Miltos Ladikas · Sachin Chaturvedi
Yandong Zhao · Dirk Stemerding *Editors*

Science and Technology Governance and Ethics

A Global Perspective from Europe, India and China

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Foreword

Science and Technology is evident in every aspect of modern life for most humans. We can hardly work, communicate, travel or even eat without the crucial support of some modern technological development. This is true whether we live in the developed or the developing world. The overall dependence we have developed on modern science and technology is both significant and terrifying, as it has reached high levels of intimacy in our lives. The terrifying part of this intimacy derives from our inability to either understand or control it, and the difficulty we are having in setting common rules of engagement. But such "rules of engagement" are the cornerstone of our relationship with modern science and technology that come under the term of "ethics" and this is exactly the theme of this book.

Europe has taken great leaps towards common research policies in the last 30 years. I was fortunate to have been involved in developing the European Union's science and technology strategy in the last decades and the creation of the European Research Area. The European Research Area was successful in boosting the EU's (and beyond) science and technology output but also significantly, it opened the door to global collaborations. The tremendous opportunities that global partnerships bring are not without problems though. Hard as it is to develop common ethical rules within the close-knit European societies, our new global partners have brought in new approaches, new perspectives and new values to our debates. It is clear that, if we are to have meaningful collaborations with our global partners, we need to promote common debates on the ethics of science and technology.

This book represents one of the first efforts to undertake a global debate in an analytic and multidisciplinary manner. It discusses ethics from a comparative perspective and focuses on the relevant debates in Europe, China and India; these are the two principal partners for Europe at present and doubtless more so in the future. Discussing the ethics of science and technology amongst these three key global players is proper and significant.

I applaud this effort and I am looking forward to seeing more of such endeavours in the future. We recently had a workshop at the European Parliament where we had the chance to discuss some of the results presented in this book.

The discussion was lively and informative and we all agreed in the end that if there is a single message to take home it is this: We all face similar issues, challenges and debates; there is a way to find common resolutions and create meaningful and responsible global approaches to science and technology; this can only happen if we continue the effort and stick together. So, let's stick together!

Philippe Busquin

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Chapter 1
Introduction: Embedding Ethics in Science and Technology Policy—A Global Perspective

Miltos Ladikas, Sachin Chaturvedi, Yandong Zhao and Dirk Stemerding

1.1 Introduction

Ethics is important. No one doubts this. Yet no one knows with certainty what ethics is. Since historical records began, the question of what ethics is or what it means to live 'ethically' has been akin to the well-known eternal riddles about the origins of humanity and the will of God (or the gods) for humankind. From the Vedic scriptures to the teachings of Confucius and the philosophical debates of ancient Greece and Rome, questions on ethics have been asked and answers have been given in different forms and shapes, some evidently in direct contradiction. And the debates are continuing with the same intensity and urgency as ever.

This book is about ethics, but it does not try to answer any of the basic questions that have tormented humanity for the past 3,000 or 4,000 years. It has a much more modest aim that is also quite important in its own area, as it focuses

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on a unique feature of modern societies: technological developments. Never before have technologies reached such a level of penetration in people's everyday lives or been used so widely by citizens from every walk of life. Rich and poor, young and old, educated and unschooled, male and female—everyone uses modern technologies and everyone is deeply influenced by them. The effect that technologies have on our psychological and physical functioning is unprecedented and has reached high levels of intimacy (van Est 2014). Therefore questions on ethics in science and technology developments are crucial and urgent: How ought we to view new technologies? How are we to control their effects? On what should we base our thinking and decisions on technological developments? Whom should we rely on to advise us?

These are some of the questions that became the focus of analysis for the European Commission-funded project Global Ethics in Science and Technology policy (GEST), which ran from 2011 to 2014.[1] The main aim of GEST was to analyse the concepts and issues surrounding ethics in science and technology in Europe and the two main technology-intensive emerging economies of China and India, in order to create a robust global debate that directly informs science policy.

China and India are strong contenders in the production of science and technology, new ideas and knowledge. They make up roughly half the world's population and one fourth of its economic output, and there is little doubt that both contributions will increase significantly. Europe, India and China are at different stages of economic and social development, but all face similar challenges with regard to ethics issues in science and technology.

In Europe, and in the West in general, scandals associated with scientific misconduct and food technologies have been publicized and debated in recent decades, resulting in a series of policy initiatives, and similar debates have taken place in China and India. In China, for instance, recent public controversies in areas such as scientific misconduct, food safety and public health have proven to be a catalyst for science and technology debates (Xie 2013). These controversies have raised a host of ethics issues, highlighted limitations in science and technology governance and also eroded public trust in science (Zhao and Ma 2009). This has increased calls for debates on policy-making processes that incorporate socioethical considerations alongside economic ones. Similarly, India is seeing debates on new technological developments, with contributions from lay people and stakeholders alike, triggered by scandals in clinical trials and the introduction of genetically modified crops. Views on the ethical and social implications of science and technology are increasingly being discussed as part of the standard approach to assessing the implications of new technologies, and processes of wider consultation are gaining policy acceptance (Chaturvedi 2013; Mashelkar 2008).

[1] The project was funded by the European Commission's Seventh Framework Programme under grant agreement 266592 (see http://www.uclan.ac.uk/research/environment/projects/global_ethics_science_technology.php).

1.2 The Project's View of Ethics

During the past two decades, with debates on ethics in science and technology developments reaching a level of public significance, it has become clear that the meaning of the term 'ethics' is at best debatable. What is an ethical consideration for some people might be considered an economic matter by others, and when it comes to deeply held values on life, in many instances it is even more difficult to separate opinion from dogma, or belief from religious prescription.

The chorus (some might call it a cacophony) of voices in ethical debates has abated somewhat in recent years, as more and more lay people have found a common voice to express opinions that cannot easily be accommodated within standard belief systems, whether ideological or religious. Debates have become less 'expert' and more 'open' to participation by groups or individuals that do not necessarily claim any particular expertise in the scientific subjects under discussion, but are nevertheless persuaded that their voice is as valid as those of the experts. Whether this constitutes a revolutionary step in science and technology debates is the business of future historical analysis. At present, while some argue that ethical debates have crystallized in a form that allows unconditional input from experts and lay people alike through means that range from typical opinion surveys to atypical participatory policy discussions, others claim that dynamic new forms of public participation are required to avert a crisis of international governance regarding new and emerging technologies (Grunwald 2007; Owen et al. 2012; Stilgoe et al. 2014).

It is for this reason that GEST has adopted a view of ethics as a non-disciplinary, public area of social interaction that encompasses a plethora of forms of expression. Our definition of 'ethics debate' is thus:

> A common platform for deliberation and discussion of values in society that is based on perceptions of right and wrong, is influenced by cultural norms, and aims at informing policy making.

The emphasis on 'perceptions of right and wrong' pertains to the need to acknowledge the importance of public perceptions in the debate, regardless of their origin (e.g. religious vs. secular). Public perception research, whether quantitative or qualitative, is nowadays an integral part of the ethics debate around any new science and technology development. What has been termed 'lay morality' is often even more evident in debates than the opinions of expert ethicists, and no decision can easily be taken in direct opposition to public sentiment (see Decker and Ladikas 2004).

The influence of cultural norms in ethics debates is a key subject for a project whose work has a global perspective. It is clear that ethical opinions do not appear out of a void and, whether or not one believes in an innate human nature, that upbringing plays a significant role in shaping notions of right and wrong. We therefore focus on how value systems in society influence ethical debates in the public and expert domains alike. We believe that ethics debates cannot be dissociated from cultural norms and values.

The aim of ethics debates in influencing policy-making forms another part of our definition. Ethics debates are by default policy debates. They are at core action-oriented in that they set out to allow or prohibit certain activities. As such, these debates aim to influence policy-making, and the opinions expressed are also policy opinions. Therefore it would be wrong to dissociate ethics debates from policy or doubt their impact on policy-making.

1.3 The Incorporation of Ethics in Science and Technology Policy

The incorporation of ethics in policy-making does not happen in isolation, as if ethics were a stand-alone concept. Ethics is inextricably connected to culture, and this affects its expression in a multitude of respects: dominant values, history and official governmental structures all influence the expression and direction of ethics debates. At the same time, private concerns, whether business-related or not, influence ethics debates by promoting moral arguments over certain world-views and policy choices. Figure 1.1 graphically depicts the position of ethics in a typical policy-making apparatus.

The first vital distinction to be made is that ethics can be both 'formally' and 'informally' expressed. 'Formal' expression occurs through the official structures in the decision-making system that have been created specifically to provide informed reflection on ethics issues. From government advisory bodies on science and technology to informal arms-length, quasi-governmental organizations, there is a plethora of ways to debate ethics in a reflective, formalized and disciplined manner. This contrasts with the spontaneous, public perspective on ethics expressed by lay people with little or no formal education in the field. This type of 'informal' lay view of ethics is more akin to morality, but nevertheless important in its expression of ethics in public debates (Burgess 2014). Lay morality is an

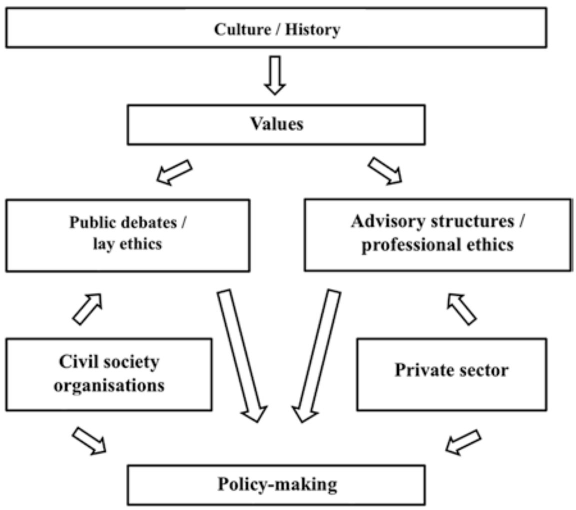

Fig. 1.1 Incorporation of ethics in science and technology policy

integral part of the incorporation of ethics in policy-making, although it requires different analytical methodologies (e.g. public surveys and citizens' dialogues).

Whether formalized or not, ethics derives from the dominant values that are held dear by society at the time of the debate. These values are easily recognized since they are promoted in official documents that organize society and policy priorities. National constitutions are the most relevant documents that describe dominant values, closely followed by international treaties, government white papers and key political speeches. In any case, ethics debates relate directly and indirectly to the dominant values in their content structure.

Also in the background is the historical and cultural context from which the dominant values, and therefore ethics views, are derived. The development of culture depends on historical events such as population movements, wars and occupations, and creates a distinct regional form expressed as much in arts and literature as in world-views and prescriptions of social behaviour. This results in specific values systems, as described above. Therefore a view on relevant history and culture in the analysis of ethics debates is necessary in order to explain the state of affairs and the main argumentation used.

Looking at the effect of ethics debates on policy-making, one ought not to disregard private activities that influence the direction of decisions. Such activities are organized in some form, for instance in terms of business interests or bringing together like-minded individuals, with the aim of influencing policy via lobbying. Business has traditionally been the most active private concern to lobby policy, but in recent decades we have seen the rise of civil society organizations as successful lobbyists. Both business and civil society organizations influence ethics debates by employing moral arguments and leading information campaigns.

The GEST project and the current book analyse in detail the most vital parts of the structure of the incorporation of ethics, namely formal and informal ethics discussions, regulatory mechanisms and dominant values systems. A perspective on history, culture and lobbying is given, but the work does not concentrate on these issues. Three regions as different as Europe, India and China offer a wealth of material for social scientists to analyse—in fact, much more than one could possibly digest in just 3 years of effort. To fully understand the antecedents and origins of three major world cultures would take a significant international effort. What we have done is to provide a snapshot of certain ethics debates in enough detail to enhance our understanding of the arguments involved, the decisions made and the values they represent. Most importantly, though, we point the way towards a common approach to ethics that can be followed at a global level with a global audience.

1.4 Structure of the Book

The book is divided into 12 chapters in three parts. Part 1 serves as the background to the remainder of the book, in that it conveys sufficient basic knowledge in relevant areas of academic research and policy to give a reader without significant prior knowledge an appreciation of the subtleties of the topic.

Chapter 2, explores the way in which ethical discussions are organized as part of the official science and technology policy-making process in the three regions. As each region has unique arrangements for ethics discussion, the development of the official structures is analysed in terms of the science and technology priorities that each region promotes, but also critically reviewed in terms of the regional needs and how these are covered by the existing structures. It shows that although overlapping structures do exist, the actual embedding of ethics in the regulatory process depends on the concrete characteristics of decision-making in each region.

Chapter 3, provides a basic comparative analysis of public perceptions of science and technology in the three regions. Comparable surveys, mainly from Europe and China, are analysed in terms of interest, information, attitudes etc. The results show remarkable similarities, but also significant differences, that have a direct influence in the dominant view of ethics in each region.

Chapter 4, addresses the societal governance issues in the three regions that are leading to increasing calls for and practice of public engagement in science and technology policy-making. It is a welcome fact that lay morality is an important analytical component of ethical debates in all regions, and that this is translated into public engagement. The processes and location of public engagement vary, though, and also depend on the context of policy-making, as discussed in this chapter.

Part 2, which discusses the value systems in the three regions, is the backbone of the book. The discussion is conducted from two perspectives: values as reflected in the dominant culture, and values as evident in official legislation in relation to science and technology governance. Based on this, the project's common analytical framework for the incorporation of ethics in decision-making process in the three regions is developed.

Chapter 5, discusses European constitutional values in terms of their influence in the governance of science and technology. Fundamental European values enshrined in the Charter of Fundamental Rights of the European Union and the Treaty of Lisbon are described and their relationship to existing science and technology policy-making is analysed.

Chapter 6, offers a similar analysis by describing the traditional Chinese concept of values in the tripartite culture of Confucianism-Buddhism-Taoism and explaining how the modernization process in China has brought in contrasting Western values and new value discourses such as scientism and developmentalism.

Chapter 7, describes the evolution of science and technology policy in India as part of the effort to promote socioeconomic development in the country. The role of science and technology in nation-building and modernization processes is analysed, along with the dominant values of equitable distribution, access and inclusion.

Chapter 8, uses the preceding analyses to develop a practical framework supporting a comparative analysis of the ethical debates in the three regions. The framework differentiates three public discourses focusing on innovation, risk, and power and control, and two reflective discourses focusing on ethics and lay morality. These form the categories that, along with the dominant values in each region, direct the analysis of the ethical debates.

Part 3, synthesizes the preceding analyses of perceptions, value systems, engagement and regulations using three major and emerging technologies for illustrative purposes. The three technologies chosen represent key science and technology aspects in all three regions and are in urgent need of further governance policies, especially at the global level.

Chapter 9, deals with the most intensely debated technology in the three regions. The chapter focuses on values and controversies relating to food technologies, including transgenic, traditional and organic perspectives as well as 'productivist' and 'post-productivist' agricultural models. It analyses the public discourses on the themes of risk, innovation, and power and control and their socioeconomic impacts so as to understand the utility of novel and emerging food technologies in the regional context and frame issues associated with ethical and broader societal discourses and consumer perceptions.

Chapter 10, offers an analysis of the ethics debates in the three regions and exposes the framing and dominance of discourses and underlying value concepts in each region. The predominance of the innovation discourse in India and China focuses on grand societal challenges and economic growth, while in Europe the strong involvement of nongovernmental actors offers alternative discursive framings and value concepts, resulting in a critical assessment of nanotechnologies.

Chapter 11, provides a comparative analysis of emerging debates on synthetic biology in the three regions in terms of the dominant discourses and themes, and their roots in the regional value systems. As this is a new technology, the formulation of the ethical debates and their anchoring with existing ones is of particular interest.

Finally, the overall conclusions of Chap. 12 bring together the insights gained throughout the book, along with policy recommendations. These aim at creating common institutional structures and common research programmes in the three regions with the object of achieving a truly global platform on which ethics can be debated and policy initiatives initiated according to a common road map.

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Chapter 2
Institutionalizing Ethical Debates in Science, Technology and Innovation Policy: A Comparison of Europe, India and China

Frans W.A. Brom, Sachin Chaturvedi, Miltos Ladikas and Wenxia Zhang

2.1 Introduction

Recent decades have witnessed a significant increase in ethical debates on science, technology and innovation, in the sense of both greater intensity and a wider plurality of voices. In addition to the standard expert perspectives, more and more lay people have found a common voice to express their opinions. People fear the negative consequences of science, technology and innovation and want to protect fundamental social values against the intrusion of new values that appear to show less respect for living entities when these are instrumentalized through the scientific world-view. The European debate on genetic modification in agriculture is a well-documented example of the 'ethicization' of the public discourse on science, technology and innovation (Bovenkerk 2012).

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It is clear that ethics debates have become less ‘expert’ and more ‘open’ to participation by groups or individuals who do not necessarily claim any particular expertise, either in scientific subjects or in ethical theory, but are nevertheless persuaded that their voices are as valid as those of the experts. Ethical debates have developed in Europe in a form that allows input from experts and lay people alike, through various means such as opinion surveys and participatory policy discussions. These debates acquire public significance because they reach parliaments, governments and scientific organizations through institutionalized means that are aimed at influencing science, technology and innovation policy (Paula 2008).

Nowadays, developments in science, technology and innovation are global phenomena in which scientists and technology experts from different countries cooperate in international consortia. Innovative solutions are often transferred globally and adapted locally. Both in Europe and in the emerging economies of China and India, the core of science, technology and innovation policy is broadly similar: stimulating science and technology as important factors in developing innovative solutions to societal needs. Against this background, the Global Ethics in Science and Technology (GEST) project is interested in comparing Europe with China and India: to what extent is there a global ethics in science and technology, and how are ethical debates institutionalized in science, technology and innovation policies? The latter is the focus of this chapter.

The issue will be addressed as follows. First we will sketch the general policy on science, technology and innovation in all three regions and the position of ethics debates in it. The common idea in the respective policies is that science and technology are important factors in developing innovative solutions to societal needs, but these solutions might have a profound influence on the moral fabric of society. Questions have been raised with regard to justice, equity, autonomy, human dignity and social harmony (see Chaps. 5, 6 and 7). In these ethical debates, however, the *tone of voice* differs greatly from region to region. This leads to the question: is this attention to ethics solely lip service, or does it have a real impact on the regulatory frameworks of science, technology and innovation? We found that each region has a unique structure of ethics debates involving the institutionalization of three related tasks: ethical governance, ethical deliberation and ethical reflection. The remainder of this chapter describes these tasks and provides examples of the institutionalization of ethics debates.

With regard to *ethical governance*, in all three regions the governance of protecting explicitly accepted social values such as scientific integrity, or human subjects involved in research, is implemented in regulatory frameworks. With regard to animal research, there are clear differences from region to region. For governance this involves discussion of the content of common standards for science, technology and innovation in terms of academic integrity, the protection of human research subjects and the protection of animals, and of questions about how to ensure common standards and comparable practices.

As for *ethical deliberation*, the institutionalization of ethics debates in Europe functions as an amalgam of advisory systems that sound early warnings on new ethical issues relating to science, technology and innovation. In Europe, ethics debates are often a mix of expert-based and lay-based ethical deliberation. This leads to the institutionalization of engagement through participatory methodologies (see Chap. 4). In China and India, on the other hand, one cannot understand the institutionalization of ethical deliberation by looking at advisory committees that are directed at protecting social values and fundamental rights within developments in science, technology and innovation. The general tone of voice of ethics in science, technology and innovation debates in these countries is aimed at setting social agendas. A short description of India's science and technology policy clarifies this point. The value discussions are not institutionalized separately, but function as an integral part of the agenda-setting discussions (see Chap. 7).

Societies develop, which is why both tasks—ethical governance and ethical deliberation—need to be aligned with new societal and scientific developments. Ethics cannot function without systematic ethical reflection. This becomes clear when we see how ethics debates on new emerging technologies proliferate in emerging economies. Based upon China's experience with agricultural biotechnology, we see the need for broadening ethical deliberation and societal engagement as a part of an early warning system for ethical issues (see Chap. 9). This requires ethical reflection, not only in terms of academic research as a reflective practice that needs to be institutionalized, but also in terms of the development of societal reflection on core values, rights and ideals.

2.2 Science and Technology for Innovation

Science and technology are important factors in developing innovative solutions to societal needs. This idea is a strong driver behind the science, technology and innovation policies in all three regions. It is against this background that the role of ethics in the regulatory regimes has to be placed.

2.2.1 Developing Innovative Solutions with Science and Technology

The European Union formulated the idea of developing itself as a competitive knowledge society in the year 2000 as was a part of the so called Lisbon Strategy (2000–2010):

> The Union has today set itself a new strategic goal for the next decade: to become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion (European Council 2000).

This strategy has been branded as the 'Innovation Union':

> Innovation Union is the European Union strategy to create an innovation-friendly environment that makes it easier for great ideas to be turned into products and services that will bring our economy growth and jobs (European Commission 2014a).

The Innovation Union is based in science and technology policy, where this policy is directed at 'turning our research into new and better services and products if we are to remain competitive in the global marketplace and improve the quality of life in Europe' (European Commission 2014b).

The challenge to Europe to remain globally competitive relates to the fundamental role of science, technology and innovation policy in competing regions such as India and China. In these regions science and technology policy have been an integral part of economic development. A rough outline of some of the dynamics in the regulatory regimes governing science, technology and innovation policy follows.

In India, the government's policy tools for setting out technology policy objectives and approaches are its science and technology policy statements. Since independence, four such statements have been issued, in 1958, 1983, 2003 and 2013. The 1958 statement was called 'Science Policy Resolution', that of 1983 'Technology Policy Statement', that of 2003 'Science and Technology Policy' and that of 2013 'Science, Technology and Innovation Policy'. These four documents have provided overarching frameworks for science and technology policy and have guided its societal linkages. The 2003 document also acknowledged the importance of linking modern technology with an indigenous knowledge base, and technology was part of a framework for an independent industrial base to be achieved through planned economic growth (Baark 1986). This led to the creation of a huge institutional base of organizations funding research and development and of research institutes.

The latest government policy statement, Science, Technology and Innovation Policy 2013 (DST 2013), mentions 'a strong and visible Science, Research and Innovation System for High-Technology-led path for India (SRISHTI) as the goal of the new STI Policy' and 'science, technology and innovation for the people' as the new paradigm of the Indian science, technology, innovation enterprise. It argues that the national science, technology and innovation system must therefore recognize Indian society as its major stakeholder: 'Innovation for inclusive growth implies ensuring access, availability and affordability of solutions to as large a population as possible.' It states that the policy will drive both investment in science and the investment of science-led technology and innovation in select areas of socioeconomic importance. It acknowledges that public understanding of science is an important dimension of reaching the people and introducing the benefits of modern science and technology to them. According to the new policy, the guiding vision of aspiring Indian science, technology and innovation enterprise is to accelerate the pace of the discovery and delivery of science-led solutions for faster, sustainable and inclusive growth.

China has, since the adoption of the reform and opening-up policy in 1978, been following the lead set by Deng Xiaoping's observation that 'science and technology are the primary productive forces', and pursuing a science and technology development strategy which stresses that 'economic development must be based on science and technology, and science and technology must serve the need of economic development' (Deng 1993). In 2007, the Chinese government set a new strategic objective of ‘enhancing indigenous innovation capacity and building an innovation-oriented country’. The history of China in the past century shows that recognition of the important role of science and technology has played a crucial part in every major decision affecting economic and social development strategy in China. It also clearly demonstrates that the Chinese people cherish the value of science and technology and that China is firmly committed to catching up with the world’s leading nations in science and technology. Through one hundred years of hard effort, China has made notable progress in science and technology development, having started with a blank slate. In the meantime, a big proportion of the Chinese public now recognizes the importance of science and technology and the dominant position of science and scientific pragmatism in the mainstream value system.

2.2.2 ‘Ethics Debates’: Discussing the Societal Impact of Science, Technology and Innovation Policies

It is clear that, as one might expect, science, technology and innovation policies have not, in any of the three regions, been blind to the impact of scientific and technological developments on the moral fabric of society. Questions have been raised about the impact of science, technology and innovation on dominant social values such as justice, equity, autonomy, human dignity and social harmony, relating to both individual and social life.

A recent example of the European tone of voice in raising ethical questions in the science, technology and innovation debate was a resolution on science and technology ethics adopted with an overwhelming majority by the senate of the Netherlands (Eerste Kamer 2014). The senate concluded that technological innovations were necessary for a competitive economy, that some technological innovations, such as the convergence between nanotechnology, information technology, biotechnology and cognitive science, might have profound consequences for privacy and citizenship, and that these consequences raised fundamental ethical questions. Based upon this conclusion, the senate asked the government to structurally embed ethics in its technology and innovation policy and to inform the senate regularly of the results. This tone of voice in raising ethical questions in the debate on science, technology and innovation signifies a recognition of the importance of technological innovation for a competitive economy, while at the same time stressing that its consequences for social values and fundamental rights need close scrutiny.

Value questions are not, of course, exclusive to Europe: they have also been raised in India and in China.

An example of the Chinese tone of voice is what then Chinese president Jiang Zemin pointed out at a meeting with Nobel laureates in Beidaihe on 5 August 2000:

> The issue of scientific ethics is going to become more prominent in the 21st century. The bottom line is: advances in science and technology should serve the interests of the mankind, serve the lofty cause of world peace, development and progress, rather than hurt the

> human race itself … To build and improve scientific ethics, respect and protect intellectual property rights, and provide policy guidance for the research and use of science and technology in ways that meet the common interests of people around the world is a major issue to be resolved in the 21st century (Jiang 2000).

That science, technology and innovation should be directed at the interests of humankind and the benefits broadly accessible in society has been a core issue in the ethics debates in India, where ‘access’ itself is a larger issue that provokes intense and passionate debate when intellectual property rights are under discussion. India’s tone of voice can be discerned from the debate’s focus on inclusion and equity. These are brought up against the background of wider inequality within the country and across various regions. The idea of ethics in this respect is also significant, since technology and gender divides are strongly evident across the board. Access, equity and inclusion have repeatedly been emphasized in the series of five-year plans emanating from India’s Planning Commission (Planning Commission 2011). The focus on inclusion and access has primarily been in policy statements, however; there are not many reports or studies on evaluated actual implementation.

2.2.3 An Amalgam of Institutionalizations

To the question posed above—is this attention to ethics solely lip service, or does it have a real impact on the regulatory frameworks of science, technology and innovation policies?—we can attest that there is a broad and interesting discussion on the institutionalization of ethics debates in science, technology and innovation policy in all three regions. Our research identified a variety of structures, ranging from institutes and committees that are part of government departments to arms-length quasi-governmental organizations and influential non-governmental entities that include ethics in their remits.

Presenting a complete overview would be neither helpful nor possible. Institutional structures are dynamic fields that change and develop along with science, technology and innovation policies. Detailed descriptions could only have temporary value. As political and regulatory perspectives change, committees are established, transformed, merged and eventually abandoned, while regulation adapts to new situations and issues. Instead of striving for a full description of the amalgam of institutions in the three regions, we propose a systematic description of the three main tasks that the institutionalizations of ethics debates in science, technology and innovation policy concentrate on. This is based on a synthesis of the empirical material analysed as part of the GEST project. We will undertake this along three lines of inquiry:

- ethical governance: institutionalizing ethics debates in terms of the implementation of standards in research ethics in science, technology and innovation policies
- ethical deliberation: institutionalizing ethics debates that raise ethical issues in scientific and technological developments in science, technology and innovation policies

- ethical reflection: institutionalizing ethics debates that support critical reflection and engagement in debates on research standards, emerging technology issues and social justice in science, technology and innovation policies.

2.3 Ethical Governance

The first function that one sees in the institutionalization of ethics debates is the institutionalization of compliance. Ethics debates do not start from scratch: some of the values, rights and ideals that are relevant to the development of science, technology and innovation are already broadly shared and sometimes even explicitly codified in codes of conduct or legal requirements for research. These form the firm core of research ethics describing behaviour with regard to science (scientific integrity) and with regard to society (human research subjects, animals and the environment). There are three fields of governance in which ethics is of clear importance for the societal impact of science and technology directed at innovation:

- academic integrity
- research (including medical research) involving human subjects
- research involving animals.

2.3.1 Academic Integrity

There is a debate on academic integrity evolving in all three regions. Our analysis shows that this debate is very intense in Europe and has recently become so in China. The discussion on research integrity and compliance with standards of academic integrity forms an important focus point for the discussion on the ethics of science, technology and innovation in China. The core question here concerns the relationship between academic integrity and broader issues of science, technology and innovation ethics. Here are three examples from the respective regions:

- The UK Research Integrity Office, an independent body that provides expert advice and guidance on the conduct of research, covers all subject areas and helps everyone involved in research deal with integrity issues.
- In China the Ministry of Science and Technology has established an office for research and development integrity and a committee that focuses on developing research and development integrity to administer issues concerning the research and development ethics of Chinese scientists.
- The Department of Biotechnology in India’s Ministry of Science and Technology has issued a ‘Statement on Handling of Allegations of Research Misconduct’ for departmentally funded organizations and researchers all across the country. The department asserts that integrity is naturally expected in the

communication of science through seminars, meetings and publications. The policy statement also stipulates punishments for research misconduct.

2.3.2 Research on Human Subjects

In all three regions there is a strong focus on the institutionalization of research ethics involving human research subjects, especially in medical research (Jesani 2009; Muthuswamy 2010). The main question in this field is whether the regulations and institutionalizations are comparable between the different regions.

2.3.3 Protecting Research Animals

With regard to the ethics debate on animals in research, we find comparable structures in Europe and India in terms of national legislation and ethics committees at institutional level. In China, discussion on the use of animals in research is not prominent. The core question for a global ethics of science, technology and innovation revolves around two issues: the fundamental ethical question of whether, why and how animals are to be considered proper objects of moral concern, and the practical ethical question of comparing existing regulations and applications in the field of animal research.

2.3.4 Conclusion

Overall, the institutionalization of ethics debates in the field of governance highlights the importance of further comparing ethical standards and their application in practice. In other words, the challenges confronting the development of a global ethics in science, technology and innovation in relation to governance are:

- To what extent are common standards for science, technology and innovation with regard to academic integrity, the protection of human research subjects and the protection of animals necessary and possible?
- How does one ensure that common standards lead to the development of comparable practices?

2.4 Ethical Deliberation: Explicating Ethical Issues in Science, Technology and Innovation Developments

New emerging technologies raise new ethical issues. From a European perspective, the institutionalization of ethics debates functions as an advisory system that issues early warnings about new ethical issues relating to science, technology and innovation. The existing and developing European institutes are directed at opening up new developments for ethical deliberation. Official advisory reports place these issues on the policy agenda with authority and inform policymakers and researchers of relevant issues to consider. Developing ethical deliberation is often a mix of expert-based and society-based ethical deliberation. Engagement through participatory trajectories is a crucial part of the institutionalization of ethical deliberation (see Chap. 4).

In order to understand the institutionalization of ethical deliberation in India and China, however, we should look beyond advisory committees that are directed at protecting social values and fundamental rights against developments in science, technology and innovation. In Sect. 2.2.2 we saw that the general tone of voice of ethics within science, technology and innovation debates is directed at priority setting in order to solve broad societal issues and improve the life situation of those in need—in other words, setting social justice innovation agendas. Instead of an examination of individual committees, a description of the history of the agenda-setting process might help clarify the ethics structure in these regions. An example from India will clarify this point.

2.4.1 Ethics Advisory Committees

One way in which ethical debates are institutionalized to foster engagement in public discourses on regulations, politics and governance is by the installation of official ethics advisory committees that give public advice aimed at broadening policy discourses. These committees institutionalize ethics debates if, and only if, they advise publicly. Giving advice based upon accessible systematic reflective argumentation broadens the possibilities of public engagement in the discussion. Once arguments are given publicly, they can be challenged publicly too.

The idea of the ethics advisory structures in Europe follows strongly the tone of voice as described above in Sect. 2.2.2: recognizing the importance of technological innovations for a competitive economy while at the same time stressing that their consequences for social values and fundamental rights need close scrutiny. The ethics structures need to advise how the social values and fundamental rights can be protected.

2.4.2 Ethics in Agenda Setting in Science, Technology and Innovation

The institutionalization of the ethics debates in India and China does not follow the pattern of advisory committees directed at protecting social values and fundamental rights against developments in science, technology and innovation. An outline of the history of Indian research and development policy makes it clear that institutionalizations aim to steer developments in science, technology and innovation towards solving broad societal issues and improving the life situation of those in need: in other words, setting social justice innovation agendas.

India embarked upon an ambitious development path after gaining independence in 1947. Led by the visionary prime minister Jawaharlal Nehru, the government revamped the science and technology infrastructure and established many new laboratories across the country. Their vision was to harness science and technology for social development and economic growth. The various national plans and science and technology policies recognize that science and technology are vital aspects of national capability. The central focus of the Twelfth Five Year Plan for the period 2012–2017 is to ensure that science and technology become major drivers in the process of national development (GOI 2012). The government has declared 2010–2020 the Decade of Innovation, with the object of achieving access, equity and inclusion. In fact, this has been on the agenda of the government since the 1950s.

The Scientific Policy Resolution of 1958, the Technology Policy Statement of 1983, the Science and Technology Policy of 2003 and the Science, Technology and Innovation Policy of 2013 categorically declare that science and technology have an unprecedented impact on economic growth and social development. They state that one of the aims of the policy is to secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge. The objective is to ensure the security of the people in terms of food, agriculture, nutrition, the environment, water, health and energy on a sustainable basis, with special emphasis on equity in development, so that the benefits of technological growth reach the majority of the population, particularly the disadvantaged, leading to an improved quality of life for every citizen. According to the new Science, Technology and Innovation Policy, the guiding vision of aspiring Indian science, technology and innovation enterprise is to accelerate the pace of the discovery and delivery of science-led solutions for faster, sustainable and inclusive growth.

The policies also call for close coordination of the various government departments, and also among those concerned, at all levels, with any sector of economic, scientific or technological activity, and not least the understanding and involvement of the entire Indian people. It is realized too that 'scientific and technological developments today also have deep ethical, legal and social implications. There are deep concerns in society about these. … Scientific work and policies arising from these have to be highly transparent and widely understood' (DST 2003).

The Science, Technology and Innovation Policy of 2013, which is the latest such document, states that 'a strong and visible Science, Research and Innovation System for High-Technology-led path for India (SRISHTI) is the goal of the new STI Policy' and 'science, technology and innovation for the people' is the new paradigm of the Indian science, technology and innovation enterprise. It declares that the national science, technology and innovation system must therefore recognize Indian society as its major stakeholder: 'Innovation for inclusive growth implies ensuring access, availability and affordability of solutions to as large a population as possible.' It says that the policy will drive both investment in science and the investment of science-led technology and innovation in select areas of socioeconomic importance. It acknowledges that the public understanding of science is an important dimension for reaching the people and introducing the benefits of modern science and technology to them. However, it also argues that this public and political understanding of science should be based on evidence and debated with an open mind. ‘People and decision makers must be made aware of the implications of emerging technologies, including their ethical, social and economic dimensions’ (DST 2013). This new policy acknowledges the increasing role of the private sector in research and development and advocates the public-private partnership model.

Within these policy contours, the Department of Science and Technology, as part of its ‘S&T Programmes for Socio-Economic Development’ has set up a Science for Equity, Empowerment and Development Division. This has the objective of ‘working for technological empowerment and sustainable livelihoods at the grass-root levels’, aiming at the socioeconomic upliftment of poor, disadvantaged sections of society. The department has programmes to facilitate participation by women in science and technology. It has also established a Nanotechnology Mission to give emphasis to research and development and capacity building in nanosciences and technology, with a view to harnessing these to address societal challenges and economic growth by leveraging its industrial applications. Similarly, the Department of Biotechnology has initiated many programmes in frontier areas of the biosciences.

Thus the orientation of science and technology programmes has been to use science and technology for development purposes, and to catch up with advanced countries. From time to time the Indian Council of Medical Research issues ethical guidelines for biomedical research on human participants (ICMR 2006). These stipulate that all research involving human participants should be conducted in accordance with the four basic ethical principles, namely autonomy (respect for persons or participants), beneficence, non-maleficence (do no harm) and justice (Kumar 2006). The council’s Health Research Policy (ICMR 2007), in its section on operating principles, says that the ethical guidelines should be mandatory for all research.

2.4.3 Conclusion

Europe, India and China can learn from one another. The discussion in Europe could benefit from the Indian example of opening up the agenda setting for science, technology and innovation to broader value-based discussions. The basic idea of responsible research and innovation in the EU’s new Horizon 2020 agenda might give opportunities for this, while the existing amalgam of European ethics advisory structures as an early warning system might also be a source of inspiration for China and India. This is because, as the next section of this chapter will demonstrate, strong societal debates on emerging technologies are popping up in

China and India too. A telling example of such a debate is the discussion on agricultural biotechnology in both China and India.

2.5 Ethical Reflection

Ethical discussion on new emerging technologies has proliferated in China and India. The example of agricultural biotechnology shows the need to broaden the ethics debate and for societal engagement through participatory trajectories as an early warning system. The Chinese example serves to clarify this point.

A genetically modified cotton variety developed by Monsanto was introduced to China in 1995, for the purpose of dealing with severe outbreaks of bollworm. Meanwhile, the Chinese government was also intensifying its efforts to develop related biological technologies. In China, the discourse on supporting genetically modified foods and related technologies through innovation takes the form of two intertwined systems. The first is the discourse of developmentalism and the second the discourse of scientism, both of which provide an excellent environment and great opportunities for the development of genetic modification. Whether in scientific research or industry development, the government of China has given substantial support to modern biotechnology as a national strategy. Hence genetically modified crops are developing rapidly in the country and enjoy strong market opportunities. In addition to the cotton variety, genetically modified crops and products that have been granted biosafety certificates since 1998 include tomato, papaya, pimento and animal vaccines.

In August 2009, China's Ministry of Agriculture formally approved the issuing of safety certificates to two transgenic rice varieties and a transgenic corn variety. When Greenpeace International learned of this and made it widely known through the media, a huge public backlash ensued. In a demonstration of widespread concern about genetically modified crops, there was much discussion in both traditional and online media. Some unverified negative reports were widely circulated. In March 2010, the Center for Science Communication, Peking University, published on its official website an open letter jointly signed by some scholars in humanities and social sciences, claiming that the safety certificates granted to the transgenic rice and maize varieties 'were not based on adequate demonstration. If decisive measures are not taken immediately to put a halt to commercial planting of genetically modified corps, China's food security and food sovereignty will face major impacts.' The views carried by the media have a strong influence on the degree of acceptance among Chinese consumers for genetically modified foods. Because the debate on these foods has not been settled, the majority of people with no interest in the scientific details of the issue have left the middle ground to join the conservative camp. In recent years, as urban consumers have become more aware of genetically modified foods, acceptance of these foods has decreased.

2.6 Conclusion

We conclude that the institutionalization of ethics debates in science, technology and innovation needs to be analysed from three different perspectives, each of which has a unique structure: ethical governance, ethical deliberation and ethical reflection.

From the *ethical governance* perspective, deliberation targets compliance issues within the existing ethical frameworks. The institutionalization of ethics debates in the field of governance highlights two challenges for the development of a global ethics in science, technology and innovation in relation to governance:

- the extent to which common standards for science, technology and innovation with regard to academic integrity, the protection of human research subjects and the protection of animals are necessary and possible
- how to ensure that common standards lead to the development of comparable practices.

In *ethical deliberation*, new emerging issues and the social agenda for science, technology and innovation are debated. The idea of the ethics advisory structures in Europe follows strongly a tone of voice that recognizes the importance of technological innovations for a competitive economy, while at the same time stressing that its consequences for social values and fundamental rights need close scrutiny. European ethics structures are designed to provide advice on how to protect social values and fundamental rights. The Chinese and Indian advisory structures on science, technology and innovation, in which new emerging issues and the social agenda are debated, aim to steer developments in science, technology and innovation towards solving broad societal issues and improving the life situation of those in need: in other words, setting social justice innovation agendas.

Finally the institutionalization of societal and academic *reflection on ethics* to feed governance and deliberation shows that the ethical debate on new emerging technologies has flourished in China and India. Agricultural biotechnology shows the need to broaden the ethics debate and for societal engagement through participatory trajectories as an early warning system. Societal and academic reflection is directed at the question: how does one organize these trajectories? (see also Chap. …).

2.7 Background Material

This chapter builds upon the reports of the EU research project Global Ethics in Science and Technology (GEST), specifically the following:

EU country reports from Deliverable 1.1, Ethics state of the art: EU debate

- Chapter 2: S&T ethics advisory structures in the United Kingdom, by Miltos Ladikas and Cathy Lennon (University of Central Lancashire)

- Chapter 3: S&T ethics advisory structure in Germany, by Leonhard Hennen (Institute for Technology Assessment and Systems Analysis—ITAS) and Arnold Sauter (ITAS and Office of Technology Assessment at the German Bundestag)
- Chapter 4: S&T ethics structure in Netherlands, by Virgil Rerimassie, Frans W.A. Brom (Rathenau Instituut)

GEST background papers

- Ethics state of the art: Yesterday, today, and tomorrow in China, by Wenxia Zhang, Yandong Zhao Ying Ma, Miao Liao (Chinese Academy of Science and Technology for Development)
- Science and technology policy in India: Policy contours, institutional framework and ethical considerations, by Sachin Chaturvedi, K. Ravi Sriniva, Pallavi Singh (Research and Information System for Developing Countries, New Delhi)

In these reports the data collected is available for further analysis and discussion. These reports are available on the GEST project website and in the deliverables (EU website) for the European Commission.

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Chapter 3
Public Perceptions of Science and Technology in Europe, China and India

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3.1 Introduction

Science and technology are held in high esteem by important Chinese, European and Indian political leaders.

> Science and technology constitute a primary productive force …. The future of agriculture will eventually lie in bioengineering and other highly advanced technologies. So we must recognize the full importance of science and technology (Deng 1993).

These words of Deng Xiaoping, leader of the People's Republic of China from 1982 to 1987, turned out to be the cornerstone of the Chinese science and technology policy that followed. Similarly, Jawaharlal Nehru, the first prime minister of

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post-Independent India gave importance to development of S&T and emphasized its role in national development and in finding solutions to hunger and poverty. He advocated inculcation of scientific temper.

Also when we turn to the European Union (EU), we find high hopes for science and technology among political leaders. For instance, in a speech about the EU funding scheme Horizon 2020, Máire Geoghegan-Quinn, the European Commissioner for Research, Innovation and Science, noted that 'research and innovation are the best tools at our disposal to renew our economy and tackle a long list of other major challenges that we face' (Geoghegan-Quinn 2012).

Indeed, science and technology are highly valued by important political leaders of the three regions. But how are they perceived by the citizens those leaders represent? For history has shown that the public reception of science and technology exerts a crucial influence on the development of science and technology.

This chapter provides a brief comparative analysis of public perceptions of science and technology in Europe, China and India. Compiling such an analysis is not an easy task, however. First of all, while research on public perceptions of science and technology has been common practice in Europe and China, this is not the case in India. In addition, the comparability of the available information is limited, since the surveys differ in scope and the questions asked vary widely. Moreover, one has to be aware of the multitude of different cultures and subcultures, belief systems and traditions found in each region, which are manifestly hard to differentiate and analyse in a fair and just manner.

We therefore do not claim to have conducted a comprehensive, detailed analysis, but aim merely to provide an impression of public perceptions of science and technology in the three regions that can serve as a backdrop for the other chapters of this book. Discussions of the case studies of genetically modified foods, nanotechnology and synthetic biology are certainly informed by more general perceptions of science and technology.

To gauge public perceptions of science and technology in the EU, we draw on Eurobarometer, the main series of polling surveys by the European Commission, run regularly in all EU member states. Our primary source of information is the Special Eurobarometer 340 (European Commission 2010).[1] For China, the national survey of public scientific literacy (Ren et al. 2010, 2011), provides the most comprehensive and systematic statistics concerning public perceptions of science and technology. Since the 1990s, the China Association for Science and Technology has conducted the national survey approximately every 2 years. Information on public perceptions in India is, however, far more scarce: the most relevant and recent study is the India Science Report (NCAER 2005), commissioned by the Indian National Science Academy from the National Council of Applied Economic Research, which included a questionnaire on science and technology perceptions. A key objective was to understand public attitudes to science

[1] Occasionally this chapter refers to earlier editions, or to the more recent 2014 report (European Commission 2014). We focus mainly on the 2010 survey, however, because it is the most directly comparable to the surveys of the other regions.

through a primary survey. The sample size was limited, and there have been no subsequent studies based on this questionnaire. Yet it provides a glimpse of Indian public perceptions of science and technology, and moreover contains some directly comparable survey questions.

The following section discusses and compares the key themes of interest in and basic knowledge of science and technology, the image of science and technology and scientists, tensions between science and faith, and the weighing up of the benefits and potential risks of science and technology.

3.2 Interest and Knowledge Regarding Science and Technology

How much interest do citizens have in science and technology? All three surveys compared interest in science and technology with interest in other issues.

According to the Eurobarometer report (European Commission 2010), EU citizens consider themselves very, or at least moderately, interested in and informed about issues of everyday life, such as politics, environmental problems and culture and the arts. Regarding new scientific discoveries and technological developments, 79 % of EU citizens are interested (30 % very interested, 49 % moderately so), whereas 20 % are not interested at all. Interest in environmental problems and new medical discoveries is higher, but interest in science and technology is higher than interest in politics, culture, the arts, and sports news. If we compare this with the level of interest in science and technology according to the earlier Eurobarometer surveys of 1993 and 2005, we can conclude that interest in science and technology has been fairly high over the years.[2] In 2005 about 76 % indicated an interest in science and technology (European Commission 2005), and in 1992 the figure was 82 % (European Commission 1993).[3] In Special Eurobarometer 401 (European Commission 2014), interest in science and technology was also gauged, but without reference to other issues (politics, culture and arts, sports news etc.). In the 2014 survey, 53 % indicated their interest in scientific and technological developments, compared with 46 % who were not interested. While the question is formulated differently from its equivalent in the 2010 Eurobarometer, the lower numbers in 2014 are certainly notable.

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[2] Regarding comparisons over time, it is important to keep in mind that the composition of the European Union has changed considerably. The survey work for the Eurobarometer report *Europeans, Science and Technology* (European Commission 1993), was conducted in 1992, when the European Community, as it was then, consisted of only 12 member states. There were 15 member states in 2001 and 25 in 2005.

[3] In 2001 just 45 % of respondents indicated an interest in science and technology, but this survey posed the question and possible answers differently. The survey question read: ‘Are you rather interested or not very interested in each of the following subjects?’. The possible answers were ‘rather interested’, ‘not very interested’ and ‘do not know’. The level of interest registered in other subjects was lower too, due to the different way the statement was posed (European Commission 2001).

Regarding active interest in science and technology, Eurobarometer 2010 shows that European citizens are actually not very active in science and technology issues. They are most active in donating money to fundraising campaigns for medical research (39 %), as well as the 13 % of respondents who claim that they sign petitions or take part in street demonstrations on science and technology matters such as nuclear power and biotechnology (European Commission 2010). Overall, we find that EU citizens are indeed interested in science and technology, but this does not translate into an active involvement in science and technology issues.

Like the Eurobarometer survey, the Chinese scientific literacy survey in 2010 included questions on the public's interest in various news topics. Of the 11 topics covered, four clearly related to science and technology: new scientific discoveries, new medical discoveries, suitable production technologies, inventions and new technologies. Generally speaking, developments in science and technology were not the area that attracted the greatest interest. The public was most interested in culture and education (79 %), public security (77 %) and economic development (76 %), followed by agricultural development (73 %), and resources and energy saving (72 %). The four topics relating to science and technology ranked from sixth to ninth place—new scientific discoveries (72 %), new medical discoveries (71 %), inventions and new technologies (68 %), and suitable production technologies (64 %)—with sports and entertainment and international and foreign policy at the bottom (Ren et al. 2011). Among the four news topics related to science and technology, public interest was highest in new scientific discoveries and new medical discoveries.

Although fewer Chinese respondents expressed an interest in these topics than Europeans, the proportion of the Chinese public explicitly expressing 'no interest' was also lower than that of the EU: only about 7 % said they were 'not interested' in the four topics, while the figure for Europe was more than 17 %. Apart from the options 'interested' and 'not interested', a considerable proportion of the Chinese public chose the option 'do not care' or 'do not know': in fact, for all four topics, more than 20 % chose one of these options (Ren et al. 2011), whereas in Europe only 1 % of respondents selected 'do not know'. This shows not only that the Chinese public, compared with the European public, has a lower explicit interest in science and technology, but also, and more significantly, that a higher proportion of the public does not have a clear attitude on the issue.

Turning to India, we find that according to the India Science Report (NCAER 2005), high levels of illiteracy and low levels of income have not prevented Indians from having very high interest in a wide range of social issues as well as a reasonably good knowledge of scientific and other events. Indians profess to be most interested in issues of poverty (77 %), followed by those concerning old people (75 %), women (74 %), local schools (71 %) and agriculture (71 %). Only 47 % of those surveyed were interested in economic issues other than employment (in which 66 % were interested). In comparison, interest in science and technology was actually rather low: only 30 % indicated interest, while 40 % said they were not interested. Also striking was that 30 % of the respondents claimed not to have an opinion on this subject matter (NCAER 2005: 45, 46).

While it is difficult to compare the results from the European, Chinese and Indian surveys directly, we can make some cautious observations. First, notwithstanding a stronger interest in other topics, citizens in the EU and in China do appear to have considerable interest in developments of science and technology: the survey results indicate that more than two thirds expressed an interest in such developments. Indian citizens, however, have a significantly lower degree of interest in science and technology, according to the India Science Report. They are certainly less outspoken on science and technology developments, with almost a third indicating that they had no opinion on whether they had an interest or not.

Level of interest is an important parameter for public engagement with science and technology, as is the level of knowledge of the subject. In all three regions, efforts were made to gauge the level of basic scientific knowledge. In order to do so, the respective surveys incorporated comparable quiz sections, in which true-or-false questions were asked, testing basic knowledge on, for example, astronomy, biology and physics. These included 'the oxygen we breathe comes from plants', and 'the centre of the Earth is very hot'.

According to the 2005 Eurobarometer (the last edition to address the basic scientific knowledge of European citizens), respondents had a good knowledge of scientific topics. On average, two thirds of the given answers were correct (European Commission 2005). In the India Science Report, almost half of the survey participants gave the correct answers to a similar set of questions: in other words, although illiteracy is widespread in India, a significant percentage of the survey participants had a good basic knowledge of science (NCAER 2005: 50). Last, turning to the most recent Chinese survey of 2011, we find that about 40 % of respondents gave the correct answer (Ren et al. 2011). We may conclude that the basic scientific knowledge in the European Union is high in comparison with India and China.

3.3 The Image of Science and Technology

The level of interest in science and technology is important, but it does not tell us anything about the image of science and technology—that is, whether it is viewed in a positive or negative light. The available Chinese, European and Indian surveys include questions that tell us something about the image of science and technology among citizens in the three regions. We will look at responses to the following statements:

- Science and technology can sort out any problem.
- Science and technology will ensure that the planet does not run out of resources.
- Science and technology will create more opportunities for future generations.
- Science and technology will make our lives healthier, easier and more comfortable.

It should be noted that not all of the surveys address all of these issues. While the last is addressed in all three regions, the first three are dealt with in the European and Chinese surveys only.

3.3.1 Science and Technology Can Sort Out Any Problem

First, EU citizens do not believe that science and technology can sort out any problem: 'Only 22 % at the EU27 average indicate that they agree that science and technology can sort out any problem, while a clear majority of 57 % shows disagreement to this statement' (European Commission 2010: 39). This does not significantly deviate from the Eurobarometer report of 2005 (European Commission 2005: 53), but a comparison with the 2001 survey indicates that EU citizens have actually grown more optimistic about science and technology: in that year, 16.5 % agreed and 73 % disagreed with the statement (European Commission 2001: 29).

Interestingly, in the 2005 Chinese survey, this statement drew agreement from 22 % of respondents, significantly fewer than the 39 % of 2003 (Ren et al. 2010). Since the Chinese and EU surveys were conducted in different years, it is not possible to compare the results directly, but one can note the different trends: while the Chinese public is becoming less optimistic, the EU survey points in the opposite direction.

3.3.2 Science and Technology Will Ensure that the Planet Does Not Run Out of Resources

Nanotechnologies and synthetic biology are expected to make an important contribution to more sustainable 'bio-based' production strategies. Just as they have little faith in the potential of science and technology to sort out any problem, EU citizens do not regard it as likely that the advances of science and technology will prevent the exhaustion of Earth's natural resources. Only 21 % believe that science and technology will render the Earth's natural resources inexhaustible (European Commission 2010). Comparison with the support level of 23 % in 2005 suggests that EU citizens have grown slightly more sceptical on this subject (European Commission 2005: 53). In 2001, however, the rate of support was just as high as in the most recent survey (European Commission 2001: 29).

Turning to China, we actually find slightly more optimism on this issue than in the EU, with 28 % of the public endorsing the statement in 2010 (Ren et al. 2011) (Fig. 3.1).

3.3.3 Science and Technology Will Create More Opportunities for Future Generations

In the EU this statement is certainly supported: in the most recent Eurobarometer three-quarters of respondents agreed and just 7 % disagreed (European Commission 2014). Earlier editions of the survey also reflect widespread agreement: the 2014 and 2010 results are almost identical. This is a slight decrease

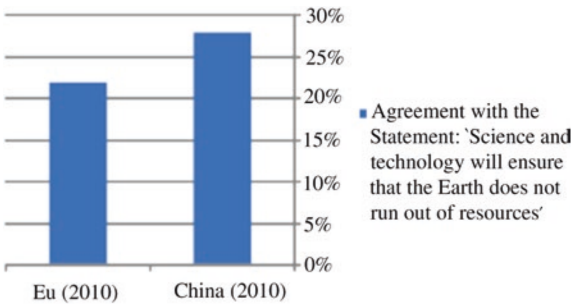

Fig. 3.1 Science and technology will ensure that the earth does not run out of resources

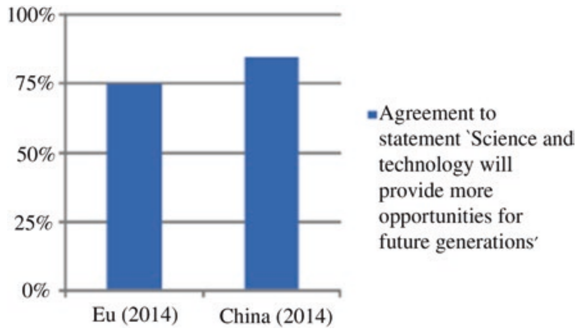

Fig. 3.2 Science and technology will provide more opportunities for future generations

on 2005, when support was at 77 %. In 2001 it was about 72 % (European Commission 2001: 30). All of these numbers are considerably more favourable than the response in 1992, when 63 % believed science and technology would create more opportunities for future generations (European Commission 1993: 70).

Meanwhile, asked in 2010 whether science and technology would provide more development opportunities for future generations, 85 % of Chinese respondents said yes. Earlier Chinese surveys indicate that support from the Chinese public has always been slightly higher than that of EU citizens (Ren et al. 2011).

As Fig. 3.2 shows, both Chinese and EU public are quite optimistic about science and technology enabling more opportunities or future generations, but there is even more optimism in China than in the EU.

3.3.4 Science and Technology Will Make Our Lives Healthier, Easier and More Comfortable

This matter is addressed in all three regional surveys. The Eurobarometer 2010 demonstrates widespread agreement with the statement (including strong agreement) among EU member states, with two thirds (66 %) of respondents agreeing. This level of support was similar in the 2014 Eurobarometer survey, but had, in fact, been even higher in earlier surveys. In 2005, 78 % of the respondents

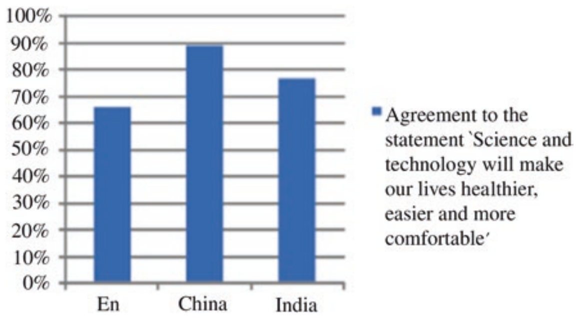

Fig. 3.3 Science and technology will make our lives healthier, easier and more comfortable

subscribed to this statement (European Commission 2005: 53), and in 2001 support was at about 71 % (European Commission 2001: 29).[4]

If citizens of the EU are quite optimistic about science and technology, the Chinese public is even more positive: no less than 89 % of Chinese respondents agreed with this statement in the 2010 survey. As for trends, as many as 94 % of Chinese citizens supported the statement in 2001.[5] After falling to 83 and 70 % in 2003 and 2005, the support rate climbed back to 76 and 89 % in 2007 and 2010 (Ren et al. 2010, 2011).

The India Science Report indicates that the Indian public is also more optimistic than the EU public, with 77 % of respondents believing that science and technology make lives healthier and more comfortable. The researchers note, however, that there are pronounced differences in perception according to educational and income levels. The report records that just 56 % of illiterate respondents felt that science and technology makes lives healthier, easier and more comfortable, while 98 % of postgraduates felt the same way (NCAER 2005). Yet overall, the balance of opinion was that science and technology benefited the country:

> (T)his remains true for all sets of people, ranging from the illiterate to postgraduates and from the bottom-most income quintile to the top-most income quintile. Over three-fourths people in rural India also, for instance, feel that S&T makes life healthier and easier (against 80 % for urban areas) and 57 % feel that new technology makes work more interesting (68 % for urban areas) (NCAER 2005: 40).

Interestingly, in the first section we observed that the interest of the Indian public in science and technology developments was rather low, and yet they are quite optimistic about the benefits such developments might bring.

Figure 3.3 graphically demonstrates that the public in all three regions are quite certain of the benefits that science and technology may bring, and convinced that science and technology will make their lives healthier, easier and more comfortable. Yet we find remarkable differences in the levels of optimism: in the EU two

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[4] Strikingly we can observe a steep decline in support for this statement in Germany: from 86 % in 2005 to 57 % in 2010 and 54 % in 2014 (European Commission 2005, 2010, 2014).

[5] The proposition before 2010 was: 'Generally speaking, the work of scientists has made our life easier and more comfortable.'

thirds agree with the statement, in India about three quarters and in China almost nine out of ten respondents.

3.4 Fear of Scientists

We have seen that Chinese and EU citizens do not expect miracles from science and technology: science cannot solve all problems, nor can it ensure that the Earth never runs out of natural resources. They are, however, quite confident that science and technology will enable more opportunities for future generations. We do not know as much about Indian public perceptions of science and technology in this regard as we know of the sentiment in China and the EU. What little information is available, though, points in a similar direction: Chinese, Indian and EU citizens are all quite convinced that science and technology will enable healthier, easier and more comfortable ways of living. Scientific knowledge, however, equals power. How do members of the public view scientists in this regard? Here we can examine the EU and Chinese publics.

More than half of EU citizens (53 %) agree with the statement ‘Because of their knowledge, scientists have a power that makes them dangerous,’ while 24 % explicitly disagree (European Commission 2010: 42). This fear of scientists has diminished since 2005, however, when an average of 59 % of respondents in the then 25 member states believed that scientists have a power that makes them dangerous (European Commission 2005: 82). In 2001 even more respondents, 63 %, agreed with the statement (European Commission 2001: 36).

Few people in China agreed with a comparable statement, namely ‘Scientists are scary because they have the knowledge and capability to change the world.’ Only 14 % of the Chinese public supported this statement in 2007, and the support rates in 2005 and 2003 were 11 and 15 % respectively (Ren et al. 2010, 2011).

The results of the Chinese survey are therefore set in stark contrast with those of the EU, as more than half of EU citizens see scientists as wielding a power that makes them dangerous. This divergence reveals a major difference between the Chinese and European publics: although the Chinese public is less optimistic on this question than in the past, its cautious attitude is far from materializing into worries and fears for science and technology in general, and its negative attitude and sentiment towards science and technology therefore seem rather limited in scope.

3.5 Between Science and Faith

Faith and religion have had a delicate relationship with science and technology throughout history. Therefore both the Eurobarometer survey and the Chinese national survey of public scientific literacy test the proposition: we depend too much on science and not enough on faith.

The Eurobarometer 2014 report points to a public divide on this statement. On average 39 % of EU citizens agree and 32 % disagree, which is not very different from the 2010 survey. In addition, the reports show that opinions differ greatly between countries, with respondents in the eastern and Mediterranean countries more inclined to agree (European Commission 2010, 2014). On a related subject, most people (58 %) agree that the pace of developments in science and technology makes our ways of life change too fast.

In contrast the Chinese survey conducted in 2007 showed that only 16 % of respondents supported this argument. Moreover, support from the Chinese public shows a steady declining trend: while 23 % of respondents said yes to the question in 2001, the support rate was only 18 % in 2005 and as low as 16 % in 2007. These results show that the Chinese public is clearly not as worried about the issue as the EU public. Based hereon, we may wonder whether the Chinese public is disinclined to consider and judge issues arising from science and technology developments from the perspective of the dominant belief system, than the European public.

3.6 Balancing Risks and Benefits

Nanotechnology, genetically modified crops and synthetic biology all hold the promise of major benefits for society. However, they also have in common that they raise potential risks. In this section we discuss how EU, Chinese and Indian citizens perceive the benefits that science and technology may bring and the risks that these entail.

'Close to half of Europeans, 46 % of respondents at the EU27 level, agree that the benefits of science are greater than any harmful effects it may have' (European Commission 2010: 74). However, 20 % disagree. The level of agreement has declined since earlier surveys (European Commission 1993: 74, 2001: 29, 2005: 75). This raises the issue of what role the precautionary principle should have in coping with science and technology, which was examined through the statement: 'If a new technology poses risks that are uncertain and not yet fully understood, the development of this technology should be stopped even if benefits are expected' (European Commission 2010: 78). Interestingly, the survey demonstrates that almost one in two (49 %) EU citizens agree with this statement, while only 22 % disagree. To make the situation even more complicated, 'while Europeans express the need for risk management, at the same time they do not want to miss out on technological progress. A slim majority of 52 % of respondents at the EU27 level agree that technological progress will be slowed down if risks that are not yet fully understood receive too much importance' (European Commission 2010: 81).

Once again the Chinese public seems more optimistic: almost three-fourths (74 %) of respondents indicated that science and technology could 'bring good and bad and the good is always more than the bad'. In earlier years, however, the support rate was slightly lower, but in any case significantly higher than that of EU citizens on this issue (Ren et al. 2010, 2011).

The issue is not addressed in the India Science Report, but it does ask whether ‘technologies will eventually destroy the Earth’, which evidently tells us something about the perception among the Indian public of the risks involved in science and technology. The report shows that a striking 39 % agree with this statement, while 25 % disagree. Another 36 % answered ‘do not know’ (NCAER 2005: 109).

In sum: EU citizens and Indian citizens perceive science and technology very much as a double-edged sword. On the one hand, they are quite confident about its potential benefits and, in case of the EU, do not really want to miss out. On the other hand, they are quite wary of the potential downsides of developments in science and technology. The Chinese public, on the other hand, is optimistic about the benefits and convinced that the potential downsides can be accommodated.

3.7 Conclusion

What have we learned from this comparison? It is hard to draw elaborate conclusions in the absence of fully comparable data sets. But while we work towards establishing more comparable surveys, it would be foolish to disregard the obvious opportunity to draw certain cautious conclusions from the material that is available.

Science and technology perceptions are, overall, positive in the three regions. Interest in science and technology varies between the high levels of the EU and China and a somewhat lower level in India. This might be the result of access to science and technology developments in everyday life currently being higher in the EU and China than in India. Interest grows with increased exposure to science and technology. Interest does not, though, necessarily translate into involvement, as we have seen in the case of EU. Actual engagement with science and technology issues relates to proximity to technological developments (e.g. genetically modified food), while the incorporation of engagement into policy-making requires the establishment of official structures that might not exist in every region yet (see Chap. 2).

The overall image of science and technology is positive in all three regions, and this does not appear to be related to one’s knowledge level, educational background or income. Rich and poor, literate and illiterate find the promise of science and technology compelling and worth supporting. The fact that most people do not regard science and technology as a panacea for the problems society faces is merely the reflection of a pragmatic attitude on the part of citizens who have experienced financial crises, unemployment or even a lack of basic amenities. It does not translate into lower support for science and technology.

What appears to put the brakes on people’s optimism is the awareness that power can serve good as well as bad aims. The power that individuals (i.e. scientists) can wield is problematic for Europeans, while it does not appear to be an issue for the Chinese public (yet). This could reflect the instinctive uneasiness that the average European would have with the concentration of power in few hands, something that the average Chinese might perhaps be less worried about.

A related matter is the perception of a precarious balance between faith and science in the minds of the more religious European publics, in contrast to the less religious Chinese public. Here one recalls the uneasy dichotomy between faith and state that developed during the Enlightenment in Europe; in China, however, the dominant belief system has happily incorporated science and technology as a main pillar, thus easing the potential tension between traditional beliefs and new developments. As for India, one can only make an informed guess that the tension between faith on one hand and science and technology on the other is real and strong in the most traditional sectors of society (see Chap. 7).

Finally, perceptions of risks and benefits vary in the three regions, demonstrating that this is a very volatile variable, depending on the focus of the questions (i.e. the specific technology) and the current social context (e.g. recent scandals and media attention). Few people in the three regions see science and technology as without risk, but most retain a guarded optimism about the overall benefits. When it comes to application of the precautionary principle, the EU leads support, naturally influenced by the widespread debates in Europe on genetically modified foods and crops. Increasing support for precaution can certainly be expected in China and India too, once the debates there acquires a focus similar to what we have seen elsewhere (for instance, see Chap. 9).

Overall, the available comparisons provide many valuable insights into state of affairs in the three regions, but they also highlight the need to create fully comparable surveys to facilitate detailed analysis of the parameters affecting science and technology perceptions. Once such surveys have been executed, then our understanding of the three regions will increase substantially, and our aim of promoting meaningful science and technology collaborations among them will be more easily realized.

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Chapter 4
Public Engagement in the Governance of Science and Technology

Yandong Zhao, Camilo Fautz, Leonhard Hennen, Krishna Ravi Srinivas and Qiang Li

4.1 Introduction

In contemporary societies 'public engagement' or 'public participation' is becoming an increasingly popular means of approaching certain highly awkward issues such as the management of risks or the development and socially sound implementation of emerging technologies. There are many reasons, practical and normative, for policymakers to involve lay people in policy-making (e.g. Fiorino 1990; National Research Council 1996). In the field of emerging technologies scientific uncertainties frequently exist in combination with a plurality of value-based perspectives. In those cases decisions may be influenced to a significant extent by the values of the experts involved, who cannot claim that their moral sentiments have a higher validity than those of the public.

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Aside from ethical and normative reflections, decisions made without public support tend to provoke a loss of empirical legitimacy that may be expressed in confrontation, disruption and public distrust. Emerging technologies such as food technologies, nanotechnologies and synthetic biology are increasingly regarded as political issues due to their potentially immense impact on society associated with controversies about risk and benefits and ethical disputes about human dignity, the common good and questions of responsible research. Hence the fact that many questions, such as the setting of security standards and the social distribution of costs and benefits, as well as their compatibility with ethical standards, are not just of a technical or scientific character, but have to be dealt with politically as well (Wynne 2001). This is taken into account by the trend of including a range of interests and moral values in science and technology governance processes by engaging representatives of the general public.

The expected benefits of public engagement are easier and faster decision-making by preventing public discontent, greater trust in decision-makers and in decisions reached through open and fair procedures, and enhanced knowledge of complex issues among decision-makers and citizens through the inclusion of lay knowledge and values as well as through mutual learning.

The ways in which citizens are becoming involved differ from country to country, depending on cultural and institutional structures—the civic epistemology of a country (Jasanoff 2005). This chapter will take a close look at public engagement in European countries, China and India. There are huge differences among the regions in economic development, political systems and levels of science and technology development. A comparison of these regions will help us better understand public engagement in science and technology governance.

4.2 Public Engagement in Europe

In Europe, forms and methodologies of public involvement have attracted increasing attention since the 1960s, in line with successive waves of societal democratization. The 1990s in particular, when the Soviet system disintegrated, marked a phase of transition and, to some extent, democratization for Europe. Concepts and theories of deliberative and participatory democracy gained importance in scientific and policy circles.

These developments coincided with the increasing emergence of critical debates on science and technology provoked by environmental, health, safety and food scandals, such as those relating to asbestos, contaminated blood reserves and the BSE (‘mad cow disease’) crisis. Thus the equating of technological progress with the amelioration of human living conditions was challenged, with scientific expertise becoming a politically contested field.

The failure of science, in the eyes of many members of the public, to speak truth to power in fields such as the environment, consumer protection and agriculture, as well as the strong opposition to genetically modified organisms in sections of the public, has led to reappraisals in the field of policy advice and to the establishment of technology assessment institutions in many European countries.

In the past 10–15 years, a series of documents and actions in Europe have marked a shift from the 'public understanding of science' paradigm to a new appreciation of citizens and their views on ethical problems, including risk management and legal and socioeconomic issues related to new technologies (Hennen 2013). A case in point is the call for dialogue, participation and empowerment of the European citizen in the European Commission white paper of 2001 on European governance (EC 2001a). A report by the white paper working group (EC 2001b) recommended that the selection of expertise used in the process of policy-making be revised, that guidelines be established for the selection of expertise, and that as broad as possible a spectrum of expertise be consulted in policy advice. Most prominent of the recommendations regarding socially robust knowledge for decision-making was the creation of 'greater opportunity for informed participation by society in policy-making'. The promotion of participatory procedures was one of the means to be employed to support 'public debate, knowledge-sharing and scrutiny of policy makers and experts' (EC 2001b: ii). The EC took up this reorientation of science and technology governance in its Science and Society Action Plan (EC 2001c). The action plan recommended involving people actively in technological development and giving them the 'opportunity to express their views in the appropriate bodies' (EC 2001c: 14). To this end participatory policy-making would have 'to be widened and deepened to systematically include other sectors of civil society at all stages' (EC 2001c: 14).

Participatory technology assessment (pTA) is one of the most important exercises for promoting public engagement in science and technology governance (Decker and Ladikas 2004). Some standard participatory methods have been developed in the course of such exercises—such as citizen juries, consensus conferences, 21st century meetings, charrettes, focus groups, deliberative polling, scenario building exercises and technology festivals—as well as new and experimental forms that mostly recombine the standard methods. The following analysis will describe a case study of technology assessment practices with lay participation in genetically modified food technology.

4.2.1 PTA Practices in the Governance of Genetically Modified Foods in Europe

The shift to the predominance of the science and society paradigm in Europe corresponds with several events related to food and agriculture, such as the BSE crisis, the birth of the cloned sheep Dolly, the arrival of genetically modified corn and soybeans from the United States and the trade conflict between the US and Europe resulting from Europe's ban on hormone-raised beef (Ansell et al. 2006: 97). In this context, decision-makers realized that governmental food safety policies could easily provoke high politicization and public distrust.

Genetic modification in food production provokes concerns about health and safety issues and raises ethical and moral objections. For example, the consumption of genetically modified food would be ethically problematic, in an indirect way, if its production caused or risked harm, violated rights or caused injustice. Genetically modified foods also provoke other reactions: some perceive them as ‘unnatural’ and as a violation of the intrinsic value of nature. Thus, when nature or the environment is thought of as an object of ethical concern, regardless of how the environment affects the interests of humans, genetically modified foods raise ethical issues about the rights and wrongs of the ways humankind affects nature that are particularly difficult to explore and resolve. Surveys show that there is a gap between the favourable public perception of biomedical applications and the negative perception of agri-food biotechnology, although there are significant differences among European countries. This is in line with the observation that over the past two decades heated debates have taken place in many European countries between decision-makers, experts and stakeholders, including lay people as consumers, about genetically modified plants and foods without common ground having been found between proponents and opponents.

One could add here that in several EU member states, such as France, the United Kingdom and Germany, public engagement started with self-organized activism on the part of citizens who destroyed genetically modified test crops or occupied supermarkets that were selling genetically modified products. In particular, countries that had not used pTA beforehand tried to introduce it to appease activists and the broader public. This was the case in France, the UK, Germany and Austria. In countries including Norway, Denmark, Switzerland and the Netherlands (all relatively small, with fewer than ten million inhabitants), forms of pTA or other forms of political participation had already been established, and the genetic modification debate did not become as intense as in the other countries.

Based on documents available on the internet and scientific literature on pTA published since the 1990s, we have identified 20 pTA exercises in the field of genetically modified foods, 15 of which involve lay people. These can be subdivided into eight consensus conferences, three focus groups, one charrette, two 21st century town meetings, one scenario building exercise, and one event in a science museum that cannot be categorized. The UK’s ‘consumer views on genetically modified food’ combined focus groups, a local citizens jury and events for students, but we have listed it as a focus group exercise because the exercise consisted mainly of focus groups. Of the 15 lay pTA exercises, 13 were organized by specialized technology assessment bodies or state institutions, one by a research organization that had no direct link to a national parliament or government (Citizen GMO UK) and one by a science museum (Future Foods (UK)).

The common objectives of almost all of these pTA practices comprised the improvement of information about genetically modified organisms, the stimulation of a broad public discourse based on a higher quality level, and the facilitation of dialogue between experts and non-experts. Some organizing bodies additionally mentioned that they wanted to test or improve methodologies of discursive practice.

Regarding the impacts of the analyzed practices, the picture is mixed. Nearly all practices ended with written reports, but for many of them, the trail of political impact got lost after the written report and some press coverage, especially in France, the UK and Germany. Other procedures, however, seemed to have a closer link with political institutions. TA-SWISS, for example, was able to present the results of a citizen conference, or 'PubliForum', on genetically modified food to the parliamentary commission for science, education and culture. The Danish Board of Technology stated that political interest in the field of genetically modified food had increased in the wake of a consensus conference held on the issue, and that both national and EU politicians had shown interest in the project, with a view to becoming better informed about citizens' perspectives. In the end, however, the interest shown may not have been sufficient to modify policies or regulatory principles (Hansen 2006). In Norway there was the special case of two consecutive consensus conferences within 4 years with the same lay panel. Both enjoyed high mass media coverage, and the conference facilitators were invited to present the major conclusions and recommendations in the Norwegian parliament.

What is the lay people's opinion on genetically modified food, as far as it can be summarized from these activities? While the proponents of genetically modified plants highlight the environmental and economic benefits (fewer fertilizers, fewer pesticides, less tillage, higher productivity), the opponents put more emphasis on health and environmental risks, as well as factors such as naturalness and the integrity of nature. Furthermore, many consumers have difficulty identifying clear benefits of genetically modified food products. Some consumers would be willing to spend more money on genetically modified products if they provided a better taste or a higher nutritional value.

Concerning the governance of science and technology in the field of genetically modified food, French and UK citizens in particular complained that public debate had come too late. Their suspicion focused on the government having made a decision already, with inadequate knowledge of citizens' needs, and on the motivation of multinational companies to promote their own interests above the wider public interest. Many lay people felt that very little information was available to the public on genetic modification: they needed to know more about what genetic modification was, what safety tests had been done, and about the regulating bodies and their responsibilities. Many citizens expressed concern about the power multinational companies exerted through the patenting of seeds—power that might affect the social distribution of costs and benefits. Consequently new regulations that were fair to primary producers, developers and end users were recommended. Another big topic for almost all citizens was openness and transparency. Consumers wanted clear and effective labelling and tracing that allowed them to make an informed choice between food that was genetically modified and food that was not.

With regard to risk and regulation, many lay people were worried about the possible impacts of genetic modification on the environment and biodiversity. They were therefore in favour of more precaution and argued that more time was needed to understand the long-term implications of genetically modified crops before farmers started growing them.

What the analyzed pTA practices have in common are concerns about the non-excludability of specific risks in the context of today's level of scientific knowledge—for example, the theoretical risk of antibiotic resistance being transferred to human beings. There are calls for intensified independent public research, combined with strong ethical guidelines.

Most lay recommendations include calls for greater consideration of ethical aspects in genetically modified research, for example via a code of practice or the establishment of a council on gene ethics, to ensure a continuing ethical debate in society. There is particular concern about the genetic modification of animals, as well as the crossing of barriers between animals and plants. In this context the Danish lay panel stated that ethical considerations of interference with individual plants or animals should be seen in an overall framework, taking into account the whole of living nature and its integrity.

4.2.2 Conclusions

In Europe, the search for new forms of governance of science and technology is ongoing, and part of it is about a redefinition of the role of experts, stakeholders and lay people in policy-making. The science and society paradigm now sees everyday aspects of life, previously deemed apolitical, as politically relevant. Given the increased frequency and widespread use of participatory procedures in technology assessment, it can be said that pTA and public engagement in science and technology policy-making are widely established practices in Europe.

To date, however, there has been little systematic empirical evaluation of the role and impact of pTA processes (Hennen 2013). Some reports clearly show that lay people are able to discuss highly complex societal and ethical aspects of science and technology reasonably and can engage in dialogue with experts, and that formats such as consensus conferences are suitable for initiating cooperative learning processes among lay people. There are thus indications that deliberation—in the sense of joint reasoning on societal problems—can be achieved in pTA processes.

Studies indicate that the resonance of pTA in the media and in policy-making is often quite restricted (Joss and Bellucci 2002). Analysis of the factors conducive or obstructive to the public and political resonance of pTA arrangements (Hennen 2002) suggests that the potential influence of pTA is affected by the quality of the outcome of a pTA process or by features of the procedure itself (management, actors involved). More important than features of the procedure, however, is the context in which the procedure takes place. The nature of the issue or problem at stake and the institutional and political setting of the pTA arrangement appear to be of the greatest importance.

4.3 Public Engagement in China

Before reforms and opening up started in China in 1978, the state-led science and technology system was a highly hierarchical one in which public participation was rare. In the past 30 years, the Chinese government has taken active measures to involve more parties, including the public, in science and technology governance. The Law of the People's Republic of China on Science and Technology Progress, as amended in 2008, explicitly provides for the rights of the public to participate in decision-making on science and technology affairs: 'The State encourages government departments, enterprises, institutions, public organizations and citizens to participate in and support activities for progress of science and technology' (China 2008).

This encouragement of public participation in the formulation of the country's science and technology policies was reflected, for example, in the compilation of the Outline of the National Program for Long- and Medium-Term Scientific and Technological Development. In 2003, the Chinese government had begun to design multiple forms of public participation in accordance with the principle of 'public participation, brainstorming, democratic decision-making and scientific decision-making'. The Ministry of Science and Technology, for example, opened a new channel about the outline on its official website to keep the public informed of progress, and launched a public participation forum with 19 topics that the public could visit to make comments and share views on the compilation of the outline. These measures strengthened communication and interaction with the public. Later, in the review and evaluation of the implementation of the outline, the office in charge of the programme issued more than 2,000 questionnaires and organized more than 100 working meetings to solicit expert opinions from relevant government departments, enterprises, higher-learning institutions, research institutes and industry associations (Li 2011).

Meanwhile, as the rapid economic growth of the past 30 years has greatly improved Chinese people's living conditions and levels of education, the Chinese public's awareness of rights and perception of risks have risen accordingly. As a result, the Chinese people are more willing and able to participate in the governance of science and technology.

The case of the protests against PX projects in China is a good illustration of this tendency. PX is the abbreviated name for the dangerous chemical p-Xylene, which is strongly carcinogenic and teratogenic. In 2007, a petition cosigned by six members of the Chinese Academy of Sciences and 100 members of the Chinese People's Political Consultative Congress was submitted to the congress against the plan to establish a PX plant in Xiamen city, Fujian province. This proposition was reported in the media and received extensive public attention. Local people debated furiously in online forums and took to the streets holding banners bearing words such as 'I love Xiamen' and 'We oppose PX'. However, the city government did not pay enough attention to the protest. On the contrary, the government accelerated the project while taking control measures such as confiscating magazines, closing websites and blocking SMS messages. These measures only fuelled the circulation of the PX information among local residents, who planned a street 'stroll' against the PX project via SMS. In early June, some residents wearing yellow ribbons launched a 'stroll' in front of the seat of the city's government, bringing public participation in the matter to a head (Song and Yu 2012). It was only then that the government took account of the public's demands and responded positively. After that, the government made active efforts to listen extensively to the opinions of residents through a variety of channels such as SMS, telephone, fax, email and mail. In December 2007, the Xiamen government formally issued an environmental assessment report on the PX project and convened a symposium. Eventually it was decided, on 9 January 2009, that the PX project would be moved to another city.

From this case and many others, it is possible to identify some general characteristics of public engagement in China. First, the main public participants in science and technology governance include direct stakeholders, indirect stakeholders, social groups, lay experts and the general public. There is a lack of independent third-party social groups, especially in large-scale campaigns, in which independent NGOs are not allowed to participate. It is the absence of independent organizations that has led to the occasion-specificity and disorderliness of public participation.

Second, the direct cause of public participation in science and technology governance is their shared stake. Why did the Xiamen PX incident provoke a strong public response? The answer is that it was localized, it touched the vital interests of local residents, and it was caused by the omission of local government from the process. When the local public have shared motivations and common interests, they are better positioned to launch a large-scale mass campaign as a means of public participation.

Third, public participation in science and technology governance is mainly bottom-up and post-occurrence, and lacks formal channels. Many important incidents of public participation have taken place after, rather than before, the occurrence of the problems. They have mostly taken the form of bottom-up campaigns to exert pressure on the authorities, which in some cases respond by setting up formal consultative and participatory processes. Just as some scholars have observed, public participation in the decision-making on science and technology affairs is mostly spontaneous and non-institutionalized and lacks legal protection, and is also often ignored by decision-makers (Fan et al. 2011).

4.4 Public Engagement in India

Four pillars underlie India's science and technology goals: techno-nationalism, inclusive growth, techno-globalism, and global leadership (Mashelkar 2008). The Science, Technology and Innovation Policy 2013 issued by the Ministry of Science and Technology observed that science and technology systems had to undergo a paradigm shift from the current input-driven innovation model to a more development-led strategy. The document emphasized the importance of public awareness of Indian science and technology. It stated that 'public and political understanding of science should be based on evidence and debates with open mind. People and decision makers must be made aware of the implications of emerging technologies, including the ethical, social and economic dimensions'.

India has a vibrant civil society, but in science and technology issues that civil society has much more potential to contribute. To begin with, not many groups are active in science and technology policy or in promoting pTA in India, and those that are there work on issues like sustainable agriculture, traditional medicine and the rights of forest dwellers, with a focus on praxis rather than on policy aspects. In the controversy over Bt brinjal, many of these groups came together and opposed the granting of permission for the commercial cultivation of the plant, but the same level of involvement is missing from the debate on policy issues like the proposed Biotechnology Regulatory Authority of India Bill. Although civil society groups opposed the bill, which proposed replacing the current regulatory system with a new regulatory authority, the debate was not as intense as the controversy over Bt brinjal.

There are not many civil society groups working on science and technology policy issues in India. One reason, perhaps, is that not many universities or institutions of higher learning offer courses in science and technology policy or studies. Another factor could be that science and technology policy is too diffuse a topic to attract NGOs that usually focus on a single sector, such as health, agriculture or workers' rights. Some groups are working on nuclear energy and atomic energy issues, but are divided on nuclear energy for peaceful uses.

There are some think tanks and other initiatives that have links with academic institutions working on science and technology policy issues, broadly speaking, but these are not activist groups. They can, however, be considered part of civil society. For example, the Knowledge in Civil Society Forum is a network of academic institutions, researchers and NGOs working on agriculture, knowledge and innovation. As part of the SET-DEV (Science, Ethics and Technological Responsibility in Developing and Emerging Countries) project funded by the European Commission, the forum published Knowledge Swaraj: An Indian Manifesto on Science and Technology in 2011. Earlier it held a national workshop with civil society groups engaged in science and technology issues. A perusal of the papers and proceedings indicates that the groups working on irrigation, energy, sustainable agriculture and forestry, and researchers working on traditional medicine, innovation studies, and agricultural research and extension, participated in the workshop. However, although they covered many issues, there was no focus on science and technology policy or policy making per se.

Participation is an important issue in India, however. There are groups that work on participatory rural appraisal, irrigation, the participatory auditing of projects and the participation of marginalized groups in civic bodies. But their focus on participation is more on empowerment issues than on assessing systems and technologies. As in the case of science and technology policy, it is also difficult with pTA to identify any group or organization that is focusing on this, although there are many groups promoting alternative technologies in different sectors. One reason is that technology assessment itself is not a well-developed or thoroughly researched topic in India. The Technology Information, Forecasting and Assessment Council is an agency under the Department of Science and Technology that performs technology assessment, but pTA is a new concept in India and not much work has been done on it.

The major constraint is the fact that civil society groups are not involved in science and technology policy issues and lack expertise in technology assessment. Environmental groups, trades unions and people's science groups are quite active in defending people's rights and interests with regard to technological change, among other areas, and aspects of technology assessment play a role in relation to these activities, but technology assessment as a methodology is perceived as a matter for researchers. There is enough scope for pTA in India, particularly in the case of biotechnology, agricultural technologies and energy technologies. Participatory rural appraisal and the participatory management of natural resources in joint forest management have been thoroughly tested in India. The challenge lies in translating the need into action. What is required is interaction between civil society, policy-making and research to strengthen public participation in interdisciplinary problem-oriented research.

4.5 Discussion and Conclusion

It can be concluded from the research on pTA and its political role that the chances of public engagement being visible in public or political debates are relatively good when the political situation is open, with interested parties looking for new ways to solve problems and no immediate decisions at stake. Typically these are situations in which the problem has not yet been well defined politically or in which the interested parties are searching for common paradigms to solve the problem. The results of public engagement arrangements have a good chance of being referred to in the public sphere and in policy-making if the focus is on the development of ideas and the objectives are not highly contested. When the issue at stake is highly contested and interest groups hold definite positions on it, public debate of the benefits and risks may still continue, but it is highly unlikely that independent policy advice or consultation will have any kind of impact, regardless of whether it is expert or participatory (On this and the following, see Hennen 2013).

The unclear political status of public engagement and the fact that it often appears to have little influence on decision-making have, taking pTA as an example, led to criticism (Rayner 2003; Stirling 2007; Abels 2007; Bora and Hausendorfer 2006). Although such criticism is justified with regard to many individual pTA exercises, the conclusions drawn from observation of the limited effect of pTA seem unduly strong. The effect is limited because there is no defined role for pTA in the established decision-making processes, not through any inherent bias against pTA procedures. It can be demonstrated that the outcomes of many pTA procedures (i.e. their conclusions and recommendations) contradict the expectations held by experts and decision-makers. The argument that pTA is a way of framing issues that allows non-scientific arguments (considered to be irrational) to be ruled out by the process, or that it involves citizens in a procedure that rules out their authentic attitudes, does not find much support in empirical studies of the outcomes of citizen juries in contested fields of technology or scientific development.

Framing and the instrumental use of outcomes are, as Stirling (2007) has argued, a problem for any type of policy advice and technology appraisal. He holds that participatory appraisal is as open to power and justification strategies as is expert appraisal. PTA can be used to induce 'technical commitments', that is, a closure of processes of technology development, instead of opening them up for new perspectives and values.

However, it is by providing for transparency and by giving as much control of the process as possible to participants that practitioners strive for an open and unbiased process. In brief, there are rules of good practice, some of them derived from Habermasian discourse ethics, that can protect against instrumental use and framing. With regard to expert appraisal (science), one cannot deny the relevance of central institutional features of science such as peer review and methodological scepticism, despite known cases of scientific fraud. Similarly, participatory appraisal is guided by discourse rules and the principle of transparency, which are functional equivalents to the Mertonian principles of science.

An evaluation of the effects of pTA must take into account that it is quite difficult, and often impossible, to identify the effects of scientific advice on decision-making processes. Such processes are generally influenced by a complex set of interests and rationalities (Albaek 1995). Thus expert appraisal often suffers from the same lack of visible impact as participatory appraisal. In contrast to expert appraisal, however, pTA cannot simply be regarded as a paid service to policy-making that may be heeded or not. Because it includes underrepresented societal perspectives, pTA carries a connotation of democratizing science and technology policy and produces expectations of democratic inclusion. A lack of perceivable impact is therefore more problematical for pTA than for expert appraisal and might, in the long run, create grave disappointments.

For our comparison among the three regions of the state of the art in public participation, it is worth noting that civil society in European countries has been fighting for more participation in local, environmental, and technological decision-making since the 1960s. In Germany, for example, the *Planungszelle*, a kind of citizen jury, was developed in the 1970s to handle local environmental conflicts. Concerning participation in technology policy, it took over 20 years, particularly in the bigger European countries, for methods like the citizen jury to be transferred to the field of technology policy.

This evolution in Europe has been advanced by different developments, including the waves of democratization since the 1960s, the rise of environmental activism and civil society organizations since the 1970s and 1980s, and the publicly perceived accumulation of governance failures or scandals in the 1990s.

The Chinese PX case shows some parallels to European environmental activism and disputes in the 1970s and 1980s, when environmental NGOs and parties evolved. But, of course, these developments took place in different sociocultural settings. The Chinese government is starting to emphasize the importance of social engagement in science and technology governance. Meanwhile, the Chinese public are more willing and able to participate. In future, the more difficult work is going to be building up a better institutional environment for public engagement in China.

In India, there is already a certain sentiment for self-organized bottom-up engagement and empowerment of local civil society groups and NGOs acting in specific local and cultural or application-oriented contexts. However, these groups and organizations still face problems in reaching or addressing science policy actors because they often lack the technical capacity to address broader and overarching science and technology issues beyond their operational context, and they also lack channels to the policy-making levels.

Europe, on the other hand, has to some extent managed to channelize, and even forestall, activist movements by offering alternative different channels for more or less extensive participation by stakeholders and the general public. In addition, science and technology governance in Europe could profit from a range of context-specific knowledge leading to more robust technology implementation processes.

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Chapter 5
Science and Technology Governance and European Values

Doris Schroeder and Virgil Rerimassie

5.1 Introduction

This chapter is in four parts. The first describes the most fundamental European values as recognized by the Charter of Fundamental Rights of the European Union (EU) and the Treaty of Lisbon. One value that will be discussed in addition to those contained in the charter is that of sustainability. While the idea of sustainable development was included in previous European treaties and instruments, it has been given more emphasis in the Treaty of Lisbon through Art. 3(3) (EU 2007):

> The Union … shall work for the *sustainable development* of Europe based on balanced economic growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and *a high level of protection and improvement of the quality of the environment* (our emphasis).

A brief historical section will explain how many of these fundamental values attained prominence. Explanation of what exactly these values mean forms the main part of the chapter, followed by a case study section on preimplantation diagnostics.

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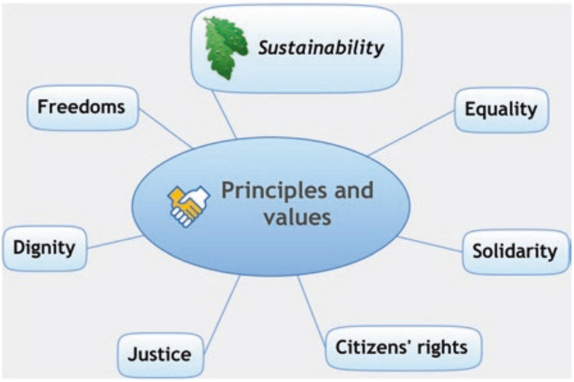


Fig. 5.1 Main principles of the charter of fundamental rights and the treaty on the European Union

5.2 Fundamental European Values

Science and technology policies will succeed best if built on strong ethical foundations. These foundations are being debated worldwide, and the need for effective global governance of science is becoming more and more urgent. Given the democratic backing of the Charter of Fundamental Rights of the European Union and the Treaty of Lisbon (EU 2007), we shall explore fundamental European values and how they relate to science and technology policies (Fig. 5.1).

The EU Charter of Fundamental Rights (EU Charter) was signed on 7 December 2000. Importantly, the charter is legally binding. This was achieved by incorporating a reference to the charter into a binding treaty. Article 6(1) of the Treaty of Lisbon (EU 2007) reads:

> The Union recognises the rights, freedoms and principles set out in the Charter of Fundamental Rights of the European Union of 7 December 2000, as adapted at Strasbourg, on 12 December 2007, which shall have the same legal value as the Treaties.

This reference to 'the same legal value as the Treaties' means that the charter now forms part of the primary law of the EU, and as a result provisions are potentially enforceable through national courts as well as in the European Court of Justice (Barnard 2008). (The scope of the charter is specifically aimed at institutions of the EU and only applies to member states, when implementing EU law.[1])

[1] The field of application is addressed in Art. 51(1) of the charter, which reads: 'The provisions of this Charter are addressed to the institutions, bodies, offices and agencies of the Union with due regard for the principle of subsidiarity and to the Member States only when they are implementing Union law.'

5.3 European Enlightenment

The European Enlightenment was broadly coextensive with the 18th century. The German philosopher Immanuel Kant (1724–1804) described it as a process of moving from superstition, unawareness and blind belief in authorities to progress for humanity through the power of reason (Kant 1990). The term 'Enlightenment' is thus generally used in Europe to describe a process of liberation from traditions, institutions, conventions and norms that could not be rationally justified. Essential ideas associated with this period include the convictions that mastery over nature will lead to the advancement of humanity, that tolerance is a virtue of states needed to maintain public order and that human beings can be perfected through education (Mickel 1986). Amartya Sen summarizes the European Enlightenment as an 'intellectual climate … with [an] interest in reasoned construction of social order' (Sen 2000).

Common to all ideas of the Enlightenment is the core belief that human reason and *not* religious or state authority ought to decide on the norms of ethical, political and social action as well as the differences between truth and error. As a result, some of the values now found in the EU Charter rose to prominence when authoritarian regimes were challenged, especially on questions of freedoms, citizens' rights, solidarity and equality. This was particularly obvious in the French Revolution of 1789, with its rallying cry of 'Liberté, égalité, fraternité' [Liberty, equality, brotherhood].

Immanuel Kant was an exceptionally important figure in the European Enlightenment (Hampson 1982), and he has most often been credited as the father of human rights in their modern sense. In the West, the history of human rights is often told in two different ways. The first takes an inclusive approach, and claims that human rights are based on universal beliefs that can be traced back to most religions (Hampson 1982). For instance, believers in Islam have issued a Universal Declaration of Islamic Human Rights containing 23 rights, including the right to a fair trial, the right to protection against torture and the right to social security (Islamic Council 1981).

On the other hand, 'Islam stresses the submission of the individual to Allah [as] God has rights, people do not…' (Dalacoura 2005). This statement clearly contradicts both the idea of individual human rights and the European Enlightenment belief that one should question religious authorities. Likewise, Buddhism seems incompatible with rights assigned to autonomous individuals, given that it 'denies the very idea of autonomy, continuity and authenticity of the self' (Chan 2005a). Similarly, Confucianism and its focus on virtue (the attainment of *ren* being the most perfect of virtues) links better to ideas of ethics of obligations than to rights; in particular, obligations to respect and care for others (Chan 2005b).

The second approach maintains from the start that the idea of human rights is of Western origin, usually credited to the Enlightenment and specifically to John Locke (1632–1704) and Immanuel Kant (1727–1804).

Analyses of the historical predecessors of the contemporary theory of human rights typically accord a high degree of importance to Locke's contribution.

Certainly, Locke provided the precedent of establishing legitimate political authority upon a rights foundation. This is undeniably an essential component of human rights. However, while the philosophically adequate completion of a theoretical basis of human rights requires an account of moral reasoning that is consistent with the concept of rights, it does not necessarily require an appeal to the authority of some superhuman entity in justifying human beings' claims to certain, fundamental rights. Immanuel Kant provides such an account (Fagan 2005).

How does Kant justify his belief in universal human rights—in other words, in individual rights irrespective of gender, race, ethnicity, sexual orientation etc.? For Kant, human beings have the capacity to act morally: their ability to separate good and bad actions depends on their faculty of reason, and only because they are rational is it possible for them to decide between right and wrong. This human ability to be rational and to make decisions leads to a particular way of looking at the world. As Kant says in a famous passage from the *Metaphysics of Morals* (Kant 1996):

> [B]ut a human being regarded as a person, that is, as the subject of a morally practical reason, is exalted above any price; for as a person… he is not to be valued merely as a means to the ends of others or even to his own ends, but as an end in himself, that is, he possesses a dignity (an absolute inner worth) by which he exacts respect for himself from all other beings in the world.

In justifying human rights through the human ability to reason, Kant also introduces a value which has since become central to European value systems, namely that of dignity. Humans have dignity *and* possess human rights because of their 'rational nature in its capacity to be morally self-legislative' (Wood 1999). Kant therefore based individual, universal human rights on human dignity understood as the ability to be self-legislative. (For a broader view of dignity, see below.) This is why he is often regarded as the Father of Human Rights, which are now also reflected in the EU Charter.

The value of dignity was given added importance through the horrendous acts of Nazi doctors during the Second World War and other harmful, highly exploitative medical experiments. As a result, the 1949 German Constitution now places respect for human dignity ahead of all other values, enshrined in Art. 1(1): 'Human dignity shall be inviolable'.

When European Enlightenment ideas of the questioning of authorities (political and religious), mastery over nature, belief in human progress and individual autonomy are combined, it is clear why the development of science and innovation has accelerated in the West since the 17th century.

For instance, the optimistic notion of *progress* was paramount to the development of modern science. It is often said that Western philosophers still debate Aristotle's *Nichomachean Ethics*, while his scientific assumptions (for instance, that the void around the earth is filled with aether) have long since been discarded.

Only with the wider use of nuclear energy and nuclear deterrence (Lehming 1991) in the 1950s and 1960s, and later with the development of genetically modified organisms, was the belief in social progress through science questioned among broader populations in Europe. The first European Green parties emerged in the 1970s, and the most powerful—the German Green Party—has been sharing government responsibilities since the 1980s either locally, regionally or nationally, based on opposition to nuclear power and genetic modification. The value of sustainability derives from this movement, which is active throughout Europe.

In addition to the Green movement's subversion of an uncritical belief in science, it is today widely acknowledged that the European Enlightenment, with its emphasis on human progress, human domination over nature and the importance of reason, nourished the European colonial enterprise. Indian scholar Sanjay Seth, who heads the London-based Centre for Postcolonial Studies, writes (Seth 2011):

> Armed with the certainty that it possessed nothing less than universal Reason, Europe could proceed with its colonial conquests, no longer principally in the name of bringing the true word of god to the heathen, but rather in the name of bringing Enlightenment and civilization to the benighted.

While Seth emphasizes that 'neither the modern age nor Europe has had a monopoly on … dogmatism' (Seth 2011), he notes that the belief in tradition-free reason, which does not realize the cultural context of ideals and practices, made colonialism possible.

At the same time, thinkers from different continents continue to stress a key idea from the Enlightenment period, namely humanism: the belief that all individual human beings are important and deserve respect. For instance, according to Nigerian scholar in African Studies M.O. Eze, a 'peculiar form of African humanism' (Eze 2011) can be identified in the philosophy of Ubuntu. 'Ubuntu' is often summed up as meaning 'I am because you are' and the belief system emphasizes 'compassion, generosity, honesty, magnanimity, empathy, understanding, forgiveness, and the ability to share' (Eze 2011). According to this system of thought, human beings flourish best through supportive relationships with others.

The new humanism, according to Mexican professor of political and social philosophy Oliver Kozlarek, is a humanism that does not stop at recognizing cultural differences in postcolonial times, but instead looks for normative perspectives that all humans can agree upon. Importantly, these perspectives need to filter down into everyday life and practice (Kozlarek 2011). Once this is achieved, humanism will have succeeded in ensuring that human beings flourish in a culturally diverse world.

5.4 European Fundamental Values

5.4.1 Justice

The unjust ignore justified rules, exploit others and are enemies to equality, according to Aristotle (1985). An earthquake or a hurricane cannot be just or unjust, nor can a lion or a monkey. Even a human being, if entirely alone on a desert island, cannot be just or unjust. Justice is a principle that requires human interaction. It can characterize agents and their actions, social rules or states of affairs (Pogge 2006). Justice is a wide field, and as Rawls (1999) has rightly observed:

> Justice is the first virtue of social institutions, as truth is of system of thought. A theory however elegant and economical must be rejected or revised if it is untrue; likewise laws and institutions no matter how efficient and well-arranged must be reformed or abolished if they are unjust.

Among the ethical principles that inform science and technology policy, justice is therefore likely to play a major role, given its supremacy as a virtue of social rules and institutions. Articles 47 to 50 of the EU Charter deal with justice: they include the right to a fair trial, the right to be presumed innocent and the right to proportionate punishment. These rights have no direct relevance to science and technology policy; however, it has to be noted that the charter does not use the full scope of the justice principle, but is restricted to corrective and retributive justice. These are two of four distinct justice subprinciples that philosophers traditionally distinguish.

Of the subprinciples set out in Table 5.1, distributive justice could be especially relevant to science and technology policy. For instance, 'nano-divide' describes a concern that the gap between the rich and the poor, both within nation states and globally, will increase through the use of advanced technologies (Barakat and Jiao 2010):

> If global economic progress in producing high-value products and services depends upon exploiting scientific knowledge, the high entry price for new procedures and skills (for example, in the medical domain) is very likely to exacerbate existing divisions between rich and poor (Royal Society and Royal Academy of Engineering 2004, p. 52).

While such concerns can be grouped under 'distributive justice' as a subprinciple of justice, they can also be seen as relevant to the principles of solidarity or equality.

5.4.2 Solidarity

'Solidarity' means mutual support, especially among individuals with common interests. Solidarity is not as complex and long-debated a principle as justice. In fact, it does not even appear in Aristotle's work, nor in Immanuel Kant's.

Table 5.1 Justice

Justice subprinciple	Description
Justice in exchange	Establishes the fairness or equity of transactions
Distributive justice	Deals with the division of existing, scarce resources amongst qualifying recipients
Corrective justice	Rights a wrong that one has brought upon another, usually through a court declaring a remedy to correct the given injustice
Retributive justice	Establishes which punishment is appropriate for any given crime

However, it has become a much debated topic in bioethics, with some arguing that solidarity is a value that characterizes continental European welfare states as opposed to Anglo-American states, which rather focus on individual autonomy (Habermas 2003; Bayertz 1998; Hermerén 2008). As a group of Dutch researchers put it (Hoedemaekers et al. 2007):

> In a number of European welfare states altruistic solidarity as a commitment to help or support the needy and disadvantaged has been incorporated in their institutions and law. We term this institutional solidarity.

This institutional solidarity for the needy and disadvantaged is also part of the EU Charter, in Art. 27 to 38. While these articles also deal with workers' rights, the main emphasis is on access to social security and (preventive) health care for all. How is this value relevant to science and technology policy?

An example: it has been argued that large-scale genetic research should be governed by the value of solidarity rather than the value of autonomy. Chadwick and Berg (2001) believe that medical progress depends on research participants' accepting it as their duty to participate in research for the benefit of others Their use of the principle of solidarity focuses on *duties*, while the EU Charter focuses on *rights*. It is clear that such a duty-based use of the principle could have considerable implications for research and development, especially the recruitment of research participants or sample donors in medical research. At the same time, extended globally, the principle could be used to lobby for capacity building and technology transfer in the context of the nano-divide referred to above.

It is worth noting, though, that the solidarity principle as used in the EU Charter does not extend to international aid beyond the EU member states. Hence, global solidarity is not covered. Here one would have to look at global legal instruments such as the UN International Covenant on Economic, Social and Cultural Rights, which calls for international aid to achieve access to health care for all human beings based on the premise of the Universal Declaration of Human Rights that all human beings are born equal.

5.4.3 Equality

Only in logic is the principle of equality straightforward: two items or entities that cannot be distinguished are equal. In ethics and political theory, equality is not as easily described. Rather than referring to identical entities, the moral value of equality refers to equal *rights*, equal *opportunities* and equal *moral status*. It is only in this regard that we are all equal. The rights pronounced in the EU Charter are a good example: Arts. 20 to 27 are based on the understanding that nobody should be discriminated against, because we are all born equal in rights.

Difficulties arise not so much in the legal attribution of rights, but in political action. What does it mean *in practice* to have equal rights? In the *Nicomachean Ethics*, Aristotle referred to the formal equality principle, the principle of non-discrimination (1985). According to Aristotle, it does not matter whether a good man steals from a bad man, or a good man rather than a bad man commits adultery: only the action counts. Hence, a court would have to ensure corrective and retributive justice for the bad man *and* the good man in order to preserve legal equality.

Yet even among philosophers who promote egalitarian policies, the principle is not clear. There are four interpretations of what equality means when linked to public policies: equality of wellbeing, resources, opportunity and capabilities (Daniels 1990).

Equal concern for the *wellbeing* of citizens is outcome-focused and tries to achieve equal welfare or at least equal preference satisfaction for all. This approach does not imply equal treatment, given that some citizens will require more support to achieve wellbeing than others (for instance, those with serious disabilities).

This account of equality puts responsibility for citizen welfare onto the government. Equality of resources, on the other hand, moves responsibility for welfare onto individual citizens, provided they are given access to resources. It is then left to them to convert these into wellbeing. Likewise, on the policy of equality of opportunity citizens are provided with the means to obtain certain ends for which they have to strive themselves. For instance, equal opportunity policies will provide education to all so that not only the wealthy acquire the skills and knowledge necessary to find satisfying jobs. The capabilities approach to equality aims to lift all human beings up to a given benchmark of functioning that allows them to pursue alternative life plans freely chosen.

What is important in all discussions of equality is to be aware of the privileges and restrictions ingrained in all societies, for instance the privileges that men enjoy versus women in terms of realizing life plans, or the privileges enjoyed by most in affluent versus lower income countries. As 'The World's Greatest Money Maker' (BBC 2009), Warren Buffett, has noted, 'If you stick me down in the middle of Bangladesh or Peru, you'll find out how much this talent is going to produce in the wrong kind of soil' (Singer 2009).

5.4.4 Dignity

None of the six values from the EU Charter is as contested, in either scholarly or policy debates, as that of dignity. The principle has been described as useless (Macklin 2003), arbitrary (Van Steendam et al. 2006), elusive (Ullrich 2003), groundless (Rachels 1990), a nebulous drug (Wetz 2004) and without reference point (Statman 2000). In fact, the Canadian Supreme Court decided in 2008 that dignity was not to be used in anti-discrimination cases any longer as it was 'confusing and difficult to apply'.[2] At the same time, dignity is a principle evoked in almost all modern constitutions and human rights treaties.

Articles 1 to 5 of the EU Charter summarize dignity rights, which include the right to life and integrity of the person, the prohibition of torture and inhuman or degrading treatment, and the prohibition of slavery and forced labour.

[2] *R. v Kapp [2008] Supreme Court Canada 41* at §22: '[H]uman dignity is an abstract and subjective notion that… cannot only become confusing and difficult to apply; it has also proven to be an additional burden on equality claimants, rather than the philosophical enhancement it was intended to be.'

An example of the complexity and difficulty of interpreting what the principle of dignity means can be given in the context of nanotechnology. When the European Group on Ethics in Science and New Technologies (EGE) identified the ethical questions relating to the development of nanomedicine, its first question was: 'How should the dignity of people participating in nanomedicine research trials be respected?' (EGE 2007). If one links this back to the dignity rights in the EU Charter, one wonders which right could be violated by taking part in nanomedicine research trials. Certainly not the prohibition against torture or slavery. The right to life? But then safety concerns are usually discussed outside of dignity debates. The right to integrity of the person? The further explications of this right given in Art. 3(2) of the charter are:

In the fields of medicine and biology, the following must be respected in particular:

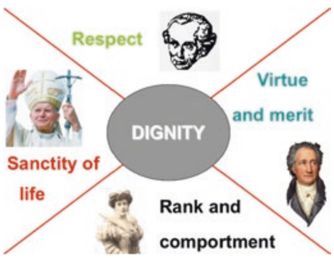
- the free and informed consent of the person concerned, according to the procedures laid down by law,
- the prohibition of eugenic practices, in particular those aiming at the selection of persons,
- the prohibition on making the human body and its parts as such a source of financial gain,
- the prohibition of the reproductive cloning of human beings.

Looking at the above, it is still not possible to link the dignity concern of the EGE to the explicated rights. The reason could be that the concept is used in widely different ways: 'dignity' can serve, for example, as a synonym for religious principles or in a comment on a person's manners. Figure 5.2 demonstrates the principle's breadth of application by coupling definitions of common understandings of dignity with illustrative quotations (Schroeder 2008, 2010).

Looking at this range of dignity concepts, it is not surprising that the Canadian Supreme Court decided that dignity was too confusing and difficult to apply in its decisions. However, the principle plays a supreme role in most constitutions,

'A human being … possesses a dignity (an absolute inner worth) by which he exacts respect for himself from all other beings in the world' (Kant 1996).

'[T]he Gospel of the dignity of the person and the Gospel of life are a single and indivisible Gospel' (John Paul II 1995).



'A wreath is much easier bound than a dignified head for it found' (my translation: In the original German: 'Ein Kranz ist gar viel leichter binden, als ihm ein würdig Haupt zu finden) (Goethe n.d.)

'Conducting a public romance may have reduced the dignity of the presidency, but Sarkozy is president for an era in which dignity is less important than humanity' (Tharoor 2008).

Fig. 5.2 Meanings of dignity

and any attempt at purging such a powerful concept from ethical discourse would amount to whistling in the wind, in the view of some legal scholars (Beyleveld and Brownsword 2001).

5.4.5 Citizens' Rights

Articles 39 to 46 describe very specific citizens' rights, ranging from the right to vote in European elections to the entitlement to diplomatic support when travelling abroad. Given that the whole charter consists of citizens' rights, it is somewhat surprising that the drafters chose these terms. Aside from that, however, what is of some interest here is the concept of a right in itself, in particular given current debates about the differences between Western and Asian ethical systems.

It has been argued that the Asian approach to ethics is community-based, focusing on the recognition of the interdependence of all forms of life on earth. It thereby presents 'holistic harmony' as an essential feature of its ethics (Sakamoto 1999). Likewise, in traditional Chinese society, 'there is less emphasis on individual rights, self-expression, and self-determination. In the community, qualities such as harmony, function, and responsibility are stressed more than individual rights, and familial relationships assume primary importance' (Ip et al. 1998).

What, then, is a right? Human communities are organized by social rules, many of which are encoded in law and administered through courts. These rules can be rights-centred or obligation-centred. As early as 1861, John Stuart Mill defined rights in a way that is still valid today (Mill 2002):

> When we call anything a person's right, we mean that he has a valid claim on society to protect him in the possession of it, either by the force of law, or by that of education and opinion … To have a right, then, is … to have something which society ought to defend me in the possession of.

A right as understood in the EU Charter is therefore a claim that individual EU citizens have on EU bodies. This claim right is open to each one of the approximately 500 million people living under EU law. It is centred on the individual, not on the community he or she lives in. In the context of science and technology, the rights of individuals can be usefully illustrated by way of the field of research ethics in medical research.

To achieve progress in medical research, experiments on human beings are necessary. Research ethics is the field that governs how such research must be conducted if it is to respect fundamental human rights. These rights are non-negotiable and cannot be overridden by reference to, for example, the common good. Hence, no human being can be involved in research against his or her will. Individual rights take precedence over the good of the community in medical research. Article 8 of the World Medical Association Declaration of Helsinki reads (WMA 1964):

> While the primary purpose of medical research is to generate new knowledge, this goal can never take precedence over the rights and interests of individual research subjects.

5.4.6 Freedoms

Rights and freedoms are closely linked concepts. Western philosophers usually distinguish negative freedom from positive freedom. 'Negative freedom' describes the absence of barriers or external restraint, while 'positive freedom' describes the powers and resources required to pursue one's life plans (Berlin and Hardy 2002). To be able to move to a different country as a privileged academic is a negative freedom, in that nobody stops us from going and no immigration control stops us from entering. However, this same ability would be a positive freedom for an orphaned child rescued in a war zone and taken abroad for hospital treatment or perhaps to stay.

The freedoms given to EU citizens through the charter include broad negative rights such as the right to property (Art. 17) and the right to liberty (Art. 6), as well as more specific negative rights such as the right to marry (Art. 9) and the right to religious freedom (Art. 10). On the other hand, the right to education (Art. 15) is a positive freedom as it provides resources for individual citizens in order to increase their choices in life.

Strict libertarians argue that the state should be minimalist and focus on protecting negative freedom only (Nozick 1974). However, it is one of the defining features of Europe, especially continental Europe, that positive freedoms are given prominence. This approach can be observed, for instance, in the European Commission's action plan on nanosciences and nanotechnologies. Rather than focusing on the negative freedom of researchers to 'choose an occupation and right to engage in work' (Art. 15), the plan focuses on the positive freedom of the public 'to establish an effective dialogue with all stakeholders' (European Commission 2005) and to take people's expectations and concerns into account.

5.4.7 Sustainability

The values discussed so far are about people; sustainability is about the environment. Yet some approaches to environmental protection and sustainable development are highly people-focused or instrumental (Fox 1996).

Instrumental approaches to the environment value the environment only in so far as it is useful for or appreciated by humans. In this regard, concern for the environment is only indirect, mediated through a direct moral concern for other people. The different instrumental approaches are set out in Table 5.2.

In contrast with instrumental approaches, intrinsic value approaches to the environment accept that the environment, independent of humans, has a value in its own right. Hence, the concern for the environment is direct. This is set out in Table 5.3.

The emphasis in the Treaty of Lisbon on sustainable *development* and the promotion of *scientific and technological advancement* (Art. 3(3)) suggests that the European Union's stance on sustainability and environment is instrumental, in

Table 5.2 Instrumental approaches to the environment

Term	Approach
Expansionism	The environment is valued instrumentally for its contribution to economic growth and there are no limits to such growth
Conservation	The environment is valued instrumentally for resources required in farming, mining, logging etc., and it needs to be conserved for future use
Preservation	The environment is valued instrumentally for contributions to human wellbeing (e.g. it is good for physical recreation or a potential source of new medicines) and ought to be preserved, including for future generations. By contrast with conservation, which focuses on use value, preservation focuses on keeping the environment from harm, including unrestrained economic exploitation

Table 5.3 Intrinsic value approaches to the environment

Term	Approach
Sentience	Entities are intrinsically valuable if they are sentient. This is also called the animal liberation approach, and its most famous proponents are Bentham (1996) and Singer (1995)
Life	Entities are intrinsically valuable if they exhibit a biologically based 'interest' in maintaining their own integrity—put simply, if they strive to maintain their own existence (e.g. a plant will expand its roots until it can reach water)
Holistic integrity	Entities are intrinsically valuable if they have self-renewing properties as a whole, i.e. if they are autopoietic systems such as ecosystems. The most famous proponent of this approach is Leopold (1980)

other words people-centred or anthropocentric. The environment is to be protected and preserved in order to enable the sustainable use and continued availability of valuable resources for the benefit of today's and tomorrow's humans.

5.5 Case Study: Preimplantation Genetic Diagnosis in Europe

The far-reaching collaboration necessary to form a union of 28 countries has been accompanied by the transfer of national competences to EU institutions and, as we have seen above, by the codification of shared values. One can find striking consensus on certain applications of science and technology, such as the shared rejection of eugenic practices and reproductive cloning of human beings, both deemed to be in violation of human dignity, according to Art. 3(2) of the Charter of Fundamental Rights. However, the European Union is still a constellation of more than two dozen member states, each with its own distinct cultures and values, which also apply to its approach to science and technology and the applications thereof. In the light of such differences, it is important to keep in mind that in spite of the far-reaching collaborative nature of the EU, member states still have considerable autonomy in some areas. In fact, the competences of the EU itself are strictly limited to those conferred upon it by its member states (Art. 5(1) and

(2) Treaty on European Union). This section of the chapter examines differences in the understanding of values by way of a case study on preimplantation genetic diagnosis (PGD).

5.5.1 Preimplantation Genetic Diagnosis

What is PGD? The Health Council of the Netherlands defines it as 'the examination in vitro of an embryo (or an egg cell prior to fertilisation) in order to exclude a genetic condition in case a very high risk of that condition is known' (Health Council of the Netherlands 2006). Since PGD takes place prior to transfer to the womb, it can only be used in combination with in vitro fertilization (IVF). PGD is most commonly used by prospective parents who are carriers of (severe) hereditary diseases, such as Duchenne muscular dystrophy or sickle cell disease (Health Council of the Netherlands 2006). By using PGD, parents aim to ensure that only unaffected embryos are transferred to the womb. PGD is considered ethically controversial in several regards:

- The life and moral status of the embryo are not respected by PGD.
- IVF and PGD are too burdensome for women.
- PGD leads onto a slippery slope towards 'designer babies'.
- PGD can detect genes for diseases that may never develop (e.g. BRCA1 and BRCA2 mutations that predispose respectively for breast cancer and ovarian cancer).
- 'Saviour siblings'[3] are instrumentalized and treated as a commodity.
- PGD can be used for non-medical sex selection, a practice quite common in the United States (Dondorp and De Wert 2005; Health Council of the Netherlands 2006; De Wert 2005; Pennings and De Wert 2003; Brownsword 2005).

The next section briefly examines how PGD is governed in the United Kingdom, the Netherlands and Germany.

5.5.2 PGD in the United Kingdom

The United Kingdom has a long history of assisted reproduction. The first baby ever to be conceived via IVF was born there in 1978. This event and the rapid speed of developments in assisted reproduction led to the establishment of a national committee to develop principles for the regulation of IVF and embryology. The committee, chaired by philosopher Mary Warnock, concluded in its 1984 report that the human embryo should be protected, but research on embryos and IVF was permissible as long as appropriate safeguards were respected (Warnock 1984).

[3] A child born specifically in order to secure the health of an older sibling, for instance to provide matching tissue for a bone marrow transplant.

In the United Kingdom, PGD is allowed as long as the Human Fertilisation and Embryology Authority agrees that the condition the parents could pass on to the child is sufficiently severe. To this end, the authority has published a list of the conditions it has approved so far. The list is quite extensive, and includes BRCA1 and BRCA2 mutations, which predispose to breast and ovarian cancer (HFEA 2014). PGD for human leukocyte antigen (HLA) typing as required for 'saviour siblings' is allowed, but such tests are licensed case by case (HFEA 2014). By contrast, sex selection for non-medical reasons is not allowed in the United Kingdom, in terms of the Human Fertilisation and Embryology Act of 1990. Overall, the United Kingdom has a rather *liberal* approach to the application of PGD.

5.5.3 PGD in the Netherlands

In the Netherlands PGD is allowed for the screening of severe hereditary diseases. The permitted scope of screening is determined by the 'Ministerial regulation of pre-implantation genetic diagnosis' (Aarden et al. 2009), which is based on the Embryo Act (*Embryowet*) of 2002. Whether or not PGD will be allowed is determined case by case by the performing clinic. To comply with the Act, the clinic has to consider the following criteria listed in the regulation:

- the severity and nature of the disease,
- treatment possibilities,
- additional medical criteria (e.g. whether or not expression of the condition at hand could be prevented) and
- psychological and moral factors.

The Dutch cabinet intended to allow PGD for prospective parents who were carriers of (severe) hereditary diseases with a high likelihood that the disease would be contracted by the child. After an intense parliamentary debate in 2008, the scope of permissible PGD was expanded to include hereditary conditions, even where they might never present as a (severe) disease. The regulation specifically mentions the BRCA1 and BRCA2 genes as examples. PGD for HLA typing is, however, explicitly banned in the Dutch regulation, in contrast to the United Kingdom, as the 'new child' would only be conceived to benefit another child. In the Netherlands, as in the United Kingdom, sex selection is strictly limited: there must be medical reasons, according to Art. 26 of the Embryo Act. One might say that the Netherlands has a *moderately tolerant* stance towards PGD.

5.5.4 PGD in Germany

Until 2010, PGD was banned in Germany. In particular, the German Embryo Protection Act (*Embryonenschutzgesetz*) of 1990 prohibited any use of human embryos created in vitro that did not serve the embryo's preservation and the establishment of a pregnancy. Although the Act did not explicitly mention PGD, several articles were interpreted by academics and policymakers as forbidding the technology (Aarden et al. 2009). In July 2010, however, the German Supreme Court (*Bundesgerichtshof*) ruled that the Embryo Protection Act did not establish a ban on PGD. This in turn led to major public and political discussion (Deutscher Bundestag 2011).

In December 2011, after an intense political debate, PGD was eventually allowed under strict conditions, when the Preimplantation Diagnosis Act (*Präimplantationsdiagnostikgesetz*) came into force. According to the Act, PGD is prohibited in principle, but can be allowed if exceptional conditions are met, for instance case-by-case approval by an interdisciplinary ethics commission combined with extensive counselling of the prospective parents. More importantly, PGD is limited to (severe) conditions that are highly likely to lead to miscarriage or the death of the infant within the first year. This effectively prohibits PGD for HLA typing, for the screening of hereditary conditions that might not develop into a disease (e.g. BRCA1 breast cancer) or for sex selection for non-medical reasons (Deutscher Bundestag 2011). As a result, one can characterize Germany as being *restrictive* towards PGD.

5.5.5 Comparing PGD Dispensations in Europe

Comparing the three EU member states examined above, one sees two commonalities. First, all three allow PGD in screening for acute life-threatening conditions, and second, they prohibit sex selection for non-medical reasons. However, if we look at other (contested) applications of PGD, we see notable differences (Table 5.4).

Values are a decisive factor in regulatory choices made regarding PGD in the three countries. The United Kingdom, the Netherlands and Germany, which all fall under the EU Charter of Fundamental Rights, have considerable room to develop policies to govern contested science and technology applications.

Table 5.4 Preimplantation genetic diagnosis in the United Kingdom, the Netherlands and Germany

PGD applications	 United Kingdom	 The Netherlands	 Germany
Sex selection for non-medical reasons	Prohibited	Prohibited	Prohibited
HLA matching ('saviour siblings')	Allowed	Prohibited	Prohibited
Cancer predisposition (e.g. BRCA1)	Allowed	Allowed	Prohibited
Acute life-threatening conditions	Allowed	Allowed	Allowed

5.6 Conclusion

The principles and values recognized by the Charter of Fundamental Rights of the EU and the Treaty of Lisbon constitute the point of reference for all acts by bodies of the EU. Hence, they also apply to science and technology policies and guidelines.

The EU thus conforms to a human rights framework and culture that prioritizes non-negotiable individual human rights over the common good. As the case of PGD has shown, member states retain considerable autonomy to develop independent policies to govern contested science and technology applications, an autonomy that is justified through the subsidiarity principle of the charter. However, this principle is most certainly not unproblematic, since the autonomy of each member state extends beyond its own citizens, due to the free movement of persons and of services that is a core freedom of the EU in terms of Art. 26(2) of the Treaty on the Functioning of the European Union (EU 2008). EU citizens of restrictive member states can easily travel to more liberal countries to make use of controversial technologies. Belgium, for instance, has a more liberal policy on PGD (comparable to the regulations in the United Kingdom) than its neighbour Germany (see, for instance, Centrum voor Reproductieve Geneeskunde n.d.).[4] According to a study by Leopoldina (the German National Academy of Sciences) PGD is carried out for around a hundred German couples every year in one Belgian centre alone (Leopoldina 2011). Regulating reproductive tourism is just one unresolved instance of uniting differing value systems in the far-reaching collaboration of the EU. Given that science and technology developments occur at rapid speed, such regulation will certainly remain a challenge within the union.

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[4] See for instance: http://www.brusselsivf.be/genetic-diagnosis-embryo (In English).

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Chapter 6
The Values Demonstrated in the Constitution of the People's Republic of China

Ying Ma, Yandong Zhao and Miao Liao

6.1 Introduction

Science and technology are among the most important factors that have shaped modern society. They also have a direct bearing on the orientation of social development and even the prospects of mankind. 'Where is society heading?' and 'What kind of life should mankind live?' are both questions pertaining to the appraisal of happiness in life: namely, what kind of life is happy and wonderful? Judgment on the pursuit of life is, in essence, a matter of values. Therefore values should be employed to guide, promote and constrain the direction in which science and technology develop.

As the primary law of a state, a constitution is the fundamental rule for reining in state behaviour and regulating relations between the state and its people. Therefore the values reflected in the constitution are codified in the form of primary law and offer important guidance for making laws and policies and regulating the actions of the government. An analysis of the values in the Chinese Constitution will help us better understand and judge current events and policies concerning science and technology in China and form a clearer picture of ethical issues.

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The first Constitution of the People's Republic of China was promulgated in 1954, and another two versions were drafted in 1975 and 1978 respectively. The year 1982 saw a fourth version, which is the Constitution now in force. This version underwent revisions in 1988, 1993, 1999 and 2004. These continuous revisions are evidence of efforts made to adapt the Constitution to new situations and conditions.

In effect, the values in the Constitution are rooted in society. So, before focusing on the values in the Chinese Constitution, it is helpful to review the value system in Chinese society with a view to gaining a better understanding of constitutional values.

6.2 Major Sources and Elements of the Value System in Modern China

Chinese culture can be traced back thousands of years and has experienced several major transformations in this long process of evolution. The Yin Dynasty (about 1556–1046 BC) is considered to be the beginning of Chinese civilization. In the Spring and Autumn Period and the Period of Warring States (771–221 BC), Chinese civilization reached its first golden age, with a hundred different schools of thought contending for intellectual superiority. It was an era of Chinese history that produced a galaxy of great thinkers and philosophers. However, the order by Emperor Shihuang in the Qin Dynasty (221–206 BC) to burn books and kill scholars caused a serious setback in the evolution of Chinese culture.

Later, in the Han Dynasty (206 BC–220 AD), Emperor Wu carried out a policy of proscribing all non-Confucian schools of thought and espousing Confucianism as the orthodox state ideology, which established the Confucian classics as the dominant intellectual discipline in Chinese society. In this era of Confucian dominance, the intensive philosophical debate seen in the Hundred Schools era disappeared from society. Indian Buddhism was introduced into China in the middle of the Han Dynasty, and steadily expanded its influence during the Jin Dynasty (265–420 AD) and the Southern and Northern Dynasties (420–589 AD). Then Confucianism, Buddhism and Taoism emerged as equally dominant in the Sui (581–618 AD) and Tang dynasties (618–907 AD).

In the Northern Song Dynasty (960–1127 AD), neo-Confucianism ascended to the intellectual stage. Scholars of this school heavily criticized Buddhist and Taoist teachings, and brought Confucianism back to the centre. As a result, the Southern Song (1127–1279 AD), Ming (1368–1644 AD) and Qing (1616–1911 AD) dynasties were known as the neo-Confucianism era.

In the late Ming Dynasty, European missionaries started coming to China, which facilitated cultural exchanges between China and Western civilizations. In the middle of the Qing Dynasty, the Opium War plunged the Chinese nation into a grave crisis, and some progressive elements started seeking solutions from the West to save the country from total collapse, which set the stage for the beginning of a new era of learning from the West (Zhang 2004).

This prolonged process of cultural evolution has shaped the diverse, complex and conflicting values of Chinese society today. Based on the historical background, the value system has three parts: traditional Chinese values, Western values imported since 1840, and new values grown in contemporary Chinese society.

6.2.1 The Traditional Values of China

The tripartite culture of Confucianism-Buddhism-Taoism, with Confucianism dominant, comprises traditional Chinese values. These values take an individual as the basis of value judgment and focus on the moral cultivation of an individual, extending from the self to others, from an individual to a family, and from a group to a state and even the whole world. What is elaborated in the Confucian classic *The Great Learning*—from individual cultivation to familial regulation, governance by the state and universal tranquility and happiness—is only an ideal description of the lifetime accomplishments of an individual in Confucianism.

Confucianism regards virtue (*ren*) as the general principle guiding people's ethics, and embraces wisdom, courage, filial piety, brotherhood, loyalty, integrity, humility, tolerance, ingenuity, kindness and respect as the ethical codes for constraining behaviour. It underlines the different social status of the emperor, the official, the father, the son, the husband and the wife, and the importance of abiding by the moral principles and standards that exhort the son to love the father, officials to stay loyal to the emperor, the wife to follow the orders of the husband, the young to respect the elder, and friends to treat each other with honesty. Taoism, on the other hand, advocates the principle of inaction and urges people to endure humiliation, lower social status and a position of weakness, stay out of conflict, cherish life, maintain purity and refrain from making moral judgments (Jiao 1993).

6.2.2 Western Values Imported Since 1840

In the process of global modernization, a number of concepts and ideas came to China gradually. A series of reforms and revolutions after 1840 allowed Western religions, science and technology, and political concepts of democracy and freedom, and Marxism to exert an immense influence on intellectual elites and the public in China (Zhu 2002: 304). Over one to two hundred years, an affinity for Western science and technology, the ideology of freedom, equality, and affluence, and the concepts of rights and legal awareness has taken root in Chinese society and constitutes an important criterion for value judgments by the public.

6.2.3 New Values Grown in Contemporary Chinese Society

New values have grown in contemporary China under the new social conditions of building a socialist market economy towards independence and rejuvenation. On one hand, the pursuit is towards the socialist ideal of national development, common prosperity, social harmony and improved quality of life; on the other, it focuses on the philosophy of the market economy, featuring individual achievements and fair competition. These two aspects stand in conflict yet have common grounds, such as the pursuit of economic development. Consequently, developing the economy has become the most essential discourse in contemporary China.

Meanwhile, along with economic development, unintended consequences such as environmental risks and social inequality have undergone adjustment and integration by other elements of values to form the concept of sustainable development. Sustainable development as a moral concept emphasizes development not just in the economy but also in society, science, culture and the environment; it expresses equity among generations and within one generation; and it calls for respecting nature, learning from nature, protecting nature and living in harmony with nature (Zhu 2002: 144).

6.3 The Basis of Values in the Chinese Constitution

The value system in modern China provides a backdrop against which the values in the Chinese Constitution can be understood. As the fundamental law of the People's Republic of China, the Constitution defines the regime, which builds the foundation for the values to rest upon.

Article 1 of the General Principles of the Chinese Constitution clearly stipulates that:

> The People's Republic of China is a socialist state under the people's democratic dictatorship led by the working class and based on the alliance of workers and peasants. The socialist system is the basic system of the People's Republic of China. Sabotage of the socialist system by any organization or individual is prohibited.

Since China is a socialist country practising a socialist economic system, the relationships between the state and society and between the state and citizens reflected in the Constitution are different from those in countries with capitalist economic systems. Socialism pursues the collective interests of society (Chen et al. 2011). Its manifestations in the Constitution include not only the obligations of the state in social and economic life, such as developing education, the economy, culture and science, and building socialist ethics and ideas, but also the principle of democratic centralism that calls upon the minority to follow the majority in decision-making.

Such an emphasis on collective interests is highly consistent with the focus on community interests in China's traditional moral values. The only difference is that the concept of community in traditional Chinese culture is a concentric structure of interpersonal relations with each and every individual at its core (Fei 1998),[1] whereas the collective interests defined by socialism have moved beyond the boundary of individuals or individual relations.

Article 3 of the General Principles of the Chinese Constitution states:

> The state organs of the People's Republic of China apply the principle of democratic centralism.

The socialist system and the emphasis on collective interests constitute the basis for understanding the values embodied in the Chinese Constitution.

6.4 The Key Values in the Chinese Constitution

6.4.1 Progress

'Progress' refers to the process from the beginning to the aim, or from the elementary to the higher stage in a given linear history. According to the Marxist theory of social development, human history goes through stages: primitive society, slave society, feudal society and capitalist society, and then socialist society and communist society, as a result of constant progress in the motion of contradictions between productive forces and relations of production (Shao 1993).

The value of progress finds expression in Marxist theories as well as in the Constitution of the new republic, which is greatly influenced by Marxism. A large part of the preamble is devoted to the history of the progress of modern and contemporary China. It is thus easy to understand why the concept of progress holds a position of importance in Chinese society.

A measure of progress is the overall situation of society, including material, political and spiritual civilization. Economic development occupies a primary position here, because the economic foundation underpins the superstructure, and economic development is the necessary condition and guarantee for other social developments. Economic development depends on improved productive forces, while the major driver of productive forces is the development of science and technology.

Article 14 of the General Principles of the Chinese Constitution states:

> The state continuously raises labour productivity, improves economic results and develops the productive forces by enhancing the enthusiasm of the working people, raising the level of their technical skill, disseminating advanced science and technology …

In other words, to improve productivity and the development of productive forces in society, it is necessary to popularize knowledge of and skills in advanced science and technology. In fact, enthusiasm and support for scientific progress serve as manifestations of the importance of this concept of value.

[1] Xiaotong Fei termed interpersonal relations of this type *cha xu ge ju*, which can be translated as 'the differential mode of association' or 'social egoism'.

6.4.2 Affluence

'Affluence' means having adequate possessions and occupying a concomitantly superior position. Affluence is one goal-orientation of progress. The affluence pursued in China covers:

- the modernization drive regarding industry, agriculture, national defence, and science and technology;
- the advanced development of education, science, and culture;
- higher living standards of the people; and
- China's independence and self-reliance among the countries of the world.

In China today, the value of affluence is embodied at national level, in the pursuit of an independent, wealthy and strong nation standing confidently among all the nations of the world, and at the level of individual livelihood, in the pursuit of a higher level of material and spiritual wellbeing. From transcending basic subsistence to achieving a better-off society, to the pursuit of the rejuvenation of the Chinese nation, all serves to prove the overwhelming momentum of the value of 'affluence'.

Articles 19 and 20 of the General Principles of the Chinese Constitution state:

> The state develops socialist educational undertakings and works to raise the scientific and cultural level of the whole nation … The state promotes the development of the natural and social sciences, disseminates scientific and technical knowledge, and commends and rewards achievements in scientific research as well as technological discoveries and inventions.

It is clear from these provisions that China values science and encourages innovation. In today's world, where science has become an overwhelming culture, a high level of science and education is no doubt a manifestation of affluence. Moreover, a high level of scientific development can advance technical invention and innovation and thus substantially enrich the material life of people. To become an independent, wealthy, modernized nation, it is imperative that China should possess solid strengths in terms of science and technical invention and innovation.

6.4.3 Peace and Safety

The value of peace and safety (*ping an*) is of immense influence in traditional Chinese society. For individuals, 'peace and safety' refers to good health and wellbeing in daily life, free from illness and calamity. In ancient times there were prayers on festive days for peace and safety each year (*sui sui ping an*); today there are wishes to friends and relatives to be safe and sound both at home and outside (*chu ru ping an*). Thus peace and safety have been a most basic pursuit of the Chinese people in everyday life over thousands of years.

Article 21 of the General Principles of the Chinese Constitution states:

> The state develops medical and health services, promotes modern medicine and traditional Chinese medicine, encourages and supports the setting up of various medical and

> health facilities by the rural economic collectives, state enterprises and undertakings and neighbourhood organizations, and promotes sanitation activities of a mass character, all to protect the people's health …

The advocacy of people's health in the General Principles of the Constitution and the stipulation that medical and health services are important to the country demonstrate the important position of health and hygiene in China while reflecting, from another perspective, one aspect of the pursuit of the value of peace and safety.

6.4.4 Harmony

Harmony is another value that has existed in traditional Chinese society since time immemorial. Harmony envisages a state of coexistence, mutual help and mutual benefit, coordination and cooperation among multiple elements. To quote two old proverbs: 'a family in harmony finds everything in good order' (*jia he wan shi xing*) and 'fortune favours those in harmony' (*he qi sheng cai*). These sayings demonstrate that the concept of harmony is closely related to the everyday life of the general public and is an important prerequisite for becoming prosperous and affluent in life. Harmony is deeply rooted at all levels and in every aspect of life of the Chinese general population. That is why this value has survived and thrived up to the present, becoming part of the national pursuit of building a harmonious society in present-day China.

According to a speech made in February 2005 by Mr Hu Jintao, the then President of the People's Republic of China, the six features of a harmonious society are democracy and the rule of law, fairness and justice, integrity and friendliness, vigour and drive, peace and order, and harmony between man and nature (Qin 2006). In particular, the harmonious state of man and nature echoes the traditional Chinese belief in 'heaven and man in one'. This philosophy describes man and nature as an integrated whole, coordinated and in harmony, which is different from the Western cultural concept that man and nature are contradictory, one being active and the other passive. The Chinese idea is a philosophical one typical of oriental cultures (Zhu 2002: 325). In these terms the harmony of man and nature calls for a perspective beyond considering the natural environment as a mere pool of energy and resources: one that approaches environmental issues through perspectives of ecology, coordination and sustainable development.

Article 26 of the General Principles of the Chinese Constitution states:

> The state protects and improves the living environment and the ecological environment, and prevents and controls pollution and other public hazards …

The stipulation of environmental protection and improvement in the fundamental law means that China has grasped the possible problems of modern economic production and the mode of social development; and it also serves as the China's response to these problems amid the pursuit of the value of harmony.

6.5 Conclusion

Three streams of values, namely traditional values, Western values and new values established in contemporary Chinese society, converged to build China's current value system. The traditional values were once considered a major obstacle to Chinese modernization that should be amended or even abandoned. For example, the hierarchical values of Confucianism, described above as 'the different social status of the emperor, the official, the father, the son, the husband and the wife', have been replaced by equality among the people. In the Chinese Constitution, Article 4 notes that all nationalities in the People's Republic of China are equal, while Article 48 states that women enjoy equal rights. In recent years, however, there has been a trend towards a return to traditional values in Chinese society. Some key values, for example 'harmony' (*he*), have entered mainstream discourse in Chinese society. Among the Western values and the new values grown in contemporary society, 'scientism' and 'developmentalism' are currently the two most influential discourses in China. The former focuses on the positive function of science and technology, and the latter puts an emphasis on economic development. Therefore the two discourses also have strong impacts on the current value system in China.

The values in the Chinese Constitution outline the core pursuits of Chinese people and form the basis for making policies related to science and technology. China being a socialist country, the Chinese Constitution emphasizes collective interests. Progress, affluence, peace and safety, and harmony are the four values identified in the Chinese Constitution that relate to people's ethical considerations of science and technology development.

In recent years, realizing the importance of solidarity in values, the central government and the Communist Party of China have made a series of efforts to refine and codify the values. The core socialist value system that embodied the spirit of the nation and the time gradually germinated and formed over the period from the 16th national congress of the party in 2002 to the 18th in 2012 (Guo 2014). In September of 2012, the party formally put forward the core socialist values as follows:

> Core socialist values are the soul of the Chinese nation and serve as the guide for building socialism with Chinese characteristics … We should promote prosperity, democracy, civility, and harmony, uphold freedom, equality, justice and the rule of law and advocate patriotism, dedication, integrity, and friendship, so as to cultivate and observe core socialist values (Hu 2012).

The core socialist values echo the values in Chinese Constitution and make them more explicit, so that they are more influential in guiding the government's and the public's activities.

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Chapter 7
Science and Technology for Socio-economic Development and Quest for Inclusive Growth: Emerging Evidence from India

Sachin Chaturvedi and Krishna Ravi Srinivas

7.1 Introduction

This chapter discusses the evolution of science and technology policy in India, its linkage with national developmental plans and the challenges ahead for India in science, technology and innovation policy. In India, as in many post-colonial countries, the state has played a major role in using science and technology for national development besides giving it a special thrust. While India succeeded in creating a sizeable science and technology infrastructure within five decades of independence, the globalization of science and technology and changes in the external economic environment necessitated a change in the orientation of policymakers. The Twelfth Five Year Plan (2012–2017) focuses on sustainable and inclusive growth, while the Science, Technology and Innovation Policy of 2013 emphasizes new models for promoting innovation. In the global innovation discourse, India's capacity for frugal and inclusive innovation is recognized, and the National Innovation System is also bringing about change, with contributions from many quarters ranging from multinational corporations to grassroots innovators.

Although ethical values have not been explicitly indicated in policy statements, key objectives of the policies have applied science and technology for socio–economic development and ensured that the benefits of science and technology reach the masses. In the Indian context, access, inclusion and equity can be regarded

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as ethical values and guiding principles in science, technology and innovation policy. This is compatible with the vision of sustainable and inclusive growth. The challenges remain translating this into practice and developing suitable indicators.

7.2 Science and Technology Policy in India

'Science: The Endless Frontier', a report by Vannevar Bush published in 1945, played an important role in setting the agenda for post-war science and technology policy in the USA. The report saw it as the task of science policy to contribute to national security, health and economic growth. It emphasised the potential economic impact of investing in science. Science policy is a tool for managing and funding the accumulation of knowledge by establishing, funding and sustaining organizations (e.g. universities and research laboratories) and directing their outputs and accumulated knowledge towards meeting national objectives, among other things—and it can be justified from an economic perspective:

> A general economic rationale for STI policy is that we pursue it because we think it will lead to technological progress, and we think that technological progress is a crucial determinant of economic growth, which in turn we regard as ultimately vital to welfare of the individuals who comprise society (Kane 2001).

Given the wider impact of science policy, it can be analysed from various disciplinary perspectives (see, for example, Husbands Fealing et al. 2011). In post-colonial societies science policy became a prominent policy in national developmental agendas (Salami1 and Soltanzadeh 2012). Thus science policy is primarily a post-Second World War phenomenon. This is equally true of India, but the development of science policy there can be traced to the response of Indian society to modern science (Sinha 1992).

With the introduction of English-medium instruction in higher education in 1835, many Indians were exposed to modern science, and this resulted in a section of the community arguing for modern approaches, including science for social advancement. While the British set up colleges and universities, indigenous initiatives such as the Indian Association for Cultivation of Science and science popularization efforts increased access to science and enhanced the appreciation of science. The responses to modern science in India's traditional society were of three kinds: modernists wanted India to follow the European model, critical modernists argued for a creative synthesis of European and Indian civilizations, absorbing the best from Europe, and critical traditionalists emphasized the need to give primary importance to Indian tradition and culture while drawing upon European knowledge and culture (Parekh 1989). The responses to modern science within the national movement and Indian society were varied, and so was the understanding of science. Often science was equated with modernity.

By the 1930s, groups of scientists, nationalists and others were arguing that science would have to play an important role in post-independence India. The

National Planning Committee constituted in 1940 had a subcommittee on science. India gained its freedom in 1947, and the first prime minister, Jawaharlal Nehru, inspired by Fabian socialism and centralized planning in the then USSR, envisaged centralized planning and strong support for science in India. He gained the support of scientists such as Homi Bhabha, Meghnad Saha and S.S. Bhatnagar, and the restructuring of science and technology infrastructure was started. The infrastructure left behind by the British was upgraded, and many new laboratories and universities and research centres were set up. India gave priority to research in atomic energy.

The first science policy statement was issued in 1958. In 1983 the government came out with a Technology Policy Statement, followed by a Science and Technology Policy Statement in 2003. In 2013 the Department of Science and Technology issued its Science, Technology and Innovation Policy. These statements and policies have provided the overarching frameworks for science and technology policy and its linkage with developmental goals.

Since 1952 there have been 12 five-year plans. The current five year plan (2012–2017) emphasizes sustainable and inclusive growth. The key features of the five year plans are set out in Table 7.1 [Source: Dogra (2011)].

Science for national development and security, and self-reliance, have been at the core of India's science and technology policies. Although India had no document similar to 'Science: The Endless Frontier', its science and technology planning was led by scientists and technocrats who shared the visions of the politicians. This alliance led to a broad consensus on applying science and technology in India and to continued support for science and technology from successive governments. In that sense the post-colonial state in India was an ardent supporter of science and technology.

Table 7.1 India's five year plans[a]

Plan	Timeline	Key feature
First	1951–1956	Agriculture-led
Second	1956–1961	Socialistic industrial policy
Third	1961–1966	Self-reliance in agriculture and industry (plan affected by wars with China and Pakistan in 1962 and 1965 respectively), price stabilization
Fourth	1969–1974	Society-oriented (education, employment and family planning)
Fifth	1974–1979	Non-economic variables
Sixth	1980–1985	Infrastructure (6 % per annum growth achieved)
Seventh	1985–1989	Welfare sector, programmes such as Jawahar Rozgar Yojana
Eighth	1992–1997	Dismantling licence prerequisites and reducing trade barriers
Ninth	1997–2002	Agriculture and rural focus
Tenth	2002–2007	Globally competitive growth
Eleventh	2007–2012	Employment and social indicators
Twelfth	2012–2017	Sustainable and inclusive growth

[a]India had three annual plans between 1966 and 1969

The Department of Science and Technology was set up in 1972. Over the years the number of ministries and departments supporting science and technology has increased. In different periods India set up different departments, such as the Department of Electronics and the Department of Biotechnology, to capitalize on emerging technologies, while the mission mode approach was used for tackling problems. In the mid-1960s India launched its Green Revolution to overcome food shortages and achieve food security. This was the first mission mode application of science and technology to solve problems. The Green Revolution was driven with the support of private foundations, while the US government and the World Bank paid rich dividends and also enhanced the research and development capacity in agriculture. This was followed by the 'White Revolution' in the dairy sector. Later the same approach was used in telecommunications and oil seeds. In 2007 the Department of Science and Technology launched the Nano Mission to promote research in nanosciences and nanotechnologies and to ensure that India did not lag behind in this emerging field.

Science for national development and security has been a key driver in India's science and technology policy. This is expressed in various statements including the Technology Policy Statement, which stressed the point that the fundamental objective of science in India was to meet the basic needs of people: food, water, housing, health and education. Self-reliance in core sectors and in advanced technologies such as atomic energy, space technologies and defence-related applications has been another important driver in India's science and technology policy. This thrust has enabled India to achieve substantial progress in sectors such as space, and self-reliance has helped in applying science and technology for national development.

The opening up of the economy in 1991, subsequent developments in the global economic environment and changes in the science and technology milieu have had their impacts on science and technology policy. The earlier approach of relying solely on publicly funded science and technology, with restrictions on technology imports and licensing, was abandoned. The growth of the Indian economy, the availability of skilled human resources and changes in economic policies resulted in increased foreign investment in research and development in India by multinational corporations, and Indian institutions also increased the level and scope of collaboration with institutions and industries abroad. The change is evident in the Science, Technology and Innovation Policy of 2013, which goes beyond the state-led science, technology and innovation approach. Thus the Indian science and technology policy has come a long way from the 1950s, when science was regarded as a key component of the growth strategy. Table 7.1 sums up the changes over the decades.

Although applying science and technology for social development has been a key principle since the beginning, important initiatives in realizing this were taken by the Department of Science and Technology during the Sixth Five Year Plan in 1971, in the form of the Science and Society Programme. In 2011, based on the experiences gained from various initiatives under the Science and Society Programme and other activities, a new programme, Science for Equity, Empowerment and Development (SEED), was established to provide technology solutions to challenges in rural and urban areas for the disadvantaged sections of society. The idea was to link innovations developed in laboratories with the needs of the disadvantaged sections of society and improve their quality of life.

India's science and technology policy has seen both continuity and change. While there has been change in the choice of policy instruments, areas of thrust and priorities, continuity is evident in issues such as self-reliance in core sectors, and capacity building. In the past two decades, the horizontal focus of science and technology has been replaced with an emphasis on promoting innovation in a range of sectors including biotechnology, pharmaceuticals, automobiles and information technology. In terms of regulation, the emphasis on restrictions on the importation of trade and technology has been replaced with liberal policies, payments for licensing and royalties. Similarly, the push for self-reliance and indigenous development in all sectors of technology has given way to the importance of collaborative research, public-private partnerships and international collaboration, with due acknowledgement of the opportunities that arise from outsourcing research and development to India. In some sectors such as space and atomic energy, self-reliance remains the objective. The shift in focus and instrumentality is quite apparent in the Science, Technology and Innovation Policy of 2013.

Translating advances in science and technology into innovations is a big challenge. In the past few years the government of India has formed a National Innovation Council and announced a Decade of Innovation. The 2013 policy is different from the previous policies on science and technology in many ways. According to the policy:

> Global innovation systems tend to bypass large sections of the community. Innovation for inclusive growth implies ensuring access, availability and affordability of solutions to as large a population as possible. Innovation therefore must be inclusive.

The policy goes on to list 'Linking contributions of science, research and innovation system with the inclusive economic growth agenda and combining priorities of excellence and relevance' as an important objective. The policy advocates the strengthening of linkages between the scientific and socio–economic sectors, and it states that NGOs will be accorded an important role in delivering science, technology and innovation outputs.

Thus, over the past six decades or so, the scope of the policy instruments and the regulatory environment has undergone significant changes. The results are evident in India's global ranking in publications and patents, and in other indicators. The Twelfth Five Year Plan envisages spending on research and development increasing from 0.9 to 2 % of gross domestic product (GDP) by the end of 2017. It underscores the need for research towards breakthrough innovation in important sectors. However, challenges remain and key questions are: how much should India invest in science and technology and what should be the objectives of science, technology and innovation policy in the years to come?

A policymaker, after analysing investments and trends in science and technology, concludes that India has to balance between competitiveness and inclusiveness, and this will be a challenge for the research and development system (Ramasami 2014). Nation-building and socio–economic development became the dominant themes in science and technology policy, and India is not the only country that has had this approach to science and technology policy. Science and technology policy is one of the policy instruments, and it is necessary but not sufficient to address all the issues in socio–economic development.

In India, prior to 1991, centralized planning by the state was the determining factor in setting priorities for science and technology. As Table 7.1 indicates, the key features of the plans have changed, although the basic objectives remain the same. After 1991, economic liberalization and globalization brought new challenges and opportunities in science and technology forward. India joined the World Trade Organization and had to amend its laws and enact new ones to meet the requirements of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). Similarly, India enacted a law to comply with the Convention on Biological Diversity. Globalization helped India realize its competitiveness in information technology services and the pharmaceutical industry. India became an attractive destination for foreign direct investment in research and development (Basant and Mani 2012).

According to R.A. Mashelkar, science and technology in India rests on four pillars: techno-nationalism, inclusive growth, techno-globalism and global leadership. He categorizes India as a nation with ‘high indigenous science and technology capacity but relatively low economic strength’ and includes China, Brazil and Argentina in that category with India (Mashelkar 2008). Pointing out the country’s achievements in science and technology, he argues that India should aim for global leadership in some areas in science and technology, and should focus on basic science. In 2010 the Science Advisory Council to the Prime Minister introduced its vision document entitled ‘India as a Global Leader in Science’ with the following statement:

> In the next two decades, India is likely to become an economically prosperous nation and move significantly towards being a far more inclusive society, with the bulk of its population gaining access to facilities for education and health care and living a life with hope and security. To realize such a vision, it is essential that science is at the heart of the strategy that the next stage of national development demands (Science Advisory Council to the Prime Minister 2010).

It listed India’s achievements in science and pointed out that the complex problems the country faced called for a ‘proper use of science’. It argued that India itself was the most cost-effective source of research and development in India as it accounted for 0.5 % of global expenditure on science and produced 2.5 % of the global output in science. The document suggested many measures, including more funding for science to help India become a leader in global science (Science Advisory Council to the Prime Minister 2010).

Such statements and documents acknowledge the potential in India for science and technology and innovation and take the position that India can use science to address its complex problems and also aspire to be a global leader in science. This is a formidable challenge, however, because global ranking in publications is not a measure of innovation, and even if the number of publications in a field is reasonably high, their quality and impact matter too. For example, it has been pointed out that while India ranks sixth globally in publications on nanotechnology, its ranking is lower in terms of citations of papers from India.[1] A report from the World Bank published in 2007 pointed out the innovation potential in India and called for a three-pronged strategy to realize this potential: increasing competition and improving innovation infrastructure, strengthening the creation and communication of knowledge, and fostering more inclusive innovation (Dutz 2007). Thus while the literature generally acknowledges India's potential, the suggestions on how this potential should be realized differ. Since independence, the Indian state has played a dominant role in science and technology policy and in funding research and development. It has incentivized private-sector research and development through various schemes. As Daniele Archibugi and Jonathan Michie point out, technological globalization does not mean less support for innovation from governments: more support is needed to enhance a country's competitive advantage (Archibugi and Michie 1997). This is nowhere more true than in India.

Given the fact that India has become the third-largest economy in the world, the mantra 'science and technology for development' is all the more relevant. As Indian companies acquire foreign companies and invest in research and development outside India while India continues to be an important destination for foreign direct investment in research and development, the picture is becoming more complex. According to Sunil Mani, while the knowledge intensity of India's output has increased to 14 % of India's net domestic product, much of this emanates from the services sector, whose share of knowledge-intensive production was 11.55 % in 2009. The proportion of exports comprising high-technology products doubled from 1988 to 2008, when it stood at 16.94 % (Mani 2010). From the current trends in investment, publications and patents it is clear that India is entering a new growth phase in science and technology that has to be sustained if India is to emerge as a global leader in this field. In terms of spending on science and technology, publications and patents, India has made significant progress in the past decade. While the government is the major funder, the private sector's share has increased significantly.

India's planners and scientific establishment are aware of the need to increase investment in science and technology, to enlarge India's share of science and technology publications, and to ensure that India is actively engaged in emerging technologies such as nanotechnology. Various measures have been taken to achieve these objectives. The Innovation in Science Pursuit for Inspired Research (INSPIRE) programme aims to attract talent to the sciences by providing scholarships right from school stage as incentives to students to pursue a career in science. In terms of publications, India's share has increased significantly in the past few years, but to ensure that this continues and that India does not lag

[1] 'Thus India was ranking 6th and had the fastest growth rate from 2001 to 2011, albeit from a low base. When looking at the citations of these papers, however, India ranks lower. For the top 1 % of cited papers India ranks 14th and for the top 10 % of cited papers it ranks 9th. This indicates that the country's scientific output was not as much in the frontier domain as the simple volume indicator might have led us to believe' (Greenhalgh 2013).

behind countries such as Korea, the Twelfth Five Year Plan India invests heavily in science and technology. A study for the Department of Science and Technology points out that the citation impact of papers has increased to about 0.68 in 2006–2010 from 0.35 in 1981–1985, and the targeted value is 1 for the period covered by the Twelfth Five Year Plan. The number of publications from India increased from 15,000 in 1981 to 40,000 in 2008, while India's share rose from 3 to 3.5 % in the same period (DST 2012). Fully aware of the fact that India has to compete with countries such as Korea, Brazil and China, India's planners believe that it's share should increase to 5 % from the current 3.5 % within the next five years.

The challenge before policymakers is: how can India meet multiple objectives with the available infrastructure and human resources? As there is no guarantee that increased spending will automatically translate into desired outcomes, and as the National Innovation System in India is more complex today than ever before, old approaches may not work. State-supported public-sector research and development are necessary, but not sufficient, and hence new models such as public-private partnerships in research and development and joint product development may be necessary.

To conclude, the science and technology policy in post-independence India has been shaped by concerns over socio–economic development and the need for self-reliance. In years to come, however, the policy will have to address new issues emerging on account of the globalization of science and technology, the opportunities provided by emerging technologies and the technological convergence and other changes taking place in the global science and technology landscape. At the same time, the science and technology policy will have make a substantial contribution to sustainable and inclusive growth.

7.3 Science and Technology Policy Discourses in India

Although science and technology policy in India is largely driven by the state, the debates on the role of science and technology in Indian society and modes of applying science and technology help us understand the policy discourses. For convenience, we can classify these discourses into the following categories:

- Nehruvian discourse
- Gandhian discourse
- People's science movements and their discourse on science and technology
- Other voices and discourses on science and technology

According to Dinesh Abrol:

> The 'Gandhian', 'Nehruvian' and 'Left' political traditions differed radically with each other in terms of the conception of 'socio-technical imagination', 'vision of path of development' and 'social carriers of innovations' to be encouraged (Abrol 2012).

Of these, the Nehruvian discourse has been the dominant one and has had significant influence on science and technology policy-making. This discourse emphasizes the key role of the state in applying science and technology for national development, modernization and socio–economic development. The Nehruvian vision envisaged the transformation of Indian society through the application of science and technology and the inculcation of a scientific temper. Nehru supported big projects, rapid industrialization made possible by state-centred planning and a key role for the public sector. In this perspective the state ensures that the benefits of science and technology reach all sections of society and that science and technology themselves are scale-neutral and value-neutral.

On the other hand, the Gandhian discourse saw the application of science and technology as helping village revitalization. The Gandhian discourse, influenced by the ideas and life of Mohandas Karamchand Gandhi, attached importance to the principle of production by the masses, village self-sufficiency and a decentralized approach to planning. This discourse favoured limiting the role of the state in society and supported the autonomy of communities. Gandhians regarded values in science and technology as important and cautioned against applying science and technology to satisfy greed rather than genuine needs. The Gandhian discourse was influential in the freedom movement, but was eclipsed by the Nehruvian perspective in post-1947 India. Although this discourse gained support from E.F. Schumacher some decades later, and was used by scientists such as A.K.N. Reddy and C.V. Seshadri to develop alternative technologies and approaches, its impact on science and technology policy-making was minimal.

People's science movements are influenced by leftist ideology and see science as a tool for social revolution. While they agree with the Nehruvian discourse on the scientific temper, they are critical of many projects and programmes initiated by the state in the name of development. Kerala Sastra Sahitya Parishad, the best-known people's science movement in India, played an important role in the struggle to stop the Silent Valley project, which the central government abandoned. These movements regard renewable sources of energy as important, are against multinationals in the agri-biotech sector and see a key role for public-sector research and development in finding innovative solutions.

Besides these three discourses, there have been other voices and views on science and technology in India. Scientists including A.K.N. Reddy and C.V. Seshardri advocated a different approach that regarded it as important to find appropriate solutions to meet the needs of people and argued for a blend of traditional technologies and modern science and technology. Groups such as Patriotic and People-Oriented Science and Technology called for a relook at India's traditional science and technology and their relevance to modern society.[2] Figures such as Shiv Visvanathan, Ashis Nandy, J.P. Uberoi, Vandana Shiva, Jayanto Bandhbadhyay and Anil Agarwal, from different vantage points, provided critiques of modern science, of science and technology policy and of major projects. The resistance to large projects such as the Narmada Valley project, nuclear power, genetically modified organisms in agriculture and mega-projects in the power

[2] See Rajan (2005) and Prasad (2006) for a discussion of this.

sector indicated that at the grass roots, the response to science and technology policy and development projects was ambiguous, and that not everyone shared the vision of the Nehruvian discourse. The dissenting voices and discourses did not have much impact on science and technology policy-making, but over the years they have contributed to the debates and discourses on science and technology policy by bringing in issues that had not received much attention. They raised issues relating to equity and development, environmental justice and alternatives that were not being explored. This, in turn, resulted in changes in policies relating to land acquisition, environment impact assessment and rehabilitation of the displaced. The dissidents also worked on alternatives in agriculture, medicine, and energy.[3]

7.4 Ethics in Science and Technology Policy in India

Indian science and technology policies have been shaped by the concern that the application of science and technology should enable faster socio–economic development and that all sections should benefit from scientific and technological advances. The unstated assumption in these policies is that value-neutrality and scale-neutrality are to be addressed by appropriate interventions in favour of marginalized sections of the population. According to Rajeswari Raina:

> Many of the inadequacies in current decision-making in S&T for development stem from a lack of shared understanding of causal relationships and common ethical principles that can guide decision-making (Raina 2010: 27).

The ethical assessment of technologies at their initial stages poses many problems, and there are challenges that have to be addressed by policymakers (Bostrom 2007). But many principles, including the precautionary principle and the principle of public participation, have been developed to address ethical issues in science and technology (UNESCO 2007). An important question, however, is: what are these common ethical principles? India has accepted global norms in bioethics and has created institutional infrastructure to give effect to them. Through the intervention of the supreme court and the efforts of the Indian Council of Medical Research, clinical trials are regulated by ethical principles and guidelines.

Although science and technology are universal, are there universal ethical principles that are relevant for science and technology policy-making in all countries? Should a country like India opt for ethical principles based on European or American values, or should it use its traditional ethics and theories to arrive at more appropriate principles? Those who espouse universal values could argue that since science and technology are universal and common to all cultures, such

[3] For reasons of space we do not discuss this in detail. Suffice it to say that while technocrats such as A.K.N. Reddy and C.V. Seshadri worked on developing alternative technologies, Gandhians worked on rural industrialization, agriculture and textiles.

values should guide science and technology policy. Those who are against the universal values approach would not only question the idea of universal values, but would also point out that in bioethics the debate has been inclusive, taking into account bioethical values in different traditions including religions and cultures. In the case of research integrity and ethics, while there is consensus on some issues, divergent perspectives are expressed on others (Anderson 2011). According to Henk ten Have:

> The need to establish common values and benchmarks, as well as to promote ethical principles and standards to guide scientific progress and technological development, is becoming increasingly acute, especially in developing countries that do not equally enjoy the benefits of scientific and technological advances. UNESCO's work in ethics of science and technology reflects these global concerns. It examines such progress in light of ethical considerations rooted in the cultural, legal, philosophical and religious heritage of the various human communities (ten Have 2006).

Similarly, the report of the European Commission's Expert Group on Global Governance of Science stresses the need to strike a balance between paternalism and irresponsibility. It calls for harmonizing general ethical principles and the recognition of religions, traditions and local cultures in dialogues (Ozoliņa et al. 2009).

As science and technology policy is not an exercise in philosophy and is linked to larger societal visions, aspirations and demands, a blind application of universal value would not be suitable. Taking a culturally relativist approach and denying the need for value orientation in science and technology policy, or arguing that the values of a region or country alone should be considered in determining ethical values, would not be the right approach as such a view reflects a parochial mindset that refuses to recognize that science and technology are global and so are their impacts and implications.

A concern about ethics in science and technology policy can be expressed in many ways. For example, in the Fourth Basic Plan of Japan, ethics is reflected in the objective that policy should be created and promoted with society. The plan attaches importance to the promotion of 'green innovation' and 'life innovation'. It proposes more involvement of the public in science, technology and innovation policies, improving regulatory science and improving technology assessment (Ida 2011). This is a response to the problems—including earthquakes, a tsunami, a nuclear incident, ageing, a declining birthrate and the falling competitiveness of Japanese industries—faced by Japanese society and changes in the global science and technology system (Ida 2011). A concrete response by expressing ethical concerns in science and technology policy is evidence that science, technology and innovation policy can incorporate ethical values based on need and relevance, and can choose from various principles and values the relevant one. Thus, while increasing public participation and improving regulatory science and technology assessment might be found as ethical concerns or norms in the science, technology and innovation policies of other countries, in the Japanese context incorporating them is a response to the needs of the society and its experience with promoting science, technology and innovation.

Often ethics in science and technology is associated with values such as autonomy, human dignity and justice, and it is contended that science and technology should be practiced in such a way that they do not negate or disrespect these values and do contribute to furthering the wellbeing of humankind (Evers 2001). But in the case of science and technology policy, the picture is more complex as distributional effects of policies have to be taken into account. Scholars working on science and technology policy have pointed out that access to science and technology and its benefits are often unevenly distributed, resulting in inequities in distribution that can result in outcomes that aggravate the broader inequities (Cozzens 2007; Woodhouse and Sarewit 2007). Bozeman et al. (2011) have analyzed the equity issues in science and technology and their linkages with science and technology policy. One of the ways of assessing the equity impacts of science and technology policy is to find out whether science and technology policy has enabled the basic needs of most sections of society to be met, and has contributed to better access to the outcomes of science and technology. Access and equity are interlinked. Better access may reduce inequities. In the literature, access is often discussed in the context of access to technology and services, including health services, and how race, gender and poverty affect access (see, for example, UNCTAD 2011).

If we regard equity as distribution with due consideration for basic needs and fairness, access is a determining factor. The policy framework might have taken equitable outcomes as an objective, but lack of access on account of various factors will skew the outcome. Hence policies to promote access may result in better and more equitable outcomes. In the literature, equity in science and technology has been examined in the context of specific technologies (Cozzens and Wetmore 2011). In the case of innovation policies, it has been hypothesized that although innovation policy is not often considered in terms of distributional implications, left-oriented governments are more likely to attach importance to it (Breznitz and Zehavi 2013).

India's Twelfth Five-Year Plan states that 'our focus should not be just on GDP growth itself, but on achieving a growth process that is as inclusive as possible' and rightly accepts that 'strong inclusive growth is the only scenario that will meet the aspiration of the people'. This reflection indicates that the planners are aware of the need to move beyond GDP growth and that the challenge lies in framing policies to promote inclusive growth. In fact, in view of the fact that economic growth does not result in equitable benefits across different sections of the population, inclusive growth has been suggested as an objective. Organizations such as the Asian Development Bank and the Economic Commission for Latin America and the Caribbean have researched exclusion and equality (McKinley 2010; ECLAC 2014). In the case of science and technology policies and specific technologies, inclusion and exclusion issues have been analyzed at length (see, for example, Mercado 2012; Haribabu 2009; Thomas and Fressoli 2011; Sutz and

Tomasini 2013). According to the United Nations Conference on Trade and Development, policymakers should attach importance to addressing horizontal and vertical inequalities. Interestingly. a recent statement from the Indian government on science, technology and innovation for the post-2015 development agenda indicates that it is sensitive to issues of inclusion and to using science and technology to meet basic needs:

> India stands for and will be pleased to contribute on following dimensions of UNCSTD STI efforts vis-à-vis post 2015 Development Agenda:
>
> - Affordable Innovations, encompassing access, availability and usable solutions to meeting basic needs;
> - Accelerated Inclusive Growth for aspiring nations – developing countries with thrust on base of pyramid population (as a better replacement to the prevalent expression of bottom of the pyramid) … (Relia 2014)

Thus, in our view, access, inclusion and equity can be considered ethical values in relation to science and technology policy. There are many issues that need to be addressed, including developing science, technology and innovation indicators for access, inclusion and equity, and developing methodologies for measuring policy outcomes for access, inclusion and equity, and more theoretical work needs to be done on access, inclusion and equity.

7.5 Conclusion

Indian science and technology policy has come a long way since the early 1950s. Today, as India aspires to be a global leader in science and technology, it is important for Indian policy to give attention to ethics in science and technology policy. However, this does not mean that science and technology policy has to import values from Europe or the USA. Rather, in our view, access, inclusion and equity can be considered ethical values and can be used to assess policy outcomes. This makes better sense in the Indian context, as it links societal development with science and technology policy. It also reflects the current thinking on sustainable and inclusive growth.

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Chapter 8
A Comparative Framework for Studying Global Ethics in Science and Technology

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8.1 Introduction

Science and technology are an important source of progress as well as tension and conflict in society (Swierstra and Rip 2007). This basic assumption has been taken as a starting point in the Global Ethics in Science and Technology (GEST) project

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for a comparative study of three different fields of science and technology. In the field of new *food technologies*, especially genetically modified crops, the expectations, tensions and conflicts surrounding these technologies can be documented and discussed from a historical point of view. In the new and emerging fields of *nanotechnology* and *synthetic biology*, on the other hand, we can show how more and more attempts are being made to manage expectations, tensions and conflicts in an anticipatory way.

Another basic assumption of the GEST project is that the nature of expectations, tensions and conflicts will vary, not only in relation to the contents of particular fields of science and technology, but also according to particular socioeconomic conditions, cultural contexts and values in the different global regions of Europe, China and India. Our aim in the three case studies presented in the following chapters is to better understand the ways in which the expectations, tensions and conflicts surrounding science and technology relate to the specifics of different fields and to the broader societal contexts shaping developments in these fields. This chapter presents a framework for a more detailed comparative analysis of the three fields—food technology, nanotechnology and synthetic biology—in the three regions.

In the framework that we propose, the emphasis is on societal *discourses* as central storylines in the case study descriptions (Hanssen et al. 2008). This focus on the discursive aspect will enable us to systematically map the expectations, tensions and conflicts arising, or potentially arising, from developments in the three fields of science and technology in the different regions. We will distinguish three discourses that are primarily defined by their specific content, namely those relating to issues of *innovation*, *risk* and *power and control*. In addition we will differentiate between discourses of *reflective ethics* and *lay morality*, showing how the issues of innovation, risk, and power and control are perceived, both in the context of practices of ethical analysis and in the context of wider public debate. In other words, with regard to the three content-related discourses, the discourses of reflective ethics and lay morality are both reflective and crosscutting.

The aim of our comparative analysis is, first, to highlight particular commonalities and differences between cases and regions in terms of the issues discussed and reflected upon in these various discourses, and, second, to show how these commonalities and differences can be understood in terms of the specific nature of scientific and technological fields, and in terms of particular socioeconomic conditions, cultural contexts and values in the different regions.

The focus on science and technology discourses in describing and comparing our case studies should help us address some crucial questions from the GEST project. Governments in all three regions stimulate scientific and technological innovation and seek ways to deal with potential risks and conflicts arising from new and emerging science and technology. The object of our comparative analysis is a better understanding of the history and evolution of these tensions and conflicts and to see how this understanding might be translated into more responsive and robust practices of anticipatory governance of science and technology in the three regions. More specifically we focus in the GEST project on the discourses of *reflective ethics* and *lay morality* as important sources of understanding that, especially in Europe and the US, have been 'mainstreamed' through the establishment and promotion of public ethics bodies, programmes on ethical, legal and social implications, and more comprehensive technology assessment practices, including various forms of public deliberation and engagement (Paula 2008; van Est and Brom 2012).

The main questions guiding our comparative analysis might thus be phrased as follows: how are the different science and technology discourses in the three regions being translated into *science and technology policy-making*, and how is this translation mediated by *institutionalized forms of ethical reflection and public deliberation*? We will present an outline of our framework by discussing:

- the nature of the five discourses that we have distinguished,
- more specific definitions of these five discourses,
- the questions that will guide our comparative analysis, including some main findings from the case studies, and
- some concluding observations about the governance implications of our comparative analysis.

8.2 Nature of the Five Science and Technology Discourses

We see discourses as 'frames' structuring societal debates in terms of particular ideals, concerns, rights and values that may engage actors in politics, governance and regulation. Science and technology discourses will relate, on the one hand, to expectations about innovation and the goals and problem-solving opportunities of science and technology and, on the other hand, to concerns about the risks, side effects and wider societal consequences of science and technology. Such discourses should be seen as rooted in common cultural experiences in which debates about science and technology have crystallized around particular recurrent themes and values, in terms of which scientific and technological developments can be both justified and challenged. These experiences will be framed by particular historical and 'iconic' exemplars of science and technology, figuring either as icons of progress, like electric light or penicillin, or as icons of risk, like asbestos, nuclear energy or genetic modification. These common cultural experiences refer to a *historical dimension* of science and technology discourses in society, which will also shape current and future discourses about new and emerging technologies.

Science and technology discourses will likewise be fostered and shaped by specific culturally embedded *reflective practices* in society, including ethics, philosophy, the social sciences, media and art. These two dimensions are translated in our framework into three content-related and two reflective and crosscutting discourses, as described above in the introduction and depicted in Fig. 8.1. The discourses of innovation, risk, and power and control are primarily defined by their specific content. The discourses of reflective ethics and lay morality are primarily

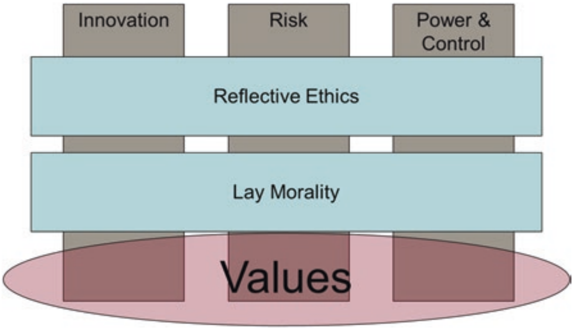

Fig. 8.1 Three content-related and two reflective and crosscutting science and technology discourses

defined as reflective and crosscutting debates articulating various perceptions and assessments of the themes and values that are discussed in the other three discourses.

There are two important observations to make with regard to the use of this framework in the case studies presented in the following chapters. The historical dimension of science and technology discourses implies that these discourses are shaped by specific historical and cultural conditions and experiences that may differ from region to region. In other words, the ideals, concerns, rights and values that will inform these discourses in our case studies should be understood in the context of the specific histories and cultures of the three regions of Europe, China and India. This is also true, of course, for the reflective practices informing these discourses and the particular values that characterize public debate and science and technology policy-making in the context of different political institutions and cultural traditions in the three regions (see Chaps. 5, 6 and 7). Our comparative analysis therefore sets out to highlight, in the three case studies of the GEST project, the commonalities and differences between science and technology discourses in the context of these different and regionally specific histories, experiences and values.

As a second observation about the use of our framework, it is important to note that it has to be empirically established to what extent the different discourses can indeed be clearly recognized in describing the debates, tensions and conflicts surrounding the fields of science and technology in the three regions. Moreover, in considering these debates, tensions and conflicts, the distinctions between the different discourses often will not be clear-cut or easy to demarcate. However, by drawing these distinctions, our framework can serve as a valuable investigatory searchlight that may help us define relevant storylines in our case studies for comparative analysis.

8.3 Definitions of the Science and Technology Discourses

Even though the discourses that we have distinguished in our framework do not constitute sharply delineated categories, we do, of course, need definitions to work with in our case study descriptions. In the following, the five science and technology discourses are more specifically defined in terms of the main themes that are addressed, the values that are implicated in discussions about these themes, and the actors that are most involved in these discussions.

8.3.1 Innovation Discourse

The main theme of the innovation discourse is the potential benefits of investments in science and technology: that is, the ways in which science and technology may contribute to important societal aims and challenges, such as economic competitiveness, general societal progress, increasing scientific temper and more specific societal challenges concerning the environment, energy, food and health, including public health. Thus the innovation discourse sets societal agendas for science and technology policy-making and defines steps and conditions to succeed. Values implicated in these science and technology debates may include market freedoms, progress, self-reliance, sustainability, social justice (including access) and equality. The actors most involved in the innovation discourse are scientists, industry and government: that is, the parties directly involved in the 'innovation system'. But there may also be other, critical voices from more marginally involved groups, including civil society organizations.

8.3.2 Risk Discourse

The main theme of the risk discourse is the harm potentially caused by scientific and technological developments to health (including public health), to the environment or to individual rights such as privacy. Although there is traditionally a strong focus in governmental risk regulation on 'physical' harms to human health and the environment, societal concerns about risks often also relate to 'non-physical' harms, including wider socioeconomic and socioethical impacts in society. Values implicated in these risk debates include safety as a citizen right (i.e. the right to protection), harmony, dignity, precaution, social justice and sustainability. The actors most involved are scientists, government and regulatory agencies: that is, the parties directly involved in the 'risk governance system', which may however also include the more wide-ranging activities of public ethics and bioethics bodies and technology assessment organizations. Here again, there may be other, particularly strong and critical voices from groups outside this system, including civil society organizations.

8.3.3 Power and Control Discourse

In societal debates about science and technology, tensions and conflicts may arise not only within, but also between, different discourses. Such power struggles raise controversial questions about control, responsibility and participation in dealing with issues of innovation and risk and with the tensions between the two. The wider implications of scientific and technological developments for existing social, economic and geopolitical power relationships are another important theme in the power and control discourse, also involving questions about whose interests are served and about the ownership of knowledge and technology. Debates over power and control may involve the entire spectrum of values related to innovation and risks, including market freedoms, self-reliance, citizens' rights (to protection and choice), harmony, sustainability, global justice (access) and equality. Civil society organizations and other public voices are often especially important actors outside established systems of innovation and risk governance that may raise questions about these issues.

8.3.4 Discourse of Reflective Ethics

Ethics has emerged as an increasingly important topic in public debates about science and technology, stimulating reflective ethics as a crosscutting discourse involving expectations, concerns, rights and values relating to innovation, risk, and power and control (see Chap. 2). Reflective ethics may contribute to public debates by articulating ethical issues, stressing the consequences of scientific and technological developments for social values and fundamental rights, and opening up debates about new ways to align values with these developments. Thus reflective ethics may enrich or initiate ethical debate by acting as an 'early warning' system, highlight tensions between values and scientific and technological developments, and translate ethical deliberation into policy-oriented guidelines or recommendations. Reflective ethics discourses have been institutionalized in public ethics and bioethics bodies and technology assessment organizations, supporting public debate or playing an advisory role in governmental policy-making. Reflective ethics has also taken shape in research programmes focusing on the ethical, legal and social issues raised by new and emerging science and technology, and may find expression in less formalized modes of ethics deliberation, such as the media or art.

8.3.5 Discourse of Lay Morality

In the history of science and technology debates, we also see the emergence of a discourse more open to participation by groups or individuals that do not necessarily claim any particular expertise in the scientific subjects under discussion, but nevertheless believe or are persuaded that their voices are as valid as those of the experts in the field of science or ethics (see Chaps. 3 and 4). Like the reflective ethics discourse, this public discourse may relate to the whole range of issues and values relating to innovation, risk, and power and control. As a crosscutting discourse it is an important expression of what has been termed ‘lay morality’. The discourse of lay morality may find expression in spontaneously emerging public debates and controversies, but can also take shape in organized forms of public dialogue or consultation, such as focus groups or opinion surveys, and, last but not least, will often be embodied in activities and initiatives from civil society organizations.

8.4 Comparative Analysis of Science and Technology Discourses

Our framework helps us structure the case study descriptions and analyses in two ways. It serves, first of all, as a ‘searchlight’, defining different discourses as relevant storylines. Thus we have examined the role of these discourses in debates and policy-making relating to different fields of science and technology in the three regions of Europe, China and India: how significant are the different discourses in shaping debates and policy-making, what are the issues and values at stake, who are the main actors involved, and which tensions and conflicts do we see within and between these discourses? In structuring the case study descriptions along these lines, the framework also facilitates a comparative analysis, guided by the following questions:

- What are the commonalities and differences between the three regions, if we compare the discourses in any particular field of science and technology?
- How are these commonalities and differences to be understood in relation to the specific socioeconomic conditions, cultural traditions, political institutions and values in the three regions?
- What is the role of the different science and technology discourses in science and technology policy-making in the three regions: that is, how are these discourses being translated into science and technology policy-making?
- To what extent and in what ways is this translation mediated by the two crosscutting discourses of reflective ethics and lay morality?

8.4.1 Findings from the Case Studies

The next three chapters of this book focus on developments in food technologies, nanotechnology and synthetic biology, comparing the ways in which science and technology discourses in each of these fields have evolved in the three regions (see Chaps. 9, 10 and 11). Here we present a summary of the most significant findings from this comparative analysis, guided by the GEST framework and the questions listed above.

8.4.1.1 New Food Technologies in the Three Regions

In the past 20–30 years Europe has seen attempts to introduce genetically modified food products commercially, which has led to strong resistance from civil society organizations and consumers. As a result, genetically modified food products have remained effectively barred from the European market. In this context a risk discourse has become predominant in Europe, emphasizing the principle of precaution and consumers' freedom of choice. However, this risk debate also involves a more comprehensive value-laden tension between, on the one hand, a 'productivist' innovation discourse of industrially driven agriculture directed towards increasing levels of production through convergent applications of biotechnology, and, on the other hand, a 'post-productivist' power and control discourse aiming at more sustainable, environmentally friendly, localized and pluralistic agricultural practices, including organic farming.

For the Chinese government, food security is a core issue, and there is a basic consensus that China should catch up with developments in transgenic technology in developed countries by building up its own transgenic technological strengths in agriculture. In this innovation discourse, there is a strong emphasis on ensuring that China develops and maintains an independent ownership of its intellectual property rights in the area of genetic modification. Indeed, in terms of power and control, the food security and safety agendas are largely driven by the government, and there is very little scientific or public debate on the implementation of new technologies, including genetically modified products in the Chinese food chain. More recently, however, issues of risk related to genetically modified food products have become a focus of public concern in China.

Debates on food technologies in India highlight several challenges: food insecurity, declining productivity, the depletion of natural resources, increased risk from climate change, rising input costs, changing food habits and extremely high post-harvest losses. At the same time, debates and deliberation on issues of risk and regulation related to genetically modified foods have intensified in India, and this has led to the complete suspension of the process of commercializing genetically modified products. According to the opponents of genetic modification, such crops have negative effects on the environment and biodiversity, and also on socio-economic conditions, as capital-intensive agriculture increases economic disparities between large and small farmers. In addition to this emerging risk discourse, we also see in India an active innovation and power and control discourse about the right balance between the various technological choices for food production: that is, transgenic technology, traditional breeding and organic farming.

8.4.1.2 Nanotechnology in the Three Regions

In Europe, many governments have promoted innovation in nanotechnology as a contribution to economic growth and competitiveness. Besides the strong and early involvement of science and industry stakeholders in this innovation discourse, we have also seen the early emergence of a predominant risk discourse involving a range of state, private and civil society actors. This risk discourse not only relates to technical issues of risk, but has also emerged around other topics, such as uncertainty and precaution, with some civil society organizations calling for a moratorium on nanotechnologies. In this context, a strong power and control, and also ethics, discourse has emerged, mainly driven by philosophers, social scientists and civil society organizations, emphasizing the socioeconomic and socioethical dimensions of nanotechnology. Several expert ethics bodies and technology assessment institutions in Europe have been conducting ethical assessments of nanotechnology. Nanotechnology has not become a big public issue in Europe—not yet, at least—but there have been various experiments in public engagement.

In China there is a clearly predominant innovation discourse highlighting, as in Europe, the potential of nanotechnology to foster economic growth and global competitiveness. Although support for this pursuit of progress and 'leapfrog' development is widespread in China, the scientific community there has been active in putting issues of safety on the research agenda at an early stage. There have also been recommendations from within the scientific community for more transparent working methods, strengthened self-regulation and improved relations between science and society as important conditions for a harmonious innovation process. The thematization of broader, socially and ethically ambivalent aspects of nanotechnology is mostly limited to a closed community of Chinese scholars, but the first structures of a genuine ethics discourse are emerging in scientific circles. Moreover, there is some research effort taking place in China on public perceptions of nanotechnology.

In India a predominant innovation discourse has also emerged, motivated by a concern 'not to miss the nanotechnology bus' and, at the same time, laying special emphasis on the enabling role of nanotechnology in solving urgent national problems and addressing the basic needs of the masses, such as clean drinking water and alternative energy sources. The risk aspects of nanotechnology have not received much attention, however. Although it was announced in 2010 that a nanotechnology regulatory board would be set up, and a committee was formed on risks and ethical issues, nothing much has happened. The power and control discourse in India comes down to 'innovate first, regulate later'. Hardly any attention is being paid to the role of the public in the nanotechnology discourse and little is being done to address ethical challenges such as that of the distribution of benefits (Beumer and Bhattacharya 2013).

8.4.1.3 Synthetic Biology in the Three Regions

In Europe, synthetic biology is basically funded as 'blue sky' research in support of market-driven development, 'smart and sustainable' growth and competitiveness. Moreover, experts have emphasized, from the very beginning, the need to address concerns about biosafety and biosecurity and broader ethical issues.

International civil society organizations have also been critically examining synthetic biology from an early stage, not only as a new source of risk, but also as driver of the relentless global exploitation of natural resources and the communities dependent on them. In Europe, therefore, the emergence of synthetic biology immediately prompted active discourses on innovation, risk and also reflective ethics, stimulated by European funding of research into ethical, legal and social implications. Synthetic biology is regarded as having arrived at a time when the role and position of science in society are facing increased public scrutiny. In this context, governments and scientists, including social scientists, advocate the early involvement of stakeholders and the broader public in the governance of synthetic biology. In the European power and control discourse, these issues converge in the overall theme of ‘responsible research and innovation’.

In China synthetic biology is also actively supported by the government, with the aim of catching up with developments in the US and Europe. More than in Europe, however, the Chinese innovation discourse involves deliberate attempts at priority setting in the framework of governmental five-year plans, in which synthetic biology has been identified as a strategic priority in the nation’s applied biotechnological research, especially in the biomedical and health care field. Issues of biosafety and biosecurity have also caught the attention of scientists in China, pointing to the need for the government to match global standards of regulation laid down in international agreements, but the major concern in this context is that issues of risk and regulation should not hamper China’s striving for progress in synthetic biology. In China the government is the principal agent in synthetic biology policy-making. There has not been much demand for control from scientists or the public, and systematic ethical reflection on synthetic biology is mostly lacking.

In India there is only fragmented support for synthetic biology innovation from the government, and also little involvement of scientists or other stakeholders in discourses about the field. The most concerted contribution to synthetic biology policy-making in India has come from a special task force instituted by the government, which took a broad view of the promotion and regulation of synthetic biology, emphasizing not only its potential benefits, but also the need to address safety and ethical issues and to take the public into account. In considering India’s potential for innovation in synthetic biology, the task force report put the emphasis on meeting the developmental needs of the country, identifying biofuels as one of the key applications.

8.5 Conclusion: Governance Implications of GEST’s Comparative Analysis

The GEST project has focused on the relationships between the five science and technology *discourses* and science and technology *policy-making* in the three regions of Europe, China and India. What does the comparative analysis in the three case studies tell us about these relationships? In general we observe a strong intertwinement and interactive dynamics between the discourses and science and technology policy-making. However, the GEST project has been interested in particular in the mediating role in science and technology policy-making of the two *crosscutting discourses* of reflective ethics and lay morality. As already indicated, these discourses have recently been more and more institutionalized and 'mainstreamed', especially in Europe, in response to tensions and conflicts arising from the introduction of new science and technology.

The first part of this book has discussed this emerging landscape of ethics and public discourses and their various forms of institutionalization in the three regions. What, then, can we conclude from the case studies about the role of these discourses in science and technology policy-making?

In comparing the science and technology discourses of the three regions, there is a notable contrast between Europe on the one hand, and China and India on the other. In all three case studies we see in Europe the predominance of a *risk discourse* that has been translated into a general regime of 'risk governance' with a strong international dimension (International Risk Governance Council 2005). In this context, the European discourses of reflective ethics and lay morality are strongly founded in a pervasive risk governance paradigm, based primarily on fundamental individual rights to protection against harm. In China and India, on the other hand, the *innovation discourse* is predominant in the three cases that we have described. This innovation discourse mostly translates into definitions of collective interests or needs that should guide the governance of innovation in terms of the 'common good'.

In general terms these observations suggest that in Europe more emphasis is placed on individual than community values, whereas in the other regions community values are emphasized over individual values (see Chap. 4). In the case of China, this picture is most clear-cut and also implies, in the context of China's political system, that it is the government that defines the collective interests in science and technology policy-making, without a role for public or indeed ethics debate. In India the picture is more complex. Individual rights have been secured in the country's constitution, and India has a culture of vibrant public debate, but in science and technology policy-making a reflective ethics discourse is lacking.

These observations suggest, finally, that *tensions within and between the governance of innovation and the governance of risk* are major challenges for science and technology policy-making—and indeed for a 'global ethics'—in all three regions. In each of the regions, however, these global ethical challenges of power and control take a different form.

- In Europe, the major challenge is to strike a better balance in science and technology policy-making between risk governance, which is the currently dominant paradigm, and a governance of innovation informed by values related to the common good and grand societal challenges.
- In China, the major challenge is to strengthen ethics and public discourses as a basis for a more participatory governance of both innovation and risk,

preserving harmony as a core value in the face of mounting public concerns about the role and risks of science and technology in society.

- In India, a lack of risk governance is one of the important challenges. Another major challenge is how to bridge the gap in the governance of innovation between the socioeconomic needs of the country in terms of access, equity and inclusion, and the imperatives of global economic competition, which are often paramount in science and technology policy-making.

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Chapter 9
New Food Technologies in Europe, India and China

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9.1 Historical Developments in Food and Agriculture

The past 20–30 years have seen significant changes in the way in which food security, safety and the food economy have developed. These changes are due *inter alia* to advances in technology, together with changes in the roles of stakeholders and increasing awareness of ethical considerations that incorporate consumer perceptions, animal welfare and environmental issues, and may vary according to local cultural influences.

9.2 The European Case

Over the past three decades, the dominant agri-industrial food production system in Europe has been challenged by a post-productivist model that is popularly perceived as more environment-friendly and grass-roots-initiated. This shift is a consequence

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Table 9.1 Food technologies discourse and values: Europe

	Justice and equality	Sustainability	Freedoms and rights
Innovation	Economic development; health benefit effects; unaffordable products	Disease resistance; extreme-climate crops; bioenergy crops	Choice between agri-industrial and post-productivist products
Risk	Adverse health side-effects	Crop cross-pollination	Monopoly market; lack of choice
Power and control	Substantial equivalence; precautionary principle	Food security; food monopoly; crop coexistence	Labelling of GM products

of changes in value systems, representing a change from a materialist to a post-materialist value orientation that has recently been evident in European societies (Inglehart 1990; Lowe et al. 1993). This value shift can be superimposed on the ethical continuum of utilitarianism and deontology. The obvious utilitarian gains of the agri-industrial model are becoming less significant than the gains in sustainability and wellbeing of the post-productivist model. It seems that society is looking beyond the material improvements in the quantity and price of food and, as in Maslow's pyramid, attempting to incorporate what are often held to be the higher values that are required to actualize societal inspirations (Levidow et al. 2012). These values are entrenched in the process of governance in Europe, through the various treaties of the European Union, as justice, freedoms, rights, sustainability, dignity, solidarity and equality (see Chap. 5), and some of them influence the arguments and perceptions of stakeholders.

The discourses on innovation, risk, and power and control overlap in terms of argumentation embedded in scientific complexity, human values and socioeconomic impact. The discourse of innovation and its focus on economic prerogatives cannot be clearly differentiated from that of risk, with its focus on individual effects, or that of power and control, which attempts to balance the two in a societally sustainable manner.

The relevant values themselves are used more as guiding principles than as defined legal concepts. The values of justice, equality, sustainability, freedoms and rights that are dominant in European societies show significant overlaps (and even contradictions) when it comes to real-life applications. Nevertheless, it is neither counterproductive nor undesirable to attempt a categorization of a scientific debate in terms of values and discourses, as long as there is clarity of source and purpose in the debate process. Table 9.1 summarizes the main arguments in terms of dominant value and type of discourse in food technologies.

9.2.1 Justice and Equality

Justice and equality are combined in Table 9.1 because the overlap in the relevant argumentation is sufficient to make them indistinguishable. Both refer to attempts to uphold fairness in societal dealings, rejecting prejudice or preference of treatment for one group over another. The innovation discourse derived from these values deals with two main arguments, the more straightforward of which focuses on the opportunity for new food technologies to provide for societal prosperity through economic development. This argument is promoted for many new technologies. However, the European food industry is substantial. Failure to adopt new technology may have an impact on many people, including employees and consumers. Equality is interpreted in this case in terms of (equal) access to work and food products. Preventing the implementation of a technology with direct health benefit effects runs contrary to the values of justice and equality (i.e. fair and equal access to wellbeing). Against this, an increase in injustice and inequality may be associated with products of new technology that are prized more highly than equivalents perceived as less healthy, and may be unaffordable for less affluent citizens.

The discourse of risk focuses on technical details, namely whether novel foods carry any risks to human or animal health. This discourse is also the least conclusive in terms of values. Justice and equality would prohibit the unnecessary taking of risks, particularly if these are distributed inequitably across the population. From here, it could be argued that food technologies may represent a risky experiment with human health and wellbeing, therefore breaching the value of justice.

The power and control discourse is where justice and equality are enshrined in law. For example, the interplay between two different arguments relating to risk assessment has been observed: substantial equivalence versus the precautionary principle. From a global perspective, substantial equivalence represents a just and equal risk assessment process, and its abandonment creates unfairness and inequalities in international relations. The opposite might be true for the precautionary principle applied at the level of the individual: it promotes fairness and equality for citizens who do not agree with the status quo and are unwilling to become what they see as research subjects.

9.2.2 Sustainability

The value of sustainability refers mainly to environmental protection, which includes the environment seen as a resource for future generations. Thus sustainability relates to the way in which, and reasons why, food is produced. Innovation discourse revolves around the specific characteristics of food crops and their relationship to the environment. New technologies may be promoted as a solution to environmental threats (diseases), conditions (extreme climate) and energy production (biofuels) that otherwise would be impossible or expensive to achieve. As such, it is argued that technologies promote a cleaner and more sustainable environment.

The sustainability risk discourse focuses on the introduction into the environment of novel crops that cannot be separated from the current ones. For example, cross-pollination may result in diminished biodiversity.

The primary policy issue (i.e. regarding how to develop and maintain food security) is whether existing environmental conditions are sufficient to produce a sustainable source of food for the increasing human population. New food technologies have the potential to improve food security. At the same time, domination by a small number of profitable enterprises could create the opposite effect: a world where biodiversity is dwindling while what remains is governed by a few. Evidence in favour of developing a sustainable coexistence strategy is required scientifically, and legislative hurdles may be associated with its implementation.

9.2.3 Freedoms and Rights

The values of freedoms and rights are almost interchangeable. In the innovation discourse on food technologies, both proponents and opponents argue that citizens should have the right and the freedom to choose between products deriving from either agri-industrial or post-productivist types of agriculture. This usually, but not always, translates into choices between organic, nonorganic and genetically modified (GM) foods in Europe. What differentiates the arguments is not whether choice should exist, but how society should achieve it. The issue of intellectual property rights (IPR) is located in the risk discourse. IPR can have significant effects on the availability of food on the market, thus creating dangerous market shifts. For instance, extensive IPR protection could lead to monopolies, while weak protection could lead to lack of innovation. Different perspectives are not easily reconcilable.

The power and control discourse in Europe has focused primarily on the issue of labelling, in which the freedom to choose is associated with the right to know. Despite opposition by the food industry, the use of labelling to identify products containing or derived from GM material has been viewed as a basic right and has been legislated as such. The only undecided issue is the level of tolerance for new technology (i.e. GM) ingredients that is acceptable for labelling purposes.

9.2.4 Ethics and Public Perceptions

Dominant values are not easily distinguishable in public discourse because they permeate all argumentation. Reflective discourses may be better represented using a traditional approach to ethics discourse analysis that includes the description of stakeholder perspectives in terms of ethical principles. This analytic approach, termed ‘ethical matrix’, is inspired by the ‘principled approach’ in standard biomedical ethics (Bhuiyan 2010).

Such analysis identifies stakeholders’ perspectives on fundamental ethical principles, both inward-facing, as they relate to themselves, and outward-facing, in terms of their ethical responsibility to other stakeholders and wider society. It is possible that these different perspectives might in some cases be conflicting, even for a single stakeholder. The values individual stakeholders hold can affect the way in which they balance what they perceive as their own interests with those of other stakeholders, of particular importance where the interests and/or perspectives of different stakeholders appear to clash. For example, innovators whose primary focus is on their own freedom to innovate and market their inventions in a way that maximizes financial gain, while avoiding any negative impact on their brand or image, may find themselves in conflict with other stakeholders who see the right to open and transparent information as an essential factor in their freedom to choose and make decisions. Farmers who focus on their freedom to choose whether or not to grow GM crops or animals may find themselves in conflict with other stakeholders who prioritize the protection of human health, the environment or animal welfare, or who perceive GM products as having unidentified potential risks.

Thus it is important for all stakeholders to understand not only their own needs but also the needs and perspectives of other stakeholders. Without a balanced ethical perspective, novel innovations may stall through opposition, or companies may be disincentivized from developing certain new technologies. This is, to a large extent, what has happened in Europe. One argument used by innovators and the food industry is that GM products can increase the food supply and strengthen food security, particularly in the developing world. However, these arguments are irrelevant to Europe, where food is plentiful and consumers feel entitled to make their own choices about the food they eat: they see no reason for exposing themselves to any level of potential risk when there are no evident benefits. It has been argued that consumers in countries suffering chronic food shortages are less concerned, although a number of developing countries have also expressed concerns about GM foods.

If people are struggling to meet their basic physiological needs and perhaps have only one source of food, they are unlikely to reject food whatever its origins. This does not mean that any of their concerns can be ignored. As physiological and safety needs are met, people have greater opportunities to express the ethical principle of autonomy or freedom of choice. They may also have greater opportunity and inclination to express outward-directed or altruistic choices, for example in relation to other communities, animal welfare or the environment.

It is argued by some innovators and policymakers that the benefits associated with GM foods are increasing and that consumer acceptance of GM products would lead to important economic growth. While there is some evidence that consumers are more likely to accept GM products if benefits can be clearly identified, the broader economic-growth argument may be outside the field of interest of most consumers.

Other stakeholders have repeatedly failed to understand or accept the perspectives and values that drive consumer acceptance, arguing that if consumers understood the science, all would be well. Patently this approach does not work. European consumers appear to value their freedom to choose which food products they can buy. Although it is widely recognized that providing consumers with information on real and potential risks and benefits associated with GM foods in general is important, this alone is not sufficient to secure consumer acceptance. Labelling provides for consumer choice. Manufacturers argue that consumers perceive that GM products are unsafe.

9.3 The Indian Case

Food security has been an extremely serious problem in India over the past 60 years. In the early years of independence, from 1947, India was dependent on food aid programmes. Thus the need for technological intervention to produce higher yields was a national policy priority. The Green Revolution was embraced by the Indian government as a technological response to the increasing gap between food demand and food availability. India was transformed from a food-deficient country into a leading food producer. The Green Revolution resulted in a record grain output of 131 million tonnes in 1978/1979, establishing India as one of the world's biggest agricultural producers. For example, the crop area under high-yielding varieties of wheat and rice grew considerably (Edugreen n.d.). Capital-intensive agriculture increased economic disparities between large farmers and small farmers.

The change from traditional subsistence farming to industrial monocropping had negative effects on small farmers. They found themselves trapped in a cycle of high interest rates associated with the purchase of seeds, fertilizers and pesticides. Lack of competition meant that prices remained very high (Sebby 2010). The negative socioeconomic and environmental impacts of the Green Revolution are visible today. The institutional and economic conditions for applying Green Revolution technology effectively and safely were not fully in place, particularly for small and marginal farmers. The services needed for small-scale producers to gain access to or to realize the benefits were inadequate, especially for the resource-poor, the indigent and marginalized, and women (McIntyre et al. 2009).

The debate on environmental impact has led to an increase in policy support for organic production. However, post-production losses of perishable and semi-perishable products are extremely high.

A further issue relates to inequality in access in relation to Green Revolution technologies that were available to producers in the rich northern states of Punjab, Haryana, parts of Uttar Pradesh, Madhya Pradesh and Maharashtra. This has led to supplementary programmes aimed at improving food security at the subregional level.

The impediments to enhanced food production are also associated with urbanization and market incentive structures that adversely affect areas under cultivation across different crops (Brahmanand et al. 2013). The overall costs of cultivation, largely an outcome of input costs, have increased significantly, pushing up overall food prices. As a result, India witnessed intense political debate, which led to the complete suspension of the whole process of GM commercialization (Chaturvedi et al. 2012; Chaturvedi and Srinivas 2013).

However, food production techniques have diversified. Technologies like biosensors, genomics, biotechnology and nanotechnology are now being developed and implemented. Technology-led paths should deliver prosperity, sustainability and employment to farming communities.

In India, farmers are increasingly experimenting with indigenous practices associated with alternative agriculture, although research in the area is less frequently funded. Against this, more affluent farmers are adopting advanced technological solutions, largely led and supported by private-sector seed firms.

An ethical analysis can be applied to establishing a linkage between technologies and their socioeconomic aspects, environmental sustainability, the influence of global or external factors and equitable access. The proponents of GM technology base their arguments on the environmental sustainability associated with its introduction. The opponents argue that the research and development infrastructure is very expensive and poorly regulated.

Three discourses—those of innovation, risk, and power and control—overlap, with socioeconomic issues cutting across them. Here the term 'socioeconomic' may seem too vague or broad, but it is possible to identify the key issues of relevance.

The key lessons from this analysis of food technologies in India are:

- Innovation cannot be divorced from broader concerns relating to socioeconomic impacts. Considering such concerns as part of technological innovation policy and management will result in greater benefits to society, increased acceptability and the wider adoption of technologies.
- Power and control should be understood in terms of impacts and how they can result in distorted markets, a less-than-optimum use of technology and societal resistance. The examples from India show that stakeholders may differ about regulatory activities. Those who question technologically based power and control often use socioeconomic discourse to highlight their concerns and to make counterclaims regarding benefits and risks, which are discussed in forums that may be unequal in terms of their influence on the policy process. Regulation and policy must address socioeconomic issues.
- Various technological options have to be assessed and promoted to maximize gains. It is here that assessments of socioeconomic factors have an important role in policy formulation. For example, technological options like non-GM biotechnology, traditional plant breeding and organic agriculture can be supplemented with GM biotechnology.
- Food technologies may ensure better productivity and environmental sustainability. Access, equity and inclusion can be criteria in deciding on and implementing technologies. Socioeconomic impact assessment may be applied in areas ranging from deploying innovation to protecting farmers from vulnerabilities and risks associated with technologies.

In summary: in India, innovation issues cannot be divorced from broader concerns relating to socioeconomic impacts. Addressing these as part of technological innovation policy and management will optimize benefits to society.

9.4 The Chinese Case: Genetically Modified Foods in China

GM food cases in China cannot be discussed without reference to a GM cotton variety that was introduced to the country in the 1990s and rapidly promoted, leading to the establishment of an associated regulatory system.

In 1992, the cotton-growing areas in northern China suffered severely from bollworms, which caused the yield per unit area in Hebei, Shandong and Henan to decline by nearly 30 %. The significant decrease in cotton production endangered the textile and related industries (Zhang and Wang 1993; Qiu and Wang 1998). A GM cotton variety developed by Monsanto was introduced to China in 1995 and approved for commercialization by the Ministry of Agriculture. In 1998, this cotton variety was promoted widely in China. Monsanto acquired an advantage in the cotton seed market and quickly became the favoured choice of cotton growers across the country.

Meanwhile, the Chinese government increased efforts to develop related biological technologies. In 1991, the then State Science and Technology Commission of China initiated a research project on the development of insect-resistant GM cotton varieties. By 2005, China had successfully developed more than 30 such varieties, which were grown in nearly all cotton-growing areas, accounting for more than 70 % of the total cultivated area of all insect-resistant cotton varieties. With the improvement of their research and development capacity and their superior knowledge of the needs of domestic cotton growers, Chinese cotton seed breeding companies have achieved rapid development and gradually established a competitive edge in the market. Insect-resistant cotton seeds independently developed by Chinese companies account for 90 % of the domestic market.

With respect to GM foods and related technologies, the Chinese government adopts a largely empirical approach, emphasizing industry security and innovation. However, the process has been not without flaws, for example the lack of concern on the part of the government, researchers and the public regarding the environmental impact of GM crops. Not only consumers, but most cotton growers as well, were ill-informed about transgenic technology, and public knowledge remains limited, even now that GM crops have been promoted. The absence of a forum for stakeholders and the susceptibility of the public to anti-science rumours make it very difficult to conduct an effective dialogue between researchers and the public and to build consensus across groups.

The success in cotton production has given the government, research institutes and agricultural enterprises a deep understanding of the importance of transgenic technology. There is consensus that China should catch up with developed countries in transgenic technology and build its own transgenic technological strengths in agriculture and related fields. China has developed scientific programmes in both basic and applied research that have produced an extensive body of knowledge about biology, thus laying a solid foundation for further research and development. The Chinese government has been very prudent, however, about the commercial production of GM crops. Only a limited number of GM varieties such as tomato, papaya and pimento have been approved for commercial cultivation. No permission has been given for the commercial GM cultivation of any staple crop, apart from biosafety certificates being granted to two GM rice varieties and one GM corn variety in 2009. However, the issuing of these certificates did not allow immediate commercial cultivation: to date, no GM staple crop has been approved for commercial cultivation in China.

China is concerned about whether GM foods will cause harm to human health and/or the ecology and environment. There are concerns that the long-term ingestion of the substance containing the Bt toxalbumin found in GM crops may be harmful to health. Supporters of GM foods cite research findings that the toxalbumin produced by the Bt gene is only toxic to certain organisms. Foreign research institutes have reported that GM foods may have a negative effect on the human liver, kidney and immune system, as frequently cited by the opponents of GM foods. A second concern relates to potential allergens that may be introduced into new crop varieties through GM. Therefore plants with any allergen gene inserted are prohibited from commercialization.

Transgene escape can potentially have negative impacts on the environment. Natural crossing will take place between some cultivated plants and nearby related wild species, introducing the genes of the cultivated plants into the wild species, to the extent that wild plants may take on the characteristics of the GM plants (e.g. pesticide resistance). China's arable land is widely fragmented across farms, and therefore the asylum or refuge method for reducing the ecological impact of the transgenic technology is not feasible. A further risk is that because Chinese agriculture is so highly fragmented, effective governance and monitoring of GM crops is almost impossible and many GM crops are grown illegally (Zi 2005).

The Chinese government has identified a further risk issue that could best be described as 'industrial risk', meaning that the globally integrated agricultural production system poses a threat to the agricultural security of developing countries, resulting in problems with access to foods and compromising the survival of millions of people. The population excluded from the economic system may generate political and economic crises in developing countries. Through such means as mergers and acquisitions, control of IPR and specialized production, the multinational agricultural companies, which are based in developed countries, have implemented a vertical integration strategy centred on a few developed countries that control the entire agricultural and food production chain from raw material supply to sales. As multinational agricultural companies become increasingly monopolistic globally, many individual medium and small-sized farms face bankruptcy. Developing countries are gradually losing their independence with regard to food production. Transgenic technologies are mostly controlled by large-scale agricultural and chemical companies in developed countries. As a response, the Chinese government maintains strong vigilance over the potential risks of opening the markets concerned (Magdoff et al. 1998; Shiva 2000; Amin 2003).

At present, China's GM food administration system still faces various problems, including poor coordination and cooperation between different government departments, inadequate administrative measures and a lack of public participation, communication and decision-making transparency. From the perspective of policies, laws and regulations, China's regulatory system for GM foods covers the economy, trade, production and environmental protection horizontally and research, experimentation, processing, production, operation, and import and export vertically, but there is still no specialized comprehensive legislation. The regulations issued by the various competent government departments are not only jumbled but also unable to address major biosafety issues that fall outside their scope. Moreover, the lack of coordination of the different laws and regulations has led to overlapping, conflicts or omission in responsibilities between the various departments.

Whether the farmers adopt new technologies is dependent on their cost and promised return. Even though GM seeds are several times more expensive than conventional seeds, the premium is worthwhile in the short term in view of the many benefits they bring, including savings in pesticide costs, the reduced use of labour and the prevention of pesticide-caused poisoning. Therefore farmers are generally willing to adopt these new technologies. In the long term, the degree of acceptance by consumers of GM foods and the implementation of a GM food marking system may lead to changes in demand, and uncertainty in this respect may cause fluctuation in the farmers' expected returns (Ma and Huang 2003; Zhao and Chen 2011; Zheng et al. 2012).

The degree of acceptance by consumers of GM foods will eventually determine their growth. Two surveys in 2002 and 2003 showed that approximately 67 % of urban consumers were aware of transgenic technology and approximately 60 % accepted GM foods (Huang et al. 2006). Comparable surveys in recent years have indicated some improvement in urban consumer awareness of GM foods but a decrease in acceptance (Luo et al 2010; Zhou et al. 2012). The main determinants of consumer attitudes to GM foods are food safety and income. There is a positive correlation between perceived food safety and willingness to buy, and a negative correlation between income and the willingness to buy. Food safety is dependent on information symmetry, which is mainly subject to the influence of media publicity and the degree of trust in the government. The views presented in the media influence the degree of acceptance of GM foods on the part of Chinese consumers.

A Chinese consensus conference on GM foods in 2008 suggested that Chinese consumers, especially those living in large and medium-sized cities, were increasingly worried about GM food, and that the public were paying closer attention to the risks of biotechnology, particular in relation to GM foods. The Chinese public in general trust the government and scientists, a confidence that is enhanced by direct dialogue among the parties. The public are cautious about the development of GM, but supportive of the country's efforts in developing GM technology.

In China, the discourse on supporting GM foods and related technologies through innovation involves two intertwined systems. The first is the discourse of developmentalism, which holds that only by giving full scope to the advantages of biological technology and using transgenic technology to transform products into productivity can China's agriculture undergo fundamental changes.

It further states that transgenic technology will improve the inherent value of traditional agriculture because the reduced production costs and improved outputs will increase agricultural productivity. Thus, it is argued, the development of GM foods is a long-term global agricultural trend, and will help solve China's future food security problems. The second is the discourse of scientism, which, starting out from Deng Xiaoping's judgment that 'science and technology constitute a primary productive force' (Deng 1994), holds that GM foods naturally have political legitimacy and that the aura of science lends scientists and technologies an authority and reputation that tend to foreclose reflection on the legitimacy and social consequence of GM foods, thus endowing them with an automatic correctness.

The production and consumption of GM foods in China are also associated with potential risks—in general, and specifically in relation to China's existing agricultural situation and administration, and to the industry security. The Chinese government does not want to see the country's industrial security undermined either by foreign control of key technologies or by China's own lack of technological preparation.

The Chinese government has a mixed attitude towards GM food technology. On one hand it is prudent about the commercial application of relevant technologies and, on the other, it takes research and development and independent possession of transgenic technologies as a strategic policy for supporting agricultural development at the national level.

9.5 Conclusions from the Three Regions Analysis

A number of important factors affect the way in which policy is elaborated and established for the development and implementation of innovative food technologies in the three regions. The identity of the key actors and their position in relation to power and control influence policy implementation. Local food security considerations and socioeconomic factors are also relevant, particularly as they affect regional and national economies and global competitiveness. The role of ethical considerations depends on the extent to which such values influence these factors.

In Europe, consumers play a crucial role in developing policy and influencing the extent to which innovative food technologies are introduced. The European consumers' response to technologies such as GM food has carried considerably more weight in the market than pure economic considerations. In the European context, regulatory transparency, risk perception and communication, fairness, trust and freedom of choice underlie and influence the extent to which consumer opinion affects novel food technology policies. It is useful to compare this expression of values in Europe with their relative influence in the different political, societal and economic situations of China and India.

The Chinese case study focuses specifically on the use of GM in agriculture. The introduction of food technology has been influenced by a different relationship between the state and its citizens. Associated policy appears to be influenced largely by Chinese scientific research, closely allied to government policies on the need to ensure economic independence and control, which are related in turn to an ideological perspective on the ability of science to deliver economic benefit.

Although public concern about GM food is increasing in China, there appears to be relatively little direct engagement, either with public interest groups or with Chinese consumers, to ascertain whether there are any ethical or other values held by citizens that may impact on the introduction of such food. At the same time, the Chinese government is aware of the need to protect its citizens from any risks associated with GM products, and recognizes that there is little point in introducing GM staples into the food chain if these are likely to be rejected by consumers. This demonstrates that the Chinese government is concerned about its ethical responsibility to protect its citizens from harm and acknowledges consumers' right to choose whether or not to consume GM food products. Although trust in government, regulators and scientists may be higher in China than in Europe, the principle of consumer *informed* choice through the informative labelling of foods produced using new technologies may well still be an important consumer condition of acceptance of GM foods, and potentially other innovative food technologies (Coles and Frewer 2013).

In India, agrifood innovation cannot be divorced from broader socioeconomic impacts (effects on small farmer communities, the environment, labour costs, traditional agriculture, etc.). Stakeholder debates are often based on socioeconomic concerns. Discussion of putative risks (and associated policy measures) is an important issue in India, while food security is a major preoccupation for policymakers. Traditional plant breeding and organic agriculture too are important in Indian agricultural production.

Food policy in India is also influenced by various interest groups and/or trade bodies for which socioeconomic considerations (based on access, equity and inclusion) are key value considerations. This appears to have produced a number of very pragmatic policy choices that aim to sustain and develop organic agriculture while at the same time making room for the sustainable implementation of biotechnology innovations.

9.5.1 Regional Commonalities

Taken together, certain similarities between the three regions offer a road map for collaboration. Public multi-stakeholder debates are becoming the norm, rather than the exception, in all regions. The proximity of food to consumer-citizens and a strong and increasingly educated and assertive civil society in all three regions are changing the rules of policy debates. To an increasing extent, policy agendas are influenced by the outcomes of multi-actor and multi-stakeholder public interaction. Understanding the social dimensions of new food technologies may become an important consideration in the policy process.

The growing vocalization of consumer concerns may lead to a shift of balance in the power and control spectrum. As the existing risk assessment paradigm is questioned, measurements of long-term effects are becoming prominent elements in the official risk assessment process that require a greater emphasis on collaborative activities in constructing a new common procedure.

While there are similar concerns in all three regions about issues of risk and safety and how these are expressed, the mechanism to deal with these still varies considerably. The precautionary principle plays a major role in the European context, and is also now taken into account by the World Trade Organization and the Codex Alimentarius. In India, the focus is on developing an increasingly stringent regulatory framework for food safety with the introduction of the National Food Security Act of 2013 and a new regulatory body, the Food Safety and Standards Authority of India in the Ministry of Health and Family Welfare. In China, although the precautionary approach operates in relation to the introduction of GM staple foods, the ideological scientism position is still an important consideration.

Despite these differences, in the context of a global market in food products, some clarification of parameters for a common approach to global risk assessment standards is required. In any common collaborative activity between the three regions, food security has to be accepted as a valid indicator of the potential impact and value assessment of new technologies. A commonly understood socio-economic analysis is also required as a basis for policy development.

The engagement of the public and stakeholders in food debates is increasingly seen as an integral part of the policy process. Participatory technology assessment exercises have been conducted in all three regions (e.g. consensus conferences), but formal institutional structures are missing in China and India (see Chap. 4). Some context-based structures that presuppose a common understanding of methodological parameters in public engagement should be developed in pursuit of collaborations that will see an integrated food policy input in the three regions.

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Chapter 10
Discourses on Nanotechnology in Europe, China and India

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10.1 Introduction

For roughly 15 years, 'nanotechnology' has been established as a generic term for a wide and inhomogeneous field of science and technology branches that enable us to manipulate, observe and measure at a scale of less than 100 nm. One nanometre is equal to one billionth of a metre. Nanotechnology or, more precisely, nanotechnologies as the application of nanoscience—an interdisciplinary science that cuts across established scientific and engineering disciplines like chemistry, physics, biology, or engineering—consists of overlapping technologies in which different

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industrial sectors such as communication, health care and biotechnology meet and partly converge. Moreover, because it provides a toolkit for realizing certain (pre-) products in many sectors, nanotechnology has been classified as an 'enabling technology' and as a starting point or exemplar of a new industrial revolution. The broad and open definition of the umbrella term 'nanotechnology', as well as comprehensive visions and expected research and development programmes, have led to the creation or designation of new subdisciplines (or 'hyphen disciplines') such as nano-electronics, nano-medicine, nano-ethics and nano-toxicology.

At the nanoscale the characteristics of matter can be significantly altered because of size-specific properties such as the dominance of quantum effects: for example, downsized material structures that consist of the same chemical elements may change their mechanical, magnetic, electronic and optical properties. Engineered nanomaterials[1] are manufactured for specific ends, such as carbon nanotubes for reinforced car tyres or antistatic packaging, nanosilver particles for antibacterial coatings, titanium carbide for harder cutting tools and nanoparticles for drug delivery. Nanomaterials appear in different forms and are generally categorized according to their dimensions: for instance, very thin surface coatings, films or layers are nanoscale in one dimension; nanotubes, nanowires and fibres are nanoscale in two dimensions; nanoparticles, quantum dots and nanoshells are nanoscale in three dimensions.

During the 1990s some governments set up state-run promotional programmes for nanotechnology, although they did not then use the actual term 'nanotechnology' (Wullweber 2010: 157). At the end of the 1990s nanotechnology became a positive guiding vision (*Leitbild*)[2] for future technology development. Science policy and governmental actors succeeded in shaping a programmatic nano-discourse by linking far-reaching promising nano-visions to the current state of the art in specific fields of nanotechnology, such as nanomaterials and nanoelectronics. The fields identified for governmental action were taken up in governmental nanotechnology research and development programmes introducing mid-term guiding visions for the shaping of the nanotechnology discourse in particular and the science and technology policy discourse in general. Important technology policy actors from leading industrial countries started framing the field of nanotechnology by conceptualizing different developments under the umbrella term 'nanotechnology', through research and development programmes showing the medium- and long-term way forward, and by establishing and maintaining networks embracing actors in research, industry, politics and the public sphere. 'Nanotechnology has arguably been the strongest movement in the re-organization of the disciplinary landscape of science and engineering worldwide in the past decade' (Schummer 2007: 670, 671).

[1] Besides engineered or manufactured nanomaterials, there are also natural nanomaterials like volcanic ash, fire smoke, clay and evaporating sea salt.

[2] *Leitbilder* (guiding visions) are close to being concrete technological developments, but have not yet been realized, though there is good evidence of their feasibility (Grunwald 2005).

The first and biggest nanotechnology research and development programme explicitly promoting nanotechnology, the National Nanotechnology Initiative, was initiated by the US government in 2000:

> Nanotechnology is the first economically important revolution in science and technology (S&T) since World War II that the United States has not entered with a commanding lead. Federal and industrial support of R&D in the United States for this field already is significant, but Europe and Japan are each making greater investments than the United States is, generally in carefully focused programs. Now is the time to act (National Science and Technology Council 2000: 114).

From 2000 to 2007 more than 60 countries established more or less comprehensive and coherent nanotechnology research and development programmes (Roco 2007: 37). This worldwide nanotechnology-oriented innovation process is situated in a highly competitive field among leading industrial nations and regions. Governments and actors in the science industry in particular are encouraging a robust innovation discourse that characterizes nanotechnology as a revolutionary key technology, highlighting its potential benefits and possible contribution to big societal challenges, such as global competitiveness and sustainability, and aims, such as economic growth and the wellbeing of the population. In the field of energy production, for example, semiconductor nanowires and quantum dots have potential for sustainable solar energy harvesting. Promising applications in the field of medicine are personalized drug delivery and the in situ regeneration of bones.

Some actors, on the other hand, including researchers in science and technology studies and non-governmental organizations (NGOs), contrast the potential benefits with uncertainties and possible environmental, health, and safety risks as a counterbalance to this innovation paradigm, since not much is known about the interaction of nanomaterials with the human body or the environment. Besides these primary or absolute risks there are also secondary or related socioeconomic risks involving autonomy and democratic codetermination or global justice and societal equity through an entrenchment of current market and political power imbalances (the nano-divide). In particular, the discussion on governance and the risk assessment of nanotechnologies has led to an entanglement of different argumentation patterns, principles and value concepts.

Nanotechnology encompasses a wide and heterogeneous field of technologies and possible applications, including far-reaching visions of converging technologies, human enhancement and transhumanism. Here we apply a more down-to-earth approach to nanotechnologies, focusing on nanomaterials.

10.2 Discourses on Innovation, Risk, and Power and Control

Since we are comparing discourses on nanotechnologies in Europe, China and India—three different regions with different sociocultural histories and socioeconomic contexts—the term ‘discourse’ is to be understood in quite a broad sense.

Our analysis[3] will show how the umbrella term ‘nanotechnology’ is conceptualized by one or more actors in each of the three regions, as well as how this conceptualization refers to region-specific sociocultural value conceptions.

10.2.1 Innovation

As stated in the introduction, nanotechnology has become a worldwide exemplar of industrial progress and innovation. Actors in science policy and the science industry link the development of nanotechnology to a wide range of beneficial applications. In each region, those involved in any innovation discourse have to show how their conceptualization of nanotechnology fits societal needs in order to represent nanotechnology as a socially robust sociotechnical system.

All three regions have been involved in research at the nanoscale since the 1980s, with awareness of nanomaterials growing during the 1990s. The nanotechnology innovation discourse also started in all three at about the same time, the beginning of the 2000s. But there are significant differences between the regions in innovation policy. Whereas China and many EU member states set up guiding and envisioning nano-strategies and permanent central coordinating bodies, India started by launching a Nano Science and Technology Initiative coordinated by the Department of Science and Technology, which also oversees other science and technology activities.

10.2.1.1 European Union

The development of a coherent policy for nanotechnologies at a European level can be traced back to the year 2000, when the cross-departmental Unit G4: Nanosciences and Nanotechnologies was established in the European Commission’s Directorate-General for Research, in order to gather information from other directorates-general and services with the aim of providing guidance for the European nanotechnology strategy and distributing research funds for nanotechnologies from the EU’s multi-annual Framework Programmes for Research and Technological Development. Although nano-specific promotion programmes did not exist before the year 2000, there were some early efforts at nanotechnology research and development in the fourth and fifth framework programmes of the European Commission.

In May 2004 the commission adopted the communication ‘Towards a European strategy for nanotechnology’ (European Commission 2004), followed by an action plan for nanosciences and nanotechnologies in 2005 (European Commission 2005). In these policy papers the commission refers to the potential contribution of nanosciences and nanotechnology to addressing many of today’s societal challenges, especially in medicine, information technologies, food and water, energy and

[3] This analysis is mainly based on Fautz et al. 2014.

environment, as well as security. It notes the strong knowledge base in nanosciences that the EU has established over the preceding decade, but doubts that the EU is in a good position relative to its main international competitors, since it is investing less and lacks world-class infrastructure. The commission makes the point that European excellence has to be translated into commercially viable products within a favourable environment for innovation. At the same time it addresses environmental, health and safety (EHS) aspects and ethical, legal and social implications, confirming that nanotechnologies must be developed in a safe and responsible manner.

The EU and its member states have continued to foster nanotechnologies by issuing action plans and research strategies with international engagement and by supporting or releasing codes of conduct for research and development.

So, for Europe, we can observe a broad governmental policy engagement to develop a coherent strategy on nanotechnology including a variety of actors, particularly in science and industry. Critical voices make references to prior discourses, developments and governance failures in the field of new and emerging technologies, such as biotechnologies, but governments too have learned from prior conflicts and developed more sophisticated strategies of anticipatory governance and conflict reduction, including certain forms of dialogue and participation.

The main innovation narrative is that of nanotechnologies exercising a kind of collective beneficence for society as a whole. Government policy papers raise expectations and emphasize how nanotechnologies can potentially benefit all citizens and the environment by addressing grand societal challenges—like fighting diseases, improving food and water safety, making the production and use of energy more efficient, protecting the environment, enhancing the security of human life and private property and increasing the economic wealth of the whole of society—in accordance with basic principles such as justice, autonomy and sustainability. In this way the main drivers of the innovation discourse directly or indirectly invoke the European values of equality, freedom and solidarity: equality of chances for wellbeing through economic growth; freedom of research as well as to conduct business; and solidarity by improving the health situation of the people and the environment through nanotechnologies.

10.2.1.2 China

In China, the main driver of the innovation discourse is the government. This is welcomed by industry, but also overwhelmingly by researchers, social scientists and the public, who all largely share a common vision and conception of national progress. In March 2001, the Chinese government established the National Committee for Direction and Coordination of Nanoscience and Nanotechnology Research to allow the comprehensive and coherent planning of such research across the country and to coordinate the actions of the various players. In July 2001, the National Programme on the Development of Nanoscience and Nanotechnology (MOST 2001) was released to provide specific planning for the overall development of nanotechnologies. In 2006, the State Council of the People's Republic of China released the Outline of National Medium- and Long-Term Science and Technology Development Plan (MOST 2006), in which nanoscience was described as 'one of the most promising areas where leap-frog development is possible' since nanotechnologies had the potential to 'give birth to a new technology revolution, and create huge development space for materials, information, green manufacturing, biology, and medicine in China' [our translation]. In 2012, a special five-year nano research plan (MOST 2012a) was formulated in order to deepen the implementation of the outline plan (MOST 2006) and advance major national scientific research programmes.

Although a handful of big national companies, such as Haier, are involved in nanotechnologies research, most industrial investments come from new business actors, in contrast to what is happening in other countries, where the majority of investors are big companies (Ren and Zhang 2010). Moreover, the nano industry field is subject to the economic need and political will for high increases in gross domestic product, making local governments eager for earlier returns on investment (Zhou 2007). This impatience has led to the low level of industrialization of nanotechnologies in China.

In terms of values, both progress and affluence can be identified as important reference points for the Chinese innovation discourse. The value of progress is embedded in the widely shared concept of social evolutionism. This is evident in the government's praise of economic progress through innovation aimed at catching up in international market competition and making the Chinese nation a self-reliant global leader in science, technology, and innovation. The scientific community supports these aims, with a particular focus on promoting research in order to perform well in international science and technology competition. Chinese enterprises that jump on the nano-train expect improved products for international competition, and can benefit from the public's appreciation of technological applications that symbolize societal progressiveness and individual wealth. Therefore affluence is the other main value of the government's innovation discourse, with the Communist Party deriving its legitimacy from its ability to guide the Chinese people to an affluent life through the improvement of their livelihood and the creation of material wealth. Closely related to this are the values of personal wellbeing and of social and ecological harmony.

10.2.1.3 India

In India, the main focus area of nanotechnology for government and industry lies in addressing urgent societal needs and challenges, as well as in the competitive commercialization of nano-enabled consumer products. The Department of Science and Technology launched the Programme on Nanomaterials: Science and Devices in 2000 in order to initiate some end-to-end projects leading to tangible technologies, processes and technologies. The emphasis was on projects addressing urgent national challenges like water purification, alternative energy production and conservation (DST 2001). An expert group on Nanomaterials: Science and Devices, charged with the development of a National Nanoscience and Nanotechnology Initiative, was launched in October 2001 under the aegis of the department. The key targets of the initiative were to create research infrastructure and to promote basic research in nanoscience and nanotechnology. It focused on various issues relating to infrastructure development, basic research and application-oriented programmes in nanomaterial, including drugs, drug delivery, gene targeting and DNA chips. Nanotechnology was heralded as a revolutionary technology with applications in almost every aspect of life. In recognition of the important role and multifaceted applications of nanotechnologies, the initiative was elevated to the level of a mission programme in 2007 (called the Nano Mission), with enhanced funding from the government. Primary objectives of the Nano Mission are basic research promotion, infrastructure development, the creation of public-private partnerships and technology development centres, human resource development, and international collaboration (DST 2008).

In terms of values and principles, the innovation discourse in India is mainly driven by the principle of beneficence—that is, doing good for others, here referring to society and the nation. This means that nanotechnological innovation is seen as bringing society wellbeing and justice in terms of access, equity and inclusion, since nanotechnologies are expected to address major social challenges and to push economic growth.

10.2.2 Risk

One of the challenges in nanotechnology policy, and in related ethics discourses, is the heterogeneity of the field, something that has become particularly obvious in the case of risk discourses. In early stages, these dealt with various nanotechnology approaches and applications, but since the mid-2000s, they have focused on the EHS risks of nanomaterials. For our comparison of risk discourses, important questions are:

- What kinds of risks are linked to nanotechnologies?
- How are they dealt with?
- How are they balanced against expected benefits?

EHS risk issues appeared almost at the same time in Chinese and European research communities. The Chinese government integrated risk research into its policy agenda—in particular thanks to advocacy and promotion by scientists—on the basis of a cost-benefit framework. In India, a risk management framework still has to be developed.

10.2.2.1 European Union

Within its Fifth Framework Programme for Research and Technological Development (1998–2002), the EU started funding specific research on EHS aspects of nanotechnologies (Aguar and Murcia Nicolas 2008). Since the years 2003 and 2004, EHS issues have increasingly been addressed by a variety of actors in Europe—including NGOs, the European Parliament, regulatory authorities, expert bodies, reinsurance companies and those involved in science and technology studies—and the risk (governance) discourse has become one of the strongest and most visible discourses in the debate on nanotechnologies, creating linkages with other nano-discourses and scrutinizing conventional risk assessment frameworks with reference to the precautionary principle or sustainability. By the year 2004, the first expert recommendations initiated by the European Commission appeared (e.g. Malsch 2004), emphasizing the need to assign new Chemical Abstracts Service (CAS) registry numbers to manufactured nanoparticles and to classify them in categories of risk, toxicity and proliferation. This has since been elaborated in the emerging subdiscipline of nanotoxicology (Kurath and Maasen 2006), where new risk assessment methods are being developed for the new and unknown properties of nanomaterials. Also reinsurance companies, by applying consequentialist risk assessment frameworks, soon became aware of possible EHS risks and emphasized the need for increasing risk research funds (Hett 2004; Lauterwasser 2005).

Even though there are no separate regulatory frameworks for nanotechnologies, the current EU regulations provide the most important framework for the activities of EU member states in this field. Moreover, in October 2011, the European Commission adopted a recommendation on the definition of the term 'nanomaterial', which was criticized by environmental, health and animal protection NGOs (CIEL et al. 2011) for being too narrow in scope and hence not adequate to deal with the risks of nanomaterials outside the range of 1–100 nm.

The European Parliament, the European Commission and several authoritative European and national research bodies commissioned by the European Commission and member state governments discussed and analysed the appropriateness of risk management frameworks in current legislation for handling nano-related risks, and the commission addressed EHS issues in many statements and funded research projects. But on concrete risk assessment and management measures, differences in risk perceptions became obvious between the more proactionary commission and industry on one side and the more precautionary European Parliament and civil society stakeholders on the other. Scientific expert bodies generally recommended a case-by-case approach to risk assessment and sometimes expressed doubts about the fitness of relevant legislation for nanoscale materials, in the absence of sufficient data on the behaviour of nanomaterials in the human body and the environment.

As a counterbalance to the Promethean innovation rationale, the main advocates of an alternative European risk discourse base their argumentation mainly on the principles of non-maleficence, justice and precaution. They reject consequentialist or utilitarian standard risk frameworks as falling short of the challenges entailed in given scientific uncertainties and call for new and enhanced measures for the evaluation of and protection from EHS risks and physical harm, referring to principles such as sustainability and precaution. A good example is the risk and regulation discourse centred on European chemicals regulation, as outlined in the report Ethics Debates on Nanotechnologies in the EU (Fautz 2013). Moreover, there is ongoing discussion among those engaged in science and technology studies, as well as between NGOs and governments, on risk assessment procedures as such: whether they can still be based on classical and mainly consequentialist frameworks or should rely on specific interpretations of the precautionary principle.

The values invoked in this discourse are mainly solidarity, human dignity and equality: solidarity in terms of protecting human and environmental health, for instance by insisting on high regulatory standards for the use and release of nanomaterials; human dignity and equality in terms of individual physical integrity, in that no-one should be exposed to risks against his/her own will or for the profit of others, even if utilitarian positions would justify exposing some people to higher risks for the sake of majority welfare.

10.2.2.2 China

Nanotoxicology research has become an important field for Chinese researchers to raise their profile as international high-level scientists. Moreover, the nano-scientists can be seen as the dominant actors in the Chinese risk discourse on nanotechnologies. It is particularly thanks to the advocacy and promotion of the scientists that the government included the topic of nanosafety in its policy documents and earmarked funds for the research of EHS aspects.

The Chinese State Guidelines on Nanotechnology Development released in 2001 did not mention risk research and management. Nevertheless, China's science community paid attention to the safety of nanotechnologies quite early. In November 2001, a group of chief scientists on nanotechnologies proposed conducting research on the bio-effects, toxicity and safety of nanotechnologies (Zhao and Chai 2005). In 2003, the Chinese Academy of Sciences set up an open lab on nano bio-effects and nano safety, which later became the Key Laboratory for Biomedical Effects of Nanomaterials and Nanosafety. Since its establishment, the lab has made important contributions to nanotoxicology. In addition, the Chinese research community has held several symposiums since 2004 on the safety of nanotechnologies.

In 2005, the Chinese government started formulating standards to regulate nano-related research, production and application and to control possible risks and harm (Shen and Wang 2011). The nanotechnology health, safety and environment standardization group was established in March 2010 to take responsibility for standardization in relation to the EHS impacts of nanomaterials and products during their manufacture, packing, transportation and use. In 2011, a standards research project, Health and Safety of Nanotechnology in Workplace, was set up. In the 12th Five-Year Special Plan for Major National Scientific Research Program on Nano Research, from 2012, efforts were announced to 'pay attention to standardized manufacture of nanotechnology products and formulate several product standards and safe production rules for important nanotechnology products'. In addition, 'nanotechnology safety' was listed as one of the nine major research tasks (MOST 2012b). But still there are no regulatory policy measures apart from international attempts at standardization.

Discussions of health and environment issues in the risk discourse are related to the values of safety and harmony. But all participants in that discourse link safety and harmony directly to progress and innovation by emphasizing the importance of reducing the occurrence of hazardous or anomalous situations that could threaten progress and affluence. The relatively uncontroversial framing of the risk discourse among those involved might also be based on the fact that currently applied conventional risk assessment frameworks of cost-benefit analysis, which acknowledge only proven risks, remain largely uncontested.

10.2.2.3 India

In India, risk assessment of nanotechnologies does not rank as high on the policy agenda as in China or Europe. Some actors have tried to push this issue, but so far there has not been much significant research or policy action. There are a few Indian authors who follow international risk research and debates (e.g. Seetharam and Sridhar 2007; Srinivasan 2008), trying to get these issues higher up the Indian policy agenda or, at least, to promote them in the Indian research community and raise awareness (e.g. Pradeep and Burgi 2006). Dhawan and Sharma (2011) criticized the fact that among more than 200 funded projects of the Indian Nano Mission programme from 2001 to 2010, only one could be directly related to nanotoxicity studies. The International Conference on Nanomaterial Toxicology (ICONTOX), jointly organized by the Indian Institute of Toxicology Research and the Indian Nanoscience Society in 2008, was a rare exception.

In 2010 the government appointed a 'Task Force for developing Regulatory Framework on Nanotechnology' and announced that a nanotechnology regulatory board would be set up, but so far not much has happened. The Department of Science and Technology and other agencies have meanwhile sponsored some research on EHS aspects of nanotechnologies, but the outcome of that research and its policy impact remain unclear. Risk governance of nanomaterials is an important subject of research and negotiation in various international arenas, including the Organisation for Economic Co-operation and Development and the United Nations Educational, Scientific and Cultural Organization. But so far, there has not been much significant research or policy action in India.

In terms of invoked values, the few critical voices that are trying to develop a risk discourse argue in favour of protecting the health of all potentially affected individuals as well as the environment. This concept corresponds with the Indian value of fraternity, which refers to the dignity of the person.

10.2.3 Power and Control

The power and control discourse deals with issues of political and economic power and justice. It is about whose interests are served by nanotechnology development policies and regulations, about who has to take the risks and who can profit from its benefits. These are very sensitive issues, since stakeholders in the nanotechnology field may have conflicting interests concerning the use and framing of nanotechnologies.

10.2.3.1 European Union

Like the risk discourse on nanomaterials, the power and control discourse in Europe emerged around the years 2003 and 2004, when current nanotechnology developments underwent their first technology assessment studies. With a strong innovation discourse making nanotechnology an exemplar of technologically driven innovation, the question of an adequate and inclusive governance framework consequently became a hot topic among actors in the field of nanotechnology discourse. The leading figures in the power and control discourse are philosophers, writers on science and technology studies, and NGOs that are keeping a critical eye on the high expectations that accompany the development of nanotechnologies. They are tackling issues of controllability and power, or of access and equity, and advocate the inclusion of broader socioeconomic impacts, such as the consequences for developing countries, in governance frameworks for nanotechnologies. In doing so they also refer to similar developments in other fields of technology, for instance biotechnologies. Furthermore, the power and control discourse overlaps broadly with the risk discourse, where the Promethean positions of governments and industry, focusing on opportunities for innovation and competitiveness, are opposed by the precautionary world views and inclinations of NGOs, the European Parliament and the general public.

In 2006 NGOs began to contribute substantially to the social debate on nanotechnologies in Europe. Most NGOs focused on threats to health and the environment posed by nanomaterials, issues of controllability and power, and questions of access and equity. After initial calls for a moratorium on the use of nanomaterials in consumer products, civil society organizations and trade unions developed quite distinct positions on nanotechnologies. On the one hand they acknowledged the beneficial potential of nanosciences and nanotechnology for society, the environment and the economy, and shared expectations raised by governments. On the other hand they were concerned because the risks of manufactured nanoparticles were not being fully assessed, and they favoured stricter precautionary legal frameworks to protect consumers, workers and the ecosystem. Important issues of the European power and control discourse were labelling, privacy and security, regulatory issues, risk-benefit distribution and the nano-divide, research funding for EHS aspects, public funding as against private funding, and market power.

In order to promote and demonstrate the responsible development of nanotechnologies, governments, regulatory bodies and industry set up—more or less successfully—voluntary reporting schemes, risk management frameworks and codes of conduct, measures that can be seen as experimental approaches to dealing with the uncertainties and challenges in the dynamic field of nanotechnologies. On 7

February 2008, the European Commission recommended the adoption of a code of conduct for responsible nanosciences and nanotechnology research, which had been developed during an open consultation phase. The code combines a number of general EU policy objectives, such as competitiveness, precaution, sustainability and public consultation, with the aim of ensuring integrated, safe and responsible nanosciences and nanotechnologies research for the benefit of the society as a whole (European Commission 2008). A survey in 2011 showed, however, that while respondents generally agreed with the code, only 15 % said that their organizations had adopted it.

In terms of principles and values, the most proactive participants in the European power and control discourse—philosophers, authors on science and technology studies, and NGOs—are expanding the risk discourse, which is mainly centred on scientific evidences and paradigms, by emphasizing the socioeconomic and sociocultural dimensions of nanotechnology. Within this broader framework the potential benefits of nanotechnologies are balanced not only against possible EHS risks and principles such as non-maleficence and sustainability, but also against possible socioeconomic risks and principles like autonomy or justice. Here the concept of autonomy—which is a core element of all modern Western theories of democracy—refers to the European values of freedom, solidarity, equality and human dignity, and to principles such as citizens' rights, justice, sustainability and precaution, which guarantee citizens a life free of coercion and make them co-authors of their common life contexts within their political communities. Dignity is addressed in terms of the individual integrity and individual rights of a person; freedom in terms of the person's right to liberty, security and information, as well as respect for and protection of privacy and personal data; and solidarity and equality in terms of social security, access to basic goods and services, and societal inclusion.

10.2.3.2 China

In China, generally speaking, the power and control discourse is overshadowed by the government's innovation discourse and the widely shared aim of rapid progress for China among actors in the science and technology field.

Concerning questions related to this discourse, Chinese participants in the nanotechnology field remain quite reserved or cautious. Some calls for a moratorium on nanotechnologies in China have been brought into the discussion via international NGOs. When reporting on these debates, the media have basically maintained a neutral stance, but a few reports have called attention to the right of the public to know and urged government administrations to take note of public attitudes and consider mechanisms for government supervision and policy adjustment.

The government's attitude to power and control issues is primarily focused on bolstering the country's independence of external influences, particularly by ensuring that it attains a leading position in international military and economic competition. This perspective, which relates the value of progress to the principles of autonomy and self-sufficiency, and thus underlines the primary status of innovation and progress, is widely shared by participants in the Chinese power and control discourse. The government has also started some action for consumer information and workplace safety, but without any significant outcome yet.

For researchers, the power and control discourse is mainly framed by reflections on scientists' responsibility to society. With the outbreak of a series of food safety scandals in recent years, however, there has been growing public concern about the negative implications of science and the social responsibility of scientists. Therefore some elite scientists have expressed views on the potential negative impact of nanotechnologies and recommended an increased public awareness of nanotechnologies.

Many issues that can be related to power and control discourse arose with the emergence of systematic and intensified ethical reflection in Chinese science communities from 2009. Besides advocating the participation of sociologists and humanists in nano research, elite scientists have called for self-regulation by the academic community and initiated the formulation of a code of conduct for nano research, which will be completed soon. These actions reflect the scientists' realization of their own social responsibility and their willingness to establish a more harmonious relationship between science and society—not least in order to foster and secure society's support for nanotechnological innovations. Some philosophers and social scientists have picked up the issues of social equity (the nano-divide) and of the consumer's right to make an informed choice. So far, however, there have been no systematic or in-depth discussions on the attribution of responsibilities among the state, enterprises and scientists in the management of nanotechnology or on the mechanism of accountability.

Overall, the power and control discourse in academia is centred on the value of harmony. Here harmony serves as an overarching or integral concept covering a wide range of other values and principles, including equity, justice, citizen's rights and freedom, non-maleficence and sustainability. By arranging these values and principles in a harmonious way, progress and affluence will be secured.

10.2.3.3 India

In India too, the nanotechnology power and control discourse is overshadowed by the government's innovation discourse, which harbours an optimistic vision of the application of nanotechnologies in addressing many societal challenges and furthering economic development. Therefore, as in China, many of those involved in the nanotechnology field hold the view that India should 'innovate now, regulate later'. Some experts do criticize the government, though, for particularly promoting research projects that lead to commercially viable and profitable products, while not giving enough support to those that focus on addressing societal needs and integrating different stakeholders' views. A few experts also call for more governmental activity to inform the public about the risks and benefits of nanotechnologies, as well as the introduction of a labelling system giving consumers the opportunity to make an informed choice. A significant difference between the Indian and the Chinese discourses on power and control is that criticism in India is directed at the government, which is held responsible for the governance of nanotechnologies—or its failure.

Power and control discussions in India seem to be driven by the principles of justice and autonomy. Justice is addressed by calls to ensure access, equity and inclusion concerning the benefits of nanotechnologies: nano-based products and services should be available and affordable for all. The principle of autonomy is invoked in calls for increased stakeholder involvement in nanotechnology policy framing, as well as in claims for product labelling to ensure consumer choice.

10.3 Crosscutting Spheres of Lay Morality and Reflective Ethics

Culturally embedded values play an important role in the construction of sociotechnical systems: they are the context in which the sociotechnical system of nanotechnology is situated in each region. Therefore an assessment of lay morality and of professional ethical considerations plays an important role in translating nanotechnology into a robust sociotechnical system. Ethical reflections can help to clarify the value-laden discussions and confusion around the acceptability of nanotechnologies, particularly by exposing and elucidating the (partly hidden) conflict lines, in order to allow substantive discussions. Even if ethical reflections cannot always provide solutions to value conflicts, they can at least structure argumentation lines and thus enable conflicting parties to enter a process of mutual learning and understanding as an important precursor to the discursive solution of conflicts arising within new sociotechnical systems.

Concerning the social robustness of nanotechnologies, it can be stated that nanotechnology has not (yet) become a big public issue provoking discussions and opinion-forming processes among citizens in the three regions. Studies on the media reporting of nanotechnologies suggest that there is no wide-ranging societal debate in any of the regions. Most newspaper articles on nanotechnology are formulated in a neutral and descriptive style.

10.3.1 European Union

Various more or less experimental public engagement projects and opinion assessment procedures have been carried out to assess public attitudes towards nanotechnologies in Europe and thus anticipate and assess the social robustness of nanotechnologies. A great deal of research into the translation of lay views into technology policy-making processes remains to be done, but the main issues of lay perception of nanotechnologies can be summarized as follows: Lay people acknowledge the potential benefits of nanotechnologies for human health and the environment, but, at the same time, express concerns about different aspects of nanotechnologies, like privacy, justice, market power, regulatory gaps, transparency and risk management.

Besides these experimental forms of technology assessment, the ethical assessment of nanotechnologies has been undertaken by several expert bodies and technology assessment institutions in Europe, along with scholars of science and technology studies from ethics, philosophy and the social sciences, as well as NGOs. The inclusion of ethical expertise in technology policy-making has become standard in European technology assessment methodologies. In the past 10 years the ethical debate on nanotechnologies has evolved, since it was characterized by the dispute between a dominant consequentialist approach and opposing deontological frameworks, into an opening up of the consequentialist framework of classical EHS risk assessment. The ethics discourse as such has also covered the other discourses and related value conflicts. Besides considerations of the precautionary principle as an instrument to deal with scientific and normative uncertainties, the broader issues of socioeconomic and cultural implications have been addressed. Several authors have emphasized the coevolution of science, technology and society. There has also been (meta-) reflection on the proper framework for ethical reflection on nanotechnologies. That development has been dominated by ethicists, philosophers and social scientists.

Throughout their strong engagement in the risk and the power and control debate, the NGOs have also made important contributions. The European Commission too has taken part in the reflective ethics discourse, for instance by funding ethical research projects and requesting an opinion on nanomedicine from the European Group on Ethics. At least with its code of conduct the commission took up ethical principles and values, but in quite a vague and non-binding manner.

10.3.2 China

Such institutionalized ethics debates and structures can be found in neither China nor India. But with the first academic meetings on the ethics of nanotechnologies in China, from 2009 onwards, structures of a genuine ethics discourse emerged within scientific circles, similar to and overlapping with the power and control discourse.

In China, moral and ethical reflections on nanotechnology can mainly be found in the academic circles of scholars on ethics and philosophy. From 2002, when discussion of the ethical issues of nanotechnology began, to 2008, a dozen papers were published on the ethical and social aspects of nanotechnology, mainly inspired by foreign research in the field. In 2009, when the first academic meeting focusing on the ethics of nanotechnology in China took place, the ethics discussion entered a new stage. The discussion of nanoethics mainly treats three aspects: ethical accountability, ethical consequences and ethical practices. Those ethics discussions are thematically crosscutting, in linking various aspects of nanotechnology to ethical considerations. But it is questionable whether the matter is crosscutting among actors in the nanotechnology field, especially concerning policy-makers and industry. This observation goes hand in hand with the low visibility of lay morality expressions, although there is an increasing perceived need—particularly among scientists, but also among policymakers—for lay opinion assessment in science policy. The media report on nanotechnologies from time to time, but in a distant and neutral manner.

10.3.3 India

For India, apparently, the moral and ethical assessment of nanotechnologies is not an important topic, although a qualitative study involving 120 practitioners from 21 laboratories across India (Patra et al. 2010) indicated that most of the Indian practitioners working in the field of nanoscience and nanotechnology research recognized ethical issues in this research area. These findings are supported by a recent survey among 35 nanoscientists in public funded research and development centres across India (Sahoo 2013). As in the risk discourse, there are certain Indian authors who are trying to get internationally discussed ethics issues higher up on Indian science and policy agendas (e.g. Radhakrishnan 2007).

10.4 Conclusion: Governance, Discourses and Values

This chapter's comparative analysis of nanodiscourses, nanopolicies and their underlying value concepts across three regions has revealed differences in the governance settings of technological innovation. These differences are, of course, strongly related to socioeconomic conditions, but are also influenced by dominant value concepts, which serve as focal points for ethical reflections on nanotechnology issues and are inherently part of the political core beliefs of policy-makers. When comparing the discourses of innovation, risk, and power and control, and their references to distinct cultural value concepts and principles, we can observe differences between the discourse structures in each region—that is, in the alignment of the discourses to each other.

In Europe, the proponents of the risk discourse as well as of the power and control discourse scrutinize or attack the innovation discourse and try to offer an alternative innovation path with a more critical and precautionary focus on risk issues and questions of power and control, thereby invoking the same European values, but with a different conception. Public authorities use a kind of incremental governance approach that recognizes critical issues and takes them up on the agenda if public pressure is anticipated—a lesson from the controversy around genetically modified organisms. An important point that distinguishes Europe from China and India is the early and strong involvement of science and industry stakeholders, together with stakeholders from civil society organizations and ethics experts, in nanotechnology policy formulation. Bringing all stakeholders and experts together allows creative solutions for innovative products to be found and market opportunities better anticipated. This is where the Chinese government in particular has a problem: China has large research capacities, but few spillovers from science into industry.

In China, the innovation discourse is the integral part of the nano discourse, in that it sets the framework for the subdiscourse of risk and that of power and control. On the value side, this goes hand in hand with a rather broad assumption of peace and harmony relating to issues of risk and power and control that promises progress and affluence for the Chinese nation. Therefore the Chinese governance style in nanotechnology development can be characterized as vertical and technocratic or scientistic. This also applies to ethics and moral issues, which are aligned to the innovation rationale and discussed in closed scientific circles. It is still an open question whether scientists, thanks to their high reputation and authority, are able to place critical issues touching on moral and ethical questions on the policy agenda.

In India, the innovation discourse is almost the only discourse on nanotechnologies. Nonetheless, some arguments are put forward against this strong innovation rationale, to the effect that it could undermine the values of access, equity and inclusion. Almost all government funding for nanotechnologies is spent on promising basic research and, most important, application-oriented research. Risk assessment is a minor activity that is at an early stage of development, since other societal challenges outweigh the perceived need for research on possible risks related to nanotechnologies. The Indian governance approach towards nanotechnologies can therefore be characterized as quite reductionist. This situation of rather weak risk governance is most likely due to the government's view that it is too early to decide on regulating a new and promising technology.

These different governance settings in each region are also distinct in the cross-cutting spheres of ethics and lay morality: in China, there is an evolving genuine ethics discourse on nanotechnologies, with scientists reflecting on the relationship between science and society—something that has not yet happened in India. But these reflections by Chinese researchers have not yet reached policy circles or the stage of institutionalization. In Europe, there are several institutionalized forms of ethical expertise, as well as civil society organizations and others, situated in the spheres between lay morality and professional ethics. They form a kind of background to discussions and discourses on nanotechnology development, and the development of further technologies. Some researchers are even trying to explore and deepen our understanding of lay morality and its cultural embeddedness in European member states or regions, whereas in China and India, the integration of forms of lay morality into nanotechnology development policy seems hardly present yet.

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Chapter 11
Discourses on Synthetic Biology in Europe, India and China

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11.1 Introduction

Synthetic biology constitutes a new field of research, in which scientists are gaining more and more control over the fundamental building blocks of life. This allows them to 'design' and 'create' microorganisms that may perform a variety of useful tasks, but at the same time become increasingly isolated from organisms we may find in nature. Given the potential of synthetic biology to contribute to addressing important challenges in, for example, health, the scarcity of resources and energy security, it is no surprise that this field has been embraced as a promising scientific endeavour by scientists all over the globe. On the other hand, like agro-biotechnology and nanotechnologies—or any other field of science and technology, for that matter—synthetic biology also gives rise to concerns about potential risks. In addition, it raises moral questions and concerns, since it allows scientists to put 'life' and 'nature' on the drawing board as never before.

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Synthetic biology may thus—once more, like any other science or technology—also lead to tensions (and even conflict) and therefore debate. The nature and dynamics of these tensions and debates are, however, not solely informed by the character of a particular science or technology; they are also informed by the specific socioeconomic conditions, cultures and values in a given locality, which will therefore be taken into account in our comparative analysis of the three regions. Furthermore, we see synthetic biology as a global endeavour, contributing to an increased global interconnectedness. This is expressed, for instance, by increasing international scientific cooperation, but also by potential risks that are not constrained by state borders.

The contribution of synthetic biology to this increased global interconnectedness was recently underscored by the Global Network of Science Academies (IAP) (IAP 2014a).[1] The IAP issued a statement appealing for global commitment regarding synthetic biology, recommending continuing worldwide collaboration between researchers and those regulating and enabling synthetic biology, and also calling for controversial issues to be settled. However, as we previously mentioned, moral concerns may lead to tension within a specific region, but also between different regions.

Against the backdrop of these region-specific traits and global interconnectedness, this chapter will analyse and compare the emerging debate on synthetic biology in the EU, China and India. The analysis will be based primarily on three reports of the Global Ethics in Science and Technology (GEST) project, each focusing on discourses on synthetic biology in the region concerned (Stemerding and Rerimassie 2013; Zhang 2014; Srinivas 2014). We consider the debate in the EU rather mature in comparison with those in the other regions, and moreover believe that it reflects many traits of the international debate on synthetic biology. We will therefore use the European debate as a starting point, and then highlight region-specific traits in China and India.

In conducting this analysis we will use the analytical framework described in Chap. 8, thus analysing discourses on innovation, risk, and power and control. In addition, we will focus on two crosscutting discourses: first, public debates expressing lay morality—what expectations and issues have been raised concerning synthetic biology by voices from civil society and the broader public?—and second, how reflective ethics voices have engaged with synthetic biology in the three regions. We will examine the nature of each discourse: that is, what kinds of issues are discussed and to what values do they relate? What kinds of actors take part in the discussion? Then we will consider whether certain discourses are dominant. This will allow a comparative analysis of the three regions, which will consider similarities and differences.

[1] The Global Network of Science Academies consists of 106 scientific academies from all over the world, including the EU, China and India (IAP 2014b).

Throughout this endeavour we will pay specific attention to the role of region-specific values, as described in Chaps. 5, 6 and 7, in the debate. We will begin, however, by briefly describing the understanding, framing and state of the art of synthetic biology in the three regions, since its understanding and the degree of development are highly likely to be core parameters for the nature, and even emergence, of the different discourses in the three regions.

11.2 Understanding Synthetic Biology

The theoretical basis of the contemporary understanding of synthetic biology is attributed largely to Waclaw Szybalski, who proclaimed in 1974:

> Up to now we are working on the descriptive phase of molecular biology. … But the real challenge will start when we enter the synthetic biology phase of research in our field. We will then devise new control elements and add these new modules to the existing genomes or build up wholly new genomes. This would be a field with unlimited expansion potential and hardly any limitations to building 'new better control circuits' and … finally other 'synthetic' organisms … (EGE 2009).[2]

Thus, according to Szybalski, biology will eventually evolve into a different kind of science, in which we shift from describing to designing, or redesigning, life. Szybalski's words have turned out to be prophetic, but it was not until the turn of the century that scientists started research under the explicit heading of synthetic biology. Interestingly, many of these researchers were not primarily involved in molecular biology. Today 'synthetic biologists' employ a variety of novel approaches, all of which allow increasing control over the fundamental building blocks of life. This unique quality can therefore also be found in the definitions used in the three regions to describe synthetic biology.[3] A definition by a high-level expert group for the European Commission (NEST 2005), for instance, reads as follows:

> Synthetic biology is the engineering of biology: the synthesis of complex, biologically based (or inspired) systems, which display functions that do not exist in nature. This engineering perspective may be applied at all levels of the hierarchy of biological structures—from individual molecules to whole cells, tissues and organisms. In essence, synthetic biology will enable the design of 'biological systems' in a rational and systematic way.

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[2] Luis Campos demonstrates that the label 'synthetic biology' can actually already be traced back to the beginning of the 20th century. The earliest explicit reference to 'synthetic biology' comes from the book *La biologie synthetique* by Stéphane Leduc (1853–1939) (Campos 2009).

[3] For a more detailed account of dominant approaches in synthetic biology see Stemerding and Rerimassie (2013).

The Indian Task Force on Synthetic and Systems Biology Resource Network produced the following, quite similar, definition:

> Synthetic biology refers to both:
>
> - the design and fabrication of biological components and systems that do not already exist in the natural world; and
> - the re-design and fabrication of existing biological systems (SSBRN 2012).

In the official China Biotechnological Development Report, synthetic biology is described as:

> … a new trend of biotechnological development … to form new biological systems and achieve expected industrial application (Department of Science and Technology for Social Development under the Ministry of Science and Technology of China, China National Center for Biotechnology Development 2009).

Synthetic biology is thus commonly understood as the application to biology of a true engineering approach, in order to design, or redesign, organisms that are useful for society.

11.2.1 Framing of Synthetic Biology as an Emerging and Converging Technology

The emergence and introduction of new science and technology in society are, more often than not, accompanied by tensions and conflicts. However, as a new and emerging field of engineering, synthetic biology is still largely at a laboratory stage. Therefore discussions about synthetic biology as a potential source of tensions and conflicts will be strongly influenced by experiences with other science and technology developments in the recent past:

> To debate a still quite abstract technology, participants functionally need a frame that determines which arguments are legitimate and which issues are relevant (Torgersen and Schmidt 2013).

According to Torgersen and Schmidt, three fields of science and technology currently provide important frames for discussing synthetic biology: (green) biotechnology, nanotechnology and information technology.[4] This makes even more sense, because synthetic biology is often considered to be enabled by so-called 'NBIC convergence': the synergetic convergence of nanotechnologies, biotechnologies, information and communications technologies and, though less relevant in this context, cognitive sciences (Van Est and Stemerding 2012).

[4] 'In the biotechnology debate, risk has long been emphasised over economic benefits. More recently, nanotechnology has been referred to mostly in terms of benefits, while risks tended to be an issue for scientific discourses. This has frequently been related to the many outreach activities around nanotechnology. Information technology, finally, has retained the image of being "cool" and useful on a personal level' (Torgersen and Schmidt 2013).

When looking at the three regions, we must conclude that synthetic biology is predominantly framed, and debated, as a new phase in the development of *biotechnology*, as illustrated in statements by important spokespersons in the field. According to the New and Emerging Science and Technology High-Level Expert Group for the European Commission (NEST 2005), synthetic biology could revolutionize the biotechnology industries and perhaps even biology as a science. In important symposiums, such as those organized by the China Association for Science and Technology, synthetic biology is described by Chinese biologists as one of the great frontiers of modern biotechnology. The Indian task force sees synthetic biology as a science of the future, which may change the profile of the biotechnology industry. Synthetic biology is thus commonly understood in the three regions as the next wave in biotechnology, which will also strongly frame societal debates about its potential implications. Conceived as a new form of 'extreme genetic engineering', synthetic biology may well add fuel to the ongoing debates and controversies surrounding genetically modified organisms (ETC Group 2007).

11.3 The Development of Synthetic Biology in the Three Regions: The State of the Art

Ever since the turn of the century, synthetic biology has been gaining international momentum and the number of published papers has been steadily increasing (Zhang 2014). As illustrated in an interactive map (reproduced in Fig. 11.1) produced by the Synthetic Biology Project, which is led by the US-based Woodrow Wilson International Center for Scholars, synthetic biology research activity has emerged all over the globe. In addition, there is increasing international

Fig. 11.1 Map tracking the number of synthetic biology research groups across the globe (Reproduced from http://www.synbioproject.org/library/inventories/map/)

collaboration among synthetic biologists, contributing to an ever growing global interconnectedness.

There are significant differences across the three regions in the development of synthetic biology, which ranges from rather advanced to just starting. In Europe such development is not quite as advanced as in the United States, but is still very much at the forefront. Once synthetic biology emerged in the United States, it was almost immediately embraced by the European scientific community, and the EU (as well as several individual EU member states) rapidly started investing in synthetic biology as well (Stemerding and Rerimassie 2013). By 2014, synthetic biology was gradually being applied in industrial settings (Schmidt 2012).

Synthetic biology has also attracted the attention of Chinese researchers, although this did not begin happening as early as in Europe. The Chinese government started funding synthetic biology research in about 2008, and ever since has given the field more and more support. The development of synthetic biology in China is therefore not as advanced as in Europe, but now the country is fully equipped to catch up with countries at the forefront (Zhang 2014).

In sharp contrast, synthetic biology has so far gained little attention in India, and is as yet largely confined to certain institutes and groups—very few in comparison with the number of Indian groups working in life sciences and biotechnology. Also the interest from the Indian government and industry is limited so far (Srinivas 2014). Accordingly, this chapter's discussion of the discourses on synthetic biology in India will be primarily based on the findings of the aforementioned task force, made up of government representatives and academics, which was established by the government to examine the opportunities for synthetic biology and systems biology for India.

11.4 Comparing Discourses on Synthetic Biology in the Three Regions

Preceding chapters have described dominant approaches in synthetic biology and observed that in all three regions the field is understood as a new phase in the development of biotechnology. It has also been noted, however, that the state of the art of the development of synthetic biology differs widely among the three regions: development in the EU can be seen as 'advanced', in China as 'rapidly catching up' and in India as 'just starting'. Against this backdrop, we will now analyse and compare how synthetic biology has been debated so far in the three regions, based on discourses relating respectively to innovation, to risk, and to power and control, and also those concerning lay morality and reflective ethics. We will highlight the issues being discussed, the values to which they relate and the actors that play a part in the discourse. A more detailed account of the discourses in each region can be found in the three GEST reports on this topic (Stemerding and Rerimassie 2013; Zhang 2014; Srinivas 2014).

11.4.1 Discourses on Innovation

Why is synthetic biology important? What are the opportunities? What can the field deliver? What is needed for synthetic biology to mature into an industrially relevant and socially robust discipline? These are the central questions of an innovation discourse.

In all three regions voices are heard on the opportunities synthetic biology might bring for society. It is perceived as a potentially powerful field of research whose applications might help address challenges that all three regions face. Such challenges may relate to (public) health, sustainability, energy sources and ecology. Synthetic biology is also seen as a vital source of future economic development in the context of global competition between the three regions. Thus support for synthetic biology should enable China to 'catch up' with the US and Europe and is called for in India so that the country does not 'miss the bus' (Zhang 2014; Srinivas 2014).

In Europe, the New and Emerging Science and Technology (NEST) Pathfinder funding scheme, set up in 2004, was an important starting point for the development of synthetic biology (Pei et al. 2011). It was followed by several other initiatives, including those under the Seventh Framework Programme and the road map of the project called Towards a European Strategy for Synthetic Biology (TESSY), which is dedicated to strategy development for synthetic biology in Europe (TESSY 2008; Gaisser et al. 2009). More recently, from 2012 to 2014, came the establishment of ERASynBio, a European initiative aimed at the development and coordination of synthetic biology in the European research area. One of the important aims of this initiative was to comprehensively map national and transnational funding programmes, funded synthetic biology projects, relevant strategies and reports, and active companies, in order to develop a strategic vision. According to these mapping activities, about €450 million of public research funding was allocated to synthetic biology from 2004 to 2014 (ERASynBio 2014) (Fig. 11.2).

Important issues that need to be addressed, according to the ERASynBio network, include building a transnational multidisciplinary research community, data sharing, standardization and accelerating the applied and industrial use of synthetic biology. Another particularly important issue is what a proper intellectual property regime for synthetic biology would look like. Should it allow broad patenting or would an open-source regime be more desirable? As for values, we find that the European discourse is predominately informed by values of freedoms, including market freedoms, and sustainability (e.g. EASAC 2010). Furthermore, in the EU a need is felt to go beyond technoscientific support actions in order to make synthetic biology successful, for instance by addressing ethical and regulatory concerns early on (e.g. TESSY 2008; OECD, Royal Society 2010). This is aptly expressed in a broadly shared call for responsible research and innovation (RRI) in synthetic biology (e.g. ERASynBio 2014). Interestingly, in considering the innovation potential of synthetic biology, the Indian task force also explicitly mentioned issues of risk and ethics as equally important to address.

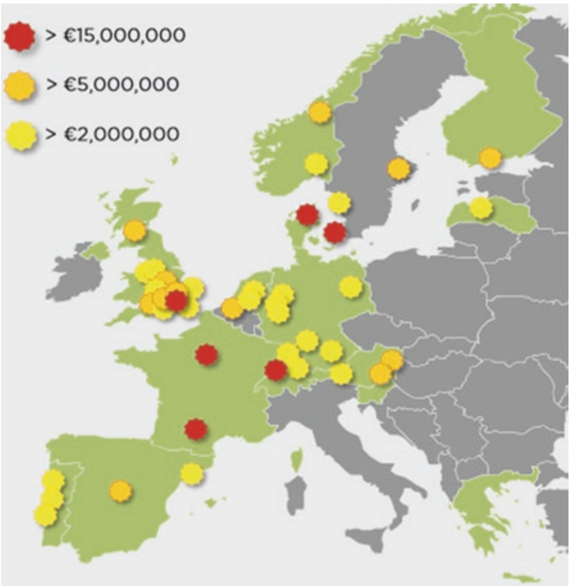

Fig. 11.2 Sites of major European public investment in synthetic biology (ERASynBio 2014)

As in Europe, there is in China a strongly developed innovation discourse, from which several support actions are apparent, such as capacity and community building (Zhang 2014). In many scientific symposia, such as the Xiangshan Science Conference sessions, it is evident that Chinese biologists consider synthetic biology to be one of the great frontiers of modern biotechnology. These biologists have therefore called for government support on many occasions, and not without success. For example, synthetic biology is marked as one of the 12 core key technologies for prioritized development in the 12th Five-year Plan for Biotechnological Development (MOST 2011) released by the Ministry of Science and Technology. Furthermore, synthetic biology has been financed by a series of programmes, such as the 863 programme,[5] the 973 programme[6] and the National Natural Science Foundation.

Regarding values, the innovation discourse is informed by the full spectrum of Chinese values. Stimulating synthetic biology is expected to contribute to promoting economic development (progress), protecting public health (harmony), safeguarding national security and coping with an ageing and growing population (peace), and last, addressing resource and environmental needs (sustainability) (CNCBD 2010). This illustrates that while ethics is not institutionalized in China

[5] The 863 programme, or the National High-tech R&D Programme, was approved in 1986 to promote high-technology research and development in China. Biotechnology is listed as one of its eight priority fields.

[6] The 973 programme, or the National Basic Research Programme of China, was approved in 1997 to support basic science and technology research. It promotes research and innovation in fields of far-reaching and strategic importance, such the life sciences.

in the same way as it is in the EU or the US, it certainly has a place in directing the course of synthetic biology in China.

India, unlike Europe and China, does not have a strongly developed innovation discourse yet. In the recommendations of the Indian task force, however, there is a strong link between the identified potential aims for synthetic biology in India and the needs of the country, ranging from energy security to improvements in agriculture and health, topics that strongly relate to values of access and equity.

Last, in all three regions the International Genetically Engineered Machine competition (iGEM), a synthetic biology design contest for students, is considered an important educational, capacity-building and community-building tool (see e.g. ERASynBio 2014; SSBRN Task Force 2012; Zhang 2014).

11.4.2 Discourses on Risk

Like any other technology, synthetic biology not only promises potential benefits, but also raises concerns about possible risks. What types of risks are perceived? By whom? What weight do they assign to the risks in relation to the benefits? How should society deal with these potential risks?

The potential risks of synthetic biology make up an important part of the evolving story of synthetic biology. This is the case for the EU, but also for China and India. Two types of categories of risks are distinguished: first, biosafety, relating to potential unintended consequences for humankind and the environment, and second, biosecurity, relating to potential misuse (e.g. EGE 2009; CNCBD 2010; SSBRN Task Force 2012). The fact that all three regions devote attention to these issues is no real surprise, however, since EU member states, India and China are all party to several international conventions, such as the Cartagena Protocol on Biosafety and the Biological Weapons Convention, which call for these issues to be addressed as well.

Civil society organizations in Europe, unlike the other regions, are strongly involved in the evolving risk discourse. A central value in the European discourse is protection as a citizen's right. In terms of this right, civil society organizations demand a strict precautionary approach and also bring in a more inclusive perspective of justice, solidarity and equality. Whereas synthetic biology is supported in the innovation discourse for its potential contribution to a greener economy, civil society organizations challenge it for its detrimental effects on sustainability; that is, for promoting the exploitation of natural resources and the communities that are dependent on them (FOE et al. 2012). Indeed, similar concerns have been voiced in India (Srinivas 2014).

In China risks are also seen as a point of concern, but hampering innovation and missing out on the opportunities of synthetic biology are actually perceived as much bigger risks by both the government and the scientific community. This became clear, for instance, at an academic symposium dedicated to synthetic biology and ethical and biosecurity concerns, organized by the China Association for Science and Technology in 2010. In fact, some experts, such as the Chinese scientist Yang Huanming, expressed their concern about the influence of critical public opinion in the developed countries on public perceptions in China and called for positive publicity for synthetic biology (Yang 2011). Another Chinese scientist, Du Lin, advocated efforts to create a consensus that the discussion of ethical and biosafety issues relating to synthetic biology should not hinder synthetic biology research in China. In his view, such a discussion should serve the purpose of responding to future international opposition, rather than hindering China's development in this field of research (Du 2011). Progress therefore seems to be dominant value in the Chinese risk discourse.

11.4.3 Discourses on Power and Control

On one hand, synthetic biology may provide opportunities to address the grand challenges societies are facing, including those relating to health, energy and sustainability. On the other hand, synthetic biology may give rise to risks and ethical concerns. In a response to this tension, a recent statement by the Global Network of Science Academies called for a global commitment regarding synthetic biology (IAP 2014a). According to IAP chairman Volker ter Meulen, it is time to settle the 'synthetic controversy' (ter Meulen 2014). He notes that if synthetic biology is to thrive, the world needs to decide now how the field should be regulated and supported. In a comment in *The Guardian*, science and technology studies scholar Jack Stilgoe (2014) responded:

> My question is why we, the public, are shut out of the conversation about benefits. 'Realising the potential' of SynBio is talked about as though that potential is pre-ordained. It isn't. SynBio will become what scientists, innovators, users, regulators and others make of it. It could be used to create brilliant, emancipatory, subversive, public-value innovation, or it could bolster existing power structures. The direction will depend on who is involved, what they value, what research gets done, how intellectual property (IP) is arranged and more.

So who gets to decide the direction in which synthetic biology should develop and under what conditions? In other words: who gets to exercise the power and control over synthetic biology?

Our case studies found a strongly developed discourse on this topic only in the EU. The main actors are government and the scientific community, but civil society is also making its mark (ETC Group 2007; Roco 2008; Tait 2009; IRGC 2010; EASAC 2010; Zhang et al. 2011; FOE et al. 2012; ERASynBio 2014). Largely inspired by earlier bad experiences with the public reception of technologies, both policymakers and the scientific community feel the need to involve stakeholders and the broader public early in the development of synthetic biology. The aim is that such involvement, besides addressing ethical, legal and social issues head on, allows synthetic biology to be better embedded in society, which resonates well with the European striving towards responsible research and innovation

(EC 2013). In order to foster responsible research and innovation in the field of synthetic biology, the European Commission for instance funded the Synenergene programme (2013–2017), which is dedicated to responsible research and innovation and public engagement in synthetic biology (Synenergene 2014). Furthermore, European policymakers and the scientific community call attention to issues that require a delicate balance, such as devising forward-looking regulation without stifling innovation and maintaining the equilibrium between scientific freedom and self-regulation vis-à-vis state-driven regulation and coercion. This latter form of hard government is particularly advocated by internationally operating NGOs such as Friends of the Earth and the Action Group on Erosion, Technology and Concentration, or ETC Group. As a result, the European governance landscape of synthetic biology is already rather complex, even while synthetic biology is still predominantly confined to the laboratory.

Turning to the Indian case, the Indian task force also recommends that ethical, legal and social implications should be addressed and public opinion mapped upfront, rather than technological development alone being stimulated as a top priority. To substantiate this stance, it refers to the negative consequences of prematurely pushing biofuels. In addition, the task force raises the tension between open-source initiatives and rigid intellectual property approaches, as these relate to the Indian values of access, equity and inclusion.

The Chinese discourse shows a different picture, namely that the development and management of synthetic biology are largely in the hands of the government and the scientific community, and are considered sufficient so far (Zhang 2014).

11.4.4 Synthetic Biology and Lay Morality

Public reception is crucial for the course of development of a technology. To put it bluntly: it can make or break a technology. The concerns of members of the public may involve potential physical harms, but to a large extent they will also relate to non-physical issues: that is, boundaries related to their values and culture that should not be overstepped.

However, given its early stage of development, synthetic biology has not yet given rise to significant public debate. In fact, even public awareness is rather low.[7] In the EU there is no real active debate so far, apart from the voices of a small number of NGOs, but surveys among the general public and organized public dialogues already demonstrate a large degree of pluralism, involving a variety of issues and values (RAE 2009; Battachary et al. 2010; Rerimassie and Stemerding 2014; EC 2010). Such issues include concerns regarding biosafety and biosecurity,

[7] Only in the EU has public awareness of synthetic biology been gauged via surveys. The 2010 Biotechnology Eurobarometer (EC 2010) revealed that a large majority of EU citizens (83 %) had never heard of synthetic biology.

freedom of research, monopolization and increasing global inequalities, relating to a broad spectrum of values, such as citizens' rights and market freedoms, justice, solidarity, equality and sustainability. These issues and values will prove difficult to reconcile. This is sure to become a serious challenge for the governance of synthetic biology, given the aspiration to include a wide array of actors and the issues they put forward.

China has not seen an active debate on synthetic biology so far. The public hold science in high esteem and trust the government's management of synthetic biology. This attitude reflects the Chinese value system, in which, in the pursuit of progress and affluence, pragmatism and developmentalism prevail over potential risks as long as the latter have not materialized as actual threats (Zhang 2014). This fits in well with the findings on Chinese public perceptions of science and technology (See Chap. 3).

Unsurprisingly, there is no public debate on synthetic biology in the Indian case either. However, a well-known opponent of genetic modification, Vandana Shiva, recently voiced criticism of synthetic biology, as did certain environmental groups in India (Domicone 2013). The concerns raised mostly relate to socioeconomic considerations and values such as equity and access.

11.4.5 Synthetic Biology and Reflective Ethics

In addition to public expressions of lay morality, morality is reflected upon by voices in the field of reflective ethics. Such voices may belong to academia or to ethics advisory bodies, including groups and organizations engaged in technology assessment and the examination of ethical, legal and social (ELSI) implications. Have such voices been heard so far in the emerging debate on synthetic biology? If so, are they making an impact on science and technology policy-making and development?

In the EU there is strong involvement by reflective ethics voices. In fact, the European technology assessment and academic communities engaged with synthetic biology early (Douglas and Stemerding 2014). The EU has contributed substantially to this effort by funding several programmes on ethical, legal and social implications, such as SYNBIOSAFE, Synth-Ethics and SYBHEL (for Synthetic Biology for Human Health: Ethical and Legal Issues). On one hand, reflective ethics voices analyse and deepen issues and concerns that have already been raised by other actors. On the other hand, reflective ethics also enriches debate by addressing issues that so far have not played a big part, but might in future. A good example is an in-depth analysis of the notion of 'playing God' conducted by the EU project SYNTH-ETHICS (Link 2011). This notion is considered potentially controversial in the context of synthetic biology since it revives concerns that have been voiced regarding earlier biotechnology as well.

Another important contribution was made by the European Group on Ethics, which gave a detailed account of EU regulations and the relevant global provisions with regard to biosafety, biosecurity, intellectual property and potential applications of synthetic biology, and also the international framework of ethics and human rights (EGE 2009). On the basis of this international human rights framework, the European Group on Ethics articulates the main values that should guide the ethics of synthetic biology, including human dignity, autonomy and responsibility, freedom, equality, solidarity, justice and sustainability—indeed, largely corresponding with the spectrum of European values described in Chap. 5. Broadly speaking it is possible to identify four different roles that reflective ethics is playing in the emerging debate on synthetic biology:

- Articulating values and issues
- Highlighting tensions (often hidden) between values
- Enriching debate
- Translating the articulated values and issues into science and technology policy-making

It is perhaps not surprising that such efforts are being made in Europe, since earlier biotechnologies aroused considerable controversy.

In China some reflective ethics voices from academia are heard, but systematic reflection on the moral aspects of synthetic biology is generally lacking. In fact, ethical reflection has so far mainly been limited to the general introduction and citing of foreign views. A few ethics scholars have raised their voice in an appeal for issues of risk and ethics to be addressed in more 'authentic' ways by surveying the important philosophical and cultural factors in Chinese public policy-making concerning synthetic biology (Zhai and Renzong 2010). Given China's social and cultural environment and its prevailing pragmatism and developmentalism, little public resistance against synthetic biology is expected (Zhang 2014).

In India, too, no clearly visible tradition of reflective ethics can be found, but the Indian task force does recommend that ethical issues be addressed in a an 'atmosphere of public acceptance and transparency', given potential sensitivities raised by synthetic biology as a science that interferes with life (Srinivas 2014).

11.5 Conclusion and Discussion: Governance Challenges

This chapter has set out to map the evolving debates on synthetic biology in the EU, China and India. It has demonstrated that the European debate on synthetic biology has already become quite mature, the debate in China is taking form, and the Indian debate is slowly emerging (Table 11.1).

Comparing the nature of the debates in the three regions reveals distinct features and positions on the pros and cons of synthetic biology. On one hand, these debates are informed by differences in the state of the art of synthetic biology in the respective regions. On the other, they are informed by region-specific socio-economic conditions, cultures and value systems. Based on our analysis we have identified a number of region-specific governance challenges that will play an

Table 11.1 Overview of synthetic biology discourses in China, the EU and India (shading of cells indicates degree of development)

	EU	China	India
Development of synthetic biology			
Innovation			
Risk			
Power and control			
Lay morality			
Reflective ethics			

important role in the evolution of the debates on synthetic biology in the three regions. These challenges are summarized in Table 11.2.

To better understand these governance challenges we should distinguish between risk governance and innovation governance. Discourses of risk in the three regions are being framed by scientific knowledge and legal regimes that are negotiated and established not only in a national or regional context, but also a global context. In other words, risk governance has a strong international dimension. In all three regions we have seen that, in discussions of synthetic biology, attention is drawn to issues of biosafety and biosecurity, articulating the need for governments to match global standards of regulation laid down in international agreements, such as the Cartagena Protocol on Biosafety and the Biological Weapon Convention. This global interconnectedness also creates international forums in which parties can search for common ground on how to deal with biosafety and biosecurity risks in synthetic biology.

In our understanding of innovation governance in the three regions, a global perspective is also obviously important, given the dynamics of international competition, exchange and cooperation. At the same time, innovation governance in the three regions relates to socioeconomic and socioethical issues that are more specifically framed by regional contexts, values and concerns. In Europe, synthetic biology is basically funded as 'blue sky' research in support of market-driven development. In China and India one finds more deliberate attempts at priority setting in the framework of governmental five-year plans. The Chinese government has identified synthetic biology as a technology to be prioritized strategically in the nation's applied biotechnological research, especially in the biomedical and health care field. The Indian task force synthetic biology report put the emphasis on meeting the developmental needs of the country, and identified biofuels as one of the key applications.

In these different regional contexts of synthetic biology innovation, the role of the public and reflective ethics also differs, raising governance challenges that are specific for each region (as indicated in Table 11.2). In Europe, as we have seen, experts have emphasized the need to address ethical and safety concerns

Table 11.2 Synthetic biology governance challenges in the three regions

 EU	 China	 India
How to balance a range of conflicting interests and values in society?	How to maintain public trust in the context of international debate?	How to overcome institutional lock-ins?
Active support for reflective ethics, including activities of public ethics advisory bodies and studies of ethical, legal and social implications	More research on ethical, legal and social issues, because the debate is still mainly confined to the general introduction and citing of foreign views	Reduction of the fragmented nature of decision-making resulting from the narrow focus of scientific disciplines, departments and agencies
Involvement of a wide range of stakeholders and the public in dialogues and policy-making, promoting a culture of responsible research and innovation in synthetic biology	Independent and systematic ethical reflection and surveys of public perceptions of synthetic biology, demonstrating the peculiarities of ethical considerations in China	More effective ways to harness synthetic biology to developmental needs, recognizing important ethical and socioeconomic issues in an atmosphere of public acceptance and transparency

from the very beginning. Studies of the ethical, legal and social implications have received active support, and there have been several public dialogue initiatives about synthetic biology. The resulting challenge for the European governance of synthetic biology is how to balance the range of interests and values of all relevant stakeholders.

In China the government is the principal agent in synthetic biology policy-making, and there has not been much demand for control from scientists or the public. The public generally hold science in high esteem, and systematic ethical reflection on synthetic biology is mostly lacking. However, there is clear concern among scientists that public opinion might be swayed by critical accounts of synthetic biology in the foreign media. How to maintain public trust in the context of international public debate thus arises as a key governance challenge in China.

In India, the task force took a broad view of the promotion and regulation of synthetic biology, emphasizing its potential benefits but also the need to address safety and ethical issues and to take the public into account. However, conventional patterns of budget allocation and established institutional divisions in India are not conducive to the development of a broad interdisciplinary field and to effectively directing synthetic biology innovation to the country's socioeconomic needs.

What are the implications of these governance challenges for our aim to strengthen 'global ethics' in science and technology policy-making in a world of increasing interconnectedness? Our case study demonstrates that issues articulated in public and ethics discourses about synthetic biology are strongly framed by debates emerging in a European and American context. Indeed, to the extent that these issues are addressed in the Chinese or Indian regional context, they often reflect or replicate European public and ethics discourses rather than more specific regional values and concerns.

A truly global dialogue will therefore require a strengthening of public and ethics voices in all three regions, in ways that respond to the specific governance challenges in each region and more specifically reflect regional values and concerns. Such a dialogue will also require a global forum to support mutual learning about the possibilities and implications of synthetic biology on the basis of international exchange and cooperation. We have identified two forums that may play an important role in this regard. First, related to the world of synthetic biology innovation, we would like to highlight iGEM, the annual International Genetically Engineered Machine competition, which attracts student teams from all over the world. In just 10 years iGEM has developed into a global hub for thousands of young scientists to 'meet and compete' (Zhang et al. 2011). This global community not only offers a fascinating learning environment, it has also promoted an interest in synthetic biology among researchers in China, and could do so in India as well. Moreover, and most importantly for a global ethics in synthetic biology, iGEM requires teams to include in their projects 'policy and practices' work, which stimulates a global exchange and dissemination of ideas about biosafety and biosecurity, questions of intellectual property, ethics and public engagement in the emerging field of synthetic biology. Second, from the perspective of international public policy making, we see an important role for the United Nations Educational, Scientific and Cultural Organization (UNESCO). Over the course of time, UNESCO has been manifesting itself more and more as an important global ethics forum. In 2005 the general conference of UNESCO pioneered in this regard by acclamation of the Universal Declaration on Bioethics and Human Rights. For the first time in history, such a large number of UN member States committed themselves and the international community to respect and apply fundamental principles of bioethics set forth within a single document (UNESCO 2006). Therefore, we consider this an excellent opportunity to build on in dealing with emerging science and technology.

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Chapter 12
Conclusions: Incorporating Ethics into Science and Technology Policy

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The rapid developments in science and technology raise many ethical questions and regulatory challenges. To address these, we need to understand the impacts of such developments and how society should develop frameworks and institutions to address them continually. In post-World War II Europe and the USA, many initiatives have been taken to address ethical issues, including the development of institutional frameworks based on ethical guidelines and values, and of appropriate international protocols and guidelines. The World Health Organization, the United Nations Educational, Scientific and Cultural Organization and other international institutions including professional bodies have played an important role in the internationalization of ethics in science and technology.

In developed countries, various bodies and independent initiatives carry out some form of social-ethical analysis. Often organizations conducting technology assessments or advising governments on such assessments perform this function. In the USA, the Presidential Commission for the Study of Bioethical Issues undertakes

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the task when required, and the erstwhile Office of Technology Assessment used to include social-ethical analysis in its findings and reports. But the social-ethical analysis of technologies received a boost when, as part of human genome research, studies on ethical, legal and social issues were funded in the USA and Europe. There are many bodies in Europe that can undertake technology assessment and/or analyse ethical, legal and social issues in new technologies. In China there are initiatives in this direction, but not many bodies to undertake such assessment, nor is there a single organization with this role. In the case of India, the Technology Information, Forecasting and Assessment Council was established with a mandate to perform technology assessment, but it has not done much work in that area.

As is clear from the preceding chapters, Global Ethics in Science and Technology is a project that seeks to contribute to these assessments and processes by developing frameworks that facilitate dialogue and by improving practices that bring together policy-makers and stakeholders.

12.1 State of the Art of Debates in the Three Regions

Naturally the three regions have different needs, perspectives and priorities in science and technology developments that in turn influence debates on ethics and the social impacts of science and technology. Nevertheless, many similarities are evident in the roots, processes and even resolutions of some debates. The starting point of the comparison undertaken in this book was to look at the roots of attitudes and perspectives in value and belief systems in the three regions.

The value systems display perhaps the most obvious differences between the three regions. The Enlightenment-derived values of justice, dignity, freedom, citizen's rights, solidarity and equality in Europe appear rather different from those of progress, affluence, peace and harmony that we see in China, or those of development, self-reliance and scientific temper that are pursued in India. This is perhaps not surprising, as the trajectories of science and technology and historical developments are different in each region. But, as we have seen in the cases of India and China, a contemporary understanding of ethics is not necessarily attached to traditional belief systems. Instead, those systems derive their logic from notions of development (mainly economic), social progress and social coherence. These appear less contradictory to contemporary European values that derive from the common understanding of a new humanism than the prescriptions of traditional belief systems deriving from religion. There are similarities among regions at the level of applying science and technology.

There are similarities in the official ethics advisory structures of the three regions. All three have also established quasi-official institutional ethics advisory structures at the level of professional associations, health care practitioners and environmental organizations. There is a clear trend in all three regions towards the institutionalization of ethics advisory mechanisms within the official decision-making structures that permeate most national science and technology bodies.

Our comparison of lay morality indicators was drawn mainly from public perception survey data, mainly in China and Europe. We found that the European public appear to have a twofold, and perhaps contradictory, view of science and technology—simultaneously positive and extremely cautious—while the Chinese public seem more inclined towards a categorically positive view. For instance, 89 % of Chinese respondents agree that ‘science and technology make our life healthier, easier and more comfortable’, compared to 66 % of Europeans. Similarly, on the other side of the spectrum, only 14 % of the Chinese questioned agree that ‘scientists are scary because they have the knowledge and capability to change the world’, compared to 53 % of Europeans. The limited data that we examined in India point in the general direction of a highly positive view of science and technology, with some reservations when it comes to developments that have created intense public debate, such as genetically modified foods.

In the case of Europe, the strong civil society culture has a direct influence on various debates about specific technologies (e.g. genetically modified foods and nanotechnologies), whereas far more limited but nevertheless intense civil society participation is evident in China and India. The Chinese government’s most recent science and technology programme explicitly promotes public participation in decision-making, although it is uncertain how this will be realized. In India, civil society groups are organized around specific themes (e.g. the genetically modified Bt brinjal), with activities focusing on the empowerment of marginalized groups to influence policy processes.

The development of participatory technology assessment has also been widely dissimilar in the three regions. This approach is well established in Europe as a means of bringing about a structured stakeholder debate on science and technology. In China, which has an energetic but unstructured civil society sector, participatory technology assessment is recognized as a positive development but not applied widely yet: the occasional exercises in this form of assessment are the result of isolated institutional initiatives. In India there is no evidence of such development at either governmental or institutional level.

Based on this comparison, the parameters were identified on which to base an analytical methodology that could produce in-depth comparisons between the three regions on the discussion and adoption of ethics. The methodology was designed to compare debates on values, rights and ideals aiming at engagement in public discourses on regulations, politics and governance. These debates are historic, influenced by cultural norms, and reflective. They focus on the risks and side effects of science and technology, but also on goals and problem-solving possibilities, and thus address in addition the chances for innovation in socio-economic contexts.

12.2 Mainstreaming Socio-ethical Analysis in the Three Regions

Mainstreaming social-ethical analysis in science and technology policy is an important objective, and there are many ways of achieving it. This is not so easy, however, when social-ethical analysis is considered irrelevant or an impediment to policy-making. The dearth of institutions that give priority to mainstreaming or integrate it as part of their mandate constrains mainstreaming. Another important issue is that of the values and normative guidelines that should help mainstreaming. Often the introduction of universal values and claims that seek to guide institutions is resisted, as they are perceived to be impositions from abroad, or the values are perceived to be out of context or likely to create conflicts with current practices. The challenge lies in addressing these concerns, but this can be done by identifying values that are acceptable and during the process of framing ethical issues.

In China and India, the innovation discourse is the dominant discourse, and science and technology policies have objectives that are closely linked to national development, economic competitiveness, self-reliance and strategic interests. Hence the science and technology policy-making process is more influenced and directed by actors and agencies that articulate visions embracing such objectives. Elsewhere in Asia, in countries where the hands of the developmental state not only point the direction but also set the objectives, this has had significant impacts on science and technology policy. Thus the experience of India and China indicates that the science and technology policy process has provided little scope for other voices and discourses, and social-ethical analysis has not been given the importance it deserves. This is changing, however, as evident in India's Science, Technology and Innovation Policy and in the initiatives taken by the Chinese government to assess public opinion and perception, as well as the increase in importance given to ethical, legal and social issues in science and technology policy.

Mainstreaming social-ethical analysis does not mean that India and China should replicate structures and processes that are found in Europe or the USA, nor that they should adopt the same policies. Mainstreaming as a process will take time to take root and expand. Hence the modalities of mainstreaming have to develop, taking into account the science and technology contexts, the relationship between science and technology and society, and the diversity in stakeholders in either country.

India and China have agencies for technology assessment and significant power to undertake social science research involving social-ethical analysis. Scientific bodies and scientists' organizations often express interest in understanding social-ethical implications and in issues of science, technology and society. With policy-makers acknowledging the importance of understanding social-ethical implications, the modalities of mainstreaming can be developed. Both countries need to expand their institutions for technology assessment and to broaden the mandate of those institutions to include social-ethical analysis. The use of public perception surveys should be expanded in China, and in India such surveys need to be undertaken systematically. Science academies, universities and publicly funded institutions can act as bridges between policy-makers, those who undertake social-ethical analysis and those who represent other voices.

Mainstreaming can thus be achieved by giving due weight to modalities, institutionalizing and mutual learning. Such an approach will help develop mainstreaming that is contextual and appropriate, and this will contribute to understanding convergences and divergences in approaches and the comparative analysis of value systems and ethical principles in the three regions.

12.3 Food Technologies in the Three Regions

Mainstreaming social-ethical analysis in food technologies is an important task, but as social impacts and implications are considered in policy-making and in technology assessment, the major task lies in incorporating ethical concerns and linking them with the technology assessment and social impact assessment of food technologies. As discussed earlier, the idea of ethics varies from region to region, depending on each region's unique value system. China has ample experience in this context, as the frequency of such surveys has gone up recently. Both India and China have robust systems for assessing gains in productivity and measuring economic benefits from technological interventions. These can be used effectively to develop the analysis of socio-economic impacts and also to investigate whether technological interventions enhance access to better technologies.

Mainstreaming social-ethical analysis in food technologies means going beyond a productivity-oriented innovation discourse in assessing technologies and incorporating wider concerns and values. For this, the capacity of the current system to address these concerns has to be improved. The institutional capacities have to be strengthened so that, through dialogue and consultation, the experts, lay public and farmers can interact and come to know and understand the positions and views of other stakeholders. India and China have a long way to go in this, and can learn from Europe, which has rich experience of stakeholder engagement and getting feedback on technology from consumers. At the same time, however, Europe can also learn from the strong focus in China and India on societal goals as part of science and technology programmes.

Similarly, India and China can jointly assess the technological options and what social-ethical aspects need to be studied as a priority to ensure that policy-making is sensitive to the different concerns of different stakeholders. Europe can learn from the experience of India about how to deal with different technological solutions and how to develop approaches to food technology that go beyond simply taking a stance for or against genetically modified foods.

12.4 Nanotechnology in the Three Regions

Our brief survey, as evident from the case studies, reveals that innovation is the dominant discourse in all three regions, while the risk discourse does not have the same importance. The power and control discourse, which is articulated through important actors who are also the promoters of nanotechnology, in conjunction with the innovation discourse, sets the baseline for policy-making. While nanotechnology is an emerging technology with universal appeal and application, the capacity of countries to invest in and apply it is not uniform. A social-ethical analysis of nanotechnology needs to be mainstreamed, and would not be the antithesis of innovation discourse. If this is understood clearly, then it will be easy to evolve policies to mainstream.

In the case of nanotechnology, modalities to mainstream range from institutionalizing structures supporting research into ethical, legal and social implications to integrating socio-ethical assessment into decision-making. But when innovation discourse dominates the policy discourse and regulatory issues are neglected, mainstreaming has to begin with the task of advocacy and arguing for socio-ethical analysis, to gain space for such thinking in policy-making. Dialogue with policy-makers and scientists, and creating an understanding that mainstreaming socio-ethical analysis will not hinder innovation or the funding of nanotechnology, can be used as the first two steps in convincing the policy-makers and other actors about the need for mainstreaming. Simultaneously it is important to contextualize mainstreaming on the basis of relevant issues and concrete objectives. For example, environmental, health and safety issues can be emphasized in relation to the need to avert disasters like the Bhopal gas tragedy, while the safety of products can be stressed as a precondition for winning consumer acceptance.

12.5 Synthetic Biology in the Three Regions

The innovation discourse in synthetic biology capitalizes on the potential of this field and emphasizes the new avenues that it opens up. In Europe this discourse integrates synthetic biology with the knowledge-based bioeconomy perspective, which envisages a greater role for biotechnology and synthetic biology in the transition to a bioeconomy. In contrast, the innovation discourses in India and China do not give emphasis to the idea of bioeconomy and perceive synthetic biology more as a continuation of the biotechnology and genetic engineering paradigm. In China the innovation discourse highlights opportunities for China to leapfrog its competitors using synthetic biology and considers this a great frontier of modern biotechnology. While the risk discourse in China underscores the case for cautious optimism, there is also a perception that considering ethical issues and risk dimension at an early stage hinders progress. In India, while the innovation discourse is dominant, concerns about societal issues and risks are also expressed. In the case of India, the task force report takes a comprehensive approach to synthetic biology, recognizing its potential. At the same time it draws attention to regulatory, ethical and social issues, pointing out that these have to be addressed, and also gives prominence to public engagement.

In Europe the discourses on synthetic biology have gone beyond innovation and given weight to risk aspects too, particularly the issue of dual use. Moreover, studies on ethical, legal and social issues in synthetic biology have contributed to policy-making in this field. Thus Europe has a better understanding of and road map for synthetic biology, and the innovation discourse is tempered by risk discourse and social-ethical concerns. This has influenced the policy-making process too. In India and China, the risk dimension is underplayed or considered a technical issue, while in Europe it is assessed differently, focusing on regulation, biosafety and stakeholder involvement in decision-making. While public engagement is virtually absent from the discourses in India and China, it is given enough importance in Europe.

But as synthetic biology is in its nascent stages in India and China, and is yet to get major support from governments, we can expect more vigorous debate and discussion in future. At the same time, because these countries have not paid any attention to ethical, legal and social issues so far, while Europe has given them some weight, discourses on social-ethical analysis may not evolve rapidly. Since industry and scientists are aware of issues in biosafety and risk, which are becoming increasingly important to research and development, it is likely that even if civil society is not active in this area, industry and scientists will press for greater biosafety and more comprehensive regulation and harmonization with global standards and practices.

Mainstreaming therefore has to be done taking into account the contexts and issues. For this it is better to start with technology assessment mechanisms. Since some scientists are concerned about biosafety and regulation, persuading them that, while these are important, there is also a need for the broader perspective that social-ethical analysis can provide will enable more support for mainstreaming. Because synthetic biology is more complex than biotechnology or genetic engineering, it would be useful to form interdisciplinary groups of scientists to address issues, and more interaction with stakeholders would help create awareness and open up spaces for dialogue and debate. National academies of sciences and professional bodies can play an important role in this.

Another important issue is that of assessing lay perceptions and values, and the public's understanding of synthetic biology. China has carried out many surveys on public perceptions of science and technology, but India has yet to begin. Mutual learning between India and China in addressing social-ethical issues is desirable. As both countries are in the initial stages of development in synthetic biology, now is the time to initiate these efforts. For example, India and China can develop models for public engagement, identify key issues in biosafety that are of interest to both countries and consider joint programmes for developing biosafety regimes and regulating synthetic biology. As both countries have to take positions at global level on dual use and on the linkages between synthetic biology and the Biological and Toxin Weapons Convention, the Cartagena Protocol on Biosafety and the Convention on Biological Diversity in addressing issues of global governance, the scope for joint work on these issues is immense. This work can also be used in social-ethical analysis. Hence India and China can explore options for greater collaboration and mutual learning in synthetic biology.

12.6 Conclusion

Mainstreaming ethics in science and technology policy-making is a major challenge that needs to be addressed flexibly. Given the diverse contexts, and the influence of various discourses in policy-making and the normative values embedded in them, it is not possible to suggest a one-size-fits-all approach or solutions based on that. The innovation discourse on science and technology for development is dominant in China and India, while in Europe the institutional mechanisms are in place to consider stakeholder views and introduce ethical values into technology assessment exercises. Mainstreaming can be achieved in many ways, and the outcomes need not converge but can result in divergences that are relevant and suitable to the given national context. Besides the suggestions made in the various case studies, the project has found that a number of specific steps would be necessary to make mainstreaming more acceptable and relevant in the three regions.

- *Establish common global deliberation platforms on the social determinants of science and technology*

Global Ethics in Science and Technology has been the start of such a deliberation platform. Establishing a permanent forum that includes all major global science and technology players will provide space for global deliberation. This will need a specific programme with wide membership and equitable financial contributions to set up a regular platform for discussion and to initiate research programmes on specific global challenges in science and technology.

- *Initiate capacity-building programmes for common structures on ethics policy advisory*

Our review has shown that proper ethics institutionalization requires official structures to analyse relevant issues and accordingly advise policy-makers on the options available for action. Technology assessment has taken up this role in most European countries, while participatory technology assessment has specialised in drawing in divergent stakeholders and engaging the public in the process of issue analysis. Such an institutional function and setting would be welcome in China and India. There is scope to initiate capacity-building programmes on (participatory) technology assessment methodologies in order to allow similar initiatives to take hold in the particular context of India and China.

- *Promote the development of common social impact indicators for science and technology*

Impact assessment is important in establishing socio-ethical analysis in any region. Impact indicators are a complex but necessary step in such assessment. The Organisation for Economic Co-operation and Development has already started by bringing together an expert group to work on improving the current set of indicators. The United Nations Educational, Scientific and Cultural Organization and other relevant United Nations organizations can contribute. In this context, developing such indicators for emerging technologies is very important, and will be relevant for studies on responsible research and innovation.

- *Develop comparative systematic public perceptions databases*

Public perception surveys on science and technology in general or on specific technologies are important sources of feedback and information. Unfortunately, such surveys are not widely used, which hampers the possibility of direct comparisons between countries and cultures. Directly comparable public perceptions data will be needed if a common understanding is to be reached and a common analysis pursued. This can be done with the establishment of an expert group to devise a common survey to capture the diversity of values and local perceptions of risk and benefit.

- *Promote common templates of public engagement*

This is a serious challenge in all three regions. Europe has a clear tradition of public engagement, while India and China are willing to develop structures to promote it locally. It would be desirable to develop common templates and structures of public engagement in order to allow for direct comparisons where possible. With respect to national traditions in public discussion and decision making, it would be possible to develop common programmes of engagement through established participatory technology assessment methodologies.