Post-Genomics and Complexity
(POCO)

The Post-Genomic Era: How does increasing complexity change the debate on genetics?

Final report

A project under the GEN-AU Ethical, Legal and Social Affairs (ELSA) Program

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Progress report for 2006

The third year of POCO was dedicated to the summing up of empirical research results within the individual sub-projects and compiling them to sub-project reports, and to the development of an overarching frame out of a comparison of the findings from the sub-projects. Apart from final analysis and discussion, additional empirical work was carried out in some of the sub-projects where it had turned out that some questions remained to be solved, which also entailed additional analysis and interpretation activities.

We held two general project meetings with all POCO team members on the 13th March and the 4th September 2006; in addition, there were several meetings between the co-ordinator and individual project members. The project meeting in March served predominantly to present three to six of the most important preliminary findings of each sub project to the other members of the team. Departing from these findings, we discussed theoretically informed possible interpretations with a view to devise a common frame for the final report. . It became clear that even the issue of 'genome research' is too narrow with a view to mechanisms of how the public deals with reports on progress in the biological sciences. Therefore, attempts to confine the issue investigate to genomics proper would not deliver results that gave the necessary insights.

The September meeting had the purpose to align the results and to prepare the detailed strategy for compiling the final report from the individual sub-project reports. We decided to go for a presentation mainly building on the individual sub-project reports as well as to devise an overall interpretation. This will be part of a major publication planned for 2007 and therefore will be only sketched out in the present final report. Another point for discussion was dissemination activities, which have been initiated already (in particular, sub-project 2 and 5; see the sub-project reports) and will be considerably enhanced during 2007.

Several project members participated in the final project workshop of the 'sister' GEN-AU/ELSA project 'Let's speak about GOLD' (co-ordinated by Ulrike Felt, Univ. Vienna) on the 21st/22nd/23rd September, where two team members (AC and BR) presented a poster on results from sub-project 2. We found this to be a good opportunity to discuss and compare our findings; however, we considered our previous decision at the project meeting in September not to hold a scientific conference dedicated to the POCO results at this point in time and to postpone such an event to further dissemination activities to be justified. In particular, and as already mentioned, we plan a major publication in the form of a book with contributions from all project members. Presently we explore possibilities for issuing such a volume and therefore came to the conclusion that a premature dissemination of results would make little sense and even may be counter-productive.

In general, we think could achieve our main goals set out in the project outline and in our previous interim reports. However, and as almost inevitable in every project of this size, a certain delay occurred in some of the sub-projects due to commitments to other tasks or for more general reasons of personal resources. Hence, difficulties arose in sub-project 1 as a planned co-operation with a British research team did not materialise, so the international perspective was curtailed. Sub-project 5 could not fully reach the time deadline with one deliverable due to work overload. Problems also arose in sub-project 6 since there was no dedicated funding from the POCO project and means had to be found from other sources. The most problematic part, however, was sub-project 3 where severe and unforeseeable obstacles had delayed the progress early on (see previous mentioning in the second interim report 2005). Especially the loss of our cherished team member Susanna Jonas could not be made due, so the sub-project ran into methodological problems despite additional sub-contracting and a partial take-over by the co-ordinator.

Finances

In general, and with a view to the unexpected obstacles already referred to, the project kept its expenses reasonably well within the planned budget. Resources available from the previous years were used to cater for the longer project duration (36 instead of 30 months as initially planned). Due to the longer duration and to the necessary shifts within sub-project 3 a certain amendment of the original budget plan became necessary. As already mentioned, additional sub-contracting (indicated in the 2nd interim report for 2005) had to be done; furthermore, personnel resources had to be dedicated to scientific work performed by the co-ordinator for sub-project 3. Sub-project 7 demanded more resources as initially foreseen due to work for sub-project 6. For details please refer to the cost sheets to be compiled after the official duration of the project (22nd Dec. 2006) has come to an end.

Dissemination of research results

Sub-project 2: First results of the feminist studies sub-project were presented at the 31st congress of women in science and technology in May 2005 in Bremen, Germany. Results have been published in Ratzer (2006). Results on the social-philosophical and SCOT perspectives were presented on a poster in September 2006 at the Closing Workshop of the ELSA Project 'Let's talk about GOLD!'.

Sub-project 4: M. Tumpej is currently preparing her diploma work on results from the media analysis within sub-project 4: Tumpej, M., Wissenschaftsjournalismus zwischen Medienrealität und Life Science – Die Darstellung der Komplexität in der Genforschung in österreichischen Medien.

Sub-project 5: First results on the question of everyday information search on embryonic stem cell research were published in Gaskell et al. (2006); further results will be presented at a symposium of the next AAAS meeting in San Francisco, February 2007. Results were submitted for publication in 2006 under: Wagner, W., Kronberger, N., Nagata, M. & Sen, R. The Monstrosity Effect Across Cultures: Affective Entailments of Cognizing Violations of Animal Kind Essence.

All sub-projects: Supported by ITA/OEAW, a major publication (book) is planned for 2007 on the basis of the results from POCO with contributions from all sub-projects. Editorial work will start in January 2007.

Structure of the report

In the following we will present the results of the seven sub-projects in short summaries. In order to provide the reader with a more integral view of the rather different project results, we decided to go for an interpretative summary over the whole of the project, putting the pieces into perspective. We will then turn to some best practice suggestions for future communication strategies mainly from sub-project 4, supported by insights from other sub-projects.

Finally, for the full reports over the sub-projects (see annex), we decided to present the findings of sub-projects 3 and 6 together with the reports from related sub-projects 4 and 7, respectively. We think that this integration benefits both the respective sub-project reports and opened up new perspectives for the interpretation of the data. A list of references will be found at the end.

Summaries of Sub-Projects

Sub-project 1: The Science Base: Paradigm Change in Genomics

In order to assess the changes within relevant biological sciences over the last decade we performed a series of 16 in-depth interviews with leading Austrian scientists from different fields. Pilot interviews served to set up a guideline, and full transcripts were analysed using ATLAS TI software based on Grounded Theory.

Initial reluctance among scientists about the rationale of the human (and other) genome sequencing efforts gave rise to the acknowledgement that 'the sequence' is indeed a major breakthrough for the biological sciences. Conceptually, there were few new insights in the beginning, except that it became clear that things are not so easy. Major impacts were on different levels:

- in terms of content, different questions and many more experiments were made possible because of the sequence information;
- methodologically, high throughput approaches received a boost and made it possible to analyse a lot of parameters simultaneously. The analysis not only of DNA but also RNA and proteins and gave rise to various „-omics';
- in order to make sense from the wealth of data generated, a closer co-operation with computer science became necessary, which supported the rise of bioinformatics;
- building on bio-informatics, systems biology sets out to understand larger entities such as the cell by generating hypotheses from prior data analysis rather than defining them a priori;
- in terms of research organisation, big consortia and 'broad approaches' became state of the art; in parallel, ventures with industry and the importance of patenting also had an impact on university research.

New concepts are emerging, some of which question long-held tenets in biological research, especially with respect to regulation, development and the nature and role of genes. The technological approaches developed to sequence millions of base pairs and various other innovations generated a flood of data that posed new challenges in terms of complexity. Solutions found, for example from bioinformatics, gave rise to new problems such as the need to develop a common understanding between different fields and mindsets. Increasingly complex systems' approaches make it difficult for researchers clinging to a more traditional 'hypothesis-driven' experimental research. Thus we see a race between new approaches to cope with complexity, creating complexity at another level.

Compared with the development of new conceptual insights, the impact of the rapid technological development and increasing competition on the daily lives of the researchers seems to be even more profound, even if this is not restricted to genome research. In particular, the need to communicate more results in less time among peers and, in particular, colleagues from various other disciplines increased. Together with the necessity to deal with companies, politics and the public this posed new challenges in terms of developing an understandable language that were often not met sufficiently. New forms of financing research led to a tendency towards 'commodification' in terms of measurable outcome. The speeding up of research increased competition especially in fields that appear commercially interesting such as mammalian biomedical research; in contrast, basic research in other organisms remained more co-operative and rendered better results – at least subjectively.

A short textbook comparison revealed that the conceptualisation of 'genes' was astonishingly advanced already in the 1980s at least in US textbooks on molecular genetics. In contrast, textbooks on human genetics did not scrutinise the term or used it in a Mendelian way. In particular in short definitions the understanding of 'gene' oriented at more simple bacterial genetics suggesting the 'one gene-one protein' concept. In later textbooks and even in popularising literature especially after 2000, the discussion of the term 'gene' was much more elaborate, taking into account the complexity of mammalian genomes.

Sub-project 2: Social Sciences Challenged: Genome Research in STS and Feminist Studies

Feminist Studies and Social studies of Science and Technology (STS) are two fields of social science known to have critically dealt with modern biotechnology, in particular with genetic research. We wanted to know how these fields deal with the new complexity in genome research and whether and how argumentation patterns could have been influential in public debate.

We performed a literature research and a critical analysis of the positions in both fields using Grounded Theory. The categorisation of the feminist literature (Ratzer 2006: 43ff) revealed several different approaches and topics. Core categories were chosen in meetings with the POCO research group. Widening our analysis, we found causal and generic relationships between categories using the technique of axial coding (Strauss/Corbin 1996). To begin with, we looked for indications for a perception of increasing complexity in biotechnology within relevant studies. In contrast to our expectations, few STS or feminist scientists comment on the complexities of modern genome research. A comparative analysis of literature before and after 2003 showed that argumentation patterns got more complex, however, this was due to more links drawn to related discourses rather than to a deepening of existing discourses. The question of argumentation patterns influential in public debate could not be answered in general; rather, we investigated it in relation to the risk debate on genetic testing and 'biobanks'. We identified the sociological paradigm of normative socialisation of innovation as a basic pattern to explain the attribution of risk.

Conclusions: Feminist Studies

- the vast majority of the feminist criticism of human genome research is not affected at all by current developments in the pertaining research fields;
- few feminist articles directly address recent developments in human genome research, but there is a growing number of scientific reports concerned with the implementation of genetic testing and diagnosis into everyday medical practice;
- only few previous debates are obsolete also in the light of recent scientific developments;
- recent feminist discourses themselves have generated complexity as this a characteristic of modern society with regard to ongoing debates in the social sciences.

Social Science and Technology Studies

- Human genome research has been strongly reflected within recent social philosophical debates in Germany, particularly on whether and how to optimize the human condition either per se or through the mechanisation of the human existence.
- The socio-philosophical discourses on the mechanisation of human existence, including discourses about human genome research, have been linked to the paradigm of socio-technical 'instrumentalisation'. The core question is not any more

whether genome research is good or bad but how its implementation takes place and what the results are.

- Some articles within STS even reflect the attribution of complexity to natural sciences, but there aren't any discussions about the increase of complexity within genome research as represented by the 'interactiveness' of the genome and new theories of system biology.
- Discourses on genome research are led separately within the different fields of biotechnology, medicine, feminism or sociology. The human genome is therefore also attributed, valued and represented with different characteristics. According to the Social Construction of Technology Theory this indicates the first stage of a socialisation of innovation. The second stage would then initiate the process of closure and the complexity of multiple meanings will decrease, as will the number of relevant groups and stakeholders.

Gender perspective

- Sharing our research results with the entire group, it turned out that the strategy chosen is not adequate for the introduction of a gender perspective into the overall project.

Sub-project 3: Doctors and patients

Only limited specialist resources are available to cope with a foreseeable rising demand for genetic services. Therefore, it has been proposed that at least some of these services will be provided by primary care, which entails a new role for general practitioners. With this hypothesis in mind we tried to investigate attitudes towards and the practical relevance of new insights from genetic research among general practitioners and other medical doctors. The sample was collected randomly using cluster sampling. Due to a very low questionnaire return we changed the research strategy to telephone interviews, but the willingness to be interviewed was equally low: from 60 outgoing calls only nine telephone interviews could be performed, so the results cannot be taken as robust. In contrast to general practitioners, physicians having to do with some form of genetics were more willing to co-operate. In addition, we carried out five interviews with leaders of self-help groups for diseases with a genetic background; recruitment turned out to be difficult due to the small number of relevant groups in Austria.

Although none of the general practitioners interviewed considered genetics relevant for his/her work all interviewees agreed that genetics will increase in importance. Most respondents considered their knowledge in genetics low and further education desirable. Patients' representatives confirmed that only specialists do counselling, general practitioners have no role. Criteria for good counselling, accordingly, were simplicity and individual care-taking. Although many patients seemed to already have some knowledge (from internet or radio broadcasts) when receiving counselling comprehensibility should improve.

Despite the disappointing outcome we may take the obvious reluctance to deal with genetics among general practitioners to be a result as such. We interpret it as a confirmation that it is difficult to bring new theoretical knowledge from genome research into the daily medical practice. The most important problem for physicians is time pressure in making the right decisions, and rather than to pro-actively seek information, physicians may look for concrete data only if they need them to treat a patient.

Sub-project 4: Meeting the Public: Perception of Complexity in the Post-Genomic Era - a Stakeholder Survey in Austria

Our starting point was the hypothesis that changes in the cognitive and institutional frameworks of post-genomic science are accompanied by changes in the relationship between natural scientists and the public. Sub-project 4 aimed at analyzing and comparing various stakeholders: on the one hand, students in the role of lay people; on the other hand, journalists, teachers, public relation officials, members of non-governmental organizations (NGOs) and scientists in the role of multipliers. We focused on four aspects: the perception of complexity and changes thereof (1), the transfer of scientific information to the public, i.e. the translation process (2), factors influencing communication (3) and the stakeholders' perception of themselves and others (4). The research work was carried out using media analysis (MA), a survey (questionnaire, QU) with 918 participants and a focus group discussion (FGD).

Media reports rarely address genome research as such, so we chose to use the term 'gene research'. Media tend to present results uncritically and to suffer from a lack of contextualisation. A general increase in efforts to communicate complexity in gene research can be observed in 2005 compared to 2000. Complexity often is expressed indirectly, and genetic determinism seemed to decrease. Journalists address in a rather detailed way the difference in expert opinions, the provisional value of research results, possible applications, social effects and long-term aspects.

Complexity in gene research is associated mainly with network characteristics (multilayered, interlaced) towards higher interrelatedness between its parts (network theory). Increase in complexity is not perceived as an increase in uncertainty or a decrease in controllability, which is in contrast to the theory of reflexive modernization. For a general public, gene research is just another science: complexity in gene research is assumed to have increased during the last 15 years, but this is also the case in other cutting edge science fields. The publication of the human genome sequence does not seem to have particularly boosted the perceived complexity in genome science. A further increase in complexity is not expected within the next 15 years.

There are large differences in the perception of self and others: especially with NGO actors, science journalists and scientists the self-perception differs from the perception by others. Generally, scientists are judged to be the most trustworthy and competent stakeholders but environmental NGOs and journalists rate themselves also very trustworthy and very competent in. It seems that these actors tend to overestimate their own skills and status in society. The reason could be psychological (e.g. cognitive dissonance, confabulation) or a different approach to genome science, weighing natural scientific and other aspects such as ethics and social implications differently.

In order to improve communication between the stakeholders, the above differences in perceptions as well as the underlying mechanisms should be addressed. Since various stakeholder groups rarely present complex issues comprehensively there is also a need for alternative communication channels. In addition to written information, discussion rounds with experts, (hands-on) exhibitions, and (documentary) films are in demand. Scientists are ready to communicate with high school students and/or teachers, but they view an increase in basic knowledge among lay people as a prerequisite. Teachers, too, consider gene research an important topic but criticize sub-optimal conditions for doing experiments and restrictions with regard to time and curriculum. Finally, both NGO and PR people recognize a deficit in communicating uncertainties in gene research within their own group. Thus, our results allow some best practice suggestions for scientists, teachers and the media.

Sub-project 5: Public Perceptions of Complex Technology

Sub-project 5 tackled three topics: the perceptions of monstrosity (work-package 1), the role of information seeking (work-package 2) and of metaphorical and imaginative reasoning (work-package 3) in the context of complex biotechnology.

Work-package 1 involved a series of five psychological experiments testing how people from the street as well as students reason about genetic hybrids produced by genetic engineering. The experimental independent variables were biological distance between the animals (animals of the same species vs. animals of the same biological class vs. animals of different biological classes) and the combination of matching vs. mismatched capabilities of the genetic parents. An additional experiment varied the method of creating cross-species hybrids (sexual procreation vs. in vitro fertilization vs. genetic engineering).

The experiments tested hypotheses resulting from our knowledge about essentialist thinking about living beings where the genome takes the role of the carrier of essence in common sense. Essentialist thinking is a way of reducing perceived complexity in novel and complicated scientific matters. Genetic hybrids combining genetic information of different animals are perceived as leading to a 'category crisis' in that long held expectations about the essence of members of clearly separated categories can no longer be taken for granted, leading to a primarily emotional reaction, the 'monstrosity response': Hybrid animals as the result of genetic modification are perceived to be uglier, more dangerous and less pure than their parents. We interpret such affective evaluations as the expression of 'monstrosity perceptions' and as a way of coping with a category crisis.

Work-package 2 investigated how people form their opinions on technological innovation in everyday life where they lack textbook knowledge. Using the methodology of active information search we performed an interview study and subsequently set up an experiment where lay people were to ask questions and seek information about the topic. Additionally we placed items asking for information desires in a Eurobarometer survey in 2006. Data analysis revealed that issues about a technology’s utility, its dangers, definition and regulatory issues were of highest interest to the participants. Less interest was shown for scientific details and practical scientific methods in this research. Accordingly, it is the moral aspects of embryonic stem-cell research that polarizes people most where about half of the Austrian population is quite relaxed about using embryonic material in research and medicine.

Work-package 3 continued an earlier line of research on the use and role of metaphors in speech and cognitive complexity reduction. Based on an analysis of focus group discussions with different segments of the Austrian public and a literature review on the use of metaphors in the context of modern biotechnology we designed a number of metaphor questions that were included in an interview study on embryonic stem cell research. Note that due to time constraints a systematic metaphor analysis of media articles, as originally planned in the project proposal, could not yet be finished. Media data on embryonic stem cell research for both the newspapers ‘Der Standard’ und ‘Kronen Zeitung’ were collected over a ten years’ period (1996 – 2006). These data are currently analysed according to the procedures of systematic metaphor analysis. The results suggest that in the context of modern biotechnology there is a fundamental distinction between anatomized metaphors on the one hand, and holistic metaphors on the other. Each leads to a distinct understanding and evaluation of the target. Proponents of the research are more likely to consider a few days old embryos as a bunch of cells rather than a real human being. Opponents, in contrast, voice concerns that echo our findings on essentialist thinking and imply an embryo to be essentially a human being. Also, embryonic stem cell research is embedded in a broader understanding of progress: the new research domain can be perceived as either ‘conquering new land’ or as ‘transgressing a dangerous border’.

Sub-project 6: Genetic privacy

International and national regulation protects privacy as a prerequisite for the autonomy of citizens. For genetic data being most personal there is an even higher level of protection. As recent insights from genetic research revealed higher complexity regarding the role of genes, the ability to predict an individual's future from his/her genetic data in a deterministic way has been questioned. We supposed that this might have an influence on the use of such data, on their protection and the very concept of genetic privacy. After screening the existing relevant regulations we conducted seven in-depth interviews with decision makers and stakeholders to find out main arguments regarding a possible change in regulation.

Genetic data are subject to all relevant regulation on personal data and privacy and, in addition, to a higher level of protection for particularly sensitive data. Based on the EU-Directive 95/46/EC on the protection of individuals the Austrian data-protection act stipulates that, with listed exceptions, sensitive data may not be used at all. This is supplemented by legal requirements concerning confidential medical communication according to the Ärztegesetz and other laws on health care. Furthermore, the Austrian Gentechnikgesetz prohibits the use genetic data by employers and insurance companies. Thus, the level of privacy protection regarding genetic data is very high.

From our interviews, we could not find arguments supporting the hypothesis that higher complexity regarding the role of genes will impact this high level of protection nor the concept of genetic privacy. Even though genetic data cannot be applied in a deterministic way as some previously assumed they are still considered very personal data revealing individual specifics. Secondly, genomic research is considered at the very beginning of understanding the relationships between genes and traits and the processes involved. Therefore, it is seen as adequate to apply the precautionary principle and not to skip basic rights. Thirdly, it is the perception of rather than the 'real' risk that is considered relevant for policy making. Even though a 'real' increase in complexity may entail less deterministic predictions of an individual's future health, genetic data are still perceived to be the basis of prediction. As long as this attitude persists there is no good argument to relieve the restrictions for their use.

Sub project 7: Policy Advice

Sub-project 7 dealt with the question of how genome research becomes an object of societal controversy and, subsequently, of political regulation. Empirically, the analysis refers to two exemplary cases: stem cell and pre-implantation genetic diagnosis (PGD) (as concrete applications of medical biotechnology informed by genome research). Especially in the field of biosciences, contentions on certain applications are framed as value conflicts beyond the coordination system of party political logics (left/right, emancipatory/conservative). This emphasises the importance of ethical expertise in these conflicts: politics has to acquire, on the one hand, an overview over the state of natural sciences in order to be able to decide in an informed way; on the other hand, the orientation knowledge of ethical experts is needed to sort out the – party politically ambiguous – problem potential of the conflict at hand and render the matters of dispute politically negotiable and capable of being balloted.

National bioethics commissions were constituted to give scientific advice to politics in the 'big questions' about life sciences such as genetic testing, stem cell research or cloning. The institutionalisation of bioethical expertise in Austria (and elsewhere) illustrates a new way of politically dealing with complexity generated by bio-scientific progress. It also illustrates the difficulty for politics to come to terms with political questions not framed in a traditional party-political way. The labelling of the expert bodies as 'ethics commissions' already indicates that there is not only a need for advice on scientific-technical issues, but also for normative clarification. Yet it is not obvious that biomedical issues should be framed in terms of ethical problems. Rather, this specific focus has to be understood as the result of 'ethicising' as a social process. The ethical discourse and its specific way of 'problem framing' has become recognised as a legitimate form of conflict negotiation and management. Consequently, the debate evolves within typical ethical-philosophical categories such as dignity, autonomy, fundamental rights, freedom etc.

'Ethicising' stabilises dissent. Expert dissent can be expected, and expert councils cluster their opinions so that, in the end, there are only two or three divergent positions left. This formation of positions is pragmatically oriented, the guiding principle being negotiation rather than exhaustive discussion. Finding 'coalition partners' within a commission does not require sharp arguments but strategic action. The primary goal of expert negotiations is the consolidation of an integrative opinion rather than the formulation of a position that all parties involved could in principle consider superior as an argument.

Ethically framed disputes about biomedicine take place on the feature pages of newspapers, in discussions and conferences. Civil society representatives do not act as pressure groups, on the contrary, civil society has to be mobilised for example by experimental forms of participation by laypeople. ‘Citizens' conferences’ are ways of involving representatives of the silent public in a discursive and participatory process rather than channelling explicitly articulated efforts into political participation. A closer look at the group dynamics within lay panels, however, reveals a process of excluding broader perspectives and alternative rationalities. This is the result of two processes of closure: a decline in membership that affects those with extreme or exotic positions; and a restriction of the discourse on ‘official’ issues of the bioethics debate. In the course of a citizens’ conference the members turn into ‘mock bioethics experts’ so that precisely those alternative rationalities stemming from individual experiences the process is set up to mobilise tend to be lost. Citizens’ conferences as experiments of participation have practically no influence on political decision making nor on public discourse, since their status within the institutional framework is unclear. From a political perspective, public participation is no source of legitimisation, and politics remain primarily based upon experts’ votes to legitimise its decisions.

Expert dissent does not challenge political legitimation, rather, we think that it is even functional for political decision-making. Ethics commissions are not expected to produce a unanimous opinion o decision 'blueprint'. Seen from outside is not the main role of the experts to produce decision-related knowledge but to highlight that politics is independent and decisions are taken according to political rules. They are then successfully justified precisely because plural and possibly contradictory expertise is available. Thus, expert dissent does not result in a loss of legitimacy for politics; rather, the divergence of expert opinions re-establishes politics as decision(-making). This indicates that increasing complexity in ‘factual’ issues goes parallel to a process of ‘scientification’ in politics but not towards expertocracy. Rather, complexity and the ‘ethicisation’ of technology conflicts are factors that foster a genuine political type of decision-making.

Interpretative Summary: Genomics, complexity and society

Modern genome research is said to have arrived at complex insights into the human and other genomes' structure and function (Levine/Tjian 2003). Generally, the term complexity refers to particular properties of complex network systems. Such properties are, for example, relationships between elements being non-linear, which entails that the effect of their interaction is not proportional to the cause. Complex systems are open and dynamic; they show pattern stability despite being far from (energetic) equilibrium. They have a memory; although they change over time, prior states may have an influence on present states. The components of a complex system may themselves be complex systems; boundaries are difficult to determine and subject to the observer's decision. Finally, they may produce emergent phenomena that cannot be determined from the level of the individual elements.[1] Thus, being complex is different from being complicated, the latter term pointing at intricate yet strictly determined relations.

However, applied to other fields, and also in an everyday understanding, complexity can take on different meanings. On the one hand, Nature as such reveals its secrets being complex – but this has been so for centuries, since Man set out to investigate natural phenomena. More specifically in genomics, such complexity manifests itself not only in the number of different sequences of base-pairs in a particular genome, but also for example, in the emerging structural architecture of the genetic apparatus and the functional differentiation of genes and other elements beyond open reading frames as determinants of a particular amino acid sequence often considered synonymous to genes. In addition, these elements are embedded in an inherently self-organising regulatory network comprised of different layers.

However, complexity also refers to the experience that ever more scientific insights into an issue (such as the genome, its architecture and regulation) not only close knowledge gaps but open up new fields where there is an obvious lack of knowledge. As a result, it becomes increasingly difficult to arrive at simplistic cause-effect relationships (for example, between a particular phenotypic property and 'the gene for it') without taking into account the wider genetic, physiological or even environmental context. This is highlighted in difficulties to arrive at a coherent definition of what a gene is, notably being one of biology's core terms. It appears as if new knowledge not only contributes new insights to the nature and role of genes, but also to the erosion of established functional concepts and pragmatic understandings.

Social sciences have long been emphasising that new areas of non-knowledge always emerge together with an increase in knowledge. This is one of the reasons why many authors have concluded that knowledge has become problematic (Luhmann 1995). A major feature other authors postulated is that boundaries between categories previously held to be clearly discernible tend to blur, and that there are things we might not even want to know, but obviously we cannot know in advance what exactly they are. Thus, scientific and technical advances produce new uncertainties, to the effect that doubts continually undermine knowledge – an argument Beck further developed in the thesis of 'reflexive modernisation' (Beck 1992). At the same time, knowledge has become an important factor for productivity, decisive for innovation and sustainability, as hallmarked in the self-description of modern societies as 'knowledge societies'. Therefore, we can conclude that the relation between science and society is no longer simple or linear and can be understood to be complex as well (Stehr 2005).

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[1] See for example http://en.wikipedia.org/wiki/Complex_system

Genome research, together with other fields in biology, is one of the focal points of scientific knowledge production and of the science-society interface today. The importance for society is highlighted by the many expectations this highly prolific field is raising. Consequently, Few areas of science have elicited similar political and media attention, at least for a certain time span. Yet it is not clear what this attention has resulted in with respect to perceptions in various parts of the public. Has the plethora of recent insights changed the view on modern biology and its practical possibilities, and if so, in which direction? Have new findings opening up for technological possibilities flagged up new areas of non-knowledge? Have these insights become problematic in themselves, triggering the question whether this is really something we want to know, or whether we should contains such knowledge? From an outside position, modern genome research may be seen as sending out paradoxical messages.

On the one hand, the availability of the base sequence of an increasing number of genomes gave rise to great expectations about immediate and applicable medical progress, based on the possible interference with the ‘genes for’ this and that disease. On the other hand, boundaries formerly held to be distinct and clear tend to become blurred. The popular concept of the gene as a defined source of information that ‘causes’ a particular property of the organism may be at disposition in the light of, for example, the apparent small numbers of genes in a traditional sense and the huge amount of ‘junk’ DNA within the genome, which biology presently has difficulties in explaining from a conceptual point of view. Such inconsistencies could, at least in the minds of a lay audience, give rise to either a reinforcement of cause-effect type of views with an eye towards hoped-for cures for diseases or means to individually anticipate future illnesses or even one’s fate, or to a number of question marks behind past simplistic and strictly deterministic views in the form of genes for almost everything.

So we may ask whether the increasing complexity of modern genome research results has translated into altered conceptions of post-genomic biomedical progress in non-scientific parts of society, or whether they have corroborated more traditional views of how to master Nature to the better of mankind, or at least some privileged part of it. Drawing an analogy to different concepts of modernity (Giddens 1990), we could ask whether the messages coming from modern genome research are considered to be ‘genomic’ or ‘‘post-genomic’, just as they render themselves to different interpretations of scientific-technical progress as new opportunities for mastering Nature by mechanistically applying what has been learned from experiments (such as the ‘gene for’), or as new insights increasingly undermining traditional linear postulates of cause-effect relations (in the sense of the gene as an elusive element within a complex network). In such a view, we may ask whether we are in a post-genomic era today or still in a genomic one – or whether we have ever been genomic at all. Drawing from experiences of past debates on biotechnology, it could well be that people in an everyday situation still perceive the living world and its parts in more or less pre-modern ‘essentialist’ categories irrespective of the results of modern ‘reductionist’ research, and align their reactions to new findings to more or less pragmatic intuitions. Such a pattern may not at all be confined to illiterate lay people but constitute a widespread attitude implicitly governing many reactions to modern science and technology.

We could extend the question to another level, asking how various institutions deal with the societal consequences of modern biological research – for example, how do they apply emerging knowledge (and handle non-knowledge)? Is knowledge taken to be unproblematic, or does it give rise to conflicts? And how are the ensuing conflicts framed and resolved? Traditional understandings of conflict as distributional arise over the allocation of scarce resources. Membership with different conflict parties is usually quite obvious as it is clearly defined qua economic status and position. Economic constraints and direct political violence are resources of power in the confrontation. In contrast, knowledge conflicts arise over the quality of knowledge; for example, how big is a risk really? These conflicts – often about environmental and risk problems – are characterised by what one could call ‘unconfined concern' and the dissolution of clear positions and group identities. Finally, value conflicts are characterised by the phenomenon of ‘ethicisation’. Main questions are: what do we want to do and to know? Where are the ethical boundaries of research? Ethically framed disputes about biomedicine are obviously a topical issue for any societal dealing with results from genome research. Empirically, we can find examples where of one form of conflict is transferred into the other, depending on the context. Such changes in framing provide different understandings of what science seems to say in an – allegedly – independent and unbiased way.

To find a starting point, we established a reference from within science by investigating how practices in relevant parts of modern biological research have changed over the last decade or so in the wake of genomics. In other words, we tried to establish how voices from within science itself see a development that may be differently perceived from an outside perspective. Then we looked at parts of society where one can readily assume that the practical consequences of scientific insights will meet particular interest. Firstly, we considered a natural target those fields of social sciences that professionally deal with new developments in science and technology. In particular, we expected that critical approaches such as feminist studies would closely watch and reflect new developments. Secondly, medical doctors were supposed to be interested as insights from biomedical sciences may well affect their daily work as well as the relation to their patients. Thirdly, we considered professional multipliers such as teachers and journalists, but also activists from civic society and pubic relation specialists to be among those who are supposed to closely watch changes in the natural sciences, and compared their attitudes with those of scientists. Regulators are also among those supposed to accept that new scientific insights may affect the way they deal with contested questions around modern biomedicine and genetics, in particular data privacy and ethics. In general, we looked for possible re-alignments of previously held opinions, approaches and practices due to the changed input from natural sciences.

From within biological science, we learned that scientists did not unanimously consider the sequence of the human genome to be a paradigmatic change to biology. Establishing the genome sequence has from the very beginning been understood as a means for scientific achievements rather than being an achievement in itself (see e.g. Lösch 2001:99). In fact, many researchers saw its announcement as a predominantly political and media event and thought the public and politicians would be made to think this was a revolution. From a conceptual point of view, it seems nevertheless too early yet to speak of a scientific revolution.

This is not to say that biological sciences have remained the same ever since. Obviously, many changes in the daily lives of laboratory scientists have their roots in big scientific-organisational efforts involving high throughput methods big and automated machinery of which the human genome sequence is only one among several. It is the age of efforts to investigate virtually all elements of a class of cellular molecules, usually subsumed under the suffix ‘-omics’. Their significance seems to be primarily methodological, resulting in new opportunities for research to be undertaken in the future. Many developments and the demand for new skills can therefore be traced back to changes in research organisation.

Complexity comes into the picture with the advent of new approaches such as systems biology, which try to make sense from it in a novel way and render research quantitative in a way unfamiliar to experimental biologists. Another factor is increasing competition, closely linked to the commodification of research and the need to communicate both scientific success stories and practical benefits to widely varying audiences such as peers, politicians and the public. Despite the increasing importance of ‘applicability’ for medicine and the role of industrial interests it is nevertheless incorrect to consider basic research to ‘dissolve’. On the contrary, it is expected that innovation may rather come from this form of doing science, notably if it is more co-operative as exaggerated competition often ruins a productive research climate within a community.

When it comes to the diffusion and processing of insights from genome research to other areas of science, and to society at large, it becomes very clear that we cannot confine our analysis to topics of genome research proper. Firstly, there are too few references to this field of natural sciences to provide a clear picture of how other fields consider, and deal with, insights from modern biology. Secondly, although genome research and its implications have a certain impact on, for example, how certain social sciences ‘digest’ biological findings, this exceeds issues strictly linked to genomics by far. However, there are general mechanisms and ways of treating such insights that can be exploited to gain insights and draw parallels. For our analysis, we therefore extended our scope to topics at the margin, or even outside, genomics as well.

We found that in fields of social science such as philosophy of feminist studies the reduction of complexity from the natural sciences frequently takes place by selective uptake. On the one hand, there are philosophers such as Peter Sloterdjik and even feminist authors such as Donna Haraway who welcomed the new possibilities to artificially shape the human being. Yet from a natural scientific point of view such claims appear exaggerated and subject to developments in a distant future. On the other hand, many social scientific critics of modern biotechnological medicine and genetics seem unaware that the role of genes is understood differently today – or they refuse to acknowledge it in order to escape moral relativism. A great part of the more recent literature, with few notable exceptions such as Fox Keller, takes little notice of new scientific insights and rather stresses traditional critical arguments.

Thus, we end up with a slightly paradoxical finding: On the one hand there has been a profound change in the scientific practice of research in biology, albeit not due to direct conceptual insights from genome research but rather due to organisational developments; nevertheless, long-held tenets might appear not as robust any more as they used to be. On the other hand, there are only few indications that from a social scientific perspective the erosion of a strictly linear conception of information flow from the (determining) gene to the individual trait has suffered a blow. On the contrary, what we see is a continuation of critical arguments based on deterministic conceptualisations about the link between one’s fate and the pertinent genes that appear slightly out-of-date, at times corroborated by claims from natural science to have found the gene for this, that or the other.

However, it would be inappropriate to simply attribute the negligence of new insights from genome research to a lack of understanding by social scientists. Rather, the criticism at for example implicitly eugenic goals, deliberate reductionism to trigger commercial expectations is held to be valid irrespective of how the role of genes is understood scientifically. Rather, it aims at world-views and interests ascribed to dominant actors and not at cognitive insights. In other words, the conflict is on values and not on knowledge. Thus, attempts (mostly by scientists) to re-define interest and value conflicts as knowledge conflicts does not lead very far, although it is tempting in a rapidly developing field.

If we turn to the ‘outside world’, the expectations raised by apologists of genome research about the significance of its results get a rapid chill. For example, medical doctors in their daily practice are supposed to be affected by new knowledge produced almost by definition. However, there is hardly any interest to be found beyond those who specialise in a particularly relevant field. Social scientific critics see one reason for this neglect in delusion:

unfulfilled expectation from research results touted to deliver not only predictive diagnostics but even cures may have chilled interest. Complex findings difficult to interpret and to assess from a practical-medical point of view may have made it uninteresting to spend much time on genomics for the average physician. There are many more pressing informational needs to be served in daily practice. To conclude, new scientific findings have to be unambiguous to be relevant; any doubt about their significance may be counter-productive in the doctors' daily life with their patients.

Also for a more general public (as far as accessible through our research methods), genome research as such hardly enters the horizon. In contrast, other fields of modern biology such as cloning or stem cell research are much closer to an everyday understanding. With regard to complexity, the perception on modern biology is not different compared to other areas of modern research and technology. Metaphorically, complexity is rightly associated with network characteristics such as 'multilayered' or 'interlaced', but obviously does not entail an increase in uncertainty. This finding may point at an overlap between (non-deterministic) complexity and (deterministic, in principle) complicatedness in an everyday use of the word. Accordingly, a further increase in complicatedness is considered unlikely – science is already complicated enough for the average lay people today.

This does not imply that people would shy away from the issue. Multipliers such as journalists, teachers and NGO activists have a certain interest and consider themselves able to deal with the issue. The story of teachers being unwilling to cover modern bio(techno)logy seems to be outdated – they appear to be willing to engage in covering it if only they could. Also the media are interested, but not surprising, only to the degree reporting is expected to meet interest. In contrast to scientists, who tend to see the medias' main role in educating people, both recipients and media people have a more realistic view on the medias' function – entertainment. Media consumers take this into account as journalists are expected to give a distorted picture because they need to frame the news in a sensationalist way – they want 'a story' rather than sophisticated ambiguities. Journalists consequently prefer to use the term 'gene' in a broad sense in reporting about medically relevant findings that may stimulate interest. Despite the implicitly deterministic way of coverage there are nevertheless indications that simple cause-effect relationships have slightly given way to more sophisticated reporting.

We may ask our initial question whether we see a 'modern' or 'post-modern' way of dealing with problems. Regarding the media, what is at stake (and interests consumers) is progress in mastering Nature for the better of mankind. This is also in accordance with the perception that new insights into genomics may be complicated but do not entail a loss of predictability. Hence, we could interpret this to be a modern program. However, this is in contrast to scientists' perception of the media distorting the truth for purposes of raising interest, i.e. entertainment. In this contrasting view, scientists would take on the role of the protectors of Enlightenment, while the media appear in the light of post-modern arbitrariness.

A seeming contradiction arises when it comes to information gathering: although scientists are seen to know most, journalists and NGO people prefer their own peer group for information gathering because they consider them to be more trustworthy and to be capable to deal with complex issues. The lack of trust in scientists to explain things properly may be exacerbated by the scientists' disdain of others regarding their ability to comprehend complex findings. The issue of trust is interesting as there is a dissonance between the cognitive (scientists are believed to know most) and the interest aspect (scientists are not believed to be free of interests), so scientists may be right when referring to the public as 'not trusting' them. The dissonance between knowledge and interest is also reflected in many scientists' enthusiasm for explanations of public unease that follow the so-called deficit model of public understanding, where a lack of acceptance is considered to result from a lack of factual knowledge. This empirically hardly tenable view, popular among many stakeholders from science and politics, reflects a tendency to transfer conflicts of values and interests into such of knowledge. A consequence is, for example, that adherents perceive media and NGO people as ill-willing seducers of public perception and should not have a legitimate opinion of their own at all. This commingling of interest and knowledge seems at the base of a fundamental incapability to acknowledge, on both sides, the existence of different forms of skills and knowledge, besides obviously different but legitimate interests.

To accommodate conflicts of interests is normally seen as a task of politics. Genome research has had repercussions in politics on several levels. Apart from the obvious question of national research funding mostly dealt with in terms of competitiveness, regulation has not specifically focussed on genomics. There are exceptions, however, in two respects: firstly, genomics are said to render results that could jeopardise genetic privacy, and secondly, in order to adequately deal with future problems arising from such research, ethics commissions are considered indispensable to give advice on a high level.

Genetic privacy has become topical as ever more data can be created from very tiny amounts of material. Apart from forensic identification, predictive genetic testing has become possible for many conditions. Problems arising pertain informed consent for investigations and data access, storage and managed. Data privacy is a fundamental personal right, and problems from genetic testing can be seen as a test case whether modern technology is compatible with fundamental rights and democracy or whether such rights are expressions of an ‘old age’.

Apart from the obvious lack of awareness among key actors, one may ask what the significance of genetic data is; after all, if there their predictive value is restricted, any costly attempt at protecting them would be wasted. This hypothesis neglects the character of personal data, genetic or other, as being significant to the amount significance is attributed to them: the moment people believe that data indicate a real property of a person, their misuse is something to be prevented irrespective whether the significance is ‘real’ or not. At present, it does not seem to be justified to erode pertinent standards of data protection on the grounds that genetic data are not as predictive as they often are understood to be. In such a view, complexity is less a problem of the data themselves as of how society deals with them and values a fundamental right against interests and costs. In a way, it can be understood as a value conflict turned to a conflict of interests.

With ethics commissions for policy advice, we enter exactly this problem of transferring different types of conflict into each other. Shaped after the pattern of medical committees, they have made their way into politics, changing their remit from intra-medical to broadly political advice and at the same time tearing down the boundary between science and politics. It is a feature of such bodies that they predominantly deal with questions of human (and recently, also animal) life and death – in particular, of the unborn and of the (almost) dead and their protection versus the rendering of their body at disposition for various interests. In the case of genome research such ethics commissions have ruled on different issues mostly related to genetic testing of the embryo.

Ethics commissions are supposed to decide contentious issues; however, as previous analyses have shown, their main task is to transfer into each other and negotiate different forms of conflict. They usually do not ‘produce’ ethics in an academic sense; rather, they negotiate facts and argue values in order to arrive at a compromise – or at dissenting views. Dissent may be politically useful at times, as it opens up for different solutions politically chosen. Therefore, politics need such commissions for legitimacy, but also to solve practical problems arising from complex scientific findings and incompatible interpretations. The perception of complexity therefore not only applies to the science; obviously, the relation between the categories of values, interests and facts as well as between different actors and the subjects dealt with become ever more complex. In such a view, ethic commissions in their function of giving advice to politics point the way at a different modernity. In terms of genome research, they deal with uncertainty rather than with better mastering Nature; hence, we may attribute to them a 'post-genomic' character – they aim at re-establishing a view on the entire problem or person.

Such holistic view is also a feature of everyday reasoning and, as such, a pre-modern form of dealing with the world. Assuming that our target audiences as described above can be considered predominantly lay people in terms of modern genomics, we investigated the mechanism by which biological (as well as many other) conceptions are formed in the minds of a lay public. As it turned out, the way of conceptualising genetic modification is inherently linked to the way species-specific identity (in a daily life way of thinking and not in a scientific definition of species) is mentally constructed, irrespective of any change of how science may define the role of genes. What counts is the inherent and inseparable 'essence' of an animal, for example, and this is defined by something that may be called genes. Anything that would blur the boundaries of such mental construction would be considered 'monstrous'. NB, this is not to say that people would be incapable of understanding the scientific content of the term gene. Rather, it points at a mechanism of dealing with new information, which usually renders usable results in dealing with a complex everyday world. In the same vein, information on new and possibly challenging issues is welcome, provided it is relevant to the practical dealing with those issues rather than consisting of scientific details.

Thus, it is less a question of incapability of ordinary citizens (including medical doctors, journalists, teachers, NGO people and regulators) to tackle complexity as it emerges from modern genome research than a mode of digesting news from a strange and at times contentious scientific field. We may conclude that such findings may be represented under different framings simultaneously. A particular scientific finding or concept can elicit conflicts of interest, of value as well as being challenged on the basis of different knowledge claims, subject to contingencies. It can trigger a pre-modern, essentialist way of thinking and dealing with novel insights as well as it can give rise to a modern, for example utilitarian perception in the sense of a means to master Nature. Finally, it can be taken as an indication that things are not so easy, after all, and may contribute to blur boundaries of categories formerly considered strictly separated such as science and politics. The ensuing cognitive dissonance is not restricted to lay people; after all, we are lay in almost every field. Complexity, finally, seemingly has not yet found its way into the minds of the public when it comes to genome research as the perception of linear cause-effect relations still are dominant. However, in the light of the above findings, is it really realistic to expect such perceptions to change?

Best practice suggestions

The results of the media analysis, the analysis of the questionnaire and the focus group discussions of sub-project 4 allow some best practice suggestions to be derived for the groups of scientists, teachers and for the media. NB: As feedback from the groups of NGOs and public relations was rather poor, we provide a recommendation for the patient organisations as one of the NGO subgroups only.

Scientists

(1) Communicate with the public

Grants like FWF in Austria assign up to 10% for science communication. Use the money!

(2) Too many details hurt

We all know that natural sciences are based on the precision of details. However the public wants a more general picture. Try to keep complex issues comprehensible even though precision is lost.

(3) Pick up the publics' focus

The level of knowledge on gene research is low in the public. It is incorrect to assume though that acceptance is linked to the level of factual knowledge as attitude does not depend on knowledge but on personal experience and trust. People trust scientists not blindly, but more than they often think. Don't focus on scientific details.

(4) Be prepared for the media

Journalists want stories. Understand their job. Give them a simple story but make sure that it remains your story, although that may not be easy. So, seek out the appropriate training to deal with the media. There are media workshops available. Journalists seek and value your contact. The greater the contact, the better the story.

(5) Investment in the future

Make contact with high school students. This is the best way of raising young people's interest in science, of raising awareness in scientific issues and of building trust in science.

Media

(1) Check story with an expert

Complex issues need simplification, but if you make it too simple you actually may write the story incorrectly and misleading in the end. Obtain a final feedback from an expert. Show respect for scientists' working style priorities.

(2) Know your experts

Make sure that you have a real story. Use different sources and check on quality. Know your experts and talk to more than one of them. Work on your contacts in the scientific community. Build your own expert network.

(3) Avoid unrealistic hopes and scaremongering

Readers would like to know when an idea finally hits the market. But don't trust too ambitious time frames and don't exaggerate. Even a scientist may dream and be overly optimistic (same applies to overly pessimistic scientists).

(4) Use the right metaphors

Media can't do without metaphors such as 'The genome - the book of life'. But be aware – there is a danger of misleading metaphors. Check them very carefully.

Teachers

(1) Gene research as a topic

Students are very interested in gene research. It is an important topic in general, can be very spectacular and many aspects can be personally touching. So, take the time and introduce gene research as a topic. Your curriculum will offer you more freedom than you think. Choose topics which deal with 'real life' and which are up-to-date.

(2) Suited for project based class

Gene research includes scientific, ethical, social, economic and political aspects. Thus, many subjects can be included. Communicate the topic in an attractive way - it's not only perfectly suited for project based classes, but it is necessary to grasp the full impact of gene research.

(3) Contact with scientists

Make contact with scientists to bring new knowledge across to your students – scientists love to share their enthusiasm with high school students.

(4) Hands-on projects

Use the potential of gene research for hands-on-experiments. Visit places outside school, like the Vienna Open Lab, or use the material collection for experiments.

Patient groups

(1) Raising awareness

Patient groups are very heterogeneous – not all of them act professionally. Attract attention by professional appearance and behaviour.

Annex: Full reports

Sub-project 1: The Science Base: Paradigm Change in Genomics

Helge Torgersen, ITA/OEAW

Introduction

In public announcements, the availability of the human genome sequence was greeted as a hallmark of a new millennium. The wording that the 'book of life' had been deciphered raised high expectations with respect to cures for many diseases. In the long run, scientists predicted important discoveries, but the short-term expectations were set back when the sequence turned out to be difficult to interpret. Some questioned whether this really was a revolution.

We wanted to learn how scientists today perceive the advent of the human sequence symbolising modern genomic research. What is their opinion of this effort now, what did the availability of the sequence really change, and how have the biological sciences developed ever since? In other words, what are the characteristics of the 'post-genomic era in practical terms? In order to find out we interviewed scientists from molecular genetics, biochemistry, cell biology, pharmaceutical development etc., engaged in investigating various model organisms and working at universities, in basic research laboratories, hospitals or companies. Informed by explorative short interviews we focussed on the following questions: In the wake of the human genome sequence,

- what were the changes in basic concepts, and which implications did they have?
- What were major methodological and organisational impacts from genome research? What implication did they have for research organisation, what are the new fields?
- Which kind of new skills do researchers had to develop?
- Which effects did increasing competition have on research? Is classical hypothesis-driven or low-budget research possible any more? Did patents influence research?
- What were the effects of economic or organisational contingencies? Has the division of labour increased? Has the role of the individual researcher changed?
- What kind of significance does the public and its attitudes have for researchers?

From a series of in-depth interviews with senior researchers we transcribed the recordings of 15 and analysed them using Atlas TI. Statements made by interviewees were coded and assigned to 28 code families. Ensuing networks were further investigated, main lines of argumentation identified and compared to individual statements. The results, which have to be read as referring to interviewees' statements, will be presented in six chapters in the form of a compilation of main argumentation lines:

- the significance for scientists of the human genome sequence;
- the consequences of new methods having been developed;
- the role of new research concepts;
- the role of communication with peers, other scientists and the public;
- the role of communities and of competition for the research climate;
- the relation of basic and applied research.

The Genome Sequence – a Watershed?

The availability human genome sequence was hallmarked as a revolution for biology. However, not all scientists shared this opinion. Originally, the task had been criticised as scientifically unrewarding, and many experimental biologists initially considered the human genome sequence as an uninspiring but technologically demanding and hugely expensive aim hardly worth the effort (Sulston/Ferry 2002). Some feared that the sequencing initiative would draw money from intellectually more interesting experimental work. In contrast, the sequence of the simpler genomes of laboratory organisms such as bakers' yeast appeared more accessible, and their sequencing in the early 1990s served to establish the technology. With some smaller genomes available, the costs per base pair rapidly declining and the speed increasing, scientists became convinced that the human genome was within reach.

When the media celebrated the announcement of the human sequence it was nevertheless far from complete. For many scientists, this was one reason why the event was not considered the watershed it had been denominated for a general public, and the framing of the announcement was met with suspicion. Even when complete, the problems with interpreting the sequence jeopardised hopes for a quick gain in conceptual insights. The puzzle became apparent to a wider audience when researchers established that, contrary to the estimated 100.000 genes or so considered 'necessary' there were less than 30000. In comparison, Drosophila has got around 20.000 genes despite being much less complex, so gene regulation became most interesting. Another puzzle was the huge amount of often highly repetitious DNA without an obvious function. Conventional theory would not permit such 'junk' to be carried on without conferring a selective advantage. Since it got retained, what 'was it for'? No wonder prominent researchers considered the genome, together with other innovations in biology, as a harbinger of complexity (Levine/Tjian 2003). In the same vein, our interviewees used the 'book of life'-metaphor scarcely and only to highlight problems in understanding the genome.

Today, there seems to be a consensus among scientists that it is the methodological advancement rather than the immediate insights that constitutes the reason for calling the sequence a watershed. Due to new methods, research rapidly accelerated and formerly inaccessible questions could be answered. The sequence became a starting point for new fields national grant-giving institutions could focus on. In addition, the PR effect of the human genome sequence helped to set up national programmes (rather late in Austria).

Conceptually, the sequences (also those of plant genomes) gave rise to new questions about how genes work and even what a gene 'really' is. This goes back to a distinction that has accompanied genetic research forever: genes as hereditable units vs. genes as blueprints for phenotypical traits (Moss 2004). The molecular genetic paradigm 'one gene – one protein' has for some time created a bridge but has become too simplistic. However, this problem has been addressed already in the 1980s, as a look at textbooks easily reveals (for example Lewin 1983). The author stresses that there is 'no precise connotations of complementation and uniqueness of representation any more', and old definitions have become elusive. More recently, the quest for finding genes within the genome sequence has created a new need to arrive at usable definitions of what a gene is. Pragmatically referring to experimental methodology, for example Snyder and Gerstein (2003) therefore considered a gene to be a 'complete chromosomal segment responsible for making a functional product'. Such a somewhat shallow functional definition omits any prediction about information transfer or regulation and thus makes it possible to arrive at a common understanding despite different scientific interests. A gene is thus an entity pragmatically understood according to the context investigated, and no longer a defining concept of biology. Such theoretical considerations are, however, rarely relevant for the daily laboratory life, and although many scientists are aware of the shortcomings, their everyday use of the term ‘gene’ does not seem to reflect the new complexity emerging from genome research. Since a comprehensive definition is difficult to give, some interviewees were grateful for a simple everyday description proposed to them.

A major source of complexity is regulation. It became clear that another layer of information is involved, which must be coded in the DNA but not necessarily in the form of a sequence. For regulation, also the context of the nucleus, the cell, and its environment play a role. New insights into the contextualised regulatory networks of a complex genome questioned the deterministic model where information only originates from the nucleotide sequence. There are additional means of regulation such as DNA packaging, RNA metabolism or protein modification. Epigenetics investigating these additional layers found that under certain conditions, some traditional understandings of genetics would not apply. RNA not translated into proteins but having a role in regulation may help to explain why the genome can do with such a small number of genes. In plants, it may even shake basic concepts such as the impossibility of inheriting acquired properties. New insights have implications not only for the theoretical understanding but for practical applications as well. For example, the discovery that interfering small RNA molecules can functionally silence gene expression has led to a powerful experimental tool to study the role of genes. In combination with the sequence, it is considered a methodological quantum leap.

Taken together, the significance of genome research can be seen on different levels:

- the sequence information showed the complexity of the genome rather than providing a full understanding of it;
- together with methodological innovations it allowed to ‘design different experiments’ and to ‘think about experiments in a different way’;
- epigenetics and the re-appraisal of the role of RNA had great impact on new concepts;
- both came along mostly by coincidence and not as a part of the Genome Project.

Hence, different methodological developments led to a challenge for existing paradigms. The human (and other organisms’) genome sequences provided the basis, but new knowledge about proteins and RNA were essential as well. It became clear that genome organisation is highly complex and to be fully understood only in a distant future.

The change in the ‘meaning’ of the term ‘gene’ is reflected in the use by different textbooks. Departing from the ‘one gene-one protein’ concept derived from bacterial genetics in the 1960s, textbooks on human genetics (intended for medical doctors) of the 1980s still use the term in a way as if its functional meaning had to be taken for granted, emphasising its Mendelian content (the gene as a carrier of the information for a phenotypic trait). In contrast, molecular genetics of the 1980s were more advanced, stressing the difficulty to arrive at a functional definition of a gene suitable for all purposes. Already then it had became clear that such a definition would be futile, and that the content of the term would have to be defined according to the context especially in mammalian genomes. This way of dealing with the problem got a heavy boost after 2000 and arrived also in the more popular literature. Nevertheless, in short compilations of definitions in lexical form, conceptualisations oriented at bacterial genetics prevailed for quite long.

New methods

Rather than new concepts, progress is seen as new methodology having accelerated research and changed the daily life in the laboratory. The sequencing initiative, among other projects, paved the way to high throughput methods, i.e. automated high-speed laboratory analyses profoundly changing research. Apart from DNA, other biological molecules began to be analysed on a large scale, giving the respective fields the suffix '-omics'. In particular, tools for the analysis of proteins such as separating techniques and mass spectroscopy have made it possible to analyse huge numbers of molecules present in a cell at a certain point in time.

Genome data also inspired the development of chips, automatically processed tests with thousands of probes on little plates, generating huge amounts of data with great speed, accuracy and reproducibility. One particular company (Affymetrix) set an informal standard if not quasi-monopoly implying that its products being used, otherwise the resulting paper could meet problems during peer review. Critics doubt however whether high throughput approaches yield the results they promise. Some researchers think they only produce scientifically questionable data with huge technological effort. At least their results need a form of interpretation only specialists have access to – for others doing experimental small-scale research they remain enigmatic. Apart from chips, commercial pre-fabricated 'kits' of reagents for experimental routine tasks speed up research, but scientists cannot fully understand and control the methods applied any more. Innovations save time, but research gets more expensive as technical equipment becomes more complex, 'commercialising' it.

The biggest challenge, according to many interviewees, is to make sense of the wealth of data. To this end, new approaches apply computer science to molecular biological problems. This field has grown over the last twenty years from a support activity to a genuine area of research. The more data were acquired under genome sequencing and through high throughput activities the more pressing became the need to reduce the complexity generated, in order to gain reliable insights for example into the function of genes within their context or the structure of proteins. Today, laboratory scientists need bio-informatics to help them sorting out not only experimental or sequence data but also to screen publications and patents by data mining. 'In silico' searches and comparisons of databases deliver results without doing a single 'wet' experiment and save time.

The expectation is that technical development and simplification will render advanced statistical methods part of the daily work of ordinary biologists, as long as they know how to use them, so students will have to acquire knowledge both in experimental biology and in computer science. Today, this is seen as not sufficiently reflected in Austrian curricula, in contrast to other countries; skills in informatics seem to be more or less subject to the students' personal efforts. Apart from general skills, specialists are still sought after, with new tasks such as genomic functional analysis adding to the demand. However, after 20 years of development in the field, people with a dual education who can speak to biologists as well as to technical scientists seem to be still lacking.

New research concepts

Different mindsets: Many interviewees attributed problems to transform biological questions into the language of computer science to differences in the way of thinking. Researchers remain computer scientists or biologists, respectively, with their particular mindsets and approaches, and communication across the disciplinary gap is difficult. Rather than to contribute auxiliary skills, bioinformatics appear to some laboratory biologists as a 'secret science' deliberately not to be understood by outsiders. Biologists sometimes get annoyed with the performance of computer scientists, while they consider the task assigned to them to be more difficult than biologists think. Most of the difficulties can be tracked down to misunderstandings: scientists get lost in translation.

Bioinformatics is a technical science, and adepts claim to have a profoundly different way of thinking compared to traditional molecular biology: in a technical world, there is one best solution that can be reproduced indefinitely. This technical approach is referred to as 'deterministic': the result can be determined provided one knows all the relevant parameters. In experimental biology, every successful set-up may lead to slightly different results, and it is difficult to exclude contextual factors – computer scientists point at the many lab experiments that fail. Application of informatics methods often proved futile not because they would, in principle, not apply to biological subjects. Rather, the framing of a biological research question appeared entirely unfamiliar to technical scientists; they consider laboratory experimentation a bit erratic and the data generated 'dirty'. Conversely, biologists had to learn not only a new terminology but also what kind of data is needed to fruitfully co-operate.

The problem is not new: before the age of genomics, mathematical models already played a role in enzyme kinetics, protein structure determination and molecular evolution. This part of chemistry was considered less 'dirty' than biochemistry. Then came sequencing, and the data had to be aligned. The problem was to construct a consolidated sequence from multiple sources and different laboratories. With some organisms, this is still a problem despite the respective genome sequence having been 'determined' officially, but the quality is still questionable. Also for practical applications in the pharmaceutical industry many problems arose with methods to 'clean' data and render them accessible to statistical analysis.

The quantitative-technical approach not only changed the way laboratory research is performed but also demanded to acquire a different mindset. Biologists have to live with biological processes being described using probability rather than qualitative yes-or-no-answers. This is not entirely new to lab scientists, but according to some scientists virtually all research questions have to be framed in such a way now, and documentation must follow more stringent standards. Parallels were drawn to medicine, where statistical investigations have largely replaced case studies, and to developments in particle physics fifty years ago when big accelerator experiments rendered huge amounts of data. Some interviewees saw a similar development to take place in biology: from a largely individually determined experimental laboratory science towards big quantitative experiments where the individual researcher only plays a minor role within a large group of specialists. In laboratory studies (Knorr-Cetina 1999), exactly this individual vs. group approach had been taken as a main distinction between different types of research, so this change may be highly significant.

The 'systems approach': Compared to experimental molecular biology, bio-informatics are said to give better results in less time. Some interviewees even considered experimental biologists a species facing extinction as an increasing part of the relevant insights come from bioinformatics. Largely based on this field, a new approach under the header of 'systems' biology aims at a broad, unbiased, integral and comprehensive understanding of cellular processes. For example, the analysis of all proteins and their functional association is said to provide insights in the form of a 'protein sociology', which a conventional analysis of a few particular molecules would not deliver. In their self-interpretation, researchers advocating this approach do context-based and process-oriented unbiased analyses. Systems biology aims at generating mathematical models simulating all relevant events in a cell 'in silico'.

Apart from the broad approach based on high throughput data the 'systems philosophy' puts the conventional research agenda upside down. At the beginning, it is no longer a hypothesis about the function of an element that triggers a set of experiments. Of course researchers do not start from scratch without taking notice of the current state of knowledge but the initial general question is formulated more generally compared to experimental research. In a systems approach, data generated without a particular hypothesis undergo mathematical analysis for patterns emerging, which only then give rise to hypotheses. Rather than to directly discover the function of single elements within the cell it uses automated data gathering and information technologies to 'let the cell speak to us' by very broad and comprehensive analyses. The pattern emerging from the data is considered more robust compared to those developed from previous interpretations of contextual experimental laboratory research. The role of the latter is only to then prove or disprove the hypotheses generated by previous systematic data analyses.

The different concepts of arriving at hypotheses have consequences for the understanding of the research process. Those aiming at a 'systemic' approach consider traditional hypothesis-driven experimental research as literally non-systematic and hence difficult to compare. Accordingly, it highlights particular elements chosen by historical contingency without taking into account the context of the system. Such research unduly generalises about its little reproducible and statistically weak findings; it is merely 'anecdotic', focussing on fractional and sporadic analyses of tiny parts of a problem determined by the incidental availability of certain tests and reagents. Consequently, traditional hypothesis-driven experimental type of research appears to be out-dated.

As with bioinformatics and 'wet' biology, there is a similar split between systems biology and experimental or 'hypothesis-driven' approaches: those considering the new approaches capable of revolutionising biology, and those who see them as a fashion unable to replace hypothesis-driven research. The latter criticise the former as following a scientifically ill-conceived approach without any tangible success so far. Accordingly, results cannot answer biological questions about cellular mechanisms but result in a flood of non-interpretable data. In the end, no statement about biological mechanisms will be tenable without doing experiments to 'prove' it. In addition, some researchers suspect that the controversial term of the 'system' is at best ill defined or may be no more than a buzzword misused to acquire resources for big research groups.

The two schools of thought not only compete over scarce resources; the conflicts go deeper and concern professional attitudes towards science, manifesting in almost personal injuries. Some lab scientists refer to those who do 'electronic' research in biology as being fascinated by technology as an end in itself but lacking biological understanding. In contrast, those supporting quantitative approaches consider 'wet' scientists as not focussing on reproducibility and exactness but being content with wooly qualitative results lacking statistical corroboration if only they fit their pet hypotheses.

These extremes of course stand out of a spectrum of opinions, with many scientists taking a position in-between. In the long run at least, differences are supposed to fade or to be resolved by a division of labour: to stay competitive it will be necessary to combine approaches. There is a unanimous feeling that hypotheses cannot be omitted and will continue to guide research, but systemic approaches will be more important in formulating them. The role of 'wet' laboratory experiments will be to establish how different parts of the cellular machinery work together in a mechanistic way. Bioinformatics is necessary to make sense of the data from high throughput methods, to save time and to avoid duplication of existing work. It can also play with large amounts of data to make more sense of or exclude possible explanations. So the future is seen in pragmatically filling in the gaps between systems biology rendering the big picture and laboratory work for the functional analysis of individual components.

Communication

In science, communication has gained in importance on various levels: between scientists in a group, in inter-disciplinary co-operation and with peers and grant-giving agencies as well as with the public. Some researchers considered communication with colleagues in their field it to be ‘half the job’, as the need to specialise within a research group increases.

Communication among peers

In the light of growing competition, communication to the scientific outside world is most important. Apart from journal publications, scientists must increasingly be able to explain what they do in a very concise way (‘10 overheads’) irrespective of the knowledge of the target audience. They must do so at meetings with fellow scientists, to attract talented students, under calls for proposals to impress peers and grant giving agencies, to make companies invest money, and in many other instances. Condensing the results of years of research into a few minutes’ talk can also serve a heuristic purpose: it forces scientists to selectively follow a convincing flow of arguments. Gaps or redundancies emerge and direct the attention to missing parts of the ‘story’ – for each research project an interviewee imagined giving a talk before designing the necessary experiments. Weekly group seminars serve also to train young scientists how to present their findings. Students have to meet international standards irrespective of shortcomings in the domestic education, and although they have less problems with communication today than their professors had as a young, they must exactly know what they want and compete.

This continuous need to justify gives many researchers way beyond the status of a student the impression to be subject to permanent, informal evaluation vis-à-vis an anonymous power. It also creates a selection pressure: those fully convinced of their concepts are in a better position while sceptics are at a disadvantage, which contradicts the popular image of the scientist being sceptical literally by profession. Rather, a researcher needs to be a ‘natural communicator’ with skills to understandably simplify and sell his or her message without unduly trivialising it but also without raising too many doubts. This is not only important in communicating with the public but mostly so within science – after all, scientists from other fields are also ‘lay’ people.

Communication across fields

The increasingly complex methodologies of experimentation, data gathering and data analysis demand a division of labour, which entails specialisation both within working groups and among them. Co-operation across rather distant fields, such as between biology and computer science, is considered to have grown in importance. Although it is not clear whether teams are really larger now, the variety of professions involved is greater. Scientists are dependent on their colleagues’ results; across groups, the exchange of data has increased. This is not only so in academic but also in commercial research, where the development of new pharmaceutical products has become more demanding. Quick interdisciplinary co-operation within a company is state of the art, not only among biological disciplines but also with computer science, chemistry, pharmacology, medical sciences, law and others. Beyond sharing the knowledge it is also seen to be necessary to anticipate what could be interesting for colleagues from other fields. In other words, researchers have to partly adopt the particular disciplinary view of their co-workers in order to swiftly communicate. Under time pressure, scientists from different fields have to use a language their colleagues easily understand.

However, the problem of ‘science-speak’ is notorious not only in the relation between a (sceptical) public and scientists but also in the relation between researchers from various disciplines. Since group members have to rely on what they are told, researchers consider it necessary to build trust because colleagues from different fields lack the knowledge to assess whether what they have been told is right or not. Interestingly, some scientists see a general need for a more cooperative attitude due to inter-disciplinary work, in contradiction to the frequently addressed trend towards increased competition. In particular, the medical sciences are seen as a field where expertise from other disciplines must be accepted at least in research.

Communication with the public

Some scientists put a question mark to public outreach activities as they thought that only those colleagues fond of personal publicity would enjoy going public – nothing a ‘real’ scientist would ever like. Nevertheless, and despite incentives lacking, communication was held to be important for two reasons: on the one hand, there is an impression that spending taxpayers’ money implies the need to justify that it has been used for the better of society. Some time ago, researchers had deemed it neither necessary nor feasible to give an account of what they do, but activities of public outreach in order to convince people that science is worthwhile have become a matter of course today. This is, by the way, also considered necessary vis-à-vis politicians, an activity demanding much more effort today in the view of some scientists. On the other hand, researchers are afraid of a generally hostile public. They do not fear vandal acts by animal liberationists such as in Britain – foreign interviewees considered Austria a much better place regarding attitudes towards scientists. Rather, negative public sentiments may influence the politicians’ incentive to secure public funding in some fields. With respect to genome research, scientists supposed that due to promised new applications, genome research initially may have appeared more attractive to the public than to scientists, while today, scientists are more enthusiastic over the new research possibilities and the public may be disappointed. This could result in backfire for medical applications because of unfulfilled expectations.

There were different opinions on whether the need to communicate within science helps in communicating with the public. Some interviewees did not see the problems to be different in principle, with one exception: scientists have positive attitudes irrespective of the field they come from, particularly if they work on the same project but even if they are competitors. In contrast, there was a widespread fear among scientists that the public would tend to be negative, and this put them in a position to have to defend what they do. Other interviewees could not see why the ability to communicate among scientists should help in the communication with the public. They considered speaking to scientists and speaking to the public to be two entirely different tasks.

Neither was there a unanimous view on whether communication has become easier or more difficult. Some interviewees saw more problems in explaining complex new findings. In general, they expected the task of bringing modern biology to a lay audience to grow in difficulty along with complexity. Others did not consider it more difficult to explain new concepts compared with older ones; however, the aims to convey understanding might be more ambitious today. On the contrary, findings about biological mechanisms including genomics had made it easier to communicate them to a lay public. They saw it as an empirical fact that new findings can, in principle, be explained to people with no prior knowledge; it depended on the scientist’s skill rather than on the content. Vice versa, some interviewees suspected that scientists unable to adequately communicate might use the argument of increasing complexity as an excuse.

In summary, the public was considered to be more interested in scientific findings today. This was partly attributed to a shift in generations: technology sceptics have grown of age and become conservatives. Commercial effects of new technology such as job growth and competitiveness are accepted arguments today. Admitting that things are complex was considered necessary to retain credibility, although some researchers proposed to get professional communicators for research institutes in order to do away with expert dissent in the public. One interviewee found that public scepticism against exaggerated claims over various ‘genes for’ raises the hope that complexity can be communicated as fascinating despite the fact that many would like things to be simple.

Communities and research climate

Research communities

Individual research communities define themselves not only according to the scientific problem but also to the organism the researchers use. Thus, there is a mouse, a worm (C. elegans), a fly (Drosophila), a yeast community, etc. These communities have different cultures and their own set of rules in handling conflicts or views on competition and co-operation. For example, the very co-operative mood within the worm and the fly community contrasts that in the mouse community, which is said to have become rather harsh.

Several reasons were mentioned: firstly, the individual personalities of the ‘founding fathers’ or ‘mothers’ of a community, those who have started the research using a particular organism, have established the way how people in this field ought to behave. Such informal standards can be rather coercive. The second reason is said to be the distance to medical research, a field that has a tradition of being competitive and little ‘friendly’. Accordingly, the more basic the research is and the less immediate applicability can be ascribed to the results, the less prone is the community to indulge in heavy and sometimes unsound competition. Commercial interests thus can spoil a community, a risk that becomes more substantial with commercialisation of research. For example, the mouse people reportedly had been co-operative before the age of molecular biology and have become rather competitive now. Interviewees referred to the importance of mouse genetics for medical research as a reason. This has effects on the field: while the sequences of both Drosophila and C. elegans seem to be in a good shape, the quality of the mouse sequence is considered inadequate, which was partly ascribed to the lack of co-ordination and co-operation.

Another effect of a ‘bad climate’ is that researchers are cautious to promote new ideas, so that ground-braking new concepts have been first developed within the yeast, the fly and the worm community. Researchers were considered more flexible and less anxious to try out new ideas and experiments and to draw the consequences of new insights even if they contradicted established concepts. A particular example of unconventional thinking comes from basic plant research in Arabidopsis, a little flower plant without any commercial importance. The Arabidopsis community is very co-operative and researchers get support from their colleagues, so freedom of research is high. The plant genome is of a similar complexity to mammalian genomes, but experiments are easier to do. Thus, new heretic ideas can be developed, such as the possibility of a kind of ‘Lamarckian’ inheritance. In contrast, with crop plant science, the climate is similar to medical research communities due to commercial interests, and scientific exchange is said to be difficult.

Climate change and competition

Some interviewees consider climate change with getting nearer to medical applications a possibility. For example, the Vienna university administration wants to bring applied and basic research together to arrive at clinically applicable results and patents. Since medical related fields tend to be less co-operative, this may also have an influence on the research culture in the long run. Another reason for a loss of cooperativeness in basic research is the becoming hot of a topic, which may rapidly change and is partly a question of fashion. While research on oncogenes was hot around 1990, today it is research on RNAi, with the result that competition is fierce. Combining applicability and ‘hotness’ often serves to justify basic research by relating it to a practical application in a grant proposal. The role of 'cancer research' seems now to have been taken over by various '-omics'. Some popular and easily understandable practical purposes are said to be still ritually necessary even in a peer-reviewed application for basic research.

A prominent interviewee questioned whether today's incentives for research based on individual competitiveness will be sustainable. In the light of growing specialisation even large groups may not be able to hold all necessary expertise. Therefore, co-operation will become more important in the future, both on the individual and on a group level. This will in turn change the structure of the reward system: no longer will the individual achievement be the measure but the work done in co-operation. The researcher promised that this will also exert an influence on the organisation of research as well as on the properties of those who will be successful: inter-personal skills will be highly sought after. In the same vein, another researcher proposed to found new institutions on a more co-operative basis, with an international team of divergent ages, skills and interests in order to secure mutual help and support. Drawing from past failures, the dream of a leading research scientist for a state-of-the-art scientific institution to come included sufficient money guaranteed for a decade through national, EU and industry contributions, but also for the research team. Such an institution should not do 'directed' research as often demanded, since this is considered a reason why some formerly respected institutions no longer exist. Basic research, accordingly, needs freedom for new ideas, and this is possible with industry contributions as well, contrary to a frequently held belief. A good example is the IMP: at first glance it appears enigmatic why a pharmaceutical company would spend so much money for seemingly no 'substantial' return, but there are advantages as it has access to new ideas long before they get patented or published. Thus, it could be a master-copy for other companies.

Basic vs. applied research: An outdated distinction?

Some scientists drew a sharp border between basic research and applied and therefore hardly 'true' research. Accordingly, any direction given, any lack of choice of what to do next leads to doing a 'job' and not 'research'. New ideas emerging as a fortunate by-product of other investigations would not to be expected as any applied research project has to stick with its target and has to be abandoned on command even if this is hard to accept for the researchers. Another differentiation introduced was that between 'curiosity driven' and 'medical driven'. While the former only follows the intentions of a curious scientist, the latter is out after a cure. Regarding objects, curiosity can be satisfied using organisms such as worms or flies, while medical interest has to use mice or human cells and is nearer to commercialisation and therefore more competitive.

Due to financial constraints, the boundary between basic and applied research is seen to blur. Without industry funding, accordingly, there would be no cutting edge research possible any more, and projects having been started as 'basic' often develop into an 'applied' one. In practice industry dependence varies from one group to the other, but in general it seems to be increasing, with a view to create long-lasting and stable co-operations between groups and companies. However, interviewees contradicted the view that there is hardly any distinction any more. Rather, basic research is still considered free in the sense that it sets its own goals. When cooperating with industry, it tries to confine its influence to the absolute necessary. Researchers still see themselves to define the issues provided they have the necessary skills and reputation, and they work within a traditional university or basic research laboratory setting. Joint basic and applied research, as it appears to be the standard these days, does not enjoy a high reputation among 'basic' scientists: for them, it is possible only if the commercial side confines itself to a narrow goal that plays a marginal role within the project. Hence, basic researchers actively keep the context in the form of both industry influence and societal desirability outside and only permit it to enter if they are able to tightly contain it.

Industry involvement entails communication constraints mainly due to patenting. Patents are a big issue today, but from our interviews the image of a mixed blessing emerges – patents foster research, but can be a nuisance. For commercial research, the patent situation is of course decisive. For scientists in any hot field, it is a main determinant to start or skip a project. For others, it seems to be virtually without any influence on the choice of a topic, particularly if there is little commercial interest. For example with basic plant research in Austria, there are patentable findings but no interest to exploit them, which provides research a relaxed setting. For most scientists, the situation seems to be something in between. For basic research, patents can be severe obstacles for the communication between scientific groups, for example at conferences. In daily practice however, many researchers still do not consider patents to be something important to bother with. In addition, a view on application is not seen as negative as such since ‘society has the right to expect something in return for their money’ as an interviewee put it – as long as it remains a by-product. And for the most part patents are still considered by-products only. One reason why patents increasingly play a role also in basic research, however, is the rhetorical commitment by public bodies to ‘strengthen the knowledge base of the economy’. In fact, some interviewees considered the official expectations on the number of patents (or even Nobel laureates) emerging from particular research programs to be ridiculously exaggerated and dangerously unrealistic.

In summary, the expectation that basic research is an outdated model cannot be confirmed at least regarding the self-estimation of researches, both in universities and commercial research labs. There are too many differences in the motivation and the way research is done in practice. Due to its success, basic research seems to gain ground again, which is in a certain contrast to the concept of a largely contextualised ‘mode 2’ science as postulated by Nowotny et al. (2001). Although the authors agree that traditional ‘mode 1’ research as a means in itself still exists, we got the impression that basic research more or less unimpaired by considerations of applicability or desirability is a much more vivid and powerful form of science than many would believe. It acquires its strength partly from being unpredictable – after all, a topical property in the post-genomic age of complexity.

Sub-project 2: Social Sciences Challenged: Genome Research in STS and Feminist Studies

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Background

Case Study 2 investigated how genome research is reflected within social science and technology studies. In this context, particular emphasis was placed on the feminist perspective. The analysis of relevant publications was performed according to Grounded Theory (Strauss/Corbin 1996). Core categories were chosen in several meetings with the entire POCO research group. Initially, we concentrated on indications within social science and feminist studies of a perception of increasing complexity in biotechnology. The categorisation of the feminist literature (Ratzer 2006: 43ff) revealed 13 different approaches and topics.

A comparative analysis of literature before and after 2003 showed that the pattern of argumentation got more complex indeed, however, this was due to more links drawn to related discourses rather than to existing discourses having become intensified and deepened. Over 2006 we widened our analysis, developed new categories and found causal and generic relationships between them using the technique of axial coding (Strauss/Corbin 1996). For example, the discourse on the boundary between nature and culture could be significantly valorised through the sociological paradigm of ‘instrumentalisation’ and ‘habitualisation’. (Berger/Luckmann 2000)

The first chapter of the final report presents an overview over current socio-philosophical discussions, where open and axial coding helped to analyse different views. Finally the found categories have been strongly organized in relation to the sociological paradigm of instrumentalisation and habitualisation (Berger/Luckmann 2000). In the second chapter the process of norm, as a second sociological paradigm (see Bahrdt 1992; Korte, Schäfers 1993: 17 ff), has been applied to the discourse of risk prediction in cases of genetic testing.

In chapter 3 the feminist discourse is explored. Because of the plurality of feminist debates a few discourses are presented exemplarily. The chapter closes with a summary of apparent discoursive changes as related to changes in genome research concepts and practice. Chapter 4, informed by the Social Construction of Technology approach, assesses the separate discourses of biotechnology, socio-philosophy and feminist studies. The many flexible interpretations and socialisation patterns produced point at genome technology to occupy the first stage of an innovation cycle.

Socio-philosophical and sociological perspectives on genomics

The reflection of genome research by social science started with the question how the bio-scientific inquiry such as human genome research pursues a perspective of a separation of nature and society. In this context of a ‘culturalification’ of nature, the ideology of eugenic becomes to be a basic theme, important enough for the valuation of the genetic revolution.

The social-philosophical view on genome research takes motives of innovation and possible consequences of technological progress into account. These themes are discussed through philosophical paradigms concerning the basic definition of human being. (see Sloterdijk 2001, Habermas 2002) The progressive development of genome research towards socio-technical application created a need to focus on the social consequences of the implementation of genetic artefacts. The first chapter is therefore structured along different forms of predicted instrumentalisation through forecasted applications of genetics.

Optimising the human species is generally seen as a basic intention of genome research. On a socio-philosophical level, this intention triggers discussions about the human being and his environment as a cultural artefact. Biotechnology is seen as blurring the boundary between nature and the human being. Authors such as Sloterdijk (2001), Habermas (2002), Berger and Luckmann (2000), Bowring (2003) and Wajcman (2004) critically analyse different relations and valuations of human genome 'tuning'.

Different critiques on attempts of optimizing the human genome can be wonderfully explained with the sociological paradigm of 'instrumentalisation'. This sociological paradigm is concerned with the socio-technical processes of intentional use of something or somebody in the interest of something or someone. (Berger/Luckmann 2000) Sloterdijk is a philosopher of central importance for the critical assessment of genome research in Germany. He emphasises that the human being is, among other criteria, defined by his ability to use and built tools and artefacts (Sloterdijk 2001: 59 ff.). He sees the intention to optimize the human genome as a logical consequence of this principle. For him, the human being is a domestic animal; therefore he proclaims that it is about time that humans apply the tools they made on themselves. He considers this to constitute a more reflexive domestication compared to the process normally happening via socialisation.

Also Habermas, who is normally considered to be an opponent to Sloterdijk, does not question the powerful impetus of biotechnology (Habermas 2002). In his interpretation of technology he gets close to a certain technophilia, but refers to moral arguments in worrying about citizens' rights and the questionable freedom of any artificially generated human being: is he/she a thing? Who is responsible for the results of the so far untested genetic programming of an artificial human being?

Any intention of use has to be defined before a genome is 'programmed'. Such intention could be, for example, to gain a body more power- and beautiful or resistance against psychological stress or a poisoned environment. Interpreting such ends, sociologists consider, for example, the aim to gain a beautiful body to be an expression of culturally personified fantasies. Klein (2000) argues therefore that this is to be considered an aesthetic instrumentalisation of the body. In times of mass medialisation of everyday life, genome technology is seen as just another tool to shape the individual body. Klein points out that with genome technology, the human flesh becomes institutionally formable not only by 'outer' but also by 'inner', i.e. injected technology. Artificial human bodies therefore are considered bodies of art. Interestingly, many authors do not criticise the application of genome technology for the means of beauty as such but refer to inherited values. Do individuals consciously choose values or is this a result of sub-conscious influence, maybe brought about via advertisements in order to increase global market-players' profits? (Bowring 2003; Hengstschläger 2003) The aesthetic instrumentalisation of the human body through genome technology is sometimes also considered a socio-political one. Berger and Luckmann (2000) describe how human beings are shaped and actively shape social norms and values over their whole life span. The socialisation process not only shapes beliefs and habits but also individual bodies. In the authors' view, material contingencies such as physical conditions are a source of social performance. With respect to genome manipulation the question is how this could individually pre-determine social performance. Or as Habermas points out, is a genetically modified person still a person, or is he or she a thing with special means to an end? This distinction is important as long as genetic modifications are unchangeable. Habermas emphasises that the societal assessment of genomics is not at all finished as genetic modification could become stigmatising. (Habermas 2002: 141 ff)

The eugenics movement considered genetic modification to optimise the human body as a question of social politics. (see Weß 1989) Based on ideas of Francis Galton, a cousin of

Charles Darwin, the main idea was to create healthy citizens in order to decrease governmental health care funding. Although eugenic ideas were influential in the U.S.A and in several European countries, it was during the national-socialist rule in Germany they took a lead through 'negative' eugenics. As is well known, persons labelled as Jews, antisocials, homosexuals, communists or disabled were murdered in order to create a fictitious 'healthy body' of aryan folk. In contrast, the idea of 'positive' eugenics wanted to create a healthy populace through indirect government measures. In a common good oriented way, the American scientist Osborn (Weß 1989: 46) demanded governmental funding of genetic research, sensibility for individual birth control and the bettering of everyday living standards as the only way towards a voluntary eugenic selection. The American version of positive eugenics viewed genetic health to be the basis for a healthy body and as such also a major precondition for good social performance. Both ideas of positive and negative eugenics are based on a conception of genes as strictly determining factors.

The question of determination is a fundamental issue in the social scientific discussion of genomics. The idea is based on the belief that in nature, causal one-dimensional processes are to the fore: any result has a causal relation to a particular process. This implies that it is not necessary to ask whether the outcome could have been achieved by other means or whether it has been influenced by other parameters. Pervasively, and remarkably, material expressions such as bodily performance are considered to be the only determining source for social action.

As a consequence, Bowring (2003) asks why to change human conditions at all – or is it in order to cope with an inhuman world? He argues that optimizing the human body at different levels jeopardises the impetus to revise bad cultural conditions or to stop the devastation of nature. For example, if genetic processes responsible for the development of some cancers are found, the remaining 95% of (social) causes such as wrong eating habits, unhealthy work conditions, stressful psycho-social attitudes are disregarded. Health care focuses on the body as a material and not as a living, social phenomenon.

In summary, socio-philosophic critics emphasise that the possibilities of genomics may reduce the human existence to its material body, and that this body may get instrumentalised not only as a culturally formed artefact but, ultimately, as a thing.

The second chapter reflects on the process of instrumentalisation in detail exemplified by attitudes to safety and risks in cases of genetic testing. Risk attribution is seen as a significant attitude in a special social relation, without the hegemony of normative habits and traditions. The finding of normative habits and traditions represent within the sociological paradigm of instrumentalisation a micro process.

Today, genomic research as the basis of an innovative technology is still in the process of searching for inherently typical features of genetic processes. So far, parallel social habits in dealing with products of applied genomics haven't been found. Reasons are reported to be the newness and the innovativeness of the technology. In order to develop habits one needs comparable settings of socio-technical activities in relation to genomics. For example, one needs access to collections of tissues, blood and saliva in order to identify representative typicalities of genetic performance. So-called bio-banks are said to offer the potential to establish genomic norms in scientific biotechnology (Wegerer 2005; v. Randow 2004). While the development of a socio-technical norm, to value and deal with genomics and products of genomics, is also achieved through a slowly gathering of individually gained experiences. Sociotechnical experiences which lead to representative models, significant enough to build normative social technique around. (Berger/Luckmann 2000)

As a side effect of the sociological normative processes of sociotechnical activities with (see Korte, Schäfers 1993: 17ff, Reimann 1991) genomics is the patenting of newly created artefacts. (Innovation urges not only new activities to be normed, but also things, which are newly used or newly created.) In the case of genomics for example newly extracted and objected methods and genes get the imprint of uniqueness, although the discovery is a matter of new technologies and sometimes may represent a new perspective on or approach towards already existing materials only. In case special techniques to gain a particular information is needed, the difference between natural thing and artefact becomes blurred. Ever since Latour and Woolgar (1979) and Fox Keller (1992) have analysed laboratory life, lab techniques have been considered a significant epistemological take of the world. Of course, sociology reflects this take in terms of power relations. Today, many authors (i.e.: Latour 1999, Collins and Pinch 2005, Klein 2000, Lösch 2001, Fox Keller 1992) criticise the laboratory to be a colonialist and capitalist institution. Using examples such as the Human Genome Diversity Project or newly implemented genetic testing methods for PND, authors related to the social science and technology field (i.e.: Strachota 2006, Sloterdijk 2001, v. Randow 2004, Hables Gray 2001, Bowring 2003) question power relations between stakeholders within biotechnology and those affected by their performance.

The Feminist Perspective on the Human Genome

In the following four of the 13 identified categories will exemplarily be presented to give an overview over some important debates on genome research and its impact on women.

General perspectives on the concepts of Nature

In many debates over genomics, arguments postulating a crucial change within predominant concepts of Nature play an important role. In the antiquity, Nature was seen as an everlasting and reasonable order that only man and man-made technology could imitate or influence. In early modern times, intended by the dominant scientific discourse, Nature was considered dead matter following the eternal laws of formal logic. Despite their differences, both concepts of Nature share the perception of Nature as a constant and unalterable factor (Weber 2003: 42).

Jutta Weber (2003) shows that these concepts have shifted and Nature is increasingly seen as alterable. For example, cybernetics in the 1940s and 1950s interpreted Nature according to concepts such as homeostasis and dynamic equilibrium. Inspired by theories of self-organisation promoted by researchers such as Maturana and Varela, the dominant picture in the 1960s and 1970s was that of self-reproduction and autopoiesis. With the rise of research on artificial life in the 1990s the focus shifted on emergence, evolution and complexity in the context of chaos theory and nonlinear systems. In the investigations on living Nature the aspects of innovation and unpredictability take centre stage while scientific research also wants to make non-deterministic complex systems calculable (Weber 2003: 197). Presently, Nature is mostly conceptualised as a self-organising program that can be improved at any time. Consequently, if organisms can be pre-defined by data processing, the option for optimisation through genetic or computer programs is self-evident (Fox Keller 1998, Haraway 1995).

Feminist Studies dealing with concepts of nature are numerous. Many argue with the shift and/or blurring of the boundaries between Nature and culture (Haraway 1994, 1995, 1997; Orland/Roessler 1995, Palm 1998, Scheich 1993). Already in 1980 in ‘Death of Nature’, Carolyn Merchant worked out the modern-scientific separation of Nature and culture, of object and subject and the equating of women with an understanding of Nature as a subject to suppression and exploitation by men (Merchant 1980). Also in current Feminist theory the authoresses stress that ‘the societal Nature conceptions and Nature conditions were and are in each case closely linked with gender conceptions’ (see Palm 1998: 148). In particular, the eco-feminism of the late 1980's and early 1990’s examined and largely denounced the exploitation and suppression of Nature, women and non-European people within a systematic power formation. While this feminist discourse increasingly lost influence, feminist theoreticians recently referred to parts of its argumentation (Ernst 2006: 99).

The development of science and technology from a feminist theory point of view exhibits a new quality regarding the elimination of the female sex. Departing forom the notion that those boundaries are eroding which were considered essential in modernity – boundaries between humans and animal, between machine and organism, between material and immaterial entities. The female sex, which in modernity was held for the creatural part of live and dying, birth and death, ‘… belongs now to what is to be abolished on behalf of the technological evolution. Culture is transferred into technology.’ (Becker-Schmidt 1999: 340; Scheich 1993, 1996, Ritter 1999). This conception is in particular represented in reproductive technologies. ‘The dominance of the artificial causes a considerable degradation of nature as a sign of the body and its limitations. In the denial of humans as bodily, sensual and emotional creatures women are cancelled doubly’ (Krings 2002: 16).

While the German-language feminist debate is dominated by ‘radical progress scepticism’ (Krings 2002: 7) with the simultaneous demand for abolishment of patriarchal gender relationships, the Anglo-American discourse reveals a much stronger technology-optimistic view. ‘To be unnatural, or act unnaturally, has not been considered healthy, moral, legal, or, in general, a good idea. Can ‘empty’ or ‘enterprised up’ nature continue to fulfil all these discursive tasks? Perversely, the answer is yes. Nature in technoscience still functions as a foundational resource, but in an inverted way, that is, through its artifice’ (Haraway 1997: 102).

‘We all are Cyborgs’ Donna Haraway proclaims. She sees cyborgs as hermaphrodite natures and an imagination dissolving the thinking in dualisms as it developed in the western civilization. At the same time she understands the new technologies as a radicalization of the scientific-technologic process, which entails further destruction and alienations. The informational and reproduction technologies play a specific role in this process since they translate the world into a codification system. Everything becomes text: codeable, readable and recordable (Haraway 1995: 51). Her „Cyborg Manifesto’ (Haraway 1991) requests women to take part in a responsible reorganization of the technical development.

We may conclude that in the feminist debate on Nature there are several discourse strands that do not get addressed by newer developments in genome research, in particular, the ‘disappearance’ of nature and the simultaneous devaluation of women, the meaning of a shift or even blurring of the boundaries of Nature and the meaning of the reduction of our world to a codification system.

Symbolic and practical meanings of reproduction medicine

Principal item of the feminist critique in the 1980s was a comprehensive social criticism, which particularly focused on the practices in reproductive medicine and the promises of genetic engineering. Main arguments were the criticism of international population politics and the alleged eugenic interest of the protagonists of genetic engineering. In particular, critics referred to enforced sterilizations in the south while at the same time reproductive medicine was intensified in the north. This was put against the background of a broad public debate over the threat of over-population on earth (Strobl 1991). Authoresses brought up for discussion a ‘misogynic armament character of the gene- and reproduction medicine’

(Riegler 1999: 148), and they insinuated a precarious connection between war, research and gender politics.

Until today feminists again and again referred to the fact that ‘the actual break-through of human genetics and reproduction medicine [succeeds] with the establishment of the atomic industry in the fifties. The warning of the biologists and geneticists before a genetic disaster by radioactivity did not lead to the prevention of the atomic program but to intensification of atomic and genetic engineering’ (Voss 2002: 124). ‘Rather we announce well-founded doubts to the helpfulness and benefit of techniques, which were developed in the context of power and suppression and are designed to work satisfactorily within this context’ (Salzburger Erklärung 2002). The question of a patriarchically designed reproduction control likewise remained an issue until today (Trallori 1990, Bock von Wuelfingen 2001).

The Primate of Economics

For quite a long time, scientific research has been confronted with criticism that it acts solely in the interest ‘of the powerful’. In particular in connection with (allegedly) risky technologies this criticism arises anew and even stronger, and the question ‘cui bono?’ is loudly placed. From the beginning of the debate, we can observe coalitions of feminist activists with other critical civic society movements in public debates on genetic engineering (Praetorius 1995: 157f). In accordance with particular sociological views on science and scientific progress the technology-critical positions of the 1970's and 1980's assumed that technologies follow their own development, which would entail inevitable consequences. This triggered a pronounced attitude of not to step on the ‘slippery slope’. Consistent with newer science and technology studies (see Felt et al. 1995), recent feminist positions also emphasise the network character and the institutional and personnel entanglement of technological systems with their environment(s).

In this respect, economically relevant actors play a very prominent role. According to feminist economic analyses, within genetic research we find exactly the same conditions to be found in every highly capitalised field of economy. Financially strong participants of a certain market use their position in order to influence politics. This again produces ‘including and excluding mechanisms that cause exploitations and ownership structures’ (Hofmann 2003: 40). In connection with questions of economic interests in genetic research the general suspicion is expressed that economic interests and those of women/patients/users do not necessarily coincide or even exclude each other. The observation that genetic diagnosis was often applied to originally not intended target groups fosters this suspicion and supplies practical examples for methods for the development of new sales markets.

Conditions for production and application of scientific knowledge

Many feminist theorists in the German-speaking countries emphasise power structures as being inherent to technology in principle. Many publications describe the so called ‘techno-patriarchy’ (Notz 1999, Cacioppo 2003). Following the feminist authoresses of three decades, knowledge production happens always within a specific context. Scientifically produced knowledge is the product of humans with specific interests in a historical and cultural situation. The selection of the investigation object is not arbitrary but is linked to certain problem definitions and a specific interest of realisation, behind which we find values and ideas. This criticism refers also very strongly to the fact that almost exclusively men were and are the ones to be the recognizing subjects and that it is only men who decide on the contents of science and technology (Kollek 2002).

Conclusion

Considering the categories compiled with regard to the central questions of this project – i.e. the implications of the increasingly complex findings from post-genomic research, and the growing awareness of complexity, in different parts of society – the following observations can be made:

- The vast majority of the feminist criticism on the Human Genome Research is not affected at all by current developments in the pertaining research fields as characterised in sub-project 1. This is especially true for approaches such as feminist ethics, feminist epistemology, feminist concepts of Nature, feminist debates on the autonomy of individuals, feminist critique of biomedical concepts of the body, discourses on 'informed consent' and the power relation between medical practitioners and patients.
- Only very few debates can be regarded as obsolete when considering recent scientific developments, in particular the debate on genetic determinism. Evelyn Fox Keller proclaimed a new paradigm in genetic research that radically undermined the primacy of the gene – both as a word and an object – as the core explanatory concept of heredity and development (Fox Keller 2002). Unfortunately, there is no end to the discussion of genetic determinism with respect to public debate and medial representation of genomics. So the feminist critique on genetic determinism is still topical when the discourse on genomics leaves the laboratory and enters the public arena.
- There is very little feminist literature that directly addresses recent developments in human genome research. At the same time there is a growing number of scientific reports concerned with the implementation of genetic testing and diagnosis into everyday medical practice.
- Recent feminist discourses themselves have to a certain degree generated growing complexity. This highlights the fact that the increase in complexity is of course not a singular property of human genome research but – with regard to ongoing debates in the social sciences – a characteristic of society in the beginning of the 21st century.

Genomics in the Reflection of Social Construction of Technology Theory

In a final step we applied the theory of social construction of technology (SCOT) (see Bijker and Pinch 1984) to relate the different discourses. Along the whole project it became obvious that different expert fields lead different discourses about genome research, and different stakeholders assessed genomics differently, for example. SCOT helped to put these differences into perspective. It claims that innovative technology in its first phase is characterised by many different and almost paradoxical interpretations. Several persons and groups produce nearly independent artefacts of a new technology, applied with different intentions and displaying different performances. The artefact proving successful is not only a result of brilliant material and technological performance; rather, it is also an outcome of the fruitful connection to dominant values and to members of powerful societal groups.

Actually, different groups and persons assess genomic technology and the human genome in particular very differently. The shared interpretations of genomic technology and the human genome have the ability to foster the formation of explicit or implicit groups. The interpretations also influence the kind of possible predicted and real uses. As a consequence of different possibilities of use, genome technology and the human genome develop different 'faces' or 'surfaces'. So the human genome is not a single thing or issue with an autonomous intention for existence and use but an artificial tool and instrument intended for different existences and use in different hands. Which hands to which means and ends? SCOT proclaims that a consensus of assessments of use between stakeholders of an innovative technology also leads to a ‘consensus’ of the artefacts, with the consequence that the initial multiplicity of innovative artefacts decreases. Actually in genomic technology, there was a consolidation of research units and biotechnology companies to be observed. This can be taken as an indication of a closure mechanism, which according to SCOT initiates the second phase of innovation.

Sub-project 3/4: Meeting the Public: Perception of Complexity in the Post-Genomic Era - a Stakeholder Survey in Austria

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Introduction

Progress in fundamental bioscience research – including the Human Genome Project - in the fields of genomics and proteomics as well as systematic approaches to various other '-omics' has contributed to an increase in complexity (Levine/Tjian 2003) as well as to an erosion of long-standing paradigms (see also sub-project 1). Thus, in communicating biosciences, stakeholders have to deal with a 'new' complexity. Our starting point is the hypothesis that changes in the cognitive and institutional frameworks of post-genomic science accompanying changes in the relationship between natural scientists and the public. Sub-project 4 was aimed at analyzing and comparing various stakeholders: on the one hand, students in the role of lay people; on the other hand, journalists, teachers, public relation officials and members of non-governmental organizations (NGOs) and scientists in the role of multipliers. We focused on four aspects: the perception of complexity and changes thereof (1), the transfer of scientific information to the public, i.e. the translation process (2), factors influencing communication (3) and stakeholders' perception of themselves and others (4).

Methods

The research work was carried out in a consecutive sequence using media analysis (MA, see Tumpej, in prep.), a survey with 918 participants (questionnaire, QU, see Schmidt/Wei 2006) and focus group discussion (FGD) (see table 1 for details on survey participants). As a first approach to the perception of complexity in gene research in the media, a content analysis of the Austrian media was performed. MA aimed at showing the extent to which Austrian media cover the topic of gene research and how they illustrate its complexity and if and how the reporting on topics of gene research changed since 2005. The results of the MA had implications on the development of the survey instrument (QU). The questionnaire was comprised of an introduction explaining background and aims, a general part addressing the perception of complexity, the self-perception of interviewees and their perception of others, and on information policy and trust. In addition, there were specific questions for each stakeholder group covering their working conditions and experiences and on the participants' socio-demographic variables. FDG was performed last. It aimed at a qualitative analysis enabling further interpretation and explaining group differences of the survey's results. For more information on MA, QU and FDG, see the appendix.

Table 1: Number and main characteristics of stakeholders participating in the survey.

subgroup	n	% of total	Mean age	SD age	% female
Students	545	59,4	26,0	5,2	57
Scientists	184	20,0	33,9	9,3	54
Teachers	114	12,4	47,5	9,1	60
Journalists	27	2,9	38,0	10,7	48
NGO-members	27	2,9	26,6	4,8	78
PR-representatives	21	2,3	28,3	7,3	57
Total	918	100	30,6	10,0	57

Results

‘Gene research’: definitions and important results.

MA showed that terms such as ‘post-genome’ and ‘genome research’ are used only rarely in media reports and thus are supposedly not familiar to the public. Therefore, we chose the term ‘gene research’ to be used in the questionnaire in which we gave the following definition: ‘Gene research means research in the fields of the life sciences, of gene technology, biotechnology and genome research as well as applications developed from it.’ FGD participants confirmed this definition. Medical gene research, with its enormous potential for invoking empathy, is at present most prominent in the Austrian media, whereas interest in other fields of gene research such as genetically modified organisms, cloning or stem cell research has decreased drastically within the last five years. We conclude that topics need outstanding news value, a controversial debate and/or a strong medical reference to acquire press coverage. Gene research obtains press coverage mostly in the context of ‘research’ and ‘benefits’, followed by ‘medicine’. Compared to the year 2000, aspects such as ‘research’, ‘ethics’, ‘benefits’ and ‘economics’ lost overall attention in 2005. In comparison, survey data show that most respondents considered ‘natural scientific’ and ‘medical’ aspects to be the most relevant. Other aspects such as ecological, legal, economical, social and political aspects found less attention. However, this differs significantly between the groups. While scientists mainly focus on medical and natural scientific aspects, NGOs and journalists also seem to rate social, political and ethical (NGOs) aspects as highly relevant.

1. Perception and understanding of complexity.

Coverage of gene research in the media could result in better public understanding in the long term. However, it holds the danger of simplification or even misinformation. Reports present research results as punctual events; they use simplifying metaphors (see details), tend to present results uncritically and suffer from a lack of contextualisation. Nevertheless from 2000 to 2005, we observed a general increase in efforts to communicate complexity in gene research, although MA showed that the term ‘complexity’ is rarely mentioned. More often, complexity is expressed indirectly by criteria such as ‘time’, ‘environment’, ‘actual limitations to knowledge’, ‘potential incorrectness of research results’ and by the ‘number of experts cited’.

Genetic determinism seemed to decrease in the years 2000 to 2005. As MA shows, nature (i.e. genes) as a shaping factor was still considered to be the most important subject in 2005. However, environmental factors are taken into consideration more frequently compared to 2000. Although QU identified various degrees of determinism, many metaphors related to genetic determinism (offered within QU) were considered of little relevance.

Associations with the term ‘complex’ enable interpretation of the different perceptions of gene research and its complexity among stakeholders. Rather than ‘complicated’, which in daily use is often applied instead of ‘complex’, the (neutral) associations ‘interlaced’ and ‘multilayered’ were considered the most suitable descriptions. These descriptive, structural terms can be associated with network theory (Barabasi 2002). We conclude that complexity is not predominantly perceived as a limit to controllability of a system in the way the reflexive modernization approach would suggest (Beck 1999, Giddens 1990). Rather, complexity is perceived as a factor that makes a system more difficult to control; control is best achieved by a network-style approach. Also complexity is not supposed to lead to an increase in uncertainty.

Time scale: We intended to learn if and how respondents perceive changes in the complexity of five different key research fields or technologies (quantum research, climate research, gene research, brain research, internet/computer) over time. The respondents rated their view of the changes from 1990 to 2005 and from 2005 to 2020 from today's perspective. The results were quite similar for all stakeholder groups. All fields are perceived to have become increasingly complex up to now (with the exception of 'internet, computer') with the largest increase in climate, gene and brain research. For 2020, all stakeholder groups expect gene research to range somewhere between complex and very complex. Thus, gene research is not perceived by all respondents at the highest complexity level. Also, gene research was not rated significantly different than quantum research, climate and brain research). It is hard to explain why people now believe, that within the next 15 years complexity will remain at the same level or even decrease in all fields. In contrast to QU, some participants in FGD (natural scientists, teachers) actually expected a further increase in complexity in the future. To explain the discrepancy between this perception and the survey results, we assume that respondents associated 'complex' with 'complicated'. For them, being even more complicated is not imaginable. Another reason may be that media reporting hit its peak in 2001 with the publication of the human genome (International Human Genome Sequencing Consortium 2001, Roberts et al. 2001), and has dropped since then. Finally, strategies of science communication have changed over recent years. Not only are scientists today more inclined towards transparency, but also the presentation techniques have improved, for example, by the inclusion of diagrams and graphic illustrations, suggesting a better understanding.

The stakeholders' judgment of themselves being able to actually *understand complex relationships* in gene research showed pronounced differences among respondents. We see a tendency to rate one's own peer group as being particularly high, especially among NGO activists and journalists. In contrast, the general public is perceived as understanding complex relationships the least, followed by politicians. Especially students and NGO activists consider physicians as understanding very well. Not surprisingly, scientists are identified as the group with the best understanding of complex relationships.

2. Translation of scientific information to the public.

One of the survey's main aims was to explore the perception of other groups as well as of one's own peer group. The following aspects were rated: source of information, trustworthiness, the ability to explain gene research in a comprehensible way and the capacity to understand complex issues in gene research. The results revealed considerable group differences.

Sources of information: MA shows the Austrian Press Agency as the most important source of reporting on gene research in the Austrian media. Experts are an important source in longer articles. According to our MA, scientific journals are used very rarely (quality press) as information material. According to QU, the most important source of personal information on gene research are scientists, followed by the media (journalists) and medical doctors. Politicians, industry and patient organisations come last, environmental organisations are somewhere in-between. For scientists, journalists and NGO actvists their own peer group is the most relevant source of information. According to QU, stakeholders use different tools and materials to gather information. Scientists use the internet and scientific publications the most, newspapers or magazines, TV and radio the least. Journalists frequently use press releases, press conferences and professional information centres. Teachers use all kinds of sources with a similar frequency, but slightly prefer the internet and specialized books. In this analysis, NGOs were found to rarely use one of the information sources mentioned above particularly often. Only newspaper and magazines were used occasionally. Overall, it seems that homepages and books with acceptable quality as well as articles offering in-depth analysis and scientific lectures were available sufficiently. In contrast, more discussions (discussion rounds) with experts could be offered. A real need was diagnosed by most respondents for an increase in exhibitions and films on gene research.

Comprehensibility of the information: Comprehensibility of information provided by various stakeholders is rated in QU highest within one's own peer group in the case of scientists, journalists and NGO's. It is rated significantly lower for other peer groups by these stakeholders. No stakeholder is judged to present complex information in a highly comprehensible manner nor in an incomprehensible manner. According to FGD, media are generally rated to not understand and also to not present complex issues very well. However, participants in FGD claim that journalists may know more than they actually publish. They are forced to present facts in a sensational way (see results of MA), so misinformation might result as a consequence. However, misinformation may also result as a consequence of the scientists' behaviour as shown for example in the case of the Korean researcher Hwang, who published even falsified data recently (Pincock 2005). QU shows that complex issues are rarely presented comprehensively. This underlines the need for improved communication. Respondents want to be exposed to activities such as discussions, exhibitions and movies (QU).

Trust in stakeholders: There are large differences in the level of trust in one's own peer group (high, especially NGO's) and other groups (low). All respondents judged scientists to be the source of the most trustworthy information. Physicians are ranked second (exception: rating of the journalists), followed by environmental organizations in the third place. In general, there is much trust extended towards scientists even though, according to QU, scientists believe, that the public does not trust them very much. According to the FGD, 'trust' has more than one meaning. This may explain the divergent perceptions. Thus, public trust could refer to the scientists' knowledge and to their understanding of complex facts. However, it may not include trust in how scientists interpret these facts and which conclusions they reach. The latter goes hand in hand with uncertainties and unfulfilled expectations, which scientists experience in their daily life in the laboratory. Scientists are aware of the importance of uncertainties. In contrast, journalists want a 'story' without uncertainties.

3. Factors influencing communication.

Scientists: QU shows that scientists mostly appreciate precision. Entertaining (Edutainment) is seen as the least important component in a discussion. In the view of the scientists (QU), the broad public is interested in how genetic research works and that it should be involved more in discussions. Scientists on the other hand do not seek discussions with lay people and are even less interested in contacts with journalists. They are ready to communicate with high school students and/or teachers. Participation in policy counselling is the least popular form of communication among scientists. Scientists view an increase in basic knowledge among lay people as a prerequisite for successful communication with the public (FGD), whereas other stakeholders warn against the expectation that more knowledge would automatically results in higher acceptance. This is supported by recent developments in science communication away from the previous concept known as 'Public Understanding of Science'. Indeed, the so-called deficit-model (if people had more knowledge, they would understand better) is out-of-date by now, and a new citizen oriented science and contextual approach might replace it (Conein 2004). Scientists are convinced that the public should not be involved in political decision making on research funding. FGD revealed the arument that basic democracy is also not applied in other fields, as for example cultural funding. The interviewees state that they would intensify their engagement in public understanding of science if they had more time, more money, if they were already better established in the scientific community in terms of their career and if they were better prepared for media relations. Approval from their superiors or colleagues is seen as less important for engaging more in science communication.

Teachers: Gene research is seen as an important topic (FGD). Students are very interested because these topics involve them personally or can be very spectacular. Since gene research includes scientific, ethical, social, economic and political aspects, it is best suited for project-based learning. Therefore, teachers are recommended to choose topics which deal with ‘real life’ and which are up-to-date. Topics of gene research have a high need for hands-on tuition in class. Teachers criticize that basic conditions for doing experiments are sub-optimal and restrictions with regard to time and curriculum are high (QU). Thus, topics of genetic research cannot be integrated adequately into the course program (QU), and daily school life does not sufficiently allow an interdisciplinary way of working and project based learning. According to FGD, it seems that teachers have more freedom than they believe. Thus, they could focus on gene research in class, if they wanted to. Teachers believe that they themselves understand complex issues very well. However, teachers lack confidence to approach scientists.

The survey resulted in a smaller number of participants from the following three stakeholder groups (details see in appendix). Therefore we considered those results as mere trends and tried to back up the with results from the media analysis as well as the focus group discussion (see topics 3.2 and 3.3)

Journalists: The interviewees seem to address in a rather detailed way the issues of difference in expert opinions, provisional value of research results, possible applications, social effects and long-term aspects (QU). The legal situation, economic aspects and scientific details are considered to a minor degree. Among the factors influencing the choice of topic for a media publication, the most important ones are: being up-to-date, time, up-coming political decisions, access to sources and specific applications. Factors such as one’s own knowledge, personal interest, current events and editorial freedom were considered to be only partly important. Surprisingly, factors such as information manuals, reference to Austria and other media reports are negligible. Media reporting aims more at entertainment than at education.

Non-governmental organizations (NGOs): The NGO-stakeholder group was very heterogeneous: representatives from professional themes such as environment, globalization, social sector, health and other were included. Environmental NGOs rate themselves to be very competent in complex issues (QU). According to FGD, this can be explained by the complex background of their activities. Otherwise they could not fulfil their mission and would fail. Self-help organisations are generally less trusted. This seems to be due to lack of awareness of these groups. All self help-groups aim at raising awareness with regard to their requests but not all of them are well known. There are noticeable differences in publicity depending on the persons representing them. Their ‘recipe’ for ‘good communication’ of complex topics is very similar to the job-description of a NGO-member, according to NGO representatives. It has to be comprehensible, independent, objective, critically, balanced and personally addressing. The language used in successfully communicating complex issues is characterized as simple, connected to the every-day life and working with examples.

Public relations representatives: The interviewees from public relations (PR: marketing, research) describe a text that is communicated effectively as one written in a clear language. The content should be reduced as far as possible according to the listener’s needs, and illustrated with pictures. Nevertheless, the PR-group hardly gave examples for particularly successful communication of a complex content. According to the PR-group, communicating scientific knowledge needs an appropriate language, which should be simple and clear, emotional and illustrated by pictures – again the interviewees specified criteria that are typical for PR-language. As it is the case with the NGO-interviewees, the PR-interviewees recognize a deficit in communicating uncertainties in gene research within their own group.

4. Perception of self and others

Having a closer look on the results regarding stakeholders as information source, trust in these stakeholders and the alleged capability of these stakeholders to understand and communicate complex relationships, three respondent groups are of particular interest: scientists, journalists and NGO representatives. These groups seem to have substantial misrepresentation of their own groups´ capabilities.

- Journalists, scientists and NGO representatives received much more information from their peers than other groups did.
- Journalists and NGOs believed their own peers to be much more trustworthy than all other respondents believed.
- Journalists and NGOs also believed their own peers to be much more capable of understanding complex relations, and
- scientists, journalists and NGOs believed that their own peers are more able to comprehensively communicate issues of gene research than other respondents thought they can.

In summary scientists, but especially journalists and NGO representatives seem to consistently overestimate their own (peer's) capabilities. The difference in respect to the image they have of themselves in comparison to the image others have of them is particular striking in the case of journalists and NGO representatives. For example NGO representatives believe that they are nearly as trustworthy as scientists are, but other respondents saw great differences in the trustworthiness of these groups. Also journalists and especially NGOs believe that they may understand the complex relationships in gene research nearly as well as scientists do, but again they are alone with this point of view. What explanations could be provided for these different perception? The following hypotheses come to mind:

a) The questionnaire respondents do not fully represent their groups (journalist, NGO) due to respondents self-selection

b) The judgement of their own group is influenced by the judgement of themselves as an individual.

c) The overestimation is an effect of ignorance, combined with the wish to influence people.

d) Some stakeholders experience a cognitive dissonance between their tasks and their skills, leading to choice supportive bias and a mild form of confabulation.

e) The stakeholders do not agree which kind of knowledge is important, leading to different assumptions of expertise.

a) Respondents self-selection: Sometimes self selection is known to affect survey work especially when the issue is a highly emotional one or fits into the particular worldview of some people (e.g. GM food surveys in the UK, see Spence/Townsend 2006). There is, however, one argument against this hypothesis, namely that self-selection interferes with survey work in case the survey is intended to represent 'the general public' which was not intended in our work. A journalist and a NGO member have self selected themselves to become a member of this group for a variety of reasons. These reasons together with their work experience make up the individual as a part of its group. There is the first self-selection of the person to become member of the group and there is a second self-selection to participate in the survey. A survey that is trying to depict the general public generally wants to avoid the first kind self-selection (e.g. too many students, to many women). But as we were interested in particular groups we would only have to deal with the second kind of self selection which is probably much less of a problem than the first kind. It cannot be ruled out that the overestimation effect is a consequence of a second kind self-selection but there is no strong indication for it.

b) Judgement of groups and individuals: It is known that people explain intentional actions performed by groups differently from actions performed by individuals. Two explanation modes are used: (i) the agent's reasons (beliefs or desires in light of which the agent decided to act) and (ii) causal histories of reasons (factors that preceded and brought about the agent's reasons). It has been suggested that people use more causal histories of reasons explanations when explaining group actions than when explaining individual actions (O'Laughlin/Malle 2002). This effect could have influenced the self-judgement of some stakeholders, as they judge other groups mainly as groups, but judge their own group both as group and on an individual basis.

c) Overestimation and ignorance: Harry Collins has stated that '[D]istance from the cutting edge of science is the source of what certainty we have' (quoted in MacKenzie, 1990: 370) arguing that there is an inverse relationship between the level of certainty attached to any particular scientific construction and proximity to its site of construction. This refers to the observed tendency for the acknowledgement of ignorance and uncertainty to diminish in the intermediate domain between the forefront of research activity and its broader public dissemination by intermediary information spreader such as journalists. The intermediate domain in this so-called 'trough of certainty' (MacKenzie, 1990) is precisely the region where the body of knowledge tends to be most intensively employed as a basis for action. This is certainly the case in the use of sciences such as climatology, toxicology, genetics or ecology in the regulatory appraisal of technology. In other words, it is precisely where the stakes are highest that the uncertainties and ignorance (lack of knowledge) tend to be most strongly understated (Sterling 1999). The 'pretence of knowledge' of experts and its misuse to influence and manipulate lay people, politicians, civil servants and the public in general, has already been lamented by the economist Hayek in his Nobel acceptance speech2 (Hayek 1974). In a recent study by M. Lahsen (2005), investigating climate modelers' perceived accuracy regarding their own models, a distinction between modelers' public and non-public representations was found. 'The distinction implies that in their interaction with external audiences, modelers at times downplay model inaccuracies because 'they are interested in securing their authority'. This framework needs to be stretched further to account for limitations in modelers' ability to identify such inaccuracies, limitations that may arise from a combination of psychological, social, and political factors' (Lahsen 2005, italics added). The pretence of knowledge, the attempt to influence people, the interest in securing their authority and limitations to identify inaccuracies of psychological, social, and political factors are characteristics that could be transferred as well to at least some journalists and NGOs (as well as to some scientists). In reformulating one of the sentences above to the results of this study one could say: '….it is precisely where the stakes are highest that trust (social

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[2] Hayek even asked for a sort of hippocratic oath for experts, never to exceed in public pronouncements the limits of their competence.

status), the ability to understand (pretence of knowledge, authority) and the ability to communicate (influence) tend to be most strongly overstated.'

d) Coping strategies: Is it wishful thinking - a coping strategy - that creates the illusion to fulfil all necessary requirements to be successful in influencing people? Asked in another way, do journalists and NGO activists have to overestimate their own competence and skills to become an established journalist and NGO activist, or do they overestimate it from an ex post perspective? Maybe someone who doesn't overstate wouldn't be happy in telling stories to so many people knowing that she or he is not capable of doing so? In the FGD discussion it was stated that 'environmental groups have to believe that they are competent, otherwise they could not fulfil their mission and would fail.' We might ask which one of the following two options is more plausible: Environmental groups do not fail because they are competent, or Environmental groups believe they are competent because they don't want to fail.

Although both options might be true in one or the other situation, the second one appears to be a highly interesting one. There is a large amount of literature on the psychology related to the confusion of cause and effect. Without going into much detail the possible explanation models are at hand, e.g. confabulation and choice blindness (e.g. Hirstein 2005, Schnider 2005, Johansson et al. 2005), cognitive dissonance (see Festinger 1957), attribution theory (see e.g. Heider 1958), self perception theory (Bem 1967, Bem 1972), choice-supportive bias (e.g Mather et al. 2000).

e) Different kinds of knowledge: Another reason why these stakeholder judged themselves differently from the rest, could be that they actually have a different meaning of 'gene research'. Scientists mainly associate natural scientific issues, whereas journalists and environmental groups also focus strongly on ethical or environmental issues. Scientists talking to NGO members (or journalists) see themselves to be in the expert area, while they assume NGO members (or journalists) to be in the blind spot area (see figure 1). But from the point of view of NGO members and journalists, they would be much closer – in terms of understanding - to the scientists, somewhere between the common and the expert area.

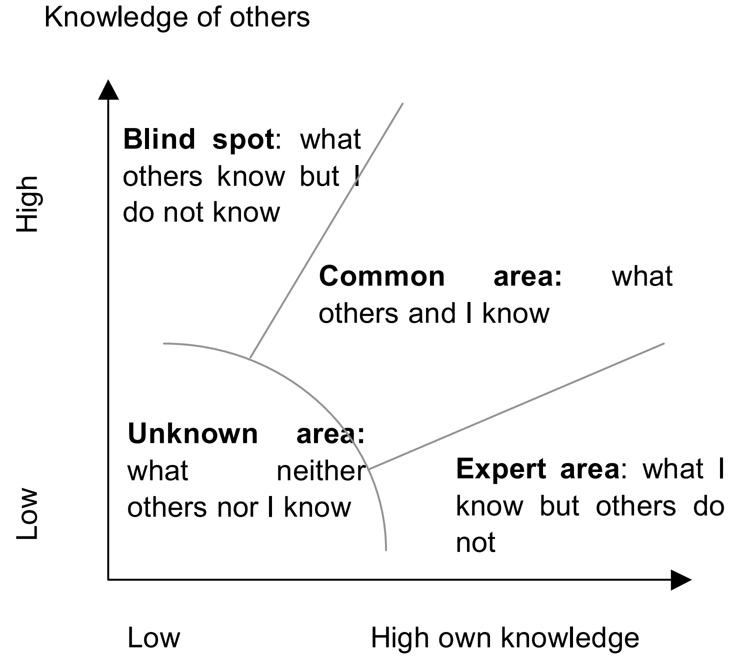

Figure 1: Different degrees of knowledge of others and oneself about a specific issue, lead to regions of common knowledge, expert areas, unknown areas and blind spots.

The public holds natural sciences in high esteem compared to other fields such as social sciences, economics or politics (Eurobarometer 2005). The question of being accepted as an expert or not may be a key issue for future debates and participatory approaches on gene research and its applications.

Summary

Network theory: Complexity in genome science is associated mainly with network characteristics (multilayered, interlaced) towards higher interrelatedness between its parts (genes). Increase in complexity is not perceived as an increase in uncertainty or a decrease in controllability. This finding is in contrast to what the theory of reflexive modernization (Beck 1999, Giddens 1990) would predict.

Just another science: It is generally assumed that complexity in gene research has increased during the last 15 years, similar to other cutting edge science fields. Though, publication of the Human Genome does not seem to have 'boosted' the perceived complexity in genome science particularly. A further increase in complexity is not expected in the next 15 years.

Perception of self and others: Actors such as NGO activists, science journalists and scientists perceive their respective skills and characteristics differently themselves than other groups do. These actors tend to overestimate their own skills and status in society probably due to some well-known psychological effects (e.g. cognitive dissonance, confabulation) or to different evaluations concerning scientific and other aspects. The underlying constraints should be addressed be improve inter- and trans-disciplinary communication.

Need for new communication tools: In addition to existing written information, there is a demand for discussion rounds with experts, (hands-on) exhibitions and (documentary) films.

Doctors and patients

A similar picture emerges from a part of the POCO project that dealt with attitudes of medical doctors and patient groups. Due to problems already mentioned this part of research could not be completed in the way it was originally intended; nevertheless, we arrived at some conclusions.

Genetics as applied in current practice mainly focuses on (rare) monogenic diseases dealt with by specialists but in the future, general practitioners are considered to provide certain genetic counselling services. Personalized genetic risk assessment is predicted to constitute a part of a holistic, patient-oriented primary health care, for example detecting and managing the risk of multi-factorial disorders, genetic reproductive risks or in focused drug therapy. As well as various medical specialists, general practitioners, too, seem to recognize that genetics will be relevant for their daily practice. However, previous investigations have established that a lack of confidence in their ability to apply genetic approaches will lead to problems. Watson et al. (1999) investigated how general practitioners (GP's) deal with 'new genetics'. They found that although GPs perceive genetics as increasingly relevant, they lack the necessary skills, have no time, money or shy away from ethical or legal concerns.

We tried to do telephone interviews to investigate how GPs and various specialists perceive the practical changes to their work brought about by 'modern genetic research'. We telephoned a random sample of 60 GPs and specialists; however, only 9 were willing to talk, most of them elderly. More than half (mostly GPs and gynecologists, other specialists were slightly more responsive) argued that 'genetic is not relevant' to them. Genetic relevant topics hardly seem to pop up in the physicians´ practice, and given the time pressure genetics is of little importance. Those few who responded, however, considered genetics to be increasingly relevant in their practice, although patients rarely seem to ask about it. About half of the interviewees did not consider the latest research findings to be significant for their practice. Representatives of five relevant patient groups interviewed confirmed that counselling is always done by particular specialists and GPs do not play a role. The most important criteria for good counselling, accordingly, are simplicity and individual care-taking; a general complaint is that comprehensibility could improve, although more than half of the patients seem to already have some knowledge when they receive counselling. Information mostly comes from the internet and from radio, a source also physicians appear to use. Interestingly, self-help group people seem to trust more in information provided by scientists than by physicians. Taken together, it seems a long way before insights from genomics may find their way into the daily practice of general practitioners and other medical doctors seeing many patients a day.

Sub-project 5: Public Perceptions of Complex Technology

Wolfgang Wagner, Nicole Kronberger, Univ. Linz

Background

Contrary to traditional assumptions of public understanding of science studies, recent research has shown that scientific information being communicated to the general public undergoes a transformation process. The review of this literature suggests that scientific knowledge is not transmitted unchanged from scientific to public contexts. Rather, when entering the public sphere such knowledge is transformed according to the needs and rules of everyday reasoning. Aiming at a better understanding of such processes, we planned a series of studies dealing with a number of aspects concerning the public perception of modern genomic science, and more specifically with everyday coping and collective sense-making with regard to the technology's complexity. Everyday thinking contrasts in a number of ways from expert reasoning. More precisely, sub-project 5 has picked up three aspects of everyday thinking that merit special attention: perceptions of monstrosity (work-package 1), the role of information seeking (work-package 2) and of metaphorical and imaginative reasoning (work-package 3) in the context of complex technology.

Genome research: seeking contexts for everyday reasoning

In the work-packages of sub-project 5 we chose specific applications in the context of genome research in order to investigate public understandings of and responses to these developments. More concretely, we analysed everyday understandings in the context of genetic hybrids and embryonic stem cell research. We decided not to ask everyday people directly about the genome because we expected that this would result in exam-like memorizations on what was ever heard on the genome. Thereby, it would not come as a surprise that lay understandings do not correspond to expert understandings very much. The public cannot be expected to closely follow all the discussions and developments within genome research and to be as aware of the scientific community's view of increasing complexity of the object of research. People in everyday life are subject to a 'pragmatic imperative': neither do they have the time nor the resources to learn about scientific findings in detail. What they need to, however, is to know how to behave if confronted with such innovation; they need to form a rough idea about whether such developments imply beneficial or dangerous consequences for them, whether to approach or to avoid the new, and how to talk about it in an everyday setting. Consequently, such developments only become relevant to the public if they concern everyday life, routine practices and communication.

If specific applications become part of modern life, however, and if they need to be symbolically coped with, then implicit understandings and ideas of the genome and its workings do play a crucial role. Thus, in sub-project 5, we investigated the public perception of the genome 'in context', addressing representations of the genome via the backdoor (in the form of concrete applications of genome research). For example, thinking about genetic hybrids involves ideas about the workings of genes, genetic transfer and the role of the genome, respectively. Work-package 1 showed that the genome is thought to be associated with the idea of 'essence', where a fish genome is related to fish essence, and a human genome is related to human essence. Consequently, genetic transfer from one living being to another questions our most fundamental categories of perception and reasoning, such as those of natural kinds and living beings. The reaction to this confusion often comes in the form of an affective reply, classifying the hybrids as dangerous and monstrous. In workpackages 2 and 3 we referred to embryonic stem cell research. This application was chosen because at the time of the project start this development was both relatively new to the public and discussed controversially, and because it implies strong value judgements. Research on the uses of the genetic information of embryonic stem cells is of great interest to medical research, but also tied to the idea of the embryo. Consequently, genetic information always is thought of both in an abstract and in a concretized form: genetic information can only be accessed and used in the form of concrete living entities (it always is the genome of a living being). Concrete living beings thus are seen as the carriers of the genome, and images of such genetic information (either as material or as carrier of humanness, for example) play an important role for support of, or opposition to scientific developments.

Overview on Activities

During the first phase of the POCO project the conceptual and methodological framework of the sub-project was developed. Based on a thorough literature review and discussions in various workshops within the POCO team and among the researchers of sub-project 5, the research questions were refined and concretised. During the second phase of the POCO project the main focus was on data collection and data analysis with regard to the three aspects of everyday coping with complexity mentioned above and described in more detail below. During the final project phase we finalized the data analysis and wrote the report.

In the following, research questions, research activities and key results are presented for each of the three workpackages.

Workpackage 1: Monstrosity perceptions

Research question

Earlier studies revealed that in everyday imagination genetically modified animals frequently are attributed monstrosity (Wagner et al. 2006). But what makes people imagine hybrids as something threatening and menacing? What role do everyday expectations concerning the genotype – phenotype relation play? What are the sources of monstrosity perceptions?

Activities

In order to disentangle these questions concerning monstrosity perceptions, a systematic two factor experiment with 192 lay people was conducted. Respondents first rated two animals on a number of adjective polarities and then used the same polarity scale to rate the genetic hybrid. This research connects to previous work of the authors. In addition, it was possible to win research partners to conduct the same experiment in Japan and in India during the POCO project timeline. The results are presented in detail in a journal article that currently is under review (Wagner et al., submitted).

Results

The results show that people tend to categorize animals as if they had an immutable 'essence' defining kind membership. In psychology 'essence' is understood as a placeholder term that stands for one or more 'subsurface' properties that are causally responsible for observable features of members of a kind. The term 'essence' allows assuming deep-seated properties even if people do not know exactly what these properties are. In modern societies, the idea of essence is increasingly addressed in terms of genes and the genome. It should be noted however, that essentialist thinking, both occurring in children and adults, has been part of human reasoning well before the age of biotechnology and not necessarily needs to be connected to thinking in terms of genes.

The psychological advantage of thinking in terms of 'essences' is that by treating living beings as having an innate and non-obvious basis, it allows drawing inferences concerning category memberships and boundaries between such categories: a fish, for example, being characterised by its specific essence of fish-ness, can be expected to act and behave like a fish. Genetic hybrids matching the genome of different beings, in contrast, lead to a 'category crisis' in that long held expectations about the essence of members of clearly separated categories can no longer be taken for granted, leading to a primarily emotional reaction, the 'monstrosity response': Hybrid animals as the result of genetic modification are perceived to be uglier, more dangerous and less pure than their parents. We interpret such affective evaluations as the expression of 'monstrosity perceptions'.

Hybrids are imagined to be dangerous and frightening, regardless of what is the evaluation of the original animals. Monstrosity is perceived highest for hybrids resulting from genetic combinations across kinds, medium for within-kind hybrids, and lowest for within-species hybrids. It is also higher for hybrids from parents with mismatched capabilities (e.g. swallow-trout hybrids, mismatching the associated capabilities of flying and swimming) than it is when the parents' capabilities are for roughly the same habitat and activity (e.g. penguin-trout hybrids, both associated with the capability of swimming). The results hold for Austrian, Indian and Japanese adults and across a wide range of animal kinds including humans. The findings emphasize that if essence is perceived as being modified, cognizing animals also involves evaluative and affective responses, which hitherto have not been assessed in science and technology studies.

Workpackage 2: Information search in everyday life

Research question

How does opinion formation on technological innovation occur in everyday life? Lay people often lack textbook knowledge on technological innovation since such developments are complex and were not part of the school curriculum at their time. Furthermore it is hardly realistic to expect people to study all technological innovation in detail. But people nevertheless do make up their mind and form an opinion. But what is the information that people use to evaluate complex technology? What pieces of information do they regard as relevant? Consequently, we asked what information people are interested in when being hard-pressed to form an opinion on a comparatively new development, such as embryonic stem cell research.

Activities

This line of research made use of the method of active information search (Huber et al. 1997) which allows following up processes of opinion formation and of everyday evaluation. The topic of embryonic stem cell research was chosen since it represents a contemporary controversial issue. In a first step, pilot interviews with ten lay people were conducted in order to compile a list of typical questions on this issue. In a next step interviews with 32 lay people were conducted in public places such as in cafes, at the train station, etc. The core of these interviews was to ask people to imagine that next Sunday there was a referendum on embryonic stem cell research and asking them to make up their mind. More precisely, they were invited to choose questions from a list for which they then received prepared answers. The elaboration of these answers occurred in close collaboration with dialog<>gentechnik in order to assure the scientific accuracy of the presented material. The interviews were recorded, transcribed verbatim and in-depth analysed. The analysis aimed at identifying patterns of information search and opinion formation in the context of the evaluation of complex and modern technologies.

Furthermore, we had the chance of collaborating on the development of the 2005 Eurobarometer survey on modern biotechnology. This allowed for an unexpected chance to follow up the issue of information search in more detail and to determine how representative our initial findings are. We were lucky to succeed in introducing a question on information search in the survey. This question was developed on the basis of the interview study. The representative Eurobarometer survey was fielded in the 25 European member states in late 2005 with approximately 1000 respondents per country. We published first results on the question of everyday information search on embryonic stem cell research in Gaskell et al. (2006); further results will be presented at a symposium of the next AAAS meeting in San Francisco, February 2007.

Results

Inevitably people often lack detailed knowledge about technological innovation. And it is hardly realistic to expect the public to study such things in detail. Nevertheless people are sometimes called upon to make up their mind and come to a judgement. What information do people then use to evaluate complex technologies? What pieces of information do they regard as relevant, and what questions would they like to be answered?

Table 1 lists the questions on embryonic stem cell research as voiced in the pilot interviews. These questions were subsequently presented to the interviewees of the interview study who were asked to both choose those pieces of information they would like to hear more about, and to mark those questions that seem irrelevant to them. During this process of information search they furthermore were asked to think aloud, that is, to say whatever comes to their mind. Table 1 shows what questions appear important to the respondents in the interview study and what aspects are considered irrelevant. Aspects neither chosen for more detail nor classified as irrelevant are listed under the label ‘not chosen’; they may be considered issues of medium interest.

Table 1 highlights that issues of high interest (chosen by at least half of the respondents) are utilities (for what purposes can stem cells be used?), risks (what risks, dangers and problems exist with embryonic stem cell research?), definitions (what is embryonic stem cell research?) and actors responsible for moral regulation (who is responsible for setting moral limits?). Qualitative analyses show that with regard to definition, there is not so much interest in scientific details but rather in procedures of conducting embryonic stem cell research, that is in aspects explaining how research is being done practically (e.g. how old are embryos when cells are being extracted, what happens to the embryos after the extraction etc.). This is supported by the fact that the question ‘where do embryonic stem cells come from and what happens with them once they are available for research?’ is, although not one of the most frequently chosen questions, the only piece of information that is not considered irrelevant by any respondent. Information uptake on issues describing what embryonic stem cell research is about thereby is often related to everyday moral consideration on the issue. Moral regulation, however, is a polarizing topic: while 50% of respondents choose the corresponding question as important to them, 22% consider it to be irrelevant. Issues most likely to be considered irrelevant are the views of religious groups, economic consequences, funding and regulation in other countries.

	chosen	not chosen	irrelevant
For what purposes can stem cells be used?	66	31	3
What risks, dangers and problems exist with embryonic stem cell research?	65	31	3
What is embryonic stem cell research?	53	44	3
Who is responsible for setting moral limits?	50	28	22
What opinions are being voiced against the use of embryonic stem cells?	44	47	9
Who is going to profit from stem cell research in what ways?	44	47	9
Are there any alternative ways to win embryonic stem cells?	43	53	3
What is the probability for risks, dangers and problems to occur?	40	56	3
What is the probability for embryonic stem cell research to develop useful applications?	37	53	9
Will the utilities of embryonic stem cell research be available to all human beings alike?	35	53	13
Where do embryonic stem cells come from and what happens with them once they are available for research?	34	66	0
How is embryonic stem cell research currently being regulated in Austria?	22	69	9
Who is doing embryonic stem cell research?	22	72	6
What opinions are being voiced in favour of the use of embryonic stem cells?	16	63	22
How is embryonic stem cell research being financed?	13	53	34
How is the issue regulated in other countries?	12	56	31
What is the view of religious groups?	9	34	56
What economic consequences are to be expected for Austria?	9	53	38
Who controls the prohibition to use embryonic stem cells in Austria?	6	78	16

Table 1. Everyday questions on embryonic stem cell research sorted by attributed relevance (numbers indicate percentages)

Similar results are observed on a European level. Respondents to the 2005 Eurobarometer were asked ‘if there was a referendum on stem cell research, what information would you like to hear about?’. Subsequently, they were asked to choose two out of five issues that would be of most interest to them (What scientific processes and techniques are being used?/ What are the claimed benefits and what are the possible risks?/ What are the current regulations and who is enforcing the regulation?/ Who is responsible for setting the moral limits?/ Who is funding the research and who will benefit from it?).

European respondents to the 2005 Eurobarometer generally do not consider it important to be informed about scientific details. What they want to know about are the societal consequences of stem cell research – the risks and benefits – and whether regulations and ethical oversight are sufficient. Across all 25 EU States, people most want to be informed about potential benefits and possible risks of embryonic stem cell research. Out of those respondents who expressed a choice (that is, excluding those who say they ‘don’t know’) 69 per cent select ‘benefits and risks.’ 40 per cent want to know more about current regulations and about who is enforcing them, 36 per cent express interest in who is responsible for setting moral limits, 33 per cent want to know what scientific processes and techniques are used, and 22 per cent want to hear about who is funding the research and who will benefit from it.

The interest in information on potential benefits and possible risks is observed in virtually all European Member States. Where there are national differences, it is in interest in regulatory issues and scientific details. It may be concluded that when forming an opinion on embryonic stem cell research, European citizens tend not to consider it too important to be thoroughly informed about scientific details. It appears as though the public want to leave the details of science to experts. They want to know about the consequences of technological developments – the risks and benefits – and whether regulations and ethical oversight is sufficient.

Workpackage 3: Imaginative Thinking and Metaphors

Research question

Research in the line of Cognitive Linguistics has shown that metaphors play a crucial role for thinking. The role of imaginative reasoning is important since metaphorical understandings of the new not only describe what the new is about, but also entail evaluations and affective connotations. As such, metaphors can be understood as a means to reduce complexity. Sub-project 5 investigated the metaphor use of lay people in understanding complex technology, again taking the example of embryonic stem cell research. What metaphors are being used, and what conclusions are drawn from specific metaphoric understandings?

Activities

Based both on an analysis of focus group discussions with different segments of the Austrian public and on a literature review on the use of metaphors in the context of modern biotechnology, we designed a number of metaphor questions that were included in the interview study on embryonic stem cell research mentioned above. Because of time constraints a systematic metaphor analysis of media articles, as originally planned in the project proposal, could not be carried out yet. However, media data on embryonic stem cell research for both the newspapers Der Standard und Kronen Zeitung were collected over a ten years’ period (1996 – 2006). These data are currently analysed according to the procedures of systematic metaphor analysis (Schmitt 2003) in a master thesis supervised by the authors.

Results

The role of imaginative reasoning is important since metaphorical understandings of the new not only describe what the new is about, but also entail evaluations and affective connotations. A metaphor consists of three parts (Lakoff, 1987): a target domain, a source domain, and a relation defined between target and source domain. The source domain is closer to personal experience than the domain to be understood and, because of its experiential basis, it is immediately comprehensible. The source domain provides the pictorial content by which another less comprehensible concept – the target – is being made more intelligible. By mapping the structure of the source to the target, the concept to be understood is both defined and evaluated in terms of the more intuitive source domain.

Imaginative and metaphorical reasoning is a way to deal with overly complex knowledge issues where detailed information is unavailable or personally unknown. Both focus group discussions with different segments of the Austrian public and a literature review on the use of metaphors in the context of modern biotechnology suggest a fundamental distinction between anatomized metaphors on the one hand, and holistic metaphors on the other hand, both leading to different understandings and evaluations of the target. For example, proponents of the kind of research under question are more likely to consider a few days old embryos as a bunch of cells rather than a full-blown human being. Supporters in the interview study made statements such as ‘I think after a few days, this is no embryo yet, it’s really only cells’. Opponents, in contrast, voice concerns such as ‘if there are ten embryos destroyed for that then there have happened ten murders in my view’; here the implicit understanding of the entities of research are radically different.

Furthermore, the evaluation of endeavours such as embryonic stem cell research is embedded in a broader understanding of progress: the new research domain can be perceived as either ‘conquering new land’ or as ‘transgressing a dangerous border’ (for a similar opposition see Nerlich 2005). Supporters spontaneously use words such as ‘research has to happen, otherwise we come to a standstill … you may not stop research’. Opponents, in contrast, frequently talk of crossing a dangerous border: ‘well, for me the ethical and moral part still is more important than the medical part, because there are borders being transgressed, and who decides that?’.

Based on preliminary qualitative analyses we developed the following items that were used in the interview study on embryonic stem cell research; respondents indicated what statement better matched their understanding (table 2).

Further analyses addressed the relationship of metaphor plausibility with other variables. Table 3, for example, cross-tabulates the relationship between metaphorical understandings and the voting for or against a fictive referendum on embryonic stem cell research. All of the respondents opposing embryonic stem cell research construe the entities of stem cells as full-blown human beings. Supporters, in contrast, are divided: about half of them conceive the entities as human beings and half as bunch of cells. This latter finding suggests furthermore that supporters not necessarily need to understand stem cells in an atomized way; in the qualitative analysis it becomes obvious that supporters often on perceive it to be a moral dilemma but, even if understanding embryonic stem cells as human beings, feel ready to sacrifice those entities in order to bring about desired utilities (‘you always think of babies first, you think of children, of children being thrown into a mixer … but who supports abortion, needs to support this as well I think’). On the whole, however, our results suggest that an anatomized understanding of entities such as embryonic stem cells tends to go along with higher levels of perceived moral acceptability and with higher levels of support of such research.

Anatomized versus holistic understanding of embryonic stem cells	A few days old embryo is nothing else but a bunch of cells that can be used for research. (bunch of cells)	A few days old embryos are human beings that should not be misused for research. (human being)
	After embryos have died off, they can be thrown away like other research materials. (throw away)	Embryos as potential human beings have to be buried after having died off. (bury)
Progress as conquest versus transgression	Embryonic stem cell research offers the possibility to leave for new shores. We have the chance to conquer new land and to discover promising things. (new land)	Embryonic stem cell research brings us to a dangerous border that should not be transgressed. It is better to remain on the secure side. (dangerous border)
	We have to jump on the train and invest in research on embryonic stem cells in order not to fall back behind other countries. (jump on train)	We may not be carried away with the euphoria of other countries. Instead we need to look for a better way. (better way)

Table 2: Items used in the interview study on embryonic stem cell research

Opponents and supporters of embryonic stem cell research furthermore show differences in evaluating progress: while opponents mostly think that such research is crossing a dangerous border that should not be transgressed, supporters tend to assume that it is a chance that has to be taken (conquering new land). Accordingly, opponents are more likely to call for alternative ways to bring about the proposed utilities (searching for ‘better ways’ in metaphorical terms). Again, the group of supporters is more ambivalent: nearly half of them also think, although supporting embryonic stem cell research, that alternatives would be better, thus voting for a cautious approach.

	referendum	
	pro	contra
bunch of cells	47%	0%
human being	53%	100%
throw away	75%	46%
bury	25%	55%
new land	95%	18%
dangerous Border	5%	82%
jump on train	53%	9%
better way	47%	91%

Table 3. Metaphor plausibility and support of a fictive referendum

Sub-project 6/7: Policy Advice, Regulation and Genetic Privacy

Alexander Bogner, Walter Peissl, ITA/OEAW

Introduction

In case studies 6 and 7 we return to the question of the relevance of genome research for society, yet from a more specific perspective. Rather than societal processes of perception or communication, as in case studies 3, 4 or 5, we address the question of how genome research becomes an object of societal controversy and, subsequently, of political regulation.

Empirically, our analysis refers to three exemplary cases: genetic testing, stem cell and pre-implantation genetic diagnosis (PGD). We are aware that these fields may appear somewhat off the very issue of genome research from a natural scientific point of view; however, in a social scientific view, they appear closely linked as fields of application of modern medical biotechnology with a strong background in genetics, and therefore may be taken as concrete applications of genome research in a wider sense. After all, it is not genome research 'as a whole' but certain applications out of its context that are socially addressed. Since they, so to speak, flag up the socially visible scope of genome research we have to refer to these applications if we seek suitable cases for our studies. Genetic testing or PGD are examples of socially relevant issues, which nonetheless would be unthinkable without current developments in genome research, and which establish an immediate link. However, it would be wrong to equate them with the much broader field of genome research as such.

Our focus on the conflict potential and on regulation requirements implies the notion that science and technology have become essentially disputable and controversial. In other words, we depart from the assumption that technological change or, respectively, technology development is no longer considered to be subject to inherent necessities only. In a previously dominating technology deterministic view, such necessities would strongly confine any opportunity for political interference and marginalise societal bargaining processes on the desirability of different research options and on the question whether or not to apply specific technologies. Today (in a Beckian view), technological change is considered to result on the one hand, in the disclosure of new options to act and, on the other hand, in new conflict fields and decision-making constraints.

Genetic testing, stem cell research or PGD are current issues of value conflicts and also of conflicts on questions such as: What are we allowed to do? What knowledge do we want to gain? This moral charging implies that science and technology conflicts get ethicised (Bogner 2005), i.e. these topics are debated and decided in ethical terms and concepts. Thus, the moral and ethical charging facilitates to put into question science and technology (in a very special way) and leads in many cases to a discussion about regulation requirements and, thus, to the need to decide politically in the end. At the same time, this ethicisation sets free complexity.

Complexity refers, on the one hand, to the factual level, because the relevant questions pertaining genome research are no longer addressed at technicians and experts only. From a natural scientific point of view, the transition to a 'post-genomic era' entails an increase in complexity with various methodological and organisational results (Case study 1). With regard to politics, growing complexity can be understood as an effect of ethicisation: especially in the field of biosciences, contentions on certain applications are framed as value conflicts which transcend the coordinate system of party political logics (left/right, emancipatory/conservative). The latter aspect emphasises the importance of ethical expertise in these conflicts: Politics has to acquire, on the one hand, an overview of the state of affairs in the natural sciences in order to be able to decide in an informed way. On the other hand, the orientation knowledge of ethical experts is needed to sort out the – party politically ambiguous – problem potential of the conflict and render the matters of dispute politically negotiable and capable of being balloted.

These few remarks served to outline the essential points of our analysis. More precisely, our analysis asks what regulatory questions emanate for politics in relation to concrete applications of genome research and how politics organises expertise in order to be able to make and to legitimise decisions with a view on the complex set of problems met.

In a first step (sub-project 6), we discuss the challenges for existing forms of regulation from natural scientific progress taking the example of genetic data. The main question is which regulations exist and what the challenges are the new developments will induce. From the point of view of technology assessment, it is of fundamental importance to assess whether and how the rapid processes of technisisation and informatisation collide with the proven basic rights of liberal-democratic societies. In particular, the right of privacy is an adequate concept to analyse potential incompatibilities between technology and society.

Politics depend on scientific advice for the processing, ruling and legitimising of such regulatory questions. Therefore, we turn to the question of how the relation between science and politics is shaped in the context of political decision-making on particular applications of genome research as outlined above (sub-project 7). In the beginning, we provide a review of the political organisation of expertise, which in the case of biomedical problems is an ethical one (dealing with a value conflict). Then we will show how experts achieve to translate complex matters into politically negotiable attitudes, in other words, how scrutinising and questioning technologies produces and stabilises an order or a ‘frame’, respectively, that enables politics to choose among clearly defined options (orienting knowledge). Finally, we discuss whether the dependence on scientific advice makes politics follow the experts. So, the main topic ‘complexity and genome research’ gets elaborated in a twofold way: On the one hand, we analyse the processes inside the experts’ board, in other words, how the experts cope with complexity within their group (translation process). On the other hand, we investigate to what extent the internally bargained expertise determines how politics handle these complex questions.

Problem and perspective

Particularly in the field of science and technology conflicts, and especially in the area of biomedicine, new needs for regulation emerge. In the following we will discuss challenges for political action in the context of bio-scientific progress. Main questions are: Which regulatory problems arise in the context of (post-)genome research? And which requirements for politics result from these problems? In particular, how does politics manage the complexity inherent in these issues? In order to approach the first question, we will introduce general criteria for comparing conflict topics:

- What is the dispute about? In which categories is the controversy carried out? What basic values are at disposition?

Then we will take up the second questions and investigate the requirements for politics in two case studies. First, we will investigate the relevance of bio-scientific progress for regulatory systems. Main questions are:

- Do basic values such as privacy come under pressure? What regulatory ‘adjustments’ appear to be necessary?

Secondly, we will have a look at the relationship between science and politics, asking

- How does politics cope with increased (factual and political) complexity? How does politics arrive at an informed decision? How does this process heavily dependent on experts influence politics? And what does this imply for science; for example, does politics instrumentalise science?

Answering these questions we can establish a cross reference to the thesis of reflexive modernisation, which assumes that the foundations of modernity (nation state, traditional family, positivist understanding of science) get challenged in the course of on-going modernisation. This implies especially for politics and science, as the fields we are interested in, that they do not function any longer following the logic of differentiation and specialisation; rather, they are subject to the logic of 'boundary-dissolution'. For politics, and particularly in questions of technology policy, this means that policy-relevant actors may come to an agreement outside of the established political system. The commitment of these actors (citizens' initiatives, counter-experts, etc.) entails a politicisation of phenomena such as technical progress, which the established institutional system formerly would not have taken up and negotiated as issues political.

In a positive reading, the dissolution of the boundaries of science means that the doubts in science capture the logical sub-structures of science, to the effect that knowledge claims are put into perspective and their pluralisation is legitimised. In a more pessimistic reading, boundary-dissolution means that 'truth' becomes a tool in the hands of (political) negotiators. Since there are so many scientific knowledge claims, one may choose whatever one likes.

Against this background, our two case studies provide an opportunity to discuss the theory's central thesis. For example, on could conceive the basic value of privacy as a sensor for testing technical change for 'democracy'. The question here is:

- to what extent does the concept of privacy provide an answer to the challenges of the general pattern of mechanisation/technisisation? And is there any evidence, respectively, that certain aspects of technical progress become problematic precisely because of this basic value? And can we perceive this in real-time, i.e., do we have a chance to countersteer?

The growing relevance of policy advice in the field of biotechnology is, not least, a hint at the politics' readiness to establish an 'early-warning system' and not to lag behind in important technology issues. The question is:

- is there a risk for expertocracy? Does politics gets into inherent necessities due to new advice authorities?

The framing of conflicts

Conflicts on how to handle biomedical research and practices in society are negotiated in ethical categories. The particular structure of these conflicts becomes evident when they are compared to other types of conflicts. In the following, we briefly summarise different types of conflicts.

Distributional conflicts arise over the allocation of scarce resources. Membership with different conflict parties is usually quite obvious as it is clearly defined qua economic status and position. The class conflict of the 19th century is paradigmatic. The distribution of resources immediately affects the parties involved in the conflict, their interests and the way they conduct their lives. Science and expertise are subordinate to the actual conflict structure. Economic constraints as well as direct political violence are resources of power in the confrontation.

Knowledge conflicts have become more frequent since the 1970s. These conflicts are characterised by disputes on the quality of knowledge: which knowledge is true? For example, how big is a risk really? These conflicts – often about environmental and risk problems – are characterised by what one could call 'unconfined concern' and the dissolution of clear positions and group identities. The consequences of mechanisation and modernisation undermine the clear and unambiguous party structures of classical conflicts of interest. Ulrich Beck (1992: 36) has condensed this into the saying: 'Poverty is hierarchical, smog is democratic.' Health or ecological risks provide the common frame of reference for such conflicts. These risks are abstract by nature; the human senses cannot directly perceive them and they can hardly be attributed to. In order to become relevant to politics, expertise must transform them into 'real' risks, and they must bear the label of a systematic consequence of modernisation. This is the reason why science plays such an important role in these conflicts. The battles between experts and counter-experts reveal irreconcilable assessments of risk, which refer to equally sound applications of scientific methods, respectively. These disputes are by no means restricted to experts' debates; at least until the late 1980s they involved many local groups and civil society initiatives.

Value conflicts are characterised by the phenomenon of 'ethicisation'. Main questions are: what do we want to do and to know? Where are the ethical boundaries of research? Examples are ethically framed disputes about biomedicine. They take place on the feature pages of newspapers, in intellectual discussions and conferences rather than on the streets. Representatives of civil society do not act as pressure groups, nor do they promote single established positions. Rather, they operate as organisers of a public discourse, deliberately keeping it open. One example of such an open debate facilitated by civil society actors is the project known as '1000fragen' ('1000questions') launched by an important German Disability Association; this is a primarily internet-based public debate.

Especially in the area of biomedicine, experimental forms of participation by lay people – such as 'citizens' conferences' – are another way of involving representatives of the silent public in a discursive process rather than channelling explicitly articulated positions into the political process. Bioethical value disputes seem to originate in expert discussions rather than in explicit conflict situations of socially defined groups.

Case Study Genetic Privacy

This case-study dealt with the possible impacts of complexity in the post-genomic era with regard to the international regulation and perception of genetic privacy. The theoretical background for the analysis is the common understanding that privacy is a necessary prerequisite for the citizen to stay autonomous, and for liberal democracy to remain functional. This is why international regulations protect individual privacy. The keyword in this respect is 'personal data' and there is no doubt that genetic material and data gained from it are the most personal data ever. In many countries, and in international arrangements, genetic privacy is therefore subject to a higher level of protection.

However, in the light of the discussion on complexity and uncertainty in the post-genomic era, the relevance of genetic data may change. Recent insights into the role of 'genes' in the form of a sequence of DNA suggest that they are not the only determinant of, say, the propensity of an individual to develop a certain condition or property. As a consequence, the power to predict, in a deterministic way, the individual's future from a certain base sequence may no longer be taken for granted. Such reasoning may have an impact on the use of genetic data and, ultimately, on their protection and the concept of genetic privacy. This leads to the guiding research question: *Does higher complexity and uncertainty change the character of genetic data and if so, what are the impacts on genetic privacy?*

Privacy – the basics

There is a long tradition in European constitutions in safeguarding individual property, sanctity of the home and individual communication. These values were the origins of the basic right of privacy established later. In 1890 Warren and Brandeis, two lawyers in the United States, first argued that new technologies (e.g. photography) establish new forms of intrusion and need to be coped by new rights to the individual. The right to privacy was defined as the 'right to be let alone' (Warren/Brandeis 1890).

The second half of the last century saw several attempts by international agreements and national regulations to establish and guarantee the basic right of privacy. The basis was established with Article 12 of the Universal Declaration of Human Rights (UN 1948) and with Article 8 of the European Convention for Protection of Human Rights and Fundamental Freedoms in 1950 (Council of Europe 2003). The obvious danger that the emerging practice of electronic data processing could jeopardise this human right was met by specific regulations and agreements for this sector.

In 1960s and 70s, a broad debate in several European states on the use of electronic data processing by public authorities gave rise to the initial national data-protection laws in the late 1970s. With Convention No. 108 from 1981, the Council of Europe passed a treaty for the protection of human rights in relation to automated processing of personal data (Council of Europe 1981). The OECD developed a set of Guidelines on the Protection of Privacy and Transborder Flows of Personal Data in 1980 (OECD 1980). These regulations were the principal elements for the protection of privacy. Explicitly or implicitly, the 'Fair Information Principles' are a part of all respective regulations.

One of the most important regulations in a global perspective is the EU-Directive 95/46/EC on the protection of individuals with regard to the processing of personal data and on the free movement of such data. This directive sets the standard for data protection and privacy policy within the European Union and far beyond. In its Art. 1 the Directive states that 'Member States shall protect the fundamental rights and freedoms of natural persons, and in particular their right to privacy with respect to the processing of personal data'.

Basically the right to privacy prohibits any processing of personal data. In order to make data processing legitimate, criteria were set out in Art. 7 of the directive. Accordingly, data processing is only legitimate if:

- the data subject has unambiguously given his or her consent; or
- processing is necessary for the performance of a contract to which the data subject is party or in order to take steps at the request of the data subject prior to entering into a contract; or
- processing is necessary for compliance with a legal obligation to which the controller is subject; or
- processing is necessary in order to protect the vital interests of the data subject; or
- processing is necessary for the performance of a task carried out in the public interest or in the exercise of official authority vested in the controller or in a third party to whom the data are disclosed; or
- processing is necessary for the purposes of the legitimate interests pursued by the controller or by the third party or parties to whom the data are disclosed, except where such interests are overridden by the interests for fundamental rights and freedoms of the data subject which require protection under Article 1 (1).

Reasons fort the strong protection of privacy can be found on different fields. Privacy is a multifaceted phenomenon (Peissl 2003), which has psychological, philosophical, as well as political dimensions. Studies show that there is a basic need of every human being to find opportunities to withdraw (Egger 1990: 67 FN 2; Gridl 1999: 19 FN 19). Consequently, at the basis of all privacy concepts is the idea that every individual should have a sphere of private living, separated from the public sphere, where he or she is free from societal or governmental constraints and may act as an autonomous person (Funk 1994:562). One can only live a 'successful life' if one lives freely and autonomously (Rössler 2001:19). In the same vein, the German Federal Constitutional Court stated in an important decision in 1983 that 'self-determination', i.e. autonomous and free decisions of free people, are a prerequisite of democracy (BeVerfGE 1983:42f). There are good reasons for privacy being a well-acknowledged basic right on international level, so it is to no wonder that a lot of organisations are dealing with the issue: apart from the Council of Europe, the Organization for Economic Cooperation and Development (OECD), the European Union and several international standards' bodies are heavily involved (Bennett 2003).

Data protection policy and privacy policy are strongly linked to the issue of surveillance (commercial as well as state-run) and the protection of an autonomous sphere in every individual's life. A second aspect under more recent consideration is the characterisation of people from their behaviour (or rather: due to data gathered from their daily life). 'Social sorting' (Lyon 2003) implies different chances in life, i.e. discrimination, and therefore challenges the principle of equality. However, it can – at least theoretically – be managed by restricting data usage and by changes in the individuals' behaviour. This leads directly to the much more problematic field of genetic privacy: discrimination in this field may only be prevented by regulation. The individual cannot change his or her genetic material and the data gained from it. This is why genetic privacy demands a much higher level of security and more restrictive rules for data usage.

The most important property of genetic data is the impossibility to escape from it. Above all, genetic data bear specific information on individuals with a high explanatory power on the possible future of the respective individual, at least in a traditional understanding. This makes genetic data highly susceptible to misuse. It is exactly this generally assumed 'ability to predict' that is under discussion in this project. The question to be answered was whether or not the awareness of higher complexity and uncertainty is reflected in current discussions on regulatory issues of genetic privacy.

Privacy and ICT

Privacy issues derive to a great extent from developments in the area of information and communication technologies (ICT). In many spheres of daily life we are used to apply electronic equipment and therefore leave electronic traces. These traces may be gathered, inter-connected and put together to virtual personality profiles. These profiles tell something about the individual's way of living: traces from web-browsing tell a lot about his or her interests, traces from mobile-phones about the person's mobility, data from all communication systems about the social networks, and data from web 2.0 applications can disclose very intimate details about a person. Data from credit-card purchases tell a lot about a persons income and buying habits, etc.. All these data from different databases create a picture of a virtual personality and this may have direct consequences for one's daily life. Especially after the attacks of the proverbial 'nine-eleven' 2001 in the USA and in 2005 in London and Madrid, law-enforcement agencies are very eager in data gathering. Under the simple – nevertheless wrong – equation that more surveillance leads to more societal security almost all existing databases have become sources of investigation.

But it's not only the war on terror that makes data gathering and profiling a rewarding business. The more an enterprise know about its customers, the more it can tailor its range of products and its logistics behind. Individualisation is one strong trend we encounter in ICT developments.

In ICT we see developments that lead to an erosion of privacy safeguards and, at the same time, to a commodification of privacy. Since some parallels can be drawn to the handling of genetic data, we tried to find out whether or not new models of governance of privacy (Bennett/Raab 2003) may render adequate solutions for genetic privacy, too. From a technological point of view bio-banks and data-mining processes lead to new challenges.

4.3 Genetic privacy

As stated above, genetic data bear certain features that make them special. This is reflected in the ongoing discussion on genetic privacy – although there are some arguments against 'genetic exeptionalism', too. Privacy is all about individual data, and genetic data are the most individual data one can imagine. Genetic data are medical data and therefore secured on a higher level than other individual data. But there are some more specific features that make genetic data special. Genetic data

- cannot be separated from the individual
- cannot be anonymized
- cannot be altered
- cannot be held back
- are future-oriented
- are intransparent and not easily understandable
- exercise effects on others (relatives)
- give reason for the right not to know

Even though genes are no longer seen as the easily readable book of life or a ready-to-use blueprint, they still bear information on individuals. They contain personal data not to be separated from the individual. All other specific properties listed above still apply to them. From a privacy point of view, new levels of complexity and uncertainty do not alter the basic characteristics of genetic data.

Which regulations exist regarding genetic data?

There is no European Union wide regulation for genetic data in place. Austria plays a leading role with respect to genetic privacy. Apart from the basic law on data protection (DSG 2000), which basically provides national regulation on the basis of the European Directive on Data Protection (95/46/EU), there is a specific law on 'gene technology' in Austria (Gentechnikgesetz – GTG). Although it is much broader and focuses on agricultural use of biotechnology as well it bears in its section four on 'Genetic Analysis and Gene Therapy for Human Beings' some specific paragraphs[3] on data-protection (Stelzer 2004). § 67 prohibits the collection and use of genetic data by insurance companies and employers. This seems to be the strongest regulation with respect to genetic data in this very sensitive field by far. In the UK there is only a non-statutory framework, the Concordat and Moratorium on Genetics and Insurance, in place since 2005 (Mittra 2005) and supposed to hold until 2011. These two different ways to deal with genetic privacy show the variety of approaches throughout

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[3] §§ 65, 66, 67, 71 and 71a

Europe. Other ways of governance of privacy evolve from scientific research projects and networks. Within the scientific community, a set of criteria for anonymous or pseudonymous use of genetic data was developed. They are mostly based on the Council of Europe's draft recommendation on research on human biological materials and on guidelines for research projects within the EU framework programmes. One of the driving forces may have been the necessity to make databases interoperable and establish the validity of data as well as render data unproblematic with respect to publication.

How are data protection principles challenged by the particularities of genetic data?

Over the last 30 years of discussion of privacy some basic principles evolved, the 'Fair Information Principles'. They are the basis for different codifications in different settings and read as follows: an organization (public or private)

- must be accountable for all the personal information in its possession;
- should identify the purposes for which the information is processed at or before the time of collection;
- should only collect personal information with the knowledge and consent of the individual (except under specified circumstances);
- should limit the collection of personal information to that which is necessary for pursuing the identified purposes;
- should not use or disclose personal information for purposes other than those identified, except with the consent of the individual (the finality principle);
- should retain information only as long as necessary;
- should ensure that personal information is kept accurate, complete and up-to-date;
- should protect personal information with appropriate security safeguards;
- should be open about its policies and practices and maintain no secret information system;
- should allow data subjects access to their personal information, with an ability to amend it if it is inaccurate, incomplete or obsolete. (Bennett 2003)

These principles are, however, subject to consideration. However conceptualized, privacy is not an absolute right; it must be balanced against correlative rights and obligations to the community, although the concept of 'consideration' and the process of balancing are highly ambiguous (Raab 1999). The use of genetic data – especially developments with so-called bio-banks – are supposed to challenge some of these fair information principles. From the interviews with experts we learned that among the principles most challenged are the principle of purpose, limitation and finality. While these principles clearly state restrictions in collecting and using data, it is the main purpose of bio-banks to provide biological materials for future research, including genetic analyses supposed to render more information in the near future than can be obtained today.

The second dimension challenged by genetic data is the principle of knowledge and (informed) consent. Genetic mechanisms and molecular processes are by no means transparent and easy to understand for lay people. It is obvious that it takes quite some time to explain the meaning or possible impacts of certain tests or treatments to patients. Especially in times of pain or fear it is likely that patients will give their consent to various treatments and will not ask for possible or long-term impacts on their genetic privacy.

What is the impact of complexity and uncertainty in the post-genomic era on the regulation of genetic privacy?

In none of the interviews with experts we could find any influence of a perceived higher complexity or uncertainty on policy making so far. It seems as if the awareness of uncertainty and complexity has not yet reached the sphere of policy making at all.

The Austrian Gentechnikgesetz was rather strict in its first version from 1994. Genetic data had to be stored in different systems away from other medical data and there were specific rules for transmitting and communicating these kinds of data to patients. Because of complaints about unfeasible approaches for the workflow in laboratories and hospitals the law was altered. In its reform from 2005, the law (in its § 65) now defines four different types of genetic data. In short,

- Type 1 are diagnostic data on an existing disease, or for preparing or controlling a therapy, based on concrete somatic modifications of chromosomes, genes or particular DNA sequences.
- Type 2 are diagnostic data existing diseases caused by a mutation in the germ line.
- Type 3 are data about a predisposition for a genetic disease for which a prophylaxis and a therapy is available.
- Type 4 are data about predispositions for diseases for which a prophylaxis and a therapy is not available.

These four types of genetic data are now subject to different documentation. While type1 data may be used in letters to the patients and in the medical records, type 2 and 3 data are only to be used in these documents if the patient has given his or her informed and written consent. Type 4 data are to be documented only in the institution that performed the anamnesis, separated from other medical data, to be accessed only by a very small number of people with secure access protocols. The same is the case for type 2 and 3 data if the patient has not given his or her consent.

This is the only example where a new regulation opened up and gave way to a more differentiated view on genetic data. However, this was not initiated, nor does it reflect, the discussion of complexity as it is the subject in the context of this project. Rather, it reflects the complexity of the everyday life in hospitals and with different forms of therapy.

Conclusions

With respect to genetic privacy regulation we could not find any influence of the discussion on higher complexity and uncertainty in the post-genomic era. Furthermore, we could not find any arguments fort he hypothesis that higher complexity will render genetic privacy less precarious. Arguments for this conclusion come from the unchanged character of genetic data – even though they may not be taken to be deterministic, they are still very personal data revealing specific characteristics and properties of individuals. Secondly, we have to admit that genomic research is still at the very beginning of understanding the processes behind the base sequence of the DNA. Therefore, and in the light of the precautionary principle, it is advisable not to skip or even restrict basic rights.

This conclusion is even more robust if we consider that it is much more the perception of risk than the ‘real risk’ that counts for policy making. Even though a real increase in complexity may lead to less deterministic statements about an individual’s predisposition and possible future health, genetic data are still widely perceived to be predictive. As long as this attitude towards genetic data persists there is no good argument in favour of relieving the strong data protection measures genetic data are subject to at present.

Case study Ethics Committees

The complexity of, and the controversies around, biomedical research and the application of its results entail new forms of policy advice: multidisciplinary ethics committees of mostly academic experts replace traditional interest representation. National bioethics commissions were constituted to give scientific advice to politics in the ‘big questions’ about life sciences such as genetic testing, stem cell research or cloning. The institutionalisation of bioethical expertise in Austria (and other European countries) illustrates a new way of politically dealing with complexity generated by the bio-scientific progress. Secondly, it illustrates the difficulty for politics to come to terms with political questions ‘beyond left and right’ (Giddens 1995). In particular, new insights in the life sciences often lead to controversial issues, which are not framed in a traditional party-political way.

Ethics commissions as an instrument of policy advice are derived from the model of clinical ethics committees (this holds, at least, for the German-speaking countries). Clinical ethics committees are located, and have their specific function, within the medical system; they operate according to an administrative logic. They evaluate well-defined research projects referring to general principles of law and ethics (such as informed consent). What is ‘right’ or ‘wrong’ is not subject to any controversies, and the tasks of the experts is only to look for consistency and adherence to given principles. In effect, clinical ethics committees do not deal with values to be at stake but with procedures to be maintained.

In contrast, national bioethics commissions as an instrument of policy advice aim at developing assessments of value regarding politically controversial issues. In this perspective, the negotiation of biomedical controversies in terms of ethical categories indicates that political regulation has to take place. Obviously, *ethically framed issues* have to be *politically* regulated; they cannot be left to a form of regulation established by the scientific community itself.

The demand for bioethical expertise has resulted in a veritable boom of 'commission ethics'. In Austria, but also in Germany the phenomenon manifests itself in coexistence, confusion, and sometimes confrontation of institutionalised expertise.

Institutionalisation of policy advice in moral questions

At the federal level in Austria, the ‘Bioethics Commission at the Federal Chancellery’ was established following an initiative by chancellor Schüssel in 2001. However, the Austrian example shows that ethics committees are not necessarily established on political initiative only. In addition to the Bioethics Commission at the Federal Chancellery with 19 members there was – until recently – an alternative commission, the ‘Ethics Commission FOR the Austrian Government’. Its establishment was motivated by criticism of the commission of the Chancellor for being not representative; in order to provide the missing alternative expertise, it consisted of 13 stakeholders from disability organisations. As the name clearly indicates, this commission claimed to advise and influence government policy. Usually in parallel with the committee of the Chancellor, it formulated a ‘second opinion’, as it was officially called, on a particular problem. Due to financial restrictions the work of this alternative commission ended in autumn 2006.

At the federal level in Germany we have seen at least three expert bodies over the last decade whose main task has been advising political decision makers with regard to biomedicine. In 1995, the ‘Ethics Advisory Board at the Ministry of Health’ with 13 members was set up during the conservative-liberal government. After the change in government, with the coalition of Social Democrats and Greens, the board’s activities were first suspended and then it got dissolved. One reason for the dissolution was the fact that medical genetic engineering had become the responsibility of the Chancellor. Gerhard Schröder had established his own, publicly more visible ethics commission in 2001, the 'National Ethics Council (Nationaler Ethikrat) with 25 members. It is comparable to the Austrian Bioethics Commission established shortly before. From 2000 on there was also a commission of the Lower House of the German Parliament; originally called 'Study Commission on Law and Ethics in Modern Medicine', consisting of 13 members of the Bundestag and 13 experts. The work of this Study Commission ended in summer 2005.[4]

These examples demonstrate that expertise in ethics is not at all organised within a neutral space detached from politics and interests. The National Ethics Council was considered a kind of counter project to the 'green' commission of the Ministry of Health, which consisted mostly of members critical of research and medicine. The Study Commission too tends to be critical of the National Ethics Council set up by the Chancellor, regarding it as a competitor. In fact, especially in the first period of the Bundestag, these two bodies produced competing reports on the same topics, including stem cell research and cloning.

In addition to the experts' policy advice, lay expertise plays a more important role in bio-politics compared to other policy fields. This does not mean that lay expertise generated by consensus conferences or scenario workshops has a measurable impact. But these experiments of citizens' participation are regarded as being politically correct. However, lay committees in the sense of the consensus conference have been convened only twice by now in Austria (and it should be noted that these citizens' conferences were initiated by social scientists rather than by the members of the grassroots organisations):

- the consensus conference on 'Ozone' in 1997:
- the citizens' conference on 'Genetic Data' in 2003.

Similar to Austria, there have been only two citizens' conferences in Germany by now (strongly supported by members of Academia, too):

- the citizens' conference on genetic diagnostics in 2001;
- the citizens' conference on stem-cell research in 2004.

Dealing with complexity and dissent: Negotiation processes in ethics commissions

'Ethicising', i.e. the negotiation of science- and technology-political issues in terms of ethical categories, stabilises dissent. Neither the Austrian Chancellor's commission nor the Ethics Council and the Study Commission in Germany managed to produce consensus and agreement about stem cell research or to issue a consensual recommendation. The same applies to therapeutic cloning (in Austria the decision is still pending, but it has been clear for a long time that there will be no consensus). Expert dissent can be expected; and one is tempted to put the question the other way round: how come that individual opinions within expert councils cluster in a way that, at the end, there are only two or three divergent positions left instead of, say, 19 single votes?

The answer comes from interpreting our interviews with members of the Austrian Bioethics Commission: the formation of positions is pragmatically oriented. The guiding principle is negotiation rather than fully discussing the matter. As an instrument of policy advice, ethics commissions do not provide space for debates on fundamental ethical principles and theories – an ethics council is certainly not a graduate class in philosophy. This does not mean that fundamental ethical principles on which the individual positions were based were irrelevant. On the contrary, if one wanted to exaggerate one could suggest that the statement

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[4] For a complete survey of the landscape of bioethical advice by commissions see Bogner (2006).

'Ethics does not take place in ethics commissions' actually has the following meaning: the underlying moral philosophical principles of the discussion are not made explicit but remain latent. This is partly so because political recommendations, which matter most in the end, have to build on compromises even in areas of extensive ethical discussions. Even where partial agreement is achieved – e.g. within separate competing votes – it does not necessarily indicate a substantive consensus or a common understanding of the normative foundations of society and of the definition and valuation of life. To the contrary, it may be the result of a pragmatic agreement on single issues. For example, the medical doctor suspicious of the vast promises made by stem cell researchers enters into coalition with the moral theologian who considers the embryo to be sacred from the beginning.

Reaching an agreement that informs action becomes easier if the process is less hampered by painstaking attempts to reach consensus. Finding 'coalition partners' within a commission does not require sharp arguments but strategic action. The primary goal of expert negotiations is the consolidation of an integrative opinion rather than the formulation of a position that all parties involved could in principle consider superior as an argument.

Policy advice by lay people

One main aim of participatory technology assessment is the mobilisation of perspectives and rationalities of lay people that have no voice in the choir of expert commissions. Citizens are therefore conceptualised as ‘representatives of a life-world rationality’. Alternative knowledge of this kind is supposed to be fed back into the process of decision-making or at least to become more relevant.

However, according to our findings, the group dynamics within lay panels can be interpreted as a process of exclusion of broader perspectives and alternative rationalities. This is the result of two processes of closure:

- a decline in membership that primarily affects those with extreme or exotic positions, who feel ill-represented by the group.
- a restriction of the discourse on ‘official’ issues of the bioethics debate. This means that in the course of a citizens’ conference the involved citizens turn into ‘mock bioethics experts’ with the result that precisely those alternative rationalities stemming from individual experiences etc. the process is set up to mobilise tend to be lost.

Let us take the German citizens’ conference on stem-cell research as an example. At the beginning of the conference the perspective on the topic was a broad one and included issues such as the distribution within the health sector or feminist aspects such as the instrumentalisation of women as ‘material’ for research. There was space also for example for anthroposophical approaches, individual experiences etc. In the course of the discussion the perspective narrowed down on the status of the embryo; this is typical for the debate among ethics experts and within politics. Finally, the vote of the citizens strongly resembles the statements of the experts – it is a ‘mock experts’ vote’.

We can observe a similar way of argumentative mainstreaming during the citizens’ conference in Austria. Like in Germany, a citizen with a strongly catholic standpoint left the lay panel dominated by rather liberal opinions. But there are, of course, differences between the Austrian and German case. For example, in Austria the vote of the lay panel did not document dissent within the group; its recommendations are abstract, the scientific and political background of the problem is not discussed, etc.. In our view, these differences between Germany and Austria are based in characteristics of a local order rather than in differences, for example, between the political culture or national style.

There is practically no influence of citizens' conferences in Austria and Germany neither on the process of political decision making nor on public discourse. One of the reasons is that the status of citizens' conferences within the legal and political institutional framework is unclear. They are experiments of participation. The votes of citizens do not imply any political commitments; laypeople are not elected, thus they are not representatives. Nor are they real experts, neither representatives of interests. Their political influence depends on contingent factors and is, as expected, low. On the other hand, and from the political perspective, this means that the participation of the public is not a source of legitimation.

Legitimation by expert dissent

We stated that 'ethicising', i.e. the negotiation of science- and technology-political issues in terms of ethical categories, stabilises dissent. What are the implications of such expert dissent for political decision-making? Does the ambiguity of ethics expertise entail problems of action and legitimisation for political actors? Our hypothesis is that not only is the expert dissent fairly unsurprising, it is even functional for political decision-making in the end. Ethics commissions are hardly convened with the expectation that they will produce a unanimous opinion on a higher level of aggregation, a 'blueprint' of a subsequent decision, as it were.

From an outside point of view it appears as if it is not the main role of the experts to produce definite decision-related knowledge. Rather, in this perspective their task is to highlight that politics is an independent field where decisions are taken according to political rules. The resulting divergent expertise demonstrates a number of things: firstly, it indicates that the problem is relevant and needs to be tackled; second, it shows that the problem remains in principle not to be decided among experts and therefore *needs* to be decided within the sphere of politics and precisely through genuinely political action. Against the background of divergent forms of expertise, the political decision obtains both its particular quality and its legitimacy precisely due to fact that it could have turned out differently. The justification of political action can be successful *precisely* because a plurality of possibly contradictory expertise is available.

What commissions reveal is the fact that decisions need to be taken under conditions where everyone is aware that there is no single best solution. An increase in expert knowledge is of little use here. Thus, political action is shifted to the sphere of individual value assessment. The very discussion of the stem cell issue reveals the extent to which parliamentarians or governments are actually faced with the necessarily 'personal' judgements or 'decisions on a matter of conscience'. Although decisions are informed by expert knowledge, they are not determined by it; they remain decisions reached only within the context of individual value horizons.

On the way to expertocracy? Politics, Expertise and Complexity

To conclude: in the case of ethically framed issues of biomedicine, politics boils down to individual moral decisions on a matter of conscience against a background of being comprehensively informed by the experts of a commission. Secondly, expert dissent does not result in a loss of legitimacy for politics; in fact, the divergence of expert opinions re-establishes politics as decision(-making).

The case of stem cell research can be used to illustrate this. In Austria, the Bioethics Commission had to discuss in 2002 whether to approve the funding of stem cell research under the framework of the European Union. The majority of experts voted in favour of supporting stem cell research under certain conditions; a minority was against. The minister responsible, Mrs. Gehrer, joined the minority position in Brussels critical of research. She substantiated her decision by referring also to the liberal majority position. The argument was that the latter position's condition for an ethically acceptable stem cell research to be committed to a deadline regulation was insufficient to provide European-wide security.

Our example of ethics expertise does not allow us to conclude that we are on the road to expert domination, a development that used to be both demanded and feared within the technocracy debate of the 1960s. Even advancing ‘scientification’ cannot transform uncertainties into certainty, or do away with diversity and heterogeneity. This applies not only to ‘factual’ issues such as, for instance, the debate on risky technologies, but also, and even more so, to issues like biomedicine that are negotiated in terms of ethical frames. Not even under the condition of an advanced knowledge society is politics – in contrast to Schelsky's (1965) argument – the executive body of a superior expert rationality.

According to our interviews with members of ethics councils, this is not only considered an unintended consequence or the result of an inability to reach agreement upon consolidated knowledge and value orientations; it also corresponds to the experts' self-understanding. They do not consider themselves to hold authoritative views about politics by virtue of any superior knowledge. Rather, they represent a reflective type of expert who is aware of the uncertainty of expertise in ethical issues and who does not consider this to be the result of a lack of methodical precision or even deficient scientific quality.

This indicates that increasing complexity in ‘factual’ issues does in fact go parallel to an on-going process of scientification in politics – but this is not equivalent to a tendency towards expertocracy. Obviously, increasing complexity and the ethicisation of technology conflicts as described above are factors that foster a genuine political type of decision-making.

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