Summary: Nuclear fission can power cities or kill millions. It is an inherent dual-use science, as biology or chemistry, suitable for both civilian and military purposes. In order to minimize the security threats posed by the proliferation of nuclear or biological weapons, states have designed international institutions to regulate these sciences. The Nuclear Non-Proliferation Treaty (NPT) and the Biological and Toxic Weapons Convention (BTWC) are two treaties that try to avoid the weaponization of science.

Kurz gefasst: Die Kernspaltung kann Städte mit Strom versorgen oder millionenfachen Tod bringen. Kernforschung ist typische *dual use*-Forschung, die militärischen wie zivilen Zwecken dienen kann. Um die Gefahren militärischen Missbrauchs zu mindern, wurden internationale Vertragswerke entwickelt, wie der Atomwaffensperrvertrag und die Toxinwaffenkonvention (BTWC). Staaten und internationale Institutionen wie die Internationale Atomenergie-Organisation arbeiten dabei eng zusammen.

Preventing global disaster International governance of dual-use sciences

Alexandros Tokhi

Albert Einstein and Leó Szilárd intended to develop a new refrigeration system by pumping liquid metals through tubes with the help of electromagnetic fields. But their invention, though patented, did not have any commercial success. Instead, it was employed in 1942 in the Manhattan Project, the U.S. program to develop the first nuclear bomb. This example illustrates the dual-use character of technology: features of a primarily civilian technology are used for a military end. And of course, dual-use features are not confined to technological applications as such but extend, most importantly, to hazardous material like enriched uranium or plutonium – used to power cities or fuel nuclear weapons.

More than in nuclear physics, the dual-use dilemma is an almost pervasive feature of the life sciences. The same knowledge and research that can save and improve human lives can serve to build weapons capable of killing millions. The deadliest and most frightening weapons in human history – Weapons of Mass Destruction (WMD) – have been developed with insights from nuclear physics, biology and chemistry, and have been used as weapons of deterrence or on the battlefield in international conflicts. The intricate question is how to regulate these dual-use sciences while enabling scientific progress yet preventing the production of WMD. Some Manhattan Project physicists came up with a response several decades ago: international control and regulation.

In recent decades, international governance schemes have been developed to forestall the proliferation of WMD. Two important international treaties – the Nuclear Non-Proliferation Treaty (NPT) and the Biological and Toxin Weapons Convention (BTWC) – share a common objective: to prevent weaponization of nuclear energy and biology. The institutional approaches to achieve this end differ considerably and generate different challenges for peace and security in inter-state relations.

Nuclear destruction of Hiroshima and Nagasaki surpassed any previously held beliefs about the destructive capabilities of weapons. Soon thereafter, initiatives to regulate nuclear energy on an international level materialized in the United Nations Atomic Energy Commission of 1946, which was given the task of working on recommendations for "the elimination from national armaments of atomic weapons and of all other major weapons adaptable to mass destruction." Confronted with an ever-increasing risk of the spread of nuclear weapons to other states, the United States, United Kingdom and Soviet Union took the lead in negotiating the NPT, adopted in 1968. The NPT's objective is to prevent the further spread of nuclear weapons. In effect, the treaty freezes distribution of nuclear weapons in the world. States that detonated a nuclear device before 1967 are officially recognized as Nuclear-Weapon States (NWS) and may retain their nuclear arsenals (these include the USA, Russia, the UK, France, and China).

All other states that join the treaty – also known as non-nuclear weapon states – are obliged to forego development, production or other acquisition of nuclear weapons. In addition, these states commit to monitoring by the International Atomic Energy Agency (IAEA) "for the exclusive purpose of verification of the fulfillment of ... [their] obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons." The IAEA is mandated to examine whether all nuclear material within nuclear facilities is used for peaceful purposes, or if indications of concealed weapons development exist in a non-nuclear weapon state. In turn, non-nuclear weapon states are encouraged to develop nuclear energy for peaceful purposes and co-operate with other states to this end – by exchanging material, technology, and relevant knowledge. However, the IAEA's most prominent role lies in the domain of non-proliferation verification. Verification is the process of arriving at a judgment about the consistency between a state's treaty obligations and its activities. For this purpose, the IAEA developed a system of rules and procedures that aim to prevent the diversion of nuclear material from civilian applications to military activities: the so-called 'safeguards'. These are contained in a sub-agreement to the NPT and are compulsory for all non-nuclear weapon states. The IAEA's verification work is based upon the fact that nuclear material suitable for weapons production, i.e. enriched uranium and plutonium, does not occur naturally. It is human-made and involves specific and identifiable processes, material and facilities. Therefore, the IAEA monitors the steps of the nuclear fuel cycle with particular emphasis on those steps relevant for nuclear weapons production. The nuclear fuel cycle comprises all activities and technological processes that use uranium (or other fissionable elements) to generate electricity. The enrichment and reprocessing phases are of high dual-use relevance, since the technological processes and knowledge to produce nuclear fuel for power plants or for atomic weapons is virtually the same.

A non-nuclear weapons state party to the NPT is required to report all its relevant nuclear materials and facilities each year to the IAEA correctly, completely and in a timely manner. The IAEA verifies the submitted information through on-site inspections, remote and satellite surveillance, environmental sampling and other monitoring instruments. A considerable discrepancy might be a reason of concern, especially when the involved state party cannot provide accurate evidence to explain the discrepancy (as happened with the Iranian nuclear program). Furthermore, the IAEA monitors the design of nuclear facilities to assess whether a nuclear installation serves the declared purposes or not. On-site inspections, as well as remote monitoring techniques (satellite surveillance), are employed in that process. However, the effectiveness of the IAEA safeguards systems was severely challenged by Iraq's secret nuclear weapons program at the end of the 1980s. Iraq entertained huge weaponization activities on its Tuwaitha site, which IAEA inspectors visited regularly – but only locations that Iraq itself designated for inspections. As a result, the IAEA examined only three facilities on Tuwaitha, while most of the weaponization activities were done in the majority of the other locations at that same site. As a reaction, the IAEA developed a strengthened safeguards system that provided additional inspection rights, broadened state parties' reporting obligations and extended monitoring activities to cover nuclear research and development activities as well. These rules and procedures are contained in a novel agreement, the so-called Additional Protocol. States can ratify this protocol on a voluntary basis. The Additional Protocol expands the verification mandate of the IAEA, and more information is available to assess material, technology and state intentions with regard to nuclear energy. Confidence in the peaceful application of the nuclear dual-use science should increase through closer and systematic control of sensitive activities and material.

However, the major challenge to address in the next years is the situation in the Middle East, where a renaissance of nuclear power is burgeoning and where few

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states are willing to adhere to the Additional Protocol. Most notably, Iran, Egypt and Syria concealed nuclear material and proliferation-relevant activities. Until this day, these states refuse to adopt the Additional Protocol.

In contrast to nuclear weapons, the agents used to build biological weapons occur naturally. These agents comprise living organisms such as bacteria, parasites and viruses that are highly infectious and often lethal. While there is no consensual international catalogue of hazardous biological agents, the World Health Organization (WHO) defined four risk groups of microorganisms, depending on their contagiousness and whether treatment is available. Anthrax, bubonic plague, Ebola and yellow fever are classified as agents in higher risk groups capable of serving as payloads in biological weapons. However, the WHO risk groups serve rather as points of orientation, since the object of regulation, living organisms, is difficult to capture.

The multiplicity of pathogenic microorganisms and their ability to mutate in the future due to chance and human design aggravate the composition of an international and consensual list of all potential biological weapons agents. Advances in the life sciences bear the potential to quickly outdate such a catalogue. In addition, research on lethal microorganisms, such as Ebola, does not necessarily have a military take, but often serves in the development of appropriate vaccines and treatments. To account both for this intrinsic dual-use character and the uncertainties of future scientific advances, the Biological and Toxin Weapons Convention (BTWC) establishes as the first multilateral disarmament treaty a so-called General Purpose Criterion. Instead of indexing and banning specific microorganisms, the BTWC outlaws the intention of hostile use of biological agents.

The General Purpose Criterion decouples substances that are subject to technological innovations from purposes that are subject to state decisions. States agree to forego production or other acquisition of biological agents "of types and quantities that have no justification for prophylactic, protective or other peaceful purposes." In short, states may retain and use biological agents for medical research and defensive purposes. At the same time, the above rule prohibits any activities involving the same biological agents toward hostile ends, such as producing anthrax in industrial quantities and putting it into projectiles. The General Purpose Criterion is seen as an institutional innovation, since the treaty applies to all current and future biological agents.

However, the flexibility introduced by the General Purpose Criterion is imprecise when it comes to the definition of what constitutes peaceful activity. The lack of standards and rules that delimit permitted actions from prohibited ones supplements the inherent difficulty of verifying biological dual-use activities. In contrast to the nuclear case, where the steps toward atomic weapons are known and identifiable, routes to biological weapons are difficult to recognize. Material accountancy measures, like in the nuclear safeguards system, are difficult in the biological field, because quantity thresholds cannot be defined generically. Furthermore, military biological weapon activities can be concealed in seemingly civilian laboratories, requiring, in terms of verification, higher degrees of inspection intrusiveness; most states perceive this as strongly conflicting with the free exchange of scientific knowledge and material guaranteed in the BTWC, and more importantly, with the commercial interests of their biotechnology industries.

Eventually, the problem of balancing the protection of proprietary and national security interests on the one side and detecting clandestine activities on the other drove negotiations on a draft verification protocol in 2001 to a dead end. As a result, the BTWC lacks a centralized and international verification system that produces reliable information about treaty-relevant activities in the state parties. When the treaty was drafted at the end of the 1960s, the negotiators considered the threats from biological weapons to be marginal and did not include a binding verification protocol. However, advances in bioengineering and the life sciences make the dual-use dilemma pervasive and increase the risk of proliferation to state and non-state actors alike. It has become cheap and technologically less demanding to design lethal microorganisms.

Unlike the highly legalized and formalized verification system of the IAEA, a series of auxiliary and decentralized measures is put into place to raise awareness among scientists and policy-makers about hazardous biological agents. State parties share information about biological research and development on a voluntary basis. In regular and scheduled meetings they adopt common understandings and procedures addressing biological agents, protective measures against bioweapons or update their knowledge on recent biotechnological developments.

In addition, BTWC state parties seek cooperation from other international organizations, such as the WHO or the Food and Agriculture Organization, in order to build early warning systems for disease surveillance or to adopt safety and security provisions for handling hazardous biological material. These developments suggest that the BTWC is becoming part of a larger international regulatory network concerned with public health and security (on inter-institutional relations, see Benjamin Faude's article, pp. XX–XX). It remains to be seen whether this networked approach, the few binding regulations and continuously raising awareness can keep up with the new security challenges posed by the considerable progress in the life sciences.

Literature

Lilienthal, David E./Barnard, Chester I./Thomas, Charles A./Oppenheimer, J. Robert/ Winne, Harry A.: A Report on the International Control of Atomic Energy. Washington D.C.: U.S. Government Printing Office1946.

Nixdorff, Kathryn: „Biological Weapons Convention". In: Rudolf Avenhaus/Nicholas Kyriakopoulos/Michel Richard/Gotthard Stein (Eds.): Verifying Treaty Compliance. Limiting Weapons of Mass Destruction and Monitoring Kyoto Protocol Provisions. Berlin/Heidelberg: Springer 2006, pp. 107–134.

Szilard, Leo: „His Version of the Facts". In: Bulletin of the Atomic Scientist, March 1979, Vol. 35, No. 3, pp. 55–59.

Tucker, Jonathan (Ed.): Innovation, Dual Use, and Security: Managing the Risks of Emerging Biological and Chemical Technologies. Cambridge, MA: MIT Press 2012.
Dai, Xinyuan: „Information Systems in Treaty Regimes". In: World Politics, 2002, Vol. 54, No. 4, pp. 405–436.