumulation of facts and theories to provide a complete and true (or almost complete and approximately true) description of this reality. Reality is knowable and accordingly controllable. Some would even claim we more or less already possess the truth: Namely that Nature is nothing but matter, energy and force fields that all operate according to universal laws; that Planet Earth developed life that is understood in terms of the genetic code, etc. Science produces knowledge by use of particular method – e.g. the hypothetical-deductive method – and the adherence to this method is a reliable criterion for distinguishing Science from non-science (and pseudo-science). Knowledge is essentially a set of propositions – facts, theories and ideally universal laws, preferably in mathematical language. This makes scientific knowledge objective and fully transparent and open for impartial inspection, criticism and falsification.

If taken seriously, the implications of the received view are impressive: First, Science, being a self-correcting truth machine, should be granted *autonomy.* Social, cultural and political interference will be sand in the machinery and might destroy it. Hence the insistence on scientific self-governance and academic freedom as well as the necessity of strong support of basic research. Next, although personality, cultural and political beliefs and identity may be important human features in the so-called *context of discovery,* it should not play any role when the validity of knowledge claims is tested in the so-called *context of justification.* The good scientist must remain objective. Indeed, whenever the scientific method is correctly applied, he or she cannot be anything but objective, since the method ensures objectivity by itself. In other words, human values and human passions – other than the value of and the passion for objective knowledge – have no place and are irrelevant to scientific practice, science education and scientific knowledge. Furthermore, since objective knowledge simply is the truth (or something similar to truth), it is an unquestionable good in that it improves our decision-making and allows for greater control of our environment through technology.

Since World War II, and in particular since the publication of the famous book by Thomas Kuhn *The Structure of Scientific Revolutions* (1962) – perhaps the only piece of research-based knowledge on science that has permeated into popular culture through the concept of the *paradigm* – also many natural scientists will refrain from expressing the received view in its most explicit form. In this sense it is weakened. As the French philosopher Jean-François Lyotard (1924-1998) put it, contemporary society is moving towards a post-modern condition defined by increasing incredulity to all-encompassing grand narratives such as the received view. On the other hand, in the same period one can observe a growing synergy between the received view and another grand narrative about the necessity of economic growth in order to avoid societal collapse, and the indispensable role of scientific research and innovation in the creation of economic growth. We might say that the received view has become weaker while its power has grown stronger.

The received view explains how the scientific practitioner, unlike the tobacco farmer, can be an objective expert and give advice on decisions in which his profession has a direct economic interest. First, from this perspective, to understand how science works *is* to be a scientist. Societal interference by politicians or other citizens will ruin the science. Secondly, scientists are educated and trained to be objective and rational, and their argumentation will accordingly be transparent and reproducible. Numbers, for instance, speak for themselves. What science is and how it works is by the same received view *evident and obvious,* and hence there is no need for a separate expertise to study science. A sociologist who studies tobacco farmers may understand aspects of tobacco farming unknown to the farmers themselves, but this is not the case for science: Science already perfectly understands itself. We think that those who have worked in research councils will recognise this type of belief.

The point of this chapter is not at all to argue against academic freedom or funding of basic research. Still, we stress that the received view is untenable as a general, all-encompassing grand narrative about the practice, organisation and governance of science. Part of the received view is a metaphysical position, holding beliefs about reality and human capacities that are not possible to put to test by experiment or empirical observation. Their origin is to be found in scientific practice in the form of working assumptions. With the success of science, the working assumptions have gradually been taken for the true description of reality. Other parts of the received view – such as the ideals of transparency, reproducibility, methodical rigour, etc. – are important codifications of the internal norms for good scientific practice; however what has happened is that there is a conflation between rules of practice and defining features. Objectivity and transparency are indispensable ideals, but this does not mean that they are or can be realised in full. To sum up, the received view is a mixture of empirical description, metaphysical beliefs, norms of practice and ideals to navigate by, and this mixture comprises a relatively coherent narrative that according to its own logic does not allow for empirical or theoretical refutation. In other words, it is by its own criteria an unscientific belief in science. The received view is an **ideology**.

3. The Scientific Revolution as a Counter-Renaissance

The received view is the result of philosophical and scientific traditions that can be traced in Europe back to Ancient Greece. However, to understand the peculiarities of the received view, as well as its strengths and shortcomings, it is useful to go 400 years back, to a Europe riddled by disaster and disruption during the Thirty-Years War (1618-1648). This is also the Europe of what later was called the Scientific Revolution, with René Descartes, Copernicus, Galileo Galilei, and many others. An important similarity between the heroes of the so-called Scientific Revolution is that they searched for certainty in the midst of chaos: a Europe of poverty and massive death and with eroding trust in theological and political authorities. This is the context in which Descartes turned to silent philosophical meditation to distinguish certain truth from falsity and illusion, and in which Galileo searches for laws of Nature under ideal conditions, that is conditions undisturbed by friction and imperfection. Indeed, philosopher Stephen Toulmin (1922-2009) showed how the Scientific Revolution was quite different from the Renaissance. Where Renaissance thinkers celebrated open discussion and difference in opinion, the natural philosophers of the 17th century desired unique, universal and unambiguous truth. For that purpose they developed a worldview: "The Book of Nature is written in the Language of Mathematics."

It would be a mistake to think that European history is a story of harmonious and respectful development of the different modern institutions: Science, Politics and Law, Humanities, etc. All institutions and sectors have frequently had expansive ambitions at the expense of others. For example, the German mathematician and philosopher Gottfried Wilhelm Leibniz (1646-1716) followed in Descartes' footsteps and saw in his own calculus not only a tool for astronomy and other physical sciences, but also a basis for a more general idea of calculation whereby a "community of minds" could rationally achieve political unity of Europe. This idea of rational decision-making later developed into cost-benefit analysis and other methods for calculating what is the "best option".

The scientific revolution took place at the beginning of the seventeenth century in which Galileo Galilei became a key figure of change, applying measurements, mathematics and experiments to the study of Nature.

Modern science and mathematics were not only instruments of knowledge, they were also instruments of power. Nature was not only to be studied but to be controlled in order to fulfil our human destiny as Masters. However, to appreciate what took place in the scientific revolution, we have to compare it to the Renaissance Humanism of the fifteenth century. In the traditional view the Renaissance is regarded as a continuation of Renaissance Humanism, where the revolution was extended to the study of nature.

The science that grew out of the scientific revolution in the seventeenth century has without doubt its roots in Greek science and philosophy. Nevertheless, a new element is added, and therefore it is legitimate to speak about a revolution. The outcome of this revolution is what is known as "modern science".

But what is the new element? A widespread view is that the most important aspect of modern science is the systematic use of observations. Very often Galileo is compared to Aristotle, and it is argued that Galileo made observations, whereas Aristotle was lost in speculations (Russell 45). Another version is that modern science is characterized by the uses of a "hypothetical-deductive method". The method consists of the advancement of hypotheses, deduction of consequences and finally a comparison of the deduced consequences with empirical observations (particularly in the laboratory). Galileo is often given the credit for having introduced the method.

Although there is some truth in this, the received view is flawed, and this can be clearly seen if we take a closer look at what Galileo actually did.

"The book of nature is written in the language of mathematics"

In 1609 Galileo had heard about a Dutchman who had constructed a “spyglass” by inserting two lenses into a tube. Based on this description he constructed his own telescope and directed it towards the sky to make observations of the stars and the planets. In 1610 he observed Jupiter for a long period, and noticed that four objects moved around the planet. He concluded that Jupiter had actually four moons. His observations were published in *The Starry Messenger* the same year, and caused a sensation throughout Europe. Galileo regarded his observations as strong support for the heliocentric system. According to the orthodox view, based on the Scripture and the works of Aristotle, the universe could only have one centre of rotation. That centre was the earth, and all the heavenly bodies rotated around the earth.

Although Galileo’s observations of Jupiter’s moons were important, they were not his most important contribution to science and philosophy. Observation is important in science, but it is not the distinguishing mark of modern science. For example, Aristotle was a skilled observer, whereas Galileo on several occasions emphasized that we should not rely too much on observations, because our senses may deceive us. Although it may look like a paradox, it is easy to see why Galileo had to stress the unreliability of our senses: If the heliocentric hypothesis is true, the earth moves through space with a tremendous speed. How can it be that we do not observe this motion? Galileo’s answer was that we do not observe absolute, but relative motion. (Galilei 1970, 171) This is the *principle of relativity*. But who could believe this? Galileo actually tried to persuade his contemporaries not only to *abstract*, but to put the abstract world of mathematics in the place of the world that we live in and observe immediately. If we should characterize modern science by one sentence it would be this: To prefer the abstract world of mathematics for the concrete world that we observe[1].

This can be illustrated by using Galileo’s metaphor of the book of nature. He emphasized that to read the book, we first have to learn the language in which it has been written. About this language he said:

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1 Perhaps the first to point out this was the historian of science Alexandre Koyré (Koyré, 1978). He influenced Edmund Husserl, who called it "Verhängnisvolle Missverständnisse als Folgen der Unklarheit über den Sinn der Mathematisierung" (Husserl 1962, 54) ("Portentous misunderstandings resulting from lack of clarity about the meaning of mathematization", (Husserl 1970, 53)). It is the main point in Paul Feyerabend's posthumously published book *Conquest of Abundance* (1999).

Philosophy is written in this grand book, the universe, which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and read the letters in which it is composed. It is written in the language of mathematics, and its characters are triangles, circles, and other geometric figures without which it is humanly impossible to understand a single word of it; without these, one wanders about in a dark labyrinth. (Galilei 1970, 237-8)

This quotation is from his *Dialogue on two Chief World Systems*, published in 1630, where he defended the heliocentric hypothesis. However, he had almost ten years earlier introduced the division between primary and secondary qualities. Primary qualities are the qualities that can be described mathematically, like position and velocity, whereas the secondary qualities are the qualities we perceive, like colours, smell and taste. The choice of terminology was not accidental. On the contrary, “primary” and “secondary” indicate the ontological status of the denoted objects. In brief, only the primary qualities exist objectively, and may be the object of scientific investigations (Galilei 1957, 274).

The scientific revolution as a Counter-Renaissance

The scientific revolution is a product of the Renaissance. As the word indicates, it was a reaction against the rigid institutions and thinking of the late Medieval age, known as Scholasticism, and was a return to the study of nature and to classical Greek and Roman culture. The invention of the printing press was important. Johannes Gutenberg (ca 1395-1468) is often credited with the invention. Although the invention was not due to one single person, his important contribution was the introduction of separate types for each letter. This enabled the composition of whole pages of these types, which could be reused for new pages. This new technology increased the production of books, and made them more accessible.

The Renaissance lasted for approximately two hundred years, from ca. 1450 to ca. 1650. It started with what is known as "Renaissance Humanism" and ended with the scientific revolution. According to the received view, this was a continuous process. However, the philosopher Stephen Toulmin has argued that to understand some important aspects of modern science (the aspects we have indicated above), we have to see it as a rather discontinuous process. The scientific revolution is not a product of the Renaissance, in particular not of Renaissance Humanism, but is rather a Counter-Renaissance.

Two important representatives of Renaissance Humanism were Montaigne and Erasmus. An important aspect was the recognition of the human condition as finite and knowledge as uncertain, and the important problem they tried to cope with, was: Granted that we are finite beings, and our knowledge is limited and uncertain, how do we act to make the best out of the present situation? Basic values were tolerance, humbleness, and the recognition of different perspectives.

The shift in perspective from Renaissance Humanism to the scientific revolution is demonstrated in the way uncertainty was handled. In fact, uncertainty was a main topic of Descartes' philosophy as well, but was handled in a way very different from the Renaissance Humanism. His uses of systematic doubt at the beginning of *Discourse of method* is among the most famous topics in the history of philosophy. He recalls how he as a young man decided to doubt everything: What his teachers had taught him, what wise people said, the sciences, etc. Although he points out that mathematics is more certain, he choses even to doubt mathematics. However, via his own doubt as certain, and the proof of God's existence, he returns to mathematics as certain. Therefore, mathematics is a tool for eradicating doubt and uncertainty.

Above we pointed to Galileo's introduction of the distinction between primary and secondary qualities. Descartes, who was a younger contemporary of Galileo, took over this distinction. In a famous passage from *Meditations* he contemplates a piece of wax. The wax has smell, colour, shape, size, and it is hard, cold and tangible. But if it is placed near a flame, neither smell nor colour remains. In fact, Descartes concludes that nothing of all the things that we perceive by means of our senses, remains. Therefore, these properties cannot belong to the wax itself. The only properties that may be attributed to the wax is that it is extended, flexible and malleable (Descartes 1641/1971: 108). In Descartes' own terminology, that which exists objectively is *res extensa*. *Res extensa*, like Galileo's primary qualities, are the properties that can be described mathematically.

However, contrary to the widespread opinion that Descartes only pursued theoretical questions, Toulmin argues convincingly that Descartes was deeply concerned about the human world. It is important to keep in mind that the Thirty Years' War started in 1618 and ended in 1648, and thus coincided with most of Descartes' life. As Toulmin (1990) points out, when the Thirty Years' War broke out, Descartes was in his early twenties, and when it ended he had two more years to live. This war was one of the most cruel wars in history, and the main victims of the war were the civilian populations. Entire villages were eradicated, and one third of the population of Europe was killed. It was a time when there was a real chance that any ordinary citizens could have their throat cut.

The Thirty Years' War was a religious war in which Catholics and Protestants tried to enforce their own religion by using force. Therefore, the scientific revolutions took place at one of the worst times of European history. Another thing that is worth keeping in mind: One might believe that witch-hunting and witch-burning belongs to the dark Medieval age. No doubt, witches were burned in the Middle Age, but the process gained impetus at the beginning of the seventeenth century, and it reached a peak at around 1650. It has been estimated that as many as two million people were burned at the stake as witches. It was under these circumstances the scientific revolution took place. Based on a mathematical ideal of knowledge they would be able to decide religious questions in a rational way, and thus avoiding war (Toulmin, 1990).

Descartes and the idea of a universal mathematics

Both in Galileo and Descartes mathematics is the key to knowledge. Descartes carried the mathematical program over to philosophy. In *Discourse on Method* he describes his early fascination with mathematics:

Above all I enjoyed mathematics, because of the certainty and self-evidence of its reasonings, but I did not yet see its true use and, thinking that it was useful only for the mechanical arts, I was astonished that on such firm and solid foundations nothing more exalted had been built, while on the other hand I compared the moral writings of the ancient pagans to the most proud and magnificent palaces built on nothing but sand and mud. (Discourse 1)

He describes four rules to conduct his philosophical investigations, and these are inspired by mathematics. These rules are:

The first was never to accept anything as true that I did not know to be evidently so: that is to say, carefully to avoid precipitancy and prejudice, and to include in my judgements nothing more than what presented itself so clearly and so distinctly to my mind that I might have no occasion to place it in doubt.

The second, to divide each of the difficulties that I was examining into as many parts as might be possible and necessary in order best to solve it.

The third, conduct my thoughts in an orderly way, beginning with the simplest objects and the easiest to know, in order to climb gradually, as by degrees, as far as the knowledge of the most complex, and even supposing some order among those objects which do not precede each other naturally.

And the last, everywhere to make such complete enumerations and such general reviews that I would be sure to have omitted nothing. (Discourse 2)

Descartes' application of mathematics to all areas of human activity was grounded in the idea of a *Mathesis Universalis*, a universal mathematics.

The development that led up to the idea of a universal mathematics started already in the thirteenth century. Then Leonardo Fibonacci in Pisa introduced letters for numbers. This was the beginning of that part of mathematics that we call algebra. In the sixteenth century symbols for most of the common mathematical operations – like +, -, x, :, <, >, √, were introduced. This enabled a condensed description of mathematical operations and formulas. (However, it is worth keeping in mind that it took a long time until this practice became universal. For example, both Galileo and Newton describe the laws of motion in ordinary language.)

When reading Descartes' *Regulae ad Directionem Ingenii* we see that he uses a mathematical representation that to us looks quite modern. He also argues that the algebraic representation has many advantages compared to the arithmetic. Whereas the "arithmetician" must denote magnitudes by specific numbers, in algebra one abstracts from specific numbers and uses letters. Among others he uses the example of a rectilinear triangle where the two sides opposite to the hypotenuse are 9 and 12 units respectively, to demonstrate this. The arithmetician may say that the hypotenuse must be $\sqrt{9^2 + 12^2}$, that is, 15. Using algebra, however, on can denote the two sides by a and b respectively, and express the length of the hypotenuse as $\sqrt{a^2 + b^2}$.

Algebra is an abstraction from geometry and arithmetic. In *Regulae* Descartes proposes a program for a *Mathesis Universalis* based on algebra. However, he himself only carried this program through in one area: geometry. This was done in *La Géométrie* that was published as an appendix to *Discourse on Method*. In this book he applies algebra to geometrical problems, and is thus the inventor of analytic geometry.

However, the program of a universal mathematics was continued and expanded by the German philosopher Gottfried Leibniz. Leibniz was a polymath, who among many other things invented differential and integral calculus independently of Newton, and he generalized the idea of calculus. The Latin word "calculus" means a pebble or stone used for counting, and a calculus is a system consisting of formal operations. The idea of calculus that Leibniz developed was a formalization (or even "mechanization") of language and reasoning. Like Descartes, Leibniz was deeply worried about the situation in Europe. Although he lived after the Thirty Years' War (he was born two years before the end of the war in 1648), he lived in a time when Europe was tormented by religious struggles. Leibniz tried actively to promote negotiations between the religious fractions, in particular between Protestants and Catholics. Although his success was moderate, he himself envisioned his calculus as an instrument in diplomatic negotiations because it could offer a universal language. Therefore, it could facilitate a solution to disagreements among the nations, and he even envisioned that it could solve deep theological disagreements within Christianity in Europe (Toulmin 1990, 102).

Quantification and cost-benefit analysis

The founding fathers of modern science, Francis Bacon, Galileo Galilei and René Descartes all promised technological pay-off from scientific knowledge. However, it is a historical fact that this pay-off was two centuries delayed. It happened first in the chemical industry in the second part of the nineteenth century, and later in the electrotechnical industry. In the last century scientific knowledge became more and more important for the development of technology, and after World War II technological development is by and large based on scientific knowledge.

Although the technological pay-off came late, there was from the very beginning an intimate relationship between modern science and technology in the sense that they have common roots. Science is itself based on technology, and the development of instruments is both an important part of science and an important precondition for science.

Therefore, we find a parallel development of technology in the production process. The historian of technology Lewis Mumford describes in his classic *Technics and Civilization* the development of manufacturing, which is the predecessor of machine production. Manufacturing consisted in collecting many workers under the same roof. The production process was divided into many separate operations, which were carried out by specialized workers. Efficiency was increased by decreasing the number of operations carried out by specialized workers. Mumford called this division an "empirical analysis of the work process". The work process was divided into simple organic movements, which could easily be translated into mechanical operations. Later the machine could take over the operations that the worker had previously carried out (Mumford, 1934).

Any division of labour requires coordination, and a "mechanical" division of labour requires a "mechanical" coordination. The various operations must be exactly coordinated. First, the different parts which make up the final product have to fit. Second, the various operations have to be coordinated into a mechanical rhythm. This requires a "mechanization" of time, a process that had started in the middle of the fifteenth century, when the production of mechanical clocks started. It is important to keep in mind that a clock does not just measure time; it coordinates movements. (One might even argue that measuring time can be reduced to the coordination of movements. This is the point of departure of Einstein's article "Zur Elektrodynamik bewegter Körper" (1905) where he presented his special theory of relativity.) According to Mumford the clock, and not the steam engine, is the prototypical machine.

This coordination in "time and space" requires measurements. Therefore, Galileo's dictum: "To measure what is measurable, and make measurable what is not so" is not only a key to understanding the development of modern science, but important aspects of modernity as well. An illustrative example is land survey. In his book *Trust in Numbers* the historian of science Theodore Porter uses land survey in the United States as exemplary for "the campaign for standardized measures". The process of measuring imposes a square grid on the landscape. The landscape is regarded as basically flat. Mountains are disregarded, and the only concession made is to the curvature of the earth (Porter 1995).

This standardization produces objectivity, because a measurement gives the same results regardless of who carries it out and where it is carried out. In the traditional view this is usually interpreted as producing objectivity in a depersonalized and detached way, as if the world is described "from nowhere", or from "God's eye view". However, this is a delusion. This objectivity is based on numerous presuppositions. This was already pointed out in the late 1930s by the German philosopher Edmund Husserl. These presuppositions can, at least for analytical reasons, be divided into two categories. The first category comprises the "subjective" presuppositions, like skills and measuring instruments. Husserl pointed out that even the most abstract sciences (and he uses the theory of relativity as an example) are grounded in our "lifeworld", which is the pre-scientific world that we take naively for granted.

The second category comprises the "objective" requirements, that is, the conditions that the object of measurement must satisfy for measurements to be possible. The keywords are "homogeneity" and "standardization". An example from Porter gives a good illustration. In seventeenth century Europe grain was measured in bushels in the marketplace. The bushel was a local, but official unit. If the accuracy of particular bushel was questioned, it could be controlled by comparing it to the official bushel in the town hall. However, in practice the measure was always a combination of quality and quantity. For example, if the grain was of a lower quality, a heap on top of the bushel could be negotiated. Although this system worked, trade networks required standardization of the measures. In Continental Europe the French Revolution played in important part because it introduced the metric system. And it followed that the quality of the grain had to be standardized as well (Porter 1995, 24-25).

We mentioned above that land survey imposes a grid on the landscape. But for this to be possible some requirements must be satisfied. Husserl pointed to this problem:

This purpose [of procuring objectivity] is obviously served by the art of measuring. This art involves a great deal, of which the actual measuring is only the concluding part; on the one hand, for the bodily shapes of rivers, mountains, buildings, etc., which as a rule lack strictly determining concepts and names, it must create such concepts – first for their "forms"... (Husserl 1962, § 9a)

Husserl's rather casual remarks about the shapes of rivers and mountains indicate that these requirements are far from obvious, and are not always satisfied. Planning and governance in a modern society, based on "objective measurement" and knowledge derived thereof, accordingly is left with two main options. First, one may introduce measurements, variables, indicators and metrics that are "well-defined" in terms of their mathematical properties, but that to a smaller or larger degree fail to represent the important or relevant features of the physical, economic or social world they are supposed to describe. This introduces uncertainty and ignorance. Ignorance may be defined in terms of not knowing well the boundaries between knowledge and lack of knowledge. It also introduces bias in the sense that one may focus on some properties that are easily measured at the expense of properties that may be important but are difficult or impossible to measure. For instance, "classical" Euclidian geometry in linear space is not well equipped to study fractal structures and processes that involve fractals in their dynamics. Less exotic, a static map made by imposing a grid on the landscape may be poorly suited to display and discover dynamics in time that involve functional rather than structural types (say, the availability of proper nesting places for animals). Such biases may of course be known and understood, but not by the effort of the measurement process itself.

Secondly, there is a more radical approach to managing the biases, uncertainties and ignorance created by the nontrivial relationship between the measurements and the world. One can choose to improve the fit by changing the world so that it better fits the measurements. If what Husserl called "lifeworld" is not a linear, static geometrical space, one may change the world physically, economically and socially to comply with the metrics. This is done in architecture and engineering, with the introduction of standardised materials and structures (straight lines and planes; straight angles; surfaces low in friction, etc.) but also in agriculture (e.g. monocultures) and by social and political regulation to standardise behaviour and expression of human life. Husserl called this strategy "the colonization of the lifeworld", and it shows the aggressive character of modern science and technology. In this sense, quantification and cost-benefit analysis also changes its object (of quantification). It also changes its subjects – both because we as humans also become objects of quantitative measurement and because we as such humans become a different type of decision-maker: more of a "rational actor" who decides on the basis of estimated cost-benefit ratios and less of a "reasonable person" who decides on the basis of a larger set of reasons and in deliberation with other persons with other types of reasons.

4. The Scientific Revolution as an Invention and Suspension of Nature

In several respects Modernity was founded upon a re-imagination of Nature that was also a pushing away of Nature. Nature, as reflected in both cosmology and society, had come to be seen as contingent and without intrinsic purpose, perhaps even evil. The Modern order was not merely a vehicle of steadfast progress through rational means. It was something more complex, a response to a situation in which both the social and natural order had become dysfunctional and problematic. The responses that emerged to this problem were aimed at the constitution of order and stability, through which violence, strife and war could be overcome and put to more productive uses, within society and under a new social contract. To large extents, science was the medium through which this re-imagination and re-creation took place, promising and projecting an upheaval of human existence across scales and domains of life: from morality and religion through to work, to the very ways in which humans collectively imagine and organize their societies.

However, within this process "science" should not be thought of as merely physical science. A whole range of innovations took place across a broad range of spheres: law, political science, natural science, history and (eventually) social science and economy. All of these reflected, in their way, "Nature": human, social and cosmological. Hence, it is a misunderstanding to think of Modernity as monolithic, although that has frequently been, and continues to be, a preferred strategy. This section recounts some central features relating to the problem of knowledge, and of social and natural order, from the Renaissance through to the creation of the modern national state. It can only single out some features. These will in each case be related to the question of the universality (or non-universality) of knowledge, and with the different segments, or spheres of societal order that were co-produced with them.

It is commonly supposed that Modern thought started out with a radical desire to begin anew, to set society on a new course through a systematic and secure knowledge of first principles. The alleged father of Modern thought, Rene Descartes, introduced geometrical and mathematical reasoning as the paradigm for thinking about Nature, both human and cosmological. The aim of geometry was to arrive at clear and distinct ideas, beyond uncertainty and doubt, but, even more importantly, independently of external authorities: *Before asking whether any such objects exist outside me, I ought to consider the ideas of these objects as they exist in my thoughts and see which are clear and which confused* (Meditation V: On the Essence of Material Objects and More on God's Existence). Descartes took as his proof of the existence of external things his own clear and distinct ideas, and he explicitly counterposed these to religious dogma and popular opinion. Clarity and distinctness, furthermore, could only be conceived of in terms of mathematical concepts and properties: extension, mass and movement. Following the natural philosophy of Galileo Galilei, Descartes separated the universe into two parts: those who could be subject to mathematical reasoning (primary qualities) and quantification, and those that could not (secondary qualities). The separation of the universe into two distinct parts, one marked by uncertainty, doubt and heterogeneity, the other on certainty, clear and distinct ideas, could also be used for a separation of the sciences:

> *…a reasonable conclusion (…) might be that physics, astronomy, medicine, and all other disciplines which depend on the study of composite things, are doubtful; while arithmetic, geometry and other subjects of this kind, which deal only with the simplest and most general things, regardless of whether they really exist in nature or not, contain something certain and indubitable. (Meditations, Book I)*

Included in the universe of doubtful things were the body, emotion and imagination: these depend on sensual impressions, that is, on external stimuli, and so could be manipulated. In a trick of thought Descartes imagined a vicious demon that would manipulate his senses, to the extent that he might not even know whether he was dreaming or awake. In the *Meditations* the demon appears as a figment of Descartes' own imagination. However, the demon might also be read as a stand-in for the Catholic Church and its dogma, the primary target for Descartes' rejection of external authority.

The effort to embark upon a project of radical doubt, and to accept nothing but what could be grasped by the solitary thinking subject, was not new in itself. Half a century earlier Michel de Montaigne had undertaken a similar move, like Descartes isolating himself in his study and subjecting all received knowledge to his own radical doubt: *Que-sais je?* True to Renaissance ideals he also set out for a new beginning. But Montaigne did not pretend to wipe his slate clean and start anew, but rather to provide a more truthful description of what was already in plain view. This included topics such as morals and education, politics, customs and trade, the Classic thinkers, drunkenness, cannibalism, glory and war. Explicitly highlighting sensual experience and the creative power of the imagination, the originality of Montaigne's analysis resided in the ways in which he sought to investigate these themes through his own embodied person:

> *I desire therein to be delineated in mine own genuine, simple and ordinary fashion, without contention, art or study; for it is myself I portray. My imperfections shall thus be read to the life, and my natural form discerned, so far-forth as public reverence has permitted me. For if my fortune had been to have lived among those nations which yet are said to live under the sweet liberty of Nature's first and uncorrupted laws, I assure you, I would most willingly have portrayed myself fully and naked. Thus, gentle Reader, myself am the groundwork of my book* (Montaigne 1603).

Descartes was influenced by the writings of Montaigne, and there are important parallels to be found between the two. However, differences loom large in the ways in which they imagine themselves as knowing subjects, and the wider cosmologies within which they found themselves. Whereas Montaigne rejected many of the sources provided by the Church and scholasticism, he still found himself situated within the cosmology of the Renaissance. His was a hierarchically ordered universe, in which every thing, element and person, had a proper place and was linked to any other (i.e. through The Great Chain of Being, see Foucault (1973)). For instance, the human organism was seen as consisting of the four cardinal humours (sanguine, choleric, melancholic and phlegmatic) and these again corresponded with the four elements, earth, air, fire and soil. The very interdependence and correspondence of all things natural and social was expressed in the nature of each thing, including Montaigne himself. He was, after all, a reflection of the Cosmos, and that was also how the world became accessible to reflection. Descartes, on the other hand, decided to radically distrust his own sensations and the ways in which they reflected the external world. He radically separated the activity of rational thinking from the body. In their place he put something entirely different:

impersonal, disengaged geometrical principles (what could be further from common experience?). This was not a mere invention of Descartes; it was a reflection of other developments, especially within science. Paradigmatic was the counterintuitive notion that the Sun, and not the Earth, resided at the centre of the solar system.

As pointed out by Stephen Toulmin (1990), the differences and similarities between Montaigne and Descartes were expressions of the social and political conditions in which they found themselves and to which they were responding. Montaigne was living a period of great transition, representative of both the old and the new world. On the one hand the late Renaissance was still enjoying of stability and prosperity, and still respectful of the Classical and Middle Age view of the Cosmos as an ordered and interlinked hierarchical whole. On the other hand the times displayed strong elements of a disintegration of this whole, part of what drove Montaigne and others in their searches for a new beginning. The signs were seemingly everywhere: John Donne worried about a deterioration of the climate in England, which he saw as part of a greater deterioration in Nature: the Cosmos was coming apart and Apocalypse was approaching. Similarly, in Shakespeare's *King Lear*, the King's poor state of mind is a reflection of an external state of affairs in which both family structures and social structures are disintegrating. Many writers of the age shared the experience that social mores and previous certainties about Nature were coming apart. This happened as the Reformation dethroned the hegemony of the Catholic Church, spurring religious wars across Europe between Catholics and Protestants. Says Toulmin (1990, p. 82): *The religious conflict triggered by the Reformation took place at just the same time when the traditional cosmology – the Sun and Planets moving around a stable, stationary Earth – at last came under sustained attack.*

A number of events and developments seemed to gradually converge towards a worsening situation, even threatening the end of the world and the extinction of civilization. According to Toulmin we cannot appreciate the differences and similarities between Montaigne and Descartes without taking this radical worsening of worldly affairs into account. Whereas Montaigne would highlight ambiguity and uncertainty as basic to human experience, and argue in favour of "sweet reasonableness" and tolerance, these measures were not adequate to the situation in which Descartes found himself. At that stage the disintegration observed by the Renaissance thinkers had advanced into full-blown disaster, with religious dogma and power struggles among Europe's great powers, causing the devastation of whole regions and Kingdoms, and bringing famine, destitution and economic bankruptcy across the continent. Although never actually engaged in fighting himself, Descartes travelled through Central Europe as a soldier, and he did most of his thinking and writing with the Thirty Years' War as the general backdrop. There was no way in which he could rely on a stable and ordered cosmos to sustain civilization, but instead set out to create it radically anew. He rejected the external world and its authorities, and turned himself towards new horizons through a radical inwardness.

The new world could only be constructed by way of a radical abstention from religious dogma, politics and popular opinion, and the most powerful source for doing so was the new mathematical (and experimental) sciences. Descartes' solution was marked by the very conditions he sought to overcome, no less radical than the conditions he was facing. He could not count on "reasonableness", doubt and uncertainty, as did Montaigne; these seemed to have become parts of the very problems at hand. The insertion of radical certainty, simplicity and clarity, therefore, was a direct response to war, and the need to move beyond this devastating state of affairs, and to do it through a “method” accessible to all rational beings.

His approach, whereas proceeding through radical doubt and the first person (interior) perspective, used the language of geometry and mathematics to establish a sphere of action and thought beyond worldly strife. As before, this sphere reflected Nature, but was no longer situated within tradition. Through its own act of thinking, it reconfigured its own context through its own vision, which was framed by geometry. Dethroning and pushing away previous authorities, Descartes no longer imagined the Cosmos as an ordered hierarchy, but as a great mechanical clockwork of interlocking mechanisms, and man somehow situated outside this machinery. There was still a correspondence between the world and the knowing subject, but this had been thoroughly re-configured through the language of cause and effect, of clear, distinct and certain ideas.

Inwards, Descartes projected restraint and self-discipline, abstaining from following his emotions and inclinations. By rigidly following his “method” every rational being could arrive at the truth about the world. Supposedly free, rational and transparent to itself, the thinking subject could then decide upon a proper course of action. Thus, rational method and inwardness substituted for external authority and received dogma. This, then, was one way of reconfiguring Nature in ways that would have long-lasting effects: human agency and rationality were separated from the chains of cause and effect as manifested in the natural world. He also set himself apart from his fellow beings and from society, since these were seen mainly as corrupting forces. Although that only became clear in retrospect: the vision was indeed not a private one, but about inscribing oneself into the consciousness of one’s fellow beings. And, as we know, it had an enormous influence on the ways in which the West started to imagine itself as an ordered and interlocking whole based upon fundamental laws of Nature.

Outwardly, Descartes projected the Cosmos, not as hierarchically ordered and with intrinsic meaning, but as inert and mechanistic. According to the old worldview, every thing and being in the world would carry within it an intrinsic meaning and goal (*telos*), which was realized by finding and performing its place within the greater scheme of things. According to Galileo and Descartes, no such intrinsic order, protected and carried out by the Church, as it were, existed. Instead, Nature was seen as an interlocking chain of cause and effect, an endlessly working machine without intrinsic goals and purposes. By this, they did not intend to dispel with God; Copernicus, Galileo and Descartes were all deeply religious men.

Although relegated to the fringes of knowledge, God retained a place in the cosmos and in human life: first, as a guarantee of order and stability through issuing Nature’s laws (if Nature was a clockwork, God was the clockmaker). Next, God was the ultimate guarantee for the rationality of the clear and distinct ideas available to Man. These ideas gained much more traction and popular recognition with the works of Newton, whose three laws of motion and law of gravity bestowed legitimacy on the view that Nature is governed by stable laws laid down by God at Creation. Through institutions such as the Royal Society, Newton’s laws spread among European elites and came to make up the general backdrop understanding of Nature known as “Modern”, and lasting well into the 20th century.

As described by thinkers such as Toulmin and Charles Taylor, this Modern Framework was not identical to the science that would eventually come to sustain it. Rather, it consisted of a number of presuppositions that would inform and give meaning to scientific knowledge and its broader social and political role. It worked on the level of providing a broader outlook on Nature, on Society and their mutual interrelations, what Taylor (2004) has called the social imaginary, and thereby it provided order and stability.

This could be seen by the (many) ways in which Newton implicitly included in his works most of the presuppositions established by Descartes: the notion of Godly providence as a guarantee and upholder of both Nature's laws and human ideas and Society; the radical separation of external, law-abiding causal Nature and human nature (characterized by freedom and rationality); the elevation of reason over emotion; the view of natural process as made up by inert matter; the view of the planetary system as stable and law-abiding; the view that Nature's book is written in the language of mathematics, and so on. These views more or less corresponded with those held by people like Descartes, Locke and Newton. They were not, however, strictly necessary for Newton's theories. For instance, Newton's first law describes how "Every body left to itself moves in a straight line". But how can this be? There can be no such thing as 'a body left to itself' in the universe: at the very least this is a metaphysical statement that cannot be proven. Moreover, the conception of something moving in a straight line is only possible on condition of an initial idealization. This work to "purify space" had started out with Galileo who, among other things, constructed straight ramps to measure the acceleration of a bullet. But neither the bullet nor the straight-lined ramp existed anywhere in Nature; they were *constructs* based on mathematical idealizations. The same went for Newton's laws (Husserl 1962, Heidegger 1977).

By around 1700 the view had settled that Nature is not chaotic nor in decay, but rather guided by stable laws of cause and effect. Whereas first and foremost providing a bulwark against the notion of Natural degradation and decay, this view of stability was also used to project structures of hierarchy onto Society. This was nowhere more clearly to be seen than in the newly emerging National states, paradigmatically England and France, where the Modern Framework was promoted by the ruling classes, the clergy, in the institutions of learning, and circulated through the printing press. The need for upholding social structures was not abandoned but rather re-written in the language of the new cosmology. Actually, hierarchy had not been altogether abandoned and was still seen as part of Nature's workings. God still resided at the top of the cosmos, providing initiative and motion to the lower elements of nature. Low nature was seen as passive, inert, and in need of a living and thinking agency to be set in motion or to instigate change. This seemed to follow directly from the separation between mechanical and physical nature on one hand and the world of man on the other. But this did not imply that man could have no effect on nature whatsoever. The active principle in nature, although not fully agreed upon, was generally seen as emanating from higher beings, ultimately God, but to lesser degrees also from those with the intelligence and capacity to act rationally and in accordance with His (and Nature's) laws. Hence, this view, whereas not strictly speaking grounded in science, nevertheless seemed to fit well with the science of the day. It could seamlessly be projected onto Society, thus also confirming the need for the higher classes to control and order the lower classes (Toulmin 1990, 113). Within the emerging National states, the feudal system of the Middle ages and the Renaissance had been abandoned, but that did not entail the abandonment of hierarchy and social divisions; these were re-created in the image of the Sovereign of State as the main provider and upholder of stability and order.

So far, this account has more or less followed a standard, philosophically and historically informed account of Modernity. Still, the account is also relatively speaking "novel" insofar as it takes into account perspectives that highlight how Nature and Society are mutually constituted, or co-produced (Latour 1993, Jasanoff 2004). Such a new look at history should take into account the character of main regimes for the construction of knowledge as they operate in the present, and use (critical) theoretical perspectives on such regimes and project these perspectives backwards onto history, as it were. We shall return to such present regimes in some more depth towards the end of this report. For now, it will be important to bear in mind how Modernity never was a set of fixed and established rules but rather an *ongoing experiment*, the experience of nature and society changing (in) history and as a consequence of human action. Science with its logics and laboratories is just one – albeit important – site for this experiment. In the next two chapters, we shall review other such sites of prime importance and value for European history and identity.

5. Studia Humanitatis

The "European Values" associated with modernity, progress, knowledge and humanity are the result of several lines of development. Two such lines produced what C.P. Snow (1905-1980) called "The Two Cultures": The humanities, which developed expertise in interpretation, multiple perspectives and dissent, promoted the value of reason, diversity and tolerance. The (natural) sciences, which developed expertise in the reduction of uncertainty, promoted the value of rationality, uniformity and control. The best of European culture might be seen as the result of the continuous exchange and tension between these cultures. It is also important to note how the humanities in themselves are diverse across time and space. In the Renaissance, "studia humanitatis" - "the study of what is human" - was not in opposition to the study of Nature, because the pure, "non-human" concept of Nature did not exist yet. The contrast was "studia divinitatis" - the study of the divine". Only in the 19th century do the humanities become research-based academic disciplines that define themselves in contrast to natural science. As such, they were often deeply entangled in nation-building projects: Historians, archaeologists, literary scholars, philosophers and others helped identify and formulate the identity and qualities of European nations in their quest for independence, power and expansion. Later, in the 20th century, the same disciplines developed an ever more reflexive and self-critical understanding of their own relationship with the nation and the state. Today, the humanities are a strikingly diverse field. One can find scholars who will give governments and decision-makers what they ask for with little or no questioning of the underlying politics and power structures. One can also find scholars who do little else than to raise such questions.

In classical accounts of the history of philosophy and of the sciences it is commonly presupposed that the main contender to Rationalism (as outlined) was Empiricism, as championed by John Locke and others. Although in many respects this may be so: when we depart from Rationalism, it is evident that the two share in most, if not all, of their presuppositions. They were part of the same imaginary of social and natural order. Although it was not completely clear what this order was, it was sufficient for structuring and projecting certain kinds of visions. Hence their disagreements came as results of this prior agreement. Empiricists and rationalists differed in their accounts of the scientific method, i.e. empiricists claimed natural laws to be the result of inductive empirical observation, whereas rationalists claimed natural laws to emanate from clear and distinct ideas. However, apart from this the two camps agreed on a number of issues, such as the belief that Nature is a mechanic clockwork operating according to stable laws, the elevation of reason over emotion and popular opinion, and the belief in an external, independent physical reality.

Other contestations came from philosophers and scientists who would reconfigure the cosmos and humans' place in it differently than did the rationalists and empiricists, or who were interested in exactly those aspects of reality that were downplayed or excluded by the Modern Framework. For instance, the philosopher and theologian Blaise Pascal (1669/1958) blamed Descartes for relegating God to the fringes of the cosmos and human life: *"I cannot forgive Descartes; in all his philosophy he did his best to dispense with God. But he could not avoid making Him set the world in motion with a flip of His thumb; after that he had no more use for God"* (Section 2, 77).

More pertinent to the present analysis, however, is the ways in which scholars would ascribe central importance to those aspects of human existence that had been ascribed secondary importance only by Galileo and Descartes: emotionality and the senses, language, images and imagination, etc. We have already seen how Montaigne, perhaps the first modern thinker, turned to his own experience but interpreted it in exactly those terms that so much stressed Descartes. In writing about the role of the senses and imagination and touching upon a broad specter of fields, such as science, politics and education, Montaigne did not stop at that: he also provided highly explicit descriptions of his own body, including its decay through old age, his own excrements, etc. In so doing, he not only presaged the modern novel, one could also argue with some force that he was a precursor of confessional society and psychologisation of the self (Rose 1999), and most lately the proliferation of health blogs on the Internet. In spite of sharp increases in scientific and technological systems across most specters of life, the secondary qualities have not been excluded or overcome. In the midst of scientific and technological lifeworlds and seemingly ever-expanding bureaucracies, issues of identity and belonging remain ever-important (and, if anything, even increasingly so).

These domains, which have customarily been grouped together under general headings such as “subjectivity” or “Culture”, did not disappear with the introduction of the Modern Framework. Neither did they simply continue to exist as before alongside or outside the official versions of Reality. Instead, they were compartmentalized and brought into Society through new sciences devoted to their specific objects, first and foremost History and Philology. There was no accident or coincidence involved in this: when the Italian philosopher Giovanni Battista Vico wrote his *Nuevo Scienzia*, widely hailed for establishing History and Philology as scientific disciplines, he explicitly addressed the Natural philosophers and their strong prioritization of “Nature” and mathematics over “Man”, “Language”, “Imagination”, “Symbol” or “Nation”. Indeed, Vico claimed, by going directly to natural objects, the natural philosophers forgot the very preconditions for conceiving of them:

> *“…until now, the philosophers, contemplating divine providence only through the natural order, have shown only a part of it. …But the philosophers have not yet contemplated His providence in respect of that part of it which is most proper to men, whose nature has this principal property: that of being social”* (Vico, 1744/1948, Introduction).

Neither Montaigne nor Vico claimed their writings to be “subjective”, or not to aim for truth; both proceeded by language, imagination and symbolic expressions in order to point to a greater order. However, in Montaigne this order was provided through the Great Chain of Being. Vico, on the other hand, was firmly situated within the new and emerging Modern World. Although aiming to point out God’s Providence in Society and History, he did so by claiming for the existence of Natural laws and regularities. He saw his own time as “The age of men, in which all men recognized themselves as equal in human nature…” The laws of nature, claimed Vico, are directly accessible to man because he is also the originator of language and social institutions. The age of man, therefore, was also characterized by a language *“…using words agreed upon by the people, a language of which they are absolute lords, and which is proper to the popular commonwealths and monarchical states; a language whereby the people may fix the meaning of the laws by which the nobles as well as the plebs are bound”.* Hence, Vicos project is distinctly modern whereas Montaignes can be said to be only partially so: Vico aims to demonstrate the “true civil nature of Man”. This nature also has its laws, and belongs within a certain order. This order is to be realized within the Sovereign power of the National State. These are products of man, and so also more intuitively and directly understandable than Nature.

Later in the 18th century similar arguments would be repeated with more force, what has generally been known as the counter-Enlightenment or Romanticism. In France, Jean-Jacques Rousseau rebelled against the Universalism of the Encyclopedists, which he claimed to be empty and hostile to Man's true Nature. In Germany, where the Enlightenment had been less aggressive, Romanticists such as Herder, Schlegel and Fichte also rebelled against the rationalism of the Enlightenment. Like Vico, a main locus was the phenomenon of language as a vehicle for expressing the deeper nature of Man. There is no way for thought to bypass the medium of language and grasp nature directly, Herder stated (Taylor 1975). Instead, language and consciousness, by which humans grasp nature, *is* the essence of being human. Also this notion was radically modern, insofar as it dispersed with the existence of a predetermined order: human nature could be known through its expressions, in language and in the arts. This situated the experiencing and expressive subject at the centre of attention.

However, Herder and the romanticists did not thereby embrace "atomism" or individualism. They radically opposed Cartesian dualism and scientism. Subjectivity and language were rather regarded as the media through which a greater natural and social order expresses itself. This order, however, could only be known through such subjective expression in language and the arts, and did not belong to a pre-destined order. It did, however, express something that was also new, namely *The People (das Volk)*. With Latin receding as a universal language the vernacular languages came to the fore, regaining legitimacy as expressions of collectivity and spirit. Hence, whereas the early romanticists would highlight the subject, and especially the artist and genius, the expressed content would also be one of the People, a community of language situated within an organic nature.

Clearly, the ideas voiced by the Romantics were much more diverse and complex than can be expressed here. However, in terms of history some of their ideas were brought to completion in the idealist system developed by Hegel early in the 19th century. Also Hegel would emphasize the primacy of consciousness, subjectivity and language. However, he also accepted the notion that the cosmos posits some universal, pre-existing order. This order, however, could not be known except from the ways in which it unfolded in history. Hegel's dialectic system, therefore, followed the development of the universal spirit through history. This spirit, and the laws represented by it, can only be known through its expressions, in the arts, in laws and in the institutions, including natural science. But it is radically different to the universal laws of Newton, for instance. Newton's laws allegedly were marked by their universal validity, irrespective of place or time, and so also valid in possible futures. The laws of history (and of Spirit), however, could only be known in retrospect. "The owl of Minerva spreads its wings only with the falling of the dusk": thus Hegel famously expressed the character of philosophy and history. These disciplines, by their very nature, only apply after the fact: history can only be understood backwards.

At later stages (i.e. late 19th century, early 20th century), scientists of the text developed similar themes, especially those dealing with jurisprudence and theology. Known as hermeneutics, later theorists would try and lay bare the foundations of the textual (and cultural) sciences through the operation of interpretation. Fundamental problems of hermeneutics pertain to the interpretation and understanding of text across time and distance: how to understand the intention of a text (say, the Bible or the Constitution) when the author(s) is no longer accessible to questioning, or perhaps even unknown? Fundamental to the problem is the polyphony of language: language has plural meanings and interpretations, and always exists within specific historical and cultural contexts. Hence, the sciences of the text are just as concerned with understanding phenomena in their singularity and unique manifestations, as opposed to the general laws of the natural sciences. However, the notion that each text or work of art is unique and singular may run counter to the ambitions of science, namely the establishment of general laws or principles according to which singular events attain regularity. Such regularity, it was claimed, resides in understanding and in interpretation. Hermeneutics is "The theory of the operations of understanding in their relation to the interpretation of texts" (Ricoeur 1981, 43). Writing after Kant, and around the time of Nietzsche, authors such as Friedrich Schleiermacher (1768-1834) and Vilhelm Dilthey (1833-1911), would no longer claim to lay bare universal laws of history. Instead, what they claimed was the laying bare of the universal laws of understanding, i.e. the principles by which we come to create and interpret textual expressions.

In the 20th century, philosophers such as Heidegger and Gadamer would carry further the project of hermeneutics. Later in that century, hermeneutics would be partly replaced by post-modernist and post-structuralist theories of texts and language. Whereas these are highly diverse theoretical and cultural developments, playing out differently within different scientific disciplines, they are nevertheless heirs to the project of Vico and the Romantics, positing language, imagination and consciousness at the centre of the humanistic sciences. Until quite recently, they happily existed alongside the natural sciences, either in blissful negligence or (sometimes) in direct confrontation with them. Two such confrontations may be mentioned. One topic of contention throughout the 20th century was the Unity of Science debate, in which many philosophers of science and scientists alike held that there is "essentially" only one Science, often defined in terms of a unique Scientific Method or a unique logical structure of scientific knowledge (and often with physics as the exemplar and model). Indeed, the belief in the Unity of Science played an important role in the Received View. Against this belief, there were many alternative positions: Beliefs in a dichotomy between natural science and human/social sciences (and the essential differences between non-human and human research objects); beliefs in the "orchestration of sciences", in which they together form a harmonious, "symphonic" whole; or beliefs in the essential disunity of science, even down to the fragmented and disparate character of a seemingly well-defined field such as biology or physics. Towards the end of the 20th century, another noteworthy confrontation appeared, namely the so-called "Science wars" which largely consisted of accusations about the status of natural science and the status of humanities and social science critical of natural science, or rather the prestige and power of natural science. In these debates many of the same issues voiced by Montaigne, Vico and Herder would turn up again: can nature's laws be accessed directly through (allegedly) universal ideas, or are these fundamentally products of language, social institutions and human bias?

6. Politics and Law

In order to understand modern politics, it is useful once again to return to 17th century Europe, a Europe in which authorities are collapsing. On one hand, the Church gradually lost its claim to truth about worldly matters. Physics proved better than the Bible and Aristotle's writings. As for human affairs, religious conflicts led to disaster. Accordingly, we see the rise of new political thought about the State and its legitimate claim to power. The State becomes conceived as a human affair - a social contract between free men, for the benefit of all. It should justify itself with reasonable, transparent arguments, and not by recourse to esoteric knowledge or a privileged relationship with God. The modern insistence on separating "is" from "ought" is created: Science can tell us what "is" in Nature, but what we ought to do, must be settled in culture and politics. Untamed culture and politics, however, seemed to release chaos and disaster. In a context where dissent and free argument seemed to easily develop into violence, mathematical clarity and unequivocal rules appeared attractive. Hence we find the birth of modern economics, by which issues of ownership, transaction, fairness, etc., could be solved with certainty and precision.

It was of course not scientists or philosophers who ended the war in Europe; peace was negotiated by the Roman emperor, the kings of Holland, Sweden, France and Spain, the House of Habsburg as well as representatives of city states. A decisive outcome of the peace at Westphalia (1648) was the relegation of religion from the state: each sovereign was to determine the religion of the nation, which henceforth became an internal matter for the single states. In this way, national politics established a space and an opportunity for the creation of a new set of social relations, and it was within this space that the modern framework of order would gradually emerge. And in this process the works of philosophers and scholars *were* important: they both reflected the developments of their day and prescribed possible trajectories for developments to take. As with the scientific worldview, what started out as the ideas of a few gradually became the general view, and so gradually settled in European institutions. We have already described how political stability and order in the early 18th century was predicated on the simultaneous emergence of a Newtonian universe guided by stable and universal laws. Natural philosophy and science came along with, was co-produced with, the articulation and emergence of political and legal order.

The *natural law* tradition was instigated by the Dutch jurist Hugo Grotius, and a direct response to the problem of order: in the place of religious dogma, but also gradually replacing the existing common law, Grotius inserted the idea of natural laws as immediately accessible to human rationality. Writing a quarter of a century prior to the Peace at Westphalia, Grotius was “Fully convinced...that there is a common law among nations…”. Human (and not divine) reason became the basis from which positive law could be judged, potentially also changed. It also became the basis for projecting a new set of relations among societies’ members. *The Sovereign* would no longer be seen as descending from God, but rather party to a mutual contract with his subjects: the citizens. The aims of this contract were first and foremost the establishment of a stable order that could provide security and prosperity, and these became the basic premises on which the relationship between the Sovereign and his subjects could be legitimized and judged. In the political theory of Hobbes, subjects could overthrow the Sovereign if he failed to provide these basics.

As in Natural philosophy, the “common law” articulated by Grotius was the result of idealization: it imagined a hypothetical situation in which all of society’s members would consent to handing over parts of their freedom to the Sovereign in exchange for peace, security and prosperity. First Thomas Hobbes (1588-1679) then John Locke (1632-1704), articulated the idea that Society be founded upon a contract, thus surpassing a “state of nature” in which no laws exist and every person is the possible enemy of any other. Although this contract was a fiction, it has produced institutions and practices that still make up the backbones of modern Western societies. This relates both to the creation of security through the state, and to the creation of prosperity through the market. Hence, the creation of a separate entity, the secular state, enabled the emergence of a second: the market.

The social contract was also based upon a certain view of Man as driven by self-interest and egotism if not constrained by external force, the Sovereign and law. This was a direct reflection of human relations at the time, and *the* state of affairs to be overcome: under the social contract, and guided by Reason, the destructive powers of humanity can be creatively transformed. The modern age came along with the institution of Man’s unalienable rights to life and property. Modern man was imagined as a labourer, as struggling to survive and constantly working to improve his lot. This is primarily seen as a process of transforming Nature through work. By working and refining Nature with his own body and intellect, Man transforms Nature into value, gaining the right to property in what he has extracted from her:

> *“Though the earth and all inferior creatures be common to all men, yet every man has a property in his own person. This nobody has any right to but himself. The labour of his body and the work of his hands, we may say, is properly his. Whatsoever, then, he removes out of the state that nature hath provided and left it in, he hath mixed his labour with it, and joined to it something that is his own, and thereby makes it his property. It being by him removed from the common state nature placed it in, it hath by this labour something annexed to it that excludes the common right of other men” (Locke 1966:§27).*

This view of the individual labourer cannot be regarded in isolation from an overall vision of Society: Man may enter into mutually useful agreements and negotiations with others in the marketplace. Hence, a neutral and separate sphere is constructed in which Man may creatively and productively engage in interactions with others, thus promoting his own freedom and Societal progress at the same time. Parallel to developments in Natural science and philosophy, the market was imagined as a neutral sphere based upon stable laws that could safeguard and coordinate self-interested action. In this sense, the image of Nature as an interlocking clockwork or machinery found its parallel in the idea of society as centred upon interlocking and mutually existing individual purposes. “Society” became seen as existing of in principle equal individuals that would mutually serve each other by the rational pursuit of self-interested action. This radical re-imagination was possible due to the prior image of Nature as mechanic, inert matter without intrinsic purpose. Man, however, possessing intellect and Rationality (given to him by God), has the power to impose such purpose through his innovativeness and hard work. For instance, property rights were inserted into the US constitution in order to “promote the progress of science and useful arts” (Krimsky 199:145), thus enriching society. Such progress was possible because of certain natural and societal mechanisms working independently of the selfish motivations of each individual, what Adam Smith would later famously term the *Invisible Hand of the Market*.

Hence, the Modern Framework was not merely predicated upon diminishing freedoms, of giving up one's natural state for an imposed and rigid discipline under the Sovereign. The market, working on the condition of a division of labour to grant the optimal use of natural resources, was imagined as a space of freedom and opportunity. It was this space that was guarded and upheld by the Sovereign, and so the Social contract was imagined *as a trade-off*: the citizens were to relegate parts of their freedom, hence also impose self-restraint and discipline in accordance with the law, in exchange for the freedoms to engage in mutual interaction and transaction. We have seen, (cf. also the chapter on the humanities), that the form of this contract was one in which each individual was regarded as, in principle, equal to any other. However, citizens did not negotiate the Peace at Westphalia; Kings did. Further, it was the elites of the capitals of the main countries such as England and France, whose privilege it was to gradually implement and disseminate the new order throughout the state institutions. Still, these developments, along with subsisting hierarchies that came out of the old aristocracies, did not sit easily with the emerging bourgeoisie classes. After all, it was these who made up the main entrepreneurial classes: businessmen, industrialists, engineers and state officials. As is well known, discontents with old power structures residing within the new Modern Framework led to the French and American Revolutions, and the instigation of a new kind of constitution in which *the People* is seen as the Sovereign, and the State a mere servant of the People.

Still, philosophers had already debated the character of Sovereignty, and this since the very inception of the Modern Framework. Counter to the received view that the character of Sovereignty was a purely "political" matter, whereas the laws of Nature were scientific, these discussions would take place in more intimately interconnected ways than commonly accepted. The negotiations of social and natural orders have been the topic of two influential works in Science and Technology Studies, i.e. Bruno Latour's (1993) *We Have Never been Modern*, and Shapin and Schaeffer's (1985) *Leviathan and the Air Pump*. By going back to the origins of debates over as seemingly diverse topics as the existence of vacuum in Nature and the nature of political sovereignty, these authors demonstrate how Nature's workings were not imagined separately from those of politics, but rather as co-produced.

Both works deal with a debate between the natural philosopher and scientist Robert Boyle, one of the founding fathers of experimental science, and the political philosopher Thomas Hobbes, whose theory of the Leviathan greatly influenced thinking about political sovereignty. At stake in the debate was the existence or not of vacuums in nature, much debated at the time (we cannot enter into detail about the controversy here). At stake were not only the existence (or not) of vacuum; but also the very methods by which truth about Nature was to be arrived upon, and these methods and principles went parallel with the political positions held by the two philosophers. Boyle became famous, first through the Royal Society, for his works in *experimental philosophy*, expressed through the construction of a vacuum pump that would demonstrate the existence of vacuum (or, ether winds). Because nature does not hold preconditions or opinions, but operates according to Natural laws, it could serve as a reliable arbiter about matters in dispute. The role of the experimenter was to bring Nature, the silent witness, into society and to make it *speak*. This was the role of the experimenter, and the public experiment was the means for achieving it. Boyle's invention, the authors say, was the introduction of "silent witnesses", the objects of nature, into society through the laboratory. As the practices of public experimentation spread, so did natural philosophy and the authority of science.

Hobbes, on the other hand, proceeded differently. He was not a believer in the vacuum. His was very much a project of driving out notions about such mystical forces in nature that could not be seen: these should, like spirits, ghosts, scholastic principles and religion, be relegated from any influence in Society. Instead, Hobbes taught, Rationality and Reason had to proceed according to Rational principles, that is, those of mathematics and geometry. The Sovereign, Hobbes stated, was to be the ultimate guarantee against the corrupting forces of religion, mysticism, scholasticism and war. If the Sovereign was to serve this function, his power had to be undivided and one: power *is* knowledge. Absolute power had to be transferred to the Sovereign in order to safeguard the political sphere, which could not be contaminated by irrational forces. In order to legitimate his views, Hobbes invoked the mechanistic philosophy, thereby projecting an image of society as a rational machinery watched over and controlled by the Sovereign (and not by God). Power and knowledge had to be united at one hand and imposed accordingly, and this was a matter of pure rational demonstration, of logic.

Not so according to Boyle: for him, there was no such thing as a unitary, rational order, and there was no such thing as absolute certainty; if such a thing were to emerge it had to be produced and debated. However, this did not entail a retreat to a State of Nature where no order could be seen or produced. Rather, this order had to be produced by experiment and in public. Also Boyle placed faith in a rational machine, but this machine was not a totality called Society; it was in the experiment, itself: the air pump, and the community of experimentalists that would grow up around it. Therefore, the experimental philosophy was also a social philosophy: *"The laboratory was (…) a disciplined space, where experimental, discursive, and social practices were collectively controlled by competent members"* (Shapin and Schaeffer 1985, 39). In order to construct such a space, certain rules had to be agreed upon in advance. As for the validity of the experiment, and for the "matters of fact" thereby produced these were not to be discussed. In order to enter into the "experimental community" one would first have to accept these basic rules (which is what Hobbes could not do). Thus, Boyle envisioned, the experimental community would grow in society, producing progress through rational debate and argument. Once part of this community, however, members were in principle equally entitled to challenge the results of the experiment, and to propose alternative hypotheses. According to the experimental philosophy, there are no absolute and certain principles of knowledge. Correspondingly, in the sphere of politics there is no absolute position for the Sovereign to take.

Hence, although never a matter of simple 1:1 relations, there was a correspondence between one's theory of knowledge and social and political philosophy. One decisive accomplishment of the work of Shapin and Shaeffer was to highlight how, in the period of the Restoration, experimentalism emerged as an attitude and practice. Still, as a political attitude and alternative, it was immediately also suppressed, and relegated to the spheres of "Nature" and "Science". There, it was regarded as secondary to the Hobbesian (and also Cartesian, Newtonian and Einsteinian) preoccupation with theory and the cultivation of certainty through first principles. In the philosophy and history of science, this view prevailed until the publication of Thomas Kuhn's *Structure of Scientific Revolutions* in 1962. That is, theoretical certainty was given precedence over experimental uncertainty.

According to Shapin and Shaeffer: in the end "Hobbes was right". Knowledge is produced and projected in accordance with Society's perceived needs, and so a direct extension of *power*. The Sovereign must contain and control that power so as not to allow irrational voices to interfere with the machinery of Society. Thinkers from Francis Bacon to Michel Foucault have agreed to this proposition, and along with them most of modern social thought: society (and politics) is based upon competing, largely egoistic, *interests* that have to be balanced through the exercise of Sovereign power. However, it was never so *by necessity*. We have seen that the humanists, from Montaigne through Vico and up to the German idealists, perceived things differently. It was never the case that the experimental approach was a mere prerogative of the natural sciences, whereas politics was a matter of producing Hobbes' vision of the all-powerful Sovereign. Indeed, ensuing developments would produce the *division of powers* as a means for keeping checks and balances on Hobbesian (and Machiavellian) power. And, whereas the notion of *interest* has remained predominant, especially in the Anglo-Saxon and liberalist traditions, *republican* thinkers could be seen to configure the matters differently. This section ends, therefore, with a short note on the political philosophy of Montesquieu.

In *The Spirit of the Laws* from 1748, Montesquieu strove to come to terms with the great shifts that had occurred as the world of the Ancients was definitively left behind. Not merely outlining a theory, he was trying to come to terms with a whole new way of experiencing the world: *The political men of Greece who lived under popular government recognized no other force to sustain it than virtue. Those of today speak to us only of manufacturing, commerce, finance, wealth, and even luxury* (quote from Manent 2000, 18). The experience articulated by Montesquieu parallels that of Vico in one important sense, namely that of being conscious of living in history, and subject to acts and institutions created by men, not by immutable tradition. Although the quote may seem a critique of Modernity from the point of view of ancient virtue, it is not; Montesquieu knows that "today" has definitely overtaken the past, and that there is no way to return to the order of the Ancients. The Spirit of the Laws seeks to overcome the two main sources of European morality: the Cosmos of the Ancients and their ensuing virtues, and Christian Grace. Both, in their ways, impose unity of experience and certainty in matters moral and political. With the advent of Modernity, however, such certainties were suspended. *Hobbes* was of course highly aware of this: his political theory was an attempt to establish a new order following from the principles of the new science. In the place of the virtues and Christian grace he inserted the mechanical philosophy and the Sovereign as its ultimate guarantee. But thereby he merely inserted a new kind of absolute in the place of the old, conceived through Natural Philosophy and first principles. The Sovereign was an external principle of power, imposing itself from the outside, as it were, thereby creating and upholding order.

In Montesquieu the Sovereign was not an external principle imposing itself, but rather an internal act of will of citizens. This act was none other than subordination to the law itself. It meant suspending one's immediate inclinations, not for the sake of ancient virtue or Christian grace, but for the sake of *political* virtue. Subordinating oneself to the rule of law, and the national state, it was a suppression of individual nature. Subordination was not done out of fear, of death under the state of Nature or reprisals from the Absolute, but rather from love of the law itself. This was, according to Manent, a principle that spoke more directly to the New experience: *"…thus, linked to the nation state, this supranational society of English, French, Dutch, and Italians, too much citizens to be truly Christians, too Christian to be truly citizens, who find in property, conversation, and commerce those mediating spiritual entities that speak to their situation"* (Manent 1998, 25).

Now, whereas clearly different from the experimental philosophy of Boyle, Montesquieu's republicanism nevertheless shared in its rejection of the absolute power and knowledge of the Sovereign. In the place of the Sovereign, both inserted a set of rules, imposed by citizens on themselves, and establishing new spaces of interaction. The concrete character of these spaces was not determined in advance, hence the relevance of experimentalism: they had to be created by citizens themselves, and this was part of their very meaning. This was by no means a simple task: as we have seen, Hobbesian Sovereignty prevailed over Boyle's experimentalism. And as for republicanism, Roussau would later on take up the premises established by Montesquieu and turn them on their head. The self-discipline and suspension of Nature and one's natural inclinations promoted by Montesquieu, was seen as violent and oppressive: against Nature. The French Revolution, whatever one thinks of it, violently sought to impose Unity of purpose and authority: all power to the People. The experience articulated by both the humanists and republicans would support this general preference for "the People" and the equality of men. But they also, in their different ways, sought to moderate its most violent expressions through notions of knowledge as uncertain, self-discipline and divisions of powers under the rule of law. All, in different ways, articulated experiences of living in history, under conditions created by men, for men. The most practical and political expressions of this experience remained the institutions of "property, conversation and commerce". But it was also out of such conversations, and out of shared experiences, concerns and institutions, that a most peculiar construct would gradually emerge: the public sphere.

7. “Where the cause is not known, the effect cannot be produced”

In parallel with the idea that scientific knowledge might offer truth, consensus and rational decision-making, the history of the Scientific Revolution is also often told as one of increased mastery and control over Nature. Practical applicability of physical knowledge was important already for Galileo, Descartes and Newton. Other thinkers, however, stand out as the great ideologues of the social and economic benefits promised by science. We shall mention three: Francis Bacon (1561-1626), Marquis de Condorcet (1743-1794) and Vannevar Bush (1890-1974), all of whom combined political and scientific work. Bacon formulated the basic belief that knowledge gives us power to act in the world to the benefit of our lives. Condorcet elaborated the utopia of a science-based society as one of welfare, equality, justice and happiness. Bush argued that scientific progress and a strong public funding of basic science are necessary conditions to sustain economic growth by the development of new products (or innovation in contemporary vocabulary). While similar claims can be found in most official research policies at the beginning of the 21st century, it is useful to revisit these three classic statements to appreciate their speculative and simplistic character.

Why increase our scientific knowledge? If we perform an anachronism and pretend that we could ask this question to Aristotle (384-322 BC), we might imagine that he, along with his fellow philosophers in Ancient Greece, would point to human curiosity and the fulfilment of the human potential to grasp the world with our intellect. Practical work was appropriate for slaves and not for theorizing free men. From an Aristotelian perspective, even if one was concerned with technical challenges, one would remain sceptical about the applicability of physics. Physics and other natural sciences described natural systems and spontaneous processes, while technology was seen as a matter of artificial systems and processes forced by man. It was in no way clear that knowledge of the one applied to the other. Galileo is often celebrated as one of the early scientific heroes who rejected the distinction between natural and artificial systems and thereby laid the foundation for technological development based on natural science. Indeed, ballistics, navigation and other technical issues were important interests for several of the great minds of physics already in the 17th century.

The classic formulation of the usefulness and benefits of science, however, is usually ascribed to the English philosopher, scientist and statesman Francis Bacon (1561-1626). In the post-humously published text *The New Atlantis* Bacon describes a Utopia of wealth and happiness based on scientific advancements:

> *We have also engine-houses, where are prepared engines and instruments for all sorts of motions. There we imitate and practise to make swifter motions than any you have, either out of your muskets or any engine that you have; and to make them and multiply them more easily, and with smaller force, by wheels and other means: and to make them stronger, and more violent than yours are; exceeding your greatest cannons and basilisks (Bacon 1628/1996, 485-486).*

His unfinished manuscript ended with a visionary list of “wonders of nature, in particular with respect to human use”. Here are a few examples:

The prolongation of life.
The retardation of age.
The curing of diseases counted incurable.
The altering of complexions, and fatness and leanness.
Versions of bodies into other bodies.
Making of new species.
Instruments of destruction, as of war and poison.
Drawing of new foods out of substances not now in use.
Deception of the senses.

Bacon anticipated that all this could be achieved by the use of the "new tool" of experimental and inductive science. In *Novum Organum* (1620) he explained why: "Human knowledge and human power come to the same thing, for where the cause is not known the effect cannot be produced" (Aphorism 3). Useful knowledge for Bacon is knowledge about cause-effect relationships that allows us to avoid or bring about the causes of what harms and benefits us, respectively. Knowledge is always better than ignorance because it provides us with more power, that is, more possibilities to avoid harm and achieve good. In its general and simple form, this argument has been reiterated in science education and science policy ever since. Still, the argument is obviously simplistic in at least two respects. First, Bacon presupposes a uniform and consensual "we" who decide what is beneficial and what is harmful: "we" can for instance obtain "instruments of destruction" to obtain more power (over our enemies) and in that way increase our wealth and happiness. Bacon does not – and probably could not – anticipate the more profound understanding of how Knowledge is Power that is often associated with the French philosopher Michel Foucault (1926-1984): Knowledge gives power *over somebody else,* for instance by technological control or by more subtle forms of disciplining their behaviour or mentality.

Secondly, Bacon had no concept of causal complexity: His examples are of one cause that leads to one effect. Accordingly, he did not anticipate the challenges of technological hybris. In actual cases, there is always only partial knowledge, that is knowledge of *some* causal relationships. When such knowledge is applied, there is the possibility of unforeseen and undesirable higher-order effects; indeed one may identify many environmental problems as the result of such unforeseen and undesired effects of technological intervention into the world. In practical terms, even if disputes over what is good and what is harmful are resolved, it remains an empirical question whether a particular piece of knowledge or technology in fact has created more benefit than harm. This possibility – that the benefit-cost ratio of new knowledge and technology may be smaller than 1 – is largely ignored in current regulation and governance of science and technology.

During Francis Bacon's lifetime, however, his philosophical predictions remained speculative visions without much consequence. Fast-forwarding into the Enlightenment and the period of the French Revolution, one can find the idea of scientific (and political) progress also developing into a Utopia of a better humankind. A particularly explicit formulation of such a Utopia was made by the French philosopher, mathematician and political scientist Marie Jean Antoine Nicolas de Caritat (1743-1794), known as Marquis de Condorcet.

Condorcet aligns himself with the tradition going back to Bacon, arguing that increased scientific knowledge will provide increased wealth. Secondly, he argues that increased wealth also will result in increased equality. For Condorcet, inequality is the result of tyranny, violence and prejudice. Science will produce more wealth and therefore less motivation to exploit others. However, Science will also propagate Enlightenment and Reason, resulting in less prejudice and violence. Specifically, Condorçet sees the free markets – "unrestricted commerce" – as one such mechanism for the propagation of Reason and equality. A few years later, Thomas Malthus published his pessimist view on the future of a growing human population on a finite Earth. Condorcet anticipated the same problem:

> *It may, however, be demanded, whether, amidst this improvement in industry and happiness, where the wants and faculties of men will continually become better proportioned, each successive generation possess more various stores, and of consequence in each generation the number of individuals be greatly increased; it may, I say, be demanded, whether these principles of improvement and increase may not, by their continual operation, ultimately lead to degeneracy and destruction? Whether the number of inhabitants in the universe at length exceeding the means of existence, there will not result a continual decay of happiness and population, and a progress towards barbarism, or at least a sort of oscillation between good and evil?* (Condorcet 1796, 272)

His reply on the following page, however, was the opposite of Malthus':

> *if we consider, that prior to this period the progress of reason will have walked hand in hand with that of the sciences; that the absurd prejudices of superstition will have ceased to infuse into morality a harshness that corrupts and degrades, instead of purifying and exalting it; that men will then know, that the duties they may be under relative to propagation will consist not in the question of giving* ***existence*** *to a greater number of being, but* ***happiness****; […] and not the puerile idea of encumbering the earth with useless and wretched mortals.*

We may find in Condorcet most of the ingredients in contemporary political thoughts: increased wealth and welfare through scientific and technological development and a free market; improved politics and morality through education and social, economic and political science; a theory about mature societies that are sustainable because their rational and morally sophisticated citizens value happiness, reduce their number of offspring and therefore consciously arrive at zero population growth. If we add the belief in the miniaturisation of technology, the information society and the resulting dematerialisation of the economy, Condorcet's programme is essentially identical with those of Western governments since the end of WWII. Still, the critical questions that can be raised to Bacon, are equally unresolved by Condorcet: He merely postulates that scientific progress leads to wealth and that wealth leads to happiness. And he had of course no empirical data to support that the combination of "unrestricted commerce" and scientific advance by itself reduces inequality, violence and tyranny.

Moving another 150 years ahead in time, the third manifesto on the benefit of science of equal notability is the well-known report *Science: the Endless Frontier* (1945) written by Vannevar Bush on the request from President Franklin D. Roosevelt. In this report, Bush, as Director of the US Office of Scientific Research and Development, set out to draw the lessons from the organisation of big military science, in particular the Manhattan Project (that produced the nuclear bomb). In this he echoes Bacon's and Condorcet's beliefs in science as a provider of practical benefit as well as contemporary theories of innovation – the so-called linear model that describes innovation as a linear sequence of steps:

Basic research → Applied research → Technological Development → Production → Diffusion

Although Bush never spells out the model, he insists that the strengthening of basic research is a necessary precondition for the creation of jobs and the improvement of social welfare. With striking candidness, the report combines Bacon's belief in science, Condorcet's belief in the free market and the fact of post-war consumerist society:

> *One of our hopes is that after the war there will be full employment. To reach that goal the full creative and productive energies of the American people must be released. To create more jobs we must make new and better and cheaper products. We want plenty of new, vigorous enterprises. But new products and processes are not born full-grown. They are founded on new principles and new conceptions which in turn result from basic scientific research. Basic scientific research is scientific capital. Moreover, we cannot any longer depend upon Europe as a major source of this scientific capital. Clearly, more and better scientific research is one essential to the achievement of our goal of full employment (Bush 1945).*

For Bush, economic growth is necessary, and it requires that consumers are constantly enticed by new products. The white spots in the world map being filled in and colonial goods already consumed, the West having been conquered, and Europe in ruins and in need of American aid after the War, the people of the United States have to rely on themselves. And hence the title of the report: as all other frontiers are conquered, science is the one that allows for indefinite progress and expansion:

> *It has been basic United States policy that Government should foster the opening of new frontiers. It opened the seas to clipper ships and furnished land for pioneers. Although these frontiers have more or less disappeared, the frontier of science remains. (Bush 1945)*

The political implication that Bush drew, was the need for a strong public support of basic research. Indeed, his work was influential for the establishment of the National Science Foundation in 1950. What we would like to highlight is once again the speculative nature of also this third – consumerist – Utopia of Science. Bush does mention a few statistics of research funding; they do not enter into the argument in any way as a robust set of evidence. On the contrary, the report indulges in general statements such as "Discovery of new therapeutic agents and methods usually results from basic studies in medicine and the underlying sciences" without any empirical base or reference. Indeed, within the ideological tradition that we have outlined in this chapter, the empirical evidence has only rarely been called for: It simply **could not be** that science did not produce a lot of benefit for all and only negligible harm. As we shall see in the next chapter, however, the empirical support for this belief came later and with its own problematic assumptions.

8. Life, Capitalism, Politics

> *"Bacon, Harvey, Galileo, Descartes and Newton had launched the New Science; the Enlightenment popularized it; but it was the age post-1800 that bankrolled public science, bringing new manpower, institutions, teaching, training and expectations…reformers declared science the dynamo of progress"* (Porter 1997, 305).

When Francis Bacon created his visionary list of Wonders of Nature, his contemporaries had few reasons to take him seriously; his was a vision combining both pre-modern and modern sources into a strange creature resembling today's biotechnology. Still, one should be sceptical of reading such meanings into it. We do not know exactly what he meant when he concocted his list, and his inspirations undoubtedly included pre-modern sources, such as the taxonomy of his times, astronomy and alchemy. As Bacon was writing, the modern view of nature was only just starting to shape; it was not yet neatly separated into discrete categories and disciplines such as organic and inorganic, physics, chemistry and biology, and his vision took advantage of this. The Modern view only gradually took hold, and Bacon was not its main promoter; Galileo was. Within the Galileian and (later) Newtonian vision of the universe, Nature was not responsive to intervention. It was seen as a clockwork of inert and mechanical matter, with both Man and Society situated outside or above its machinery (that is: dualism). This also reflected in political works: When Locke wrote his *Treatise on Government*, he placed at its centre labour, the process by which Man extracts value from nature through his own work, and brings it into society. This could only be imagined as a one-way process; there was no way in which the artefacts created by men would return to nature and change it, or mobilize nature's fundamental powers for the purposes of Man or Society. Similarly, as Adam Smith wrote *The Wealth of Nations*, he was referring to harvesting the fruits of the land, and not to industrial farming as we know it today. Wealth and prosperity was to come from the rationalization and specialization of work, and not from the mechanization of and intervention in Nature itself. Locke and Smith *could* not possibly, as in Bacon's list, envision the possibility that labour also consist of manipulations with Nature's workings. In this respect Locke and Smith were the true moderns, whereas Bacon was the odd fellow out: a transitional and ambiguous figure, taking his clues from wherever he found them rather than following the scientific method (as he himself had prescribed).

Two decisive and interrelated developments took place in 18th century knowledge production that would begin to change the Newtonian universe, and with it the Modern Framework. One related to biology and the view of life, the other to views on political economy, including the character of labour itself. As described by Michel Foucault (1970) these were not independent developments, but closely related through an emerging *epistême* expressed in and through the new *Sciences of Man*. Both emerged around the time of the French Revolution and the Industrial Revolution in Britain. As before, major underlying concerns were with order, with laws of nature and society. Central to the sciences emerging in the 19th century (physiology, psychology, political economy, experimental physiology, etc.) were ideas about organization, with internal and self-referential principles structuring the dynamic and autonomous development and growth of both "life" and "markets".

The notion that there is such a thing as "life", existing in separation from inorganic and mechanical matter, did not emanate from a set of clear and distinct ideas, as was arguably the case for Newtonian physics. Rather, it was the result of gradual convergences between scientific disciplines within a specific societal and political climate. Increasingly, such developments were also guided by explicit desires to bring “life” into the domain of progressive science. Along with that, and hardly separable from it, came increasing interactions with state institutions. It would, however, last until the end of the 19th century until an explicitly experimental program could arise in the laboratories. Arguably, early developments in the life sciences did not, as had been the case for physics, come out of any decisive break with the past, but also posited decisive continuities. This was first and foremost so for the discipline of taxonomy, the systematic classification of the plant and animal kingdoms. In the 17th and 18th Centuries, taxonomists and zoologists across Europe could claim descent from the classificatory systems of Aristotle. In 1735 Carolus Linnaeus introduced a new system for naming and classifying living things according to class, order, genus, species, and variety. Well before the time of Darwin it was accepted that the different species would be somehow related through descent, and this was indeed a novel conception. It became possible to agree that descent and development followed intrinsic laws, and that these laws were set by life itself. In 1794, Charles Darwin’s grandfather Erasmus Darwin posed the following question, in his *Zoonomia*:

…would it be too bold to imagine, that all warm-blooded animals have arisen from one living filament, which the GREAT FIRST CAUSE endured with animality, with the power of acquiring new parts attended with new propensities, directed by irritations, sensations, volitions, and associations; and thus possessing the faculty of continuing to improve by its own inherent activity, and of delivering down those improvements by generation to its posterity, world without end?

As can be seen from this quote, and as noted by Huneman (2007) the human sciences emerged within a Newtonian paradigm, bringing notions of ultimate causes and universal laws into the sciences of life. Still, these had to adapt to the character of their objects of study, living organisms, and these were clearly not of the same kind as those studied by physics. Across a number of disciplines the concept of the *animal economy* emerged to capture the essential properties of life. Central to such efforts were notions of self-organization, articulating the intuition that living organisms function and develop according to their own internal norms and principles. The mechanisms by which evolution works were disputed, and have to some degree remained disputed, until the present. Significant questions pertained to the character of evolution’s “first causes”: Erasmus Darwin alluded to animality, and this theme would later turn into discussions of vitalism: if living organisms are capable of setting and defining their own goals and purposes: from where comes this “inherent activity”? Is it pure mechanism, ultimately reducible to laws of chemistry and physics, or is it perhaps due to a distinct life principle? By which mechanisms does life develop and move? Is it perhaps by a kind of irritability of the muscles, or could it be located in the nervous system as sensibility? But the most important question came to be: which are the mechanisms by which evolution works?

Responding to the works of the older Darwin, *Jean-Baptiste Lamarck* (1744-1829) proposed the idea that an organism may actually adapt to its environment, and that changed characteristics may be passed onto its offspring. Charles Darwin did not reject that idea. Still, the received view has come to be that adaptation takes place according to some inherent, i.e. genetic, trait, and not phenotypic characteristics (Gould 1980). These internal mechanisms of the organism do not, as implied by Lamarckism, respond directly and creatively to challenges in the environment; rather, they work by way of random mechanisms. These mechanisms do not “communicate” with the environment, but render some individuals stronger than others as they face some of the same challenges. Hence

Darwin's theory of natural selection as the fundamental mechanism by which organisms and life develop[2]. In Darwin's own words:

If variations useful to any organic being do occur, assuredly individuals thus characterised will have the best chance of being preserved in the struggle for life; and from the strong principle of inheritance they will tend to produce offspring similarly characterised. This principle of preservation, I have called, for the sake of brevity, Natural Selection.

The view that eventually won out regards mechanisms of inheritance as somehow intrinsic to the organization of the organism itself, and is commonly perceived to have settled around the 1930s and 40s (Mayr 2004), then also starting to incorporate the concept of *the gene* (Fox Keller 2002, Kay 2000). The perspective was strengthened through experimental and theoretical developments in biomedicine, from pathology and anatomy through to Claude Bernard's experimental physiology and the concept of the *internal milieu*. Following Bernard, the organism came to be seen as a self-regulating system tending towards homeostatis, in other words a balance identified with normal functions of the organism. Adaptation through natural selection occurs as the environment somehow interacts with such internal self-regulating mechanisms, rendering certain individuals more likely to survive than others. Although anomalies exist, notably in epigenetics but also parts of embryology (Fox Keller 2002), today such theories seem to be backed up by genetics, especially the regulatory functions performed in and by the genome. We nevertheless add that, contrary to public projections of genomics, there is still no such thing as a unitary concept of genes or genomes, and there probably never will be (and this is a result of biology being different from, and fundamentally more ambiguous, than the notions of clear and distinct ideas that derive from Newtonian physics. Although outdated, these notions keep haunting the self-understanding of some scientists and policy makers aiming for high levels of predictability and control).

Still, in proposing the theory of natural selection, Darwin himself had recourse to very different sources from present-day genetics: first, it is well known how the idea of natural selection was derived from *artificial selection* in which the (seemingly) most advantageous and useful characteristics were selected by breeders (and so also inspired by folk theories of inheritance). Therefore, the notion of "usefulness" in the above quote may have been more strongly influenced by the political and economic climate of the day than frequently recognized. Relatedly: the concept of natural selection was co-extensive with, and directly inspired by, developments in political economy, especially Thomas Malthus concept of the "struggle for existence". Following the industrial revolution England's population had soared; workers had been driven off the land and large parts of the populations were flocking to the big cities for work. Poverty and starvation were massive, inspiring in the early political economists the notion of survival as competition for scarce resources.

In similar ways to how biological life came to be seen as founded upon its own internal principles, the economy and the creation of wealth were singled out as distinct spheres of both acting and knowing. Also these appeared as internally unfolding laws, this time of the market, and also these were

[2] Although never a coherent theory, Lamarckism has continued to haunt the theory of evolutionary selection. (For instance, it was popular in France in the early days of genetics (for instance in Andrè Lwoff's works on metabolic pathways), and it has been re-claimed, possibly wrongly, through recent findings in the field of epigenetics). Still, as also noted by Gould, many cultural adaptations and changes seem to follow (broadly) the pathways described by Lamarck. A recent example of this may be the notion of *memes*, i.e. cultural concepts living and changing mainly through the Internet.

situated in history – what Foucault (1970/1989, 226) termed the "organic structure of Beings". Such internal dynamics were not immediately accessible to the naked eye but dependent upon theoretical mediation. A corner stone of such theories concerned the creation of value, first articulated by Adam Smith, and later improved by David Ricardo. The so-called value theory established the quantity of labour necessary for the manufacture of a thing as the value of that thing. Because all costs incurred in the manufacturing of some goods (i.e. capital, work, profits, etc.) could be seen as based upon previous labour, value could be ascribed to the total chain of incurred costs: all value was seen as based upon prior labour, and this could be quantified. Hence, through the concept of labour all the conditions necessary for bringing about a product could be calculated. More important, however, it could be included in a historical and linear process in which each party adds value to that added by the preceding parties. This process (of production) was seen as taking place under conditions of scarcity and competition for resources (land, labour, market shares…), constantly driving wages down (towards the subsistence level). Still, due to specialization and due to competitive advantages, creation of wealth and accumulation of surplus became a possibility. This view of the process of accumulation also opened up to the view of history as a continuous economic progress in which *growth* was situated at the centre.

The same view also issued in possible conflict between labour and owners: scarcity may drive workers out of work, or worse, cause whole populations to starve and diminish. Hence, parts of the labouring population may simply be forced to disappear, i.e. to starve and die. This was a central tenet of Malthus theory: there are too many people in the world, and all cannot be fed. But granted that labour would thus decrease, this would increase demand for labour, thus driving wages to go back up; markets thus tended towards some equilibrium or self-regulation (as did the concept of homeostasis in the life sciences). On the other side, competition brings accumulation of wealth to owners and entrepreneurs (i.e. through interest and surplus value), which may be reused for new investments, and so on. Crucially, these had to be fed back into the process of wealth accumulation. They could not be redistributed, since this would destroy competition. Theorists such as Malthus, Ricardo and Marx disagreed about the details and outcomes of these processes in history (among other things depending on the groups with which they sympathized). But they agreed on many of the fundamentals, i.e. the labour theory of value as an encompassing concept weaving factors of production, capital and labour together in one dynamic and historical process.

To return to the initial question, then: there was still a long way to go until something approaching Bacon's vision was realized, i.e. until the sciences of life and production could be united, as implied and intended by the present-day concept of the *bioeconomy*. What has only been briefly mentioned here was the possibility of experimental interventions with life. This only emerged gradually, not to fully flourish until the 20th century, in the works of experimenters such as Rudolph Virchov, Robert Koch, Louis Pasteur, Claude Bernard and Paul Ehrlich. Here, concepts of life as an internally driven and organized system played important roles, also for what would later emerge as pharmaceutical and biomedical industrialization (mainly as vaccines and therapies). The closest one would get to a science-based industry in the 19th century was found in the dye industry (Bensaud-Vincent & Stengers 1996, Pickering 2005), and here the contributions of scientists (chemists) were modest. Therefore, the main importance of the developments described in this chapter could be seen as ideological: although clearly separate spheres, there were decisive commonalities in the ways in which both life and the economy were conceived and imagined. Central to both were the development of notions of internal dynamics (Foucault's Organic Structure of Beings). These were intrinsically connected to notions of growth and progress (economic and biological), and these again could be mobilized for the purposes of both state and business. On the side of the state, most European countries saw immense increases in the uses of science as an "engine of progress" across areas ranging from engineering and construction, public health and hospitals, and through to statistics as a means for regulation across a wide span of sectors (Porter 1995). On the side of business, but also of culture more generally, the late 19th century is broadly perceived as the epitaph of bourgeoisie society and of political and economic liberalism (Hobsbawm 1975, 1987). It was an epoch of general stability, progress and prosperity for an increasingly large and powerful bourgeoisie class, as for instance manifest by the World Expo in London in 1851. In the social sciences such notions of stability and progress reflected in corresponding numbers of "certainties" expressed in the program of positive science advocated by Herbert Spencer, August Comte and others. Neither theoretically sophisticated nor politically very challenging, these authors incorporated the spirit of progress as an evolutionary and market-driven process. The notion ruled supreme that Society had been set on its due course, and religion and ideology had been dispersed with. There was little reason to doubt the fact and advent of progress.

This consensus, however, would not last: in the humanities and social sciences it was to be forcefully challenged by authors such as Friedrich Nietzsche ("the reversal of all values", the will to power, etc.), Sigmund Freud (the subconscious) and the rising popularity of Karl Marx through the socialist and labour movements (internal contradictions and class struggle as intrinsic to capitalist accumulation). Common to these authors were the critique of ideology as a programme, aiming to display the darker undercurrents of both economic progress and human psychology (later labelled the "hermeneutics of suspicion"). In physics and mathematics the certainties of the Newtonian worldview were about to be shattered by developments such as Albert Einstein's relativity theory, Kurt Gödel's theorem, and the emergence of uncertainty as intrinsic to physics and scientific observation in general (i.e. Heisenberg's uncertainty principle). But even more forcefully, the darker undercurrents pointed to by Marx, Freud and Nietzsche would soon play out on a massive scale. For one, the *belle epoch* of the 19th century was accompanied by increasing nationalisms (Anderson 1982), and frequently also transpiring into xenophobia. It was also increasingly dominated by international competition between imperialist states. If people lived in a state of innocence and general stability, this was shattered to pieces by the Great War and, following that, the Russian Revolution.

Since the beginning of the life sciences, their fundamental notions of change were deeply marked by political events. Although historical change had been an explicit topic in law, the humanities and politics since the very beginnings of Modernity, there is little doubt that the new Sciences of Man were deeply inspired with changes set in motion by the "twin revolutions" in France and England (Hobsbawm 1962). But after 1917 the notion of "Revolution" was forever changed. This was important for the ways in which biology, evolution and society came to be perceived. Although Darwin himself was from the bourgeoisie, and politically speaking moderately left-leaning, tumultuous times brought about other configurations and ideas. First, counter-revolutionary and reactionary mass-movements arose from the right, a wholly new phenomenon. Some of these (Mussolini in Italy, Salazar in Portugal and Franco in Spain; Hungary and Romania) would allude to vague notions of the "social organism", thus uniting evolutionary thought with a longing for social order through a (kind of) return to Middle Age hierarchies and authority (corporatist statism). But clearly the worst case was constructed in Hitler's Germany, in which eugenics (prevalent throughout much of the Western world at the time) and race theories were united with notions of Nordic supremacy, modern technology, nationalism and mass mobilization. There is no doubt that these were gross perversions of Darwinism, and that Nazi science was pure ideology with only scarce resemblances to the projects of most scientists. It was a worst-case scenario that became real: the barriers established through the Modern Framework, of distinct and separate spheres of mutually controlling powers, collapsed (Baumann, Agamben, Weber, Arendt). In its place Hitler mobilized and inserted collective action radically enhanced through technology, bureaucracies and mass movements, coupled with partly pre-modern, partly quasi-scientific illusions of one united People with a common destiny. Such possibilities nevertheless reside as ever-present potentialities within the dynamics of modern societies: rationality, social rationalization and progress operating in autonomous and self-organizing zones altogether liberated from fundamental values, sound judgment and reason.

9. Framework Programmes and European Integration: "Why haven't we managed to do for research what we did for agriculture?"

Hegel famously stated that "the owl of Minerva spreads its wings only with the falling of the dusk". This image has been taken as a reminder of an important piece of historians' (or philosophers') wisdom: The owl of Minerva is a symbol of understanding. Deep understanding is not to be had in the midst of a development, an era or an epoch. In that sense, we may – of course at the cost of massive simplification and a number of methodological choices that are anything but obvious and innocent – tell a relatively coherent story of previous centuries such as the one we have provided over the previous pages. In the remainder of this report we will move towards contemporary events and problems, and in the final chapter we will even indicate our own suggestions for how to deal with some of these problems. This introduces a necessary break in style and epistemic status of what we have to say: From now on our observations are necessarily more piecemeal and risky.

In the commissioning of this report, part of our mandate is to reflect on observations such as that made by the European Commissioner for Internal Market and Services Michel Barnier at the "Conference on the Common Strategic Framework for EU research and innovation funding" (10 June 2011): "Why we haven't managed to do for research what we did for agriculture?" Rather than writing Barnier's statement into a long historical storyline of the European Union, we shall try to unpack some of the implicit assumptions of such a question and their relationships to the received view. Our purpose in this as well as the next chapter is not historical diagnosis, but to clarify assumptions in order to be able to challenge them and in that way offer new perspectives and possibilities for action.

Our reflection on contemporary statements will once again begin with a return to the 17th century, to show what kind of work that certain statements do: their performative function. Robert Hooke (1635-1703), curator of The Royal Society of London for Improving Natural Knowledge, wrote in 1668 that the "business and design" of the Royal Society is

> *To improve the knowledge of naturall things, and all useful Arts, Manufactures, Mechanick practises, Engynes and Inventions by Experiments (not meddling with Divinity, Metaphysics, Moralls, Politics, Grammar, Rhetorick, or Logick).* (Lyons 1944/1968, 41)

We may be reminded of previous chapters and the French scholar Bruno Latour's (1947-) claim that in modern society, there are two types of work that crucially depend on each other: the work of "purification" and the work of "translation". The work of purification is the intellectual work of making and insisting on the difference between nature and culture, and between science and politics, as seen in the quote above. The work of translation is the practical, technological, cultural and political efforts that cross the borders between nature and culture, or between science and politics, to the extent that in 21st century even the weather and the climate is a hybrid: nature but also the result of technological and political decisions. For Latour, translation depends upon purification: In particular, the massive technological interventions on our planet and therefore into the human condition would never have been let to happen if our societies had not made the intellectual effort to think of them as non-political: as the mere consequence of describing the truth about nature.

The simpler and more general lesson to be learnt from the quote about the Royal Society is the following: One does not necessarily learn the real purpose or function of an institution or a practice from its purported purpose. Whether Robert Hooke really had a general idea about the need to distinguish scientific research from religion or politics, or if his reflections were equally motivated by mundane worries and rivalries, is beside the point. From our position of distant hindsight, we can observe how the simultaneous developments of science, politics and law in the 17th century were entangled into each other in how that society changed in its passage through time. We can see how Hooke's statement performed work of purification while his actions contributed to translations between science and politics.

Analysis of developments in our own lifetime is in this sense more difficult, because we cannot support the analysis with knowledge of the *Wirkungsgeschichte*. As researchers, policy-makers or citizens we must be prepared that we fail to understand the functions and purposes of the institutions and practices in which we take part. On one hand this is a source of frustration. On the other it can be a source of emancipation and relief. A system may appear less dysfunctional and more competent after one has understood that its function is different from the purported purpose. For instance, certain contemporary financial institutions and policies may appear quite functional from the perspective that their main function is to enrich a certain set of privileged actors rather than increase wealth and distribute it fairly. This insight may call for a different strategy for change than if the problem simply were incoherence or incompetence.

We shall now take these methodological reflections, informed by the elements of European history that we have described in this report, as a point of departure for an analytical look at contemporary events and problems. Our example is Michel Barnier's question "Why we haven't managed to do for research what we did for agriculture?" By that he referred not to the quality of European research and agriculture, but the fact that EU has developed a Common Agricultural Policy that entails a common EU budget for agricultural subsidies rather than independent national budgets. In contrast, EU R&D funding is only a tenth of the total government expenditure in the EU member states.

In what remains of this chapter, we shall use Barnier's statement as a point of departure to ask: Why is it seen as dysfunctional that there is no common and comprehensive European research policy? Which functions and purposes might be served by the present European research policy, including the ERA? And how will this way of diagnosing the system open up for new ideas of change?

Why did Barnier see it as dysfunctional that there is no common and comprehensive European research policy analogous to the CAP? This particular Commissioner aside, we may turn to the body of (1) policy documents and (2) scholarly and scientific (in particular economic) analyses giving advice for an answer. The answer is that there is a purported purpose of more and faster scientific and technological development and innovation at a global level of analysis[3] in order to improve European

[3] By «global level of analysis» we here mean that the analysis and the purpose is directed towards the level of the EU, the highest level of unit from the point of view of the object of the policy. This does not preclude that European policies also attend «global» concerns in the sense of international/planetary concerns, nor that European policies do not target the regional or national level.

competitiveness and economic growth globally and regionally (with cohesion more or less in mind as a second purpose in tension with or concerted with overall competitiveness). Next, there are the assumptions (1) that governmental policy-making and policy implementation are in principle good tools to achieve the objectives in question and (2) that policy-making and policy implementation at the European level is more efficient or effective than the national level of the member states.

The first assumption is an instance of what Latour called *work of purification*. In practice it opens up for academic research and policy action that models complex societal realities as a research and innovation system described by a set of causal beliefs and aggregate variables (e.g. number of patents, national R&D expenditure, etc.). Academic research then tries to arrive at empirical support for specified (but general and therefore predictive/prescriptive) causal models, for example on "smart specialization". They may then feel to be in a position to give advice on what the policy-maker ought to do. This follows the logic first described by Francis Bacon: "Where the cause is not known, the effect cannot be produced". By implication, the government can only produce the effect if it knows the cause, and by *invalid syllogism,* the government *can (or could, or might)* produce the effect if it knows the cause.

There is of course no guarantee for success, and it is useful to reflect upon why. First of all, everybody agrees that the knowledge that is produced to prescribe policy action is a massive simplification of the reality. The regularity of phenomena such as economic or scientific development is much more doubtful than that of falling physical objects. Hence, all such studies have deep methodological problems, including that of distinguishing causality from correlation and of determining directions of the causality, say, in models that link R&D expenditures with economic growth. Worse, it is assumed that the system is not truly a complex adaptive system in the sense that the "operator" (the researcher and the policy-maker) has a privileged position outside, or on its margin. In the words of Arie Rip, it is assumed that the government can perform "governance *of* complexity" rather than being condemned to performing "governance *in* complexity". As a consequence, governmental policies risk becoming counter-productive by trying to enforce desired system states and thereby inadvertently harming desirable dynamics (Chorofakis & Pontikakis 2011). One example discussed in the literature is that governmental research and innovation policies can harm processes of "smart specialization" by trying to pick winners by non-neutral support instruments. We recognise the assumption as that of being the *rational calculator* envisaged by Leibniz. However, the originally conceived purpose of rational calculation was to resolve conflict, not to optimize action. Indeed, although it rests firmly outside the scope of this report to assess the success of the European Research Area, we observe how Chessa et al. (2013) find no evidence of increased integration of Europe as a research area since 1993. On the contrary, their econometric study concludes with evidence of the opposite trend taking place.

The belief that it is better to act at the global (European) level follows more or less logically from the assumptions described above: A comprehensive European research policy, not of 10% of government-funded research, but of 90 or 100%, would then be more effective because there would be no problem of national compliance with the strategy, and more efficient because it could have a global approach to knowledge of regional and national heterogeneities on a system level. It is from this perspective that Michel Barnier could announce the scandal: «Why haven't we managed to do for research what we did for agriculture?»

We may try to answer his question, again turning to historically based speculation. First, a half-hearted policy (as witnessed by the mere 10%) may reflect a half-hearted belief in the rationale of the policy. Even if one believes that science is a suitable object of rational planning on a par with agriculture (which has itself been contentious), we have already noted above how the work of translation involved is not one of truth but one of massive simplification and postulation. Accordingly – as always – its justification lies in the eventual empirical success, in the work of implementation and hybridization (with new mixings of science, industry and consumer society). To ask for an ERA that consumes 100% of government R&D expenditures is to ask for a huge and uncertain experiment.

In that case – that policy-makers at the national level do not really believe in the official policy discourse at the European level, or the academic advice that supports it – what requires explanation, is not the absence of a comprehensive European research policy, but the fact that there is something there at all: 10% and not 0%. There is, however, no scarcity of observations that can explain. First, cohesion has been an explicit objective of some European framework programmes. Secondly, as advocated by Alfred Nordmann (2009), in particular after the backlashes to political processes of European integration, research and education have emerged as two important domains for integration and the construction of a European identity. One could reasonably argue that exchange programmes but also joint European research consortia and research agendas promote European identity and conviviality. Accordingly, one could see the 10% as an expression of political ambitions about cohesion and conviviality and little more.

Thirdly, and perhaps deserving more attention in the literature, it appears unlikely that any European policy, including that of research and innovation, cannot in part be explained as the outcome of rent-seeking behaviour by actors in science, technology and industry. In the case of science, such a claim typically comes into conflict with the self-image of spokesmen of science, who may hold a received view of science and accordingly are unwilling or unable to see themselves as stakeholders. It would be quite easy, however, to tell the story of the 1990s and 2000s as of how universities and academic scientists have become increasingly worried and dissatisfied with the increasing focus on innovation objectives in the framework programmes (and, by inspiration and imitation, on national research council policies). One could imagine that historical distance will come to see the establishment of the European Research Council as a response to such worries and dissatisfactions. If so, ERC could become seen as the result in part of half-hearted policy convictions and in part of (financial, cultural and symbolical) rent-seeking by an elite lobby with immense cultural capital in their respective countries. Barnier's scandal would disappear; indeed, it would be an open question if there is any.

Our report is written for the EC-Joint Research Centre and more generally in part the community of analysts and advisors for research policy. As explained in the introductory chapter, our task has been to challenge the received view and show its implications in practice. Probably nowhere is this challenge more acute than in the subject matter of the present chapter. From the perspective we have outlined – that it is rather the achievement of a 10% governmental R&D expenditure that calls for explanation than the lack of a comprehensive European research policy – the work of the analysts and advisors also lends itself for reinterpretation. Exactly for those who are most involved in work of purification, one would expect the largest potential discrepancy between self-description of the work and the type of interpretation that we suggest. The self-description might be one of producing knowledge and evidence with the purpose of strengthening evidence-based policies for economic growth, and not "meddling with politics" in the words of Robert Hooke. What we have tried to outline, is the perspective where the policies are not to be explained by this purported purpose (even though they to some degree might support growth), but rather take shape through other mechanisms. From this perspective the work of translation might better be described as the production of *policy-based evidence*.

New ideas for change can follow from this perspective. From the position of Barnier's question itself there follows only a search for causes of dysfunctionality and for ways to eliminate them. Once we acknowledge as a normal state of affairs the discrepancy between official policy discourse and *de facto* governance – or more precisely, policy discourse as blueprint for governance or as speech acts in governance *in* complexity – more options emerge. In particular, one may ask political questions about which purposes to serve as well as questions about the different roles government at national and European level may assume in the governance of research and innovation. Some questions of this kind, on the relationship between public and private/corporate interest, and on the choice of virtuous grand challenges for European research, will be pursued in the final parts of this report.

10. From carbon, steel and nuclear to the knowledge economy and the Innovation Union

Can we tell a plausible story linking the process of European integration, the new and emerging technologies and the current economic, financial and institutional crisis?

What would be the use of such an exercise? Clearly the purpose would not be to show, demonstrate or prove a certain perspective or a casual link but to create a heuristic tool in order to reflect and deliberate about co-evolution, path-dependency and “what-if?”

The European Coal and Steel Community (ECSC), a six-nation supra-national organisation, was formally established by the Treaty of Paris in 1951. Its goal was to foster economic wealth and, most important, as Robert Schuman declared, a way to “make war not only unthinkable but materially impossible”.

It is a quite traditional Modern affair, coal and steel, extraction and manufacturing industry, coming together in an incipient free trade zone. The ECSC could well be embedded in what we can describe as the Cartesian Dream and the Westphalian System: prediction and control over Nature, and rational management and governance. The European-based system, resulting from the Peace of Westphalia (1648), which, on one hand, created the Modern State, and the other, originated diverse multi-state arrangements.

Vannevar Bush was not far in the horizon; and in 1957, the European Atomic Energy Community (EURATOM) was added to the previous treaty. Nuclear power was the paradigmatic new and emergent technology of the post-WWII era, promising new sources of progress. It is the beginning of the trajectory to an emerging type of Modernity, in which science and science-based technology become the main engines of economic growth and prosperity. The expectations are grand.

The New York Times (September 17, 1954) reports of a speech given the day before by the Chairman of the US Atomic Energy Commission, Lewis Strauss to the National Association of Science Writers. Strauss’s message resonates with Bacon’s New Atlantis:

> “Our children will enjoy in their homes electrical energy too cheap to meter...will travel effortlessly over the seas and under them and through the air with a minimum of danger and at great speeds, and will experience a lifespan far longer than ours, as disease yields and man comes to understand what causes him to age.”

But Hiroshima is not far back and the Cold War is in full swing. The promises of nuclear power are nevertheless ambiguous because its intimate relation with the Bomb. And the Bomb was a fundamental watershed; the time when Science, from being essentially Good became potentially (and practically) Evil. Successive generations of new and emergent technologies had to struggle with the ambiguity. The promises of everything for nothing balanced with the terror of the original sin.

There is no going back and we can trace the growing importance of science and science-based technology in the restructuring of the economy and the extension of free trade. In the European integration process, modernity gives way, slowly first but securely, to the embryonic Knowledge Economy with its own sets of grand promises: human liberation from physical work, natural resource scarcity conquered by technology and cultural substitution and no more “limits of growth”. The European coal miners and steelworkers, fundamental actors of the original Treaty, can now be affluently obsolesced, as Modern industries relocate and new jobs require new skills: handling data, developing algorithms and computer models, and continuous innovation of processes and systems.

Witnessing the current, ongoing, economic, financial and political crisis, we might well ask if we missed something in our narrative. Perhaps the new, late Modern, phase of co-evolution of knowledge and power has its own pathologies which could have been anticipated. And it was, in unexpected places.

In 1961, Dwight Eisenhower, President of the US, delivered his Farewell Address. The speech is well-known and widely discussed for his reference to the military-industrial complex (“we must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex. The potential for the disastrous rise of misplaced power exists and will persist. We must never let the weight of this combination endanger our liberties or democratic processes. We should take nothing for granted.”).

However, another part of the speech is what we are looking for:

> “Akin, and largely responsible for the sweeping changes in our industrial-military posture, has been the technological revolution during recent decades. In this revolution, research has become central; it also becomes more formalized, complex, and costly. A steadily increasing share is conducted for, by, or at the direction of, the Federal government. Today, the solitary inventor, tinkering in his shop, has been overshadowed by task forces of scientists in laboratories and testing fields. In the same fashion, the free university, historically the fountainhead of new ideas and scientific discovery has experienced a revolution in the conduct of research. Partly because of the great costs involved, a government contract becomes, virtually, a substitute for intellectual curiosity. For every old blackboard there are now hundreds of new electronic computers. The prospect of domination of the nation's scholars by Federal employment, project allocations, and the power of money is ever present – and is gravely to be regarded. Yet, in holding scientific research and discovery in respect, as we should, we must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite.”

Eisenhower describes in simple terms the transformations in the organization, political economy and methodology of science, which have been the subject of increasing academic research during the last decades, and with the traditional disciplines of history and philosophy of science now becoming hybridized with the growing interest in the social studies of science.

Industrialized science (Ravetz 1971) and fungible Mode 2 science (Gibbons et al 1994) are two among many ways to describe and prescribe new forms of science. The tension between research (more prestigious) and teaching universities reflects the growing pressure to produce economic value through patents and other intellectual property instruments. The result is the privatization of knowledge and relegating the production of public knowledge to the category of endangered species.

The process of change also has important conceptual and institutional consequences. What is the status of computer simulation models, for example, are they similar epistemologically and methodologically to more traditional laboratory or field experiments? Or, how they modify the nature of publications and peer-review, what about undisclosed proprietary data?

Eisenhower's warning about "public policy" becoming the captive of a scientific-technological elite" illustrates the ironic nature of the process; when the entanglement of techno-science with power enters a collision course with the humanistic character of the scientific project.

We believe that the changes in our understanding of science and the scientific enterprise are important in order to assess the European policies on research and the institutional arrangements put into place to promote research. However, this endogenous view is not enough.

We have also to see the effects on humankind and society, and in particular, the consequences on the process of European institutional self-understanding, aspirations and goals. In this context, there is no doubt that Modern science and even industrialized science have now become techno-scientific research and innovation, fully at the service of making Europe the most competitive economic block in the world.

Techno-scientific research and innovation is funded and promoted with the explicit aim to create jobs, to build a sustainable growth society and to improve the quality of life of the European consumer-citizen in the global market.

The operational mechanisms are the removal of obstacles to innovation, to blur the boundaries of the public and private, of business and Academia, to adapt education and training in order to fulfil the goal of making Europe a world-class science performer.

In the fifty years that followed Eisenhower's speech, the process of transformation of science has accelerated, together with the process of economic restructuring, to the point where innovation in the knowledge economy seems to be only hope of unfettered growth.

What if the reliance on techno-science, co-evolving with emerging structures of power, has put us in a path-dependent *cul-de-sac*, where to do more of the same, but faster and more efficiently, becomes the only problem-strategy possible, increasing the democratic deficit and neo-authoritarian temptations? Eisenhower has a recommendation that we might well consider: "We must never let the weight of this combination endanger our liberties or democratic processes. We should take nothing for granted. Only an alert and knowledgeable citizenry can compel the proper meshing of the huge industrial and military machinery of defence with our peaceful methods and goals, so that security and liberty may prosper together."

The elements of the combination and the actors of the meshing might be different (are they?) but the advice is still valid, only an alert, knowledgeable and committed European citizenry can govern transcendental processes of innovation to make them consistent with the Humanistic values of tolerance, humbleness, and universality in specificity.

11. Bios and Geos

Summing up so far: The received view and co-productions of science and society

We started out this report by a description of “the received view”. It represents a well-known narrative about the role of science and technology in society, one in which scientific knowledge acts as a prime mover in the production of wealth, order and prosperity. It is closely connected to a vision of progress that came along with the different stages of modernization of Western societies. We did not dispute that science and technology do play fundamental roles in modernised societies, or that they have in periods performed the role ascribed to them by the received view. However, we also argued that the received view is inadequate for understanding the complex interrelations between science, technology, economy, politics and cultures at large. The received view has its prime justification, and seems to thrive especially well, inside relatively well-defined and closed-off disciplinary domains. Scientific fields of inquiry typically work by isolating and purifying certain properties of the world: those that can be quantified and measured, those that deal with motion or with evolution through selective mechanisms. The received view also thrives well in political speeches, grand narratives and, as of relatively recently, in grand visions for future development and growth.

At the same time, and especially as science and technology fused with industries and economies on global scales, it is becoming increasingly clear how the received view is inadequate for capturing, articulating and dealing with the consequences of science, technology and industry. The sociologist Ulrich Beck made famous the notion of the Global Risk Society as one that increasingly becomes preoccupied with fending off and dealing with the unintended consequences of modernity’s progression: from pollution of the environment and changes to the climate system, over individualisation and loneliness in society, to threats towards privacy and massive surveillance through new digital technologies.

This realisation makes more relevant the other perspective of science, technology and society used in this report, namely that of co-production. Co-production is not a simple and unambiguous term (Jasanoff 2004), but opens up perspectives on the many ways in which science, technology, economy and politics mutually constitute each other. This was introduced through the concept of the Modern Framework. The Modern Framework as analysed here did indeed ascribe central roles to the ideas of Descartes, Galileo and Newton. At the same time the concept also opened up for a number of other perspectives, which were not secondary or unrelated, but intrinsic to the very structure and meaning that the Modern Framework came to occupy. We especially emphasised the following:

First, the Modern Framework was a response to an urgent problem, that of establishing order in the face of unrest and war. The fact that it did actually manage to contribute to the establishment of order and stability did not once and for all remove the underlying problem but rather displaced it. The economy became “war with other means”; nature became a machine from which value could be extracted. In both ideas and institutions, society became detached from nature. On societal levels one’s fellow beings were imagined as contractual partners and, to a large extent, economic agents. In this sense, violence was not done away with once and for all, but rather contained within a set of new ideas and institutions. These were, to some extent, capable of transforming aggressive tendencies, but not to eradicate them.

Second, the Modern Framework was in fact not one but many: although there were structural parallels, the economy was not the same as law or science. Neither were the new natural sciences identical with culture or with the nation. The nation and national culture were seen to subsist in language, tradition and history, and not in nature. Seen like this, the decisive accomplishment of the modern framework was that of establishing an ecology of ideas and practices that were mutually balanced against each other. This balance of forces must be seen as highly delicate and in need of constant renewal and care; the most clear-cut articulation of balancing separate spheres was upheld through new political institutions that gradually became based upon a balance of powers. The main function of this balance was not to achieve efficiency and progress (for this, authoritarianism may have more on offer); it came out of the realisation that power may also corrupt, and must be kept in check: by Parliament, by the constitution and the courts, by civil society and the public sphere.

Third, we indicated some “modern virtues” that came along with modern institutions and the kinds of visions entailed by them. Political and scientific institutions were sharply separated within the Modern Framework; still, they nurtured some of the same ideals: impartiality, justice, dialogue, rationality, etc. Through such ideals and their institutions Europeans established independent or “neutral” zones where ideas could be freely exchanged (ideally speaking). Both the experimental practices instigated by Boyle and the virtues of republicanism institutionalised self-criticism and the potential for mutual learning through civilised discussion. Still, as we saw, in the early days of modernity it was Hobbes’ version of nature and politics that won out. Even as impartiality and equality became central to the ways in which people imagined themselves and society, the problem of power was not solved. The French Revolution was an outcome of this.

Fourth, the modern framework provided stability and order but was not itself completely stable; rather, it is dynamic and subject to historical change. This realisation was always intrinsic to the self-understanding of the humanities (law, history and philology), but not those that went into the Newtonian worldview (natural philosophy, mathematics and physics). Later on ideas of change, development and growth became intrinsic to the human sciences, i.e. biology and biomedicine, political economy and the social sciences. We also indicated how this more dynamic view of nature and society was strongly influenced by political events, i.e. the two political and industrial revolutions. The 20th century has seen a steadfast tendency towards integrating science and technology into the very heart of other activities and spheres, centrally those of industry and the economy. This collapse of spheres should be regarded with some scepticism and even alarm, especially under the contemporary imperative to innovate, since it upsets balances of power across a number of scales (for instance, by mobilizing law for its own purposes, thus not respecting the autonomy and independence of law). The social contract between science and society was originally based on a separation; it is not clear what can replace it today (Gibbons 1999). We also saw that, whereas the imperative of innovation is frequently hailed as a vade mecum for many of our times’ ills, this has not paid off so far. Science, technology and innovation do not necessarily work according to prescription, and especially not those of the linear model of innovation, which still today persists as the most powerful expression of what we called the received view (this in spite of the fact that many, or most, scholars of innovation do not believe in it). Even if one could effectively criticize and correct the prevailing political speculations and promises that innovation will lead to more jobs and accordingly a way out of economic recession, it is not evident what other belief politicians and citizens could invest belief and hope in.

In fact, as we shall now argue, the received view does not merely cover up the more complex relations between the sciences, technology and society. The problem is not merely one of neglecting the humanities and the social sciences as providers of important parts of the puzzle. Indeed, we may today observe a number of conflicting tendencies on the intersections of science, technology, society and politics.

In the next section we shall argue that the present state of argument (i.e. the received view) about science, and its role for dealing with political, social and ecological systems, is indeed confused. This, however, should be understood on the following basis: whereas previous periods of stability and continuity within Western societies have tended to rely upon frameworks in which science has provided relatively stable sources or worldviews, today no such unity or wholeness singles itself out. The received view, in a rather Hobbesian manner, does not recognise this state of affairs, but covers it up. It is indeed difficult today to single out a stable bedrock of scientific findings upon which politicians, communities, individuals or industrialists may construct common projects. To some extent, it even makes sense to state that the sciences are internally incoherent, sometimes even contradicting each other, and that no straight and simple message can be singled out for that very reason. The received view, however, does not help us in this situation, since it prescribes certainty and unity of purpose (through science) where, in reality, this may be lacking. Neither, would we add, are we greatly helped by thinking of ourselves as living in some “post-modern condition”, according to which science and rationality are so diverse that little overarching sense can be made. This image of the sciences, and of the world in general, as fleeting and indeterminate, with no clear limits or boundaries, may also be about to change, and may indeed come to be seen as just as much part of the old order as the received view itself. In the next section we argue the view that, whereas the sciences are indeed diverse, we are today hostages to at least two partially conflicting grand narratives of the present. Both claim their basis in science, and both carry implicit or explicit political messages.

Two tales of the present

As remarked in Chapter 9, it is a risky business to write contemporary history: To ask the owl of Minerva to fly while still blinded by the bright daylight. This is even more the case if the task that is set out, is to tell an overarching story – a grand narrative – of the present. We insist that this is not our task. We do not “know the general Truth” about contemporary states of affairs. Instead we would like to re-tell, zoom into and analyse grand narratives that *are already there* in contemporary society, and that directly and indirectly give impulse and orientation to political thought and policy action; narratives to which present societies are “hostages” as referred to in the previous paragraph.

There are many such narratives. The two that we find particularly important we have called “Bios” and “Geos”. The first, “Bios”, is the one of the necessary and sufficient role of innovation, growth, adaptation, evolution, and the centrality of new and emerging sciences and technologies such as life science and biotechnology. The second, "Geos", is the one of the limits to growth, the limited supply of natural resources and the change in human behaviour and civilisation that is called for when global human impact has become of a significant force onto ecosystems, material cycles and climate systems of the Earth.

Many, but not necessarily all contemporary challenges can be discussed in light of these two narratives, and they certainly do not pre-empt the range of interesting and important perspectives. Before entering into discussion of Bios and Geos, let us therefore indicate one type of narrative that could be the legitimate focus of another report: The one of the corruption of morality within our economic and political elites and the resulting collapse of public trust in these elites. An example of this kind of narrative is provided by ordained priest and former bank director Stephen Green (2009):

> *There has been a massive breakdown of trust: trust in the financial system, trust in bankers, trust in business and business leaders, trust in politicians, trust in the media, trust in the whole process of globalisation — all have been severely damaged, in rich countries and poor countries alike (Green 2009, p. xi).*

The possibility of collapse of public trust was noted already in 2001 by the European Commission in its White Paper on Governance, although diagnosed as a problem of institutional design rather than one of morality; and certainly not one that considered European politicians and policy-makers on a par with greedy and reckless actors in the financial markets. By 2013, however, news of politicians across Europe resigning due to allegations of fraud and corruption have become a commonplace occurance, together with equally disturbing news of increased social inequalities also within the so-called developed nations. One may draw a storyline from Adam Smith's remarks that the existence of a market depends on a certain basis of common morality (e.g. that persons intend to fulfil contracts) and Marquis de Condorcet's optimistic prediction that scientific and economic progress by necessity would lead to moral progress. From such a perspective one may state a number of important challenges in terms of secular or religious restoration of morality or political struggles for equality and justice.

Still, in this report we wish to go elsewhere, also because it is not clear to us that morality was less threatened before, neither in science nor in society. Indeed, one could portray the modern framework and its social contract also as a (desperate) attempt to invent civilisatory solutions to problems of violence and evil. Specifically what is left out from discourses of morality is the understanding of the relationship between human societies and their material basis in nature. While we endorse the humanist values of the modern framework, we doubt that the contemporary challenges can be resolved by merely invoking humanist values or attempting to restore them by force. We believe the problems run deeper. We shall now try to show why.

Bios: Evolution 2.0

Innovation provides real benefits for us as citizens, consumers, and workers. It speeds up and improves the way we conceive, develop, produce and access new products, industrial processes and *services. It is the key not only to creating more jobs, building a greener society and improving our quality of life, but also to maintaining our competitiveness on the global market.*

This quote is taken from the web pages of the Innovation Union[4], central to the European Union's Horizon 2020 strategy for jobs and growth. Let us take a brief look at the prehistory and wider context of this program. Although it seems to be pushing society towards renewal and modernisation, it is not all that new any more: it started out in the early 1970s with the downturn of traditional industries, such as the manufacturing, textile and automobile industries. Western economies were suffering from stagflation, and the US economy underwent a basic change: from a net producer to net importer, from a surplus economy to a debt driven economy (Cooper 2007, Varoufakis 2011). Within that context a new "programme" emerged to replace the traditional industrial base with more knowledge-intensive industries and services. These developments were mainly initiated in the US but rapidly spread to Europe. Information technologies and biotechnologies were at the heart of this enterprise; later other fields such as nanotechnology, cognitive science and the renewables industries have joined them. This shift in emphasis, which marked the transition to the so-called knowledge-based economy, did not occur autonomously through scientific and technological progress; it was a steered development in the face of challenges to the traditional economic base of advanced Western economies.

Central to such steering was increasing injections of private and venture capital into certain types of research; increasing numbers of public-private partnerships, most visibly manifest through the occurrence of start-up companies and technology transfer offices on campus; radical expansions of intellectual property rights into research, opening up for "patents on life", and merging intellectual property regimes with trade and foreign policies. Significant was also the increase of "big science" projects organized around the use of heavy technological equipment, especially computers. An exemplary case was the Human Genome Project, conditioned by technologies such as DNA sequencers and large repositories of digital information. Finally, and seemingly at the heart of it all, there emerged a new character, the researcher-maverick, the scientific entrepreneur.

These developments, although pioneered in the US, did occur in Europe as well. However, they could not be given a coherent shape in EU policies until the creation of the Single Market through the 1992 Maastricht Treaty. At that time, although the framework programmes had already been initiated, no such thing as a European Research Area existed. Innovation in science and technology as coordinated projects first appeared, therefore, in areas related to industry and employment. In 1993 the European Commission issued a White Paper entitled *Growth, competitiveness, employment: The challenges and ways forward into the 21st century.* It laid out significant threats to European societies and ways of life: ageing populations, environmental degradation and economic stagnation, i.e. lagging behind the US and emerging Asian economies (at that time mainly Japan). The overall concern, however, was clearly stated at the beginning of the report: *The one and only reason is unemployment*. The report outlined three different sources of unemployment: cyclical, structural and technological. Here we shall confine ourselves to quoting, in some length, the section on technological unemployment:

[4] http://ec.europa.eu/research/innovation-union/index_en.cfm, Last accessed 1 December 2012.

This problem is as old as industrial society itself, which has continually changed - albeit not always smoothly - by incorporating technical progress. Nevertheless, the phenomenon now seems to be undergoing a change of scale. This is not to say that technological progress in enterprises is doing away with more jobs than it is creating: for example, the employment situation is on average more favourable in those firms that have introduced microelectronics than in those that have not done so. It is nevertheless the case that we are once again passing through a period in which a gap is opening up between the speed of technical progress, which is concerned primarily with how to produce...and which therefore often destroys jobs, and our capacity to think up new individual or collective needs which would provide new job opportunities.

As can be seen, the diagnosis was not without ambiguities: on the one hand citing technological revolutions as a main source of unemployment, on the other hand promoting such revolutions to create new growth and presumably also jobs. This was not the only ambiguity of the report: it called for *a more competitive economy*, while at the same time also encouraging an economy *characterised by Solidarity*. It described how Europe and the world was entering a phase of an open economy with Developing countries and former communist countries taking up increasing market shares. This economy, furthermore, was seen as open and de-centralized, the latter being seen as a major effect of the (Single) market(s), and clearly poised against the recent collapse of the Communist block. The White Paper identified a number of sources for the creation of jobs. In addition to macro-economic policy measures it envisioned how jobs could be created in areas relating to main societal challenges. These included local services, such as care for the elderly and children, maintenance of community spaces, buildings and infrastructures, cultural activities, small-scale shops and businesses, etc. Also included were initiatives to improve the quality of life across a number of areas, and environmental protection.

The White Paper thus outlined a complex situation and proposed a number of measures across sectors of European societies. Still, most of these measures were situated and comprehended through macro-economic lenses, and within the diagnosis of an overall industrial and economic shift. From this came the notion that *the phenomenon now seems to be undergoing a change of scale*. This change of scale, furthermore, had a name: *Information Society*. The proportions and ramifications of this shift were seen as highly significant, and as posing a set of new challenges:

The information society

- The dawning of a multi-media world (sound – text - image) represents a radical change comparable with the first industrial revolution;
- Tomorrow's world is already with us: by the end of the century there will be 10 times as many TV channels and three times the number of subscribers to cable networks. In the USA it is estimated that six million people are already involved in teleworking;
- The USA has already taken the lead: 200 of its biggest companies already use information highways;
- At the heart of the development model for the 21st century, this issue is a crucial aspect in the survival or decline of Europe;
- It can provide an answer to the new needs of European societies: communication networks within companies; widespread teleworking; widespread access to scientific and leisure databases; development of preventive health care and home medicine for the elderly.

Within this overall framework, the White Paper outlined three major technological fields for the renewal of society and the economy. These were new information technologies (as just described), biotechnology, outlining how research would create greater synergies between chemical companies and big potential users in the health and agri-foodstuffs sector, and, finally, ecotechnologies, meaning “radical innovations targeting the causes of pollution and aiming at environmental efficiency throughout the production cycle”, and expected to provide a “major competitive advantage”. From that time on, these broad areas of research and innovation have resided at the heart of programs for societal and economic renewal, and enhanced integration within the single market. After the 2000s, biotechnologies and ecotechnologies are increasingly projected to come together in the constitution of the *bioeconomy*, an economy in which biological products and processes are increasingly used for a number of purposes and for the sake of greening European societies:

Establishing a bioeconomy in Europe holds a great potential: it can maintain and create economic growth and jobs in rural, coastal and industrial areas, reduce fossil fuel dependence and improve the economic and environmental sustainability of primary production and processing industries. The bioeconomy thus contributes significantly to the objectives of the Europe 2020 flagship initiatives "Innovation Union" and "A Resource Efficient Europe". (European Commission 2012a)

The *Information Society* and, as of late, the *Bioeconomy*, are main concepts in the constitution of the European Research Area. These policies stretch from early efforts to promote growth and competitiveness, and they received a major boost with the Lisbon Agenda and the creation of the European Research Area in 2000. The Lisbon Agenda set the goal to turn Europe into the world's leading and most competitive knowledge economy by 2010. That program has fallen radically short of its own goals, and been ridiculed and criticised by a number of commentators (see for instance Wyplosz 2010). This state of affairs was not taken as an occasion for a change of course, but rather stimulated the intensification of efforts through the follow-up strategies of the *Innovation Union* and *Horizon 2020*.

From the 1993 White Paper and through to Horizon 2020, solutions to growth and competitiveness, unemployment and ecological problems were increasingly seen to come from new and emerging technologies. But whereas the 1993 White Paper noted the ambiguity of this approach by recognising technological unemployment as a potential side effect of technological innovation, such hesitations have been gradually left behind. The theme of *speed* has been repeated with ever-increasing urgency. The 1993 White Paper noted a number of achievements of the internal market. These were nevertheless not sufficient to keep up with the pace of change induced by the Information Society. It posed the rhetorical question:

How, then, can we explain the fact that all these achievements have not made it possible at least to cushion the effects of the world recession? Was the single market process merely a flash in the pan? The truth is that although we have changed, the rest of the world has changed even faster

In 1998 the European Round Table of Industrialists (ERT), issued a report called *Job Creation through Innovation and Competitiveness*. The authors of this report did not have the same hesitations about technological unemployment or other possible side effects for that matter. Instead, prospects for employment were tagged directly onto competitiveness and innovation in key technological sectors:

Employment levels are directly linked to competitiveness, which creates the wealth necessary to fund jobs. Competitiveness is in turn linked to innovation, which allows us to keep pace with, or even take the lead in, advances in world markets. The key to unlocking the potential of Europe is Innovation. Tomorrow's jobs rely on our ability to build the right conditions for innovation today, whatever the strength or weakness of the current economic cycle.

The perception of accelerating developments outpacing policy implementation, and a correspondingly shrinking time-span for decisive action, has only increased. The 2006 Aho Expert Report on R&D and Innovation, *Creating an Innovative Europe*, was highly explicit in its recommendations. The following warning was repeated twice – once at the beginning and another time at the end of the report: *Europe and its citizens should realise that their way of life is under threat but also that the path to prosperity through research and innovation is open if large scale action is taken now by their leaders before it is too late.*

Common to these visions is the perception that technological innovation is proceeding on an ever-fastening speed, and that Europeans better get on board the bandwagon of innovation and competition before it is too late. Common is also how they aim to connect a number of sectors of society, such as the economy, greening of society and job creation within the common agenda of innovation. This connecting activity can be seen as enhancing evolution itself: the main mechanisms of growth and competitiveness as manifest in the global economy is the most powerful expression of the creation of living systems and of work, that is, of value creation. Technology is imagined as the main factor that can increase productivity and competitiveness. In the Information Society this process can be engaged with and captured within powerful technoscientific constellations. The value chain, then, is seen as potentially stretching all the way from nature's own creation, now captured by powerful technologies on the molecular and nano-scale levels, through innovation to manufacturing and finally entering the markets. Through this connection the pace of evolution can be conflated with the pace of innovations in crucial sectors of the knowledge economy. The fear of falling behind is the fear of loosing out on the most significant changes to technological, industrial and economic evolution. The best means for staying in the race, then, becomes that of capturing the utmost potential of what technology has to offer. In a US report on converging technologies this program was expressed in the following poetic terms:

> *If the Cognitive Scientists can think it*
> *the Nano people can build it*
> *the Bio people can implement it, and*
> *the IT people can control it*
> (Roco and Bainbridge 2003)

This quote is from an initiative to promote "converging technologies" which was later on taken up and adapted to the European Knowledge society (Nordmann et al. 2004). Notably, the European report was more cautious on behalf of what the convergence of powerful new and emerging technologies such as the above can do[5]. Still, imaginations of convergence make up central aspects of a number of major technology platforms, such as those intended to promote the bioeconomy, and are central to all candidates for European Flagship proposals in the area of future and emerging technologies (FET). They make up central aspects of what "innovation", the art and craft of making useful combinations, is supposed to mean. In the area of ICTs, innovation takes the shape of connecting actors across a number of areas, from scientists and entrepreneurs, to large and small business enterprises and consumers. The following is a succinct expression of main steering imaginations residing at the heart of the Digital Agenda:

Everybody and everything will be permanently connected to a Network. Network bandwidth and quality will increase significantly. We can summarise this future network paradigm as: Anything, anybody, anytime, anywhere on any device. (European Commission 2012b).

Thus, there are clear and distinct ways in which imaginations of scientific and technological entrepreneurs are made to converge with those of innovation and growth policies. They take the shape of an accelerating process in which increasing numbers of actors, from different segments of societies, business and scientific disciplines are brought into the value chain (within a single market, as it were). The central message is:

Innovation boosts competitiveness and creates jobs. It is the origin of new products and services in markets which better meet existing needs and better satisfy new customer demands. A competitive

[5] For instance, it explicitly rejected the notion that converging technologies be applied to the human body and mind in order to enhance their performance.

Europe can create more jobs if it welcomes the value of new technologies and the creation of new businesses and new business sectors (ERT 1998).

No matter what one makes of this dogma, the description given throughout the last pages describes an accelerating process, ongoing since the early 1970s, in which scientific research and discovery have increasingly been enrolled into the program of innovation. This program has grown to incorporate most other pressing problems facing European and global societies in the 21st century: From ageing populations, to climate change and the provision of new energy forms to employment, even renewals of public services and bureaucracies (through "creative destruction" of inefficient ways of organisation), innovation is seen as the solution.

The process of including and inserting research and discovery into the heart of the value chain of production and political problem solving, can be seen as the culmination of a number of tendencies set in motion in the 19th century. First of all, this concerns some of the basic underlying assumptions about life itself, especially its capacity for growth and development through self-organising systems dynamics. These can be seen through the lenses of economics, as engaged in processes of competition for scarce resources and survival. Most of the so-called new and emerging technologies, such as biotechnology, ICTs, nanotechnology and robotics are deeply involved in this innovation for growth project. This particular configuration of science, technology, economy and society has deep historical roots: many of these sciences have their common roots in the same historical epoch (i.e. the 19th century) and intellectual environment. Growth was central to both biology and the theory of evolution, and to the political economy that emerged at the time. From the point of view of these sciences (what Foucault termed the human sciences; not to be confused with the humanities), both living systems and the economy can be directed, controlled and mobilised for the sake of future progress. As long as the markets were governed wisely, i.e. with a light touch, they would self-regulate and tend towards the best possible allocation of resources, both in terms of extraction, manufacture and distribution. As science learned to intervene with life at molecular levels, and as a number of useful products started to emerge, the active and constructive aspects of science became much more pronounced, especially with the coming of recombinant DNA technologies in the early 1970s, opening up prospects of "molecular factories" (Wright 1994). The notion that life's essence resides in DNA and that DNA is nothing but information has contributed strongly to this perception and promoted the integration of "life" with the operations of computers.

Today, with the coming of the technosciences (biotech, ICTs, nanotechnology, etc.), these aspects are strongly enhanced; they feed upon and are nurtured by a steady technological progress in which the innovation rate only increases with each new technological product; technological progress has never been so fast. Even more significantly, the widespread use and dissemination of computers and the emergence of the Internet have increased the perception of a major technological revolution. The most poignant expression of this may be Moore's law, which states that processing capacity doubles every second year, and even this rate has been seen as increasing (until recently). Hence, the notion arose that we are seeing not incremental, but *exponential* growth across a number of technological fields of application, and especially those that can be connected to digital networks working in coordination. Hence, some of the most powerful scientific and technological projects today are radically based upon, and also make real, the notion that progress and change is happening faster than ever. This works through expanding circles of value creation in which emerging technologies open up prospects for emerging markets. This notion enters into political programs of job creation and calls for increased competitiveness. As such, there seems to be no limits to what can be done through science and technology, if only these are provided with sufficient resources and a free reign.

Geos: Finite Earth and the Anthropocene

In 2000 the Dutch Nobel winning chemist Paul J. Crutzen proposed the concept of a new geological epoch, called the Anthropocene. The Anthropocene denotes the period of geological time in which human activities are recognized as having significant and lasting impacts on earth systems (geological, atmospheric, bionic, hydrologic, etc.). Crutzen identified the beginning of the epoch with the industrial revolution and, especially, with the increasing concentrations of CO2 in the atmosphere caused by it. *"The Anthropocene could be said to have started in the late eighteenth century, when analyses of air trapped in polar ice showed the beginning of growing global concentrations of carbon dioxide and methane" (Crutzen 2002).* Since then, the term has caught on, and in 2008 the Royal Geological Society of London proposed incorporating the term into the formal geological epoch division (Zalasiewicz et al. 2008). That decision is still pending, but the ways in which the term has caught on, in both scientific circles and beyond, is telling. Probably foremost in public imaginations, the term resonates with the findings of the climate change research community, and with the increasing certainty about human impacts on the climate system documented in the IPCC reports (in the forthcoming report projected to be upgraded from "highly likely" to "extremely likely"). This also fits well with how the "Anthropocene", in Crutzen's terminology, is predicated on atmospheric CO2 levels. Still, the validity of the concept is not restricted to the climate system only; it also resonates with research on biodiversity degradation, species extinction, soil erosion and deforestation. The Antropocene also underpins recent efforts to re-cast *history* from within the time-frame of geological time, or Earth time. Efforts are underway to establish an *Integrated History and future Of People on Earth (IHOPE)*, and a World History Network has been founded[6]. As part of these developments, the field of Big History (Christian 2004) has been instigated, both as a field of research and teaching[7]. The goal of the IHOPE project is *to understand the interactions of environmental and human processes over the past ten to hundred millennia to determine how human and biophysical changes have contributed to Earth system dynamics* (Robin and Steffen 2007).

Hence, the Anthropocene is more than a geological epoch, and much more than climate change research: it makes up a whole new framework for scientific research, and for conceiving of Man's place on Earth and in the Universe. Although it may use and incorporate some of the same theories as emerging technologies (i.e. cybernetic systems and feedbacks through their environment), and some of the same technological tools (i.e. computer modelling), the basic storylines emerging from them are fundamentally different, incorporating different, and often competing, concerns and prescriptions for action. In this section, we recount some of the main constitutive parts of this storyline, many of which emerged around the same time as the Bios paradigm of emerging and converging technologies. Already, these disciplines and the stories they tell may have provided bases for the construction of new political and societal institutions, such as the IPCC panel and the UN Convention on Biodiversity. It remains to be seen, however, to what extent the concerns they

[6] http://www.worldhistorynetwork.org/
[7] http://www.bighistoryproject.com/

embody are taken up into main societal institutions. The *Geos* disciplines are based upon the construction of a storyline of *one finite and vulnerable Earth*, and consist of several well-known ideas and events. Still, the idea underlying this section is that these storylines have remained on the fringes of (Western) scientific and political institutions, and were never capable of penetrating into the basic economic structures and political institutions. This means that, since the 1960s and 70s the message of *Geos*- was always conceived from within the institutional framework of *Bios*-. We see this, for instance, when green technologies are introduced as main drivers of economic growth. It is conceivable, however, that tipping points will be reached, in which the framework, and the storyline, provided by *Geos* overtakes that of *Bios* as a main source for making sense of our collective predicaments.

First glimpses of Earth. As noted by Sheila Jasanoff (2003), images do not by themselves acquire meanings; they crucially depend upon a community of storytellers to weave a universe of meaning around them. It was the ecology movement that provided the first stories of Earth as a limited system, vulnerable to human interventions. Rachel Carson's *Silent Spring* (1962) was published in what could still be considered the close aftermath of World War II, seeing both vast destruction from science and technology as well as a radical upscale of science and technology (through what Eisenhower termed the industrial-military complex). Carson's book, widely understood as an early landmark of the ecology movement, centred on one aspect of such industrialised science and technology, namely the use of the pesticide DDT and its adverse effects on plants, animals and humans. But in order to convey her message, Carsons consciously also made reference to other phenomena, such as nuclear fallout ("Black Rain"), already part of the public imagination. She accused science and technology of becoming handmaids to industry, and the government of upholding and protecting this unholy alliance, placing post-war science within a culture of arrogance and based upon dominance over nature. Also consciously, Carson placed the issue within the frame of Earth time, in which biological life and human societies were seen as part of a greater environmental whole:

The history of life on earth has been a history of interaction between living things and their surroundings. To a large extent, the physical form and the habits of the earth's vegetation and its animal life have been molded by the environment. Considering the whole span of earthly time, the opposite effect, in which life actually modifies its surroundings, has been relatively slight. Only within the moment of time represented by the present century has one species - man - acquired significant power to alter the world (Carson 1962, 5).

The book was a huge success: apart from inspiring a whole movement, and leaving traces such as Earth Day (every year March 20) and the Earth Day Network, Carson's message was also picked up by the political establishment. John F. Kennedy instigated both federal and state investigations into her claims, following which DDT was prohibited (first in the US, then worldwide).

Another main source for imagining the Earth as a whole came around the same time, but from a perhaps more unexpected source: space travel and the Space Age. Originally an expression of Man's unlimited ambition and the drive to grow and expand even beyond Earth's boundaries (and based within the logics of Cold War competition), expeditions such as Apollo (estimated to have been watched on TV by a fifth of the Earth's population) also told a radically different story. The expedition produced images of Earth which, when seen from space, looked lonely and vulnerable. Said the "last man on the moon”, Eugene Carnan: "We went to explore the Moon, and in fact discovered the Earth"[8]. This dimension was not lost to dawning ecologist sensitivities. A strong claim of many early Earth “interpreters” was that the image reflected back on the spectators and observers, and showed them all to be members of one global and interdependent community:

I’ve often heard people say,”I wonder what it would be like to be on board a spaceship", and the answer is very simple. What does it feel like? That’s all we have ever experienced. We are all astronauts. I know you are paying attention, but I’m sure you don’t immediately agree and say, "Yes, that’s right, I am an astronaut." I’m sure that you don’t really sense yourself to be aboard a fantastically real spaceship, our spherical Spaceship Earth. Of our little sphere you have seen only small portions. However, you have viewed more than did pre-twentieth-century man, for in his entire lifetime he saw only one-millionth of the Earth’s surface. You’ve seen a lot more. If you are a veteran world airlines pilot you may have seen one one-hundredth of Earth’s surface. But even that sum is totally not enough to see and feel Earth to be a sphere unless, unbeknownst to me, one of you happens to be a Cape Kennedy capsule (Buckminster Fuller 1963).

Some more scientific rigor was introduced with the *Gaia hypothesis*, proposed by James Lovelock in the early 1970s (Lovelock and Margulis 1974). The hypothesis states that organisms have co-evolved with the earth’s atmosphere, i.e. through the mediation of the *biosphere*. The notion of the biosphere was not introduced by Lovelock; what was new was the hypothesis that the earth makes up one “adaptive control system able to maintain the Earth in homeostasis” (*ibid,* 3). This contradicted the pre-existing view that chemical earth systems (such as the atmosphere and hydrosphere) were not connected to biological life. A fundamental challenge, Lovelock and his co-author Lynn Margulis stated, was that of providing a concept of life that would enable the recognition of life itself on a global scale. Gaia was the name of the hypothesis stating the connection of Earth’s total ecosystem seen as a system of control. The scientific basis of the hypothesis was provided by system’s theory: “Life as a phenomenon might … be considered in the context of those applied physical sciences which grew up to explain inventions and contrivances, namely thermodynamics, cybernetics and information theory” (*ibid.*). Thus, life on earth could be seen as self-regulated through a kind of thermostat that (somehow) sets the basic parameters for development and adaptation. According to this paradigm, Earth systems tend towards equilibrium or homeostatis, which is a function of life’s development (through feedback mechanisms). Whereas *Gaia*, at the time, was a hypothesis, and whereas it remains disputed, many today regard the theory as confirmed. Confirmation has emerged through the confirmations by the IPCC panel that human actions cause global warming; and it resides at the basis of the set of disciplines called Earth Systems Science.

It is interesting to note how the Gaia hypothesis was criticised, especially by biologists who saw it as incompatible with evolutionary theory. Richard Dawkins (1982) argued that since Gaia is only one planet it cannot develop according to natural selection through competition (there seems to be no other planets with which it could compete). James Lovelock answered by setting up the so-called Daisyworld simulations, trying to demonstrate how Gaia could evolve through Darwinian mechanisms. It nevertheless seems safe to assert that the Gaia hypothesis proceeds from a different set of assumptions than evolutionary theory: the vision of Earth systems as interconnected and

[8]http://en.wikipedia.org/wiki/Apollo_program#Cultural_impact

tending towards homeostasis gives rise to different associations than those triggered by Darwinian competition and self-interest.

Computing the Earth. In 1972 *The Club of Rome*, a global think-tank made up by a number of leading individuals from politics, industry, science and economics, published the report *Limits to Growth* (Meadows et al. 1972). Limits to Growth had been commissioned in order to deal with the "world problematique": dwindling resources coupled with rapid population and economic growth. The report laid out a broad framework for modelling and understanding the earth's development over two centuries, i.e. the 20th and 21st. It projected three scenarios for the future of the earth based on the computer simulation World 3. World 3 was an upgraded version of World 2, developed by US computer engineer Jay Forrester, designed to model the earth's system dynamics. A so-called integrated model linked the economy to the environment, simulating mutual interactions between the earth systems *food and agriculture*, *industry, population, non-renewable resources* and *pollution*. A basic presupposition about earth systems was that, whereas the economy and population would continue to grow (exponentially as it were), resources (food and non-renewables) remain *limited*, hence the report's title. In two of the scenarios, called the "standard run" and "comprehensive technology", this situation was projected to issue in environmental degradation coupled with scarcity of basic resources needed to sustain growing populations. Whereas great variety was admitted for the input variables, and predictive power was intended "only in the most limited sense of the world", the conclusion for two of the scenarios nevertheless seemed robust. Based on the inherent assumptions of the model, global systems collapse was predicted to take place some time around the mid 21st century. This, however, was not an inevitable outcome. The third and more optimistic scenario, called "stabilized world", assumed that equilibrium could be achieved that would maintain systemic *status quo*. As later noted by the authors and a number of commentators, this scenario has not been realised (Meadows et al. 2004). As was to be expected, the report was heavily criticised, but recent reviews have also found that its predictions have "kept up well with reality" (Turner 2008).

In the final part of this section we shall briefly mention climate change and the IPCC reports as the ultimate expressions of the *Geos* paradigm, at least as concerns publicity and political impact. We shall not here repeat the results and warnings from the IPCC but confine ourselves to a most rudimentary reminder of how notions of the finite and vulnerable Earth are now circulating throughout numerous global information and communication infrastructures, many of which are intentionally designed for that purpose: monitoring and predicting the state of the Earth. Again, the point is not to give an accurate description but rather to hint at the ways in which the paradigm of Gaia is being incorporated into basic infrastructures, whereas still not being incorporated into main *institutions*, such as politics and the economy. Paul Edwards (2010) has written one of the most comprehensive historical accounts of climate science, particularly focusing on how it emerged out of developments in weather forecasting, climatology and theoretical meteorology. As such, climate science relies on a long prehistory, beginning in the 19th century, of disciplines, theories and models, and technological infrastructures. For most of the 20th century, climate science and meteorology were not sharply separate; neither were their objects of study, i.e. weather and climate (see also Miller 2004). Both, furthermore, existed within regions, the climate being seen as a function of the weather of the very same regions. At a decisive point in time, however, developments were set in swing that would increasingly separate the two. Through the construction of new information infrastructures and new global models, regional weather systems came to be imagined as parts of a larger whole, the global climate system. But this imaginary and the ideas that came with them were not mere results of scientific and technological developments; rather, science and technology were co-produced along with a whole new set of ideas and a new global ethos. As told by Clark Miller, it was not the case that concerns about local weather or climate systems gradually sparked the creation of global infrastructures set to deal with the problem in a concerted manner. Neither was it the case that climate modellers put together a complex puzzle, resulting in “the global climate system” and, from then on, concluding that this system was at risk. Rather, the notion of the Earth’s climate system as being at risk was in place from the very beginning, and concerns about the Earth were built into the global infrastructures and climate models from the very inception. This does not mean that climate change is not real; it only means that it makes no sense to talk about it outside the models and infrastructures that makes up its central object: the global climate system (Edwards 2010).

In spite of the long prehistory (of disciplines, infrastructures and models), Edwards inserts his analysis at the same point in time and within the same historical and cultural context as outlined for other “Earth’s storytellers” (Jasanoff 2003), i.e. in the 1960s and 1970s. “Thinking globally”, says Edwards, entered public consciousness at this point in history, and it introduced a new framework for conceiving of science and technology, but also for ethics and politics:

“…it meant grasping the planet as a dynamic system: intricately interconnected, articulated, evolving, but ultimately fragile and vulnerable. Network, rather than hierarchy; complex, interlocking feedbacks, rather than central control; ecology, rather than resource: these are the watchwords of the new habit of mind that took Earth’s image for its emblem” (Edwards 2010, 2).

What this framework will turn out to be, and how it will interact with political and economic institutions, remains uncertain and will depend on a number of developments and events in the years to come. It is likely that it will increase in relevance, not the least as the IPCC reports become more vocal, and as they interact with critical events and disasters such as Fukushima, and with general increases in floods and storms in increasing parts of the world, as when the storm Sandy hit the US East Coast only days before the election and suddenly brought climate change back onto the agenda. The matter is difficult since the message of climate science goes against the grain of some of society’s most strongly vested interests as well as the structures of main institutions. However, what will become of the message remains uncertain. One discards too easily with the challenge if the Gaia message is simply identified with the ecology movement, or with the political left (from which it arguably emerged). Some of the main institutions promoting climate science or the message of the Earth’s finite resources, are not radicals: The Club of Rome was and remains conservative (if not in its message); and it is too easy to discard with the IPCC as purely driven by politics and ideology (although these certainly play important roles). Furthermore, Western societies have so far not heeded the message of the ecological movement, one reason being that it simply does not fit within its institutions or frames of thinking. One may ecologise and one may modernise, said Latour (1998), but one may not do both at the same time. So far, however, that is what the West has tried to do: The 1987 UN Brundtland Report famously set out the goal of sustainable development, a major event within the broader policy effort of ecological modernisation (Hajer 1996). A presupposition of ecological modernisation was that sustainability posed fundamentally different challenges from those of economic and industrial development. However, if human societies adapted and regulated their behaviours wisely, the goal (and hope) projected by sustainable development and ecological modernisation was that the differing requirements of both could be balanced through political (and technological) brinkmanship. However, in accordance with the developments described in the previous section, “greening” has become appropriated within main industrial regimes rather than placed at their base: it is no longer seen as an obstacle but as a business opportunity. Hence, the following statement from the European Commission, issued in advance of the (failed) 2009 Copenhagen climate summit, can be seen to express a new stage in ecological modernisation (Rommetveit, Funtowicz and Strand 2010), one in which sustainability has collapsed into the framework of emerging technologies, competitiveness and growth: “..staying below 2°C will require significant financial resources for emission reductions and adaptation, but…this will also stimulate innovation, economic growth and lead to long-term sustainable development” (European Commission 2009, 12).

From Bios to Geos?

In this chapter we outlined two present-day narratives about the sciences, technologies and innovation, and their wider societal and environmental roles. The analysis took as its background our previous descriptions of how The Modern Framework has been underlying both stability and change in Europe (and modernised societies more generally). The reason for telling two stories of the present is the contention that the two are underlying different and frequently conflicting accounts of Europe’s (and the West’s) current predicament, possibly pointing towards a transition in basic categories of human societies and their place in nature. Admittedly, pitting the two against each may be a simplification: we cannot know that a transition is taking place, from one framework to another; perhaps the two will continue to co-exist. Evidence for such large-scale scientific, technological and political change is not so much to be found in historical accounts (although they provide us with distance and perspective).

Still, it seems that the two tales underlie decisive perplexities of the present, where “science” seems to be supporting differing political projects. Put briefly: listening to dominant voices in science today, one (Geos) tells us to Stop!; another (Bios) urges us to speed up. As an example of such perplexity, consider the following extract from a debate on the web pages of The Guardian. It is an exchange between two readers, following the article with the headline: “European Commission could open GM Pandora's Box”, with the ingress stating how ”The EC could soon approve glyphosate-resistant GM crops but reports from the US and Argentina show devastating effects include more pesticides and farmers locked into seed contracts”. The first commentator, *alfredooo*, observes that:

> *It's funny, any peer reviews study that raises issues with GM technologies is immediately dismissed, yet we are all expected to accept the "rigorous" methods employed in the biotech funded research conducted in the US, a country where independent studies are not required.*

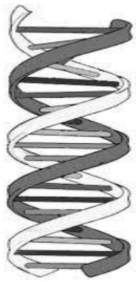
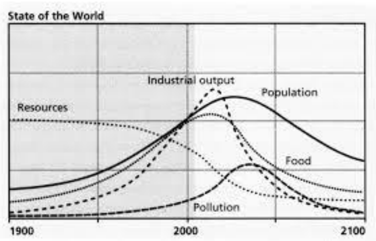
Another, called *euangray*, then replies that:

> *What's funny in reality is that there is a set of people who will listen to the science when it tells them that global warming is real and here now, but will NOT listen to the science when it says that GM is safe, or for that matter that nuclear power is safe…. it seems this group of*

people do what they accuse "deniers" of doing - selecting the science they want to select because it happens to support the same conclusion their ideology does.

Funny that, I wonder why?

A plausible answer to *euangray* is that the sciences in question, climatology and GM science, are not instantiations of one and the same thing, Science, but rather different sciences incorporating very different concerns, interests and values. By saying this we do not subscribe to a diagnosis of postmodern (endless) pluralism, or, for that matter, the idea that science is determined by social context and interest. But the two sciences do, like in Thomas Kuhn's notion of different scientific paradigms, belong to different worlds with different historical backgrounds. GM science, although heralded by its proponents as the utmost expression of progress in agriculture, is situated within a universe of growth and progress through science, innovation and industry. Climatology, on the other hand, can be seen to take direct aim at some of the main presuppositions of the world out of which GM science has emerged. Rather than seeing this as a straightforward contradiction, it makes sense to see the matter in the following way: Climate science is situated after a historical break, whereas GM is situated within a longer tradition of agricultural modernisation. This break occurred in the late 1960s, with the ecology movement and with a new (and surprising) realisation that human activities have deep impacts on the environment. The underlying meanings of this framework have since taken on a number of shapes and names (such as Gaia and the Anthropocene); it has spread throughout increasing numbers of scientific disciplines and increasingly serve to organise and structure interdisciplinary work; it has tried to enter the main institutions, and it has triggered the creation of new ones (i.e. the IPCC panel, diverse UN bodies, the Kyoto Protocol, The Rio Declaration, etc.). In a schematic way, we may portray the two frameworks as follows:

<table>
<tr><th></th><th>Bios</th><th>Geos</th></tr>
<tr><td>Main symbol</td><td>
Double Helix</td><td>
Gaia</td></tr>
<tr><td>Grand Narrative</td><td>
Growth</td><td>

Limits</td></tr>
<tr><td>Main sciences and technologies</td><td>Evolutionary theory, molecular biology, ICTs, cognitive science, nanoscience, converging technologies, neo-classical economics, etc.</td><td>Earth system science, ecology, geosciences, climatology, Big History, ecological economics, etc.</td></tr>
<tr><td>Institutions</td><td>Nation state</td><td>Post-national</td></tr>
</table>

What does it mean to say that the sciences are involved in different projects, and inhabiting different worlds? It does not mean, for instance, that there are no possible links to be drawn between earth systems science and evolutionary theory; clearly, scientists may be using some of the same technologies and models, i.e. computers, cybernetic feedback-models etc., to account for their respective objects. James Lovelock himself sought to argue that the biosphere could have been produced through evolution. Hence, it does not mean that the two are not in principle compatible. But that is not the point. Rather, the two are concerned with widely different scales of observation (one focusing on individuals in their environment, the other on integrated earth systems), and incorporating widely differing (social and environmental) concerns. Biology and evolutionary theory (in their main forms) embody the growth models that originated after the Industrial Revolution, and are strongly concerned with the upholding and fostering of industrial society. Climate science and the notion of the Anthropocene, on the other hand, take aim directly at the processes that started at that time, i.e. accumulations of $CO2$ in the atmosphere accelerating with the onset of industrialisation. It is not primarily a conflict over nitty-gritty science (models, theories, etc.); neither is it a conflict over what types of science should be funded in the future. It is a conflict over which sciences are allowed to frame the grand narratives of (Western) civilisation, to make sense of our present predicaments, including the character and roles of main political institutions. There is no way in which one may simply choose between the two. One cannot forge simple compromises such as "green growth", or expect the "bioeconomy" to provide a new direction and sustained growth across the board. It is not a matter of simple choice: a green economy or continued use of fossil fuels. Given the state and urgency of recent climate warnings, it seems imperative that societies and economies that profess to take science seriously *should* make the transition into modes of living and producing that are more in accordance with the limits of Earth. There are numerous reasons why that cannot be done, however, most of which have to do with the fact that most economic, political and scientific institutions were not designed with that purpose in mind. European societies (and the West more generally) are trying to adapt to a new situation mainly by using the formulas of a previous age. Our thinking and our basic institutions are not adapted to the realities in which we find ourselves. *If* it makes sense to talk about a transition from one framework (*Bios*-) to another (*Geos*-), this would result from a gradual debunking of the *Bios*- paradigm, through increasing anomalies appearing within existing modes of knowledge production, i.e. as the main paradigm makes less and less sense and, conversely, is incapable of serving as a source for making sense of the realities of the 21st century. At present, a number of such anomalies may be spotted within the *Bios*- framework, and we shall mention a few:

- The bioeconomy and the "information society" are not necessarily providing sustainability: biofuels increasingly compete with and take up land and energy from food production (Bowyer 2010), especially in poorer countries. And, to mention an example from the ICTs sector: Cloud computing has been singled out as a major source of job creation and growth within the internal market (Kroes 2012). But it has also been calculated to increase CO2 emissions due to the need to power servers and facilitate wireless access to the cloud (CEET 2013). It seems, then, that rather than replacing old forms of energy production, these technologies are inserting themselves at the top of existing energy regimes based on fossil fuels. The promise that they may eventually produce a new economy may turn out to be just that: a promise. In that case, wishful thinking may be diverting the attention and energies, of researchers, policy makers and the wider publics, away from more viable solutions in the present.

- Relatedly, whereas technological progress has been steadily increasing, indeed accelerating, this has not translated into general production growth. In innovation circles this is taken to mean that there is a problem of translation, from "basic research" through "applied research" to markets. But what if ICTs, biotechnologies and other emerging technologies do not really provide these kinds of developments? What if they do not provide the kind of growth that seems to be demanded and expected from them? In a much-discussed paper, the US economist Peter Gordon (2012) has argued that growth until the 1970s could rely upon a wave of useful innovations (such as electricity, combustion engine, running water, indoor toilets, communications, entertainment, chemicals and petroleum). Since that time, however, growth has been steadily slowing, in spite of the rapid spread of computers, the Internet and mobile phones. Neither has the bioeconomy unfolded in the ways initially projected. It is starting to seem likely that, whereas ICTs and other "emerging technologies" indeed do transform societies, they do not provide the kind of growth westerners are used to from the past (thus, another economist, Tyler Cowen, has argued that we have picked all the "low hanging fruits"; the remaining fruits to get from innovations are harder to get and more costly).

- Unemployment is not going down, even as (certain) technologies accelerate as never before. In fact, there are good reasons to believe that automation is strongly connected to increasing unemployment. In 1995 Jeremy Rifkin wrote a book called *The End of Work* where he argued increasing automation to be a main cause of unemployment. The argument was not new and had been put forward since at least the 1930s. In the past such arguments had been dismissed due to the fact that new sources of jobs would (normally) replace those disappearing through automation. Indeed, this was the exact argument used by the 1993 White Paper in order to overcome doubts about the impacts of automation. Increasingly, however, economists are taking Rifkin's argument seriously (also those that do not share his politics): what if there is no place for replaced workers to migrate to? In a recent book, called *Race against the Machine*, the authors Erik Brynjolfsson and Andrew MacAffee argue that we are indeed seeing major changes to the economy and ways of organising labour. These changes can be related more or less directly to the role of computers and machines for performing increasing numbers of tasks:

…. there has been relatively little talk about role of acceleration of technology. It may seem paradoxical that faster progress can hurt wages and jobs for millions of people, but we argue that's what's been happening… computers are now doing many things that used to be the domain of people only. The pace and scale of this encroachment into human skills is relatively recent and has profound economic implications. Perhaps the most important of these is that while digital progress grows the overall economic pie, it can do so while leaving some people, or even a lot of them, worse off (Brynjolfsson and McAffee 2011, Introduction).

The 1993 White Paper was probably right to hesitate about the role of increasing automation. Still, since that time such doubts have been increasingly externalised: the connection between technology, work and competitiveness has been inserted at the centre of the discourse about innovation, whereas the relationship between automation and unemployment has been ignored. The lack of creative ideas and alternatives in the face of increasing unemployment can be seen as a major "externality" connected to this state of affairs.

12. Conclusions

(1) A Plea for Deep Innovation

The depth of the problems just described can be further outlined as follows: most of the institutions cherished by Europeans as the hallmark of the Enlightenment (science, representative democracy, the rule of law, the public sphere, etc.) were predicated on the logics and institutions of *Bios*: the paradigm of the necessary and sufficient role of innovation, growth, adaptation, evolution, and the centrality of new and emerging sciences and technologies such as life science and biotechnology. But in so doing they (unintentionally) ignored the limited amount of resources upon which they relied, and for a long time they lived happily ignorant (apparently) of the side-effects to the environment as well as to deep issues of global and local inequity and injustice. Today, main concerns are connected to how one might retain, safeguard and renew democracy and welfare in the face of economic downturn, increasing inequity, increasing social unrest and with the climate change disaster possibly just waiting to happen. Even as Europe attempts to address a number of issues relating to its material and natural basis of its subsistence, it must try and keep alive the ideas and practices of democracy, and of reasonable levels of welfare for its populations. Where better to look for solutions than to science, technology and innovation?

In recent EU programs for research and innovation such as The Lisbon Agenda and Innovation 2020, a double tendency has made itself present: first, the increasing urgency for innovation has been moving steadily higher on the policy agenda; second, the view that innovations should respond to the so-called "grand challenges" of our times has become evermore prominent, even pressing. Research and innovation should contribute to societal change and improvements in a number of areas: few today would dispute the need for decisive action in a number of areas: desperate times may indeed be the best promoter of creativity, renewal and change. One could hope, then, that Horizon 2020, as a main driver of progressive thought and action, would strive to implement such developments as are needed. Although the challenges are overwhelming, Europe still presides over enormous resources: intellectually, technologically, economically, and in terms of cherished institutions and human resources. Research and innovation should be capable to significantly contribute to the solution of Europe's problems.

Briefly summarised, the "grand challenges" of Horizon 2020 pertain to the themes of *ageing, health and demography, food security and sustainability* (herein included the *bioeconomy*), *energy security, improved transportation, climate action,* and *inclusive societies*. In the General Principles section of the Horizon 2020 Framework Programme, it is also stated (Article 12) how the new framework is supposed to approach the challenges. In the process, wider groups of stakeholders should be consulted, thus bringing "societal engagement" into the research and agenda setting process. Further, Article 13 states the principle to establish "linkages and interfaces … across and within the priorities of Horizon 2020". Indeed, the principle of innovation itself can be said to be nothing but the creation of such "interlinkages": according to Schumpeter innovation is "the art of making useful combinations". In order to meet the great challenges of our times, new interlinkages, or combinations, must be made across a number of sectors. Presumably, "improved transportation" must be linked with new forms of energy production; climate action should be undertaken in collaboration with local communities, municipalities and cities, and so also promoting "inclusive societies"; "food security" must be compatible with "energy security", and so on. Finally, principles of democratic governance, participation and transparency should not be regarded as external to the process, but should be strengthened through innovation (as stated in Article 12). "Innovation", if seen like this, could aim for the solution to several pressing problems at the same time. Indeed, this was also mentioned in the 1993 White Paper on *Growth, competitiveness, and employment:* jobs could be created relating to a number of public challenges in the fields of care, environment, education and maintenance of public spaces and infrastructures. The term "deep innovation" may thus signify at least three types of depth: First, profound attempts at dealing with the grand challenges themselves and not just the development of consumer products and services that somehow may claim to be related to the challenges. Second, profound novelty in the interlinkages between the grand challenges. Third, a deep involvement of members of society in the development of new ideas and new solutions not just as passively receiving consumers but as citizens who participate and through their involvement build new forms of agency. Deep involvement would mean that citizens and governments meet grand challenges also through what they *do* and not only through what they *buy.*

Yet, as we have seen: the main solutions have long since been tagged to a paradigm of industrial growth and competitiveness. This "paradigm", furthermore, is directly linked to a macro-economic outlook that is now causing havoc across European societies. Although research and innovation is not identical to the operations of the economy, since the 1970s they have been pegged directly to it. In the present situation the continued predominance of the *Bios* paradigm inside main programmes such as Horizon 2020 and Innovation Union is not promoting change and renewal, but is instead blocking such from happening. And, as with the economy, it seems that the social and environmental concerns and goals have been lost from sight. The European Research programmes are meant to pursue and fund the following three main goals: "excellent science", "industrial leadership" and "societal challenges" (Article 6). Still, the main tendency is for both "excellent science" and "societal challenges" to be seen as instruments and vehicles for "industrial leadership". Thus, Article 12 states how "Particular attention shall be paid in this respect to the development and application of key enabling and industrial technologies". But this overlooks the fact that neither good science nor "societal benefit" can be reduced to the industrial dimension. Indeed, part of the success of the Modern Framework was to keep spheres *separate*: even the linear model of innovation, i.e. science as the endless frontier, placed scientific autonomy and freedom at the centre. The direct involvement of science into the industrialised regime of innovation is damaging science and its potential uses for the benefit of society. "Key enabling technologies", from ICTs through biotechnology to robotics are not even close to providing solutions to the societal grand challenges of our time; in many cases they are even working in direct opposition to sustainability and change. "Societal benefit" is predicated on trickle down fantasies, and on ideas that new and emerging technologies will provide us with a number of new consumer goods that will, eventually, restart the economy. The fact of the matter is that, if one views "key enabling and industrial technologies" in relation to the "grand challenges" they are meant to address, they are not really suited for the job. Many of these technologies saw the light of day in a different era, i.e. beginning in the 1950s (computers, molecular biology), and accelerating in the 1970s with the intent to kick-start the (US) economy. It remains altogether underspecified and unclear how ICTs and automation are supposed to decrease unemployment, instead of aggravating it; how genomic medicine is supposed to improve health and wellbeing in better ways than simple measures such as diet and exercise; how robotics are supposed to care for the disabled and elderly; how biofuels, carbon quotas and CO2 sequestration are supposed to significantly counter climate change; how cloud computing and broad band technologies are supposed to significantly improve the conditions of small and medium scale enterprises; or how smart phones and wearable sensors are going to improve care or alleviate loneliness and improve human connectivity; how biometrics, CCTVs and software to recognise "suspicious behaviour" is going to improve social cohesion and security; how new software and algorithms are supposed to improve health and wellbeing; how nanotechnologies are going to bring about more environmentally friendly products, and so on.

And so the list could continue. This is not to state that any of the above-mentioned technologies are, in and by themselves, bad, or that they could not be useful. The claim is, however, that their emergence has been accompanied by a gradual assimilation of science to technology, technology to industry. It may indeed seem counterproductive, then, to re-introduce societal challenges at the heart of an enterprise that seems to become less scientific and less "social" by the day.

(2) Action Points

After 8 short chapters of historical narrative and 3 chapters of sketching how the resources of history may cast light upon the contemporary situation, we are thus ready to state some suggestions for concrete action. The idea that scientific knowledge should determine or prescribe the course of action is in itself part of the 17th century solutions that contemporary society has inherited as part of the problem. Facts and values, and knowledge and action, come entangled into each other, but the one should not be taken to prescribe the other. To readers who have found our narrative and argument plausible, however, we propose the following ideas:

- **European Values: Return to Reason**

The central piece of heritage from the European Renaissance is the humanist ideal of reasoned dialogue between reasonable persons who are aware of their own limitations and are curious to learn from others. This is to be contrasted with later beliefs in the certainty of rational calculations on the basis of scientific knowledge, and the irrationality of what is not science (politics, emotions, citizens). Scientists, analysts and other experts are still asked to improve their indicators and statistics to reduce uncertainty and provide a firm basis for evidence-based policies. From history and philosophy one can learn that for many complex issues there is no certitude to be had without falling into the strategic production of policy-based evidence rather than evidence-based policy. The duty of the expert would then be to insist on the *Return to Reason,* defy requests for hyper-precise information or advice and contribute to the criticism and discreditation of unfounded claims to certitude and rationality. In a return to reason, experts and policy-makers would frequently have to admit that they lack precise knowledge of matters at hand and that there is no way of knowing if the proposed course of action will be successful. This is likely to weaken hegemonic or privileged positions of power within the current framework.

- **European Values: Diversity and Tolerance**

In the same heritage from the Renaissance, diversity of opinions and perspectives is considered a resource for understanding and living with complex issues and not as noise to be filtered away from singular truth. While this insight may be useful in many contexts and on many levels, we would like to suggest it also in the context of contemporary European research policies. Specifically, diversity of perspectives should be encouraged in order to challenge the hegemonic position of what we have called the Bios paradigm, linked to a focus on industrial growth, innovation, evolution and competitiveness. Increased diversity and tolerance of such complementary perspectives might not be achieved without loosening the ties between research policies and industrial policies as well as between their respective proponents.

- **European Values: Universalism, Democracy and Public Knowledge**

Equally central are the European values that are so closely linked to the scientific revolution and the development of modern science: Universalism, democracy and the public character of scientific knowledge in the service of the common good. If a return to reason would imply that elites admit the limitations of their knowledge and therefore the need for the citizenry to accept responsibility and commit to actively contributing to the future of society; and a celebration of diversity would imply a strengthening of other voices than those of industry, then democracy means that everybody is entitled to have their voice heard and universalism means that it is reasonable to listen to them. A logical first step on such a path could be the principle that the results of scientific research with public funding should be public knowledge. Public knowledge should have open access; however, it entails more. What is more, is discussed and developed in practical terms among theoreticians and practitioners of so-called “Open Science”, “Social Innovation”, “Post-Normal Science” and other concepts of public knowledge endeavours.

- **Grand Challenges and Deep Innovation**

We have already described our concept of deep innovation. Assessments of the success of policies on grand challenges should include assessments of ultimate outcomes and not just proxies such as the development of consumer products and services that somehow may claim to be related to the challenges. Second, grounded in the original concept of innovation, we proposed an emphasis on new interlinkages between the grand challenges. Third, and closely related to the three action points above, deep innovation would signify the deep involvement of members of society in the development of new ideas and new solutions not just as passively receiving consumers but as citizens who participate and through their involvement build new forms of agency. Deep involvement would mean that citizens and governments meet grand challenges also through what they *do* and not only through what they *buy.*

- **Reassessing the Present Function of the ERA**

We would not be surprised if our suggestions described in the above bullet points will be rendered contrary and counter-productive to existing policy on the European Research Area as it is usually interpreted and understood. In that case, we propose that analysis is performed to understand why. As explained in Ch. 9, the function of the ERA or any other institution or policy is not necessarily (only) the one purported by its dominant actors. In order to produce public knowledge that informs society about the ERA, one would need to do methodologically sound social science by not taking for granted the commonsensical assumptions and descriptions of ERA that are provided by the dominant actors themselves. In more explicit terms, this would entail the following tasks:

a) Critical analysis of commonsensical assumptions on the effectiveness of actual policies at the level of the European Union with regard to achieving an increased level of integration of research across European borders. To the extent that e.g. the penetration of policy instruments such as networking, exchange programmes, joint programming, etc., are taken as proxies for increased integration, there is a need for critical empirical research to evaluate the adequacy of such proxies, cf. Chessa et al. (2013) who specifically cast doubt on these assumptions by their conclusion that they find no evidence for increased integration of European research since 1993.

b) Critical analysis of commonsensical assumptions on the appropriateness of policy as such at the level of the European Union given the objective of integration of research across European borders. We have described how the modern framework developed the idea of action as “governance of complexity” rather than “governance in complexity”, envisioned as top-down action by a “rational calculator” who has sufficiently complete information to be able to know the correct way and has the power to coordinate the relevant players in the field so as to achieve the desired outcome. It is outside the scope of this report to assess whether the European Union has, or can have, this knowledge and power. It is within our scope, however, to point out that the existing policies share this deep assumption of the modern framework that such knowledge and power is possible and desirable. We also pointed out that the original motivation for rational calculation was not to achieve substantive outcomes, but conflict resolution between European people at war against each other. However, empirical studies can throw light on these assumptions of European policies as the implementation of a rational calculator. We offered one example of such studies above (Ch. 9; Chorofakis & Pontikakis 2011) which we take to indicate risks of inadequacy of the approach of “governance of complexity”.

c) Critical analysis of commonsensical assumptions about the appropriateness of the current policy objectives and their measures. Why exactly is it important and desirable to increase the level of integration of research across the borders of European member states, or across regions of Europe? Why exactly is it important and desirable to increase research mobility, patent numbers, numbers (and hence speed) of research publication, rates of innovation? To what extent are the justifications of the policies dependent on assumptions inherent to the Bios paradigm and/or theories of economics and innovation studies that themselves offer ample possibilities for empirical, theoretical and ideological critique? Our task has not been to answer these open questions, but to show that the questions follow from the historical narrative that we have presented.

d) Sociological analysis of the effects, functions and purposes of the European Research Area policies. The historian's task is not only to recount what the actors of the past said and possibly thought about their own actions. It is also to try to understand the less obvious effects and meanings of past actions and events that might not have been immediate to the actors themselves. Sociology, contemporary history and social research in general have the difficult task of trying to get a deeper understanding of actual actions and events, beneath purported function and purpose. What is the evidence that European research policies indeed should be best understood and assessed as attempts at governing of complexity and thereby increasing rates of innovation and accordingly competitiveness and wealth? For instance, perhaps mobility programmes are better understood as long-term investments in European peace than of integration of the research area, regardless of what main policy actors think of as their own rationale? If so, this would have consequences for the assessment of such policies as well as how their success is measured.

In sum, we point towards the need for critical research at a number of levels in order to improve the knowledge base for European research policies. We shall develop one more aspect of this need in the final bullet point.

- **Policy Indicators, Bios, Geos and European Values**

Indicators (e.g. economic indicators) for research policies are constructs that aim at measuring human social activity. In other words, they are methods of social science and as such they are subject to double hermeneutics: They form part of efforts to interpret the actions and results of self-interpreting actors. As noted above, any sound social science methodology would need to establish critical distance from the interpretational frame provided by the dominant actors themselves in order to avoid mere reproduction of dominant narratives.

Specifically, in a process of providing new understanding to escape the conceptual confinement of the Bios paradigm, it will be important to deconstruct currently used indicators to assess the extent to which they incorporate or reproduce Bios assumptions about growth, consumption and the unlimited availability of natural resources to be internalised, capitalised upon and put through the value chain and consumed. Similar questions could be raised for each of the grand challenges. Accordingly, one might conclude with the inappropriateness of a number of standard measures.

The many attempts at constructing indicators appropriate for a Geos paradigm have proven that this is no trivial issue. All such measures are to some extent controversial, for instance because they are committed to underlying theory that is too much in doubt for too many, or because they are so simplified and reductionist that their ultimate purpose is lost out of sight (such as with CO_2 emission quota). This does not mean that there cannot be reasonable and useful Geos-informed indicators. Rather, it reminds us of the need for a Return to Reason: The problem is not so much the indicators in themselves but rather the status ascribed to them as guides or proxies to truth.

Consistent with the preceding points relating to general European values, our suggestion would be that public services could have three roles with regard to policy indicators. First, there is the work of criticism and deconstruction of indicators that are presented as value-neutral or otherwise unproblematic and in that way unduly contribute to hegemonies of power. Secondly, there is the creative work of constructing new indicators that relate directly to grand challenges, either in terms of ultimate outcomes (and not only their effects as seen from a Bios paradigm), or in terms of process (for instance measuring initiative and agency in civil society). Third, with philosopher of science Paul Feyerabend one could argue that state powers should take responsibility for the diversity of perspectives in knowledge production. For instance, in issues where there is political disagreement, one way to implement European values of diversity, tolerance and democracy would be to make sure that the political interlocutors all have public support in terms of information. It would not be the right way to try to provide value-neutral, paradigm-free indicators, because that is an illusion. Rather, it would mean to sustain a diversity of value-laden indicators, grounded in their respective interpretational frameworks, be they Bios, Geos or others.

References

Bacon, F. (1620/1994), *Novum Organum; with Other Parts of the Great Instauration*, Chicago: Open Court Publishing.

Bacon, F. (1627) *The New Atlantis.*

Bensaud-Vincent, B. & I. Stengers (1996) *A History of Chemistry*. Cambridge MA: Harvard University Press.

Bowyer, C., (2010) Anticipated Indirect Land Use Change Associated with Expanded Use of Biofuels and Bioliquids in the EU – An Analysis of the National Renewable Energy Action Plans, IEEP. <http://www.ieep.eu>.

Brynjolfsson, E. & A. MacAffee (2011) *Race Against the Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy.* Lexington, MA: Digital Frontier Press.

Buckminster Fuller, R. (1963) *Operating Manual for Spaceship Earth*. E.P. Dutton & Co, New York, Ch. 13.

Bush, V. (1945) *Science: the endless frontier*, United States Office of Scientific Research and Development, U.S. Govt. print office.

Carson, R. (1962) *Silent Spring.* Houghton Mifflin Harcourt*:* Mariner Books.

CEET (2013) The Power of Wireless Cloud. Centre for Energy Efficient Telecommunications, Melbourne University. http://www.ceet.unimelb.edu.au/pdfs/ceet_white_paper_wireless_cloud.pdf

Chessa, A. et al. (2013) "Is Europe Evolving Toward an Integrated Research Area?", *Science* 339: 650-51.

Chorofakis, G. & D. Pontikakis (2011) «Theoretical underpinnings and future directions of European Union research policy: a paradigm shift?», Prometheus: Critical Studies in Innovation, 29, 131-161.

Christian, D. (2004) *Maps of Time: An Introduction to Big History.* Berkeley, CA: University of California Press.

Cooper, M. (2007) *Life as Surplus: Biotechnology and Capitalism in the Neoliberal Era.* Washington: University of Washington Press.

Crutsen, P.J. (2002) "Geology of mankind: the anthropocene". Nature 415, 23.

Darwin, C. (1859/1909-14) *On the Origin of Species.* The Harvard Classics, Vol. 11. New York: P.F. Collier & Son Company.

Darwin, E. (1794) *Zoonomia; or, The Laws of Organic Life.* Vol. 1, 505 (retrieved from http://ia600404.us.archive.org/14/items/zoonomiaorlawsof1794darw/zoonomiaorlawsof1794darw.pdf)

Dawkins, R. (1982) *The Extended Phenotype.* Oxford: Oxford Univ. Press.

Descartes, R. (1641/1971)*, Discourse on Method and the Meditations*, Harmondsworth: Penguin Classics 1971.

Edwards, P. (2010) *A Vast Machine. Computer models, climate data, and the politics of global warming*. Cambridge, MA: The MIT Press.

Einstein, A. (1905) "Zur Elektrodynamik bewegter Körper", *Annalen der Physic*, Vol 17/1905, pp. 891-921. Engl. Transl. Lorenz, Einstein, Minkowski and Weyl: *The Principles of Relativity*, New York: Dover 1952.

Eisenhower, D. (1961) President Dwight D. Eisenhower's Farewell Address, http://www.ourdocuments.gov/doc.php?flash=true&doc=90

European Commission (1993) *Growth, competitiveness, employment: The challenges and ways forward into the 21st century.* COM (93)700. Bulletin of the European Communities. Supplement 6/93.

European Commission (2009) "Towards a comprehensive climate change agreement in Copenhagen (COM(2009) 39 final). Commission of the European Communities. Brussels: Commission of the European Communities.

European Commission (2011) COM(2011) 808 final. Communication from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions. Horizon 2020 - The Framework Programme for Research and Innovation.

European Commission (2012a) COM(2012) 60 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Innovating for Sustainable Growth: A Bioeconomy for Europe.

European Commission (2012b) Consultation on Future Network Technologies Research and Innovation in HORIZON2020. Workshop Report. Brussels: European Commission.

European Round Table of Industrialists (ERT) (1998) *Creation through Innovation and Competitiveness*. Retrieved from http://www.ert.eu/node/352

Feyerabend, P. (1999) *Conquest of Abundance.* Chicago: The University of Chicago Press.

Foucault, M. (1970/1989) *The Order of Things. An Archaeology of the Human Sciences.* London and New York: Routledge.

Fox Keller, E. (2002) *The Century of the Gene.* Cambridge, Massachusetts, and London, Harvard University Press.

Galilei, G. (1623) *The Assayer* [Il Saggiatore]. In Stillman Drake, editor, *Discoveries and Opinions of Galileo*. New York: Doubleday & Company, 1957.

Galilei, G. (1970) *Dialogue Concerning the Two Chief World Systems* (1630). Berkeley and Los Angeles: University of California Press.

Gibbons, M. (1999), “Science's New Social Contract with Society”, Nature 402, C81-C84.

Gibbons, M. et al. (1994), *The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies.* London: Sage.

Gordon, P. (2012) Is U.S. Growth over? Faltering innovation confronts the six headwinds. Working paper 18315 National Bureau of Economic Research. Retrieved from http://www.nber.org/papers/w18315 .

Gould, S. J. (1980)*The Panda's Thumb*. New York: W. W. Norton.

Green, S. (2009) *Good Value: Reflections on Money, Morality and an Uncertain World.* London: Allen Lane.

Hajer, M. (1996) "Ecological modernisation as cultural politics." In S. Lash, B. Szerszynski & B. Wynne (eds): *Risk, Environment and Modernity, towards a new ecology*, London: Sage, pp. 246-68.

Heidegger, M. (1977). *The Question concerning Technology and other Writings.* New York, Harper & Row.

Hobsbawm , E. (1975) *The Age of Capital, 1848-1875.* London: Weidenfeld & Nicholson

Hobsbawm , E. (1987) *The Age of Empire: 1875-1914.* London: Weidenfeld & Nicholson

Hobsbawm, E. (1962) *The Age of Revolution.* London: Weidenfeld & Nicholson

Huneman, P. (2007) ”Animal Economy”. Anthropology and the Rise of Psychiatry from the ’Encyclopedie’ to the Alienists. In Wolff, L. (Ed. 2007) The Anthropology of the Enlightenment. Stanford, California: Stanford University Press.

Husserl, E. (1962) *Die Krisis der Europaischen Wissenschaften und die transzendentale Phaenomenologie*, Volume VI of Husserliana. Haag: Martinus Nijhoff.

Husserl, E. (1970) *The Crisis of European Sciences and Transcendental Phenomenology* Evanston: Northwestern University Press.

Jasanoff, S. (2003) “Image and Imagination: The Formation of Global Environmental Consciousness”, in: Paul Edwards and Clark Miller, (eds.), Changing the Atmosphere: Expert Knowledge and Environmental Governance, MIT Press, Cambridge MA.

Jasanoff, S. (2004) *The idiom of co-production.* In: Jasanoff (2004) States of Knowledge. The co-production of science and social order. London and New York: Routledge.

Kay, L. (2000) *Who Wrote the Book of Life? A History of the Genetic Code.* Stanford, California, Stanford University Press.

Koyré, A. (1939/1978) *Galileo Studies*. London: Harvester, 1978.

Krimsky, S. (1991) *Biotechnics and Society. The Rise of industrial Genetics.* Westport, Connecticut, London: Praeger.

Kroes, N. (2012) A European Cloud Strategy. Speech given at Economic Council Symposium “Cloudcomputing – Between growth opportunities and privacy”, Brussels 25 June 2012.

Kuhn, T. (1962) *The Structure of Scientific Revolutions,* Chicago: Univ of Chicago Press.

Latour, B. (1993) *We Have Never Been Modern.* New York: Harvester Wheatsheaf.

Latour, B. (1998) "To modernise or ecologise? That is the question''." In *Remaking Reality: Nature at the Millennium*, eds. B. Braun and N Castree. London: Routledge, pp. 221-42.

Locke, J. (1689/1966) *An Essay Concerning the True Original, Extent and End of Civil Government.* Oxford: Oxford University Press.

Lovelock, J. & L. Margulis (1974) Atmospheric homeostasis by and for the biosphere: the gaia hypothesis. *TELLUS XXVI* 1(2), 2-10.

Lyons, H. (1944/1968) *The Royal Society 1660-1940. A History of its Administration under its Charters,* New York: Greenwood Press.

Lyotard, J.-F. (1979/1984) *The postmodern condition: a report on knowledge.* Manchester: Manchester Univ. Press.

Manent, P. (2000) *The City of Man.* Princeton, NJ: Princeton University Press.

Marquis de Condorcet (M. J. A. N. de Caritat) (1796) *Outlines of an Historical View of the Progress of the Human Mind.* Philadelphia: Lang & Ustick.

Mayr, E. (2004) *What Makes Biology Unique?* Cambridge: Cambridge University Press.

Meadows, D. H. et al (1972) *The Limits to Growth*. New York: Universe Books.

Meadows, D. H. et al (2004) *The Limits to Growth: The 30-Year Update.* White River Junction: Chelsea Green.

Miller, C. (2004) "Climate science and the making of a global political order." In *States of knowledge: the co-production of science and social order*, ed. S. Jasanoff. Milton Park, Abingdon: Routledge, pp. 46-66.

Montaigne, M. (1603), *Essays*, first Book Trans. John Florio. Quote from http://www.luminarium.org/renascence-editions/montaigne/

Mumford, L. (1934) *Technics and Civilization* (1934), New York: Harcourt, Brace & World.

Nordmann, A. (2009) «European Experiments». Osiris 24, 278–302.

Nordmann, A. et al. (2004) *Converging technologies – shaping the future of European societies, report for the EuropeanCommission via an expert group on foresighting the new technology wave,* Brussels: European Commission.

Pascal, B. (1669/1958) *Pascal's Pensees.* New York: E.P. Dutton & Co.

Pickering, A. (2005). "Decentering Sociology: Synthetic Dyes and Social Theory". Perspectives on Science 13(3): 352-405.

Porter, R. (1997) *The Greatest Benefit to Mankind: A Medical History of Humanity.* New York, London: W. W. Norton & Company.

Porter, T. (1995) *Trust in Numbers. The Pursuit of Objectivity in Science and Public Life*, Princeton NJ: Princeton University Press.

Porter, T. (1995) Trust in Numbers. The Pursuit of Objectivity in Science and Public Life. Princeton, NJ: Princeton University Press.

Ravetz, J. (1971) *Scientific knowledge and its social problems*, Oxford: Clarendon Press.

Ricoeur, P. (1981) *Hermeneutics and the Human Sciences: Essays on Language, Action and Interpretation*. Cambridge: Cambridge University Press.

Rifkin, J. (1995) *The End of Work: The Decline of the Global Labor Force and the Dawn of the Post-Market Era*. Putnam Publishing Group.

Robin, L. & W. Steffen (2007) History for the Anthropocene. History Compass 5(5), 1694-1719

Roco, M. C. & W. S. Bainbridge (eds.) (2003) *Converging Technologies for Improving Human Performance.* Arlington/VA: National Science Foundation.

Rommetveit, K., S. Funtowicz & R. Strand (2010) “Knowledge, democracy and action in response to climate change” in: R. Bhaskar, C. Frank, K.G. Høyer, P. Naess & J. Parker: *Interdisciplinarity and Climate change*. Abingdon: Routledge, pp. 149-163.

Rose, N. (1999) *Powers of Freedom: Reframing Political Thought.* Cambridge UK: Cambridge University Press.

Russell, B. (1945) *A History of Western Philosophy.* London: Allen & Unwin.

Shapin, S. & S. Schaeffer (1985) *Leviathan and the Air Pump*. Princeton NJ: Princeton Univ. Press.

Snow, C.P. (1959/2001)*The Two Cultures.* London: Cambridge University Press.

Taylor, C. (1975) *Hegel*. Cambridge: Cambridge University Press.

Taylor, C. (2004) *Modern Social Imaginaries*. Durham: Duke University Press.

Toulmin, S. (1990) *Cosmopolis. The Hidden Agenda of Modernity.* Chicago: University of Chicago Press.

Turner, G. M. (2008) *A comparison of the limits to growth with thirty years of reality.* CSIRO Working Paper Series 2008-09. Retrieved from http://www.csiro.au/files/files/plje.pdf

Varoufakis, Y. (2011) *The Global Minotaur: America, The True Origins of the Financial Crisis and the Future of the World Economy*. London: Zed Books.

Vico, G. (1744/1948) *The New Science of Giambattista Vico.* Translated from the third edition (1744) by Thomas Goddard Bergin and Max Harold Fisch. Ithaca, New York: Cornell University Press.

Wright, S. (1994) *Molecular Politics. Developing American and British Regulatory Policy for Genetic Engineering, 1972-1982.* Chicago and London, The University of Chicago Press.

Wyplosz, C. (2010) *The Failure of the Lisbon Strategy.* VoxEU January 12. Retrieved from http://www.voxeu.org/article/failure-lisbon-strategy

Zalasiewicz, J. et al. (2008) «Are we now living in the Anthropocene?» GSA Today. 18(2), 4-8.

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Abstract

This report is the result of work carried out by the Centre for the Study of the Sciences and the Humanities at the University of Bergen, Norway. The work was commissioned by the European Commission's Joint Research Centre at Ispra (Italy), and as such this report is the final deliverable of our Service Contract 257218 with the EC-JRC.

The history of science has a lot to offer to contemporary debates on research policy and on science in society. This is especially true when the history of science is not seen as independent from political, economic and cultural history. This calls for a historical sensitivity also for challenges, problems, conflicts and crises; and such a sensitivity appears to be timely in present-day Europe, where the word "crisis" is taking a predominant place on public and political scenes.

Having argued that the idea that scientific knowledge should determine or prescribe the course of action is in itself part of the 17th century solutions that contemporary society has inherited as part of the problem, the report suggests possible lines of action and reflection for the European Research Area focusing on European values including diversity and tolerance, universalism, democracy and public knowledge.
The report also discusses Grand Challenges and Deep Innovation, reassessing the present function of the ERA, and what policy indicators might be of use.

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