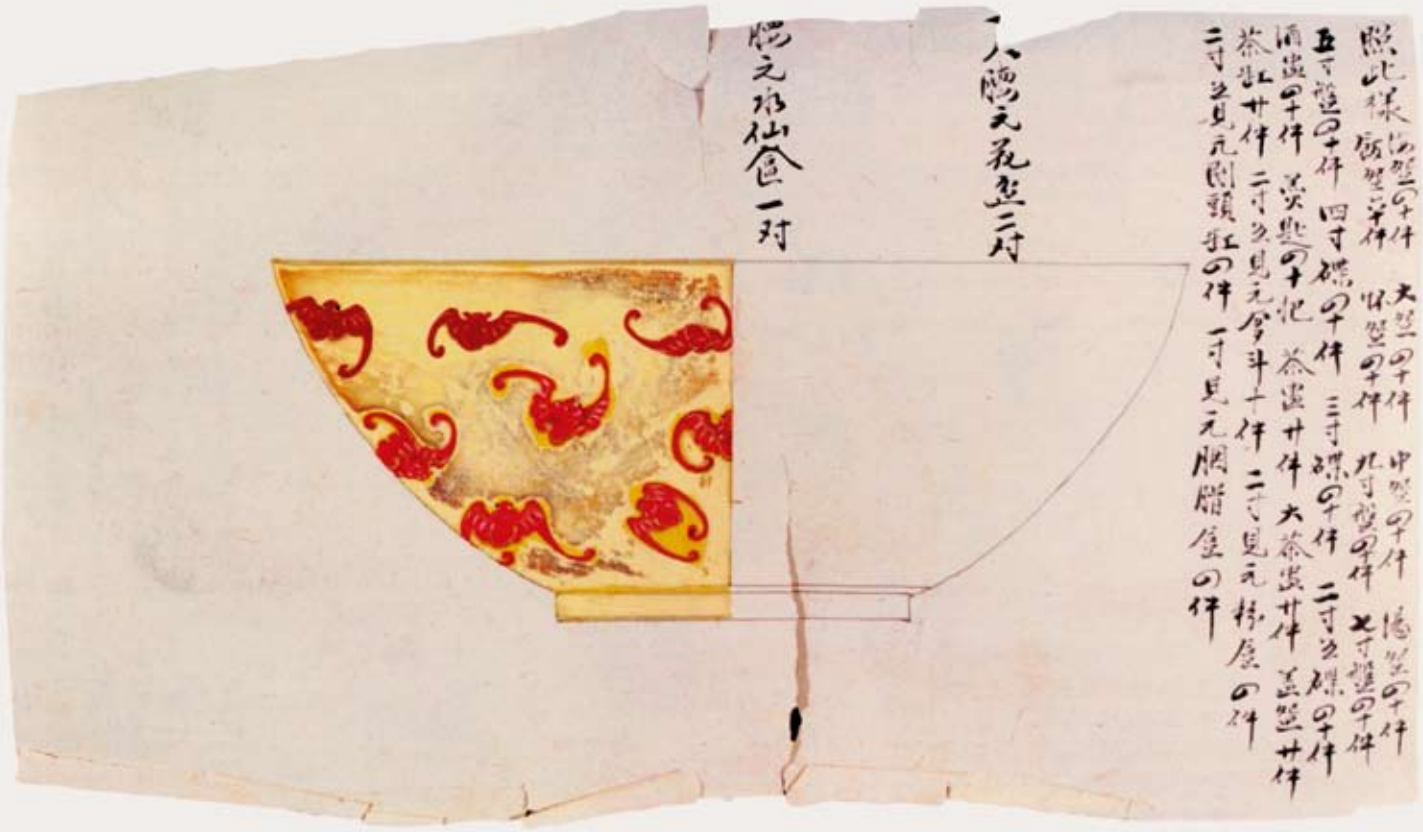
Independent Research Group I + II



"100 bats on yellow ground",
blueprint for a set of bowls of different size
(ink on paper, colored, 16.2 x 27.2 cm,
Palace Museum Beijing. Wang Guangyao:
Zhongguo gudai guanyao zhidu. Beijing
2004, p. 57)

Independent Research Group I

Concepts and Modalities:

Practical Knowledge Transmission

Director: *Dagmar Schäfer*

Historical research in recent decades has opened new ground concerning questions of discursive attitudes, economic growth and civic responsibility. The new focus on this period in Chinese history as one of commercialization and intellectual renewal raises questions about this period's technological development and in this regard its culture of innovation. The project offers an approach utilizing a variety of perspectives towards evaluating the impact a culture's tradition of knowledge transmission in the field of practical knowledge (technology) has on innovation capability. The issue of the relation between practical and theoretical knowledge was singled out, and will now be investigated by the newly established Partner Group at the Institute for the History of Natural Science, Chinese Academy of Science in Beijing, PR China. A cooperation with the Palace Museum has been initiated. It concentrates on the role of the court as a place for the appropriation of knowledge with a special focus on archival materials such as storage devices, sketches, tools, and models.

The Independent Research Group I at the MPIWG focuses on how technical knowledge was perceived, transmitted and evaluated to form a distinct, yet changing, "knowledge culture" and comprises research subjects in the period from the Song to the mid-Qing Dynasty (10th–18th Century). Promoting three fields of interest, written, material and social factors, the first phase concentrated on the role and context of technology in written culture.

Project

Written Traditions of Technical Knowledge

Written culture reflects the changing attitude towards technological knowledge from a historical perspective and influences its role in society and state. Moreover, transferring knowledge of a technical nature in text-form poses questions about transmissibility and purpose, about the given role of author as a surveyor of knowledge of a non-literary nature and about the general assessment of historical categories of knowledge such as "technical" and "technology".

Quite a variety of traditional Chinese genres of text provide descriptions and evaluations of technology. The project distinguishes between three forms: firstly, monographic writings which deal exclusively with practical matters; some of them embrace a comprehensive selection of technology, some are smaller elaborations on one technique. Secondly it singles out smaller text units that dealt with particular technologies (or the products derived from this technology) but were not independently transmitted. These kinds are collected in encyclopedic compilations or constitute part of miscellaneous private jottings (*biji* 筆記), where they are contextualized with other topics (sometimes from morals to ghost stories). Others are incorporated into more systematic collections like 'household books' etc. As a third group the project identifies local monographs and their chapters on 'local production (*tuchan* 土產)' respectively 'foods and commodities (*shihuo* 食貨)', in which local officials report on products as well as technologies, offering close insights into the role of technology in various localities and exemplifying the varied landscape of technological endeavor across time and space.

These different kinds of texts serve (in addition to administrative texts, archive materials and artifacts) as sources for the various parts of the project. They are moreover addressed as issues concerning the embedding of technological knowledge within traditional Chinese written culture. Scrutinizing place and position of technological information within a certain text—as well as the function and role of this information in context—has up to now never been properly addressed for China. Investigating the various forms and embeddings of written assessments of technology facilitates a better understanding of the cultural influences on technology, its dissemination and development. How were these texts evaluated by Chinese tradition? How did the author legitimize his text and in what tradition did he see his work? Where and how do technological descriptions placed within a work also deal with other matters? Furthermore the biography of the author, his expertise and his interest in this specific matter as well as his terminological or hermeneutical background are taken into account. What readership does the author anticipate and which impact does his documentation of technical details have? Is the reader intended to recover the knowledge from the text to perform or supervise the technology himself or does the information just satisfy intellectual curiosity?

One example of the implications of textual evidence is a text published in 1561 by Qi Jiguang 戚继光 (1528–1587). Qi was a successful general and high military official of the Ming Dynasty. Biographical sources characterize him as a practitioner, rather than an administrator. In 1561, at the climax of his career, he published a comprehensive treatise on military strategy that was distributed among his officers to train their soldiers in their campaign against the Japanese *wokou* 倭寇 pirates. Various editions and references verify that his work was widely distributed among professional soldiers and also handed around in literati circles. Qi Jiguang addressed the use of Western weapons side by side with traditional martial arts. He delineated in detail the construction of the harquebus (*niaochong* 鳥銃), offering detailed descriptions of the major technical details. He also precisely illustrated the fastening nut and bolt needed to lock the trigger mechanism. Nuts, or screws, and bolts were by that time already widely in use in China, and their earliest mention dates back to the year 1490. Yet, as we learn from Joseph Needham, they were exclusively used in Western-style weapons until the 18th century.

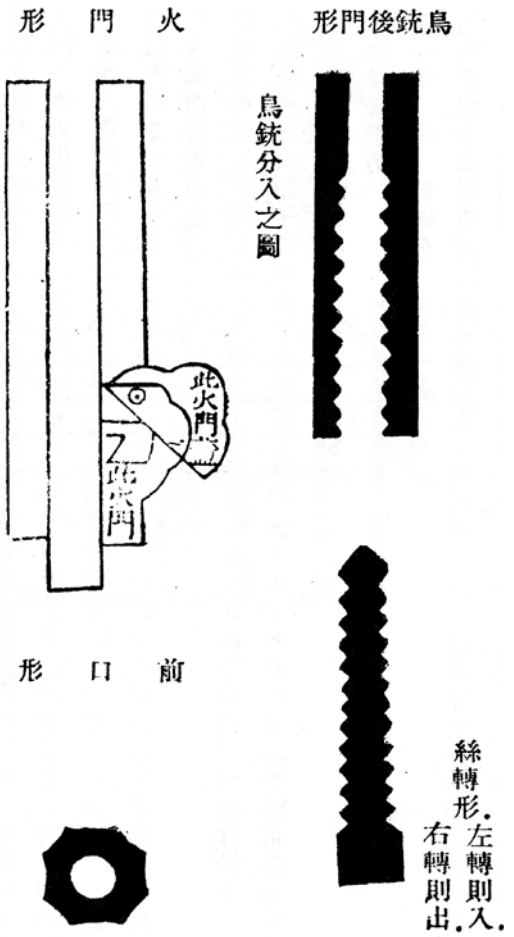
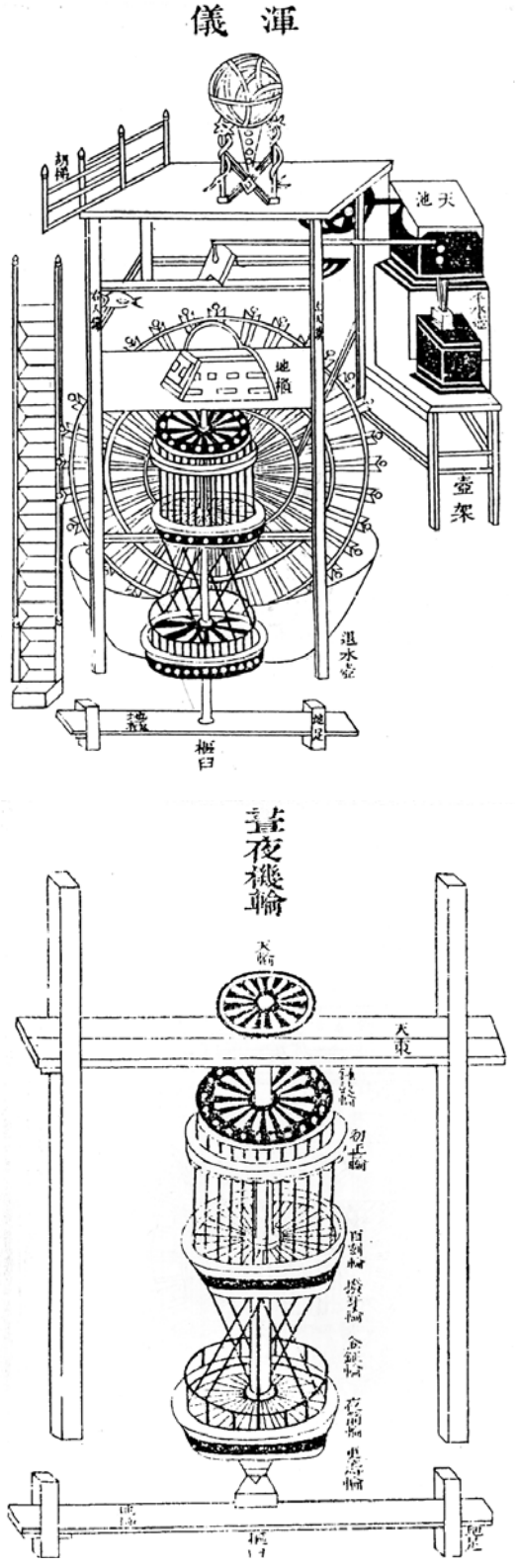


Diagram of a harquebus (niaochong) with fastening nut and bolt, Qi Jiguang, Jixiao xinshu, Hualian chubanshe, 1561, (Taibei: Taiwan Commercial Press, 1978). P. 208

Qi Jiguang's description, although emphasizing the usefulness, agility and easy handling of this construction, did not change this. His documentation made the technical information available and distributed it widely, yet the knowledge was not separated from its context. The fastening nut and bolt concept was neither described in other texts nor applied in other fields, such as architecture or machine building. The availability of this information in literati and expert military circles did hence not inspire further innovations.

Starting in 10th Century, literature with a technical content appeared on the expanding market for print-matter. They addressed a huge variety of topics, from highly specialized descriptions about the production of Chinese ink, sugar or cotton cloth, to treatises informing about basic agricultural techniques; from the latest achievements in astronomical instrument-making to standards in architecture. Su Songs 蘇頌 (960–1279) *Xin Yixiang fayao* 新儀像法要 *(Essential Methods of the new Astronomical Equipment)* from 1094, for example, describes explicitly in text and illustration the details of an astronomical clock he had devised.



Song's astronomical lock, Su Song, Xin yixiang fayao, from Ren Jiyu ed., Zhongguo kexue jishu dianji tonghui, jishu juan 1, Zhengzhou: He'nan jiaoyu chubanshe, 1994, S. 315

The *Lu Ban jing* 魯班經 (The Classic *Lu Ban*) from the 15th Century gives instructions for carpentry. Yet, both texts did not primarily serve to pass on technical details. Su Song aimed at imperial support, presenting his ideas and the results of a stately project under his supervision to the Emperor. His treatise constitutes a written counterpart to the monumental project itself, emphasizing the duty of the state to engage in such matters. His treatise was not intended to spread technical details nor was this achieved by his work.

In the case of the carpentry manual *Lu Ban jing*, the book seemed to have changed its purpose over time. Although offering comprehensive insights into house construction and carving techniques the ritual contents became more important. In the end the book itself acquired ritual status as it was handed down from one generation to the next. Ritual rulings and geomantic spiritualism then set the value of this book for carpenters, while they disregarded the technical details. From the 14th century on, the *Lu Ban jing* was in fact used by carpenters only as a quasi-religious icon of their craft.

The mentioned works assign technology a cultural and socio-political function that, although meant to enhance the value of technology, sews the seeds that put technology in the rear of epistemological inquiry. The practical usefulness of the contents was either not intended from the outset or it retreated in the course of time into the background, while the context gained meaning and significance. The example of Qi Jiguang illustrates how technical descriptions were made available in texts, and nevertheless ignored, thus indicating to the difficult role that written sources played in the transmission of practical knowledge. Scrutinizing the particular intentions that an author had for the compilation of his work and the impact of his documentation of technical content, opens a new view to the purpose and role of technological writings in Chinese culture. Pursuing a systematic approach, a relational database is conceived (see description below), subsuming a broad text basis for further inquiries into the diversity of the contents and functions of written documentation. It

is designed to allow direct access to the original texts in the future. Offering a front end in English, it furthermore opens these sources to a wider non-sinologist user-group in a searchable environment.

The individual projects, which started in October, 2006, concentrate on distinct modes of cultural and intellectual processing of technology in China. A project on the "Historization of Innovation" focuses on the changing perception of the material and technological basis and development of Chinese civilization, asking how innovation and change in this material base had been adjusted to culturally and intellectually. A second project, scrutinizing biographies of master craftsmen in Chinese historiography, reflects on the way in which historically acknowledged personalities engaged with technology, how they and their skills were valorized and which attitudes and role were assigned to this group in society. A third project focusing on architectural writings unravels the interaction of craftsmen and scholars in the knowledge sphere of architecture and the way in which such manuals affected the recognition of this discipline as a field of knowledge in later periods.

Stately concerns and fears constitute another important area of assessing, controlling and integrating practical knowledge in a society. Since the 14th century the Chinese state under the leadership of the Ming Dynasty engaged itself more and more in the production of goods such as textiles, porcelain, lacquer ware etc. The example of the state run silk manufactories during the Ming period shows that the officials gave great importance to the transmission of knowledge and the question of how to disseminate innovative techniques and products effectively. High-level ministers in the central government were responsible for such issues and had to guarantee the functionality and efficiency of the state enterprises. In sectors such as silk and porcelain production, the imperial household intervened directly. Within the political discourse the bureaucratic apparatus developed a variety of measures to ensure a continuous transfer of innovative techniques from the private to the public sector. Archival materials, memorials to the throne and local reports as well as the state manuals and collections on the economic history of that period allow us to chronologically retrace how the central government exerted control on knowledge flow, for example, by scheming the craftsman's mobility. They reveal that technology became a political issue. In these processes the public and private sectors were assigned new roles in knowledge transmission which in turn gave rise to political and philosophical discussions among concerned scholars on how to deal with craft knowledge.

An interesting example for this process is Qiu Jun 丘濬 (1421–1495) and his exemplifications on the "value of work (*gongyong* 工用)" presented in the *Daxue yanyi bu* 大學衍義補 *(Supplement to the Explanations of the great Knowledge,* 1506). In his political handbook addressed to upper level officials in the central and provincial government, Qiu Jun expounded the problem of the increasing level of skills that the craftsmen of his time pursued. He equated artfulness and subtlety in crafts with 'licentiousness (*zi* 恣)', conversely, he judged the growing discrimination of craft professions positively. The text lists for the recruitment of service levies verify that the working process during this period was subdivided into small units. The growing variety of professions was not based on a proliferation of techniques.

Incorporating craft manufacture systematically into the state enterprise, the first emperor of the Ming Zhu Yuanzhang 朱元璋 (1382–1398) challenged the officials' self image. He forced them to administer skills which they themselves did not master and which were below their social level. Qiu Jun met this challenge in a subtle intellectual way, one that allowed the official to reinforce his ability to preside over the central position within the state: they encouraged the modulisation of practical work and controlled the skill level of the specialists with ritual specifications. Through the modulisation, as described by Lothar Ledderose, the tasks of the individual were simplified. Workers, performing few recurring actions, could thus be easily trained and became interchangeable. The scholar official in turn was needed as an administrator, who possessed the overview and the ability to put the pieces in the mosaic together. Thus the officials gained control over the expertise of the craftsman. Art historian and Sinologist Martin Powers traces similar developments during the Han period (202–220 B.C.) on the basis of the decoration on ritual vessels. He interprets their changing complexity in design as a result of a new social order, in which the officials established their control over practical activities in the state. At first glance, the later decorations seem more complicated and proof of higher skill than the earlier versions. Closer inspection reveals a repetitive structure that has been performed according to standard specifications. Variety was performed only within the limits of standardization. In such a culture the expert is the administrative official. He knows the standards and how to execute the creative tasks within the given parameters. He seeks refuge in subtle alterations, not in revolutionary novelty. Through a few measures the officials could thus secure a controlling function over craft knowledge essentially affecting the conditions of innovative force. Discussions like that of Qiu Jun are one particular outcome of the subtle and many-layered processes incepted by the technological and economic development in Ming and Qing times whereby the man who works with his head positions himself in relation to the man who works with his hands.

Locating Technological Knowledge in Chinese Traditional Writing—A Database

Martina Siebert, Dagmar Schäfer, Cathleen Paethe

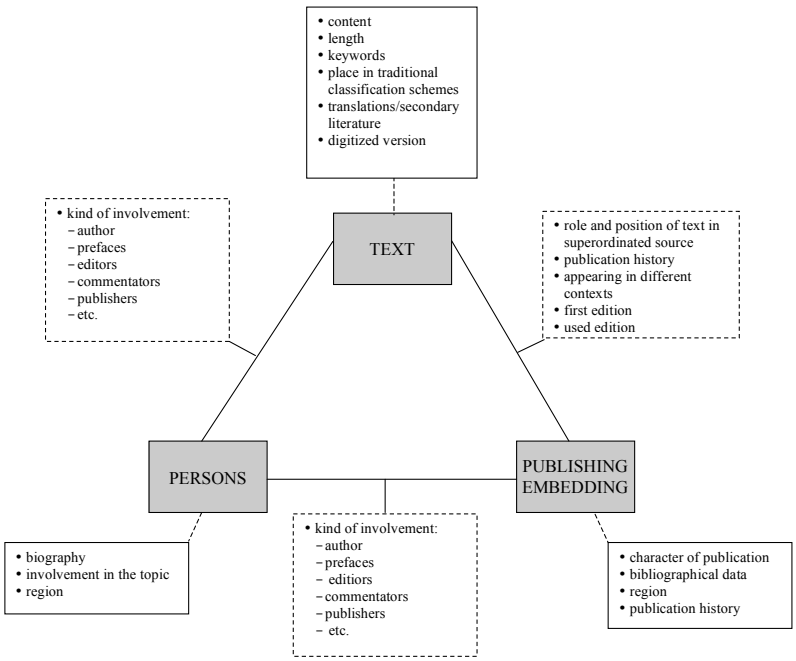
Technological issues and practical know-how are a recurring theme in the Pre-modern Chinese written tradition, addressed in various literary genres with varying purposes. Disclosing the contextual embedding of technological content, the database provides a means to develop a new trajectory of knowledge classification in Pre-Modern China, evaluating in which nexus practical issues were considered worth knowing and how this changed in the period from the 10th to 18th century.

Although monographs concentrating exclusively on technology are exceptional in Chinese history, numerous works contain scholarly elaborations relevant to technology. Dispersed among essayistic writings, poetry, entries in Chinese encyclopedic reference books *(leishu)* etc., there are signs that scholars demonstrated a keen interest in practical issues. Designed to outline the technological knowledge contained in all these different sources, the database locates technological knowledge within its writ-

ten and biographical framework. Following the idea of technology as an "object of knowledge", its classification within the framework of the book thus becomes the major focus of study, while the book in turn is positioned within the career and biography of the author and within its publication history.

Furthermore the database brings particular attention to genres less immediately identifiable as technical writing and to the mode in which authors dressed up technology in these texts. Scrutinizing the notion of stagnancy, the database illuminates the subtle changes performed when these texts were re-used in different publishing contexts. Thus the database also provides a guide through the monumental and the apparently marginal remnants of Chinese technological documentation, of benefit to interdisciplinary research. The attached diagram illustrates the information collected. There is information directly connected with the description and evaluation of the content of the source itself, information on the embedding that source is published in and on the biographical details of those involved—from authors to publishers. At the junctions of these sets of information the role and intention of the various involved actors and the position of the source within its different publishing context is elucidated.

A collection of Chinese historical texts on science and technology in the facsimile (*Zhongguo kexue jishu shi tonghui* 中國科學技術史通匯) and the source texts in focus of the research group members constitute the first fundament of data. Accessible online from the outset (planned July 2008), the project is designed to successively involve competent researchers from the fields of Chinese Studies and History of Technology to expand the entries with their annotations and add new ones. The database facilitates research in the field by providing a bibliographical and biographical reference tool to specialists and a broader audience in English and it seeks to establish a platform for the future exchange of expertise and analysis concerning writing on technology in Chinese history.



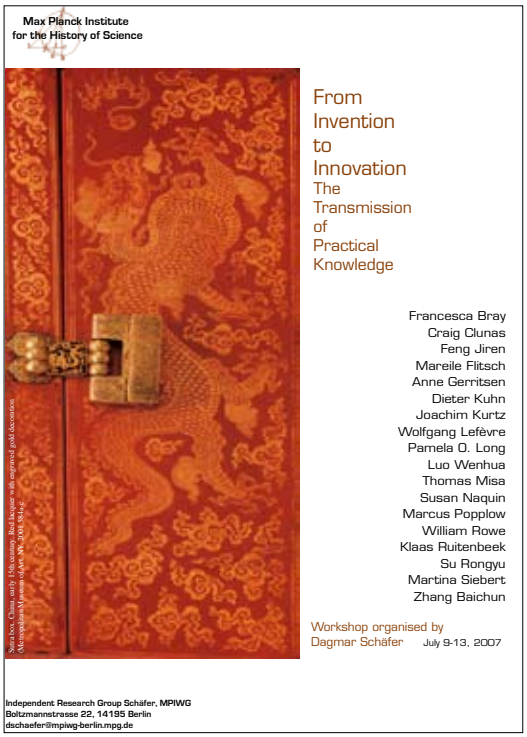
Workshop and Book Project: From Invention to Innovation

The workshop in July 2007 examined concepts and modalities that influenced practical knowledge and its transmission in pre-modern China. Identifying the factors involved in the development, transmission and perception of technology from an interdisciplinary perspective was the focus. On the basis of the workshop a volume is being collated and edited by Dagmar Schäfer provisionally titled *Towards a Cultural History of Technology in China.*

The history of technology in China presents a unique challenge for the traditional Western history of science which has not yet been adequately met: how was China so successful at inventing, establishing and maintaining technological markers of civilization such as papermaking and printing, the manufacture of compasses and of silk, for 2000 years. Many books list and expound the details of a specific technology; the nuts and bolts of paper-making or ceramics, for example, have been explained ad infinitum. This volume, however, focuses on the flux of stagnation and innovation that was the reality of Chinese civilization.

On a theoretical level the contributions examine and clarify the concepts and modalities that influence practical knowledge transmission. On the practical level technological development in China is scrutinized from the viewpoint of how technical knowledge was perceived, transmitted and evaluated to form a distinct, yet fluctuating "knowledge culture". This is a completely novel approach in Chinese studies.

Of interest to students and experts in the fields of East-Asian Studies, the History of Technology, and Knowledge Transmission the volume presents an interdisciplinary and cross-cultural perspective based on the work of renowned scholars. Experts give a comprehensive overview into a sphere of knowledge that characterizes Chinese culture: the Scholarly Arts, the sphere of documentation; the Agora, the sphere of aggregation; Imperial Technology, the sphere of appropriation and the Internode, the sphere of communication. Historians of Western Technology grasp this unprecedented opportunity to scrutinize each sphere and identify the points that reflect universal technological experience as opposed to culturally specific characteristics. The book will contribute methodologically to both the study of technology and knowledge transmission.



Individual Projects

Martina Siebert

Martina Siebert (Research Scholar)

Historicized Innovation: Knowledge Tradition and its Encounter with the New

Investigating which concepts of invention and innovation in technology were prevalent in traditional China and how they changed, this project embraces texts from the 10th to early 18th century. A sediment layer of Chinese approaches to invention and innovation is found in the encyclopedic assemblages of the 'Origin of Things' (*wuyuan* 物原). These 'things' encompass a comprehensive spectrum, among others natural and meteorological phenomena, such as heaven and hail, official agencies, cultural and material achievements, and species of flora and fauna. The 'origin' or 'beginning' of these various things differs accordingly. Technology, its artifice and artifacts, is spread through the various sections in these works. Investigating how this genre evolved, what intentions and interests the authors and compilers had, the project analyzes the reception of new things and the assessment of technological change by Chinese literati. Which things did they consider vital for Chinese civilization and civilizing processes? What role did they assign to technology and its development historically?

Assembling references from other written sources, *wuyuan* encyclopedias encompass creative acts performed by ancient saints, chance discoveries, interrelated sequential evolutions, changes in use broadening the usability of a technology, foreign imports that were incorporated into Chinese tradition etc. A systematic approach identifies types of invention and marks out stereotypes. Major results were presented on the first workshop of the research group in July 2007 and will be included into the forthcoming book project.

The extension and first publication of the *Shiwu jiyuan* 事物紀原 *(Notes on the Origin of Things and Affairs)* in the year 1472, conventionally ascribed to Gao Cheng and the 12th century, marks the beginning of the upsurge in *wuyuan* writing traditions. It ends with the publication of the *Gezhi jingyuan* 格致鏡原 *(Mirroring the Origin of Things to be Investigated for the Maximization of Knowledge)* compiled by Chen Yuanlong (1652–1736). Between these two points in time and in the course of the Song, Yuan, Ming and early Qing dynasties, intellectuals dedicated ten more compilations to 'origins', some of which were reprinted many times, keeping the genre alive over almost nine centuries. Relating to each other, the volumes progressively grew in content and size, and finally added up to 100 *juan* in Chen Yuanlong's compilation. The *wuyuan* topos evolved into a scholarly means used in the various forms of writing to establish historicity and to understand and interpret the development and pattern of the world. The increasing economic prosperity of Ming time, fostering the awareness of ever-new things, added to the popularity of the genre among scholars.

During the second phase, the project disentangles how the encyclopedically collected 'origins' were re-distributed among the learned elite and how these writings influenced their assessment of and approach to contemporary technological expertise and new artifacts.

Probing into the notion of China's orientation towards the past, the project employs the scholarly obsession with identifying 'origins' as a tool to disclose the modes by which Chinese culture appreciated new things and reflected on technological change and progress.


Martin Hofmann

Martin Hofmann (Postdoctoral Fellow)

A Philological Archaeology of Master Craftsmen

In the classical woodcut schemes of Confucian ideology, the craftsman together with the merchant is situated at the lowest tier of society, outranked by both the scholar and the farmer. Ruled by a class that based its self-recognition on scholarly learning, it is generally believed that this view prevailed in Chinese society from the 10th century until the Republican era. Yet, the scholarly interests of Song dynastic intellectuals also included to a great extent technological and practical issues. The Mongol rulers of the Yuan-period imposed their social system on the Chinese state, elevating the craftsman and practitioner. The Ming dynasty, although emulating the seemingly scholarly ideal of their chosen predecessors the Song, incorporated craft production into crucial sectors of the state system. The Qing dynastic Manchu rulers reconstituted the Ming emphasis on state manufacture and expanded the export of silk and porcelain goods. Concentrating on biographical writings, the project investigates the tension between the prevalent ideological scheme and the changing historical reality of master craftsmen. The reception of the craftsman in historical writing and the construction of identities in biographies and eulogies reflect these changes in societal placement.

The project starts its investigation with a compilation prepared during the early 20th century, the *Zhe jiang lu* 哲匠錄 *(Collected Biographies of Master Craftsmen)*. This collection of Chinese historical documentations of craftsmen from the early period until the Republican era was compiled by Zhu Qiqian 朱啓鈐 (1872–1964), an eminent Chinese scholar and politician facing the dominance of Western technology and science. Pooling materials from manifold literary sources, this compilation provides a comprehensive fundus of biographical material.

Zhu Qiqian pursued his project patterned after the style of western systematic and scientific approaches. He aimed at establishing a large-scale research project reappraising Chinese material culture as a whole by preserving, systematizing and analyzing textual sources as well as cultural relics. For this purpose Zhu assembled Chinese scholars trained in Western architecture together with master craftsmen of the imperial workshops and invited Westerner scholars researching Chinese material culture to participate in the project. The *Zhe jiang lu* is a fragment, an unfinished endeavor, only complete in three of the planned fourteen craft disciplines. As its stands it allows us to scrutinize how the traditionally educated Chinese elite, such as Zhu Qiqian, appraised and re-invented their own cultural heritage in the light of Western concepts of science and technology and under the pressing need to reconstitute their cultural pride and establish national identity .

Feng Jiren (Postdoctoral Fellow)

Chinese Building Manuals and Traditions of Architectural Technology

Examining technical manuals on architecture, this project looks into the distinctive cultural connotations reflected from their technical contents, reconstructing the intellectual setting for preserving tradition and engaging in innovation in the building profession.

Feng Jiren

Since the tenth century, master craftsmen, scholars, imperial architects or officials summarized practical building technology and methods. The architectural knowledge presented in their writings often served as guidance for contemporary building practice, some developing into a paradigm for professionals and literati alike in the domain of architecture.

An important issue of this project is how the practical knowledge of architecture was constructed, how it was preserved as tradition, and how Chinese craftsmen and writers dealt with the conflict between maintaining tradition and incorporating technical invention.

One of the research discoveries thus far is the identification of the two groups, craftsmen and literati, as the interplaying forces for formulating the knowledge field of architecture. A basis for this research was results obtained from a philological inquiry into the semantic meanings of the professional terminology in the 12th-century official building manual *Yingzao Fashi* (Building Standards, 1103). The terminology used in this central writing on Chinese architecture presents a mixture of literary and vernacular language. Its nomenclature of bracketing presents a powerful metaphorical system: bracketing elements are likened to flowers and flowering trees, and it is important to notice that such architectural conceptualization was shared by craftsmen and literati. Indicating a great impact of literature upon Song (960–1279) craftsmanship, it suggests an ongoing interaction between craftsmen and the learned society.

A significant result achieved during the first research term was that scholars and craftsmen were working towards shared architectural vocabularies and knowledge since the Song period. Ming-Qing (1368–1911) scholars who built on the legacy of the Song more actively engaged in the making of building methods. Focusing on case studies of some building manuals reveals that Chinese literati constructing architectural knowledge in manuals, venerated fanatically on the rare classics, an attitude which affected the process of technical innovation and digestion of tradition. For instance, Song accounts suggest that the tenth-century Classic of Timberwork *(Mujing)* served as guidance for building practices for almost one hundred years, prior to the official building standard *Yingzao fashi.* Nevertheless, the primitive stage of modular systems in the *Mujing* did not reflect reality. In fact, artifactual evidence substantiates that a more comprehensive modular system had been in practice. The *Mujing's* impact on building practice, to a great extent, lies in the fact that it ended the long-term silence of technical manuals on architecture in history, yet its impact on actual practices in architecture can be deemed as minor. Thus the importance assigned to it in Chinese architecture is largely a literary construct, and not an effect of its actual usage.

"Complete map of the central axis from the Daqing gate to the Kunning Palace" Gugong Palace, Beijing (ink on paper, no date)

Its influence was prolonged by Song professionals' and literati's fanatical veneration of it as a rare technical classic. Even when craftsmen depended on the *Mujing* less and less and actually created new technologies, they still claimed that their designs "followed" the *Mujing*. This was independent of the fact that actual practices had already long changed. Scholars also liked to associate favorite building designs to the principles of the *Mujing*. The case of the *Mujing* provides an example that the practical knowledge constructed in writings mainly served as an ideal of Chinese professionals and scholars in the domain of architecture. Its impact on building practice thus lies beyond its technical relevance.

Oral and Visual Transmission

Under this heading socio-cultural issues, knowledge mobility across space and the social context of artisans are addressed.

Social-cultural issues refer to esoteric tradition, popular religion and the ritualization of technologies. A structural overview helps to understand in which way guilds' structure and religion served as a protective/disseminative framework that affected the spread of inventions and innovation geographically and cross-disciplinarily. Issues of knowledge mobility focus on interregional transmission within the Chinese cultural sphere. Case studies will be conducted regarding the knowledge transmission to and from the imperial court as well as across regions.

The social context of artisans, their social interactions and artisan routines and norms determine the dynamics of shared learning within technological knowledge. Innovation is identified within this framework as a multi-faceted outcome of technological nexus, of explicit and implicit professionalism, social structures and institutional setting.

Palace Museum Cooperation and Book Project

Dagmar Schäfer, Luo Wenhua, Guo Fuxiang, Wang Guangyao, Xu Xiaodong, Zhang Qiong, Zhang Shuxian

In collaboration with the Palace Museum, Beijing, the transfer and appropriation of knowledge by the court and central government is investigated. Based on archival materials and artifacts, this collaboration issues a new look at forms of knowledge transmission beyond textual evidence, unfolding the various means and media of knowledge production. In collaboration with the Palace Museum, the National Library and the First National Archive all located in Beijing, access is granted to design sketches and architectural plans, craft tools, samples, devices and models used for the communication of new technologies, designs and ideals, that will provide part of the research basis for the material transmission of practical knowledge.

The book project of the collaboration, which started in September 2007, features as its major topics the exchange of technological knowledge between different actors in China: between China and its tributary states or foreign countries; between the elite and the common people, or the official and the craftsman; between regional and central government or urban and rural populace. These levels of knowledge transmission will be exemplified using six fields of accomplishment: enamel techniques, architecture, porcelain, jade carvings, metallurgy and silk embroidery.

Technological Landscapes—China Historical GIS

Dagmar Schäfer, Martina Siebert

Mapping technologies is increasingly being used in the humanities for research and as a tool for the representation of data. Individual projects are exploring its potential from various directions. Comprehensive in outlook and approach, the China GIS project on Technological Landscapes currently assembles data in the regions of China to develop a basic understanding of regional technologies and their distribution in space and time. The project includes reconfiguring of the existing data produced by the Shanghai Tongji University and Harvard-Yenching Institute's China Historical GIS (CHGIS), to serve as backdrop against which to display the finds of the "Technological Landscapes" project and research data of future and other projects on China. Easy handling and extensibility are major prerogatives for its technical basis that, though primarily designed for individual purposes, is aimed to accomplish a universal interface for geo-referenced historical research and the publication of its results.

Specifically, the project assembles information about technological development in pre-modern China in the period from the 10th to 18th century. Different kinds of geo-referenced finds are taken into account: accounts of state owned production sites, lists of regional products compiled for local monographs and archaeological finds etc. The CHGIS provides an acknowledged source for basic geo-data on populated places and historical administrative units for the period of Chinese history between 222 BCE and 1911. This data is recompiled according to new adaptable technology and reconfigured for display and research usage on an openly accessible platform. Building on this foundation stone, the joint project of the newly established partner group at the IHNS/CAS and the research Group are using this data to locate the finds of the project in space and time.

Material Transmission: Tools, Machinery and Products

Models and sketches provide a way of transmitting practical knowledge across distances without personal contact. Their role in Chinese history is unclear. On the basis of various resources, technical heuristics are a major focus of this project, the history of three-dimensional model building and the application of construction drawings in craft culture.
Furthermore selected processes of procedural and idiosyncratic inventions and innovations are dealt with. Case studies scrutinize (1) the environment that generates invention and (2) track how a technology is distributed in materia in pre-modern China (see Palace Museum Cooperation).

The Relationship between Practical and Theoretical Knowledge

Among the manifold factors that influence technical knowledge, its dissemination and development, a significant factor is its epistemological positioning, i. e. how it is defined and received in particular domains. Dissecting when and how practical and theoretical knowledge interact or are distinguished as viable means of inquiry thus adds an important viewpoint to understand how knowledge is produced in a culture. Developing a project in collaboration with the IHNS/CAS, the research group founded a new approach to how knowledge is produced in the fields of technology and in the field of the sciences. A number of projects exploring the "Borderlines and Intersections: Knowledge Spheres in Pre-Modern China, 10th–17th Centuries, were set up conjointly.
Inaugurated in September 2007 the Partner Group concentrates on the relationship between practical and theoretical knowledge in the Chinese cultural realm defining hierarchical and vertical knowledge spheres as a basis of inquiry. From the viewpoint of intellectual, social, geographical, political, and/or organizational features, the projects look at the internal structure of knowledge spheres in which technology and practical knowledge occurred and their external linkages. This provides a new conceptual basis for research on Chinese knowledge about nature and man, technology and its development. Comprising the period from the 10th to 18th century, the projects of the first phase concentrate on the Song Dynasty 10–13th century, looking at a time that gendered great creativity, transformations in technology and systematic approaches to knowledge about nature and man.

In pre-modern China knowledge spheres were subject to and defined by the goals to which the specific knowledge was geared. Knowledge about nature and man, i.e. scientific knowledge, and knowledge about practical or technological issues were contextualized within these spheres and linked to external issues. The borderlines and intersections of these knowledge spheres shifted because Chinese society experienced tremendous changes during the period in focus. During this long period cultural and economic centers shifted back and forth from north to south. Urban culture developed and rural life was transformed by changing agricultural methods and new crops. The state engaged in various forms and fields of production. Trade and foreign contact provided another significant incentive for the construction and production of knowledge.

All these factors combined to form the uniquely Chinese construct in which scientific and technical-practical knowledge was placed and thus developed. The project investigates the location of and relation between various knowledge spheres in order to provide an authentic lens through which Pre-modern China's scientific and technological knowledge can be seen and assessed. Six research projects in the fields of astronomical knowledge, alchemy, agriculture and sericulture are being pursued and will work in close cooperation with the MPIWG Research Group in the future.

Visiting Scholars

Sun Xiaochun

Sun Xiaochun

Xiaochun Sun, Institute for the History of Natural Science (IHNS) of the Chinese Academy of Sciences, P. R. China, studied the interaction of cosmological thinking, calendar making and astronomical measurement as reflected in astronomical instrument making in Northern Song China (960–1127). This study led to the research proposal on *Borderlines and Intersections: Knowledge Spheres in Pre-Modern China, 10–18th Century,* which was approved by the Max Planck Society as the central theme of research of the Partner Group of the Max Planck Institute for the History of Science (MPIWG) at the IHNS. Sun Xiaochun was appointed head of the Partner Group. His study here also contributed considerably to his new dissertation on *State and Science in Northern China,* which he defended successfully in 2007 for his second Ph. D. at the University of Pennsylvania, U.S.A. A joint article on the role of astronomical treatises during the 11th century has been compiled.

Guan Xiaowu

Guan Xiaowu

Conducive to first inquiries into the issue of material artifacts and the investigation of large scale edifices in irrigation engineering and machinery, Xiaowu Guan concentrated on the three aspects of transmitting, preserving and performing knowledge of the Grand Waterwheel of Lanzhou. The origin of the technical knowledge of the waterwheel was traced by way of analysis of the technical contexts prevalent in the districts surrounding Lanzhou before the appearance of the water wheel. The evolution of the waterwheel and its technological development was sketched and the uses of the Grand Waterwheel and its role in the history of Lanzhou was analysed.

Devoting his attention to analyzing, researching and categorizing his archival materials, Guan Xiaowu incorporated new approaches to his investigations in collaboration with the group. Using the sixteenth century to the present history of the waterwheel of Lanzhou as a test case the fragmentary evidences relating to its evolving showed examples of technical knowledge in the making. The accomplished results of the project have three parts: 40 pages of material and several key tables in Chinese have been completed; a primary English draft of the results was written and is expected to be completed at the end of April; and a presentation of the study will be presented at the workshop "Artisanal Practice and Popular Culture in Late Imperial China" organized by Dr. Philip Cho at the Institute for the History of Natural Science, Chinese Academy of Sciences in Beijing on June 19–20, 2008.

Joachim Kurtz

Joachim Kurtz

Joachim Kurtz, Emory University, U.S.A. studied the rhetoric of innovation in late imperial China, focusing on the hybrid persuasive strategies used in Jesuit works introducing European technology. Emulating both Chinese literary conventions and European suasory devices, Jesuit missionaries and their local collaborators used a wide array of rhetorical means to bridge the distance between foreign and native learning, embed novelty in cherished traditions, and shroud potential heterodoxy in accepted terms while simultaneously highlighting the unique value of the technologies they advertised. The goal of this study was to trace the continued refinement of the Jesuits' rhetorical arsenal in response to mixed reactions from Chinese audiences.

Ma Biao

Ma Biao

Professor Ma intensified his research into the pronunciation of the measure word "石" in the time of the ancients. He investigated the philological and material find of archaeology relation to units of measurement in pre Han time. He thus contributes substantially to founding a new basis on investigating artifacts related to scientific and technological knowledge production. Exemplifying by way of its philological and linguistic basis, Professor Ma could demonstrate that the phonological misconception of "shi" by historical research had lead to crucial fallacies about the recognition of measurements in China, the actual tool and its usages. Providing a first inquiry into the issue of material factors of knowledge production, his work divulged the difficulties in correlating textual recognition with artifact evidence.

During his stay Ma Biao successfully completed his article *"Research on the Ancient Chinese Pronunciation of the Measure Word 石"* (in Chinese). Thorough discussions with Professor Karine Chemla from the Centre National De La Recherche Scientifique (CNRS) in France about the history of measurements and weights in the Qin und Han Dynasties were held.

Nakayama Shigeru

Nakayama Shigeru

Within his project of new paradigms in post-industrial society, Prof. Nakayama mainly worked on a new ecological perspective, with particular emphasis on post-68 Germany with access to German literature. During his stay, he obtained another Cyber-perspective, which is rooted in post-68 California. This latter development has become his new research focus.

19th century painting tools: palette with oil paints, scetch indicating color positions, paper enveloppes with pigments.
See Project: Practical Knowledge Traditions and Scientific Change, 1750–1870. p. 185

Independent Research Group II

Experimental History of Science

Director: *H. Otto Sibum*

The research performed by the independent research group can be divided into two different but related projects: "Science and the Changing Senses of Reality Circa 1900" and "Practical Knowledge Traditions and Scientific Change, 1750–1870." The former has been completed, and the results will be published as a double volume of *Studies in the History and Philosophy of Science in September 2008*. Below you will find a brief description of the project and its contributors.

Project

Science and the Changing Senses of Reality Circa 1900

The turn of the century is commonly considered as a period of major changes in science and society and hence been studied extensively. However, attention was drawn to its reworking, in order to probe possibilities to reconstructing experiential spaces. i.e. to explore ways of studying the cognitive implications the material culture of science and the body techniques employed. By bringing together historians of science, art and culture studying the turn of the century, we wanted to better understand the changing experiential spaces of scientists and artists' symbolic and material expressions circa 1900.

At the turn of century, those experiencing subjects working in science, arts, and the humanities articulated diverse and often contradictory statements. For example, in 1900, observers of science were told that progress in science was based on a collective and rather expensive program of the "extension of the senses."[1] In this view, physics was mainly regarded as experimenting with newly designed instruments whose purpose was to refine the human senses or even to create new ones. These "artificial fine senses" would provide access to sensory worlds with new physical phenomena.

1. Otto Wiener, *Die Erweiterung unserer Sinne.* Akademische Antrittsvorlesung gehalten am 19. Mai 1900. Leipzig: Verlag von Johann Ambrosius Barth, 1900, pp. 1–43.

And, indeed, X-rays and the electron are just two famous examples thereof. Moreover, according to Otto Wiener, only walking along this path into the new millennium would guarantee progress. At the same time Wiener's colleague Max Planck reminded his audience not to place too much trust in the often errant human senses. The real world and its universal laws were to be found beyond sense perception, and deanthropomorphization was the precondition of progress in physics.

At the turn of the century, a number of different intellectual positions could be found and hence some actors were puzzled by the flux of developments they were experiencing. Felix Auerbach, the physicist from Jena with a strong interests in writing a developmental history of physics (*Entwicklungsgeschichte der modernen Physik*), regretted tremendously that he could not tell where science at the turn of the century would be going.[2] At a time when new discoveries were made nearly every day and the unity of nature was believed to be at stake, Auerbach was not able to present a bird's eye view from which the scattered scientific experiences of the nascent twentieth century would make sense.

2. Felix Auerbach, *Entwicklungsgeschichte der modernen Physik.* Zugleich eine Übersicht ihrer Tatsachen, Gesetze und Theorien. Berlin: Verlag von Julius Springer, 1923, p. 1.

Historians of science have tackled this period extensively, and we are familiar with famous attributions such as the "end of classical physics" and the "rise of modern physics" represented by quantum mechanics and relativity theory. But was the classical simply replaced by the modern? *Richard Staley* presented a more nuanced picture. He looked at how physicists expressed their experience with changes in the discipline at the turn of the century. To Staley, it seemed more plausible to argue that the so-called modern physicists worked hard to establish their new persona by creating the distinction between the "classical" and the "modern." Physicists at the turn of the century invented the modern to mark their scientific work as being different to the past.

More generally speaking, the project aimed at making visible what scientists, artists, and scholars were actually doing in their laboratories and studios. How did they experience the fluctuations in their field of research? In what ways did they try to make sense of this open-ended process of change?

One of the key issues in all of their studies of scientific objects was the role of sensory experience in the process of generating knowledge. What were their thoughts on this? The contradictory positions held by Ernst Mach and Max Planck are the most well known and Mach's view is epitomized in his statement about the new physics: "It would be very peculiar if the experience of the world would transcend itself through it's refinement and nothing else from the world would be left than unreachable phantoms."[3] Of course, Mach defended a strong sensationalist position that even questioned the assumption that atoms are real. But as we will see, various other important intellectual positions on the role of sensory perception can be found between Mach and Planck.

3. Ernst Mach, *Die Leitgedanken meiner naturwissenschaftlichen Erkenntnislehre und ihre Aufnahme durch die Zeitgenossen.* In Physikalische Zeitschrift XI, (1910) pp. 599–606, 604.

Felix Auerbach went so far as to tell his readers to question the very notion of natural phenomenon. He suggested to name X-rays not a natural but a physical phenomenon because they were artificially created by Röntgen in his laboratory. And hence with regard to methods used in the physical sciences, he suggested that it was no longer appropriate to speak of discovery but rather of invention.

"X-rays are not a 'natural phenomenon.' Until Röntgen there weren't such, they have been invented by him (this expression is more appropriate than the conventional

'discovered'); and in case it turns out that there are such rays in nature, this does not change the issue essentially."[4]

4. Auerbach, 1923, p. 5. On this issue see also H. Otto Sibum, *What Kind of Science is Experimental Physics?* In Science, 306 (2004) pp. 60–61.

Methodologically speaking, for Auerbach and many of his colleagues, physicists behaved as engineers who implicitly transformed the traditional understanding of scientific observation through their work. Experimentally working scientists no longer observed phenomena; observation was always intervention, too, and in their laboratories, physical realities were created. But as the following cases will show, this was a complex process of molding and being molded by the object of study. It is striking to see how this changing experiential space of science stimulated fruitful debates and reflections about the hidden entities being studied and to examine what role these artificial fine senses and the inquiring subject played in constituting the new scientific objects.

The available historical material, however, required us to further focus our attention. Hence we decided to discuss the cases in which the actors attempted to shift the scale of sensory experience, i. e., to explore phenomena that were out of reach of the common human senses. Furthermore we focused on the research fields in which the actors attempted to make invisible entities visible.

Charlotte Bigg

Charlotte Bigg engaged with the recurring issue of shifting scales between microscopic and macroscopic dimensions and how the realization progressively emerged that the physical laws governing the macroscopic world were not always adequate for describing the submicroscopic one. She focused on the research of Jean Perrin in the 1900s, in particular his use of Brownian motion to produce evidence of the existence of atoms and in favor of the kinetic theory. His results were described by many contemporaries, and subsequently by historians, as the first direct proof of atomic and molecular reality. Bigg's work examined the different strategies developed by Perrin for bridging the macro- and submicrophysical realms and making the latter accessible to the senses—although neither atoms nor molecules were ever actually seen, and in fact very few visual representations were shown and published in connection with these experiments. This instance provides a good example of how visualizing, representing, and convincing were interwoven in the production of evidence—about the submicrophysical realm circa 1900.

Richard Noakes analyzed the uneasy relationship between physics and the "occult sciences" in the decades around 1900. For some, there was no relationship at all; for others a relationship existed but they did not agree on what it looked like. Many physicists converged with spiritualists, theosophists and others in interpreting X-rays, the electrical theory of matter, and other aspects of the 'new' physics as powerful ways of rendering psychic and occult effects scientifically more understandable. Noakes showed that physicist-psychical researchers were content to ally the "new" physics with religion because it helped vanquish awkward associations with materialism. They also tried to justify the value of their experimental skills by emphasizing their expertise in investigating subtle physical effects and their ability to create tests that respected the delicate conditions of séances.

In his article "Crafting the Quantum," *Suman Seth* investigated the early quantum physics of Arnold Sommerfeld. His study of the development of the older quantum theory nicely illuminates what Sommerfeld meant by improving "die Technik der

Quanten." Crafting the quantum—as Seth translates it—draws our attention towards the existence of subcultures of theoretical physics, one of which is Sommerfeld's research, which is exemplified by the rich connotations of the German word Technik. Sommerfeld did not mean that he would merely take a "nuts and bolts" approach to quantum physics and allow others such as Planck or Einstein to undertake the philosophy of it. Rather, he understood his theoretical research as combining the engineering character of physical research with an aesthetic sensibility.

David Bloor

David Bloor compares the work of British and German engineer physicists and their attempts at *Sichtbarmachung*. A concerted effort was made in the discipline of fluid mechanics to make hidden and fleeting processes visible and to capture the results photographically. The photographs taken by H. S. Hele-Shaw in the 1890s showing the flow of a "perfect," frictionless fluid were one such attempt. Another case involved the photographs of boundary-layer separation taken by Ludwig Prandtl. Bloor's concern in both cases was the relation of the photographs to the reality that was actually or putatively portrayed in the photograph.

David Aubin was engaged with another new and most exciting physical phenomenon that became visible in a physicist's laboratory at the turn of the century: the "spontaneous emergence of forms in inanimate matter," now known as "self-organization." This phenomenon demonstrated the permeability of the border between the fields of physics and the life sciences. By experimenting with liquids of different viscosity, the French physicist Henri Bénard observed in all cases the formation of cells that tended to stabilize into a hexagonal shape after a short period of instability. Bénard's research hinged heavily on the use of cinematography, which he regarded as the only means to properly represent the phenomena in question. His work sparked various important discussions about the relation between organic and inorganic matter as well as between mathematical and experimental physics.

Hans-Jörg Rheinberger

Hans-Jörg Rheinberger described how biologists at the turn of the century came to conceptualize and define the hidden entities presumed to govern the process of hereditary transmission. With that, the stage was set for the emergence of genetics as a biological discipline that came to dominate the life sciences of the twentieth century. The annus mirabilis of 1900, with its triple re-appreciation of Gregor Mendel's work by the botanists Hugo de Vries, Carl Correns, and Erich Tschermak, can be seen as a turning point after which theorizing about heredity and experimentation—selecting pure lines and Mendelian crossing—became tightly connected. Finally, with Wilhelm Johannsen, a Danish plant physiologist, heredity was defined as "the presence of identical genes in ancestors and descendants." Although Johannsen himself refused to speculate about the material nature of the genes—and, indeed, experimenting with pure lines and analyzing their crosses did not require such knowledge—the genes, the "atoms of biology," came to dominate the life sciences for the rest of the twentieth century.

Ilana Löwy argued that Ludwik Fleck's understanding of scientific observation as a social and cultural process stemmed not only from his practical experience as a bacteriologist and serologist, but also from confronting ideas developed by other Polish thinkers. Two elements in Fleck's biography stand out as potential sources of his interest in the indeterminacy of visual evidence: his work as the head of the laboratory of skin and venereal diseases in the city hospital of Lvov (a position he

occupied after he failed to obtain a full-time research job), and his unorthodox view on the variability of bacterial species. Fleck's interest in selective observation and interpretation of visual evidence was deeply rooted. Fleck's reflective stance about his experience at the bench was unusual, however, as scientists are seldom inclined to analyze their own practices. Two Polish thinkers might have provided Fleck with conceptual tools that enabled him to question the production of scientific facts: the physician and philosopher of medicine Zygmunt Kramsztyk (1848–1920) and the mathematician, philosopher, and painter Leon Chwistek (1894–1944).

Cristina Chimisso looked at the eroding boundary between the theoretical and technical parts of science through the eyes of the philosopher Gaston Bachelard. For him, scientists did not simply observe or directly capture essences, but rather *technically* manipulated and indeed created the object of their knowledge. Bachelard pointed out that the only possible study of corpuscles is technical, that is to say it is done by using experimental apparatus; in his own words, "of all corpuscles of modern physics, one can only do a phemenotechnical study." He continued that in phenomenotechniques, no phenomenon appears naturally, no phenomenon is a given. His original concept of "phenomenotechnique" supports his revision of traditional philosophical views concerning the existence and essence of things. His position is one of the many intellectual takes on what constitutes physical realities.

Robert Brain discussed the graphic recording instrument as a new sense that makes invisible processes visible and thereby mediates between science and the arts in important ways. The applications of self-recording instruments expanded dramatically in the second half of the century when they were recognized as an emblematic and ubiquitous fixture of nearly every scientific discipline. Some called graphical recording "the universal language of science." Graphical inscription thereby acquired a new authority by enabling apprehension to shift from tactile to visual. This observational position made possible a new kind of formalist observation in the sciences, in which complex dynamic processes were reduced to relatively simple visual and quantitative relations.

Étienne-Jules Marey's graphical recording instruments provided arresting images of a range of new and previously unseen phenomena. These glimpses into "invisible worlds," "fugitive and imperceptibly slow occurrences" and the "infinitely small" stimulated widespread public fascination throughout the late nineteenth century and raised important questions among artists about the relation of physiology and aesthetic perception. At the turn of the century in the cultural arts, the lexicon of early modernism reigned supreme in discussions of the meaning of this new sense of reality.

In his work, *Brain* argued that a critical condition that enabled many of the turn-of-the-century modernist movements in the arts was the exchange of instruments, concepts, and representational media between the sciences and the arts. One route of interaction came through physiological aesthetics, the attempt to "elucidate physiologically the nature of our aesthetic feelings" and explain how works of art achieve their effects. Physiological aesthetics provided the terms for new formalist languages of art and criticism, and in some instances suggested optimistic, even utopian, possibilities for art to remake human individuals and societies.

Bettina Gockel invited us to rethink the expression "Art does not display the visible; it makes visible." The artist Paul Klee understood artistic work as a rational contribution to generating knowledge about culture and nature. This theme of the close relation between artistic and scientific methods recurs repeatedly in Klee's voluminous notes and diaries, but nowhere as succinctly as in Klee's essay "Exact experiments in the realm of art": "Where intuition is tied to exact scientific research, the progress of such research is advanced; intuition heightened by exactitude is superior." Intuition was Klee's term for the artist's task of developing the inner self into a receptive apparatus that elevates the artistic product over subjective and moral meanings. The artist, in other words, aligns his or her position with that of a sensitive instrument in the task of "making visible" (*Sichtbarmachung*) through the various material media of artistic practice. Very much like the scientists committed to the technical extensions of the senses in experimental research, Klee assumed that all knowledge—scientific and artistic—was rooted in anthropomorphism.

Doris Kaufmann's contribution showed that the artists' oscillation between the modern and the primitive echoed broader movements among European intellectuals. She argued that the primitivist turn had as much to do with colonialism as with other intellectual preoccupations. In the period between 1880 and 1930, two interrelated problems in particular were important to the centrality of primitivism as a conceptual framework in the emergence of transdisciplinary *Kulturwissenschaften* in Germany. (1) the question of the origin, existence, and modes of operation of "other" forms of thought and consciousness, which in contemporary terms were often characterized by a series of synonyms—primitive, archaic, pre-logical, savage, or mystical. This question pointed at the European dimension of the primitivism debate. (2) the research interest in these "other" modes of thought gave rise to a self-reflective epistemological question: How could "the other," that is, other forms of thought, be recognized if the researcher belonged to a particular historically determined European mode of thought and perception?

Gadi Algazi studied the process of making invisible movements visible in Norbert Elias's grand project, *The Process of Civilization* (1939). Elias's project aimed at reconstructing invisible movement—both the slow tempo of long-term historical change and the modification of psychic structures and embodied dispositions. To do this, he resorted to uncommon devices. By treating historical texts as constituting a series amenable to a rudimentary discourse analysis, he constructed an imagined "curve of civilization" serving as an approximation of the hidden process of change. Elias's curve was not supposed to represent individual past states, but movement itself, its direction and pace. This novel concept of historical representation was related to the perception of cinema as a new medium making actual movement visible. But beyond its use in imagining how one could telescope long-term historical process, cinema also held the promise of serving as a microscope, by making the minute movements of the human body, gestures, and manners available for close inspection.

Project

Practical Knowledge Traditions and Scientific Change, 1750–1870

Arianna Borelli, Frédéric Graber, Anna Märker, Annik Pietsch, H. Otto Sibum, Simon Werrett


Arianna Borelli


Frédéric Graber


Anna Märker


Annik Pietsch


Otto Sibum


Simon Werrett

Project II aims at investigating a historical period spanning the mid-eighteenth to mid-nineteenth centuries in which modern science was coming into being, a period critical for the investigation of the fruitful and reciprocal interactions between science and other forms of knowledge. It was the age of Enlightenment with its ideal of promoting "useful knowledge." As historians have come to realize the close ties between epistemology and praxis, so too their terminology for this time has come into question. Economic historians who once spoke of the industrial revolution can now be heard referring to the "Industrial Enlightenment." Historians of science, once comfortable with the "second scientific revolution" followed by the concept of the rise of "a quantifying spirit" now stress the importance of the geographical dimension of knowledge creation in the Enlightenment period.

What does it mean to work in a scientific workplace, to labor in a scientific laboratory? What kind of knowledge is situated in these specialized performances of work? These are the questions at the heart of the project—questions that took on new meaning in the period just discussed. Originally the terms "episteme," "scientia," "science," and "Wissenschaft" meant knowledge or skill in general. It is only over time that they became specialized terms to denote a more certain and authoritative form of knowledge than "ordinary knowledge." This linguistic divide is often mirrored by a social distinction between those who work with their heads and those who work with their hands. It even contributed to a cultural distinction between western European lands (and former colonies) that practiced modern science and those that did not.

Doctoral and postdoctoral researchers have participated in this project.

Annik Pietsch is finishing her studies of the production of oil paintings in Germany and the hitherto unrecognized connections between art, industry, science, and even philosophy. *Frédéric Graber* has expanded his study on the water works of French engineers to a comparative study between French and German cultures of engineers.

Anna Märker has continued her studies on the notion of "useful knowledge" in this period. *Arianna Borrelli* is tracing the early development of thermometric measurement practices and the related concepts of heat and cold. *Simon Werrett* has finished his research on fire-workers' knowledge and its importance for the development of natural philosophy.

The project has also attracted attention outside the Institute and the discipline. Collaboration began with the Ecole des Hautes des Etudes en Sciences Sociales (*Kapil Raj*, EHESS) in Paris. The project has further sparked an initiative to explore the research theme more broadly. With former members of the research group *Suman Seth* and *Trevor Pinch* (Cornell University) and ethnologist *Richard Rottenburg* (Halle University/MPI for Social Anthropology), we plan to convene three interdisciplinary conferences. The first one will be held in October 2008 at Cornell University (2009 at Uppsala University, 2010 at Halle University). In the first meeting, called *Places of Knowledge: Relocating Science, Technology and Medicine*, we will explore the research theme's potential for science and technology studies. We seek to put into dialogue analyses addressing technoscience in colonial and postcolonial contexts with work on artisanal knowledge, citizen science, and other forms of knowledge and sites of practice. We are seeking contributions that examine these places, the types of material and knowledge produced within them, and the sorts of communities and institutions that facilitated the means of knowledge production.

However the flourishing project of the independent research group will not be continued at the MPI in Berlin after 2007. Its research leader, *H. Otto Sibum*, was offered the endowed Hans Rausing Chair of History of Science and the directorship of the Office for History of Science at Uppsala University, Sweden. Other members of the research group have also been successful in taking up positions at universities and research institutions in France, England and Germany.