



Council for Science and Technology

IMAGINATION AND UNDERSTANDING

**A Report on
the Arts and Humanities in relation to Science and
Technology**

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EXECUTIVE SUMMARY

1. This report is about the relations between the arts and humanities and science and technology. The role of the Council for Science and Technology is to provide the Prime Minister with independent advice on strategic issues concerning science and technology, and we have worked on the present study during our programme in 2000/01.
2. Science and technology policy, like all other public policy, is about the future of society. The greatest challenges for UK society — globalization, inclusion (or the development of a society in which all individuals are or can be included in the process of reflecting on, participating in, and evaluating change), and the impact of science on society — are all ones in which the arts and humanities and science and technology need each other, and are needed in public discussion.
3. Life-long learning requires confidence in relation to science, to the arts, and to the connections between them. Individuals need to have a basic confidence in their capacity to adapt to future, changing circumstances, in their working lives, in their lives as consumers, and in their lives as citizens.
4. In the circumstances of modern society and the modern global economy, the concept of a distinct frontier between science and the arts and humanities is anachronistic. Successful economies depend increasingly on the creation, communication, understanding and use of ideas and images.
5. The arts and humanities are an outstanding part of UK research. They also contribute in multiple ways to the nation's prosperity and well being. They provide the foundation for the cultural, heritage, and tourism industries, as well as for the “creative industries” more generally, and for “art-science-technology” activities such as computer music or image synthesis. Universities are themselves a major, highly successful UK industry, in which the arts and humanities have a very substantial role.
6. Overall, we are encouraged by the present situation, and by the Government's developing research and education policies. The Arts and Humanities Research Board (AHRB) is well established, and its first years of operation have been widely recognised as successful. The National Endowment for Science, Technology and the Arts is already taking educational and other initiatives across the frontiers of science and the arts. The recently established Science Enterprise Centres have been welcomed, and provide valuable skills for science and technology graduates.
7. We consider that the relationships between the arts and humanities and science and technology need to be strengthened further. Education is about understanding and imagination, as well as about training and skills. Yet school education in the United Kingdom, especially for 16 to 18 year olds, is still highly specialised. Large numbers of science students have very little opportunity to study arts and humanities subjects, and large numbers of arts students study very little science. The organisation of higher

education is entering a period of substantial change, in which there will be an opportunity to encourage a more diverse undergraduate curriculum.

8. Many of the most exciting areas of research lie between and across the boundaries of the traditionally defined disciplines. But the present organisation of research funding, with six Research Councils and the AHRB, has a number of disadvantages. It is likely to discourage imaginative interdisciplinary research.

9. Our conclusions and recommendations include:

- Universities and government should give serious consideration to encouraging broader programmes of undergraduate instruction, both in the sciences and in the arts and humanities.
- The government should encourage the provision of training in information and communications technology for arts and humanities students. We support the Nuffield Inquiry's recommendation that technological potential should be “fully exploited in language teaching and learning.”
- The government should continue with its efforts to facilitate a less specialised school curriculum, including the consideration of additional elements of a Baccalaureate system. We urge universities and other higher education institutions to play a constructive role in encouraging diversity in the secondary school curriculum.
- We recommend that the Science Enterprise Centres programme be extended to include the arts and humanities.
- Government should engage the arts and humanities more fully in the discussion and implementation of national and international research priorities.
- We urge the government to ensure that arts and humanities research has access to the infrastructure (computer equipment, language instruction, library resources) required to participate in outstanding scholarship and outstanding innovation.
- We recommend that the Arts and Humanities Research Board should now develop into a UK wide Arts and Humanities Research Council.

REPORT

Introduction

1.1 The idea of a distinct frontier between science and the arts is a largely European invention, of the mid Victorian period. The use of the word “science” to denote only “physical and experimental science” was described in the 1860s as new, and particularly characteristic of “Englishmen.”¹ The conflict between the two cultures, scientific and artistic, has been a subject of intense discussion at least since the 1880s, when T.H.Huxley deplored the “pretensions of our modern Humanists to the possession of the monopoly of culture”, and Matthew Arnold said of the preponderance in the London University matriculation examination of mathematics, natural philosophy and chemistry that “it is a ridiculous thing.”²

1.2 This report is about the relations between science and technology and the arts and humanities, in the very different circumstances of the 21st century. It was prepared by a sub-group of the Council, consisting of Javaid Aziz, Vicki Bruce, David Potter, and Emma Rothschild, and chaired by Emma Rothschild. The sub-group are grateful to the Foreign and Commonwealth Office, the Department for Education and Skills, the Department for Culture, Media and Sport and its Creative Industries Task Force, the Arts and Humanities Research Board, and many individuals and organisations (see Annex) for suggestions, comments, and information.

1.3 The Council is charged with providing advice about science and technology. Our conclusion in this report is that the relations between the arts and the sciences — in education, in research, in innovation and industry, and in society — are of substantial and increasing importance to science and technology. It is in the interest of science and technology that archaic divisions between the arts and sciences should be questioned, and reduced.

Technology and Economic Change

1.4 The long industrial expansion that began in the early 19th century was based on the use of “inanimate sources of energy in the production process.”³ It was associated with large increases in productivity in agriculture, transport, and manufacturing, and with the successive growth of the railway, electrical, motor vehicle and chemical industries. The industrial expansion of our own epoch is very different. Less than 20 percent of the labour force is employed in the traditional goods-producing industries of agriculture and manufacturing, in the United Kingdom as in the United States, Canada and other developed industrial countries.⁴ Less than 50 percent of the income of households is spent on goods, and the consumption of services is growing faster than income.⁵ The “new economy” of the 21st century is expected to be based in substantial part on the communication of information and on the use of biological knowledge. These functions are as ancient as human society; they are for the first time at the centre of production and consumption.

1.5 Science and technology have shaped the new economy, and the new, global society of the 21st century. But the influence of science and the influence of the arts and humanities are far more difficult to distinguish now than they were in the 19th century manufacturing economy.⁶ The process of production in the industries where most individuals in the UK now work — business services, education and health, retail and wholesale trade, public and community services, tourism and entertainment — uses specialised knowledge which is based on the arts, humanities and social sciences as well as on the natural sciences and engineering.⁷ The process of innovation in the industries which are expected to play a leading role in the new economy — information technology, multi-media communications, medical services using understanding of the human genome — is a matter, in many cases, of cooperation at the frontier between arts and humanities and sciences.

1.6 The vast social transformations of the late 20th and early 21st centuries are similarly difficult to classify. The globalization of communication, investment and consumption has been made possible by scientific and technological innovation. But it is a globalization of images and ideas, of music and language, as much as of physical production. The construction of European Union institutions is a product of European history and politics; it has also been transformed by new information technologies. Social inclusion, which is a principal objective of UK government policy, is facilitated by a common language and common understanding, as well as by common information.⁸ The consequences of new medical and environmental technologies can be understood and evaluated only on the basis of cooperation between the natural sciences, the social sciences, and the humanities.

Science and Technology Policy

1.7 Science and technology policy is itself concerned to a striking extent with questions which engage both the sciences and the arts and humanities. The much discussed subject of science education, and of the flow of children and young people into science courses, is closely related to education in subjects other than science, and to flows into arts and humanities courses.⁹ The proportion of women in science is still substantially below the proportion of women in other research fields. The diffusion of innovation, including new technologies of production and new products, is of continuing interest to social scientists. Science in society, which is the focus of so much recent interest, is a subject which engages scientists, social scientists, historians and philosophers.¹⁰ Creativity and communication, two subjects of very recent concern for science policy, are impossible to confine to science and technology alone.

1.8 All of these questions are of interest in many countries other than the UK. There is a debate in Germany, for example, about the predicted sharp decline in the numbers of students in engineering and science subjects, with the number of graduates in engineering, mathematics and natural sciences estimated to fall from 76,000 in 1997 to 61,000 in 2004, while the number of graduates in arts-related subjects will increase from 45,000 to 48,000.¹¹ In Japan, the Science Council is seeking to encourage creativity and individualism in the educational curriculum.¹² The French government in 1998 published a major report (the “Risset Report”, Rapport de mission Art-Science-Technologie) on the institutional means to

encourage cooperation between the creative arts and scientific and technological research in such fields as electronic music and image synthesis, identified as important sources of innovation in the rapidly expanding cultural industries.¹³ The Dutch government's Advisory Council for Science and Technology Policy made recommendations in a 1997 report about ways to increase the use of knowledge from the humanities and the social sciences in the “traditionally science dominated sectors”, and about the “art of innovation”; the Danish government's recently established Information Technology University has as one of its objectives to encourage links between arts and humanities and science and technology.¹⁴

1.9 The UK — with exceptional strengths in arts and humanities research, and with a lasting tradition of dispute over the “two cultures” — is in an excellent position to contribute to these global discussions. We believe that to do so is in the interests of British science and technology.

Education

2.1 The division between the scientific and the literary or artistic cultures has been associated, at least since the 1880s, with the peculiarities of the educational curriculum, especially in England. The capacity to communicate across this division — or to invent new relationships between the sciences and the arts and humanities in which the division itself becomes less stark — can be encouraged (or discouraged) in every phase of the educational system.

2.2 Recent studies of attitudes to science suggest that children's interests in science begin to change from the age of 9. Even young pupils “draw a clear, unfavourable distinction between school science on the one hand and the value and relevance of science and technology to their lives on the other.”¹⁵ T.H.Huxley imagined that the curiosity of young children would be engaged by learning about the moon and the earth, and Matthew Arnold believed that “the knowledge of nature is interesting” to everyone.¹⁶ But school science is perceived as “authoritarian or dogmatic”, according to one recent survey, a matter of learning facts, with little opportunity for reflection and discussion, “in contrast to other subjects such as English and History.”¹⁷ These differences in ways of thinking are in no respect peculiar to the United Kingdom, or indeed to the sciences. Within arts and humanities subjects, for example, the teaching of foreign languages was described in the recent Nuffield Languages Inquiry as “desperately inadequate”, and only 20 percent of primary schools provide language learning.¹⁸ The Qualifications and Curriculum Authority (QCA) is in its recent work providing guidance on “ways to promote pupils' creativity”, especially in the curriculum for 5-14 year-olds, with an emphasis both on the arts and on science, seen as a “creative process” (“asking questions, testing ideas, describing images, discussing issues”). It is investigating the extension of language teaching in primary schools. The “Science Year” to be launched in September 2001 will explore “innovative ways of linking science to other curriculum areas.”¹⁹ We welcome these initiatives, and we encourage the QCA to further develop cooperation with groups in other countries working on similar programmes.

Specialisation in Secondary Education

2.3 Education for 15-18 year-olds in the United Kingdom is highly specialised by comparison with almost all other countries. The French Baccalaureate requires instruction in “mandatory core subjects”, including French, another modern language, history, physics, biology and mathematics. The German Abitur requires instruction in each of three main subject areas, languages, literature and arts, social sciences, and mathematics, natural sciences and technology.²⁰ The International Baccalaureate requires study of humanities, of at least two languages, science, maths, and of theories of knowledge.²¹ High school education in the United States includes required courses in English, social studies, and mathematics until grade 12 (age 18), and in science until grade 11.²² The reform of the GCSE examinations in England and Wales and the introduction of the National Curriculum is “designed to ensure a broad mix of study for all young people”, and has had a substantial positive effect over the past decade in reducing over-specialisation. The proportion of 15 year olds passing GCSE science, for example, increased from 71 percent in 1992/3 to 82 percent in 1997/8.²³

2.4 The post-15 curriculum is still strikingly specialised. Of university entrants in England in 1975, some 18,200 had taken only science and mathematics A levels, 16,500 had taken only arts, humanities and social science A levels, and 7,900 had taken mixed A levels. By 1993, the number of students who had taken science subjects was virtually unchanged, the number who had taken only non-science subjects had increased to 26,300, and the number who had taken mixed A levels had increased to 25,300. The increase in students following mixed courses is encouraging. But it is still the case that more than 60 percent of all university entrants had taken either no science or no arts subjects in the final 2 years of secondary education; almost 40 percent had studied no science subjects.²⁴ Of the 215,000 17 and 18 year-olds who achieved one or more A/AS passes in England in 1999, almost 70 percent had taken either no science subjects or no arts subjects, and 52 percent (including 60 percent of girls) had taken no science subjects.²⁵

2.5 The changes introduced in the AS curriculum in England and Wales in 2000/1 can be expected to encourage a more diverse course of study, and one that is closer to the system of Highers in Scotland (which is itself now in the process of reform.)²⁶ We encourage the government to continue with its efforts to facilitate a less specialised curriculum, including the consideration of additional elements of a Baccalaureate system. We recognise that change in the post-15 curriculum can be introduced only slowly, and should not take the form of imposing additional requirements, at the expense of extra-curricular and non-examination activities. It should not interfere, in particular, with the reflective education whose objective is to give students the opportunity not only to learn, but to ask the right questions. We also recognise that universities have a major impact on secondary and further education, through the design of courses of instruction and through admissions policies. If universities continue to require highly specialised A-level achievements in addition to GCSE and AS results, particularly in relation to science and engineering courses, then a more diverse curriculum will simply place additional demands on students and teachers. We urge universities and other higher education institutions to play a constructive role in encouraging diversity in the secondary school curriculum.

Towards Diversity

2.6 University education in the United Kingdom, as in most European countries, is largely an education in a single or double (or triple) subject: English, Physics and Mathematics, Biology and French, Philosophy, Politics and Psychology. There are exceptions. In Scotland, a substantial proportion of university courses begin with a year of instruction in different subjects. Keele, the first new UK university of the 20th century, which was founded in 1962 to promote “interdisciplinary scholarship” and a “broad educational programme”, requires that all undergraduates “study some science and some humanities or social science.”²⁷ The proportion of students in multiple degree subjects has increased in the 1990s. But the presumption which is at the heart of undergraduate education in North America — that education is a matter of instruction in “knowledge, intellectual skills, and habits of thought”, as well as training in a particular academic discipline — is the subject of continuing scepticism in many UK universities.²⁸

2.7 The major research universities in North America expect that undergraduates will follow a mixed course of instruction for much of the first 2 years of a 4 year degree. The “Core Curriculum” of Harvard University, for example, requires that all undergraduates take courses in Foreign Cultures, Historical Studies, Literature and Arts, Moral Reasoning, Quantitative Reasoning, Science, and Social Analysis.²⁹ The “General Institute Requirements” of the Massachusetts Institute of Technology undergraduate course include Science, Writing, and eight subjects within the Humanities, Arts and Social Sciences.³⁰ The Harvard curriculum is described as “both a requirement and a philosophy”, and its aims are different from the department or discipline-based emphasis on “key skills” which is now being introduced in several subjects, with the oversight of the Quality Assurance Agency, in UK universities. The objective of the Harvard curriculum is to “introduce students to major approaches to knowledge”; the objectives of the MIT programme include “awareness of concepts, ideas and systems of thought”, as well as “communication, both oral and written”, and, as a “fundamental value”, “competence in foreign language.” The ambition, that is to say, is that students in computer science, for example, should learn something about how historians look at evidence, or that students in the humanities should learn something about the underlying philosophy and methodology of physics.

2.8 The organisation of undergraduate education in UK universities and colleges is entering a period of substantial change, associated with the growth of modular courses, of cooperation with other European universities, of distance and web-based learning, of foundation degrees, of 4 year first degree courses, of postgraduate professional courses, and of postgraduate specialised courses both in the sciences and engineering and in the humanities.³¹ We urge that universities and government give serious consideration (in this period of transition) to encouraging broader programmes of instruction, both in the sciences and in the arts and humanities. Such programmes need not be based, as in North America, on an extension of “requirements.” But they should provide more space, and encouragement, in university courses for reflection on the nature of the discipline or disciplines studied, and their relation to wider interests.³²

2.9 Education is about understanding and imagination, as well as about training and skills. Science undergraduate courses are sometimes described, like school science, as routine, a matter of learning facts, a 9 to 5 job, providing little opportunity for discussion. A more diverse university education, and one in which science and technology students have more opportunity to study arts and humanities subjects, and to reflect on their own disciplines, might encourage a different view. It might also help to attract more students into science. The implications of even a modest move towards broader 3-year and 4-year degree courses are substantial, for UK schools, universities, and employers, and for the role of UK education in an increasingly global educational system. They should be discussed seriously in the coming period of change, and should be considered in the review by Sir Gareth Roberts of the supply of scientists and engineers.

Learning and Confidence

2.10 The increase in vocational and professional courses in British higher education is a response to the demands of employers in the 1980s and 1990s for graduates with specialised training.³³ But employers have also been concerned with “personal qualities/ interpersonal skills”, with work experience, and with the capacity to communicate, learn, and adapt to changing circumstances.³⁴ One of the few certainties of the new economy of the 21st century is that predictions of future innovation, and of future employment, will continue to be uncertain. Employers must try to anticipate the qualifications that they will seek in their labour force in 5 or 10 years' time; a successful education system must try to anticipate the vocations and capacities of individuals in perhaps 40 or 50 years' time. An education which introduces students to different ways of thinking and different approaches to knowledge is likely to encourage the qualities which will be of lasting importance over a lifetime of employment.³⁵

2.11 There are new opportunities for cooperation between the arts and humanities and the sciences in providing instruction in professional and vocational skills. Training in information and communications technology is less readily available to arts students than to students in science and technology. The Nuffield Language Inquiry concluded that “technology opens an extraordinary range of new possibilities” in language learning and communication, which it identifies as a key skill in a competitive world economy. We urge the government to encourage the provision of training in information and communications technology for arts and humanities students, and we support the Nuffield Inquiry's recommendation that technological potential should be “fully exploited in language teaching and learning.”

2.12 The recently established Science Enterprise Centres have been widely welcomed, and provide valuable skills for science and technology graduates. The arts-based industries, including museum, concert and theatre management, also have an urgent need for individuals with communication, design and layout and business skills.³⁶ In several innovative activities, including e-publishing, design and electronic music, collaboration between arts and humanities and science graduates is well-established. We recommend that the Enterprise Centres programme be extended to include the arts and humanities.

2.13 The ideal of life-long learning is as old as universal public instruction.³⁷ In the learning opportunities of the 21st century, which are an important objective of government policy, the exercise of individual faculties will require instruction both in the arts and humanities and in science and technology. The new facts which “everyone ought to know” are in part a matter of scientific understanding, or of familiarity with new technologies, including the technologies of learning itself, whether face-to-face, distance, or web-based. But a modern democratic society is also one in which all citizens are expected to have opinions about major political, social and economic choices, and in which public participation in these choices and discussions is itself a major source of social responsiveness, and resilience. The modern economy is one in which the increase in leisure, and in the proportion of one's life which one can expect to spend in “retirement”, has very substantially increased the demand for entertainment, culture, and travel. One objective of lifelong learning is to ensure that all individuals acquire and preserve a basic confidence in their capacity to adapt to future, changing circumstances, in their working lives, in their lives as consumers, and in their lives as citizens. It is an objective which requires confidence in relation to science, to the arts and humanities, and to the connections between them.

Research

3.1 The arts and humanities are a large and highly successful part of UK research. 20 percent of all “research-active staff” evaluated in the most recent Research Assessment Exercise were in fields (“units of assessment”) which are now under the aegis of the Arts and Humanities Research Board. 31 percent of staff in departments which were ranked as of international standing (5 and 5*) were in these fields.³⁸ Their success was achieved with modest resources. The arts and humanities accounted for only 6.7 percent of all public funding for civil research in 1998-9.³⁹ Their share of research funding was 4.4 percent, when the government's own civil research is included, and still lower with the inclusion of research funded by foundations.⁴⁰

3.2 Research in the arts and humanities, and in library and information science, is funded through the higher education funding councils, and through the Arts and Humanities Research Board (AHRB) which was established in 1998, following the recommendation of the Dearing Report on higher education for an Arts and Humanities Research Council. Research in science and technology, which is defined to include the physical, natural and environmental sciences, engineering, and the social sciences including economics and psychology, is funded through the higher education funding councils, and through the six Research Councils. This definition of “science”, like all others, poses a number of problems. It is rather more capacious, for example, than that used by the National Science Foundation in the United States. “Wissenschaft”, in German, is by contrast a very much wider concept, which denotes the systematic creation or shaping of knowledge; the Federal Ministry for Research, Science and Technology and the Deutsche Forschungsgemeinschaft (DFG) in Germany support research in the humanities, arts and social sciences, as well as in the natural sciences and engineering.⁴¹ The Centre National de la Recherche Scientifique in France (CNRS), which is the major institution for publicly funded research, includes the humanities and social sciences (“sciences de l'homme et de la société”).

3.3 The first years of operation of the AHRB, which was established with funding from the British Academy and the Higher Education Funding Council for England (HEFCE), to which the devolved funding agencies including the Scottish Higher Education Funding Council (SHEFC) have contributed, have been widely recognised as successful. The AHRB's Research Grant and Research Centre Competitions have provided project funding for research in the arts and humanities, and have attracted a large number of outstanding applications. The AHRB also provides support for infrastructure out of its overall budget, currently of £52 million per year, and has developed funding collaborations with the Research Councils and with European and other funding bodies.

3.4 The present organisation of research funding, with six Research Councils and one "Board", has a number of disadvantages. The AHRB is funded by separate contributions from the British Academy, HEFCE, SHEFC, the Northern Ireland Executive Department of Higher and Further Education, Training and Employment, and the Higher Education Funding Council for Wales, and thus obtains much of its resources from budgets which are devolved, under the provisions of the devolution Acts of 1998, rather than reserved. The participation of Scotland and Wales in the first year of the AHRB's activities was delayed because of differences in the requirements of the different funding councils, and similar difficulties might arise in future. The present arrangements also have an awkward relationship to the dual support system, the oversight of which is one of this Council's responsibilities. Under the dual support system, the funding councils support the infrastructure for research (including the salaries of academic staff), while the research councils and other funders contribute to the costs of specific projects; the AHRB, which provides project funding in the arts and humanities, is itself supported by the funding councils.

Arbitrary Distinctions

3.5 A more profound difficulty with the present organisation of research funding is that it may perpetuate the archaic distinctions between different forms of knowledge which were the point of departure for the present report. The discontinuity between "science" and "non-science", for example, or between Research Council and non-Research Council subjects, is located in the middle of the disciplines of linguistics, economic history, archaeology, design, and information science. One of the most important functions of the Research Councils is to contribute to the formation of national and European research strategies, and of priorities or themes for research which is expected to be of economic and social as well as scholarly importance. The development of research policy would be strengthened by the participation of the arts and humanities in these discussions, including the discussion of new information and communication strategies, and of their consequences for UK and global society.

3.6 The Research Councils have the function of facilitating interdisciplinary research on subjects of national or international importance. In this respect, too, the institutional distinction between scientific and non-scientific disciplines is likely to be unhelpful. The conception that all research or scholarship can be located along a single spectrum, from more "scientific" to less "scientific", is itself outmoded in the new circumstances of the 21st

century; so is the related conception of a spectrum of research from very “pure” to very “applied” (about which T.H.Huxley complained in 1880.)⁴² The collaboration between arts and sciences, in particular, is likely to involve creativity in diverse or non-contiguous research fields. The Engineering and Physical Sciences Research Council (EPSRC) thus found in its recent competition for interdisciplinary research collaboration in information technology that proposals “to a striking extent” involved cooperation with the visual arts.⁴³ Some of the more “applied”, and apparently less “scientific” fields under the aegis of the AHRB, including design and performing arts, have formed successful relationships to physics and engineering. Some of the scientific writings which have been most widely read — which have become part of a public culture — have been concerned with extremely “pure” subjects in cosmology and number theory.

3.7 The understanding of the social and ethical consequences of new medical technologies, which is widely recognised to be of profound importance for both social and economic development, is likely to require extended collaboration between scholars in the humanities, including history, philosophy and literature, the social sciences, the life sciences, and medicine. A recent study of interdisciplinary research supported by the EPSRC, the Economic and Social Research Council and the Natural Environment Research Council identified “problems of language and methodological differences” as a major disadvantage for interdisciplinary research in environment and health, and “recognising the validity of different types of knowledge and approaches to research problems” as a major advantage; the participation of the arts and humanities is likely to strengthen the design and the implementation of interdisciplinary research.⁴⁴

Research and Economic Change

3.8 Research in the arts and humanities is involved in multiple ways in the economic future of the UK. Universities and their research and scholarship are in the first place a highly successful and internationally competitive UK industry, in which the arts and humanities have a very substantial role. Scholarship in the arts, humanities, and social sciences, like scholarship in science and mathematics, is of national and international value for many different reasons. It is (or can be) a way to understand the world, and to improve the human condition.⁴⁵ But it is also at the heart of one of the largest of all global industries, and an industry which is expected to grow rapidly in the coming decades, and to be transformed radically by new technologies.

3.9 The arts and humanities provide the foundation for the cultural, heritage, and tourism industries which the French government's Rapport AST describes as a vast market on which technology will have a “decisive, fundamental impact”, and which in the UK constitute a large and rapidly growing economic sector.⁴⁶ The History Channel is based on the scholarship of historians, the National Gallery's education and publications on the scholarship of art historians and conservation scientists, and Shakespeare on the Web on the scholarship of literary critics.

3.10 Arts and humanities research is of continuing importance to the “creative industries” in a wider sense, including entertainment, design, software, advertising, and publishing, which the Department for Culture, Media and Sport's Creative Industries Task Force estimates to employ more than 1.3 million people, with revenues of some £112 billion per year.⁴⁷ “Art-science-technology” activities — electroacoustic and computer music, image synthesis, the use of computer simulations in garden design, the synthesis of colour and light, graphic animation — are of growing economic importance; they are activities in which the UK has highly innovative programmes, including the Wellcome Trust's Science and Art project and the British Council's CultureLab-UK, and where UK universities, from the Queen's University Belfast Electronic and Computer Music Studio to the University of Birmingham Electroacoustic Sound Theatre, and from the University of Brighton's programmes in computing, art and design to the Crucible initiative in art, science and design at the University of Cambridge, have substantial strengths.⁴⁸

3.11 There is a further and even more general economic role of research in the arts and humanities. If the new economy is a “disruptive and radical change” associated with information and communication, then the relationship between the arts and humanities and the sciences is at the very heart of future economic growth.⁴⁹ “The realm of the mind”, as the President of Harvard University has said in recent remarks about developments in neuroscience, is “exactly the place where the humanities and the arts become crucial and indispensable.”⁵⁰ The humanities are concerned with a reflective and disciplined inquiry into forms of human self-understanding, and they are thereby of continuing importance for the expression and communication of individual and collective identities.⁵¹ The MIT Media Lab, which began in 1985 as a cooperation among university researchers in cognition, electronic music, graphic design, video, architecture and holography, is now a major centre for international innovation, with projects from printed PCs to early childhood learning and “affective computing.”⁵² The ATR Media Integration and Communications Research Laboratories in Japan support research on art and technology, on conversation, and on facial expressions.⁵³ The CNRS department of humanities and social sciences in France cooperates with other departments in programmes on information and communication, on the history of climate change, on engineering and the science of language, and on property rights in immaterial goods.

An Arts and Humanities Research Council

3.12 The institutional separation of project funding in the arts and humanities and the sciences in the UK is likely to discourage imaginative research of this sort. It may also limit the access of arts and humanities research (including research in areas such as information science and design) to capital funding. The arts and humanities were not included in the Joint Infrastructure Fund, and they are not included in the recently announced Science Research Investment Fund. We urge government to engage the arts and humanities more fully in the discussion and implementation of national and international research priorities, and to ensure that arts and humanities research has access to the infrastructure (computer equipment, language instruction, library resources) required to participate in outstanding scholarship and outstanding innovation. In the course of the next Spending Review, a study should be undertaken into the funding needs of arts and humanities research infrastructure, as has

already been done for the science and technology infrastructure in previous reviews. We also urge the government to engage the arts and humanities more fully in the discussion and implementation of national and international research priorities. The AHRB should become a formal member of the Science and Engineering Base Co-ordinating Committee, and should participate in meetings of the Research Council Chief Executives. The Office of Science and Technology (OST) should convene meetings of all the principal funding bodies, including the Arts Council and the National Endowment for Science, Technology and the Arts (NESTA), which is itself concerned with both the arts and the sciences, and which can contribute substantially to cooperation with which this report is concerned.

3.13 The Dearing Report recommended in 1997 that “a new Arts and Humanities Research Council (AHRC) should be established as soon as possible.”⁵⁴ In the past four years, the AHRB has been widely welcomed, and the cultural, creative and art-science-technology industries have become the subject of increasing interest, in the UK and elsewhere. Research funding and research student stipends in the arts and humanities will increase in the coming years. CST endorses the suggestion of Universities UK and several other bodies that the AHRB should now develop into an Arts and Humanities Research Council.⁵⁵ The consequences of this development for relations between the Research Councils, DfES, and the British Academy should be examined in the course of the current Quinquennial Review of the Research Councils.

Communication

4.1 The great industrial and consumption booms of economic history have been associated with very general functions or needs; clothing, transport, heating and illumination. The function which is most widely associated with the new economy of the 21st century is the communication of ideas, images and knowledge. The function is not itself new, and it was indeed much discussed during the 18th century globalisation of what E.A. Wrigley has called the “advanced organic economy.”⁵⁶ The novelty, in the early 21st century, is that these old activities are at the centre of economic production.

4.2 The new economy is associated with communication within enterprises and organisations, as well as with the consumption of ideas and images. It is a revolution in the productivity of business services; “a radical and disruptive change in the way businesses are structured, how they organize themselves, where competitive advantage lies, and how the resulting economy operates.”⁵⁷ Communication is in this sense a matter of the confidence to exchange ideas and information within offices, across differences of educational or national or technical culture, within different languages and ways of thinking. The capacities sought by employers in the new economy, as elsewhere, include interpersonal communication skills, adaptability, the confidence to learn how to learn.

4.3 One of the historic roles of government has been to facilitate investment in the infrastructure of communication or transportation: canals, roads, ports, airports, telecommunications, the internet, optical networks. The new challenge for government, in the global circumstances of the 21st century, is to find ways of encouraging the capacities of

individuals to communicate (of investing in the “human capital” infrastructure of communication.) This is in part the role of education. But it is a new role, in several respects, in which the relationship between the arts and sciences is of critical importance.

Conversation and Communication

4.4 The arts and humanities are not a capital stock of expertise in communications. On one view of the relations between the two cultures, the arts and humanities will be the providers of content (words, or images), and the sciences and technology will be limited to the role of providing means of distributing this content. On another view, the sciences and technology will be the sources of economic and social change, and the arts and humanities will be limited to the role of commenting on this change, or of providing instruction in “communication skills”. The relationships with which we have been concerned in this report are rather ones of exchange and cooperation.⁵⁸ But the arts and humanities are engaged with language in a much more intense respect, in general, than are the sciences.⁵⁹ They have a peculiarly important role, for this reason, in helping to shape the new communication society. They also have peculiarly demanding responsibilities, including in relation to the increasingly serious crisis in the UK of instruction in foreign languages and cultures, in which the very ubiquity of the English language (or languages) in the new global society has proved to be a cost as well as a benefit.⁶⁰

4.5 Creativity in the arts and the sciences, the economist and psychologist Herbert Simon has written, is an extension of the “usual processes of human thinking,” and it should not be dissected, on the basis of a “romantic view” of two distinct forms of human thought, holistic or artistic versus analytic or scientific, into “two kinds of human being, each with our specialized ways of thinking.” “We can have a common discourse about our ways of thought,” Simon writes, and a common conversation about specialized knowledge. A “curriculum for liberal education” to encourage this common discourse would include the study of processes of thought and communication, and of ways of understanding the feelings and experience of others; “literature, together with music and painting, can be our laboratories of empathy.” Skills of “questioning, interpretation, translation, and popularization” are in short supply in contemporary technological society. But they are of critical importance to the “common conversation that is so essential if we are to continue to conduct our affairs and make our important public decisions in a reasoned and, above all, a democratic way.”⁶¹

4.6 Science and technology policy, like all other public policy, is about the future of society. The greatest challenges for UK society — globalization, inclusion (or the development of a society in which all individuals are or can be included in the process of reflecting on, participating in, and evaluating change), and the impact of science on society — are all ones in which the arts and the sciences need each other, and are needed in the formation of government policy.⁶² The ethical, legal and social implications of genetic discovery are of “comparable importance” to the scientific achievements, *Nature* concluded in its presentation of the draft sequence of the human genome, and they require understanding, wisdom, and the involvement of society.⁶³ One danger for the “intensely

modern world”, Matthew Arnold wrote in 1882, is that science will “give us other pieces of knowledge, other facts... but still it will be knowledge only which they give us.” What he hoped for, then, was knowledge in relation to individual and social choices, and to lucidity.⁶⁴ This is still one of the justifications for science and technology policy.

LIST OF RECOMMENDATIONS

Specialisation in Secondary Education – Paragraph 2.5

The government should continue with its efforts to facilitate a less specialised curriculum, including the consideration of additional elements of a Baccalaureate system. We urge universities and other higher education institutions to play a constructive role in encouraging diversity in the secondary school curriculum.

Towards Diversity – Paragraph 2.8

Universities and government should give serious consideration to encouraging broader programmes of undergraduate instruction, both in the sciences and in the arts and humanities.

Learning and Confidence – Paragraphs 2.11 and 2.12

We urge the government to encourage the provision of training in information and communications technology for arts and humanities students, and we support the Nuffield Inquiry's recommendation that technological potential should be “fully exploited in language teaching and learning.”

We recommend that the Science Enterprise Centres programme be extended to include the arts and humanities.

An Arts and Humanities Research Council – Paragraphs 3.12 and 3.13

Government should engage the arts and humanities more fully in the discussion and implementation of national and international research priorities.

We urge the government to ensure that arts and humanities research has access to the infrastructure (computer equipment, language instruction, library resources) required to participate in outstanding scholarship and outstanding innovation.

We recommend that the Arts and Humanities Research Board should now develop into a UK wide Arts and Humanities Research Council.

ANNEX

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Professor Sir David Watson	Director, University of Brighton
Professor David Westbury	Vice Chancellor, University of Birmingham
Mrs Patricia Williams	former Director of Publications, The National Gallery Company
Professor Sir Tony Wrigley	President, British Academy
Mr Andrew Yeates	Director General, British Phonographic Industry

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Notes

1. The Dublin Review for 1867, cited in the Oxford English Dictionary; see Stefan Collini, “Introduction”, in C.P.Snow, The Two Cultures (Cambridge: Cambridge University Press, 1992), pp. xi-xii. On French discussions of the arts and sciences in the early 19th century, see Wolf Lepenies, Between Literature and Science: The Rise of Sociology (Cambridge: Cambridge University Press, 1988).
2. “Science and Culture” (1880), in T.H.Huxley, Science and Education (London: Macmillan, 1893), p. 152; “A Liverpool Address” (1882), in Matthew Arnold, Philistinism in England and America, ed. R.H.Super (Ann Arbor: University of Michigan Press, 1974), pp. 80-81.
3. E.A.Wrigley, People, Cities and Wealth: The Transformation of Traditional Society (Oxford: Basil Blackwell, 1987), p. 45.
4. The share of the agriculture, hunting, forestry, fishing and manufacturing sectors in total employment fell in the UK from 25 percent in 1990 to 19 percent in 1999, and in the US from 21 percent to 18 percent; International Labour Organisation, total employment by economic activity, ISIC-Rev3 categories A, B and D. Calculations of the composition of employment by industry or sector are likely to overstate the shift away from employment in the production of goods. Business services, one of the industrial sectors where employment has grown most rapidly in the 1990s, thus employ individuals in occupations related to goods production and research and development, which were in earlier decades characteristic only of the manufacturing sector. The tendency to “out-sourcing” of both goods and services has become more pronounced over the period, in part because of new information technologies. But the share of goods production in total employment, as measured both by occupation and by sector, has fallen substantially in all OECD countries in the late 20th century. In the UK, the traditional manufacturing and agricultural production occupations accounted for less than 15 percent of all employment in 2000; All in Employment by Status, Occupation, and Sex, figures for Standard Occupational Classification 110, 16, 51-58, 80-86, 89-91 as a share of total employment.
5. In the US, the share of services in personal consumption expenditure increased from 33 percent in 1950 to 48 percent in 1980, 55 percent in 1990 and 58 percent in 2000; National Income and Product Account Table 2.2, available at <http://www.bea.doc.gov/bea/dn/nipaweb>; comments of Professor Sir Tony Wrigley, CST meeting at the Royal Society of Arts (RSA), 12 September 2000.
6. The amusements of the rich which Adam Smith described in the Wealth of Nations -- “profuse and sumptuous” meals, music and dancing, “ingenious trinkets”, the “amusement of reading in the newspapers” about distant events, “all sorts of dramatic representations and exhibitions”, “the study of science and philosophy” -- are now objects of mass consumption; Adam Smith, An Inquiry into the Nature and Causes of the Wealth of Nations (1776) (Oxford, 1976), pp. 346, 796, 920; Sir Tony Wrigley, comments to the Parliamentary University Group on the contribution of the humanities and social sciences to the economy, February 2001.
7. Employment in wholesale and retail trade; hotels and restaurants; renting, research, computer

and other business activities; public administration and defense; education, health and social work; and other community, personal and social services accounted for 58 percent of the total UK workforce in 1987, and 65 percent in 2000; Table B12, Employee Jobs by Industry, in Labour Market Trends (November 2000.)

8. Comments of Professor Paul Langford at the RSA meeting.

9. On science education, see the Council for Science and Technology's Report, Science Teachers (2000).

10. On recent initiatives, including the Report by the House of Lords Science and Technology Select Committee, Science and Society, and the Royal Society's Science in Society Committee, see Anniversary Address by the President Sir Aaron Klug (Royal Society, November 2000), pp. 4-5.

11. Data published in "Fächerspezifische Prognose der deutschen Hochschulabsolventen bis 2004", Statistische Veröffentlichungen der Kultusministerkonferenz 145 Juni 1998, ISSN 0937-4566. KMK (Standing Conference of Education Ministers) statistics, available at <http://www.kmk.org/>

12. See 1999 Japanese Government Policies in Education, Science, Sports and Culture: Educational Reform in Progress, at <http://www.wp.mext.go.jp/eky1999/>

13. See <http://www.education.gouv.fr/rapport/risset>

14. <http://www.awt.nl>, advice nr.29, study nr.10; http://www.it-c.dk/pub_uk

15. CST, Science Teachers, pp. 27, 52.

16. "Literature and Science", p. 60.

17. Science Teachers, p. 52; the conclusions are based on a report prepared by J. Osborne and S. Collins of King's College, London.

18. <http://www.nuffield.org/language/news>; response of the government to the Inquiry.

19. "Curriculum Development Issues", information provided by the DfES; response of the government to the Nuffield Inquiry.

20. EURYBASE, "The Education System in France" (1999), "The German Education System" (1999) available at <http://www.eurydice.org/eurybase/Application/eurybase.htm>

21. The objective of the study of theories of knowledge is to "stimulate critical reflection on knowledge and experience gained inside and outside the classroom": www.ibo.org

22. See US Department of Education, The Condition of Education 2000, available at <http://www.nces.ed.gov/pubs2000/coe2000>

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23. Science Teachers, p. 54.
24. See <http://www.cst.gov.uk/cst/sged2985.htm/ANNEXA>
25. DfEE, Statistics of Education, Public Examinations GCSE/GNVQ and GCE/AGNVQ in England 1999, Table 19.
26. On the “Higher Still” agenda in Scotland, see <http://www.scotland.gov.uk/library/documents-w2/hsl-00.htm>
27. These objectives have been important since the initial foundation of the university as the University College of North Staffordshire in 1949; <http://www.keele.ac.uk/university/>
28. Description of the principles of undergraduate education taken from <http://www.courses.fas.harvard.edu/~core/index.html>
29. <http://www.courses.fas.harvard.edu/~core/index.html>
30. <http://web.mit.edu/acadinfo/undergrad/charts/girs>
31. First degree courses, “typically lasting 3 years”, are at present considerably shorter in the UK than in several other countries: “In the US and Japan, they are typically 4 years long, in France 5 years and Germany 6 years”; DfEE, AS:HEESI 2, p. 31.
32. Discussion at the CST consultation meeting on May 8; comments of Professor Stefan Collini.
33. Sir David Watson, “The ‘Educational Dividend’: Higher Education, Expansion, Employment and Economic Development”, presentation at seminar on “Higher Education Funding Policies in the UK and the US”, Colorado Springs, December 1999.
34. DfEE, “Research into Employer Views and Concerns.”
35. In professional education, including management education, several universities now emphasise learning to learn. “The pace of change is so great that if you try to teach at the cusp of a wave, you'll find society will have moved on by the time you have your course set up”, Professor Jeffrey Garten, dean of the Yale School of Management has said recently; “what the world needs are business people who are versatile and have a palpable enthusiasm for learning”; Financial Times, 26 February 2001.
36. Comments of Mrs Patricia Williams, National Gallery Publications, at the RSA meeting; Department for Culture, Media and Sport.
37. The number of things everyone ought to know is increasing “without cease”, and there is no age at which it is not possible to learn, the French mathematician and philosopher Condorcet wrote in the early 1790s, proposing a universal system of adult instruction for women and men. The effect of such a system would be to make it possible for all citizens to “exercise their faculties, to preserve their powers or flexibility”, and, above all, to learn how to learn, or how to

“instruct oneself.” “Sur l’instruction publique”, “Fragment de l’histoire de la Xe époque”, in M.J.A.N. Condorcet, *Oeuvres* (Paris, 1847-1849), vol. 6, pp. 587-591, vol. 7, pp. 258-259, 452-456.

38. AHRB analysis of the 1996 Research Assessment Exercise. The fields included are Law; American Studies, Middle Eastern and African Studies; Asian Studies; European Studies; Celtic Studies; English Language and Literature; French; German, Dutch and Scandinavian; Italian; Russian, Slavonic, and East European Languages; Iberian and Latin American Studies; Linguistics; Classics, Ancient History, Byzantine and Modern Greek Studies; Archaeology; History; Library and Information Management; Philosophy; Theology, Divinity and Religious Studies; History of Art, Architecture and Design; Art and Design; Communication and Cultural and Media Studies; Drama, Dance and Performance; Music.

39. *SET Statistics 2000*, Tables 3.1, 5.3. The cost of doing research (in equipment, training, laboratory facilities per researcher) is much higher in many scientific and technical disciplines than in the arts and humanities.

40. *SET Statistics 2000*, Tables 3.1, 5.3. Comparable figures for private funding are not available. But they would undoubtedly reduce further the share of funding going to the arts and humanities. Of the major foundations which support research, only the Leverhulme Trust provides large-scale support to the arts and humanities. The Arts and Humanities Research Council’s budget in the current year is £52 million; the Wellcome Trust alone spent more than £110 million on medical research in 1998/9.

41. One of the major consortia providing private support to research in Germany, the *Stifterverband für die Deutsche Wissenschaft*, thus translates its name as the Donors’ Association for the Promoting of Sciences and Humanities in Germany; <http://www.stifterverband.de/tasks.html>

42. “I often wish that this phrase, ‘applied science’, had never been invented. For it suggests that there is a sort of scientific knowledge of direct practical use, which can be studied apart from another sort of scientific knowledge, which is of no practical utility, and which is termed ‘pure science.’ But there is no more complete fallacy than this. What people call applied science is nothing but the application of pure science to particular classes of problems”: Huxley, “Science and Culture”, p. 155.

43. Communication of Professor Richard Brook, Chief Executive, EPSRC; the “research objectives being identified by the EPSRC in the physical sciences and engineering touch almost inevitably upon wider cultural dimensions, where the arts and humanities would be able to provide valued comment and, indeed, co-operation”.

44. Royal Geographic Society, *Interdisciplinary Research: Approches, Pitfalls, and Funding* (May, 2000), pp. 5-6. See also, on the difficulties posed by traditional funding structures to “adequately supported, interdisciplinary, collaborate research,” Appendix 3, prepared by John Laver, in the Dearing Report, <http://www.leeds.ac.uk/educol/ncihe>

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45. On the nature of understanding in the humanities, see Neil L. Rudenstine, President of Harvard University, “Commencement Day Address, Harvard University, June 4 1998”; Colin Lucas, Vice Chancellor of Oxford University, “Don't drive the humanities to join the dole queue”, The Daily Telegraph, 28 February 2001.
46. See <http://www.education.gouv.fr/rapport/risset>, “Enjeux économiques”; Appendix 3, prepared by John Laver, in the Dearing Report, <http://www.leeds.ac.uk/educol/ncihe>
47. Department of Culture, Media and Sport, Creative Mapping Document 2001, pp.10-11.
48. On the Crucible programme for research in interdisciplinary design, including projects on collaboration and ownership in the digital economy, and on virtual reality reconstruction of baroque theatre, see <http://www.crucible.cl.cam.ac.uk>
49. David Potter, “The New Economy: Fact or Fantasy?” (The Worshipful Company of Traders: Tacitus Lecture, 2001).
50. Rudenstine, “Commencement Day Address.” Neuroscience cannot on its own provide an understanding of the concept of mind or mental functions; the biological sciences are concerned with “complex processes such as development, cognition, and evolution, as well as communication, learning”, which “lie as much in the sphere of the humanities as the natural or social sciences.”
51. Comments of Professor Stefan Collini.
52. <http://www.media.mit.edu>
53. <http://www.mic.atr.co.jp/research/index-e.html>
54. Dearing Report, Recommendation 29, following paragraphs 11.45 to 11.57; <http://www.leeds.ac.uk/educol/ncihe>
55. Those commenting on the establishment of an Arts and Humanities Research Council, since the Dearing Report's recommendation, include Universities UK, the respondents to the HEFCE consultation on the Review of Research, and the President of the Royal Society; information from AHRB.
56. The Italian poet and philosopher Giacomo Leopardi described the early 19th century as a world of “markets and offices,” and of commerce “from Boston to Goa”; of “statistics, economic, political and moral sciences, portable encyclopedias, manuals,” in which the “philosophy of newspapers” was destroying all other thought. E.A.Wrigley, Continuity chance and change: The character of the industrial revolution in England (Cambridge, 1988); Jan de Vries, “The Industrial Revolution and the Industrious Revolution”, The Journal of Economic History, 54, 2 (June 1994); Giacomo Leopardi, Zibaldone di pensieri, quoted in Emma Rothschild, “La mondialisation en perspective historique: L'Amérique hyper-puissance” (Paris: Université de tous les savoirs, 2001).

57. Potter, "The New Economy".

58. Comments of Professor Sir Howard Newby.

59. In several humanities disciplines, language, literature and written evidence are the principal object of scholarship; in many, creativity ("research") is inextricably intertwined with the "very process of writing"; see Collini, "Introduction", p. lix.

60. About 80 percent of the Web was in English in 1997; the proportion is estimated to fall to 40 percent in 2001; David Crystal, "Weaving a Web of linguistic diversity", The Guardian Weekly, 25 January 2001.

61. Herbert A. Simon, "Creativity in the Arts and the Sciences," The Kenyon Review & Stand Magazine, "Cultures of Creativity: The Centennial Celebration of the Nobel Prizes," vol. 23, No. 2 (Spring 2001)/vol 2(4), 3(1) (March 2001), 203-220.

62. "People are more likely to be creative if they have been taught the virtues of perspective, proportion, reflection and consideration, and have some broader picture of society and humanity; and also if such admirable qualities are not derided in the name of a mistaken utilitarianism"; comments of Professor David Cannadine, Institute of Historical Research, University of London.

63. "Initial sequencing and analysis of the human genome", Nature, vol. 409 (15 February 2001), p. 914.

64. "Literature and Science", pp. 55, 65; "A Liverpool Address" (1882), in Philistinism, pp. 84-88.