

Recommendations of the Commission on Professional Self Regulation in Science

Proposals for Safeguarding Good Scientific Practice January, 1998

Foreword

A case of scientific misconduct that was widely discussed in public both in Germany and abroad has led the Executive Board of the Deutsche Forschungsgemeinschaft to appoint an international commission chaired by the President with the mandate,

- to explore causes of dishonesty in the science system,
- to discuss preventive measures,
- to examine the existing mechanisms of professional self regulation in science

and to make recommendations on how to safeguard them.

The commission had the following members:

Professor Dr. Ulrike Beisiegel, Department of Internal Medicine, Hamburg University

Professor Dr. Johannes Dichgans, Department of Neurology, Tübingen University

Professor Dr. Gerhard Ertl, Fritz Haber-Institut der Max-Planck-Gesellschaft, Berlin

Professor Dr. Siegfried Großmann, Department of Physics, Marburg University

Professor Dr. Bernhard Hirt, Institut Suisse de Recherches Expérimentales sur le Cancer, Epalinges s. Lausanne

Professor Dr. Claude Kordon, INSERM U 159 Neuroendocrinologie, Paris

Professor Lennart Philipson, M.D., Ph.D., Skirball Institute of Biomolecular Medicine, New York University, New York

Professor Dr. Eberhard Schmidt-Aßmann, Institute for German and European Administrative Law, Heidelberg University

Professor Dr. Wolf Singer, Max-Planck-Institute for Brain Research, Frankfurt/Main

Professor Dr. Cornelius Weiss, Department of Chemistry, Leipzig University

Professor Dr. Sabine Werner, Max-Planck-Institute for Biochemistry, Martinsried

Professor Dr. Björn H. Wiik, Deutsches Elektronen-Synchrotron, Hamburg

As the result of its deliberations, the commission puts forward the following recommendations, unanimously adopted on 9 December, 1997. The accompanying justification and commentary contain suggestions for their implementation. They are followed by a short overview of the problems in the scientific system discussed by the commission, and of institutional regulations in other countries which were helpful for drawing up the recommendations.

I express my cordial gratitude to all who were involved in the commission's work, in particular to the cooperating institutions in Europe and in the USA.

Bonn, 19. December 1997

Professor Dr. Wolfgang Frühwald

President of the Deutsche Forschungsgemeinschaft

I. Recommendations

Introduction

The event that prompted the appointment of the commission was an unusually serious case of scientific misconduct (1). It led to a wide discussion in politics, administration and the general public in Germany whether such events are more frequent than is generally known, and whether science in its institutions has sufficient control mechanisms for quality assurance. How could it happen that the institutions of science were deceived for so long ? Nearly all the publications called into question appeared in peer reviewed international journals. All degrees awarded and all appointments relied on the conventional control mechanisms for regulating advancement in the scientific community. There were no procedural failings; yet the irregularities were not discovered. The same was true for research proposals which led to funding by the Deutsche Forschungsgemeinschaft and other funding organizations over a long period of time.

Further questions arose: Is intervention by state authorities necessary ? Is there a need for new regulations to protect science, supported with public funds, and society, depending on its results, against abusive research practices?

On the best available knowledge and on the basis of all published experience in other countries, these questions may be answered as follows:

The conduct of science rests on basic principles valid in all countries and in all scientific disciplines. The first among these is honesty towards oneself and towards others. Honesty is both an ethical principle and the basis for the rules, the details of which differ by discipline, of professional conduct in science, i.e. of good scientific practice. Conveying the principle of honesty to students and to young scientists and scholars is one of the principal missions of universities. Safeguarding its observance in practice is one of the principal tasks of the self-government of science.

The high standard of achievement in the scientific system provides daily evidence of the successful application of the principles of good scientific practice. Grave cases of scientific dishonesty are rare events. However, every case that occurs is one case too many. For

dishonesty - in contrast to error - not only fundamentally contradicts the principles and the essence of scientific work, it is also a grave danger to science itself. It can undermine public confidence in science, and it may destroy the confidence of scientists in each other without which successful scientific work is impossible.

Complete prevention of dishonesty is no more feasible in science than in other walks of life. But safeguards can and must be established. This does not require governmental action. What is necessary, however, is that not only every individual scientist and scholar, but especially the institutions of science - universities, research institutes, learned societies, scientific journals, funding organizations - develop a consciousness of good scientific practice and apply it in their day-to-day activity.

Good scientific practice therefore is the core of the following recommendations. It is the first condition for effective and internationally competitive scientific work. The opposite of good scientific practice, which must be prevented, is scientific dishonesty, i.e. the conscious violation of elementary scientific rules. The broader term "scientific misconduct" is employed in contexts (e.g. of procedural rules) where the infringement of accepted good practice is discussed as a fact (irrespective of motive).

The recommendations are principally addressed to the institutions of science, but through them also to all their individual members. They mainly spell out rules of good scientific practice that are in no way new. Their conscious observance in the daily practice of science, however, is the best preventive measure against dishonesty. Based on experiences in other countries, the recommendations also include basic rules for dealing with suspected scientific misconduct. All institutions of science should discuss, specify and enact a fair procedure for this so as to protect both the interests of the parties involved and their own good reputation.

First among the addressees are the institutions of higher education, particularly the universities, and research institutes, because research and the education of young scientists and scholars are their principal mission. Fostering good scientific practice, and providing for adequate measures when suspicions of scientific misconduct are raised, are institutional tasks. The responsibility for implementing them lies with the chief executives of every institution and with the responsible statutory bodies. This follows not only from the proximity of these institutions to those active in research, but also from their role as employers or superiors and, for institutions of higher education, from their monopoly of awarding academic degrees.

Flexibility will be necessary to allow the recommendations to be applied appropriately to specific institutions and research relationships. Therefore, they have consciously not been developed into a detailed system of regulations. They are designed to provide a framework for the deliberations and measures which each institution will have to conduct for itself according to its constitution and its mission. The accompanying text contains suggestions, based on experiences in Germany and in other countries, on how they may be implemented.

Scientific activities in many fields are governed by legal and professional norms, and by codes of conduct like the Declaration of Helsinki. The recommendations are in no way designed to replace these norms and regulations; they supplement them by a set of basic principles. They develop and extend ethical norms of science current in many universities abroad (2) and laid down

in codes of conduct of professional societies, e.g. that of the German Chemical Society (3).

Recommendation 1

Rules of good scientific practice shall include principles for the following matters (in general, and specified for individual disciplines as necessary) :

- fundamentals of scientific work, such as
- observing professional standards,
- documenting results,
- consistently questioning one's own findings,
- practising strict honesty with regard to the contributions

of partners, competitors, and predecessors,

- cooperation and leadership responsibility in working groups

(recommendation 3),

- mentorship for young scientists and scholars (recommendation 4),
- securing and storing primary data (recommendation 7),
- scientific publications (recommendation 11).

Recommendation 2

Universities and independent research institutes shall formulate rules of good scientific practice in a discussion and decision process involving their academic members. These rules shall be made known to, and shall be binding for, all members of each institution. They shall be a constituent part of teaching curricula and of the education of young scientists and scholars.

Commentary

Universities in Germany have the legal task of "fostering and developing science and scholarship through research, teaching, and studies"; they "promote young scientists ... and scholars" (§ 2 of the Framework Law for Higher Education Institutions - Hochschulrahmengesetz, HRG). This gives them the clear legitimation, but also the responsibility, to design their internal rules and regulations so that they provide for the conduct of science and scholarship in accordance with their accepted norms and values.

With modifications appropriate to their legal status and their mission, the same holds true for public research institutes independent from the universities (4).

The freedom of science in research, teaching, and studies is guaranteed in the German constitution. Freedom and responsibility - of each scientist and scholar individually as well as of the institutions of science - are inseparable from each other. Whoever practises science and scholarship as a profession is responsible for fostering the fundamental values and norms of scientific practice, to realize them in his or her daily activity and to defend them.

When, therefore, universities and research institutes formulate binding rules of good scientific practice, they must base them on a consensus of their academic members through the involvement of a corporate body of academic self-government.

Young scientists and scholars can only acquire a firm foundation for assuming their

personal responsibility if their more experienced superiors observe such rules of conduct in their own work that allow them to act as role models, and if they have sufficient opportunity to discuss the rules of good scientific practice including their ethical aspects in the widest sense. The principles and practicalities of good scientific practice should therefore be an integral part of academic teaching and of the research training of graduate students.

Recommendation 3

Heads of universities and research institutes are responsible for an adequate organizational structure. Taking into account the size of each scientific unit, the responsibilities for direction, supervision, conflict resolution, and quality assurance must be clearly allocated, and their effective fulfilment must be verifiable.

Commentary

In science as in all other fields, adherence to fundamental values is particular to each individual. Every scientist and scholar is personally responsible for his or her own conduct. But whoever is responsible for directing a unit also carries responsibility for the conditions therein.

Members of a working group must be able to rely on each other. Mutual trust is the basis for the conversations, discussions, and even confrontations (5) which are characteristic of groups that are dynamic and productive. A researcher's working group is not only his or her institutional home base; it is also the place where, in conversations, ideas become hypotheses and theories, where individual, surprising findings are interpreted and brought into a context.

Cooperation in scientific working groups must allow the findings, made in specialized division of labour, to be communicated, subjected to reciprocal criticism and integrated into a common level of knowledge and experience. This is also of vital importance to the training of graduate students in the group for independent research. In larger groups, some organized form for this process (e.g. regular seminars) is to be recommended. The same holds true for the reciprocal verification of new findings. The primary test of a scientific discovery is its reproducibility. The more surprising, but also the more welcome (in the sense of confirming a cherished hypothesis) a finding is held to be, the more important independent replication within the group becomes, prior to communicating it to others outside the group. Careful quality assurance is essential to scientific honesty.

The organization of working groups does not have to be hierarchical. But whether or not this is the case, there will always be a functional division of responsibilities, e.g. when one member of the group assumes the role of principal investigator of a grant proposal, and thereby becomes accountable to the funding institution according to its rules. Usually, one person heads a working group. He or she bears the responsibility that the group as a whole is able to fulfil its tasks, that the necessary cooperation and coordination are effective and that all members of the group are aware of their rights and their responsibilities.

This has immediate consequences for the optimum and maximum size of a group. A leadership function becomes void when it cannot be exercised responsibly on the basis of the knowledge of all relevant circumstances. Leading a working group demands presence and awareness. Where - for instance at the level of the direction of large institutes or clinics - these are no longer sufficiently assured, leadership tasks must be delegated. This will not necessarily lead to complex hierarchical structures. The 'leadership chain' must not become too long.

Institutions of science are under obligation to provide organizational structures which should ideally promote, but at least permit the type of healthy communication described above. Universities, as corporate institutions, and independent research institutes by analogy, must guarantee working conditions that allow all their members to observe the norms of good scientific practice. Heads of institutions carry the responsibility to ensure that a suitable organizational structure is (and is known to be) in place, that goals and objectives will be set and progress towards them can be monitored, and finally, that mechanisms for resolving conflicts are available.

Recommendation 4

The education and development of young scientists and scholars need special attention. Universities and research institutes shall develop standards for mentorship and make them binding for the heads of the individual scientific working units.

Commentary

Working groups as a rule consist of a mix of older and younger, experienced and less experienced scientists. Leading a group therefore includes the responsibility of ensuring that every younger member of the group - graduate students in particular, but also advanced undergraduates and younger postdocs - receives adequate supervision. Each one must have a senior partner primarily responsible for his or her progress (6).

In fields where active groups are in intensive competition with each other, there is a real danger, particularly for younger group members, of situations of real or supposed overburdening. A healthy communication within a group and high quality supervision are the best means to prevent younger or more experienced group members from slipping into dishonest practices. Leading a group includes the responsibility to guarantee such conditions at all times.

As experience in Germany and other countries shows, it is good practice for graduate students, beside their primary mentor, to be supervised by two additional experienced scientists who are available for advice and help and, if need be, for mediating in conflict situations, and who also discuss the progress of the young researchers' work with them at annual intervals. They should be accessible locally, but should not all belong to the same working group, not even necessarily to the same faculty or institution. At least one of them should be chosen by the graduate student.

Recommendation 5

Universities and research institutes shall appoint independent mediators to whom their members may turn in conflict situations, including cases of suspected scientific misconduct.

Commentary

An impartial and qualified mediator (or a small committee of such members) should advise the members of universities and research institutes on questions of good scientific practice. It would be part of their task to receive possible allegations of scientific misconduct in confidence and pass them on to the responsible authorities of the institution, if appropriate. They should be appointed from the institution's faculty.

It is important that this function, which may also have a significant effect in preventing

scientific dishonesty, be entrusted to persons of proven personal integrity and that they be equipped with the independence required by the task. In universities, this might be a deputy vice-chancellor for (research and) graduate students (as chairperson, if a committee solution is preferred). In independent research institutes, a member of the governing council or board might fulfil this role.

Members of universities and research institutes will normally prefer to discuss their problems with a person or persons locally available and familiar with local circumstances. They should not, of course, be obliged to do so if they prefer to turn immediately to the national 'Ombudsman' proposed below (recommendation 16).

Recommendation 6

Universities and research institutes shall always give originality and quality precedence before quantity in their criteria for performance evaluation. This applies to academic degrees, to career advancement, appointments and the allocation of resources.

Commentary

For the individual scientist and scholar, the conditions of his or her work and its evaluation may facilitate or hinder observing good scientific practice. Conditions that favour dishonest conduct should be changed. For example, criteria that primarily measure quantity create incentives for mass production and are therefore likely to be inimical to high quality science and scholarship.

Quantitative criteria today are common in judging academic achievement at all levels. They usually serve as an informal or implicit standard, although cases of formal requirements of this type have also been reported. They apply in many different contexts: length of Master or Ph.D. thesis, number of publications for the Habilitation (formal qualification for university professorships in German speaking countries), as criteria for career advancements, appointments, peer review of grant proposals, etc. This practice needs revision with the aim of returning to qualitative criteria. The revision should begin at the first degree level and include all stages of academic qualification. For applications for academic appointments, a maximum number of publications should regularly be requested for the evaluation of scientific merit.

Since publications are the most important 'product' of research, it may have seemed logical, when comparing achievement, to measure productivity as the number of products, i.e. publications, per length of time. But this has led to abuses like the so-called salami publications, repeated publication of the same findings, and observance of the principle of the LPU (least publishable unit). Moreover, since productivity measures yield little useful information unless refined by quality measures, the length of publication lists was soon complemented by additional criteria like the reputation of the journals in which publications appeared, quantified as their "impact factor" (see below, section II.5).

However, clearly neither counting publications nor computing their cumulative impact factors are by themselves adequate forms of performance evaluation. On the contrary, they are far removed from the features that constitute the quality element of scientific achievement: its originality, its 'level of innovation', its contribution to the advancement of knowledge. Through the growing frequency of their use, they rather run the danger of becoming surrogates for quality judgements instead of helpful indicators.

Quantitative performance indicators have their use in comparing collective activity and

output at a high level of aggregation (faculties, institutes, entire countries) in an overview, or for giving a salient impression of developments over time. For such purposes, bibliometry today supplies a variety of instruments. However, they require specific expertise in their application.

An adequate evaluation of the achievements of an individual or a small group, however, always requires qualitative criteria in the narrow sense: their publications must be read and critically compared to the relevant state of the art and to the contributions of other individuals and working groups.

This confrontation with the content of the science, which demands time and care, is the essential core of peer review for which there is no alternative. The superficial use of quantitative indicators will only serve to devalue or to obfuscate the peer review process.

The rules that follow from this for the practice of scientific work and for the supervision of young scientists and scholars are clear. They apply conversely to peer review and performance evaluation:

- Even in fields where intensive competition requires rapid publication of findings, quality of work and of publications must be the primary consideration. Findings, wherever factually possible, must be controlled and replicated before being submitted for publication.
- Wherever achievement has to be evaluated - in reviewing grant proposals, in personnel management, in comparing applications for appointments - the evaluators and reviewers must be encouraged to make explicit judgements of quality before all else. They should therefore receive the smallest reasonable number of publications - selected by their authors as the best examples of their work according to the criteria by which they are to be evaluated.

Recommendation 7

Primary data as the basis for publications shall be securely stored for ten years in a durable form in the institution of their origin.

Commentary

A scientific finding normally is a complex product of many single working steps. In all experimental sciences, the results reported in publications are generated through individual observations or measurements adding up to preliminary findings. Observation and experiment, as well as numerical calculation (used as an independent method or to support data analysis), first produce 'data'. The same is true for empirical research in the social sciences.

Experiments and numerical calculations can only be repeated if all important steps are reproducible. For this purpose, they must be recorded.

Every publication based on experiments or numerical simulations includes an obligatory chapter on "materials and methods" summing up these records in such a way that the work may be reproduced in another laboratory. Again, comparable approaches are common in the social sciences, where it has become more and more customary to archive primary survey data sets in an independent institution after they have been analyzed by the group responsible for the survey.

Being able to refer to the original records is a necessary precaution for any group if only for reasons of working efficiency. It becomes even more important when published results are challenged by others.

Therefore every research institute applying professional standards in its work has a clear policy for retaining research records and for the storage of primary data and data carriers, even when this is not obligatory on legal or comparable grounds following regulations laid down e.g. in German laws on medical drugs, on recombinant DNA technology, on animal protection, or in professional codes such as Good Clinical Practice. In the USA it is customary that such policies require the storage of primary data (with the possibility of access by third parties entitled to it):

- in the laboratory of origin
- for eight to ten years after their generation.

In addition these policies regularly provide for the event that the person responsible for generating the data moves to another institution. As a rule, the original records remain in the laboratory of origin, but duplicates may be made or rights of access specified.

Experience indicates that laboratories of high quality are able to comply comfortably with the practice of storing a duplicate of the complete data set on which a publication is based, together with the publication manuscript and the relevant correspondence. Space-saving techniques (e.g. diskette, CD-ROM) reduce the necessary effort.

The published reports on scientific misconduct are full of accounts of vanished original data and of the circumstances under which they had reputedly been lost. This, if nothing else, shows the importance of the following statement: The disappearance of primary data from a laboratory is an infraction of basic principles of careful scientific practice and justifies a *prima facie* assumption of dishonesty or gross negligence. (7)

Recommendation 8

Universities and research institutes shall establish procedures for dealing with allegations of scientific misconduct. They must be approved by the responsible corporate body. Taking account of relevant legal regulations including the law on disciplinary actions, they should include the following elements :

- a definition of categories of action which seriously deviate from good scientific practice (Nr. 1) and are held to be scientific misconduct, for instance the fabrication and falsification of data, plagiarism, or breach of confidence as a reviewer or superior,
- jurisdiction, rules of procedure (including rules for the burden of proof), and time limits for inquiries and investigations conducted to ascertain the facts,
- the rights of the involved parties to be heard and to discretion, and rules for the exclusion of conflicts of interest,
- sanctions depending on the seriousness of proven misconduct,
- the jurisdiction for determining sanctions.

Commentary

The law on disciplinary actions legally takes precedence over these internal institutional procedures as far as sanctions touching the relationship between employer and employee are

concerned. Equally, other legal regulations e.g. in labour law or in the law on academic degrees cannot be overridden by internal rules. The present recommendations are not meant to replace these existing regulations, but to call them to memory and to complement them.

Existing legal regulations do not cover all forms of possible misconduct in science, and in part they serve to protect rights other than the credibility of science and the conditions for its functioning. Owing to the different aims and contexts of these regulations, they partly postulate additional assumptions and requirements which go beyond scientific misconduct as such or address other concerns. They are not adapted to the configuration of interests typical of allegations of scientific misconduct. For instance, they do not adequately take account of the interests of the accused person, of his or her research institution, and of the 'whistle blower'. Often, legal procedures take several years.

In spite of their partly antagonistic standpoints, the person whose work has been challenged, his or her institution, and the person who has raised allegations, share an interest in a rapid clarification of the allegations and in avoiding publicity. All three wish to protect their reputation. The rules of procedure for dealing with allegations of scientific misconduct must take into account this common interest of the parties involved. They should therefore suitably provide for a procedure in several steps:

The first phase (inquiry) serves to ascertain a factual basis for judging whether or not an allegation is well founded. In this phase, the need of the respondent and the 'whistle blower' for confidentiality is balanced against the aim of reaching a clear statement of the facts within a defined short time. In this first phase, the protection of the potentially innocent respondent is particularly prominent. It ends with the decision whether the allegation has substance and therefore requires further investigations, or whether it has proved baseless.

A second phase (investigation) includes such additional inquiries as may be necessary, in particular hearings and recordings of evidence, the formal declaration that misconduct has or has not occurred, and finally the reaction to a confirmed allegation. Reactions may take the form of a settlement or arbitration, of recommendations to superiors or third parties, or of sanctions

(including e.g. the obligation to retract or correct publications with proven irregularities) imposed through the authority empowered for this in the individual institution. The protection of public confidence in science requires that not only the investigation and confirmation of the facts, but also the reaction to confirmed misconduct happen within a reasonable period of time.

Such procedures, as has been noted above, reach their limits where legal regulations apply. In the first phase of inquiry, it will not always be possible to reach an exact conclusion on the precise nature of a case. The procedural character of the inquiry phase will therefore have to be measured against the requirements of related legal proceedings to ensure that findings established in this phase may, if necessary, be used in these proceedings as well.

The relationship between internal institutional procedures and legal proceedings, e.g. according to the law on disciplinary actions, is not simply a question of determining jurisdictions or competences in parallel or joint investigations. Internal regulations may, depending on the nature and the seriousness of misconduct, offer consensual solutions through conciliation or arbitration. These generally have the advantage of allowing procedures to be concluded speedily and on the basis of a settlement between the parties involved, i.e. without the judgment of a third party having to resolve the controversy. The conciliation procedure, which is obligatory according to German labour law for litigation

concerning employer-employee relationships, shows that consensual settlements are well adapted to the long-term character often typical for employment. To avoid an erosion of the advantages of such alternative dispute resolution through time-consuming confrontations on the person of the arbitrator and on the settlement proposed, internal regulations should prescribe time limits after which formal legal proceedings (with their specific advantages and disadvantages) shall become mandatory.

Settling a dispute on a consensual basis has a potential for peace-keeping and may in many circumstances do better justice to a case than the decision by a court of justice on the basis of abstract categorizations of the facts and their legal consequences. On the other hand, this flexibility must not lead to preferential treatment for individuals or to allegations being swept under the carpet without proper clarification.

When new procedures for conflict resolution have been instituted abroad, it has proved useful to collect data for their evaluation at a later date, e.g. in the institutions involved, from the beginning of their implementation. Such data may serve as the basis for a critical evaluation of new procedures after a pilot phase, and for their improvement.

Depending on the nature of the interventions into the rights of the parties that internal regulations allow for, their juridical character, which makes them subject to verification by the courts, has to be taken into account. Such interventions may already occur in the inquiry phase, and the imposition of concrete sanctions will certainly fall under this category.

Both phases of internal procedures, inquiry and investigation, must conform to the following principles:

a) The regulations must specify in advance

- who officially receives allegations of scientific misconduct,
- when inquiries and investigations are to be initiated, by whom, and in what form,
- which steps are to be taken to set up decision-making bodies, whether they be ad hoc groups or standing committees or take a mixed form, e.g. with a permanent chairperson and individually appointed members from the institution itself or from outside. Ideally the academic members of an institution should be in control of the proceedings and have the majority in the decision-making bodies. However, involving experts from outside will always serve objectivity and may be indispensable in smaller institutions.

b) Conflict of interest of a person involved in investigations must be arguable both by him- or herself and by the respondent.

c) The respondent must have a right to be heard in every phase of the proceedings.

d) Until culpable misconduct is proven, strict confidentiality must be observed concerning the parties involved as well as the findings reached.

e) The result of an investigation shall be communicated to the science organizations and journals involved at a suitable time after its conclusion.

f) The individual phases of the procedure must be concluded within appropriate time limits.

g) Proceedings and results of the individual phases must be clearly recorded in writing.

The implementation of this recommendation will, as is evident from the above, require considerable juridical expertise. It is therefore to be recommended that a central institution, for instance the Hochschulrektorenkonferenz (German Committee of Vice-Chancellors and Principals) assume the task of formulating a model order of procedure for the universities (see also recommendation 9 for independent research institutes).

The commission, in this context, wishes to draw attention to the following:

Juridical proceedings in cases of scientific misconduct raise new and difficult legal issues. They include the role of professional scientific standards within the regulations of state law, and the proof of scientific dishonesty, and with it the rules for the distribution of the burden of proof. Issues of this type may only be resolved when all the interests of free scientific enquiry are comprehensively taken into account. The Deutsche Forschungsgemeinschaft should therefore take the initiative for a more than occasional discourse between representatives of different fields of research and practitioners of the legal profession.

The available experience of dealing with scientific misconduct in Germany reveals the different contexts in which science and the administration of justice operate. The decision of the Federal Administrative Court (Bundesverwaltungsgericht) on the reactions of the Justus Liebig University to allegations of falsification against one of its professors (8) throws a light on the image of scientific enquiry from the legal profession's point of view. In the decision, scientific enquiry is represented as a discourse in which everything that may be regarded as a serious effort to attain the truth has a claim to validity, and with it to the protection of the constitutional guarantee of the freedom of science (9). The Court has thus made the exclusion of a project and its author from the protection by the guarantee of freedom depend to a large extent on the scientist's intention. While the Administrative Court does not hold the intention to discover the scientific truth about something to be the sole condition for the assumption of a serious scientific effort protected by the Constitution, it refuses this protection only when a scientist's activity "beyond doubt" cannot be held to aim to increase scientific knowledge (10).

The decision shows the aim of the courts to prevent unconventional concepts and methods in science from being marginalized by corporate university bodies. The high rank of science in the constitution sets a high threshold for any legal regulation, and any administrative or judicial decision, which restricts the freedom of science in the interest of other values. However, the research standards, rules of responsibility and obligations of good scientific practice recognized in a discipline must not be disregarded in this context. This includes their consequences for the burden of proof; in the case underlying the decision cited above, the primary data on which the publications and the statements at issue were based were no longer available. The decision thus demonstrates that the intersections between the treatment of allegations of scientific misconduct in corporate bodies of scientific self-administration on the one hand, and in formal judicial proceedings on the other, merit discussion in a similar way to that which has been documented in the United States (11).

The commission therefore proposes to the Deutsche Forschungsgemeinschaft to hold regular colloquia involving legal practitioners, legal scholars and representatives of other branches of science and scholarship. Meetings of this kind might serve to discuss themes such as the following:

- the legal definition of science and the way in which professional scientific norms are taken into account,
- the burden of proof and the appreciation of evidence, including the keeping of

- laboratory records, in cases of scientific misconduct allegations,
- the status of scientists and scholars within the legal structures of universities and of employment regulations,
 - alternative models of conflict resolution in science, e.g. through arbitration and through consensual settlements,
 - forms of involvement of scientists in misconduct of their collaborators, and their consequences,
 - the institutional responsibility for organizational and working structures, and scientific selfregulation.

Recommendation 9

Research institutes independent of the universities not legally part of a larger organization may be well advised to provide for common rules, in particular with regard to the procedure for dealing with allegations of scientific misconduct (Nr. 8).

Commentary

The Max-Planck-Gesellschaft has enacted an order of procedure (12) for handling allegations of scientific misconduct for all its institutes in November, 1997. Its president has announced that rules of good scientific practice are to be formulated. For other independent scientific institutions, it may on the one hand be important to have rules of good scientific practice that correspond to their tasks and that are based on a consensus of their academic membership. On the other hand it may be advisable that codes of conduct and rules of procedure of the type recommended here be developed jointly for several institutes. This will be in the interest both of the desirable uniformity of principles and of avoiding excessive deliberation efforts. Thus, working out common principles might commend itself for the national laboratories that are members of the Hermann von Helmholtz Gemeinschaft Deutscher Forschungszentren, and for the institutes belonging to the Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz, while other independent institutes might cooperate with this aim.

Recommendation 10

Learned Societies should work out principles of good scientific practice for their area of work, make them binding for their members, and publish them.

Commentary

Learned societies (13) play an important role in establishing common positions of their members, not least on questions of standards and norms of professional conduct in their disciplines, and on ethical guidelines for research. A number of learned societies in Germany (in analogy to the practice common in the USA for some time) has set down and published general or discipline-specific codes of conduct, in particular for research, in their Statutes or based upon them, for example the German Chemical Society (3), the German Sociological Society (14), the German Society for Studies in Education (15), and others. Recently, some learned societies in Germany which do not yet have such rules have begun to develop them (16). Such efforts to develop codes of practice are an important element of quality assurance for research and deserve still wider attention.

Since European learned societies now exist for many scientific disciplines, it is recommended to pursue discussions of good scientific practice at the European level as well as nationally.

An analogy may be drawn - taking into account their different legal status - to the guidelines issued by the Chambers of Physicians in Germany, in particular the Bundesärztekammer at whose initiative ethical committees for research involving human subjects have been established throughout Germany since 1979. These have formed a joint working group whose administration is located with the Bundesärztekammer. Since the fifth amendment to the German law on drugs (Arzneimittelgesetz) enacted in 1995, the ethical committees, in addition to advising principal investigators of studies involving patients and/or volunteers, have acquired important new tasks in the quality assurance of clinical studies (17).

There are remarkable parallels between the codes of practice that are part of the professional law for physicians, and the basic principles of scientific work. The evaluation of the professional conduct of physicians refers, *inter alia*, to obligations in organization and documentation, and securing evidence. Behaviour contrary to these obligations may in certain cases have consequences for the burden of proof in misconduct cases (18). Such parallels afford the possibility for science to profit from certain aspects of the experiences of the Chambers of Physicians when dealing with misconduct.

Recommendation 11

Authors of scientific publications are always jointly responsible for their content. A so-called "honorary authorship" is inadmissible.

Recommendation 12

Scientific journals shall make it clear in their guidelines for authors that they are committed to best international practice with regard to the originality of submitted papers and the criteria for authorship.

Reviewers of submitted manuscripts shall be bound to respect confidentiality and to disclose conflicts of interest.

Commentary

Scientific publications are the primary medium through which scientists give an account of their work. Through a publication, authors (or groups of authors) make a new finding known and identify themselves with it; they also assume the responsibility for its content. Simultaneously the authors and/or the publishers acquire documented rights of intellectual property (copyright, etc.). In this context, the date of publication has gained specific importance in the sense of documenting priority; all good scientific journals report when a manuscript has been received and when - usually following peer review - it has been accepted.

Owing to their importance for documenting priority and performance, publications have long since been the object of many conflicts and controversies. In the course of these, however, generally accepted rules (19) have been developed for the most important issues, namely the originality and independence of the content of a publication, and for authorship. They may be summarized as follows:

Publications intended to report new scientific findings shall

- describe the findings completely and understandably,
- give correct and complete references to previous work by the authors and by others

- (citations),
- repeat previously published findings only inasmuch as it is necessary for understanding the context, and in a clearly identified form.

The guidelines for authors of many good and respected journals demand written statements that the content of a submitted manuscript has not previously been published or submitted for publication elsewhere. They do not accept manuscripts of original publications if their content has been presented to the general public prior to being subjected to criticism by reviewers and the scientific community; exceptions are granted only for full publications of findings previously presented at scientific meetings ("abstracts").

Authors of an original scientific publication shall be all those, and only those, who have made significant contributions to the conception of studies or experiments, to the generation, analysis and interpretation of the data, and to preparing the manuscript, and who have consented to its publication, thereby assuming responsibility for it. Some journals demand that this be documented through the signatures of all authors. Others ask for a written statement to this effect by the corresponding author as the person responsible for a manuscript as a whole and in all its details. Where not all authors can assume responsibility for the entire content of a publication, some journals recommend an identification of individual contributions.

With this definition of authorship, other contributions, including significant ones, such as

- the responsibility for obtaining the funds for the research,
- the contribution of important materials,
- the training of co-authors in certain methods,
- involvement in the collection and assembly of data,
- directing an institution or working unit in which the publication originates,

are not by themselves regarded sufficient to justify authorship.

A so-called "honorary authorship" is in no way acceptable either in the guidelines of the best journals or in the codes of practice of the best American research universities. Adequate mention of contributors who are not authors is recommended e.g. in footnotes or acknowledgements.

To avoid conflicts concerning authorship, journals recommend timely and clear agreements, in particular when there is a large number of contributors to the findings, to serve as guidelines for resolving disputes.

Nearly all good journals have guidelines for reviewers of manuscripts committing them to strict confidentiality and to disclosing such conflicts of interest which may have eluded the editors and their advisors in selecting reviewers. Many good journals also promise their authors to respond to a submitted manuscript within a specified, short time limit, and correspondingly set their reviewers short time limits for their comments.

Recent publications (20) document an ongoing international discussion on these questions of quality assurance among journal editors. The commission feels that this discussion merits to be pursued even more broadly at European or international level.

Recommendation 13

Research funding agencies shall, in conformity with their individual legal status, issue clear

guidelines on their requirements for information to be provided in research proposals on (i) the proposers' previous work and (ii) other work and information relevant to the proposal. The consequences of incorrect statements should be pointed out.

Commentary

Research funding takes place in different contexts. In Germany, the primary agents are federal and State ministries, foundations and funding agencies under public and private law, and the Deutsche Forschungsgemeinschaft. Funding agencies differ from universities and research institutes, which conduct research intramurally, in that their relationships with individual researchers usually reach beyond their own organizational context.

Funding agencies typically have an intermediate position between scientists submitting proposals for their research, and other scientists who act as reviewers. They extend a substantial measure of trust to the individual scientist, both in taking the statements in his or her proposal as a basis for its evaluation, and in entrusting the proposal, which typically contains new ideas demanding protection, to a colleague for review. The funding agencies' own interest in the observation of the fundamental principles of scientific practice and its review lies in safeguarding the mutual trust indispensable for their work.

For the individual scientist, funding agencies play an essential role through the financial support which they grant. By addressing scientists as applicants for funds or as beneficiaries of grants, they may exercise an influence on the consolidation and the protection of standards of scientific practice. Through the design of their requirements for proposals and their conditions for support they can reduce or prevent circumstances that may prompt or facilitate misconduct. They must also prepare themselves for dealing with the eventuality that their funds or their reputation are at issue in connection with misconduct of a scientist. Such cases may occur through incorrect statements in proposals, through the misuse of grant money, or through dishonest handling of proposals submitted for review.

To protect the basis of trust between themselves and the applicants and to provide orientation, funding agencies should clearly specify in their guidelines to what standards a qualified proposal must conform:

- Previous work must be presented specifically and completely.
- Publications must be precisely cited. Unpublished manuscripts must be clearly identified as "in press in ...", "accepted by ..." or "submitted to ...".
- Projects must be described in the way in which, to the best knowledge of the applicant, they are intended to be carried out.
- Cooperations may only be taken into account by reviewers when the relevant partners have declared their intention and shown the possibility to cooperate as stated.

Through their signature, applicants must acknowledge having noted these principles.

Recommendation 14

In the rules for the use of funds granted, the principal investigator shall be obliged to adhere to good scientific practice. When a university or a research institute is the sole or joint grantee, it must have rules of good scientific practice (Nr. 1) and procedures for handling allegations of scientific misconduct (Nr. 8).

Institutions which do not conform to recommendations 1 to 8 above shall not be eligible to receive grants.

Commentary

The relationship between a funding agency and an applicant is at first unilateral. A grant, awarded after peer evaluation, establishes a closer, bilateral relationship which provides further possibilities for addressing the individual scientist.

To protect themselves against misconduct of individual grant holders, funding institutions should, in accordance with their legal status, design the specific legal relationship (21) between themselves and the grantees, by laying down and publishing their requirements for the proper conduct of research and specifying their reactions to misconduct.

The definition of what constitutes scientific misconduct as such should be left to the institutions in which research is carried out, so as to ensure that they are appropriate to the specific research environment. The same applies to factual inquiries and investigations necessary for confirming or disproving an allegation.

Funding agencies must, however, set down in their funding conditions, and make public, their policy in relation to research they support and their reactions to abusive practices. Instead of the obvious possibility of recurring to the law of torts or of enrichment in such cases, they may also choose to provide for contractual penalties for certain actions. These would not necessarily take the form of payments, but might also include written warnings, debarments, etc. (22).

Recommendation 15

Funding organizations shall oblige their honorary reviewers to treat proposals submitted to them confidentially and to disclose conflicts of interest. They shall specify the criteria which they wish reviewers to apply. Quantitative indicators of scientific performance, e.g. so-called impact factors, shall not by themselves serve as the basis for funding decisions.

Commentary

Explicit standards for review are a useful orientation for reviewers. The confidentiality of the ideas to which a reviewer has access in a proposal absolutely precludes communicating them to third parties, not even for assistance in the review process. To ensure an objective evaluation applying scientific criteria, funding organizations must select their reviewers in a way that avoids any conflict of interest, real or apparent. Where conflicts of interest with the principal investigator or the project do occur despite these precautions, reviewers must disclose them. This is also in the individual reviewer's own best interest, since it serves to confirm his or her reputation as a fair and neutral expert.

Rules on confidentiality and on conflicts of interest should provide a sufficient basis for reactions by the funding agency, should a reviewer abuse his or her position. In contrast to the guidelines for applicants and grantees, however, contractual penalties stipulated before the beginning of the review are not acceptable here. Reviewers exercise their function in an honorary capacity. Any imputation of dishonest conduct, however hypothetical, will be demotivating and act as a deterrent. This is true regardless of the contractual relationship between the funding organization and the reviewer which might be construed from a legal point of view (23). Reactions to misconduct of reviewers should therefore be laid down in the general rules of a funding organization and not become the subject of individual agreements.

In cases of suspected use of confidential material for a reviewer's own work or other serious breach of confidentiality, the commission recommends the consultation of experts in the interest of the quickest possible clarification. A reviewer known to have abused confidential information from grant proposals must not be consulted again and, should he or she have been elected or appointed to this function, must be debarred from it.

It may also be advisable to communicate proven dishonesty of a reviewer to other funding organizations. Equally, dishonest use of confidential proposal information by a reviewer may justify the disclosure of his or her identity to the principal investigator of the proposal to enable him or her to claim compensation for damage incurred.

Rules analogous to those for reviewers must be established for the staff and for members of decision-making bodies of funding organizations who have access to confidential proposal informations.

Similar care and tact as in formulating requirements of neutrality and confidentiality must be exercised by funding organizations in setting out criteria for review. Measures to ensure a uniform high quality of reviews are nevertheless necessary, not least because different funding programmes have different sets of criteria in addition to general principles of selecting the best research. Guidelines for reviewers are therefore common practice in funding organizations (24).

More arduous than securing confidentiality of review is the maintenance of its scientific quality, i.e. the selection of those reviewers who are best qualified to assess a certain proposal, who are ready to go beyond gaining a superficial impression of the productivity of the proposers and to assess the intellectual content of the proposal and the previous work on which it is based. Therein lies a great and permanent challenge for the academic staff of all funding organizations.

Peer review of grant proposals will not provide many opportunities for uncovering scientific misconduct. However, visits to the individual laboratories in the context of site visits may be an important source of relevant information, because they enable reviewers to obtain first hand information from all members of a working group.

Recommendation 16

The Deutsche Forschungsgemeinschaft should appoint an independent authority in the form of an Ombudsman (or a small committee) and equip it with the necessary resources for exercising its functions. Its mandate should be to advise and assist scientists and scholars in questions of good scientific practice and its impairment through scientific dishonesty, and to give an annual public report on its work.

Commentary

Formulating norms and recommendations for good scientific practice only lays a foundation for their effect in real life. Difficulties in observing basic principles usually arise in their implementation. This is because the distinction between "honest" and "dishonest" is much easier in theory than in the actual circumstances of an individual case, with the involvements and value conflicts which come into play.

This is true for judging both one's own conduct in science and for doubts cast upon the conduct of others. The latter often confront scientists and scholars - particularly those still

engaged in establishing their career - with the question whether the interest of disclosing dishonest conduct of another scientist (who may be their elder and/or their superior) weighs up the consequential risks to their own career. This provides a challenging dilemma. 'Whistle blowers' or 'informants' may become victimized. To provide a way out of the isolation of such a conflict, the commission recommends that the Deutsche Forschungsgemeinschaft take the initiative of appointing an Ombusman (or a body of Ombudspersons) for science and scholarship.

Such a mediating person or committee should be vested with a clearly specified mandate which might, for instance, be based on its appointment by the DFG Senate and a commitment to report to it annually. It should not have a mandate to conduct its own investigations like, for instance, the Office of Research Integrity of the US Public Health Service (25). Through its personal authority, integrity and impartiality, it should become a competent and credible partner, to whom scientists and scholars may turn with their problems and who, if need be, may take up indications for serious concern and bring them to the attention of the institutions involved. The commission regards it as important that this mediating authority be accessible to all scientists and scholars whether or not the research in question is supported by the DFG.

By appointing such a mediating authority, the Deutsche Forschungsgemeinschaft would support public confidence in good scientific practice by demonstrating the attention which science and scholarship give to their own self regulation (26). This does not diminish the desirability that universities and research institutes appoint local independent counselors (recommendation Nr. 5 above). The two measures are complementary.

II. Problems in the scientific system

Questions and discussions similar to those which have prompted the present recommendations were first raised in a broader context almost 20 years ago in the USA after allegations of scientific misconduct had arisen at several well-known research universities in succession within a few years. They were partly confirmed after some time, partly pursued controversially for several years with substantial participation of the public and the courts, and only resolved after a long time - in one case in the eleventh year after the first allegations.

The cases of alleged scientific misconduct which have become famous in the USA between 1978 and the end of the 1980s have the following features in common (27):

- The defendants and their institutions had a high reputation; at the least, the person against whom allegations were raised belonged to a well-known group. Often, the 'whistle-blowers' were less prominent.
- The clarification of the facts by the institution concerned was conducted slowly and/or awkwardly.
- The public was alerted at an early time through the press or other media. All following steps were thus accompanied by public attention and controversies.

Most of these cases were also the object of litigation in the courts, and in some of them, politicians eagerly took part. Public attention was the major factor which caused a large number of committees to engage both in the phenomenology and in fundamental deliberations of "scientific fraud and misconduct" (28) from the beginning of the 1980s. The widespread impression that the institutions of science were poorly equipped to handle such problems led to institutional regulations reported below (section III.1).

The first attempts to assess the quantitative dimensions of the problem of scientific misconduct did not lead to conclusive results (29). Meanwhile, reports of the two most important authorities responsible for dealing with misconduct cases, the Office of Inspector General (OIG) of the National Science Foundation (NSF), and the Office of Scientific Integrity (ORI) of the Public Health Service, are available. The OIG has received an average of 30 to 80 new cases per year - compared with some 50.000 projects funded by the NSF - and found misconduct in about one tenth of these. The ORI's Annual Report for 1995 mentions 49 new cases lodged with the ORI itself and 64 new cases in institutions within its jurisdiction in the preceding year, compared to more than 30.000 projects supported by the National Institutes of Health (30).

The Danish Committee on Scientific Dishonesty (DCSD), founded in 1992 at the Initiative of the Danish Medical Research Council and working under the umbrella of the Danish research ministry since 1996, had to deal with 15 cases during the first year of its activity. In the following years, the number of new cases first decreased rapidly and then rose again to 10 in 1996 (31).

In Germany, in the ten years preceding 1997, a total of six cases of alleged scientific misconduct came to the knowledge of the Deutsche Forschungsgemeinschaft (DFG). Since 1992, those cases in which the DFG was involved have been handled according to the rules set up by its Executive Board for dealing with such events. These include the following elements:

- Allegations are examined in the directorates of the DFG central office responsible for the case in question. The parties involved are heard.
- If, after this, a suspicion of scientific misconduct appears to have substance and if a consensual settlement cannot be reached, the case is put before a subcommittee of the DFG's Grants Committee chaired by the Secretary General. After giving the parties involved the opportunity to give evidence, this committee determines the facts of the case and makes recommendations to the Grants Committee as may be necessary.
- If necessary, sanctions are imposed by the Grants Committee.

In three of the cases brought to the DFG's attention, the allegations concerned the misappropriation of confidential proposal information or other forms of misconduct by reviewers. These cases were closed after correspondence and conversations between the parties involved and the DFG head office.

In the three other cases the allegations concerned the fabrication or falsification of experimental research findings in university institutes. These cases have the following features in common:

- Published results were challenged after different lengths of time in the scientific literature.
- The responsible authorities in the universities took action, investigated the facts, collecting evidence from the defendants and partly also from other parties involved, and imposed sanctions.
- All three cases - the oldest of them goes back to the year 1988 - were still pending in court at the end of 1997. In one case the university has appealed to the Federal Constitutional Court against a decision by the Federal Administrative Court (8). Another, more recent case is pending following a decision by the local administrative court on the issue of provisional legal protection (32).

The commission's mandate was to "explore possible causes of dishonesty in the scientific system". In what follows, an attempt is made to describe some of its potential underlying causes which might justify a higher level of attention to problems of scientific dishonesty.

Dishonesty in science always comes down to the conduct of individuals, even when they do not act alone. Correspondingly, both the analysis of individual cases and generalizing statements frequently relate to considerations of individual psychology and even psychopathology (33). Such explanations, however, are of limited use when the question is raised, which general conditions might favour scientific dishonesty and what measures might be taken for its prevention.

1. Norms of science

Dishonesty and conscious violations of rules occur in all walks of life. Science, and in particular scientific research, is particularly sensitive to dishonesty for several reasons:

Research, seen as an activity, is the quest for new insights. They are generated through a combination - permanently at risk through error and self-deception - of systematic enquiry and intuition. Honesty towards oneself and towards others is a fundamental condition for achieving new insights, for establishing them as a provisional point of departure (34) for new questions. "Scientists are educated by their work to doubt everything that they do and find out ... especially what is close to their heart" (35).

Research in an idealized sense is the quest for truth. Truth is categorically opposed to dishonest methods. Dishonesty therefore not merely throws research open to doubt; it destroys it. In this, it is fundamentally different from honest error, which according to some positions in the theory of science is essential to scientific progress, and which at any rate belongs to the 'fundamental rights' of every scientist and scholar (36).

Nearly all research today is carried out with regard to a social context, both in the narrow sense of the scientific community and in the wider sense of society at large. Researchers depend on each other, in cooperation and as competitors. They cannot be successful unless they are able to trust each other and their predecessors - and even their present rivals. "Being overtaken in our scientific work is not only our common fate ... but our common mission. We cannot work without hoping that others will surpass us". Max Weber's dictum (37) applies to contemporaries no less than to predecessors and successors. Thus, honesty is not merely the obvious basic rule of professional conduct in science in the sense that "within the confines of the lecture theatre, there is simply no other virtue but straight intellectual honesty" (37); it is the very foundation of science as a social system.

2. Science as a profession - today

As early as 1919, well before the rise of the United States to becoming the leading nation in science, Max Weber - in the context cited above - observed:

"Our university life in Germany, like our life in general, is being americanized in very vital aspects, and it is my conviction that this development will spread even further ..." (37). A fortiori the USA today are the country where the structures of professional science and their inherent problems are more clearly visible and more amply documented than anywhere else (38). The fundamental characteristic of present-day science, namely that 90 % of all scientists ever active are alive today, was first published by an American (39). The USA were also the country where, after the unprecedented effort of the Manhattan Project, a

national engagement by the state for basic research as the source of intellectual capital was proposed (40) and implemented. After the establishment of the National Science Foundation in 1950 and the National Institutes of Health in 1948, the efforts of the American Federal Government grew steadily over many years and led to a rapid growth of the research system as a whole and to the evolution of the research universities where a substantial part of their overall activity is funded through project grants of research funding agencies. In contrast to conditions in Germany, these grants typically include not only the salary of the principal investigator but, in addition, by way of so-called "overheads", the cost of research infrastructure including administration. Success in the competition for these funds is thus decisive for career opportunities, for the equipment and - in cumulation - for the reputation of departments and of entire universities. The essential criterion for success in the competition for grants is scientific productivity, measured in terms of its results made available to the scientific community. Publications, over the course of time, thereby acquired a double role: beyond their function in scientific discourse and as documents of new knowledge, they became means to an end, and were soon counted more often than read. Parallel to this, the more research results became the basis of applications, the more the relationship between 'academic' research and fields of application in industry, in public health, in advice to politics, etc. grew in intensity. More recently, new and important developments have occurred in the USA: the esteem for research as a national goal, accepted without question over many years, is diminishing. Science is increasingly perceived as a consumer of government funds, among many others, and faces the obligation of justifying its requests in competition with other government priorities. Cooperation with stakeholders in applications of research gain even more importance (with large differences between disciplines), and research results are viewed in terms of their utility for financial success with growing frequency (41).

Much of this description is applicable also to Germany. When the difference in size between the two countries is taken into account, the quantitative development is not dissimilar. In 1920, the senior faculty membership of universities and comparable institutions in all Germany numbered 5.403 (42). The number of professorships in higher education institutions in West Germany grew from 5.400 in 1950 to 34.100 in 1995, while the number of positions for "other academic staff" rose from 13.700 to 55.900. Germany as a whole counted 42.000 professorships and 72.700 positions for "other academic staff" in higher education institutions in 1996 (43), not including the academic personnel funded through grants and contracts. Government expenditure for research and

development (R&D) in higher education institutions was about 20% of gross domestic expenditure for R&D (44).

These figures show that academic research in Germany (as in other developed countries) grew, within less than a century, from scholarly work conducted individually or in small communities to organizational forms of work typical of large enterprises. The term "knowledge production" has become current, and changes in the form of knowledge production are discussed in terms similar to those used for industrial production (45).

3. Competition

Competition is on record as a feature of the system of science since the 17th century (46). Priority of discovery and of publication was the major concern at issue then. Today, the issues are much broader and involve all prerequisites of scientific research up to, and including, the continuity of working groups and the professional careers of the researchers themselves. Competition between individual researchers, which has become international in all but a few fields of research, is complemented by competition between institutions and

nations (47). In contrast to the ranking lists in sports, however, the distance between the gold medalists and the field is very large: confirmation of a discovery already published brings little honour. There are no silver medals, and national records have no international significance. This makes the systematic control of published findings through independent groups working in the same field all the more important.

Every form of competition knows its own conscious violations of the rules. Their probability increases with the intensity of competition and with the pressure for success. Intolerable pressure is one of the motives presented by William Summerlin, the central figure of the first recent case of falsification in research that gained prominence in the USA. "Time after time, I was called upon to publicise experimental data and to prepare applications for grants ... Then came a time in the fall of 1973 when I had no new startling discovery, and was brutally told by Dr. Good that I was a failure ... Thus, I was placed under extreme pressure to produce" (48).

Success rates in the American system of research funding have been consistently low for many years. Thus, the motivation to gain success by breaking rules may be estimated to be high. Comparable pressure is meanwhile also felt in Germany by many scientists and scholars, particularly in the younger generation.

Besides provoking the temptation to break the rules, the pressure of competition may also lead to sloppiness and lack of care. Systematically doubting one's own findings, however, is at the core of scientific method. Repetition of experiments - if possible, independently - is particularly important when they yield the desired result. Competitive pressure and haste, trying to publish faster than one's competitors, are a source of scantily confirmed results, which in practice is much more frequent than manipulation and falsification.

4. Publications

Since the early modern forms of institutionalization of science in the 17th century, scientific findings are only recognized when they have been published and laid open to criticism and scrutiny. This principle is still valid, but it encounters several difficulties:

First, the growth of science has led to an exponential growth of the number of publications, which has long since reached dimensions defying overview (49).

Second, the use of publications as a performance indicator in the competition of scientists for career chances, research funds, etc. has in turn accelerated the growth in the number of publications and led to the technique of splitting up their content into smaller and smaller portions. Criticism of this, epitomized in terms such as the "publish or perish" principle or the LPU (least publishable unit) is of long standing, but has not slowed down the growth.

Furthermore, the number of publications with several authors has also grown rapidly throughout this century, not only for the objective reason that in nearly all fields of science and scholarship (with the exception of the humanities) cooperation has become a necessary condition of successful work, but also for the opportunistic reason that the length of a publication list is extensively used as an indicator of a researcher's rank, notwithstanding criticism of its validity.

Since the late 17th century it has been customary for new research findings to be discussed critically before publication. Good scientific journals today publish original articles only after they have been examined by competent reviewers for their validity and originality. Guidelines for authors, regularly published, often contain a description of the review

process indicating time limits and success rates. The ratio of submitted and accepted papers will often be 10 per cent or less in leading journals like Nature and Science (50).

The review process is a critical phase for publication manuscripts in two ways:

On the one hand it holds risks for the authors because ideas, research findings and texts still unprotected by patents or intellectual property rights are submitted to persons whose identity is normally unknown to the authors (nearly all review processes of this type are anonymous, and few reviewers break anonymity themselves) and who may happen to be their direct competitors. Safeguards typically used by editors are the careful selection of reviewers, avoiding members and declared opponents of a 'school', requesting reviewers to respect confidentiality and to divulge conflicts of interest, and setting brief time limits for reviews.

On the other hand, it has been argued that reviewers ought to be relied upon to recognize manipulations and falsifications, and that they have some moral obligation to make every necessary effort. In fact, this argument remains at some distance to reality. Editors and reviewers do indeed discover many inconsistencies with the consequence that manuscripts are revised or are not accepted for publication (at least in the journal in question). And editors of leading journals are discussing measures to improve their techniques of dealing with irregularities in manuscripts and in publications (20). To expect irregularities to be reliably detected would, however, be misguided: the original data are not available to reviewers, and if they were, they would not have the time to replicate experiments and observations. In this, as in other areas of self regulation in science, mutual trust is an essential component of the process. This is why it is so vulnerable to dishonest conduct.

Irregularities are more likely to be detected when published results are examined by other groups. According to estimates, between 0.1 and 1.0% of publications are retracted or corrected after their validity has been challenged. No data exist to show to what extent error or deceit is the cause here. As a rule, doubts are communicated immediately to authors by their colleagues. Editors of journals have little leeway for action when they learn of doubts informally. Publishing corrections is fraught with juridical risks unless they are jointly signed by all authors (51).

5. Quantitative performance evaluation

The susceptibilities of the scientific system to various forms of dishonesty sketched in the preceding pages have been aggravated in the last two decades with the extensive introduction of computer-based referencing systems for publications and citations and their growing use in the evaluation of achievements and performance in science. The richest and most frequently used data basis for this is the Science Citation Index published by the Institute for Scientific Information (ISI) in Philadelphia. It permits quantitative measurements of the impact of publications, based on their citations, and although details of the methodology are still being discussed in journals like *Scientometrics*, citation analysis has established itself as an integral part of performance evaluation in research, and, as recent publications show (52), plays an increasing role in shaping research policy in various countries. Bibliometric techniques also serve as a useful basis for observing the development of science through the analysis of publication and citation frequency, as exemplified by the journal *Science Watch*.

Citation analysis permits calculation of the impact of the work of individuals, groups, departments and of entire countries, but also of journals. The "journal impact factor" is annually published by the ISI and widely regarded as a measure of the reputation, and thus

indirectly of the quality, of a journal. The impact factor of Nature in 1995 was calculated to be 27, that of the Journal of Biological Chemistry 7.4, and that of *Arzneimittelforschung* 0.5. In the review of grant proposals, the 'publication performance' of the applicants regularly plays an important role. It has always made a difference whether a principal investigator and his/her group published in "good", peer-reviewed journals or merely produced 'abstracts' in congress reports or articles in collective monographs without peer review. Since the "journal impact factor" offers a ready method of quantification, it is used by reviewers for the evaluation of performance with growing frequency.

This practice, however, is open to reservations which have recently found increasing support (53). They are justified for several reasons:

First, citation frequency obviously does not only depend on the reputation of a journal or a group, but above all on the size of the community interested in the subject matter. Specialized journals typically have lesser "impact factors" than those with a broad readership, and different fields have different quantitative norms. Comparing an Assyriologist and a scholar of German by their "impact factors" would make little sense even if the publication habits in the two fields were the same. Publication habits specific to research fields have a strong influence on comparability: the publication pattern in semiconductor physics is different from that in molecular developmental biology. The literature on the methodology of bibliometric analysis therefore regularly insists on the principle of "comparing like with like" (54).

Second, reviewers who rely exclusively on publication counts and on citation frequencies, perhaps expressed by the "impact factor", in their evaluation delegate their responsibility completely to the journals in question and their readers. Counting publications and looking up "impact factors" are far removed from the competence needed to judge the quality of the content of a publication. Reviewers restricting themselves to the former end up by making themselves superfluous.

It should also be noted that all methods of performance evaluation which depend exclusively or predominantly on quantitative measures serve to promote the "publish or perish" principle with all its disadvantages.

Finally, it should be taken into account that the knowledge of the use of citations as a measure of impact and (despite all methodological reservations) of the quality of a publication so cited and its authors may influence the behaviour of the latter and lead to abuses such as citation cartels.

6. Organization

Research in universities and academic research institutes also serves the education of the next generation of scientists and scholars. Successful researchers regularly remember how they became independent in a well-conducted group with demanding standards in science (55). But not all groups measure up to this description. Young scientists and scholars frequently deplore lack of attention, insufficient guidance, and exploitation by their superiors, and even report having contributed most of the input to publications without being named as co-authors. They may also describe an atmosphere of competitive pressure and mutual distrust in their environment. A problem frequently referred to in situations like this is the lack of accessible, impartial counselors with whom concerns and problems may be discussed without having to fear that criticism will lead directly to the loss of one's job.

The commission has seen particular problems in the field of clinical research. The

difficulties which are also reported in other countries (56) are intensified in Germany through the fact that the education of medical students does not, by itself, provide a sufficient basis for independent scientific work (57). Therefore, many medical dissertations (except the growing number of theses based on experimental work) represent a mere discharge of duties and do not measure up to scientific standards observed in the sciences and the experimental medical disciplines. This is one of the reasons why medical doctorates are always shown separately in statistics of university degrees in Germany. Young medical doctors wishing to do research work will, of course, improve their familiarity with the scientific foundations of medicine and with the methods and techniques employed in the experimental medical disciplines, for example through a postdoctoral research assistantship abroad. But even then in most German university clinics the working conditions of the clinical environment are so demanding for the entire medical staff - from the first year intern to the head of the clinic - that a productive scientific activity at international level is difficult to achieve, leaving the so-called "off duty research". This overburdening is one possible cause of organizational faults in the communication structure and the supervision of clinical research groups.

Achievements in research are part of the prerequisites for an academic career in clinical medicine as in other fields. However, they are much more difficult to attain there than in other disciplines. The causes for this in the German system include the narrow leadership structure in the clinics, but also the rarity of academic staff positions offering a perspective of tenure for natural scientists in the clinics. The tightly hierarchical structure of management and leadership characteristic for patient care is not necessarily suited to clinical research and to the tasks of guidance and quality assurance which research demands. Models of delegated and shared responsibility, as they have been established in the Clinical Research Groups and Collaborative Research Centres supported by the Deutsche Forschungsgemeinschaft, offer examples of an organization more adequate to the needs of clinical research. They may also provide a better environment for the training of young clinical scientists.

7. Legal norms and norms in science

The freedom of research is established as a constituent part of the German constitutional order in the Grundgesetz with an explicitness found in few other western constitutions. Yet the practice of research is governed by a large number of specific legal provisions which may also restrict the freedom of scientific enquiry in individual cases. Examples for this are the laws on animal protection, on recombinant DNA technology, on chemicals, on data protection, and on medical drugs (58). In contrast to this, the relationship between norms internal to science, which distinguish scientific misconduct from good scientific practice, and the constitutional norm guaranteeing freedom of research is not yet well defined (59). The law on higher education institutions offers few relevant rules beyond obvious clauses such as the general obligation to respect the rights and duties of other members of the university (§ 36 paragraph 5 of the Hochschulrahmengesetz - HRG), and its specification for research supported by external grants and contracts (§ 25 paragraph 2 HRG).

In principle, the law on higher education institutions gives the universities adequate possibilities to take action when scientific misconduct is alleged and to impose internal sanctions when required, without necessarily resorting to the legal provisions governing disciplinary action. Difficulties arise, however, when the steps taken by a university become the object of litigation in the courts (8, 32). Problems concern not only the duration of court proceedings, but also uncertainties in the interpretation and application of the rules of the law on higher education institutions, and in taking into account scientific norms which are not part of the legal system, e.g. those relevant to the documentation and storage of primary

data.

At the level of research funding organizations it seems uncertain to what extent they are prepared for handling cases of scientific misconduct by internal rules and procedures.

The preparation of these recommendations has shown that the experiences of institutions in other countries with safeguarding good scientific practice and with establishing definitions and procedures for handling misconduct may provide important suggestions and models for possible measures in Germany. After a pilot phase, an exchange of information and experiences among German institutions might be useful to promote a sensible and careful further development of the implementation of these recommendations. It is therefore suggested that a meeting of experts - to be hosted by the Deutsche Forschungsgemeinschaft or another organization - be envisaged for a date one or two years after the publication of these recommendations. The prospect for such a workshop being fruitful will depend on the degree in which universities and research institutes make an effort now to implement these recommendations in practice and systematically record their experiences.

III. Experiences outside Germany

1. USA

The vast majority of allegations of scientific dishonesty that have become generally known have been raised (and to some smaller degree confirmed) in the USA. Conditions there are well and accessibly documented (21, 28), so that a brief summary will suffice here.

Owing to the structure of research funding in the USA, every case of scientific misconduct which led to a broader public discussion there from the end of the 1970s to the present time involved at least one of the two large federal research funding agencies. These are

- The National Science Foundation (NSF). Established in 1950, it now has an annual budget approaching 4 billion dollars which support research in the natural and engineering sciences, and also the behavioural sciences including such fields as linguistics, psychology, and social sciences, and in addition programmes in science education. The NSF has no research institutes of its own. It is an independent federal agency.
- The National Institutes of Health (NIH). Their beginnings reach back to the year 1888, and they have existed under their present name since 1948 (60). There are 13 institutes carrying out biomedical and clinical research. At the same time, some 80% of their total budget which approaches 14 billion dollars are spent on grants and contracts to universities and research institutions. The NIH are thus the largest research funding organization in the world. They are a federal agency within the jurisdiction of the Department of Health and Human Services (DHHS).

Both the NSF (in 1987) and the NIH (in 1989) have published definitions of scientific misconduct and regulations for handling allegations thereof. They are similar, but not identical, and are binding for all grantee institutions, which must show that they have established an internal procedure for dealing with allegations of scientific misconduct.

The responsibility for dealing with such cases rests primarily with the universities and research institutes. Their rules, largely following a model worked out by the Association of American Universities (61), typically provide for a two-step procedure:

- An informal preliminary phase ("inquiry") serves to clarify whether it is necessary to

open a formal investigation.

- Formal investigations, usually organized under the responsibility of central university authorities, serve to determine the facts of the case. Following this a decision is taken on what sanctions (if any), on a scale reaching from written warnings to termination of employment, are to be imposed. In this phase, governed by the rules of due process, the defendant usually has the right to be assisted by legal counsel.

Both the NSF and the NIH require that they be notified at the beginning and at the end of every formal investigation where grants awarded by them are involved. The responsibility in the NSF is vested in the Office of Inspector General (OIG), an authority situated in the NSF itself which is also responsible for the financial auditing of grants and reports directly to the National Science Board as the NSF's supervisory body. For the NIH, the responsibility lies with the Office of Research Integrity (ORI), an authority situated in the DHHS (the Department responsible for the NIH) and with jurisdiction for all areas of the Public Health Service except the Food and Drug Administration. Both the OIG and the ORI may conduct their own investigations during or after the local proceedings. The ORI has developed detailed guidelines for dealing with allegations of scientific misconduct locally (62).

After the closure of local proceedings, the ORI and the OIG determine what sanctions are to be imposed from their side. The ORI takes action itself, and appeals may be lodged with a Departmental Appeals Board of the DHHS. The OIG formulates a recommendation, based on its investigation report, to the Deputy Director of the NSF. The recommendation is independently examined there before sanctions are announced to the defendant and eventually imposed. Sanctions may e.g. be

- debarment from submitting grant proposals, typically for three to five years,
- exclusion from review panels and other bodies,
- conditions for future grant proposals, typically in the form of supervision requirements addressed to the institution where the research is to be carried out, usually for several years,
- the obligation to correct or retract certain publications.

Both the OIG and the ORI publish regular reports on their activities (30). They show that sanctions are imposed in 10 to 50% of all cases, nearly always in the form of a voluntary settlement. In one highly publicised case the Departmental Appeals Board exonerated the scientist against whom allegations had been brought in the summer of 1996, ten years after the allegations first became known.

The definition of what constitutes "scientific misconduct" has been, and still is, widely discussed in the USA. According to the part of the definition shared by NIH and NSF, scientific misconduct is defined as

"fabrication, falsification, plagiarism, or other serious deviation from accepted practices in proposing, carrying out, or reporting results from activities funded by ..." the respective agency; in the NSF's definition there follows a clause protecting informants who have not acted in bad faith.

The point at issue in the discussion is the generic nature of the words "other serious deviation from accepted practices". It is challenged with the political argument of permitting arbitrary decisions by the authorities, with the constitutional argument of being "void for vagueness" (63), and with the logical claim that a definition of scientific

misconduct must be limited to specific violations of fundamental rules of science and not include areas of misconduct covered by other legal regulations. The challenges are rebutted, chiefly by the NSF, arguing that the definition is close to scientific practice particularly through the reference to the norms (which may be specific to individual disciplines) of the scientific community in question. Over the years, this argument has been developed further: serious deviation from the norms of correct scientific work, it is argued, is the core of the definition. Fabrication, falsification, and plagiarism (FFP) are empirically frequent examples of such serious deviations. The proposed limitation of the definition to "FFP" would be legalistic, would exclude some particularly grave cases of scientific misconduct such as breach of confidentiality by a reviewer, and would merely shift the problem towards the exact definition of the individual constituents of "FFP" (64). The discussion in the USA continues (65).

It may be noted that the generality of the definition in the USA has not led to reported controversies over its application to individual cases. There have, on the other hand, been examples of substantial criticism of the ORI's practice in investigations and imposing sanctions.

The research support organizations in Canada have issued a joint declaration in 1994 formulating similar principles to those in force in the USA, but in a less detailed form.

2. Denmark

The first European country to form a national body to handle allegations of scientific dishonesty was Denmark. The Danish Committee on Scientific Dishonesty (DCSD) was established in 1992 at the initiative of the Danish Medical Research Council (DMRC) following recommendations by a working group which had extensively analyzed the causes, the phenomenology and the consequences of dishonesty in science (66). Like the US National Science Foundation, the working group sees the core of scientific dishonesty in the intent to deceive. This may lead to a variety of individual constellations of differing degrees of seriousness both in principle and depending on the circumstances of each case. Examples given for constellations requiring formal investigation are cases of "deliberate

- fabrication of data,
- selective and undisclosed rejection of undesired results,
- substitution with fictitious data,
- erroneous use of statistical methods with the aim of drawing other

conclusions than those warranted by the available data,

- distorted interpretation of results or distortion of conclusions,
- plagiarism of the results or entire articles of other researchers,
- distorted representation of the results of other researchers,
- wrongful or inappropriate attribution of authorship,
- misleading grant or job applications."

Examples of less serious constellations mentioned by the working group include

"- covert duplicate publication and other exaggeration of the personal publication list,

- presentation of results to the public by-passing a critical professional forum in the form of journals or scientific associations,
- omission of recognition of original observations made by other scientists,

- exclusion of persons from the group of authors despite their contributions to the paper in question." (66)

In this context, the working group also discusses intersections of the constellations examined and conduct sanctioned by the penal code (fraud, falsification of documents) or by civil law (plagiarism).

The DCSD has incorporated the essential elements of the first list quoted above (expressly marked as "not exhaustive") into its statutory rules. Until 1996, its scope of activity was defined by the mission of the DMRC. Its principal task is the determination of the facts in cases of allegations presented to it, and reporting on each case. Cases falling under criminal law are submitted to the relevant authorities. In other cases, the Committee may give recommendations to the individuals and institutions involved. In addition, the Committee and its members regard it as their duty to promote the principles of good scientific practice through lectures and publications. Its published annual reports contain many articles on questions of good scientific practice and deviations from it and their assessment. The committee, chaired by a judge of the Danish supreme court, has seven other members nominated by different universities and scientific organizations in Denmark.

In 1996, the DCSD, with its principles unchanged, was brought under the umbrella of the Danish research ministry, thus preparing the extension of its remit to all fields of science, as its chairman had recommended in the 1996 Annual Report.

The DCSD has become the model for analogous regulations, mostly less detailed, in the other Scandinavian countries.

3. United Kingdom

As in Denmark, the Medical Research Council (MRC) is the first institution in the United Kingdom known to have taken the initiative of publishing rules for correct conduct in research (67) and to codify rules for handling allegations of scientific misconduct. The MRC, established in 1913, conducts biomedical and clinical research in its own Units and awards grants for medical research in universities. It expects both its own Units and universities receiving grants to set up and publicise rules of conduct. Apart from the general rules mentioned above, it has published guidelines for a variety of questions in medical ethics, e.g. for research with persons unable to give informed consent. The guidance and policy of the MRC have had a decisive influence on a declaration of the European Medical Research Councils, a standing committee of the European Science Foundation, on the subject of "Misconduct in Medical Research" (68).

In contrast to the Danish example, and in analogy to the USA, the MRC expects allegations of scientific misconduct to be handled in the individual institutions involved. Its "Policy" (69) provides for a three-step procedure, in which the first step is a formal confrontation of the defendant with the allegations, giving him or her the opportunity to respond. The procedure is otherwise analogous to the principles current in most American institutions. The scale of sanctions includes the removal from the project in which misconduct was observed, a "final written warning" and various other measures, with termination of appointment in extreme cases. As in the USA, the MRC's rules provide for an Appeal Board which is appointed by the Executive Director of the MRC.

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