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A historical perspective on the distinction between basic and applied science

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Corresponding Author:	Nils Roll-Hansen, Dr. philos. Universitetet i Oslo NORWAY
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	Universitetet i Oslo
Corresponding Author's Secondary Institution:	
First Author:	Nils Roll-Hansen, Dr. philos.
First Author Secondary Information:	
Order of Authors:	Nils Roll-Hansen, Dr. philos.
Order of Authors Secondary Information:	
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A historical perspective on the distinction between basic and applied science.

Abstract:

The traditional distinction between basic ("pure") and applied science has been much criticized in recent decades. The criticism is based on a combination of historical and systematic epistemic argument. The present paper is mostly concerned with the historical aspect. I argue that the critics impose an understanding at odds with the way the distinction was understood by its supporters in debates on science education and science policy in the 19th and 20th centuries. And I show how a distinction that refers to difference on several epistemic and social dimensions makes good sense of representative historical cases. If this argument is tenable it suggests more continuity in the epistemology and politics of science than has been claimed by a new paradigm of science studies and politics during recent decades.

1. **Introduction**.

Half a century ago, in the aftermath of the Second World War, the distinction between basic ("pure") and applied science was taken for granted in the politics and administration of science. By the early 21st century this and similar distinctions, between science and technology, pure and applied science, etc. have little authority in academic studies of science and appear to be losing ground in practical governing of science, though they are still encoded in standard research statistics and survive as a persistent part of scientists' selfunderstanding and the public discourse about science policy. A new paradigm in science studies takes a broad contextual view of science and likes to treat science and technology as a unity called “techno-science.” It is not surprising that when this inclusive category supplants earlier narrower conceptions of science traditional ideas of “pure” and “value-free” science appear untenable or even absurd. *The New Production of Knowledge* (Gibbons et al. 1994) is a early representative example of this broad contextual understanding of science applied to science policy.

The new paradigm of science studies and the new historical narrative that goes with it has nevertheless met strong resistance and continuing criticism. Most scholarship in philosophy of science as well as large parts of history of science have taken little notice. The conceptual framework of OECD (Organization for Economic Co-ordination and Development) research statistics has been remarkably conservative in the face of continuing criticism from science administrators and academic science studies scholars. This indicates that the traditional conception is more firmly and securely rooted in the culture of science than critics believe. Some recent sociological studies confirm that working scientists generally find the distinction between basic and applied science both understandable and relevant (Bentley, Gulbrandsen, and Kyvik 2016).

The new paradigm has challenged philosophy of science to break out of academic isolation and make the discipline more relevant to contemporary policy issues. In ensuing debates the role of values in science has become a central topic. The charge is that social values play a more fundamental and pervasive role in the production of scientific knowledge than the paradigm of the mid-20th century assumed. According to the traditional ideal science at its core should be governed as far as possible by epistmic values, social values entered as an essential part of its practical applications. The American philosopher of science Philip Kitcher has argued strongly that the distinction between basic and applied has blocked a truly social and democratic governance of science and should be discarded (Kitcher 2004). He has claimed that social significance rather than descriptive truth is the ultimate criterion of valid scientific knowledge, referring to the history of eugenics as evidence (Kitcher 2001, 93-108). In an incisive analysis of the theoretical foundation of science policy American philosopher of science Heather Douglas similarly claims that social values are more fundamental in the production of scientific knowledge than recognized in the traditional ideal of "value free" science (Douglas 2009). In a more recent article she caims that the concept of basic ("pure") science implied by the traditional distinction between basic/applied is inconsistent with the actual history of modern science (Douglas 2014).

The present paper aims to scrutinize some of the historical narratives that the new paradigm have appealed to. To make my own standpoint clear the paper starts with a systematic discussion of the distinction between basic and applied science. It then follows the distinction between pure and applied science from its historical roots in politics of education in earlier centuries through increasing demands for direct practical usefulness in the 20th century stimulated by two world wars and the Cold war. In the 1970s and 1980s a long simmering critique of classical enlightenment ideals of science transformed science studies and created a new ideology of science that seems still to be gaining influence.

2. On the difference between basic (theoretical) and applied (practical) science.

Critics of the traditional basic/applied distinction tend to hold that supporters imply separation and isolation of two kinds of scientific activity. And since this is an unrealistic description both of present and history the distinction is obviously invalid. Kitcher, for instance, has argued that a “context-independent notion of epistemic significance insulates science” from social and moral values and would imply a dangerously amoral science (Kitcher 2001, 65). In justifying this view he describes an “ideal of objectivity” and a “myth of purity” (Kitcher 2001, 29-41, 85-91) which is hardly representative of those who find the basic/applied distinction meaningful and important.

In my view the distinction can be plausibly understood as referring to a conceptual distinction between two ideal types. As generally in empirical social science conceptual distinctions do not refer to exclusive categories of objects, and strict logical analysis has limited relevance. Such concepts referring to combinations of experienced differences can nevertheless describe the world. In this case the conceptual distinction refers to a set of differences in knowledge and in social functions. These differences do not correspond to sharp distinctions and are not necessarily congruent to each other. But despite such vagueness this model can still provide a valid picture of the distinction as it is typically used among scientists and in the general public. With historical as well as present discussions in mind four dimensions of difference can be discerned:

1. Different kinds of knowledge.
2. Different criteria for success.
3. Different social roles and effects.
4. Institutional differences, for instance in degree of autonomy from political authorities and economic interests.

This set of differences does not merely refer to the intentions or attitudes of researchers or patrons as many critics of the basic/applied distinction have argued. They are objective differences referring to the kind of knowledge, the criteria of success and validity, the social effects, and the governance, structure and culture of institutions.

Basic research seeks general knowledge of the world. Its role is theoretical, to improve our understanding, and it has no specific purpose outside of this. Applied science on the other hand is characterized by its instrumental role helping to solve practical problems of society. Adequate scientific competence is a necessary but not sufficient condition. The choice of problem as well as the value of the results is decided by political, economic and social considerations rather than scientific judgement. What is in demand is detailed knowledge of specific situations rather than general knowledge suitable for education.

The criteria of success differ correspondingly. Basic research is successful when it discovers new phenomena or ideas of general interest. The important criteria are epistemic, as inherent in the tradition of the scientific disciplines in question. Relevance to other disciplines is also important. A hall-mark of success in basic research is contribution to our common world picture as described in text-books. In applied research, on the other hand, the primary criterion of success is the solution of concrete practical problems, depending on relevant and accurate knowledge.

Social roles are also different. Applied research is an instrument in the service of its patron. It helps interpret and refine the problems of the patron, make them researchable, and then investigate and develop concrete solutions. Applied research is typically funded by government agencies, private firms, non-governmental interest organizations, etc., to further their respective goals. Basic research, on the other hand is ideally responsible only to common societal interests and values. According to the Enlightenment tradition society as a whole is best served when basic science has a high degree of autonomy, i.e., independence from particular political, religious and economic interests.

As here defined basic and applied research are essentially interdependent both in theory and practice. The distinction does not imply separation and isolation as critics often maintain. On the contrary it is a means to understand how the two overlap, interact and mutually support each other. Applied science provides indispensable social contact and legitimation for basic science. Basic research could not thrive without the data, the new phenomena and the new ideas that applied research discovers. Applied science on the other hand depends on basic science for its cultivation of methodological standards and general theoretical understanding.

Though universities have been a primary home of basic research this is not to say that there has not been thriving basic research in other institutions like academies of science or industrial laboratories, or that university research can generally be characterized as basic research. Historically universities started as professional schools educating people for practical work as clergy, medical doctors, jurists. This connection to practical activities is no less important today and it implies interest in applied research as well as basic. According to official research statistics roughly half of university research activity falls not under basic research but under applied research and experimental development.

Critics of the pure /applied distinction tend to draw their examples of scientific research from applied research and thus overlook the special characteristics of basic research as defined above. An example is Heather Douglas' analysis of inductive risk, the risk of making a false inductive judgement, taking a true claim to be false or a false claim to be true (Douglas 2000, 2009). Her main examples are research on how to handle humanly produced toxic substances in the environment (Douglas 2009, 108-112). The classical paper by Richard Rudner, which she repeatedly refers to, discussed research in industrial quality control and toxicity levels of drugs (Rudner 1953).

As the German-American philosopher of science Carl Gustav Hempel pointed out half a century ago all empirical science, basic and applied, is in principle faced with the problem of inductive risk. But it is in applied science aimed at immediate answers to practical questions that the problem becomes pressing. Such situations also involve disputable social values. Typical cases are tolerance levels for environmental poisons. In Hempel’s view the situation is significantly different for theoretical research with no specific kind of action in mind (Hempel 1965, 93).

Kitcher uses the birth of Dolly, the famous Scottish sheep, by cloning, as a main example against a purely “theoretical” or “epistemic” conception of epistemic significance (Kitcher 2001: 63-82). However, Dolly was part of applied scientific efforts to develop effective methods for cloning of domestic animals, and the intense public interest was obviously due to the uncomfortable possibility of doing the same with humans. The example is thus well suited for demonstrating practical social implications. The inclusion of a typical basic research example would have made the analysis more inmformative and balanced, for instance the discovery of the chemical structure of DNA.

Both Douglas and Kitcher are influenced by American pragmatism. Douglas typically wants to “remain agnostic over the realism issue” (Douglas 2009, 188). Kitcher’s belief in a modest scientific realism has weakened over the years. In a recent paper he admits to have come close to the instrumentalist views of Larry Laudan (Kitcher 2016). The Finnish philosopher of science Ilkka Niiniluoto has taken a different approach to the basic/applied distinction guided by realist intuitions (Niiniluoto 2014).

Niiniluoto agrees that the distinction between basic and applied science is “notoriously vague and ambiguous.” But he still finds it meaningful and well rooted in classical philosophical tradition as well as in present institutional and political practice. Pragmatist and instrumentalist views of science as a problem-solving rather than a descriptive activity tend to blur the classical distinction between cognitive and practical problems (Niiniluoto 2013, 265-266).

In the scheme of Niiniluoto “design science” exemplifies an important kind of applied science.[1] Design sciences like engineering, medicine, business economics, agricultural and forestry science serve specific social missions and professions. Their characteristic knowledge claims have the logical structure of technical norms: “If you wish to achieve A, and you believe you are in situation B, then you should do X” (Niiniluoto 1993, 1). Such claims combine a normative social intention with scientific descriptive knowledge. Considered from the outside they are essentially dependent on disputable social values. But seen from the inside their mission is taken for granted, and they are subject only to epistemic standards. Basic sciences, like physics, chemistry, biology, sociology are descriptive and answer only to epistemic standards and utilities. They make claims about what the world is like, not about how it ought to be (Niiniluoto 2013, 266-267).

American political scientist Donald Stokes has given an analysis of the relation between basic science and technology which has been much referred to. With extensive experience in science policy on the national level he tried to bridge the

[1] His concept draws on Herbert Simon’s *The Sciences of the Artificial* (1969) and Georg Henrik von Wright’s concept of “technological norm” (von Wright 1963).

conceptual gap between basic and applied to help resolve the difficulties of distributing research resources. In addition to "Pure basic research" exemplified by Niels Bohr and "Pure applied research" exemplified by Thomas Edison, he introduced a third category of "Use-inspired basic research" exemplified by Louis Pasteur (Stokes 1997, 73). Pasteur started as a physical chemist, became interested in the physical basis of life and was soon drawn into practical problems of industry and agriculture, and went on to medicine, constantly drawing inspiration from his ideas about the nature of life. His exceptionally broad scope of theoretical and practical achievements from structural chemistry to agriculture and medicine makes him appear as an ideal aim for an integral science policy. Though appropriate on higher levels of science policy this Pasteurian ideal is less relevant on the level of individual projects where criteria depending on the basic/applied distinction become decisive. Stokes does not question this distinction.

3. Roots of the basic/applied distinction in the context of education.

The relationship between theoretical (pure) and practical (applied) science has long been a central question in the history of science education. Recent historical studies have discussed the basic/applied distinction mostly in relation to technological and social developments. The role of theory in teaching at universities and other institutions of higher education has recieved little attention. For instance, applied science is discussed in the context of economy and technology rather than in its educational dependence on general theory.[2] From a practical technological point of view it may be hard to perceive pure and applied science as "participants in a mutually defining dyadic relation" and instead see applied science as independent of pure by "historically *preceding* it"[3]

[2] "Focus: Applied Science." Isis 103 (2012), pp. 515-563.
[3] Emphasis in original.

(Gooday 2012, 547). From an educational point of view this appears natural or even unavoidable.

18th century chemistry is an interesting early example. Growing practical importance of chemistry in agriculture and metallurgy, in addition to the traditional role in medicine, stimulated the development of theoretical principles. Concepts of pure and applied chemistry, *chemica pura* and *chemica applicata*, were articulated and chemistry was introduced as a teaching subject in combination with natural history and national economics in universities of Northern Europe. Chemistry gained recognition as an independent academic subject with professorial chairs not only in medical and philosophical faculties (Meinel 1985).

According to the German historian of science Christoph Meinel 18th century pure and applied chemistry were distinguished by "the social relevance of their research aims." Pure chemistry was aimed at "principles and general laws," applied chemistry was to be "useful for human needs." This did not imply a separation of scientific activities. The theoretical and the practical (experimental) were inseparable aspects of an integral whole. The true chemist needed to master both. It is significant that the distinction between pure ("reine") and applied ("angewandte") chemistry was developed in the context of higher education. The rapidly growing application of advanced chemical knowledge in agriculture and mining/metallurgy was a main force in adapting academic science teaching to social needs (Meinel 1985, 28-29). Debates on how to organize general and higher education to to integrate the theory and practice of the new natural and social sciences continued through the 19th century. British debates are typical and particularly significant for the input they came to give to science policy thinking.

According to the British historian of science Robert Bud (2012) the term "applied science" was introduced in England by the writer and poet Samuel Taylor Coleridge. Inspired by studies of Kantian theories about science in Germany he used this expression as a translation of "angewandte Wissenschaft" in *Treatise on method* published in 1817. He emphasized attention to empirical facts and methods rather than practical applications. But by the 1850s the term "applied science" came to be used as a synonym to "practical science". The London Great Exhibition of 1851 celebrated the social benefits of science and helped legitimate public spending on science because of its practical usefulness. At this time "applied science" was not a category of research but broad label for useful knowledge. In 1852 a new Department of Science and Arts was established with Lyon Playfair, a pupil of the German chemist Justus Liebig, as secretary of science. This new government department embodied the close integration of science and art, in the broad continental sense of arts and craft, and a main goal was the increase of public support for scientific and technological education (Bud 2012…). By the late 19th century support for practical "applied science" had grown so strong that academic scientists found it necessary to warn that science also had a "purely" theoretical aspect. To discover, articulate and teach new theories and facts was a necessary input to continued technological progress.

In a much discussed 1880 essay on "Science and Culture" the British biologist Thomas Henry Huxley emphasized the general cultural value of scientific education. Based on a speech at the opening of Mason College in Birmingham, a new technological institute, Huxley in this essay argued that knowledge of modern natural science was no less important than traditional academic training in classics and literature as preparation for the challenges of modern society. It was in tune with a broad modern humanism when this new institution of higher education concentrated on the former at the expense of the latter. Huxley wished the phrase “applied science” had never been invented because it suggested the separate existence of a purely practical kind of science. Science in his view was a unity of theory and practice. Safe and effective application to practical tasks depended on thorough understanding of the “general principles, established by reason and observation, which constitutes pure science” (Huxley 1888, 20).

Huxley did not want to separate pure from applied science. To the contrary it was their interdependence that concerned him. His worry was an imbalance due to negligence of the pure science aspect. It misses Huxley’s message to claim that he wanted to “relegate applied science to secondary status” as “the mere application of pre-existing pure science” (Gooday 2012, 546). Too much emphasis on competition for resources in present history of science tends to overlook arguments about the general cultural and educational value of cognitive content.

Through the late 19th and early 20th century British debates over pure and applied science continued to be focused on the funding, organization and content of education. The distribution of public support between basic and applied research became a topic of growing interest with the establishing of new institutions specifically dedicated to applied research and technical assistance.

The history of science is a natural arena for reflecting on cultural and social conditions and effects of science. This suggests an important role in general education. The stunning impact of new technology in two world wars greatly stimulated critical attitudes to science and technology. History of science was established as a university teaching subject after World War II (Hamlin 2016). Nagging conscience among natural scientists was an important impetus to self-scrutiny and reflection. “Social responsibility of science” was the driving idea of *The Bulletin of Atomic Scientists* started in 1945.

4. World War I – urgency of applied science.

With World War I came demands for quick practical application of science. In Britain of the Board of Education took initiative to establish a Department for Scientific and Industrial Research (DSIR) in 1916 (Clarke 2010, 289), with the training of scientific specialists as a main concern. This task was mostly in the hands of the universities, which were at the same time the home of pure science. Academic scientists argued with conviction that applied science could not work without thorough grounding in general theory. Thus the pure science of the universities needed more public support if society should continue to harvest the benefits of technological progress after the end of the war. The DSIR was careful to emphasize the strong mutual dependence of pure and applied. Substituting the expression “fundamental research” for ”pure science” was part of this bridge-building effort (Clarke 2010, 288). To DSIR the term “pure” apparently tasted too much of elevated isolation in an academic “ivory tower.”

A characteristic defence of pure science as an indispensable intellectual basis for applied science is found in *Science and the Nation*, a collection of articles published in 1917. Leading academic scientists elaborated on the practical usefulness of their scientific disciplines - chemistry, physics, mathematics, geology, botany, zoology, genetics, physiology, biochemistry, anthropology, etc. The message was that future practical benefits depended essentially on the cultivation and further progress of theoretical knowledge, i.e., on what they called pure science. It is notable how Louis Pasteur, the ideal example of “Use-inspired basic research” according to Donald Stokes, turns up repeatedly as a model hero with his unique combination of theoretical and practical achievements. Pasteur’s success with precise experimental methods loomed large during a war where bacterial diseases still took more lives than the weapons of the enemy.

The overall argument of this volume was similar that of the famous report, *The Endless Frontier*, which the engineer and key wartime science administrator Vannevar Bush wrote on assignment from President Franklin D. Roosevelt toward the end of the World War II. In both cases the purpose was to increase support for basic science, but not to set it up as a separate entity isolated from applied research. F. Gowland Hopkins, himself an internationally prominent pioneer of biochemistry, concluded that financial support alone was not enough. A broader cultural recognition was needed. "Recognition and a proper standing in the body politic" is necessary for society to reap the full benefit of scientists' special knowledge (Hopkins 1917, 255).

Science and the Nation defended pure science as an essential element in the teaching of science as well as in general culture. The worry was that the temporarily justified emphasis on applied at the expense of basic science would continue after the end of the war. The editor underlined in his preface that pure science should not be regarded as "something apart - a purely academic subject." The purpose of the book was to present facts and arguments "to enable the reader to grasp in its true perspective the relation of pure science to applied science" (Seward 1917, p. v-vi).

The volume contained an introduction written by government science advisor, trained physicist and mathematician, Lord John Fletcher Moulton. He is hesitant about the term "pure science" finding it to be "vague and artificial" and hard to understand for the general public. But this does not prevent him from using "pure science" in an appreciative sense. He balances the worries about post-war developments by striking an optimistic tone, not sharing "the fear that so-called Pure Science is in danger of being neglected" (Moulton 1917, ix). Lord Moulton starts by cautioning against sharp distinctions and polemics leading to estrangement. The rest of his introduction surveys the positive role of "pure science" as described for the various disciplines.

Thus it is hardly correct that Moulton "explicitly rejected the terminology of 'pure science'," as British historian of technology Graeme Gooday has claimed. He is right that Moulton did not accept a "dichotomy" or "the separateness of pure science from practicality" (Gooday 2012, 553-554), but neither did the editor or the other contributors to *Science and the Nation*. Gooday imposes an understanding that does not fit the discussions in the book. For example when he claims that the plant breeder Rowland Biffen does not adhere to any distinction between basic and applied science (Gooday, p. 552). Biffen's article on "Systematized plant breeding" is a counterexample rather than a confirmation of this judgement. His contribution is shot through with references to Mendel's principles and Mendelian terminology, representing the theory of biological heredity that was established soon after the turn of the 19th century. Biffen argues that this theory of heredity is confirmed in his own successful breeding of rust resistant wheat, and ends with an optimistic evaluation of the use of "Mendel's principles from the economic point of view" (Biffen 1917, 175).

The so-called Mendelian theory of heredity, as understood by Biffen and his contemporary plant geneticists and breeders, was closely involved with practical breeding. Indeed the principles of early classical genetics, regularly called Mendelism, can be said to have grown out of practical plant breeding in close interaction with botanical science systematic and experimental. The interaction of early genetics with practical breeding of plants and animals is a striking example of the co-evolution of science and technology, or their "co-production" according to presently popular terminology of science studies. By 1917, when Biffen wrote the paper in question, a relatively clear and coherent theoretical understanding of biological heredity had been formulated. The extent to which this theory influenced practical breeding in the early decades of the 20th century, and made it more effective, is controversial. Nevertheless, this appears as a unique case for detailed analysis of the impact of scientific theory on technological practice, an important empirical testing ground for ideas about the relationship between science and technology (Harwood 2015).

In line with Gooday's interpretation of *Science and the Nation* it has been claimed that proponents of "pure science" in late 19th and early 20th century America and Great Britain represented "a moral economy in which knowledge and commerce should not mix" (Lucier 2012, p. 536). I have shown that this was not the message of *Science and the Nation*. The contributors saw precisely such a "mixing" - integration of pure and applied - as a great blessing. Their argument was that success in applied science depended on close contact with pure science, and therefore pure science must not be neglected. The well-known speech by American physicist Henry Rowland at the annual meeting of the American Association for the Advancement of Science in 1883, "A plea for Pure Science," can be interpreted in the same direction. His claim that "(t)o have the applications of science, the science itself must exist" (Rowland 1883, 242) was a polemical answer to short-sighted commercial interests.

5. The socialist challenge of the interwar period.

The lively British 1930s debate on the social role of science is an important source of the ideas that formed science policy through the middle decades of the 20th century, including the classification of research that was adopted by the OECD[4] in 1963 (Godin 2005, 263-266). Marxist theory of science had a strong formative influence on public thinking through the popular writings of radical left wing intellectuals like the physicist John Desmond Bernal, the

[4] The Organization for Economic Cooperation and Development (OECD) was founded in 1961 to promote international coordination of technological and economic development.

mathematicians Hyman Levy, and the biologists J.B.S. Haldane and Joseph Needham. Other left wing scientists like the biologists Julian Huxley and Solly Zuckermann, and the physicist P.S.M. Blackett, with similar views were also influential through direct involvement in government, especially during World War II.

Already before the Bolshevik revolution of October 1917 Russian science was expanding rapidly with emphasis on applied science. The new Soviet regime further underlined the duty of science to serve the technological and economic progress of society. The first five year plan starting in 1929 included crash investment in science and higher education. This made the Soviet Union a pioneer of science policy with large scale public funding. Through the 1930s and 1940s the Soviet example inspired Western ideas on the social role of science. The influence of the Soviet model of “big science” was strong in the 1950s and early 1960s with its impressive successes in nuclear and space science and technology. Bernal was perhaps the most notable populariser of Marxist views about the politics of science. His book *The Social Function of Science* from 1939 had renewed influence in the 1960s and 1970s science policy debates.

In the early 1930s Julian Huxley, biologist and grandson of T.H. Huxley, made a survey of British scientific research in cooperation with the BBC (British Broadcasting Corporation). One result was *Scientific Research and Social Needs* (Huxley 1934) containing a series of discussions with prominent scientist colleagues. In the introductory conversation, “Raising the Issues,” with the mathematician Hyman Levy, Huxley defended pure science with arguments similar to those of *Science and Nation.* Levy promoted the Marxist view that science through technology must serve the common social good. But he also accepted the distinction between pure and applied science as a starting point for the discussion. And they agreed that the objective nature of methodologically well-founded scientific results gives science a universal character, though the validity of specific scientific claims is never independent of language and other concrete cultural circumstances. "(T)he conclusions of science in a very real sense reaches beyond the limits of the social system which gave them birth," explained Huxley (p. 19). Bernal (1939), like Levy and Huxley, accepted the pure/applied distinction as part of the natural frame for discussing the social function of science. They all held in high regard the enlightenment ideal of science, as expressed in Robert Merton's "ethos of science" (Merton 1938).

Huxley in the concluding conversation with Levy admitted that any sharp dividing line between pure and applied science "is merely arbitrary, and that often you cannot draw it at all." But, nevertheless, "research *can* be at very different degrees of remove from practice; and it is useful to be able to classify the different kinds of research" (Huxley 1934, 253). It is notable how Huxley here changes from the broad terminology of "science" to the more specific "research." Scientific research is a special kind of scientific activity and thus easier to categorize. This narrowing of focus can be seen as a shift away from general cultural and educational concerns toward technological and economic. Science is becoming a motor of social change rather than a cultural foundation of modern liberal democratic civilization.

In conclusion Huxley defined four categories of scientific research. The first two, "*background* research" and "*basic* research" make up "what is usually called 'pure science'." The third is "*ad hoc* research" with specific practical problems in mind, and the fourth is "what industry calls *development*, or *pilot* research" (Huxley 1934, 253). This schema of categories, presumably representative of contemporary discussions, was picked up by Vannevar Bush in *Science: The Endless Frontier*, where he proposed a National Science

Foundation (NSF) to take care of basic research in the United States. In cooperation with government and business schools scientists the NSF, after it was finally established in 1950, developed categories and procedures for statistics on the input of resources to R&D (research and development) that were used in OECD "Frascati Manual" of 1963 (Godin 2005, 262-272).

Both Kitcher and Douglas in their dicussions of the basic/applied distinction pay little attention to the development of these concepts in science policy debates of the 1930s and 1940s which fed into their application in OECD research statistic in the 1960. They refer to Vannevar Bush' *Science: The Edless Frontier* but without sufficint context for an adequate interpretation.

6. **OECD research statistics.**

Since the 1960s the OECD has collected statistical data on research according to a classification where distinctions between basic research, applied research and experimental development are central. Through the following half century this classification has remained "essentially unchanged" (OECD 2015: 43). In view of the persistent criticisms and the great economic, political and social changes this stability is remarkable. A pragmatic technical/administrative reason is that statistics needs long and consistent time series to be useful. But the stability also indicates an underlying continuity in the nature and social role of science in spite of the changes, and the OECD classification appears to represent a robust compromise consensus. In any case it is a natural benchmark for discussions of the basic/applied distinction, but this is widely neglected in the science studies literature.[5]

[5] Douglas (2009, 2014) and Kitcher (2001, 2004) do not discuss the OECD R&D classification. Other publications like Gibbons et a. (1994), Guston (2000), Nowotny et al. (2001), Nordmann et al. (2011) likewise gives little if any attention. Stokes (1997) and Niiniluoto (2013), however, explicitly discuss the it.

In the 2015 version of the OECD manual for collecting research statistics the definitions are presented as follows:

> The term R&D covers three types of activity: basic research, applied research and experimental development. **Basic research** is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. **Applied research** is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective. **Experimental development** is systematic work, drawing on existing knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products and processes (OECD 2015: 45).

The context of presentation in OECD documents has changed, however, reflecting increasing attention to the general social effects of R&D, and to the growing need for distinguishing R&D from innovation in a wider social sense (Godin 2015). This is reflected in an elaboration of the definition of Experimental development.[6] Also the interpretation and use of the whole scheme has varied between countries. Some have not used the differentiation into three categories, but only presented data for total R&D. Among notable defectors are Great Britain and Sweden, while for instance the US and Norway have been loyal.

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[6] According to the 1981 edition of the Frascati Manual: "Experimental development is systematic work, drawing on existing knowledge gained from research and/or practical experience that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed" (OECD 1981, p. 25).

The four dimensions of difference between basic and applied science discussed in section two of the present paper accord well with the OECD definitions: Basic research is concerned primarily with “knowledge of the underlying foundation of phenomena and facts,” which seems an apt characterization of theoretical knowledge of general interest; and in contrast applied research aims for knowledge “directed primarily towards a specific, practical aim or objective.” These two definitions point to different kinds of knowledge, general and specific, and indicate the difference in criteria of success, social roles, and institutions, that were discussed in this section. As I emphasised this is not merely a question of intentions held by funding agencies or researchers. The differences are objectively present in the nature of knowledge, the culture and the social institutions of science, as well as its social effects.

The OECD distinction between basic and applied research has been criticised for being vague and subjective. It has been argued that the distinction is dependent on subjective attitudes of the researcher and the patron, that individual projects include both basic and applied research and do not comfortably fit either category, and that the balance often shifts as a project develops. Over time a statistics built on so subjective and flexible categories is thus likely to reflect changing fashions rather than real change in research activities, critics have argued. But as noted above the OECD classification is based on long time experience with research statistics and involvement with practical politics of science. It also appears that present day scientists find the distinction reasonably easy to understand and apply (Gulbrandsen and Langfeldt 2004, Gulbrandsen and Kyvik 2010).

At first OECD was most interested in natural sciences and their applications in industry, agriculture and medicine. But from the 1970s the system increasingly included the social sciences and the humanities. These latter fields do not easily fit the British-American concept of "science", though they are well covered by the continental European term "Wissenschaft". The difference between natural sciences on the one hand and the humanities and social sciences on the other were elaborated especially in German philosophy of the late 19th and early 20th century. The latter did not aim for explanation in terms of universal laws and causality. Their aim was understanding ("Verstehen"). Knowledge in the humanities was typically embodied in accounts of individual phenomena and events and has been called "idiographic" (individually descriptive) as opposed to "nomothetic" (lawlike).[7] The feeling of being pressed into alien and unsuitable categories has motivated criticism and resistance in the humanities to the OECD definitions of basic/applied/experimental development. By the early 21st century this criticism has less force. As biology has displaced physics as the leading natural science the ideal of scientific knowledge as knowledge of universal laws has given way to more limited generalizations and explanation in terms of mechanisms. And the importance of conceptual development in close interaction between direct experience and theorizing has emerged as a basic feature in the natural science, much like in the humanities and social sciences.

In spite of scholarly criticism and political-administrative doubts the expression "basic research," and implicitly a distinction between "basic" and "applied", seems to be indispensable in debates over science policy. There is a widespread feeling that "basic research" designates a valuable social activity in need of defence against commercialization and political/bureaucratic control. In a survey based on interview with scientists and policy-makers Jane Calvert has shown how ambiguous the term "basic research" is and how the meaning shifts with user and context. However, she thinks this vigorous flora of different meanings and definitions also indicate how "resilient and necessary the term must be."

[7] The classical locus for this distinction is philosopher Wilhelm Windelband's inauguration speech as rector of the Kaiser-Wilhelm-Universität Strassburg, 1. May 1894.

Apparently the "basic research" of OECD statistics has continued to monitor changes over time as well as differences between countries in a consistent and useful way (Calvert 2004, 263- 265).

By the mid-1990s the conservative OECD schema was vigorously challenged. *The New Production of Knowledge*, sponsored by Swedish science policy establishment (Gibbons et al. 1994, viii), is a salient example. This study is still a main reference in science policy literature. It distinguishes two different ways of doing scientific research, "Mode 1" and "Mode 2." The first stands for traditional academic and discipline-oriented research and knowledge. Mode 2 is "different in nearly every respect;" it "operates within a context of application" and is "transdisciplinary rather than mono- or multidisciplinary" (Gibbons et al. 1994, vii). The thesis of the book is that Mode 2 is expanding and gradually swallowing Mode 1 to create a comprehensive system of techno-science amalgamating the research of academic institutions, industry and government (Gibbons et al. 1994, 11-16). In a follow up some of the same authors developed the epistemic aspect. Instead of traditional academic and discipline based knowledge there will be "socially robust knowledge" adapted to existing social and political circumstances. It will be a situation where "the epistemological core is empty" (Nowotny et al. 2001, 166-178,199). The pursuit of this science policy agenda has continued (Gibbons et al. 2011, Rip 2011).

In accordance with this outlook most of present science policy studies are focused on the social behavior of individuals and groups, and on the dynamics of social structures rather than the cognitive content of the science. With this social perspective it is natural that the most interesting product is social welfare/harm/change rather than new knowledge. In other words a shift from scientific research to social innovation.

6. The myth of the "ivory tower"

The Mode-1 to Mode-2 theory of development in science is an example of current ideas that sciene is undergoing a radical change with profound implications for future society. For instance, historian of physics Paul Forman has depicted a movement through the last hundred years from "the primacy of science in modernity", through "technology in postmodernity," to "ideology" in the coming age (Forman 2007). And philosopher of science Alfred Nordmann has envisioned an "epochal break" no less profound than the "scientific revolution" of the 17th century (Nordmann 2011). The coming of "techno-science" and the disappearance of politically significant differences between basic and applied science is common to these visions. There is nevertheless persistent doubts about the historical adequacy of the narratives appealed to (Schiemann 2011).

Present criticism of the basic/applied distinction often depicts theoretical academic science as isolated from the rest of society, as if in an "ivory tower." Such criticism of academic science as isolated and irrelevant to real social problems became popular in the early decades of the 20th century. It was characteristic of Soviet science policy (Bucharin 1931) as well as of influential pragmatist ideas about science in North America and Western Europe (e.g., Dewey 1927, 174f). Attacks on the academic "ivory tower" revived in the 1960s and 1970s. They are echoed in present criticism of basic science as deaf to moral, social and political values, and thus an irresponsible social actor. The criticism does indeed address real and important problems of 21st century science, but it is mostly too abstract and general to communicate well with working scientists' views and arguments.

As shown earlier in this paper some of the most important defenders of basic science and research through the 19th and 20th centuries by no means shared the ideology of an isolated and "pure" theoretical science, as assumed by the critics (e.g., Kitcher 2001, 65-66). Closer scrutiny of issues and arguments in past controversies does not support the claim that "the pure vs. applied distinction is both artificial and implausible from the perspective of historical examination" (Douglas 201, 62). To the contrary historical examination reveals how a different conception, close to the common sense of working scientists, has shaped the institutional structure and culture of scientific activities.

In his influential and thought-provoking book *Science Truth and Democracy* Kitcher poses three rethorical questions to distinguish a modest scientific rationalism from the misleading scientism of "the scientific faithful":

> Can we really make sense of the idea that sciences have a single definite aim? Can we draw a morally relevant distinction between science and technology? Can we view the kind of knowledge achieved by the sciences as having overriding value? (Kitcher 2001, 9).

The answer to the first and the last question is obviously "no." It is indeed hard to make sense of the idea that all sciences should have "a single definite aim." And similarly, what should it mean for scientific knowledge to have "overriding value"? Overriding common sense knowledge, or overriding moral values? To answer "no" to the second question, however, would directly contradict the argument of the present paper.

In support of his view Kitcher has developed an argument for "Constraints on Free Inquiry" based on "epistemic asymmetry" (Kitcher 1997; 2001, 93ff). In politically highly charged situations like the sociobiology-debates of the 1970s the optimistic belief in freedom of scientific research as a motor in social progress is not dependable, argues Kitcher. It can in fact be detrimental for efforts to achive social equality and justice. He sets up a thought experiment: If anti-egalitarian prejudices, conscious or unconscious, are widespread and strong, scientific results that are supportive, but not decisive, for racial equality are likely to be neglected, while contrary results, equally indecisive, will be perceived as proof for anti-egalitarian views. In such a situation there will be not only a political asymmetry, but also an epistemic asymmetry. People will actually believe the world accords to the anti-egalitarian claims, even if the evidence does not stand up to thorough methodological criticism. Under the pressure of general public opinion even scientific experts will be vulnerable to bias: "The greater receptivity of the lay community for announcements of inegalitarian findings itself contributes to the epistemic bias within the academic group" (Kitcher 1997, 302). In such a situation "(t)here is no chance of any genuine benefit for the underprivileged." From their perspective the "utility" of pursuing research on racial differences is "clearly negative" (Kitcher 2001, 98).

This argument is plausible with respect to applied research with direct practical motivation, but the situation is not the same for basic research with a long term perspective and more distance to practical use. That applied research on human genetics is and should be governed and to some extent restricted by political authorities is hardly controversial. Basic genetic science on the other hand is the basis of our most reliable knowledge about racial differences. Since the 1930s genetic science has increasingly confirmed that they are most likely negligible with respect to IQ and other socially important biological characters (Broberg and Roll-Hansen 1996, Roll-Hansen 2009). This illustrates the importance of making a distinction between short and long term perspectives in the politics of science, i.e., between basic and applied science. Kitcher's thought experiment presupposes confidence in this knowledge of basic genetic science.

Disregard of the difference between basic and applied science undermines proper use of historical evidence. For instance the claim that “a wealth of historical studies” demonstrates that human behavioural genetics in general is burdened by an epistemic asymmetry (Kitcher 2001, 99) is problematic. What is to be the yardstick for epistemic asymmetry and illegitimate beliefs without some kind of differentiation between applied and basic science? To hold that “a sober review into the history of research into racial and sexual differences” supports the argument for epistemic asymmetry, “and thus any attempts to read that history differently embody just that epistemic bias that the argument diagnoses” (Kitcher 2001, 106) looks like begging the question.

Historically the autonomy of science has been important for defending science against illegitimate political interference. For instance, in the case of Lysenkoism in the Soviet Union, the autonomy of science was systematically played down by the so-called practice criterion of truth (Roll-Hansen 2005). To reject autonomy of science as “an unfortunate hang-up from our past” (Kitcher 2004, 56-57) can be risky also in present politics of science. The historical experience with suppression of scientific autonomy and freedom under Nazi and Communist dictatorships of the mid-20th century is more than “a few bits of anecdotal evidence” derived from “a book on Lysenkoism, a biography of Einstein, and so forth” (Kitcher 2004, 56). It is too simple to claim that science policy in the Soviet Union is totally irrelevant Kitcher’s ideal of a democratic “well-ordered science” (Barker and Kitcher 2013, 145-148). This claim overlooks a complex and more interesting story: Modern Western policy of centrally governed big science was pioneered by the Soviet Union in the interwar period to become a model for the West after World War II. This policy gave the Soviet Union stunning successes, for instance, in atomic weaponry and space research, as well as the fiasco of Lysenkoism. Playing down the distinction between basic and applied science, the difference between science and technology, was a central principle of this Soviet science policy (Roll-Hansen 2005, 2015). The academic "ivory tower" was a guiding metaphor in Soviet politics long before it became obquitous to Western debates in the 1960s.

When asked about Niiniluoto's conception of the basic/applied distinction, Kitcher answered that he had quite different concerns: " I was interested in undermining a standard defense of insulating certain kinds of research against critiques that invoke ethical, social, and political values" (Kitcher 2011b, 376). He did not see the history of this distinction in defending science against illegitimate political interference as relevant for his own project of a well-ordered and democratically governed science (Kitcher 2001, 2011a).

8. Concluding remarks

Critics of the distinction between basic and applied science tend to make it sharp and categorical. Philip Kitcher, for instance, describes basic science in the traditional understanding as aiming for "a particular kind of truth, a kind scientists seek at all times, whatever practical projects they" and argues that such a "context-independent notion of epistemic significance insulates science" from social and moral values and would imply a dangerously amoral science (Kitcher 2001, 65). I have shown that on closer scrutiny the historical examples that he appeals to are contrary rather than suportive of such claims.

Heather Douglas similarly concludes that "the pure vs applied distinction is both artificial and implausible from the perspective of historical examination" as well as lacking in "philosophical reason" (Douglas 2014, 62). I fully agree with this conscious turn to historical cases to found an accurate and relevant philosophy of science. The discipline is completely dependent on valid references to past and present scientific practice. However, I find that her account of the basic/applied distinction and its origins in 19th and 20th century (Douglas 2014, 57-61) builds to a considerable extent on untenable historical interpretations (e.g., Bud 2012, Gooday 2012 and Lucier 2012). Douglas takes more or less for granted that the basic/applied distinction of 20th century science politics implied the so-called linear model; namely that knowledge flows in one direction from basic science to applied science to technology. The claim that Vannevar Bush's 1945 report, *Science: The Endless Frontier*, represented the linear model and inspired the domination of this model in following decades (Douglas 2014, 61) has long been criticized by leading historians of technology and science policy: "The Linear Model Did not Exist" (Edgerton 2002).

I have also pointed out that results of a number of empirical sociological investigations are contrary to the Mode 2 thesis and the associated criticism of the basic/applied distinction. Recently a survey of attitudes in 15 countries, Western as well as Eastern, finds that "basic research continues to be sustained as a major activity" (Bentley et al. 2016, 691). It remains a guiding ideal for university strategies as well as a strong internalized norm at the individual level. Thus "basic research retains a core position within the research mind sets of most academics." The study adds that this does not support "policies striving for clearer separation in the higher education landscape between institutions primarily doing basic research and others applied" (Bentley et al. 2016, 705). This conclusion, with the added warning, accords well with my claim that critics like Douglas and Kitcher rely on a misinterpretation of the basic/applied distinction as it has been routinely used among working scientists up to the present.

Finally, I would like to emphasise the educational aspect. Lacking interest in the educational role of basic science is a serious weakness of current discussions over basic and applied science. As described in this paper the distinction had its origin in institutions of higher education. The importance of basic or "pure" science as a foundation for teaching, not least the teaching of future practicioners of engineering, medicine, law, administration, social services, etc., was central to the discussions through the 19th and early 20th centuries. Present debates over academic autonomy and scientific freedom and scientific can benefit from reflecting on this history.

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Athor's contact details.

Nils Roll-Hansen
IFIKK
University of Oslo

e-amil: nils.roll-hansen@ifikk.uio.no