RESEARCH REPORT 2006—2007

MAX-PLANCK-GESELLSCHAFT

MAX-PLANCK-INSTITUT FÜR WISSENSCHAFTSGESCHICHTE

Max Planck Institute for the History of Science

Cover:
Preparation for “Sonatas and Interludes” (1939) by John Cage (1912–1990), performed by Markus Hinterhäuser in the series “Physiologie des Klaviers” (see p. 129–130) on December 14, 2006 at the Curt-Sachs-Saal, Museum for Musical Instruments, SIMPK, Berlin
Image: Michael Behr, Berlin

Back cover:
Sgrilli’s planimetry of the Pratolino Garden (1742) superimposed on a GoogleEarth satellite photo. A tool used to locate the original positions of the hydraulic devices in the Medici Garden.
Project: The History of Science in a Garden, Matteo Valleriani, Jochen Büttner (see p. 39–40).
<http://pratolino.mpiwg-berlin.mpg.de>
Image: DigitalGlobe

Most of the portrait photographs were done by Skúli Sigurdsson, Berlin/Reykjavík

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Max Planck Institute for the History of Science

Introduction

The Max Planck Institute for the History of Science (MPIWG) was founded in 1994 to promote "the development of a theoretically oriented history of science which studies scientific thinking and knowledge acquisition in their historical development and their interaction with the cultural, technical, and social contexts of science." The MPIWG has since pursued this program in breadth and depth, embracing the natural sciences and the humanities and spanning topics from the origins of counting systems in Mesopotamia to today's postgenomics. The research of the Institute cuts across conventional disciplinary lines in order to explore the dynamics of scientific change as well as the history of basic epistemological categories such as experiment and objectivity. The MPIWG here follows the general mission of Max Planck Institutes to take up new and innovative research areas of an interdisciplinary character that are either not yet represented adequately at universities in Germany or that require special equipment and funding.

The Institute comprises three Departments, each administered by a Director, and three (as of 2008) Independent Research Groups, each led for five years by an outstanding junior scholar. Department I, directed by Jürgen Renn, focuses on structural changes in systems of knowledge; Department II, directed by Lorraine Daston, investigates the history of the ideals and practices of rationality; and Department III, directed by Hans-Jörg Rheinberger, studies experimental systems and spaces of knowledge. Research Group I, led by Dagmar Schäfer, traces the history of innovation in China. The other two Research Groups will be taking up their work toward the end of 2008. This Research Report describes in detail the work of the different research units over the past two years.

Each of the Departments and Research Groups sets its research agenda and develops and cultivates its own working style. Each of the following reports briefly describes in its opening paragraphs how the work of the research unit is organized. The diversity of the formats of the reports that follow reflects the diversities of the Departments and Research Groups themselves. There are nonetheless important overlaps between the groups' research interests, as will become evident from the reports.

Department I and Research Group I, for example, share an interest in the history of science and technology in China; Departments II and III have common interests in the history of scientific observation and the ways in which observations are registered; all three Departments have joined forces to set up a Research Network on the History of Scientific Objects (funded by the Innovation Fund of the President of the Max Planck Society) that also links the MPIWG to major international centers in the history and philosophy of science and technology, both universities and museums. → p. 189

All research units take the historicity of scientific knowledge as a fundamental premise and seek new ways of characterizing and understanding it. This common commitment to historical epistemology in its various forms is a red thread that runs through all of the reports. Historical epistemology also means, in our understanding, that scientific and other forms of knowledge acquisition and transmission must often be studied together, as historical and cultural context dictate. In July 2008, a workshop on the question of "What (Good) is Historical Epistemology" (organizers Uljana Feest and Thomas Sturm) will bring together scholars from all Departments with leading international scholars in the history and philosophy of science to reflect on the past, present, and future of this research program. → p. 198

The Institute sustains collaborative research projects with other Max Planck Institutes such as the Bibliotheca Hertziana in Rome (Department I, "The Epistemic History of Architecture"), the Max Planck Institute for European Legal History in Frankfurt am Main (Department II, "Natural Law and Laws of Nature") and the Kunsthistorisches Institut in Florence (Department III, "Knowledge in the Making"). Moreover, the local cooperation between the Free University, the Humboldt University and the Technical University of Berlin and the entire MPIWG has been intensified over the past two years, resulting in a formal cooperation agreement between the Max Planck Society, the Free University and the Humboldt University; a comparable cooperation agreement with the Technical University is in preparation. All these agreements will entail the creation of new positions in history of science on the part of the Berlin universities and the cooptation of each of the leaders of our Junior Research Groups as faculty members. The ultimate goal of these cooperations is the creation of an International Center for the History of Knowledge in Berlin with the MPIWG and the three universities at its core, with affiliations with other Berlin-based research institutions such as the Center for Human and Health Sciences of the Charité Hospital, the Prussian Cultural Heritage Foundation, and the Natural History Museum. The new center aims at establishing an intellectual and organizational framework for researching and teaching past knowledge cultures in new ways. Located in Berlin next to the Institute's building, it will create a unique basis for future collaborative research projects in order to attract students and scholars from many different countries and disciplines. → p. 201

The MPIWG aims to innovate first and foremost in research, but it has also pioneered new forms of publication and the exploitation of new source materials. The MPIWG has created a new genre of publication, "working group volumes," which are the result of years of collaborative research by teams of scholars, in contrast to the more familiar conference proceedings or edited volumes. To mention only a few examples: *The Genesis of General Relativity* (Dept. I); *Things that Talk: Object Lessons from the History of Art and Science* (Dept. II); *Heredity Produced. At the Crossroads of Biology, Politics, and Culture, 1500–1870* (Dept. III). In the past years, our cooperation with museums has intensified, including several exhibitions, both small and large. In the context of the Research Network on the History of Scientific Objects, for example, a "Wandering Seminar" of pre- and postdocs visited major European collections of scientific objects and then drew on their experience to mount an exhibition at the MPIWG devoted to the problem of presenting scientific objects as "publications" in the history of science. All research units of the Institute draw upon not only published texts and written archival materials but also on images and material objects as carriers of knowledge-ranging from mechanical drawings (Dept. I) to natural history collections (Dept. II) to children's drawings (Dept. III). Finally, all research units are developing electronic research environments for historical work on science and knowledge on the basis of tools developed by the Information Technology Group. They include the collaborative database European Cultural Heritage Online (Dept. I), the Islamic Scientific Manuscripts Initiative (Dept. II), the Virtual Laboratory of Physiology (Dept. III), and the tracing of knowledge dissemination by geographic information systems (IRG Schäfer), to mention only some prominent examples.

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In the spring of 2006, the Institute moved to its new building at Boltzmannstraße 22 in Berlin-Dahlem. We are grateful to the Max Planck Society for giving the MPIWG this comfortable and well-designed home in the immediate vicinity of the Free University and the Archives of the Max Planck Society. In particular, we thank our Advisory Board for its support, and we hope that the work presented in this report will reward the reading.

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Scientific Advisory Board

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Departments and Research Groups

Jürgen Renn

Department I: Structural Changes in Systems of Knowledge

DIRECTOR *Prof. Dr. Jürgen Renn*

RESEARCH SCHOLARS *Dr. Peter Beurton* (associated), *Dr. Katja Bödeker, Jochen Büttner*, *Costanza Caraffa* (October 2006 to February 2007), *Giuseppe Castagnetti*, *Dr. Jacob Lebovitch Dahl* (since April 2007), *PD Dr. Peter Damerow* (associated), *Brian Fuchs*, *Prof. Dr. Dieter Hoffmann*, *Dr. Malcolm Hyman*, *Dr. Horst Kant*, *Dietmar Kurapkat* (until September 2007), *Prof. Dr. Wolfgang Lefèvre* (associated), *Dr. Christoph Lehner*, *Dr. Ernst-Wilhelm Osthues*, *Dr. Albert Presas i Puig* (until March 2007), *Simone Rieger*, *Matthias Schemmel*, *Dr. Volkmar Schüller*, *Matteo Valleriani*, *Milena Wazeck*

Lorraine Daston

Department II: Ideals and Practices of Rationality

DIRECTOR *Prof. Dr. Lorraine Daston*

RESEARCH SCHOLARS *Dr. Charlotte Bigg* (since July 2007), *Dr. Anke te Heesen* (until September 2006), *Dr. Bernhard Kleeberg* (until December 2006), *Dr. Andreas Mayer* (since November 2007), *Dr. Tania Munz* (since August 2007), *Dr. Christine von Oertzen*, *Dr. Thomas Sturm* (since October 2007), *PD Dr. Fernando Vidal*, *Dr. Annette Vogt*, *Dr. Kelley E. Wilder*

Hans-Jörg Rheinberger

Department III: Experimental Systems and Spaces of Knowledge

DIRECTOR Prof. Dr. Hans-Jörg Rheinberger

RESEARCH SCHOLARS *Dr. Dr. h. c. Hans Erich Bödeker* (since December 2006), *Dr. Christina Brandt* (since February 2006: Research Group Leader), *PD Dr. Sven Dierig* (until March 2006), *Dr. Uljana Feest* (until September 2006), *Dr. Bernd Gausemeier* (since June 2007), *PD Dr. Christoph Hoffmann*, *Prof. Dr. Ursula Klein*, *Dr. Julia Kursell*, *Dr. Carsten Reinhardt* (March 2006 to March 2007), *Dr. Henning Schmidgen*, *Dr. Barbara Wittmann* (since September 2006)

Independent Research Group I (2006–2009)

Concepts and Modalities: Practical Knowledge Transmission

DIRECTOR *PD Dr. Dagmar Schäfer*

RESEARCH SCHOLAR *Dr. Martina Siebert*

Dagmar Schäfer

Independent Research Group II (1999–2007)

Experimental History of Science

DIRECTOR *PD Dr. H. Otto Sibum*

Since September 2007: Hans Rausing Professor, Uppsala University, Sweden

RESEARCH SCHOLAR *Dr. Charlotte Bigg* (until June 2007), *Annik Pietsch*

H. Otto Sibum

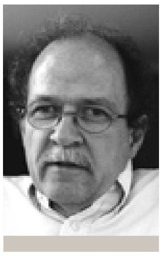
Administration, Coordination, Services

Dr. Robert Casties (Head of Information Technology Group from April 2007 to May 2008), *Hannah Lotte Lund* (Coordinator of the Network "History of Scientific Objects"), *Claudia Paaß* (Head of Administration), *Jochen Schneider* (Research Coordinator), *Urs Schoepflin* (Head of Library) *Dirk Wintergrün* (Head of Information Technology Group), *Dr. des. Hansjakob Ziemer (*Cooperations and Public Outreach, since January 2008)

Robert Casties

Hannah Lotte Lund

Claudia Paaß



Jochen Schneider

Urs Schoepflin

Dirk Wintergrün

Hansjakob Ziemer

Standing (left to right):
Yin Xiaodong, Albert Presas i Puig,
Peter Damerow, Jacob Dahl,
Milena Wazeck, Christopf Lehner,
Lindy Divarci, Christian Joas,
Anna Holterhoff, Donald Salisbury,
Ursula Müller, Matteo Valleriani,
José Pacheco, Julia Damerow,
Jochen Büttner, Shadiye Leather-Barrow,
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Elio Nenci, Jürgen Renn, Wilhelm Osthues

sitting:
Circe Dynnikov, Arianna Borrelli,
Marta Jordi, Daniela Monaldi,
Oscar João Abdounur, Stefan Trzeciok,
Chen Yue, Simone Rieger, Volkmar Schüller

Department I

Structural Changes in Systems of Knowledge

Director: *Jürgen Renn*

Research Focus

The work of the research group headed by Jürgen Renn is mainly dedicated to understanding the historical processes of structural changes in systems of knowledge. This goal comprises the reconstruction of central cognitive structures of scientific thinking, the study of the dependence of these structures on their experiential basis and on their cultural conditions, and the study of the interaction between individual thinking and institutionalized systems of knowledge. This theoretical program of a historical epistemology is the common core of the different investigations and research projects pursued and planned by the research group.

Methodology

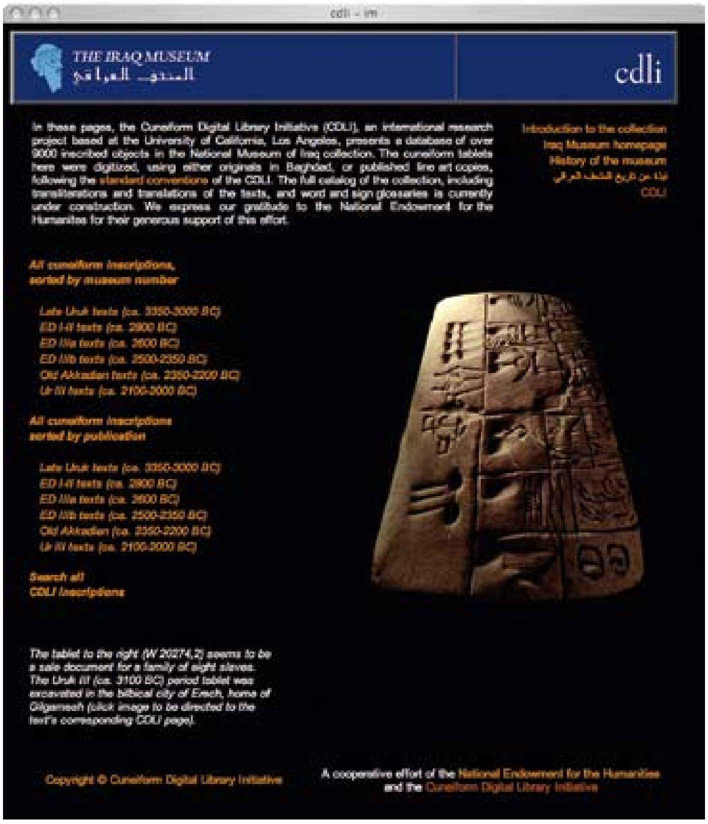
Department I understands its research program of a historical epistemology as contributing to an evolutionary history of knowledge. The emphasis is on macro-studies to enable the identification of large-scale structures of knowledge development in social, technological, and cultural contexts. Approaches, methods, and objects of inquiry are taken from a large array of disciplines, ranging from the history and philosophy of science, technology and art, via the cognitive sciences and linguistics, to archeology, Middle Eastern studies, classics, Sinology, Indology, sociology, to physics, mathematics, chemistry, and other natural sciences. The creation of innovative IT instruments is essential for managing the concrete historical evidence for the research of Department I, provided by sources that are written in various languages and come from a broad range of historical periods, cultures, and fields. The work of the Department continues to take inspiration from challenges of the present and future development of science, tackling such issues as the role of the new information technologies, globalization, and the position of science in society. It thereby opens up opportunities for younger scholars of the Department in finding positions in a broad variety of fields, including science organization and dissemination, in addition to academic positions inside and outside the history of science.

As the research projects of Department I integrate knowledge from a wide range of disciplines, cultures, and historical periods, they are realized in co-operative networks extending well beyond the boundaries of the Institute. The Institute typically represents, however, a central node of such networks, bringing together scholars to form teams characterized by intense co-operation over longer periods of time. The challenges of cross-cultural comparisons, diachronic studies of historical developments, and the close integration of computer-assisted source analysis and scholarly interpretations are addressed with the help of a combination of core teams, who bear the main responsibility for a project, and an array of informal working groups which are often independently funded, characteristically shaped by the interests of younger scholars and connected by weaker or stronger links to the activities of the core team. Exploring and validating theoretical conclusions with reference to the vast collection of primary sources, but also building upon the existing scholarly literature would be inconceivable without the support and substantial active participation of the Institute's library, and the information management facilities that were built up with the support of the IT-group.

Main Achievements

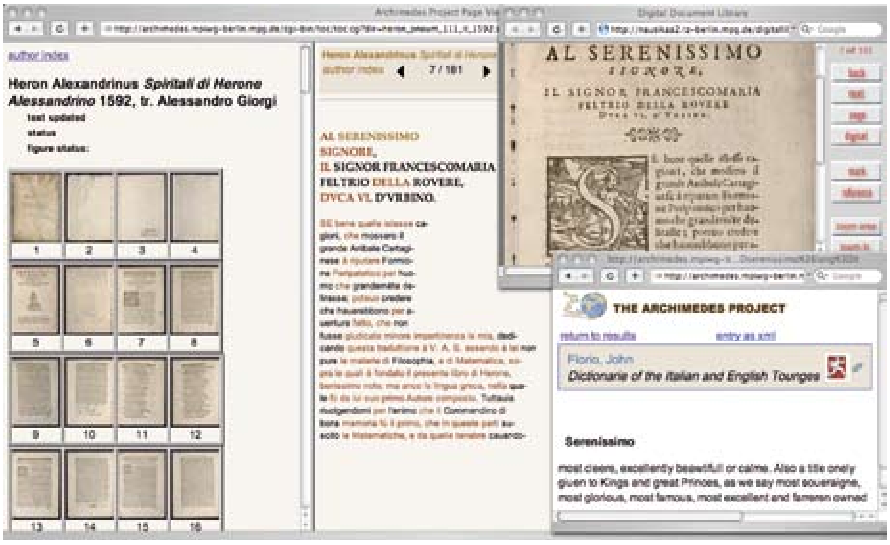
In the past, research in Department I has led to the formulation of an overarching theoretical framework, offering cohesion to the wide spectrum of individual research activities realized under its auspices. Among past achievements was the filling of this framework with studies on the emergence of writing and mathematical thinking in ancient civilizations, investigations of the role of practical knowledge for the emergence of early modern science, a comprehensive analysis of the relativity revolution at the beginning of the 20th century, groundwork for a long-term history of the development of architectural knowledge, as well as studies of knowledge development in an intercultural perspective, pursued in close collaboration with the new independent research group dealing with Chinese knowledge culture. *The Cuneiform Digital Library Initiative (CDLI),* a pioneering endeavor launched in 2000 by the Institute together with the University of California at Los Angeles, with support from the US National Science Foundation (NSF), has not only introduced advanced techniques of electronic information management into scholarly work, but has also created an international network of research institutions, universities, and museums with the aim to virtually rejoin and analyze cuneiform archives now scattered in numerous museum collections <http://cdli.ucla.edu>.

→ Concepts and Modalities, p. 161



CDLI website prepared for
The Iraq Museum

In a similar way, the *Archimedes Project,* originally funded by a major grant received from the NSF and the Deutsche Forschungsgemeinschaft, has enabled the historical reconstruction of mechanical knowledge to be addressed in a much more systematic way than was previously possible <http://archimedes.mpiwg-berlin.mpg.de>.



A page of the 1592 Italian translation of Heron of Alexandria's *Pneumatica* from Alessandro Giorgi in the Archimedes Project's display environment. One can see the thumbnail navigation and the text (left), which is linked to a dictionary (bottom right), as well as an image of the original (top right). The text and the images are downloadable as xml-files for local use.

An initiative entitled *European Cultural Heritage Online (ECHO)* was established in 2002 in collaboration with sixteen European partners, including two other Max Planck Institutes (Max Planck Institute for Psycholinguistics in Nijmegen and the Bibliotheca Hertziana in Rome). The initiative has created an open-access infrastructure bringing cultural heritage online with more than 70 collections comprising over 206,000 documents, 266,000 high-resolution images of historical and cultural source documents and artifacts, more than 240 film sequences of scientific source material, and more than 57,500 full-text page transcriptions in several languages. The ECHO

Example of a historical source (Benedetti, *Diversarum specvlationum mathematicarum, et physicarum liber*, 1585) with extensive coeval annotations by Guidobaldo Del Monte in the chapter on mechanics, representing the scholarly network and communication of the time (original book and digitization: MPIWG Library) infrastructure serves as the basic model for all research projects of the Department that deal with the digitization of cultural heritage <http://www.echo-project.eu>. These achievements form the basis for the present work of the Department as do various projects that are supported by external funding and that have been continued in the period under consideration.

Projects

Present research focuses on four central projects and on a cluster of activities directed at new forms of creating access to the empirical basis as well as to research results of the history of science. Each of the projects involves its own forum of discussion (project colloquium), while overarching issues are being discussed at team meetings involving the scholars responsible for the individual projects.

1 Mental models in the history of knowledge: the relation of practical experience and conceptual structures in the emergence of science

The first project seeks to understand the emergence of fundamental concepts of empirical science arising from the reflection of practical experiences, prior to the period in which experiments became the dominating experiential basis of science. The empirical focus of the project is twofold: On the one hand, the rich source materials left by the early cultures of Mesopotamia and Iran provide a unique occasion for studying the earliest forms of knowledge formation. Remains of technical devices and technologies and the long tradition of technical and scientific treatise on mechanics show, on the other hand, how different forms of knowledge interacted in bringing about coherent bodies of mechanical knowledge.

In the context of this project, primarily focusing on the development of mechanical knowledge, the acquisition, analysis, and commentary of a substantial number of relevant primary sources has been accomplished and major studies have been completed. The investigation has now been largely concluded and will result in a four-volume book series. Parallel to the publication, the relevant source material is being made openly available as an open-access resource within the framework of the ECHO initiative.

Left: The Ancient Peking Observatory. Unnumbered woodcut from the *Xinzhi yixiang tu* of F. Verbiest (Beijing, 1674)

Right: A group of researchers from the MPIWG and its Partner Group at the Chinese Academy of Science studying the instruments at the Ancient Peking Observatory

The joint work with the Partner Group at the Institute for the History of Natural Sciences of the Chinese Academy of Sciences in Beijing, which yielded contributions to the reconstruction of the long-range development of mechanical thinking in China and to the understanding of the interaction between western scientific knowledge and that of the Chinese tradition, has now been brought to a close. These studies will be continued with smaller scale individual studies within the context of this project.

2 Reorganizing knowledge in developed science: integration and disintegration of knowledge systems

The second project studies the reorganization of knowledge in developed science. In this context, earlier studies on the relativity revolution have been completed and published. They are currently also being linked to key primary sources of an online publication that will be openly available in the framework of the ECHO initiative. A joint venture with the Fritz-Haber-Institute of the Max Planck Society (MPG), supported by the Strategic Innovation Fund of the President of the Society, to investigate the history of quantum mechanics was launched in 2006. Its aim is to continue the reconstruction of the conceptual revolution of modern physics in order to trace the roots of quantum mechanics in the developments of classical science.

3 The epistemic history of architecture: the long-term history of the knowledge that has made the great architectural achievements of mankind possible

The third project deals with an epistemic history of architecture and analyzes the knowledge implicit in actions that emerged long before the advent of science, and that was repeatedly subjected to transformations that explain the fascinating interplay of utility, rationality, and art that is the hallmark of architecture. The work is in its final stage, with a major publication to be edited in 2008. In order to extend the research in this field, a joint proposal has been submitted to the Project Cluster of Excellence TOPOI (see below) to investigate the diffusion of practical knowledge in antiquity, focusing on tracing the techniques of stonemasonry in the ancient Mediterranean cultures. Its acceptance will provide a unique opportunity to continue the research undertaken in this project in a multidisciplinary environment.

4 The globalization of knowledge and its consequences: the transfer and transformation processes of knowledge across different cultures

The fourth project focuses on the conditions, pathways, and consequences of globalization processes of knowledge, relating them to present processes of globalization, in particular those involving the development of the Internet and the global organization of science. The following thematic foci are addressed:

- Focus 1 The spread of culture in the ancient Mediterranean and neighboring regions
- Focus 2 Knowledge transfer within Eurasia
- Focus 3 The place of local knowledge in the global community
- Focus 4 Modeling the diffusion of knowledge.

The project is conceived as a multi-disciplinary and multi-national research network in which research groups from various countries participate. Scholarly cooperation within this research network have been negotiated with numerous research groups from a range of disciplines, groups located and/or doing research in all five continents.

5 History of science in action: alternative forms of dissemination

Further areas of work belong to what may be called "history of science in action." Alternative forms of dissemination have been adopted to investigate the potential of the history of science as a mediator between science and society by exploring new forms of combining scholarly communication with public outreach. This includes the development of advanced tools for an historical epistemology: New electronic media have been used and developed—in close co-operation with the library and the IT-group of the Institute—to explore innovative ways of creating access to the empirical basis and the research results of the history of science.

The large 2005 exhibition "Albert Einstein: Chief Engineer of the Universe" conceived and organized by the Department has not only contributed to the public visibility of the history of science as a field of active research but has also created a platform for several institutes of the Max Planck Society to place their research results and technological developments into a historical context. In 2007 the exhibition won the 2007 International Museum Communication Award (Bronze). While the considerable impact of the exhibition has never been questioned, it did engender, however, discussions about the legitimacy of Max Planck Institutes adopting exhibitions as a medium for the dissemination of their scholarly work. In reaction to such ambivalence, exhibition activities of the Department were continued on a smaller scale, renouncing opportunities such as an already planned joint exhibition with the Gemäldegalerie in Berlin or the proposal by the Max Planck Society to realize a major exhibition on the occasion of the 150th anniversary of Max Planck's birthday. Work on virtual exhibitions and smaller-scale exhibitions, however, has been continued. The Department thus organized a small-scale exhibition in cooperation with the Comenius Garten, the Museum für Naturkunde and the Monash University in Melbourne to present the results of the joint venture *Wunderforschung* with contributions also from Department II.

Events

The period of the report was not only characterized by the termination of old projects and the inception of new ones but also by developments concerning its research team. Jacob Dahl, who is the Institute's responsible scientist for the Cuneiform Digital Library Initiative (CDLI) project, is leaving the Department to take up a professorship at Oxford University. Claudia Bührig, former coordinator of Project III, left the Institute to take up a position in the Orient-Department of the German Archeological Institute (DAI) in Berlin, Dietmar Kurapkat joined the department of Architectural History in the Technical University Berlin, and Ulrike Fauerbach became member of the DAI in Cairo. In 2006 Matthias Schemmel received the prize for junior scientists from the Georg-Agricola-Gesellschaft for his thesis *The English Galileo: Thomas Harriot's Work on Motion as an Example of Preclassical Mechanics.* In 2007 this work was also awarded the Georg-Uschmann-Preis für Wissenschaftsgeschichte from the German Academy of Sciences Leopoldina. The coordinator of the ECHO project, Simone Rieger, left the Department to take up a position with the MPG. She is now—together with Susanne Kiewitz, an exhibition expert recently hired by the MPG—part of a team of mediators between research and public outreach in the Berlin area which is hosted by Department I.

Collaborative Ventures

Once again, it has been possible to substantially expand the ongoing investigations of the Department with collaborative ventures supported by third-party resources. At the same time, the Department was able to contribute to the successful establishment of major research initiatives such as the excellence cluster TOPOI or joint research ventures in Mongolia and Spain.

The work of the research program "Jesuits on Statics, Dynamics, Mathematics and Astronomy between Galileo and Newton" is now underway. Partly funded by the German Israeli Foundation for Scientific Research Development (G.I.F.) and undertaken with the Cohn Institute for History and Philosophy of Science and Ideas at Tel Aviv University, it examines an important aspect of the development of mechanical knowledge: the dissemination and transmission of scientific knowledge in the early modern period through the highly developed communicative network of Jesuit colleges and universities.

Since January 2005, the Department has participated in a venture of the Sonderforschungsbereich (SFB, Collaborative Research Center) of the Humboldt University in Berlin, which concentrates on the transformation processes by which European cultures, arts, and sciences were formed in a continuation of the cultures of antiquity. The scholars of the Department taking part in this venture focus in particular on the conceptual structural changes in ancient knowledge as a result of its transmission. Within the framework of this cooperative venture, a special initiative has been launched with the Garden of Pratolino in Florence to investigate the transmission and transformation of the technical knowledge of antiquity. Its aim is to enable a comparison of the conflict between technical and theoretical knowledge during the Renaissance and during antiquity.

The Department's cooperation with the Moritz Schlick Research Institute at the University of Rostock is part of a wider scientific collaboration between the MPWIG and the University of Rostock which began in September 2006 with the founding of the Centre for Logic, History and Philosophy of Science at the University. Its aim is to initiate, coordinate, and organize research activities with the MPWIG on the interaction between science and philosophy in the 20th century, a theme that is particularly relevant to the ongoing investigations in the history of quantum theory.

The Department's activities in developing an innovative digital infrastructure to support its research have recently been strengthened by obtaining additional resources for personnel in the framework of the Max Planck Digital Library (MPDL), a central body for scientific information management.

Department I took part in the joint application of the Free University, the Humboldt University and other non-universitary institutions for the Project Cluster of

Excellence TOPOI—The Formation and Transformation of Space and Knowledge in Ancient Civilizations. The Cluster of Excellence has meanwhile been granted and, as a first joint venture of the Institute and the participating universities, an independent research group on the historical epistemology of space has been established and will start operating in April 2008. The group aims at a long-term history of fundamental structures of spatial knowledge, focusing in particular on the relation of experience and theoretical reflection in the historical development of spatial knowledge.

Several institutes of the MPG, among them the MPIWG, are developing a close cooperation with the Mongolian Academy of Sciences. Among the specific interests of the Department is the knowledge transfer along the silk road and the historical role of the Mongolian empire in fostering cultural, technological, and scientific exchanges between East and West. Against the background of existing contacts and research cooperation between Mongolian institutions and the MPI for Comparative Public Law and International Law (MPIL), as well as on the basis of a number of mutual visits, several joint research activities have been launched within the framework of the project on the globalization of knowledge and its consequences. They are being supported by the establishment of a competence center for the digitization and online presentation of Mongolian cultural heritage, following a proposal developed at the MPIWG and recently approved by the Mongolian Academy of Sciences.

→ Knowledge Management, p. 204

Jews and Muslims are shown playing games together in a garden setting.
Alfonso X *El Sabio, Libro de ajedrez, dados y tablas* (Book of Chess, Backgammon, and Dice), finished in 1283 in Seville. Biblioteca de El Escorial, Madrid T.I. 6, fol. 71v.

A new research venture together with the Spanish Consejo Superior de Investigationes Científicas (CSIC) has been launched by the Social Sciences and Humanities Section of the MPG, following an initial proposal by the Kunsthistorisches Institut in Florence and the MPIWG. The research initiative was prepared during joint workshops held in the period of the report. Its aim is to address a formative period of the European world with its cultural and religious heterogeneity from a multidisciplinary perspective. The encounters and exchanges between Jewish, Christian and Islamic communities and elites constitute an historical laboratory of great significance for understanding interaction and transformation processes of cultures in the millennium between the decline of the Roman empire and the beginning of the early modern period. Aspects of these processes have been studied by single disciplines in an isolated manner. The challenge of the proposed research initiative, involving the establishment of a joint team of scholars located in Madrid, is to overcome such division and focus instead on overarching questions which create an intense dialogue and collaboration between the disciplines involved, among them the history of art, religion, language, and science.

Project 1

Mental Models in the History of Knowledge: The Relation of Practical Experience and Conceptual Structures in the Emergence of Science

General Goals of the Project

The goal of the project is to study the causes and long-term developments of scientific knowledge and to analyze the role of practical experience for the emergence and development of fundamental scientific concepts, such as those of number, force, and motion. In order to achieve a broad historical basis for dealing with these theoretical problems and to cover at least some of the major developmental steps in the history of science, extensive research has been pursued in two different areas: the emergence of writing and calculation as symbolic systems as well as the genesis of mechanics as an empirical science. The project seeks to understand the emergence of fundamental concepts of both formal and empirical knowledge systems as a result of reflecting practical experiences, prior to the period in which experiments became the dominating experiential basis of science.

In both cases, one finds that thinking can be reconstructed in terms of a variety of mental models that partly fulfilled functions in specific contexts of application which are later covered by abstract concepts such as those of number or force. A mental model based on manipulating object-specific symbolic notations, for instance, served in Mesopotamian civilizations for accounting purposes—without presupposing an abstract number concept. Similarly, dynamical explanations in preclassical mechanics did not make use of an abstract concept of force but of a qualitative mental model, in which a projectile continues its motion because it has received an "internal motor' (called 'impetus') from the original cause of motion. The reconstruction of such mental models makes it possible to concisely describe structures of thinking related to practical experience and hence to understand the role of this experience for the emergence of fundamental theoretical concepts such as number or force.

Social conditions and material culture leave their mark on the large-scale structures of scientific development. Writing and quantitative thinking entered the historical scene for the first time as the investigation of operations with systems of symbols, in those early ancient civilizations that used such systems of symbols as a significant aspect of social or economic control mechanisms. Such systems of symbols played an important role in the complex systems of administration and social rituals of the Babylonian, Egyptian, Chinese and Mesoamerican empires, which therefore produced a class of specialists who occupied themselves with the rules of these systems even beyond the context of their direct application.

The project is focused, however, on mechanics as a part of science that has extraordinary significance for the development of science in general. In particular, and more so than other disciplines, mechanics has a continuous tradition from its origins in antiquity to the elimination of fundamental categories of mechanics by modern physics. The focus of the project has been mainly the period from antiquity to the emergence of classical mechanics in early modern times. But key issues have been followed up into the 20th century by the research activities of Project II.

The peculiar longevity of mechanics has given rise to speculations that the experiential basis of such scientific knowledge must be of a special kind, distinct from that of other sciences, which emerged much later. It has been claimed, for instance, that knowledge in mechanics or in mathematics is rooted in an essentially universal everyday experience, or even based on a priori structures of thinking. However, these and other speculations involve a very restrictive notion of experience. They exclude the by no means universal experience that human beings acquire in a historically specific material environment when dealing, for example, with the technology of their times. Therefore, the project is focused in particular on the historical reconstruction of such collective, practical experiences and their influences on the structure and content of scientific knowledge.

Administrative Experience and Conceptual Structures in Babylonian "Science"

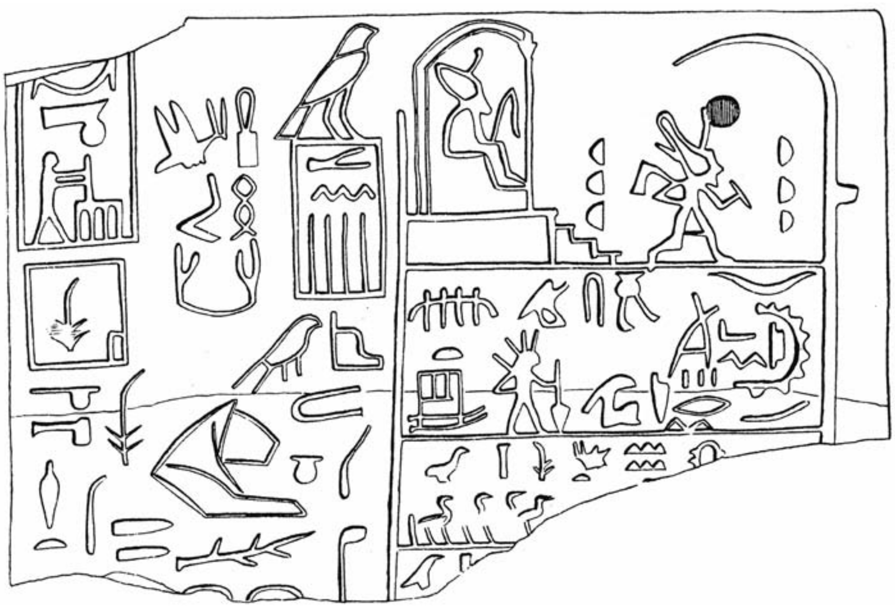
The rich textual and material record left by the early cultures of Mesopotamia and Iran provides an unparalleled opportunity for studying early forms of knowledge formation and transfer. In particular the invention and early spread of writing, being studied within the framework of the CDLI project is a case in point (Peter Damerow on early Mesopotamian writing; Jacob Dahl on early Iranian writing). In both instances, early Mesopotamia and Iran, the process of decipherment has proven to be much more than a linguistic puzzle, rather early writing is best understood as a sophisticated administrative tool which provides us with information about the local and specialized economies of the early urbanized societies of the Ancient Near East. The progress in the decipherment of early Mesopotamian and Iranian writing also exemplifies the advantages of the parallel development of an electronic infrastructure supporting this research.

Clay-cone in the collections of the New York Public Library documenting the sale of a house in the southern Mesopotamian city Nippur during the Ur III period, ca. 2050 B.C. (NYPLC 372)

The ancient Mesopotamian administrative record enables us to reconstruct in great detail the social structures of these ancient societies, among other things. Using the more than 25 000 extant documents from the ancient city of Umma (the modern Tell Djokha in southeastern Iraq), dating to ca. 2100–2000 B C, a revised version of a dissertation has been published on the structures of succession within the ruling family of that city (Jacob Dahl). The empirical basis for such a work—tens of thousands of unique, seemingly unrelated texts—become meaningful only after being made accessible in a coherent format that allows extensive data-mining and enables the reconstruction of the original ancient archives. The CDLI provides a framework for this kind of study, the results of which can at times be surprising. For example it could be shown that succession in southern Iraq during the last century of the 3rd millennium B.C. was not patrilineal, although inclusion in the line of succession was based on paternal affiliation, but rather can best be described as a system of seniority, whereby all male members of a family held rights to inclusion in the line of succession.

Equally surprising results were reached in the study of the earliest writing systems of the region, where it could be shown for example that what may be the world's earliest syllabary (found in the proto-Elamite texts from Iran) was apparently not based on the rebus principle. Instead, new signs for indicating owners were rather invented seemingly *ad hoc.*

Early writing and arithmetics has been a research focus of Department I over a number of years, and it has been conclusively demonstrated that writing and arithmetics had a common origin in early Mesopotamian administrative tools, highlighting the importance of early Babylonian practical knowledge for the understanding of modern sciences. Whereas the origin of writing in Mesopotamia and Iran is relatively well understood in terms of initial use and early development, the same is not true for the other seemingly independent inventions of writing, in Egypt, China, and Mesoamerica. Within the framework of the project on the globalization of knowledge and its consequences, the topic of the diverse backgrounds of the inventions of writing is being further explored.



An ancient Egyptian commodity label (ca. 3000 B.C.)

Although early Mesopotamian writing had a unique origin (in earlier administrative tools and processes), and although all early documents from Mesopotamia had either a purely administrative content or contained lists, presumably for learning purposes, early writing in the ancient Near East materialized in a multitude of manifestation from the earliest periods on. The earliest developed documents from Egypt, for example, may have been inspired by Mesopotamian ones, although sign-forms were certainly based on the well-known earlier "tags" from pre-dynastic Abydos which represents a unique Egyptian development. Building on the results and working within the framework of the CDLI project, now contributing to the globalization project, the research has been extended to the spread of writing in the Mediterranean and surrounding regions.

Historical Epistemology of Mechanical Knowledge

What does the term mechanical knowledge designate? Mechanical knowledge concerns material bodies in time and space, their motions, and the forces that cause or resist such motions. Mechanical knowledge allows us to predict how bodies change their position with time if only we know their current state and the forces acting upon them.

Mechanical knowledge of this kind played a special role in the process of development from natural philosophy to modern science. Natural philosophy from its very beginnings in the works of Aristotle constructed conceptual systems to represent pictures of the world as a whole, referred to in the following as world views. In contrast to such global intentions, the origins of mechanical knowledge have to be sought in the much more down-to-earth activities of realizing specific aims of practical life.

Over a long historical period, the development of mechanical knowledge and its transmission from one generation to the next remained an inherent dimension of such activities, unrelated to any cognitive endeavors aimed at constructing a mechanical world view. It was only after the first attempts in classical antiquity to include mechanical knowledge in the conceptual systems of natural philosophy that its assimilation to them and the corresponding accommodation of such systems to mechanical concepts could lead to conflicts between mechanical knowledge and knowledge about nature as a whole. It was only after the growing body of mechanical knowledge became a vital resource of early modern societies that mechanical knowledge within its own conceptual systematization started to compete with natural philosophy by constructing its own world views. This finally resulted in early modern times in what has been called the "mechanization of the world picture."

The main goal of the research project has been to explain the development and diffusion of mechanical knowledge throughout history in terms of historical-epistemological concepts. The project aims at a unified and systematic account of all kinds of mechanical knowledge which are commonly studied independently in the framework of research agendas informed by particular disciplinary perspectives such as those of anthropology, philosophy of nature, developmental psychology, ethnology, sociology, history of technology, history of education, history of science, etc. These disciplines may indeed contribute a breadth of empirical detail to the project, but none of them alone would be able to integrate them into a coherent picture. Therefore, a systematic account has so far not been given of the conditions under which mechanical knowledge developed from its anthropological origins into foundations of a mechanical world view and after that was transformed into a framework for the interpretation of material interactions within the space-time geometry and quantum mechanics of modern physics.

In the course of the project, which goes back to the inception of the Institute, numerous contributions to such an overarching picture have been made, ranging from cross-cultural studies of intuitive and practical physics, comparative studies of the origin of mechanics in European and Chinese antiquity, investigations of the role of pictorial representations for the practical knowledge of Renaissance engineers, assessments of different modes in dealing with the Scientific Revolution, the development of interpretative models for reconstructing the transition from preclassical to classical mechanics, to explorations into the genesis of the analytical tradition of mechanics and studies of the decline of the mechanical world view in the context of Project II. In addition to these investigations of the historical transformations of mechanical knowledge, a large body of primary sources have been integrated into the digital infrastructure of the project, analyzed and commented upon.

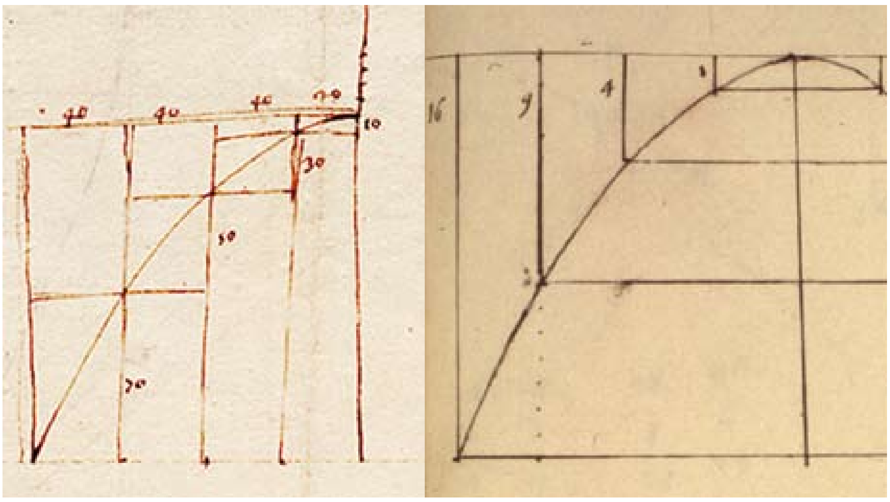
In the period of the report, a preliminary synthesis of these endeavors has been elaborated and is being prepared for publication in the form of a four-volume series under the heading *The Historical Epistemology of Mechanics,* conceived in analogy to the four-volume series on *The Genesis of General Relativity* concluding the Department's reconstruction of the relativity revolution. While the emphasis will be on the period of the Scientific Revolution, given the thrust of the investigations pursued so far, the analysis takes into account the long-term development of mechanical knowledge without which neither the emergence nor the consequences of this period can be adequately understood. Just as the reconstruction of the relativity revolution took Einstein's work as the point of reference for a thorough contextualization of his achievements, the reconstruction of the transformation of mechanical knowledge will similarly refer to Galileo's work as a point of departure for outlining a historical epistemology of mechanics.

The development of an adequate theoretical framework has been a critical aspect of the research program and provides a common basis for the investigations constituting *The Historical Epistemology of Mechanics.* The longevity of mechanics makes it particularly clear that large domains of human knowledge accumulated by experience are not simply lost when theories are revised, even if this knowledge does not explicitly appear in such theories. Formal logic is hence of little help when it comes to a description of the multi-layered architecture of scientific knowledge, allowing to account both for the continuous and the discontinuous aspects of the transmission of mechanical knowledge. In order to explain structural transformations of systems of knowledge, it is furthermore necessary to take into account the collective character and the historical specificity of the knowledge being transmitted and transformed, as well as to employ sophisticated models for reconstructing processes of knowledge development. Concepts such as that of *mental model,* of *shared knowledge,* of *challenging object,* and of *knowledge reorganization* have turned out to be pivotal for such an explanation.

We conceive of mental models as knowledge representation structures based on default logic which allow inferences to be drawn from prior experiences about complex objects and processes even when only incomplete information on them is available. Mental models relevant to the history of mechanics either belong to generally shared knowledge or to the shared knowledge of specific groups. Accordingly, they can be related either to intuitive, to practical, or to theoretical knowledge. They are, in any case, characterized by a remarkable longevity—even across historical breaks—as becomes clear when considering examples such as the mental models of an atom, of a balance, of the center of gravity, or of positional weight. Their persistence in shaping the shared knowledge documented by the historical sources becomes particularly apparent in the consistency of the terminology used, a consistency that offers one important element for an empirical control for the reconstruction of such mental models and their historical development.

We conceive of challenging objects as historically specific material objects, processes or practices entering the range of application of a system of knowledge without the system being capable of providing a canonical explanation for them. Examples run from mechanical devices challenging Aristotelian dynamics, via artillery challenging early modern theories of motion, to black body radiation challenging classical radiation theory. In reaction to such challenges, knowledge systems are typically further elaborated, occasionally to the extent of giving rise to internal tensions and even inconsistencies. Such explorations of their limits may then become starting points for their reorganization in which often previously marginal insights take on a central role in an emerging new system of knowledge. Such processes of reorganization may be exemplified by the emergence of theoretical mechanics from Aristotelian natural philosophy in ancient Greece, the transformation of preclassical into classical mechanics, or the emergence of quantum theory from classical physics at the turn of the last century.

The investigations constituting *The Historical Epistemology of Mechanics* build on this theoretical framework, three of them centering on the role of shared knowledge, of challenging objects, and of knowledge reorganization, respectively. A fourth study elaborates on this theoretical framework and provides a comprehensive survey of the long-term development of mechanical knowledge.



The parabolic trajectory resulting from horizontal projection in the research notes of Galileo (left) MS 72 , folio 117r, and of Harriot (right) British Library Add MS 6789, folio 67r

The first study *The English Galileo: Thomas Harriot's Work on Motion as an Example of Preclassical Mechanics* investigates the shared knowledge of preclassical mechanics by relating the work of Thomas Harriot on motion, documented by a wealth of manuscripts, to that of Galileo and other contemporaries (Matthias Schemmel). Harriot and Galileo indeed exploited the same shared knowledge resources in order to approach the same challenging objects. While the paths Harriot traces through the shared knowledge are different from Galileo's, the work of the two scientists displays striking similarities as regards their achievements as well as the problems they were unable to solve. The study of Harriot's parallel work thus allows the exploration of the structure of the shared knowledge of early modern mechanics, to perceive possible alternative histories, and to distinguish between individual peculiarities and shared structures of early modern mechanical reasoning.

A scientist undertaking an experiment.
Carlo de Bernardis, oil painting, 1695, Milan

The second study *Galileo Engineer: The Origins of the New Physics in Practical Knowledge* looks more closely at the role of challenging objects in early modern mechanics (Matteo Valleriani). In this period, the increased significance and advancement of technology confronted the traditional body of mechanical knowledge with challenging objects such as the trajectory of projectiles, the stability of constructions, the oscillation of a swinging body, or the curve of a hanging chain. As becomes clear from the outstanding example of Galileo's *Two New Sciences*, but also from the numerous letters Galileo exchanged with his contemporaries, these objects enriched the traditional knowledge but also induced fundamental revisions of its structure, which led eventually to classical mechanics. The study investigates the conditions for this change and sheds new light on hitherto neglected contexts of early modern science.

The third study *Galileo's Challenges: The Genesis of a New Theory of Motion* explores the reorganization of knowledge taking place in the course of Galileo's research process extending over a period of more than thirty years, pursued within a network of exchanges with his contemporaries, and documented by a vast collection of research notes (Jochen Büttner). It has revealed the challenging objects that motivated and shaped Galileo's thinking and closely followed the knowledge reorganization engendered by these challenges. It has thus turned out, for example, that the problem of reducing the properties of pendulum motion to the laws governing naturally accelerated motion on inclined planes was the mainspring for the formation of Galileo's comprehensive theory of naturally accelerated motion. It could furthermore be shown how explorative experimentation substantiated the conceptual structures of the emerging theory.

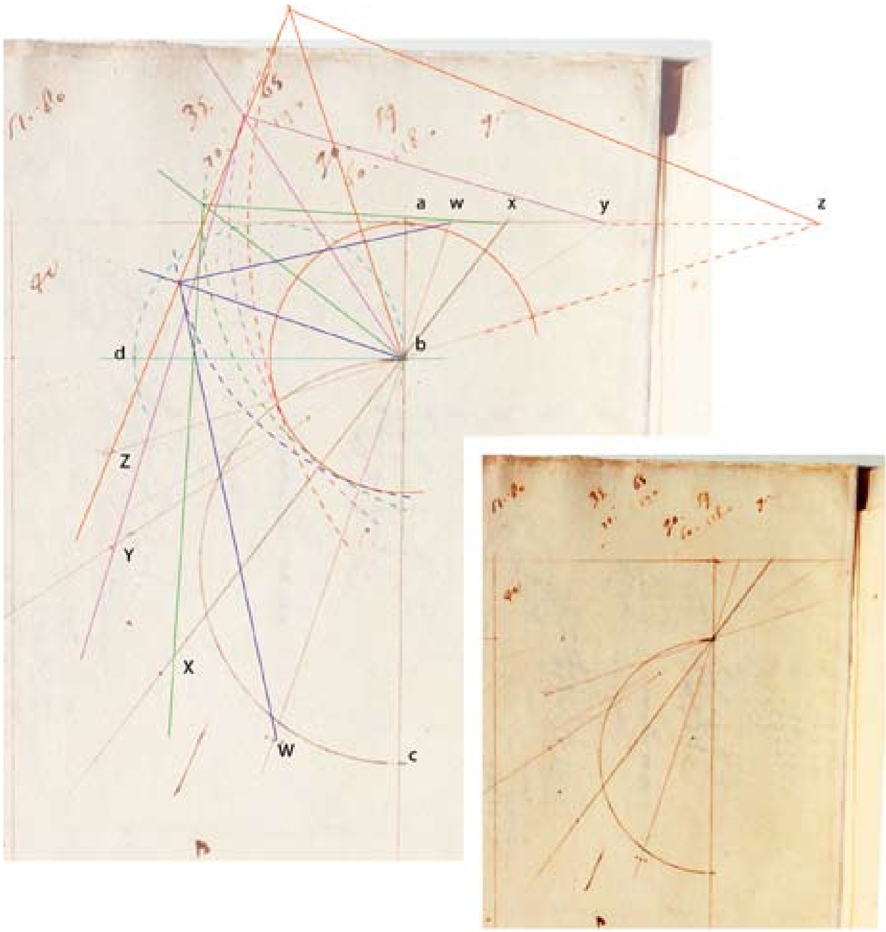


Diagram on folio 155 recto of Galileo's notes on motion (Ms. Gal. 72). A crucial part of the construction, not revealed by the original diagram (lower-right), has been reconstructed (upper-left).
Each color represents the construction necessary to find one of the five points d, Z, Y, X and W (marked but not lettered in the diagram). According to this interpretation Galileo constructed these points such that, after initial fall through the vertical ab, they are reached in the same time

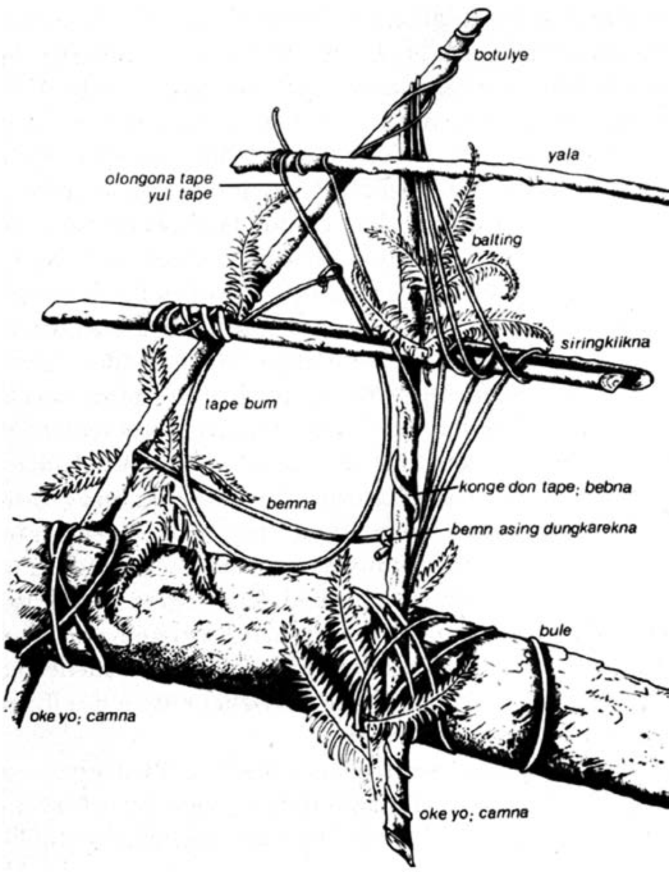
The fourth study *The Evolution of Mechanics: A Study in the Long-term Development of Knowledge* articulates more extensively the theoretical foundations of a historical epistemology of mechanics, provides an outline of the long-term development of mechanical knowledge, and offers an outlook on further research activities within the epistemological framework adopted by Project I. The theoretical foundations of the study draw on research results from various disciplines. They comprise, in particular, a conceptual structure that relates the social settings and material conditions of the development and transmission of mechanical knowledge to its cognitive structures and functions. This conceptual structure allows the methodological problems to be solved that arise from an integration of research results from different disciplinary approaches. The theoretical framework adopted makes it also possible to analyze and make explicit the relations between diverse forms of mechanical knowledge that have hitherto been mostly treated in isolation from each other. Among these different forms is the intuitive knowledge gained through basic material activities, the professional knowledge of practitioners, and the theoretical knowledge resulting from the reflection of various forms of knowledge in the context of scientific theories. On this basis it is thus possible to reconstruct the long-term history of mechanics. Major steps that are treated are:

- the origins of mechanical knowledge in elementary mechanical technologies of indigenous cultures on a stone-age level;
- the development of sophisticated machines in early civilizations;

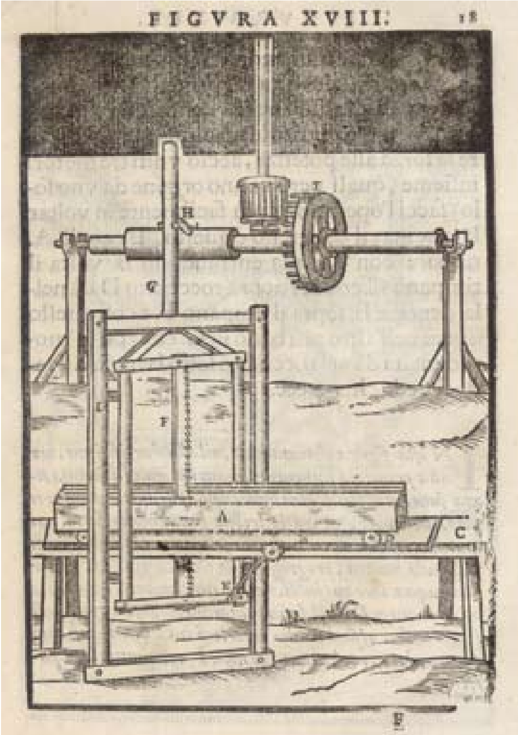
- the theoretical reflection of such technologies in ancient and medieval treatises;
- the origins of preclassical mechanics in Renaissance technologies;
- the development of mechanics into a mechanical world view;
- the failure of classical mechanics in the 19th century to deal adequately with new technologies as well as with the emerging borderline problems of classical physics; and finally
- the redefinition of the fundamental concepts of mechanics in modern relativity theory and quantum mechanics.

Using extensive reinterpretations of the historical sources documenting this long-term development, the final publication will demonstrate that changing mental models of the material reality account for the dynamics of this process (Peter Damerow, Jürgen Renn).

In addition to these studies by members of the Department, a number of further investigations have been pursued by guest scholars in coherence with the main goals of the project. It was investigated, for instance, how Guidobaldo del Monte's writings on mechanics relate to the Aristotelian category of the subalternate sciences, to which it is often assimilated (Maarten van Dyck). Also the role of conservation principles in 17th-century physics was explored, focusing on the question of how the ideal of conservation allows for the introduction of new fruitful concepts, in the work of Stevin,



The spring snare 'wena', a mechanical device of an indigenous culture of New Guinea for capturing small animals.
Left: If an animal touches the 'bemna' the small pin 'bemn asing dungkarekna' releases the string 'bebna' which holds the tensioned beam 'yala' and the noose 'tape bum' captures the animal.
Above: A photo of a spring snare camouflaged with fronds above a jungle trail



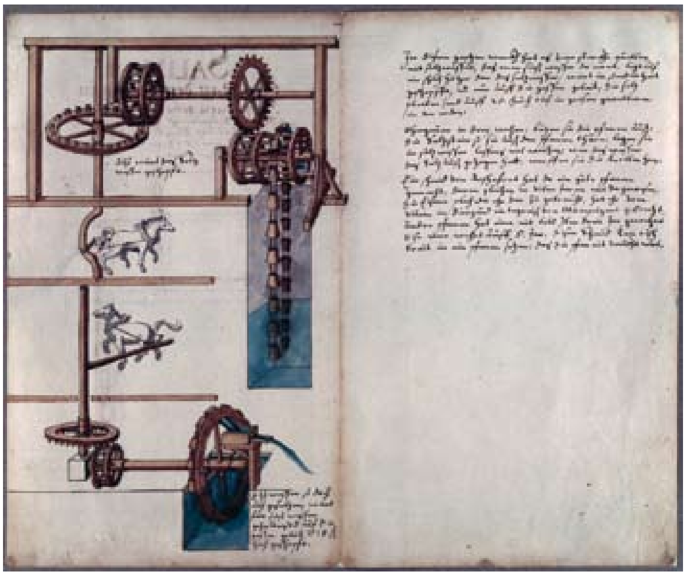
Saw mill, Giovanni Branca,
Le machine,1629

Galileo and Leibniz. The reception of Aristotle's mechanics in the Renaissance was studied, focusing on questions of the authenticity of the work and on philosophical reasons for its importance in the 16th and 17th centuries (Peter McLaughlin). Furthermore the relation of science and technology as presented in the first so-called externalist interpretations of the Scientific Revolution by Henryk Grossmann and Boris Hessen was examined along with the first internalist criticisms.

The Professional Knowledge of Practitioners

Mechanical knowledge evidently predates any systematic theoretical treatment of mechanics. The most basic knowledge presupposed by mechanics is based on experiences acquired almost universally in any culture by human activities. The outcome is an intuitive mechanical knowledge embedded in a qualitative physics, which is built up in ontogenesis and guides human activities related to our physical environment. A second kind of mechanical knowledge, which predates any systematic theoretical treatment of mechanics, is the knowledge achieved by the use of mechanical tools. In contrast to intuitive mechanical knowledge, this type of knowledge is closely linked to the production and use of tools by professionalized groups of people and it consequently develops in history. The professional knowledge of practitioners is historically transmitted by immediate participation in practices such as the processes of labor and production in which such tools are applied and by the oral explanation that accompanies their application.

Chain of buckets,
Heinrich Schickhardt, 1610.
Courtesy of Hauptstaatsarchiv Stuttgart



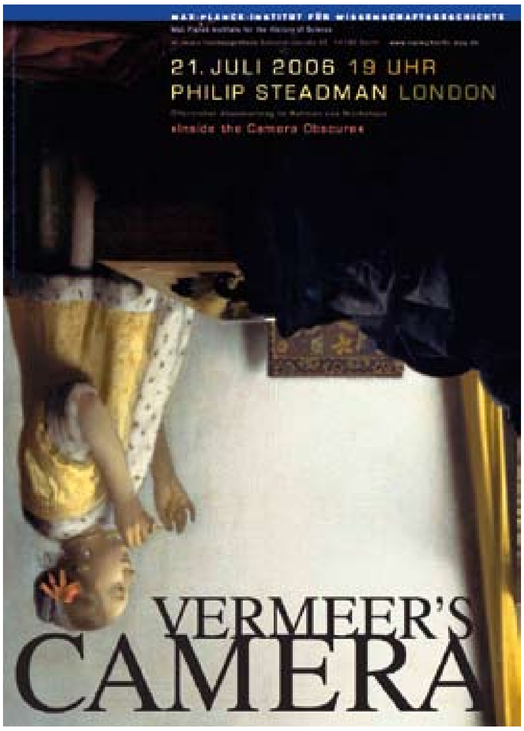
Research on professional knowledge related to mechanics has been mainly dedicated to the study of the tradition of engineering knowledge in the early modern period. To facilitate the study of contemporary engineering drawings and to enable systematic comparisons of the wealth of information contained in these drawings, an analytical database has been developed that allows a standardized description of the images and enables systematized comparisons, as is customary for texts or quantitative data (Wolfgang Lefèvre, Marcus Popplow). As part of the digital research library developed within the framework of Project I, the *Archimedes Project,* the '**d**atabase **m**achine **d**rawings' (DMD) has in the period under consideration been extensively expanded to include rare manuscripts from the 15th and 16th centuries. For example, a large set of unique drawings by engineer-architect Heinrich Schickhardt (1558–1634) is now accessible online thanks to a fruitful cooperation with the Hauptstadtsarchiv and the Württembergische Landesbibliothek in Stuttgart. The database now comprises around 1850 engineering drawings ranging from the late Middle Ages until 1650. Each drawing is presented in a frame of categories comprising bibliographical information and secondary literature, the technological details of the machines depicted, and the drawing's pictorial language and social context. In most cases, the original texts accompanying these drawings are accessible as well. All the categories can be analyzed by means of different searches: The large variety of contemporary types of machines, or the more than one hundred different machine elements they were composed of can be searched as well as graphic techniques such as sections or ground plans, or the mention of measures and materials in the accompanying texts. Statistics show that the databank is used by European and international research and teaching facilities and has close to 1000 visitors per month. Around 1500 machine drawings by Leonardo da Vinci are currently in preparation for inclusion in the databank. This has been made possible by the transference of exclusive rights held by Giunti publishers to the library of the MPIWG. Future plans include the extension of the databank to include drawings from the period 1650–1750 as well as new collaborations with other research database projects. DMD is openly accessible at <http://dmd.mpiwg-berlin.mpg.de>.

Further investigations have been dedicated to the professional knowledge employed in shipbuilding, extending earlier research on knowledge organization in the Venetian Arsenal (Matteo Valleriani) and also on the relation between ship design and developments in fluid mechanics (Horst Nowacki). A book on civil and naval architecture is being published (Wolfgang Lefèvre, Horst Nowacki).

Matthew Baker's illustration of the naval architect at work. From Mattew Baker's *Fragments of English Shipwrightry* of 1586, unpublished manuscript. Courtesy of the Pepysian Library, Magdelene College, Cambridge

The Parallel Cases of Optics and Music

The development of mechanics as the result of an interaction of practical knowledge with other forms of knowledge ranging from antiquity to the early modern period finds its parallels in the evolution of optics and music theory as fields of scientific knowledge similarly dependent on the accumulated experiences of practitioners. In this context the role of the 17th-century camera obscura as an optical instrument was further investigated in a workshop that explored its significance for both science (theory of vision as well as optics) and art (Wolfgang Lefèvre, Carsten Wirth). The results of this workshop are documented in the Institute's preprint series. In the framework of the workshop, an experimental historical camera obscura was designed and constructed for the MPIWG that allows all known types of cameras employed in the 17th century to be configured. The apparatus serves as a research tool for historians of art and science. A future prospect is to employ this tool in experimental research, particularly for the investigation of the optical performance of mirrors, lenses and further optical glass devices employed for scientific and artistic purposes during that century.

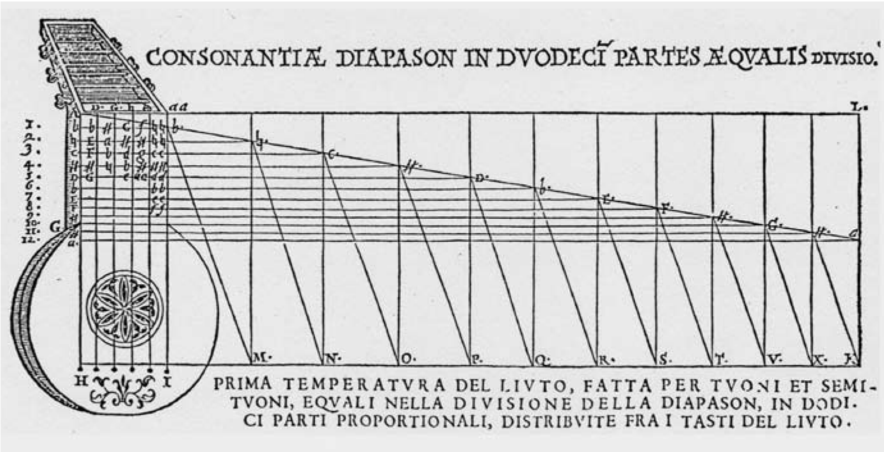


Poster of the workshop "Inside the Camera Obscura"

Work on a translation of Isaac Newton's *Opticks* into German has continued (Volkmar Schüller). Meanwhile the compilation of a critical text of the *Opticks*, which forms the basis for the new translation, has been completed. This critical text takes into account Newton's English manuscript, the three English editions of *Opticks* as well as Samuel Clarke's Latin translation carried out under Newton's supervision.

Practical needs both in mathematics and music, such as the need in the late Middle Ages to divide the tone in contrast to the predominant Platonical-Pythagorical tradition that proscribed it, caused ratio in the context of music to become gradually interpreted as a continuous magnitude, whereas previously it was a comparison between two integer numbers. This change would eventually lead to an arithmetization of the theory of proportions in music theory. In the context of practical needs both in mathematics

Experimental Historical Camera Obscura. A research tool for historians of art and science who investigate the 17th-century camera obscura. Designed and constructed for the MPIWG by Carsten Wirth and Henrik Haak and music, the skepticism against Pythagorical arithmetical dogmatism in theoretical music at the end of the 16th century stimulated interest in the physical foundations of pitch in music. The role of musical practice in the arithmetization of the theory of proportions in music theory is being investigated from this perspective. Such developments are representative of a change in the interpretation of music theory in the Renaissance, a change from a mathematical-speculative conception to a physical-empirical one. In this context it is also being investigated to what extent epistemological concepts such as that of the Scientific Revolution according to Thomas Kuhn or that of epistemological break according to Gaston Bachelard are transferable to this change in the interpretation of music in the early modern times. It is also considered how such changes in the concept of ratios are applicable to mathematical education contexts (Oscar Abdounur).



A proposal of division of the octave in 12 parts with equal and proportional semitones by Gioseffo Zarlino, *Sopplimenti Musicali*, Venetia, 1588, vol 3, book 4, chapter XXX, p. 209

Cooperative Ventures

Conferences and Workshops

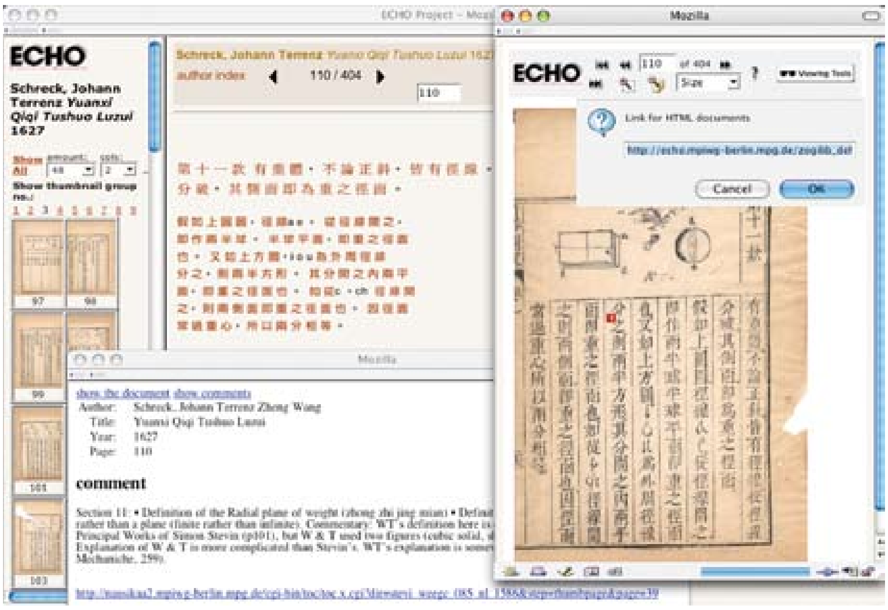
Several conferences and workshops have taken place in the framework of Project I, partly under the auspices of major cooperations that have been initiated or continued in the period of the report. They have provided occasions for presenting results by scholars of the Department to a wider scientific audience in a form that conveys their coherence in an overarching research endeavor. One such occasion was offered by the *Galilean Lectures,* a prominent lecture series held in 2007 for the first time outside of Italy at the MPIWG and organized in collaboration with the Istituto e Museo di Storia della Scienza in Florence and under the patronage of the Italian Embassy in Berlin. The event focused on the relations between Galileo's scientific work and the technology of his time.

Another such occasion was offered by a session at the HSS 2007 Annual Meeting dedicated to Aristotle's *Mechanical Questions,* bringing together members of the Project's network from Humboldt University, Harvard University and the University of Heidelberg.

In 2006 a large workshop under the title *The Machine as Model and Metaphor* was organized by Department I and funded by the European Science Foundation (ESF) in the framework of the Research Networking Program *From Natural Philosophy to Science,* co-initiated by the department in 2002. It brought together historians of science, of technology, and of philosophy to take a closer look at what in the early modern period was considered to be a machine, i.e. machines used in building, vehicles, clocks, automata, pumps, wind and water mills. It is planned to publish the results in an edited volume.

Independent Tradition and Knowledge Transfer: the Case of China

In 2006 joint work with the Institute's Partner Group at the Institute for the History of Natural Sciences of the Chinese Academy of Sciences on the exchange of practical and scientific knowledge between China and Europe in the early modern period was brought to a close (Chen Yue, Peter Damerow, Jürgen Renn, Matthias Schemmel, Tian Miao, Xiao Yunhong, Yin Xiaodong, Zhang Baichun, Zou Dahai). A major Chinese publication, an edition and commentary of the *Yuanxi Qiqi Tushuo Luzui* is ready for publication. In the English language, a preprint is available which comprises several studies of the Jesuit intervention in Chinese mechanical knowledge (Jürgen Renn, Zhang Baichun).



Annotating texts and images with scientific commentaries. MPIWG and the Chinese Academy of Science in ECHO

The *Yuanxi Qiqi Tushuo Luzui* is the first monograph on western mechanics ever to be compiled in Chinese. In order to introduce western mechanics to China, the authors of the *Qiqi Tushuo*, Wang Zheng (1571–1644) and Johann Terrenz Schreck (1576–1630), worked together on a Chinese presentation of western mechanical knowledge, thereby merging the traditions of the two cultures. The *Qiqi Tushuo* has been made available on the Internet as a high-quality facsimile with introductory notes and as a transcription linked to a dictionary, together with further texts pertinent to the history of mechanics in China. This digital library on Chinese texts on mechanics is part of the ECHO infrastructure <http://echo.mpiwg-berlin.mpg.de/content/chineseknowledge> and is being further extended. Work on a commented English translation of the *Qiqi Tushuo* is being continued.

→ Knowledge Management, p. 204

The Jesuits Matteo Ricci, Adam Schall von Bell, and Ferdinand Verbiest. In Johann Baptista du Halde, *Ausführliche Beschreibung des Chinesischen Reiches und der grossen Tartarey*, Rostock 1749

The transmission of European scientific knowledge in the early modern period has been further investigated within the framework of the globalization of knowledge project. Patterns of reception and rejection of knowledge are being explored as well as the ways in which knowledge is transformed during the process of its transmission. It has turned out that the knowledge transfer between Europe and China is best understood if the historical events are interpreted in terms of an interaction between two comprehensive systems of knowledge; the early modern European and the late-Ming/early-Qing Chinese, including their respective social and cultural embeddings (Matthias Schemmel).

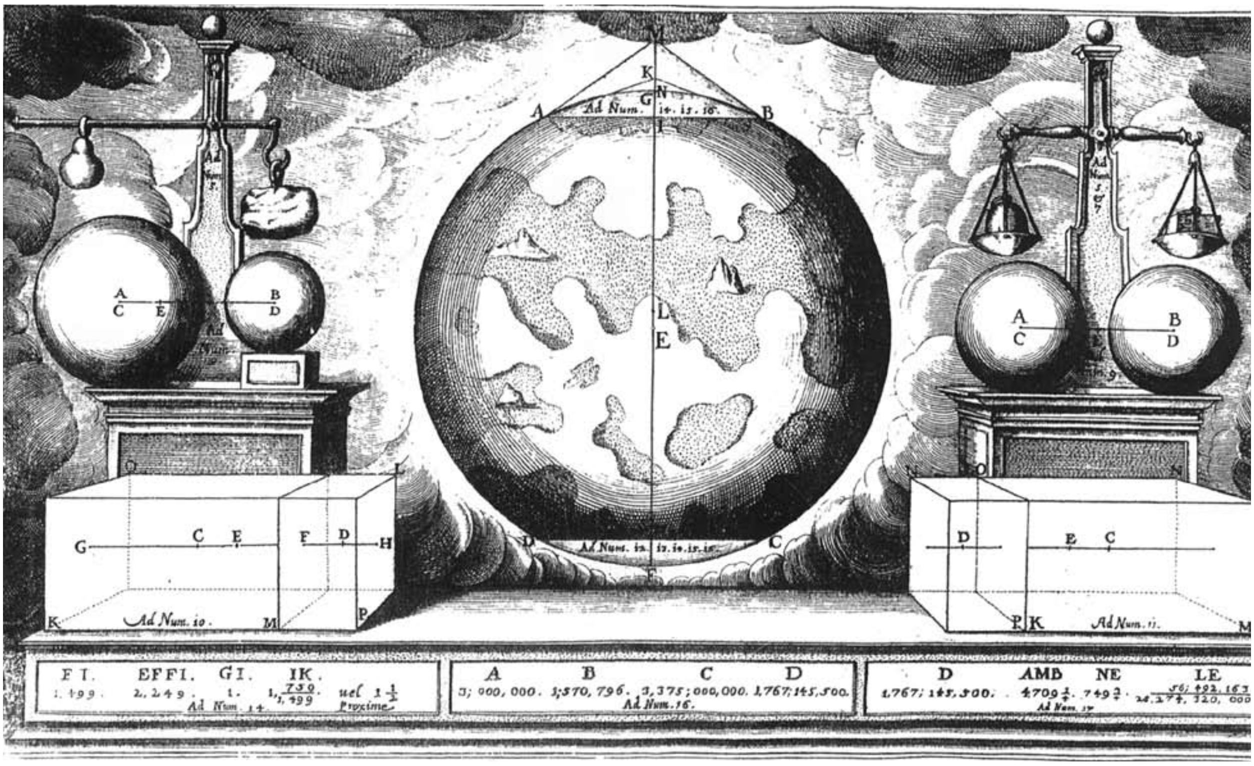
Jesuits on Statics, Dynamics, Mathematics, and Astronomy Between Galileo and Newton

The research venture *Jesuits on Statics, Dynamics, Mathematics and Astronomy between Galileo and Newton* was launched in 2006 together with the Cohn Institute for History and Philosophy of Science and Ideas at Tel Aviv University and is partially funded by a grant from the German-Israeli Foundation for Scientific Research and Development (G.I.F.). It aims at an important aspect of the development of mechanical knowledge in the early modern period: the dissemination and transmission of scientific knowledge through the highly developed communicative network of Jesuit colleges and universities (Jochen Büttner, Peter Damerow, Rivka Feldhay, Jürgen Renn, Matteo Valleriani). The three-year period envisaged for the initial research phase was recently extended until 2010. Most of the goals of the first part of the venture have been achieved during the first two-year period. Preliminary results were presented at the annual meeting of the German and Israeli group in Berlin (2007). Major problematic areas have been defined that were crucial for the transition from the ancient and medieval understanding of mechanics as a science of weights towards the "classical" understanding of mechanics as a "general theory of motion." These concern the interplay between a mathematical study of weights in equilibrium and the philosophical study of motion, attempts to build bridges between dynamics and statics, and the role of quantitative experiments. Several papers dealing with these areas have been published or are in press. A preprint of collected contributions focusing on the themes, methods and constraints of Jesuit mechanics is in preparation.

By the close reading of a selected list of 17th-century texts written by Jesuit mathematicians and philosophers concerned with problems of weight, equilibrium, resistance, machines, free fall and projectile motion, the discourse on mechanics between 1630 and 1685 is being reconstructed from the particular Jesuit perspective. During the winter and fall of 2007, a weekly seminar took place to discuss and read a series of texts in which mechanical knowledge is applied to understand and explain a possible motion of the earth in non-Copernican terms, to demonstrate its existence and measure it, or simply to clarify its implications and then reject it. The texts include Paulus Guldin's *Dissertatio de motu terrae* (1635); Paulo Casati's *De terra machinis mota* (1655) and Honoré Fabri's *Dialogi physici in quibus de motu terre disputantur* (1665).

→ Knowledge Management, p. 204

Jesuits discussing motions of the earth without adopting a Copernican worldview. In Pauli Guldini Sancto, *Gallensis et Societate Jesu De centro gravitates*, Liber Primus, Viennae 1635

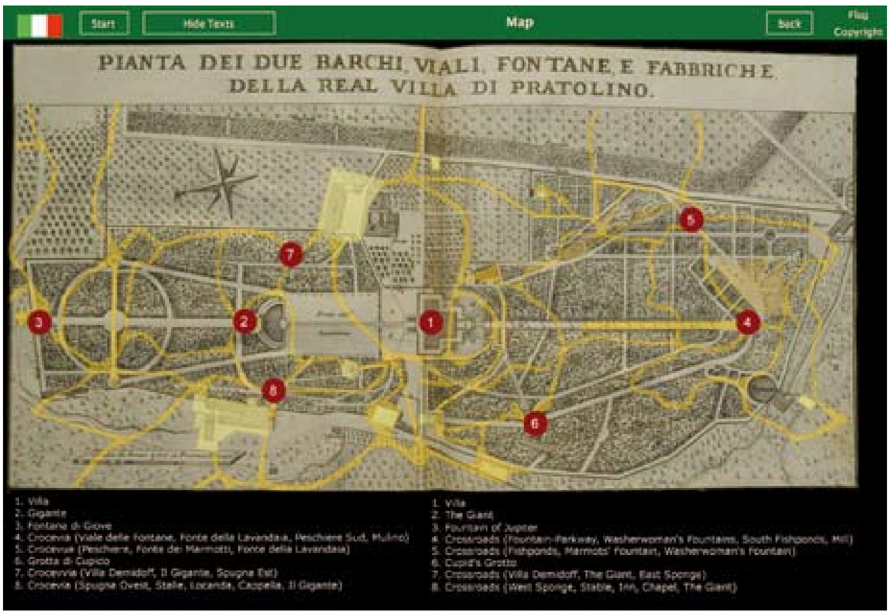


Aristotelian Mechanics, Conceptual Change, and Knowledge Transfer

Since January 2005, the department has participated in the *Sonderforschungsbereich* (SFB, Collaborative Research Center) *Transformations of Antiquity* at the Humboldt University in Berlin. The work of the Department in the framework of the SFB has focused on the sub-project "Weight, Energy and Force: Conceptual Structural Changes in Ancient Knowledge as a Result of its Transmission" (Peter Damerow, Malcolm Hyman, Jürgen Renn, Matteo Valleriani). Work on this sub-project has resulted in contributions to the first volume of a book series documenting the results of the Collaborative Research Center. These range from an account of the theoretical potential of the concept of mental model for understanding the transformation of technical knowledge, via an analysis of the understanding of Hero's pneumatics by Renaissance engineers, to an exploration of semantic networks as a tool for investigating conceptual change and knowledge transfer in the history of science.

Within the project novel techniques in the area of computational philology have been developed. These techniques are intended to provide new sorts of data for research into the long-term development and transformation of ancient scientific and technical knowledge. Moreover, they constitute a contribution to open research questions in the history of science regarding the relation between terms and concepts belonging to different scientific theories. The techniques allow for computer-assisted analysis of the semantic relations between technical terms in a text and draw upon the linguistic concept of semantic fields and work in cognitive science and computer science on semantic networks and semantic memories.

The sub-project has also produced analyses of the structure and terminology of six works selected from the 16th- and 17th-century Aristotelian translations and commentaries (by Bernardino Baldi, Giuseppe Biancani, Giovanni di Guevara, Henri de Monantheuil, Niccolò Tomeo, and Alessandro Piccolomini) that document a critical phase in the transformation of Aristotelian mechanics. These data comprise a functional description of each section of the text (in terms of categories such as premise, problem, theorem, definition, literary reference) and a core list of about six hundred technical terms



Project "Pratolino: The History of Science in a Garden" (first page of the online presentation) (together with concordance information for the six texts) chosen on the basis of their theoretical importance. The primary texts have been published in digital form as part of the open access publication initiative of the MPIWG, and the content and terminological data constitute a set of structured XML annotations on these electronic texts. These data will be crucial in further research on transformations of ancient mechanics.

→ Knowledge Management, p. 204

The reception and transformation of the technical knowledge of antiquity is being investigated also with regard to early modern translations and commentaries on Heron's *Pneumatics*, which are being related to early modern knowledge on the design and functioning of pneumatic machines. A basis for this investigation is provided by the rich source material of a partially unexploited estate: the Garden of Pratolino near Florence, which documents the construction and decoration of an outstanding achievement of early modern technology <http://pratolino.mpiwg-berlin.mpg.de>. This initiative is undertaken jointly with the Ente Provincia of Florence, which owns the garden, the Riccardiana and Moreniana libraries, the State Archive of Florence, the Biblioteca Nazionale Centrale of Florence, as well as with the Kunsthistorisches Institut of Florence.

TOPOI — The Formation and Transformation of Space and Knowledge in Ancient Civilizations

The Department participated in the original proposal for the Project Cluster of Excellence *TOPOI — The Formation and Transformation of Space and Knowledge in Ancient Civilizations* with two project proposals: one for an independent junior research group and one for a cross-sectional group aimed at linking research efforts from different areas of the cluster. The TOPOI Cluster has meanwhile been granted. In the internal reviewing process of the Cluster, the independent research group has been approved and is on the way to being realized. The project of the group, *Historical Epistemology of Space: Experience and Theoretical Reflection in the Historical Development of Spatial Knowledge,* aims at a long-term history of basic structures of spatial thinking, ranging from prehistory to the most recent and ongoing scientific revolutions. It focuses on the question of how the emergence and the development of spatial concepts is shaped by experience and how, in turn, these concepts influence the acquirement of further experiential knowledge. Experience in the sense of the project is to be understood in a broad sense, ranging from the interaction of biological organisms with their environment to the systematic production of knowledge by means of the complex experimental systems of modern science. The experiential spaces that one may thus distinguish have traditionally been investigated by different disciplines—developmental psychology, anthropology, ethnology and psycho-linguistics, archeology, and the history of science and technology—and shall in the framework of the project be set in relation to each other with respect to their research potentials and results concerning the historical development of spatial knowledge (Matthias Schemmel).

The Department's second proposal will be decided upon once the cross-sectional groups have been chosen. It is designed to investigate the diffusion of practical knowledge in antiquity. The focus will be on tracing the techniques in stonemasonry, which formed the basis of the great architectural achievements of the Mediterranean cultures. Practical knowledge of this kind can be taken as an example for the very effective circulation of knowledge in antiquity since it is much less connected to the individual characteristics of societies; their traditions, language and social organization. Since its transfer is not restricted to a specific form, knowledge can be gained from personal contact 'on the job' as well as from objects such as drawings and texts; it can even be studied and adopted without any specific documentation when existing buildings are analyzed. Details of the techniques used also help to distinguish

The oldest surviving manuscript of Euclid's *Elements*, 9th century AD. The *Elements* document an early theoretical reflection on the figures that can be drawn with compass and ruler and became a paradigm of deductive reasoning with far-reaching consequences for the later development of the concept of space

between the actual adoption of knowledge from 'stimulus diffusion'. The project shall profit from the vast expertise in archaeology and architecture present in the TOPOI cluster, from the results of the Department's project *Epistemic History of Architecture,* as well as from ongoing research in the context of the project on the globalization of knowledge and its consequences (Wilhelm Osthues).

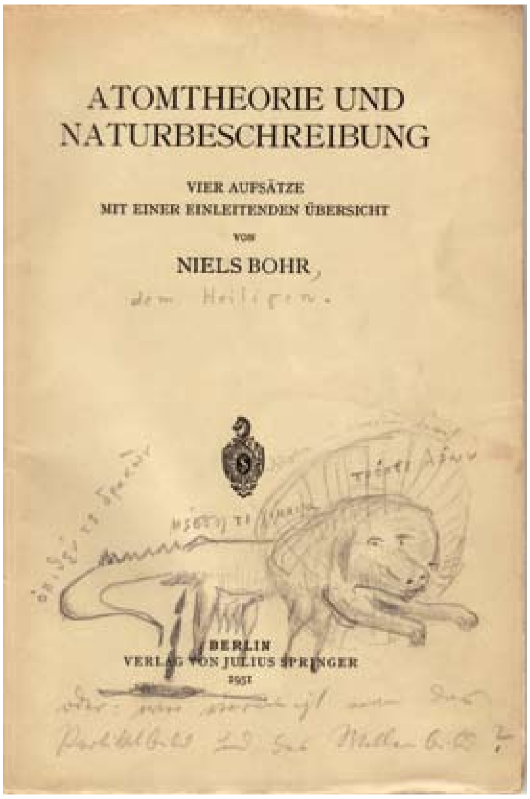
Project 2

Reorganizing Knowledge in Developed Science: Integration and Disintegration of Knowledge Systems

General Goals of the Project

The goal of the project is the study of the emergence and dissolution of core groups of concepts that structure the vast knowledge embodied in the mechanical worldview as a result of processes of knowledge integration and disintegration. In the context of the project, the emergence of such a core group of foundational concepts is conceived as a restructuring of the cognitive organization of previously acquired knowledge. Core concepts of the mechanical world view such as space, time, force, motion, and matter achieved their privileged position in the organization of knowledge only after a long process of knowledge integration in a material, social, and cognitive sense. Such concepts proved to be extremely stable in the face of an enormous growth of knowledge in the course of the further development of science. Nevertheless, physics, like many other scientific disciplines, has witnessed in the past century fundamental changes of precisely such core groups of foundational concepts. These fundamental changes were preceded by more or less extended periods of knowledge disintegration, in which the established cognitive organization of knowledge became problematic. Processes of integration and disintegration of knowledge are studied in close connection within the project since it has turned out that the essential mechanisms at work in periods of destabilization were of the same nature as those in the original processes of the emergence of core concepts of a discipline.

Erwin Schrödinger's personal copy of Niels Bohr's *Atomtheorie und Naturbeschreibung* on which he drew a wave-particle chimera



The project is focusing on the history of the central mental models which shaped scientific thinking in the periods ranging from classical mechanics to the revolutions of modern physics. These challenged fundamental categories of mechanical thinking. The project also traces the far-reaching restructuring introduced by the analytical tradition and disciplinary organization of scientific knowledge. The results already achieved for the emergence of the new concepts of space and time in the context of the two relativity theories are being complemented by similar research on the emergence of new notions of matter and causality established in the context of quantum theory.

The History and Foundations of Quantum Physics

The quantum revolution emerges from a series of crises of the classical mechanical world view from the late 19th century to the 1920s. These crises were caused in part by conflicts between theoretical expectations and experimental results, but also importantly by the difficulty of integrating relatively newly established physical theories such as electrodynamics and thermodynamics into the mechanical world view. Similar to the case of relativity theory, conflicts between theories necessitated a reorganization and re-evaluation of the most fundamental concepts of these theories.

Central to this process of re-evaluation was not only a large amount of undoubted empirical knowledge accumulated over a long period of time but also the persistence of certain theoretical structures and methods. Theoretical physicists were therefore confronted with critical decisions about which concepts and theoretical structures could be maintained in the emerging theory and could thus serve as a guide for the development of the theory. As in the case of relativity, it turned out that it was often high-level and abstract structures that survived, although frequently with a new physical interpretation.

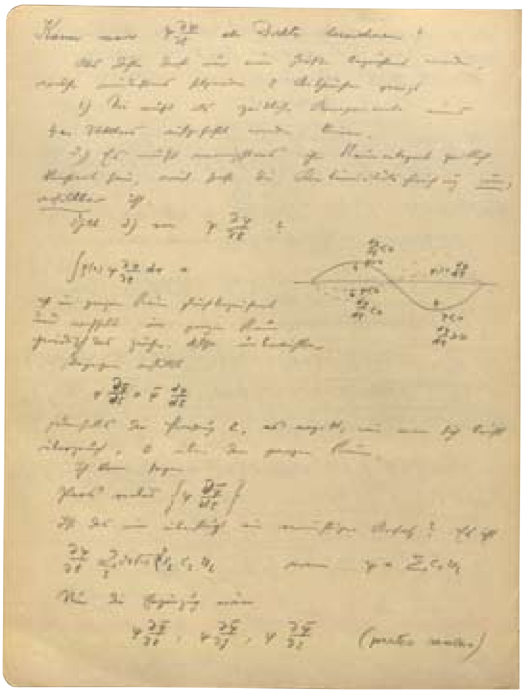
Differently from the case of relativity, a consensus about the physical reinterpretation of the abstract structures was not easily attained. Famous dissenters, such as Einstein and Schrödinger, while accepting the new theoretical structure, disagreed about its meaning and its connection to the traditional mechanical world view. Later on, the establishment of quantum field theory, including the unification with the theory of relativity, has turned out to be at odds with the traditional demands on an interpreted physical theory. These disagreements have persisted up to this day, even though quantum mechanics is a highly successful predictive theory by all counts.

Most importantly for the historian, this lack of closure of the theoretical structure has also affected the historiography of quantum theory, which can be divided into three periods:

- A first generation of historical works was written mainly by physicists who had participated in the quantum revolution themselves or witnessed it closely. Not surprisingly, these accounts have a rather whiggish character: they present the history as the triumph of good scientific practice and especially of good epistemology.
- A second generation of historical work refrained from the high-level disputes of the previous generation altogether and concentrated on the collection and presentation of large amounts of historical material. Examples are especially the Archives for the History of Quantum Physics and the monumental monograph by Mehra and Rechenberg.
- Only in a third generation of more recent publications one finds a more critical distance from the founders of quantum mechanics and their account of the course and meaning of the events. Also, the scope of the

inquiry was widened, paying more attention to experimental practices and social and cultural influences.

Aiming to present a fourth generation of historical writing, the research project on the history and foundations of quantum physics began work in October of 2006 (Christoph Lehner). It is a joint initiative with the Theory Department of the Fritz Haber Institute and has been funded for five years by the Strategic Innovation Fund of the President of the MPG. The project attempts to arrive at a deeper understanding of the genesis and the development of quantum physics, using the tools of historical epistemology that have been developed in Department I over the last years. The project thus focuses on the long-term history of the process of theory change, stressing the continuity of methods and structures. The experience in writing the history of relativity has demonstrated the strength of this method: It leads to results that have been outside the view of approaches limiting themselves to an account of historical developments narrower in a temporal and contextual sense.



A page from a notebook by Erwin Schrödinger shows him struggling for a physical interpretation of the wave function: Here he tries to understand it as a (matter or charge) density

On the other hand, the project builds on the results of the previous generations of quantum history: In the tradition of the first generation, it turns to working physicists to reach a detailed understanding of the sources. It also takes advantage of the wealth of source material amassed by the second generation, but retains a position of reflective distance introduced by the third generation. Attention is being paid to the role of experimental practices and instruments in the creation of new phenomena, and to the institutional, social, and cultural dimensions of the development of quantum physics.

Since the development of quantum physics was the achievement of a large group of researchers without a single center, the project faces distinct challenges, such as the huge amount of material and the absence of a single historical thread to lead the research. Therefore, the project was conceived from the beginning as closely cooperating with a larger network of researchers who are working on the history of quantum physics.

The research done within the project has so far covered the following topics:

Research activities on the development of wave mechanics (Christian Joas, Christoph Lehner, Jürgen Renn) are dedicated to the historical roots of wave mechanics and in particular to an extensive study of the research notebooks of Erwin Schrödinger. One aim is to reconstruct the origin of wave mechanics in discussions about the nature of light quanta and about the problems of quantum statistics. A detailed account of Schrödinger's formulation of wave mechanics, using the notebooks extensively for the first time, is in preparation.

Research on the life and work of Max Planck concentrates on his institutional, social and personal environment (Dieter Hoffmann). In preparation for his 150th birthday in 2008, a number of publications are being completed. They include a comprehensive scientific biography of Planck, a study of his role as an editor of the *Annalen der Physik,* the transcription of the correspondence between Planck and his co-editor at the *Annalen*, Wilhelm Wien, as well as an extensive annotated collection of Planck's *Annalen* papers.

Another activity is concerned with an in-depth reconstruction of the statistical derivation of Planck's radiation law and its connection with Boltzmann's combinatorics and follows the usage of statistical concepts in quantum physics from there to the eve of wave mechanics (Massimiliano Badino). Particular attention is paid to the conceptual interactions between statistical mechanics, quantum theory and thermodynamics, to the development of an adequate statistical formalism for quantum theory, and to the emergence of indistinguishability. A paper on Planck's derivation has been submitted for publication, and a paper in a volume on Boltzmann is forthcoming.

Das Rätsel des Lichts

Von E. Schrödinger

Wir Menschen gehören ausgesprochen zu den „Augentieren". Fast alle Kenntnis der Umgebung, alle Lebensfreude, Natur- und Kunstgenuß (ausgenommen nur den musikalischen) vermittelt das Auge. Wir kennen kaum ein grauenvolleres Schicksal als Blindheit. In das Licht, in den lachenden Zeus, in die strahlende Sonne versetzen wir von alters her alle Götter und Genien des Guten und Schönen, die Geister des Bösen in Nacht und Finsternis.

Die naturwissenschaftliche Betrachtungsweise führt, da sie auf objektive Erkenntnis, nicht auf die subjektiven Bedingungen und Bedürfnisse des Menschen abzielt, sehr häufig zu einer Umwertung aller Werte. Unsere königliche Sonne wird zum einfachen Staatsbürger, zum Stern unter Sternen, die alle gleich wichtig und interessant sind. Die ekelhafte Kröte und die schillernde Libelle, der

Wir sogenannten Gelehrten sollen uns der Aufgabe nicht entziehen, in beliebig weite Kreise hinaus zu „popularisieren", d. h. in großen, an das Gesamtinteresse der Menschheit anknüpfenden Zügen zu sagen, „um was es uns geht" und was wir glauben, „herausgebracht" zu haben. Aber es ist heillos schwer. Vielleicht liegt es daran, daß wir in Wirklichkeit so schrecklich wenig herausgebracht haben. Das glaubt uns aber der Leser nicht, denn erstens sieht er die märchenhaften Fortschritte der Technik, zweitens liest er viele populäre Darstellungen zweifelhafter Qualität, die in dem Gedanken schwelgen, „wie wir's denn zuletzt so herrlich weit gebracht". — „O ja, bis an die Sterne weit!" — so weit, daß sich im gegenwärtigen Augenblick kein Teufel mehr auskennt! — Und da soll man nun sich an den Schreibtisch setzen und (um wieder auf den Faust zu kommen) „mit saurem Schweiß sagen, was man nicht weiß". — Mit diesen Zeilen antwortete uns der Gelehrte, als wir ihn ursprünglich aufforderten, in einer populären Studie die Plancksche Quantentheorie darzustellen. Der Hinweis auf die großen Schwierigkeiten einer sachgerechten Popularisation hochwissenschaftlicher Gedanken erscheint uns grundsätzlich wichtig.

Pestbazillus und das menschl Spermatozoon sind als Obj der Forschung von gleichem Ra Der ganz ausgesprochene Prim des Lichtes jedoch setzt sich a in die Naturwissenschaft hi fort, er wird durch sie wenn m lich noch erhöht.

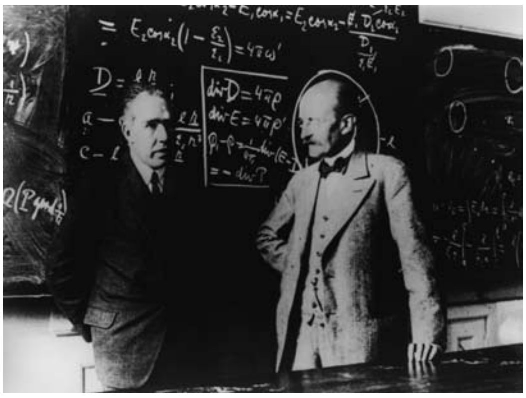
Zwar zu einer ganz klein „Umwertung" muß sich der Ph siker, wenn er über das Li sprechen will, die Erlaub erbitten. Es fiele ihm schwer, d Begriff „Licht" gerade nur auf d verhältnismäßig schmalen Welle bereich zu beschränken, auf w chen das Tier- und Menschenaug bei seiner (phylogenetischen) En stehung sich abgestimmt hat; den das Auge hat sich diesen Welle längenbereich lediglich aus de Grunde ausgesucht, weil uns Sonne vermöge ihrer Ob flächentemperatur von 5500 Gra Celsius gerade diese Wellen vo zugsweise „sendet". Und das

Max Planck with Erwin Schrödinger in *Die Koralle*, 5, (1929), pp. 294–298

An investigation into the early history of Bose-Einstein condensation has looked at the initial response to Einstein's 1925 prediction of condensation occurring in the ideal gas (Daniela Monaldi). Through this episode, the historical evolution of the innovative concepts introduced by quantum statistics has been examined as well as their interplay with the general development of statistical mechanics, for example, the concepts of indistinguishable particles and of cooperative phenomena.

A further research activity investigates the role of molecules in the development of quantum mechanics, with special attention to the contribution of Michael Polanyi and Eugene Wigner (Arianna Borrelli). In 1926, Wigner was the first to introduce group-theoretical methods in quantum mechanics when he was working in X-ray crystallography at the Kaiser-Wilhelm-Institut für Faserstoffchemie in Berlin-Dahlem. The first stage of this investigation is a study of Wigner's early work and its historical context, in particular of the different notions of symmetry—both formal definitions and operational implementations — in mathematics, classical and quantum physics and crystallography.

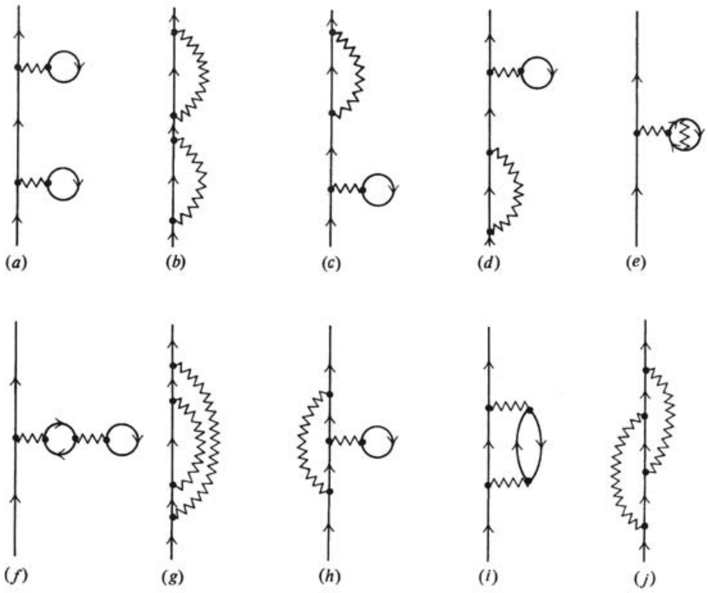
Research on the history of radioactivity and early nuclear physics is devoted to the investigation of the relationships between persons and institutions in Germany, and their international connections; it also treats the correlations between experiment and theory in this subject (Horst Kant). The investigation concentrates on the groups at the Kaiser Wilhelm-Institutes of Chemistry (at Berlin) and Physics (both at Heidel-



Niels Bohr and Max Planck, 1930.
Foto: AIP Emilio Segrè. Visual Archives, Margarethe Bohr Collections

berg and Berlin). Recently, the main focus has been on Walther Bothe and his Heidelberg group during the 1930s and 1940s. A first detailed paper is forthcoming in 2008. The contribution of Bothe to the idea of wave-particle dualism during the mid-1920s is studied with the help of his laboratory notebooks (Horst Kant, Dieter Fick).

An investigation into the advent of quantum field theoretic methods in solid state physics in the 1950s (Christian Joas) is examining the large-scale transfer of mathematical tools and computational methods from particle and nuclear physics to the then newly-evolving field of condensed matter physics, which has since become one of the largest subdomains of physical research. A paper on the use of Feynman Diagrams in theoretical solid state physics is in preparation. Two visiting scholars spent extended periods of time in the project working on the history of Feynman Diagrams in particle physics (Adrian Wüthrich) and on the history of nuclear power (Maja Fjaestad).
To support the individual projects, a coordinated effort has been made to collect, digitize, and make available a wide array of sources for the history of quantum physics (Carmen Hammer). Part of this project is the digitization by the MPIWG library of the complete *Archives for the History of Quantum Physics,* an extensive collection of sources compiled and microfilmed at the American Philosophical Society. This work is well under way and the digitized material is accessible to cooperating researchers on the project's website. This activity is now being complemented by the creation of a Digital Schrödinger Archive based on the collections in the possession of his daughter, Ruth Braunizer.



All second order Feynmann diagrams for the Green function in coordinate space

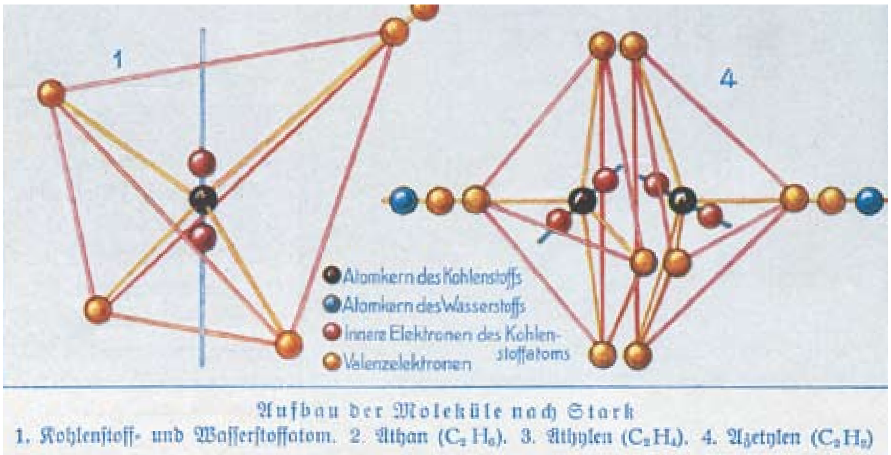
Since the inception of the project, a reading group has been meeting biweekly, joining physicists and historians from various local institutions in the study and discussion of important historical documents. To maintain contact with the project partners and to facilitate discussions, a mailing list has been established. To create an international network of researchers working in the history of quantum physics, a series of conferences has been established. The first such meeting took place at the Institute in July 2007. The talks and discussions were recorded and are available on the project's website <http://quantum-history.mpiwg-berlin.mpg.de>. A preprint volume of the proceedings is in preparation. A two-day symposium was held jointly with the Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy in honor of Max Born's 125th birthday in December 2007.

Left: Jürgen Renn and Christoph Lehner studying the Schrödinger material owned by his daughter Ruth Braunizer

Right: Poster of the first conference (HQ1) on the History of Quantum Physics

The Emergence of Modern Physics in the Public Sphere

The collective character of the formulation of quantum physics also met a great variety of discussions, interpretations and reactions from other scientists, amateurs and more or less educated audiences of the press. For this reason two research endeavors are investigating the controversial public reaction to quantum theory and modern physics in general. As part of a wider research project based at the Deutsches Museum on science communication and the changing relation between science and public in the 20th century, the first project focuses on the role of the public in shaping the concepts, notions and models in quantum physics. Two particular examples were the establishing of drawings and models of the Bohr atom, the reluctance of the physicists towards them, the negotiation process in popular science journals and the problem to adjust this model after quantum mechanics gave rise to major revisions (Arne Schirrmacher). Particularly influential for the reception of modern physics in the Weimar period were people from the border region of science, i. e. academic scientists outside the mainstream and non-academic, self-proclaimed researchers who publicly opposed the theory of relativity as well as the new quantum physics. The second endeavor, a recently accomplished dissertation, focused on this opposition phenomenon particularly in the 1920s. On the basis of a broad range of source material a hitherto unknown international network of academic and non-academic opponents, in particular to the theory of relativity, was constructed and explained as a reaction to a marginalization process that accompanied the success of modern theoretical physics in science and the public sphere (Milena Wazeck).



"Aufbau der Moleküle nach Stark" from a plate in the popular science journal *Kosmos*, vol. 26, 1929

The Role of the Deutsche Physikalische Gesellschaft in the Third Reich

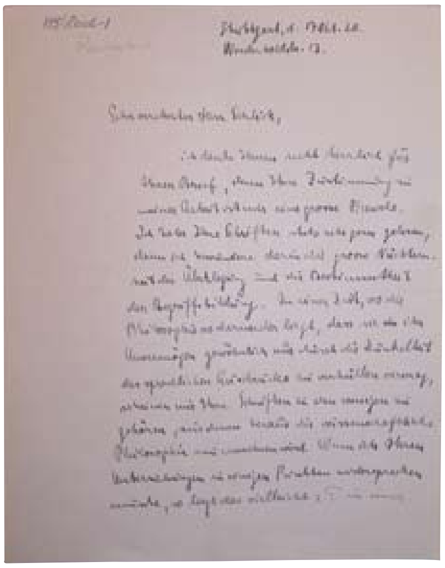
Following up on earlier research in the Department on the role of physics and its representatives in the Third Reich and the German Democratic Republic, an investigation into the conduct of physicists, the scientific institutions, and science policy during these two German dictatorships was carried out. While these studies are not central to the quantum project, they are particularly relevant as some of physicists studied—Peter Debye, Pascual Jordan, Carl Ramsauer—were among the pioneers of modern quantum theory. The role played by the Deutsche Physikalische Gesellschaft in the Third Reich was at the focus of a five-year project which has culminated in the publication of a comprehensive volume (Dieter Hoffmann, Mark Walker): An English translation is planned. Among the biographical studies carried out, that on Peter Debye merits special attention as it became part of an international discussion, which has been carried out in particular at Debye's work places (Utrecht, Maastricht, Aachen, and Cornell) and has played a key role in the initiation of a new research project at the Netherlands Institute for War Documentation to investigate Debye's role in Nazi Germany.

Peter Debye (1884–1966), Berlin 1939

Cooperative Venture

Modern Physics and Scientific Philosophy

The Department has established a close cooperation with the Moritz Schlick Research Institute at the University of Rostock, jointly forming a Centre for Logic, History and Philosophy of Science. Ongoing activities include the publication of selected parts of the literary estate of Moritz Schlick through the ECHO platform, and research on the relations between modern physics and scientific philosophy in the early 20th century, focusing on two central figures of scientific philosophy: Moritz Schlick and Hans Reichenbach. As their published papers, manuscripts and extensive correspondence indicate, both of them were very much involved in the philosophical debate about the scientific revolutions in modern physics. Reichenbach and Schlick not only gave an account of the changes of the fundamental concepts of space, time, causality and probability from a philosophical point of view, as early as the 1910s/1920s, and thereby anticipated some of the philosophical consequences of the development of quantum mechanics. Their discussion also led to an epoch-making change in scientific philosophy itself which was echoed by many physicists and scientific philosophers at the turn from the 1920s to the 1930s.



Left: First page of a letter from Reichenbach to Schlick (source information: Hans Reichenbach to Moritz Schlick, October 17, 1920; Literary Estate of Moritz Schlick, Haarlem, 115/Reich-1/2/3).

Right: Moritz Schlick at the University of Rostock in spring, 1914 (copyright: George Moritz H. Van de Velde-Schlick, Vienna Circle Foundation, Amsterdam)

Project 3

Epistemic History of Architecture: The Long-term History of the Knowledge That Has Made the Great Architectural Achievements of Mankind Possible

General Goals

The project *Epistemic History of Architecture* is a joint research endeavor with the Bibliotheca Hertziana in Rome (Max Planck Institute for the History of Art) and funded with a special grant from the Max Planck Society <http://www.biblhertz.it/deutsch/forschung/wissensgeschichte.htm>. The project is dedicated to establishing an epistemic history of architecture, a new approach which focuses on knowledge as a crucial factor for the development of architecture, in addition to the material, financial and personal resources investigated by the traditional academic disciplines. It thus comprises all dimensions of knowledge underlying the building trade, including knowledge of materials and construction techniques as well as logistics, organization and administration. The goal is to outline a long-term history of this epistemic basis, its structure, key innovations, its spreading and its interchange with other shared knowledge.

To achieve this goal, a wide range of periods and geographical regions have been selected: the very beginnings of permanent constructions in the Neolithic era, the Mediterranean high cultures (Mesopotamia, Egypt), classical antiquity (Greece and Rome), medieval cathedral buildings in northern Europe and the Italian Renaissance architecture. Since in all these periods construction is dominantly pre-scientific, i. e. it comprises only practitioners' knowledge, the project has had to extract the knowledge from a large set of sources which were not intended for communicating this knowledge. These include tools, drawings and administrative documents as well as the constructions themselves which are seen as representing knowledge 'in action.' The analysis of this intrinsic knowledge also provides insights into more general aspects of the development of practitioners' knowledge as compared to scientific, i. e. textual-based knowledge.

Oral transmission of practitioners' knowledge: construction, without centering, of a Nubian barrel vault using sun-dried bricks, Elephantine, Egypt, 2001 (photo by D. Kurapkat)

Developments

The project is now in its final stage, and a major publication of its results is in preparation. The publication will follow the revised and enlarged design of the project: The originally planned case studies will be embedded in a concept that is based on extensive review articles for each of the periods mentioned above (the so-called *basics*), flanked by in-depth investigations of relevant issues within these periods (the so-called *specials*). This two-fold concept has turned out to be necessary in order to cope with the vast amount of information that needs to be processed to produce a basis for the intended outline of the overall development of building knowledge, which will be presented in the last part of the publication.

A volume dedicated to early modern Italian architecture has already been published (Hermann Schlimme, ed.).

The enlarging of the concept required major changes, also in the personnel of the team. A range of external members had to be co-opted, because for each period covered an experienced specialist was needed. The team now consists of researchers in architecture, art history, history of science, Egyptology, Assyriology and classical archaeology from universities in Heidelberg, Cologne, Vienna, Zurich, Rome and Berlin as well as members of the German Archaeological Institute (DAI).

Besides a series of internal workshops and lectures held at the MPIWG, the project also supported the development of a digital archive for sources related to the erection of the Cupola for the Duomo in Florence at the Opera di Santa Maria del Fiore in Florence <http://www.duomo.mpiwg-berlin.mpg.de/home/_eng.html> (Margaret Haines).

The project has presented its new approach to the community of related academic disciplines at various scientific conferences and panel discussions. Three of the team members have been elected to the committee of the III. International Congress on Construction History 2009 in Cottbus (Antonio Becchi, Hermann Schlimme, Wihelm Osthues).

In the following, a preliminary synthesis of the results of the project is outlined with regard to the role of planning knowledge, the transmission of knowledge, and the relation between architectural and scientific knowledge.

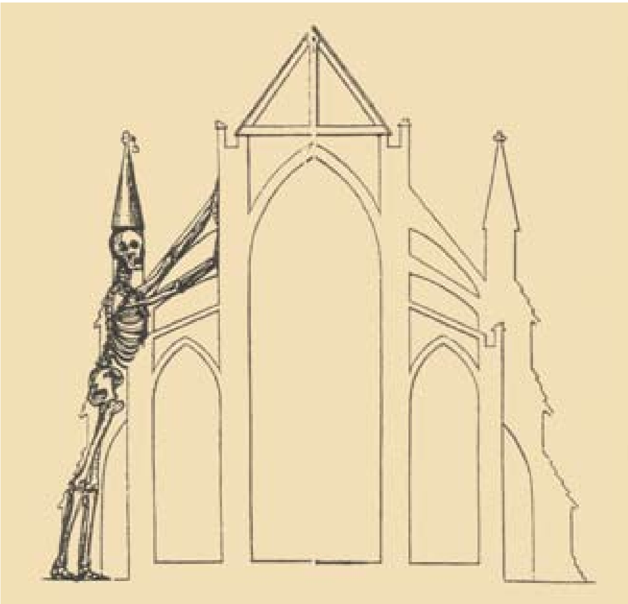
Planning Knowledge

Since the early modern times planning in architecture has been conceived as sketching and designing; the need for architects to visualize their ideas and to present these to the contractor. This is a very old concept: From the times of Vitruvius, the architect was required to present a ground plan, as well as elevation and perspective drawings. But seen from a broader perspective, the status of design in architecture should be assessed quite differently. Although plans and elevations were known already in the second millennium B.C., the specifications of larger projects were mostly given by texts and not drawings. The basic reason for this is that visualization in many cultures did not present a problem since the vast majority of projects adhered to given building types, which could easily be imagined by contractors and builders alike. If pre-

Groundplan of a house depicted on a clay tablet found in Djokha (Umma), from the Neo-Sumerian period (ca. 2100–2000 BC)

liminary planning was required, it had to clarify the amounts of materials and labor needed. For the documentation of these data, texts were quite adequate. The domain in which architectural drawings (and models) were essential is found elsewhere, in the planning of structural and ornamental details. Although the forms of such details were also often highly standardized, the architect could hardly have communicated interpretations of these types to craftsmen by any other means than drawings and models.

Imitatio naturae between mechanics and architecture.
Left: John Shute, *The First and Chief Grounds of Architecture*, Marshe, London 1563.
Right: Alfred Bartholomew, *Specifications for Practical Architecture,* Weale, London 1841



Transmission of Knowledge

Whereas the transmission of scientific knowledge is strongly based on written texts, the transmission of the practical knowledge involved in the building trade was based on a variety of media. Some of them were clearly not intended for the communication of knowledge, but nonetheless used effectively for this purpose. The most prominent examples are the buildings themselves.
This variety of media has helped considerably to preserve architectural knowledge, especially where a vivid transmission—via a continuing practical tradition—was not possible or desired. Relying solely on Vitruvius' text, Renaissance architecture would have been inconceivable. This holds not only for this most prominent case, to a lesser degree it was already the case in antiquity. In Egypt, for instance, funeral buildings were 'studied' to understand the mechanisms of closure. Certain forms of ceramic roof tiles seem to have survived the so-called dark ages between late Minoan and archaic Greece by the conservation of specimen. Similarly, the reuse from the mid-13th century onwards of the Roman crane driven by a treadmill has probably been inspired by relief carvings.
On the other hand, forms of intentional knowledge transfer apart from the participation in work practice were developed at a very early stage, but not firmly established until relatively late: Institutional training in building knowledge was already included in the curriculum of the 'scribes' of Pharaonic Egypt, but nowhere else before the founding of the Renaissance academies. Writings on technical and formal aspects of construction were published by Greek architects already in the late 6th century B.C. (now lost, but mentioned in Vitruvius), the oldest of which range among the earliest non-literary texts of European history, whereas the masters of the famous early Medieval period were typically illiterate.

Architectural and Scientific Knowledge

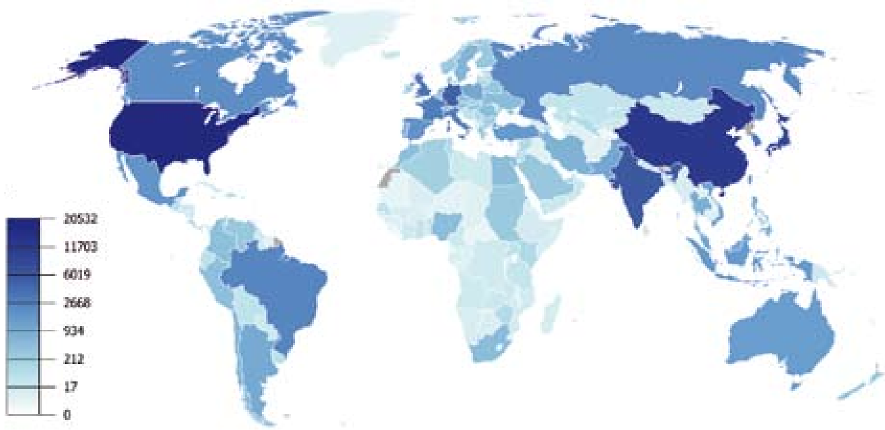
In the course of history, mathematics and especially geometry have had a varying relation to architecture. Elementary geometrical skills such as those needed for land surveying, have belonged to architects' competencies since antiquity. But the fundamental progress of geometry between the 4th and 2nd centuries B.C.. has left virtually no trace in architecture. Architecture hardly ever figures as an application—unlike surveying and astronomy—in the ancient or medieval manuals of geometry. Apart from the handling of fractions, even the architects of ambitious projects have apparently made no use of advanced mathematics. This loose relation between architectural and scientific knowledge only begins to change in the early modern period. The introduction of scientific results into architecture has been a goal for ambitious architects already in Hellenistic times, a tendency strongly promoted by Vitruvius. Its practical value has, however, remained rather limited. Instead the building trade provided, vice versa, early scientists with a significant experiential basis for their theoretical endeavors, in particular in the field of mechanics.

Project 4

The Globalization of Knowledge and its Consequences: The Transfer and Transformation Processes of Knowledge Across Different Cultures

General Goals

The aim of this newly launched project is to focus on a hitherto neglected dimension of globalization processes, the globalization of knowledge. The globalization of knowledge is being analyzed by integrating diverse studies of the conditions, pathways, and consequences of historical processes of the production, the transmission and the transformation of knowledge, relating them to present processes of globalization. The project aims at developing a new framework: comparative history of knowledge on a large scale, in which present processes, in particular processes of globalization, are conceived as the outcome of historical developments and their interactions. Science in the 21st century represents, in fact, globalized knowledge and benefits not only from the creation and exploitation of new social and technological structures that allow for the free flow of knowledge and expertise globally, but also from a historical awareness of the ways in which techniques and technology have in the past spread throughout the world. The present lack of this awareness hinges on a structural deficit of research in this field due to disciplinary boundaries. The project aims to overcome these boundaries not only by establishing an innovative research program but also by innovative forms of cooperation bridging cultural and social history and theoretically guided comparative approaches.



Internet users by country, in tens of thousands, as of 2006. Although more than one billion people worldwide can share knowledge through the Internet, there remains a huge "digital divide" between countries such as China and Somalia. Source: Wikimedia Commons

The project is pursued by the cooperation of a core research group of approximately 35 scholars covering a wide array of disciplinary fields, countries, and scientific institutions. The group will integrate results of currently 43 independently organized and funded individual research endeavors, hosted at research institutions, universities, museums, archives, and libraries.

The interest of these research endeavors in participating in the collaboration is rooted in questions that have emerged from their own research but can hardly be addressed within the scope of their current activities nor within the available conceptual frameworks. Their collaboration in the project is thus intrinsically motivated by the need of contextualizing—in terms of knowledge integration and differentiation processes—some of their most significant findings concerning the origin of knowledge, its transmission, and its transformation in cultural exchange processes. It is the primary aim of the project to develop an empirically validated conceptual framework for integrating specific findings concerning the origin, transmission, and transformation of knowledge.

The social processes constituting globalization in modern times are such processes of intercultural transmission that involve the spread or exchange of material goods, of social, political, and cultural institutions, as well as of belief systems, and result in the strengthening of worldwide interdependence. While some of these processes of intercultural transmission are as old as human history, their systemic interaction has yielded a number of outstanding historical phases that may be considered as antecedents of modern globalization and led up to their ever growing interdependence in modern times.

The project will address and historically validate some basic claims about the relation between the set of social processes constituting globalization, on the one hand, and knowledge development and diffusion, on the other hand. In terms of a short characterization, these basic claims are:

- The globalization of knowledge does not merely represent one more social process underlying globalization as precondition or consequence but rather constitutes a relatively autonomous developmental process that mediates between all the other processes involved, shaping their collective outcome.
- The globalization of knowledge is based on two complementary processes, the transformations of extrinsic contexts into conditions for the intrinsic developent of knowledge systems and the transformation of the intrinsic evolution of knowledge systems into extrinsic factors of knowledge globalization.
- The crucial role of knowledge in globalization processes is closely related to its function as a self-referential medium involving an interaction between internal cognitive and external material representations of knowledge.

Methodology

The foci of the project are chosen such that these claims can be validated with reference to outstanding historical phases in which knowledge production, transmission and transformation was critical for advancing processes of intercultural transmission:

- The spread of culture in the Mediterranean and neighboring regions will be investigated as the paradigm of a self-referential process of the globalization of knowledge constituted by the conversion of the knowledge outcome into a knowledge precondition of the stability of the levels of development attained.
- The outcomes of cultural exchange processes within Eurasia will be studied as a paradigmatic case for knowledge being a critical element in the adoption of transmitted technologies in spite of borders set by language barriers and incompatible belief systems.
- The place of local knowledge in the global community will be examined as a paradigm of obstacles and opportunities resulting from clashes between context-dependent local knowledge and the impact of the early modern and modern international science network.
- Different models of the diffusion of knowledge will be revisited in order to determine their ranges of applicability, their capability to conceptualize the interaction of the diffusion of knowledge with other diffusion processes, and the consequences of the change of media for knowledge representation, including the introduction of modern information technologies which potentially provide universal access to information as well as to the primary sources from which this information was originally derived.

The concentration on modern globalization of knowledge as well as on such historical settings in which knowledge production, transmission and transformation was critical for advancing processes of intercultural transmission has led to the choice of research foci corresponding to these four paradigmatic cases and the cooperation with a number of specific research groups. Intercultural transmission processes of this kind can only be addressed in a non-speculative way if the empirical results of historical and other research are interpreted and integrated within an adequate common theoretical framework.

The participation of the research groups representing various disciplinary approaches to historical processes of knowledge production, transmission and transformation is crucial for the initiative in order to avoid the pitfalls of speculative theory construction. The collaboration of the various participating projects towards the common overarching aim shall be realized employing an innovative knowledge platform to be implemented on the Internet, as well as by the regular exchange of scholars realized in the context of working sessions of the core project group and in the context of workshops together with the participating projects. These workshops will be dedicated to topics connecting the detailed research of the individual projects with claims emerging from the overarching research initiative and, at the same time, serving as evidence for the validity of the proposed concepts.

Developments

A kick-off meeting of the project dealing with the globalization of knowledge was held in November 2007 in the form of a Dahlem Conference funded by the DFG and the Freie Universität Berlin. It has yielded a first survey of the field, integrated research questions of collaborating projects, and delineated possible outcomes of the overall project. A preparatory workshop for this conference was also funded by the Freie Universität Berlin, following a positive decision of the Advisory Board of the Dahlem Conferences to accept the research initiative within its framework. This Board further declared willingness to consider organizing also the concluding conference after the end of the project. The results of this first meeting are being prepared for publication.

History of Science in Action: Alternative Forms of Dissemination

General Goals

Based on the insights that scientific knowledge evolves as part of a comprehensive system of knowledge and that external and cognitive representations of knowledge are closely intertwined in this evolution, the Department explores alternative forms of dissemination in order to probe the potential of research-driven technology development for opening up new horizons for the humanities and their place in society, and in order to investigate the potential of the history of science as a mediator between science and society.

Recent developments in electronic data processing have fundamentally changed the potential of research in the history of science as well as in other disciplines. The electronic storage of historical sources improves their accessibility and makes new and powerful methods of retrieving information possible. Scanning and optical character recognition techniques are being used to build electronic archives of historical sources, and databases and software tools are being developed to assist research and editorial activities. These activities aim at the creation of working environments that allow the integration of historical details into coherent models of historical developments. They are based on both the availability of a wide range of sources accessible to the scientific community as a whole, within the framework of open digital research libraries, and on scholarly cooperations extending well beyond a single institution. These cooperations, characterized by a novel unity of research and dissemination, are by their very nature international and interdisciplinary. They draw on the potential of the World Wide Web to cut across the traditional distinctions of research institutions, universities, and libraries, and also to open up scientific knowledge to the public at large.

An emerging trend is "cyberscholarship"—qualitatively different ways of working with digital data and sources, which, in their increasing proliferation, allow for the application of novel technologies and tools. Younger scholars, in particular, are accustomed to new models of content dissemination on the Web, which are characterized by rapid and easy access, sharing, and "swarming" around content. Just as computational tools have revolutionized many branches of the natural sciences, it can be expected that they will transform humanistic research and its relation to society at large.

New approaches to a public dialogue about science and its historical roots have been developed which are distinguished by:

- the representation of diverse worlds of knowledge that are subject to historical changes, along with the corresponding intellectual horizons of science and society as they evolve with these changes;
- the representation of the multitude of premises for experiencing knowledge and science, taking into account the most diverse perspectives;
- the representation of the diversity of the civilisatory and cultural spaces in which knowledge has developed historically, has been created or appropriated, and the communication between these spaces.

By introducing a historically informed perspective into the public discussion, the activities of the Institute have contributed to an awareness of the openness and plasticity of science, thus helping to overcome a polarized discussion shifting between the extremes of blind belief in progress and irrational hostility to science. Both positions are evidently based on the erroneous assumption that scientific progress is an automatism and not a historical process that can be shaped by mankind. If, however, science is connected by its very roots and not only post factum to other domains of society, unravelling these roots opens up opportunities for a new public understanding of science, relating it back to the sphere of human interventions. On this background, a new culture of science may emerge in which a public reflection on science can have repercussions on its cognitive and institutional structures.

The Cuneiform Digital Library Initiative

The Cuneiform Digital Library Initiative, CDLI, (Jacob Dahl, Peter Damerow, Robert Englund) represents the ongoing efforts of an international group of Assyriologists, museum curators and historians of science to make openly available through the Internet images and content of cuneiform tablets dating from the beginning of writing, ca. 3350 B.C., until the end of the pre-Christian era. The number of these documents currently kept in public and private collections is estimated to exceed 500,000. In the period of this report, 45,000 tablets were catalogued in electronic form by the CDLI, bringing the total to over 220,000.

In its early phases of research, the project concentrated on the digital documentation of the least understood archives of ancient cuneiform, those of the final third of the 4th-, and of the entire 3rd millennium B.C. which contained texts in Sumerian, in early Akkadian and possibly in other, still unidentified languages. Despite the 150 years since the decipherment of cuneiform, and the 100 years since Sumerian documents of the 3rd millennium B.C. from southern Babylonia were first published, basic research tools such as a reliable paleography charting the graphic development of archaic cuneiform, and a lexical and grammatical glossary of the approximately 120,000 excavated texts from this period of early state formation, remain a desideratum for specialists, not to mention scholars from other disciplines for whom these earliest sources on social development represent an extraordinary hidden treasure.

The CDLI data set consists of text and image, combining document transliterations, text glossaries and digitized originals and photo archives of early cuneiform. At present, the online catalog of the CDLI contains more than 220,000 catalog entries with information about tablets of the third millennium B.C., more than 22,000 digital images of these tablets, more than 51,000 hand copies, and more than 72,000 transliterations, all of which are openly accessible through the CDLI web site. This electronic documentation is of particular interest to scholars distant from collections, and to museum personnel intent on archiving and preserving fragile and often decaying cuneiform collections.

The partners of the project continued in 2006 and 2007 to capture the form and content of ancient Mesopotamian documents. Particular attention was paid to the following three collections: the cuneiform collection of the New York Public Library, of the Ashmolean Museum in Oxford, and in particular the traditionally inaccessible collection of the Aleppo Museum in Syria. In 2007 an agreement was reached with the French Institute for the Near East (IFPO), and the Syrian Ministry of Culture to create a Syrian digital library of cuneiform documents.

Concerning the infrastructure of the initiative, 2006 and 2007 are characterized by a substantial and enduring change and a reorganization of the data processing and the cooperation between the CDLI research groups in Los Angeles and Berlin (Robert Casties, Jacob Dahl, Peter Damerow, Malcolm Hyman, Dirk Wintergrün) and the electronic Sumerian Dictionary Project (ePSD) in Philadelphia (Steve Tinney).

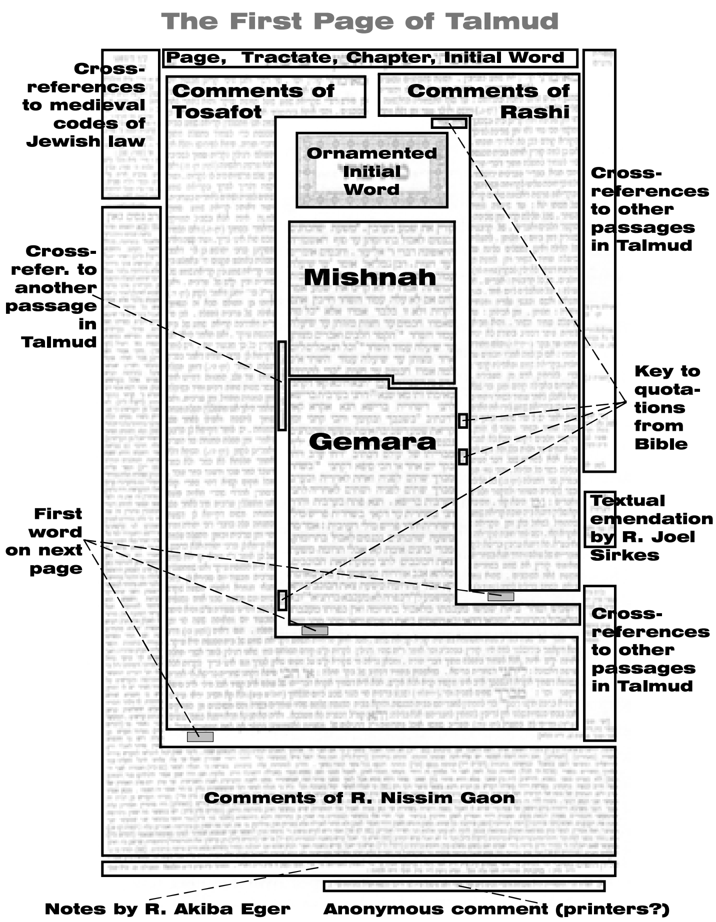
Until recently, the data were edited independently of the web presentation of the results. Data editing was done on local computers by the members of the project team. The final results were stored in databases with a front end for the web display. With the growing amount of data and participating scholars this system is increasingly confronted with technical difficulties. At a technical meeting of the Initiative in October 2005 it was therefore decided to fundamentally reorganize the data processing and distribution of the CDLI. A centralized storage system—hosted in Berlin and mirrored in Los Angeles—for versioned transliteration files has been designed and is now implemented. This can be accessed by all partners through a web front end and which at the same time forms the basis for the web display of the final transliterations. Also the catalogue data of the tablets are kept on a central server—hosted in Los Angeles—which automatically produces XML data used by the participating institutions of the initiative. The search facilities were completely reprogrammed and implemented in order to improve the response times. This new search engine is freely accessible since December 2007.

The centralized data repositories are also used for linking the entries of the electronic Sumerian Dictionary to the sources provided by the CDLI. Ongoing work is now focused on applying language technology developed by the ePSD to the translitera-tions of cuneiform tablets provided by the CDLI and to back linking these data to the Sumerian Dictionary.

Due to the close interaction between research needs and technical developments, CDLI has become prototypical for what we call content-driven technology develop-ment.

The Epistemic Web

Against the background of the development of innovative infrastructures for human-istic research in the Department, the idea of a "Web of Knowledge"—an Epistemic Web has emerged. With this model, the Web of today, which may be characterized (in a deflationary way) as a "dumping ground" for information, can evolve into a technology that facilitates the construction of new knowledge—knowledge that is needed to address the challenges of an increasingly global society. Such a Web will al-low for the creation of dynamic representations of knowledge, integrate research and dissemination, accommodate recursive processes in knowledge formation, integrate both conceptual models and data, and build "intelligence" into scholars' working en-vironments.

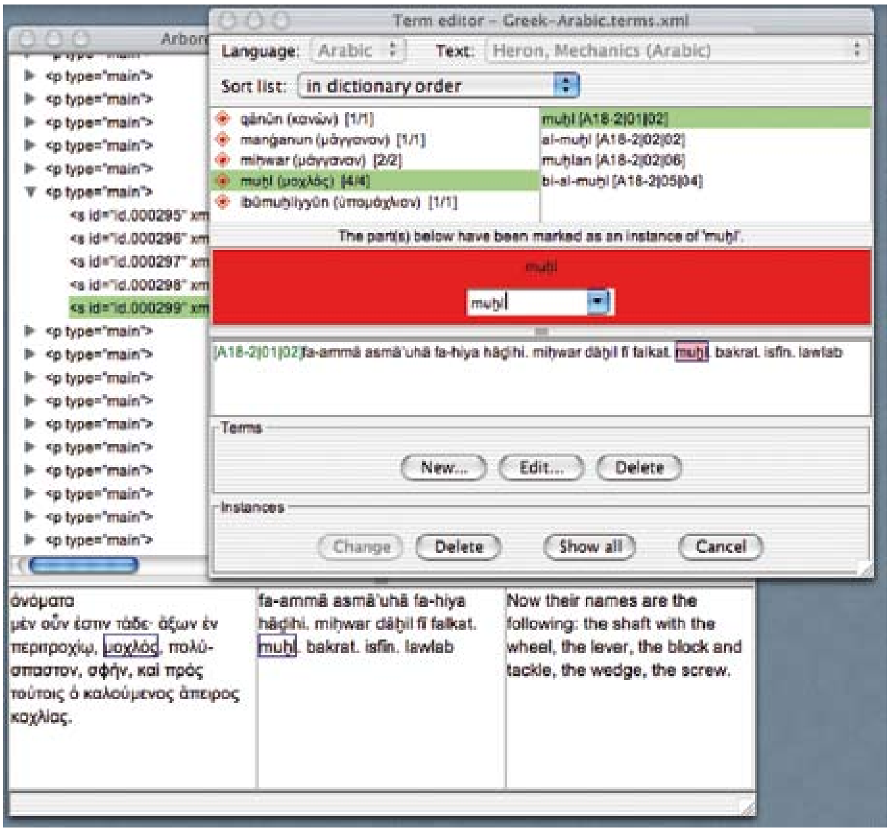


A page of the Talmud represents a complex epistemic model, incorporating commen-tary, super-commentary, annotation, and cross-reference that reflect fifteen centuries of scholarly dialogue

In the Epistemic Web, casual browsing will be replaced by the purposeful federation of documents. Users will (in accord with their interests and needs) choose which documents to view together; which documents they wish to select as entryways into the universe of knowledge; and which documents should serve as master documents, controlling the views of secondary documents. The views created by scholars can be easily shared and automatically published.

Work on realization of the key Epistemic Web concepts has recently begun, in the form of a two-year cooperative project with the MPDL, which has been established by the MPG to provide a unique structure to take up and further generalize tools and services that have been developed at individual Max Planck Institutes and to make them available for the benefit of the entire MPG. This relationship—research-driven development at the research front on the one hand and generalization by the expertise of a central body on the other—is a mechanism ensuring that the advanced services made available at the MPG have proven their specific relevance for research and can thus be expected to have an immediate impact on the work of the scholarly community. A project of the Department aimed at developing four complementary services within the MPDL framework has been approved. The services will constitute (1) a workflow for developing texts in an XML representation that represent historical (printed or manuscript) sources; (2) a content-based access mechanism for these texts to be built upon the MPDL infrastructure and to be publicly web-accessible; (3) software for Virtual Exhibitions; and (4) an Open GI (Geographic Information) network for the retrieval of scientifically relevant geo-information.

→ Knowledge Management, p. 204

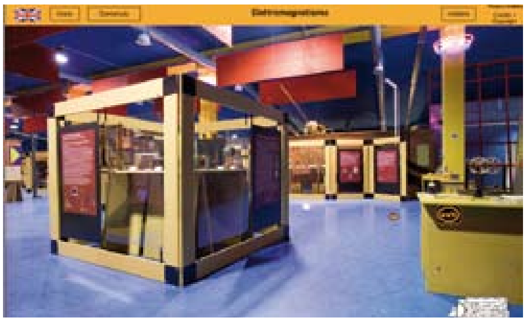


The Arboreal software, developed at the Institute since 2004, is used for the studying the development of scientific terminology in multiple languages

The Virtual Einstein Exhibition

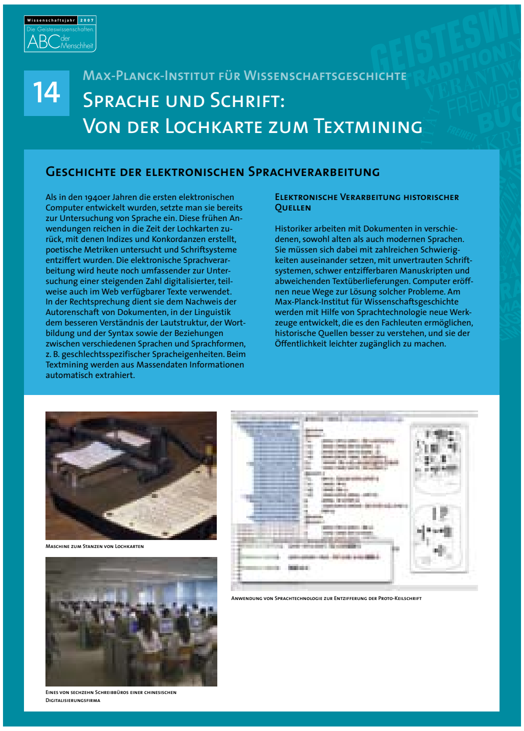
The virtual Albert Einstein exhibition continues to offer, with more than 1,000 pages which have been continuously extended and updated, a living panorama of the history of science that is useful as a learning and teaching tool but also as a resource for the history of science, and that guarantees the long-term availability of the contents assembled for the exhibition <http://www.einsteinausstellung.de>. The structure of the virtual exhibition has been further developed to include a new search function which enables a systematic search of all the texts contained within the site (Julia Damerow).

A page from the virtual Einstein Exhibition in Pavia



The 50 media stations employed within the exhibition — the precursors to the virtual exhibition — encouraged children in particular to consult additional information resources about the exhibits, or to participate in quiz games in order to learn about the exhibits in a more playful manner. An evaluation of the exhibition's children's program was undertaken in the framework of a dissertation project to evaluate science communication in out-of-school environments (Silke Vorst). Significant differences were apparent in the children's understanding of the nature of science before and after the workshop program.

The Summer of Science

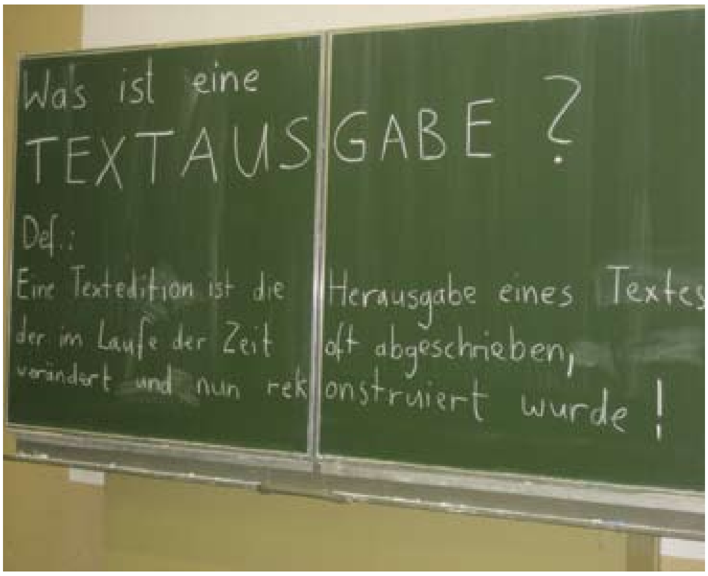


In 2007 the Institute was invited, together with other Max Planck Institutes, to represent the Max Planck Society at the "Summer of Science" in Essen. This annual event is staged by "Wissenschaft im Dialog", an initiative supported by the Federal Ministry for Education and Research and the Stifterverband to promote a broader public interest in the developments in science and technology. Department I contributed to this large event with three presentations of research results; an overview of the invention of writing and the decipherment of early Mesopotamian writing systems (Peter Damerow), new developments in the decipherment of proto-Elamite obtained within the frame of the CDLI project (Jacob Dahl), and new language technologies developed at the Institute (Malcolm Hyman). The events were documented and turned into a virtual exhibition using software developed at the MPIWG (Julia Damerow). The results can be seen at <http://wissenssommer07.mpiwg-berlin.mpg.de>.

Poster from the "Summer of Science" 2007

History of Science in Schools

In 2007, the Institute cooperated with a local secondary school, the Steglitzer Gymnasium, on the introduction of the history of science into school project work. The project days were concluded with a presentation night at the school where the results of the joint work were presented to parents, teachers, friends, and representatives of the MPIWG.



From a project to investigate the changes in text editions over historical periods.

Student taking part in an experiment to investigate Foucault's pendulum

Wunderforschung

The exhibition project *Wunderforschung* was initiated in 2007. Its main aim was to bring together the history of science, art and children's knowledge in an exhibition that is continuously changed by the interaction of the visitors. The exhibition resembles a historical curiosity cabinet displaying wonders of science and nature and is shown at Berlin's Natural History Museum <http://www.museum.hu-berlin.de/ausstellungen>. Its conception was based on research results of the Department e.g. on the intuitive knowledge of children (Katja Bödeker). The project was realized in cooperation with the Comenius Garten, the Museum für Naturkunde and the Monash University in Melbourne. Additional funding was provided by the Hauptstadt Kulturfond. Due to its success with the public, the exhibition was extended until 25 May 2008.

Children experimenting with light in a 'Wunderforschung Workshop'