THE CHEMISTRY, PHYSICS AND TECHNOLOGY SECTION

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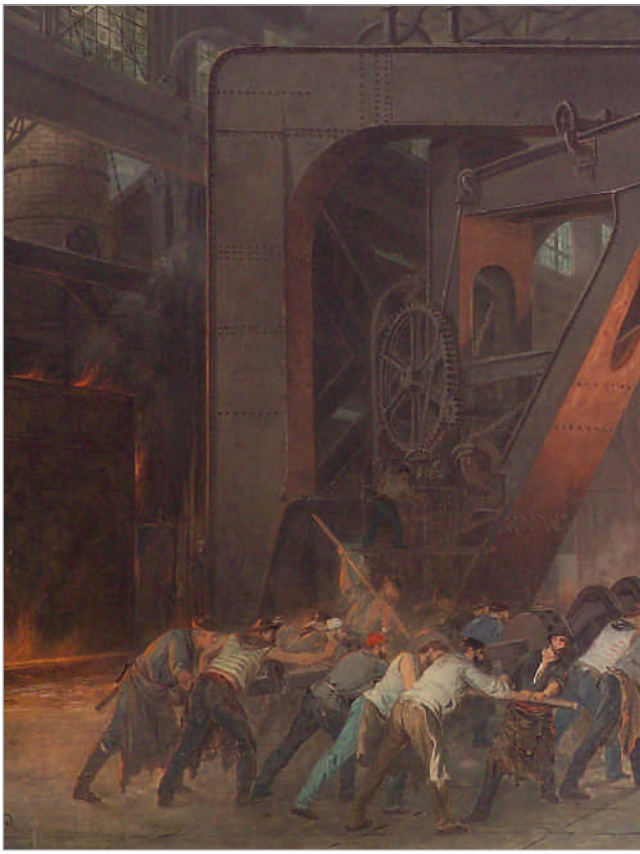

above | 'Göttingen Observatory, View from the Embankment' by Friedrich Besemann, around 1830

At present, the Chemistry, Physics and Technology Section (CPTS) includes 32 Max Planck Institutes in 21 locations over 12 German federal states. The concept of independent institutes put into action by the Max Planck Society leads to great flexibility, which is reflected by the wide diversity of topics, methods and organizational structures within the CPTS. At some institutes, individual scientists focus on a single topic, for example at the Max Planck Institute for Mathematics. At other institutes, specialists in diverse disciplines collaborate and thus maintain their competitive edge in the face of global competition. This is exemplified by the Max Planck Institute for Solid State Research and the Max Planck Institute for Chemical Physics of Solids, where chemists are synthesizing new and future-oriented materials, the properties of which are subsequently analysed by physicists. Finally, a significant fraction of CPTS institutes provide support and leadership to large international collaborations that are researching the basic building blocks of matter and the Universe.

The need for leading institutions to specialize while addressing broadly defined research problems has created strong collaborative ties among various institutes. This is clear from the following scientific reports, which generally involve several institutes. These reports can be grouped into three broad themes based on the results and future directions presented: matter and materials, complex interactions and novel light.

MATTER AND MATERIALS

Research on the foundation of matter addresses ever smaller scales by exploring elementary particles, and reaches ever larger distances with astrophysics, as

left | 'The Power Hammer. The Naval Forges and Steel Works at St. Chamond' by Joseph-Fortuné Layraud, 1889

illustrated in *The Universe as a physics laboratory* (page 64) and *Space, time, matter and forces* (page 68). This kind of research is resource intensive and can be realized only within large international collaborations, as exemplified by *Big questions, big projects* (page 62). The Max Planck Society pursues pioneering materials research at the interface of physics, chemistry and biology. *Multi-scale modelling* (page 42) illustrates the cross-linking function of modelling in the materials research carried out by the Max Planck Society. Sophisticated simulations can already replace expensive experiments in many cases. *Nanoscience and nanotechnology* (page 46) addresses the symbiotic interplay of physics and chemistry utilized in the fabrication of nanoscale devices. Finally, *Biological materials sciences* (page 60) demonstrates how organic functional matter can be used to create new materials with extraordinary properties by learning from nature.

COMPLEX INTERACTIONS

The way we live influences our environment. The consequences are controversial and there is a high demand for objective fundamental research. The work done on *The carbon cycle in the Earth system* (page 50) at specialized institutes addresses a crucial topic in this context, as does the Max Planck Society research on *The energy frontier* (page 52). Catalysis research (page 54) is also related, albeit less directly. We are beginning to realize that the Earth and humankind, both together and separately, fulfil the criteria of complex systems. However, little is yet known about the effects that the general principles of *Complex systems* have in real situations (page 56). *Computational disease models* (page 66) provide a concrete perspective for future individualized therapy, and *Multi-modal computing and interaction* (page 58) deals with the transformation of complex interconnections into formalized procedures.

NOVEL LIGHT

Light of all wavelengths plays a special role in human perception and our interaction with the environment. The generation of ultrashort light pulses, intense X-ray bursts and laser light with extremely stable frequencies for the accurate determination of time intervals is progressing rapidly, and revealing perspectives that were unimaginable a decade ago (*Matter in a new light and why light matters*, page 48). Atoms and molecules of an ultracold gas can be arranged by laser light into a regular array, as in a solid, giving rise to a close and fruitful link between parts of quantum optics and condensed matter physics (*Control of quantum many-body correlations*, page 44).

NEW INITIATIVES

The perspectives emerging from novel light research are so promising that the Max Planck Society founded the Institute for the Science of Light in 2009. New forms of collaboration with the Helmholtz Association and the University of Hamburg have been realized through the creation of the Center for Free Electron Laser Science (C-FEL). A unique radiation source for intense X-ray bursts is being built on the site of the German Electron Synchrotron (DESY) in Hamburg. Physics, chemistry, materials research, structural biology and medicine will all benefit from this development. It promises to give insight into fast material processes by filming them with microscopic resolution in space and time.

The Max Planck Society has two departments and an Advanced Study Group (ASG) concerned with C-FEL. The latter is a coalition of departments from different Max Planck institutes involved in FEL research, not only in Hamburg but also in the United States (Stanford) and Japan. The ASG is a new form of collaboration within the Max Planck Society, which will also be established for energy research in the future, and has already been substantiated by the EnerChem initiative undertaken by several institutes.

Another new addition, the Max Planck Institute for Software Systems, strengthens research on complex interactions, and supplements the well-established Max Planck Institute for Informatics. New research directions for the Max Planck Society are created not just through founding institutes: the transformation of research at existing institutes is also an important element. Part of the future work of the Max Planck Institute for Metals Research, for instance, will focus on autonomous systems. The scientists envision the development of robotics with microscopic systems on the nanoscale, with applications stretching all the way to biological devices. They intend to systematically investigate and implement all relevant processes of autonomous behaviour: namely perception, action and learning. Interestingly, these are the qualities that, together with reasoning, form the prerequisites for good research.

Small painting: www.zeno.org - Zenodot Verlagsgesellschaft mbH. Main image: Document Écomusée Creusot Montceau/cliché Daniel Busseuil.