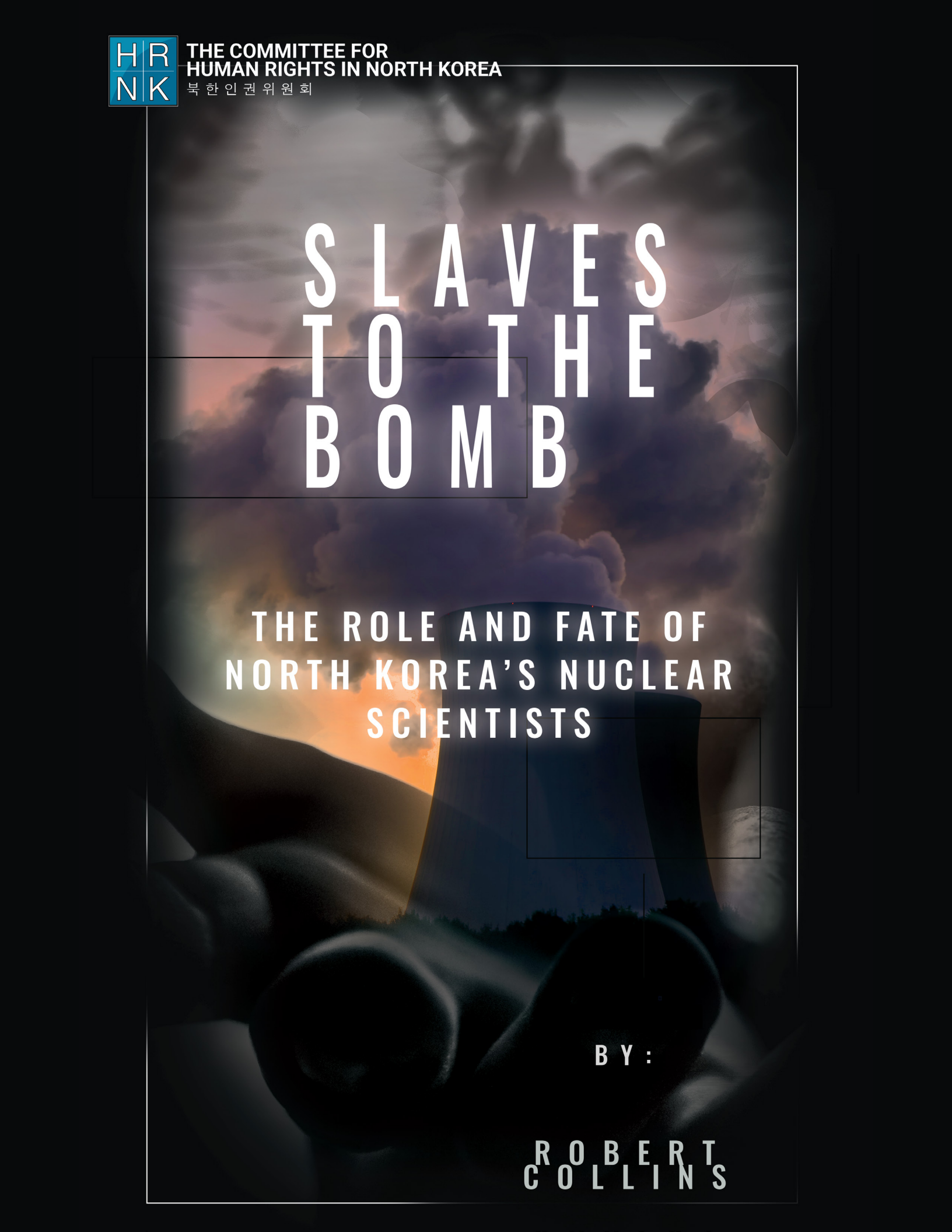
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THE COMMITTEE FOR
HUMAN RIGHTS IN NORTH KOREA
북한인권위원회
SLAVES TO THE BOMB
THE ROLE AND FATE OF NORTH KOREA'S NUCLEAR SCIENTISTS
BY:
ROBERT COLLINS

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ABOUT THE COMMITTEE FOR HUMAN RIGHTS IN NORTH KOREA

The Committee for Human Rights in North Korea (HRNK) is the leading U.S.-based nonpartisan, non-governmental organization (NGO) in the field of North Korean human rights research and advocacy, tasked to focus international attention on human rights abuses in that country. It is HRNK's mission to persistently remind policymakers, opinion leaders, and the general public that more than 20 million North Koreans need our attention. Since its establishment in October 2001, HRNK has played an important intellectual leadership role in North Korean human rights issues by publishing over 60 major reports (available at https://www.hrnk.org/ publications/hrnk-publications.php).

Recent reports have addressed North Korea's system of detention facilities, including its political prison camps, the role of security agencies and key institutions involved in human rights violations, North Korea's practice of dispatching workers overseas, and the connection between security issues and human rights when addressing North Korea.

HRNK received UN ECOSOC consultative status in April 2018. It was also the first organization to propose that the human rights situation in North Korea be addressed by the UN Security Council. HRNK was directly and actively involved in all stages of the process supporting the work of the UN Commission of Inquiry (COI) on North Korean human rights. Its reports have been cited numerous times in the report of the COI, the reports of the UN Special Rapporteur on North Korean human rights, a report by the UN Office of the High Commissioner for Human Rights, two reports of the UN Secretary-General António Guterres, and several U.S. Department of State Democratic People's Republic of Korea Human Rights Reports. HRNK has also regularly been invited to provide expert testimony before the U.S. Congress.

ABOUT THE AUTHOR

Robert M. Collins completed 37 years of service as a soldier and U.S. Department of the Army civilian employee. He served 31 years in various assignments with the U.S. military in Korea, including several liaison positions with the Republic of Korea Armed Forces. Mr. Collins' final assignment was as Chief of Strategy, ROK-US Combined Forces Command, serving the four-star American commander as a political analyst for planning on the Korean Peninsula and Northeast Asian security issues. He received the Sam-il Medal (Republic of Korea Order of National Security Medal, Fourth Class) from President Lee Myungbak and the U.S. Army Decoration for Exceptional Civilian Service by the Secretary of the Army.

Mr. Collins earned a B.A. in Asian History from the University of Maryland in 1977, and an M.A. in International Politics, focusing on North Korean Politics, from Dankook University in 1988.

Mr. Collins is a Senior Advisor at HRNK, where he conducts interviews with North Korean escapees in South Korea to gather information on the North Korean population and the human rights situation in that country. He is the author of *Marked For Life: Songbun, North Korea's Social Classification System*; *Pyongyang Republic: North Korea's Capital of Human Rights Denial*; *From Cradle to Grave: The Path of North Korean Innocents*; *Denied From the Start: Human Rights at the Local Level in North Korea*; *North Korea's Organization and Guidance Department: The Control Tower of Human Rights Denial*; *South Africa's Apartheid and North Korea's Songbun: Parallels in Crimes Against Humanity*; and *Propaganda and Agitation Department: Kim Jong-un Regime's Sword of Indoctrination*, all published by HRNK.

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ACRONYMS

5MWe	5 Megawatt (Reactor)
CEDAW	Convention on the Elimination of All Forms of Discrimination Against Women
CESCR	Committee on Economic, Social and Cultural Rights (UN)
CMC	Central Military Committe (KWP)
CRC	Convention on the Rights of the Child
CRC-OP-SC	Optional Protocol to the Convention on the Rights of the Child on the Sale of Children, Child Prostitution and Child Pornography
CRPD	Convention on the Rights of Persons with Disabilities
DEFCON	Defense Condition
DPRK	Democratic People's Republic of Korea
EU	European Union
GPB	General Political Bureau (KPA)
HIT	Harbin Institute of Technology (PRC)
HTM	Human Terrain Mapping
IAEA	International Atomic Energy Agency
ICBM	Intercontinental Ballistic Missile
ICCPR	International Covenant on Civil and Political Rights
ICESCR	International Covenant on Economic, Social and Cultural Rights
ILO	International Labour Organization
JINR	Joint Institute of Nuclear Research (Soviet Union)
KAST	Korean Association of Science and Technology (Japan)
KCNA	Korean Central News Agency
KCUT	Kim Chaek University of Technology
KEDO	Korean Peninsula Energy Development Organization
KPA	Korean People's Army
KWP	Korean Workers' Party
MID	Munitions Industry Department (KWP)
MOD	Ministry of Defense
MSC	Military Security Command (KPA)
MSS	Ministry of State Security
NAS	National Academy of Sciences
NDC	National Defense Commission (replaced by the SAC)
NDU	National Defense University
NPC	National Planning Committee
NPRI	Nuclear Physics Research Institute
NPT	Treaty on the Non-proliferation of Nuclear Weapons
NWRI	Nuclear Weapons Research Institute

OGD	Organization and Guidance Department (KWP)
PRC	People's Republic of China
RIKEN	The Institute of Physical and Chemical Research (Japan)
ROK	Republic of Korea
S/T	Science and Technology
SAC	State Affairs Commission
SEC	Second Economic Committee (KWP MID)
SED	Science Education Department (KWP)
SLBM	Submarine-launched Ballistic Missile
SPA	Supreme People's Assembly
TPMI	Ten Principles of Monolithic Ideology (since 2013: "Ten Principles for the Establishment of the Party's One-Ideology System")
UDHR	Universal Declaration of Human Rights
UN	United Nations
UNSC	UN Security Council
UNSCR	UNSC Resolution(s)
WHO	World Health Organization
WMD	Weapons of Mass Destruction
WWII	Second World War

FOREWORD

Human rights are not only a moral imperative, but also a national security issue. Kim Jong-un denies the human rights of the Korean people in the north. He also exploits every member of Korean society in brutal ways to increase his power. Nowhere is that more extant than with the nuclear scientists and engineers who design and build nuclear weapons. The entire nuclear weapons program is built on systemic human rights abuses, from mining uranium to testing weapons.

Outsiders likely assume that all nuclear scientists, people of such importance to Kim and the survival of the regime, would be well treated. That turns out not to be the case. This report highlights another of the many wide-ranging and large scale human rights abuses committed by the Kim regime.

Although beyond the scope of this report, the analysis cries out for a new approach to North Korea, its nuclear weapons, and human rights abuses. The international community, and in particular the United States and the Republic of Korea, must take a human rights upfront approach. This report debunks the argument that negotiators should avoid any human rights discussion with North Korea because it might prevent a diplomatic agreement. This report shows that human rights abuses are a central component of the nuclear program, which must therefore be addressed from both a practical and moral perspective. The Kim family regime must be held accountable for these abuses, and for all the abuses documented by the UN COI.

However, the contribution of this report does not end with providing a justification for a human rights upfront approach toward North Korea. Like all HRNK publications, including previous reports by Collins, this report provides a comprehensive overview of all aspects of the nuclear program and the relationship of the nuclear scientists to the rest of North Korea, from the party to the education system to the military.

As bad as the human rights abuses are surrounding the nuclear program, the most dangerous situation is the use of nuclear weapons, either deliberately or accidentally, by the regime and its military or after the collapse of the regime when so-called "loose nukes" could fall into the hands of other bad actors. The use of nuclear weapons will bring a scale of human suffering that we have not seen since the first nuclear weapons were detonated in 1945. And it is likely that the effects of nuclear use would have unprecedented tragic consequences for the region and the world. Therefore, Pyongyang must first be deterred from using them and then the program must be turned over to competent authorities to dismantle it and render it safe.

Collins has mapped the "human terrain" of the nuclear program. Key nuclear scientists are identified. Their education and experience is outlined. The regime's methods of security and social control are described in detail. The information leads to an understanding of the vulnerabilities and weaknesses of the nuclear program. Although beyond the scope of the report itself, the information will inform negotiators on how to discuss the nuclear program with North Korean interlocutors. The North will not be able to deny what is happening within its borders, and this can be exploited during negotiations.

The report can also inform those who are responsible for conducting information and influence activities in North Korea. It will be useful in shaping themes and messages for transmission to all members of the nuclear program to influence them to first ensure the safety of nuclear material weapons and then how to work with competent authorities who arrive to dismantle the program.

The simple knowledge that the outside world knows of their suffering and forced labor on the nuclear program and the understanding that their cooperation will lead to their freedom will contribute to the safe dismantling of the program and the prevention of so-called "loose nukes."

For those with responsibility for locating, securing, and preventing the loss of nuclear material and weapons, this report serves as a roadmap to identify key personnel. By understanding the plight of all personnel involved in the program, they will increase their chances of successful operations across the spectrum of potential conflict.

Lastly, understanding the human elements of the regime's nuclear program will be important for the eventual transitional justice process that will take place. Although this is just one part of Korean society that has suffered human rights abuses, understanding what the Kim family regime has done to the Korean people in pursuit of nuclear weapons to remain in power will contribute important information and evidence for the investigations that must occur in support of transitional justice.

In summary, this report provides critical insights into the regime's nuclear weapons development and how it abuses the Korean people in their pursuit. It will help inform a wide range of organizations that will have to address the many human rights challenges caused by the existence of the Kim dynasty.

David Maxwell
Board Member, *HRNK*
May 17, 2024

EXECUTIVE SUMMARY

This report aims to conduct human terrain mapping (HTM) for North Korea's nuclear program. While it is only an initial assessment, one thing is striking: North Korea's nuclear scientists, engineers, and workers in nuclear laboratories and installations, in uranium mines, and at nuclear weapons testing sites are caught in a forced labor environment. They are deprived of basic freedoms and exposed to grave physical dangers.

To understand the challenges faced by the personnel who are involved in North Korea's nuclear program, it is crucial to understand the recruitment, education, and training processes from the perspective of human rights. This report offers a starting point toward that understanding. It explains the political, sociological, cultural, economic, and security-related aspects of North Korea's nuclear scientists and engineers, with an emphasis on human rights violations. Although there are significant parallels to North Korea's missile program, this report will primarily address the nuclear program. The report proceeds as follows.

Section 1 characterizes North Korea's nuclear scientists and engineers as modern-day slaves of the Kim regime, focusing on the strategic objectives that influenced the nuclear program's development.

Section 2 briefly outlines the history of nuclear weapons development in northern Korea from 1910 to 1945 under Japanese occupation, beginning with Japanese efforts to develop the atomic bomb in present-day Hamhung, North Korea in 1941. This section also discusses the beginnings of North Korea's nuclear weapons program under Kim Il-sung. From 1945 to 1993, Kim established organizational programs and projects that were crucial in training and harnessing the capabilities of North Korea's nuclear scientist corps.

Section 3 provides an overview of the institutions that manage North Korea's nuclear program. It includes organizational charts displaying Korean Workers' Party (KWP) leadership and other entities that hold political and administrative authority over North Korea's weapons of mass destruction (WMD) production and operations.

Section 4 offers insight into the recruitment, education, and training of North Korea's nuclear scientists and engineers. The KWP is responsible for personnel recruitment, education, training, employment assignments, political life, and professional evaluation. From grade school to employment at nuclear facilities, nuclear scientists and engineers are left with no other occupational opportunities. This section also addresses the breadth of North Korea's scientific collaboration with foreign entities, particularly through the participation of North Korean nuclear scientists in overseas training programs.

Section 5 sheds light on the reasoning and importance behind North Korean nuclear scientists' location of employment. For the most part, nuclear scientists and engineers' socio-political classification (*songbun*) and place of work (universities, research institutes, nuclear reactors, nuclear testing sites, and uranium milling facilities and mines) determine their quality of life. This chapter includes a list of sites where nuclear scientists and engineers are assigned.

Section 6 describes the lives of North Korea's nuclear scientists and engineers under Kim Il-sung, Kim Jong-il, and Kim Jong-un. Reports about the "luxurious" lifestyle of nuclear scientists under Kim Jong-il were widely exaggerated. In reality, their lives were generally restricted. In comparison, Kim Jong-un's treatment of North Korean scientists and engineers has been far superior. Despite these improvements, the location of their work sites heavily impacts the provision of benefits. This is tied to the regime's discriminatory *songbun* system.

Section 7 contextualizes the role of foreign assistance and proliferation activities in advancing North Korea's nuclear program. Between 1950 and 1994, the Soviet Union provided critical assistance for the early research and development of North Korea's nuclear program. North Korean nuclear scientists also received significant assistance from ethnic Koreans in Japan, who provided support for nuclear and missile development.

Section 8 describes key individuals in and their contributions to the development of North Korea's nuclear program. It provides a list of current and former leaders of the Kim regime's nuclear program.

Section 9 analyzes the evolving relationship between North Korea's nuclear scientists and engineers and the Korean People's Army (KPA). The growth of North Korea's nuclear capacity has increased the responsibilities and tasks of nuclear scientists. This has complicated their professional and personal lives.

Section 10 explains how North Korea's nuclear weapons program developed at the expense of countless North Koreans working at nuclear program-related facilities. Workers at these facilities are intentionally put at risk by the Kim regime, which knowingly and willfully exposes them to radiation and chemical hazards, with no regard for their health and safety.

Section 11 offers insight into the weaknesses, vulnerabilities, and shortcomings of North Korea's nuclear scientists and engineers, focusing on security, lack of collaboration, education and training, resource shortages, and sanctions. These shortcomings contribute to North Korea's slow progress in developing nuclear weapons, a project that has taken over fifty years to accomplish.

Section 12 provides a legal analysis of the Kim regime's prioritizing of its nuclear weapons program over the welfare of its people, and the regime's human rights denial and abuses that harm North Korea's nuclear scientists, engineers, and their families.

Section 13 concludes by highlighting the critical role that North Korea's nuclear scientists play in maintaining the Kim regime's security and defense. The Kim regime's pursuit of nuclear weapons development continues to have a powerful impact on not only the lives of the personnel involved in North Korea's nuclear weapons program, but also their family members.

SECTION 1: INTRODUCTION

This report is an attempt to conduct human terrain mapping (HTM) with respect to the North Korean nuclear scientist program.[1] HTM involves "characterising cultural, anthropological, and ethnographic information about the human population and human terrain analysis" to develop an understanding of the human terrain. [2]

Moreover, this report also provides the historical context surrounding North Korea's nuclear program. It analyzes the grave predicament of North Korea's nuclear scientists, engineers, and workers who work at nuclear laboratories, uranium mines, nuclear testing sites, and other related installations. To understand the challenges of being a North Korean nuclear scientist, it is crucial to understand the recruitment, education, and training process. This report seeks to contribute to public knowledge of these issues.[3] It focuses on the political, sociological, cultural, economic, and security-related aspects of North Korean nuclear scientists and engineers, with an emphasis on human rights violations.

In addition, this report explains the lifestyle of North Korea's nuclear scientists and engineers, which is characterized by a denial of human rights under the ruling Kim regime. North Korea's scientists and engineers are forced to work on the nuclear weapons program regardless of their own personal interests, preferences, or aspirations. They do not have the freedom to choose their occupations. As such, these individuals may be described as "modern-day slaves" for the Kim regime's nuclear weapons program.[4] Put differently, they are "slaves to the bomb."[5]

1 For example, the United Kingdom's Ministry of Defence defines human geography as: "the branch of geography concerned with how human activity affects or is influenced by the earth's surface." See United Kingdom Ministry of Defence, "Joint Doctrine Note 4/13: Culture and Human Terrain," September 2013. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/819815/archive_doctrine_uk_culture_human_terrain_jdn_4_13.pdf.

2 Ibid.

3 Although there are significant parallels to North Korea's missile program, this report will primarily address HTM issues with respect to the nuclear program.

4 The Slavery Convention (1926) defines slavery as "the status or condition of a person over whom any or all of the powers attaching to the right of ownership are exercised." (UN Office of the High Commissioner for Human Rights, "Slavery Convention," accessed May 4, 2024. https://www.ohchr.org/en/instruments-mechanisms/instruments/slavery-convention.) The UN Human Rights Council has appointed a Special Rapporteur to address "contemporary forms" of slavery.

5 Image from *Rodong Sinmun*, as published at Hwang Sook-hye, "북한 지하 핵시설 가동 불가 - 中과학기술대" [Chinese Researchers Say N. Korea's Underground Nuclear Test Site is Unusable], *Newspim*, April 26, 2018. https://www.newspim.com/news/view/20180426000004.

Historical Context

In his New Year's address on January 1, 2018, Kim Jong-un made the following statement:

> *We have realized the wish of the great leaders who devoted their lives to building the strongest national defense capability to reliably safeguard our country's sovereignty, and we have created a mighty sword for defending peace, as desired by all our people who had to tighten their belts for long years.*[6]

The term "mighty sword" is a clear reference to North Korea's nuclear weapons.[7]

North Korea's success at acquiring the capability to target northeast Asia and the United States with nuclear warheads came after painstaking—and frequently mismanaged—efforts at nuclear development. These efforts sacrificed the welfare of the North Korean people, who endured a poor quality of life due to the regime's focus on the nuclear program. North Korea's nuclear scientists and engineers were no different. The KWP exercised complete control over their lives from their pre-teen years onward.

The founding of the North Korean state—the Democratic People's Republic of Korea (DPRK)—was closely related to two significant events in the history of nuclear weapons. The United States' use of atomic bombs against Japan in August 1945 led to Japan's surrender, thus ending not only the Second World War, but also the Japanese occupation of the Korean Peninsula.[8]

This was followed by the division of the peninsula between a U.S.-dominated south and a Soviet Union-dominated north. Secondly, during the Korean War (1950–53), U.S. military leaders publicly called for the use of nuclear weapons against the People's Republic of China (PRC) forces that had entered the war. Although nuclear weapons were not used, these events heavily influenced Kim Il-sung's understanding of military strategy and national defense.

Consequently, throughout his rule, Kim Il-sung sought to improve North Korea's nuclear capabilities.[9] He had no choice but to start from scratch and find scientists who could lead North Korea's nuclear program. Furthermore, the U.S. military's deployment of nuclear weapons in South Korea during the late 1950s no doubt reinforced Kim Il-sung's desire to develop his own nuclear program.[10] Kim Jong-il, Kim Il-sung's son and successor, stated on October 8, 2011—two months before his death—that North Korea needed sufficient nuclear, chemical, and biological weapons, as well as long-range missiles, to maintain peace on the Korean Peninsula.[11]

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6 Jong Kyo-jin, "The Nuclear Legacies of Kim Il Sung and Kim Jong Il," *Daily NK*, October 17, 2018. https://www.dailynk.com/english/the-nuclear-legacies-of-kim-il-sung-and-kim-jong-il/.

7 "Kim Jong Un's 2018 New Year's Address," *National Committee on North Korea*, January 1, 2018. https://www.ncnk.org/node/1427.

8 Kim Dong-won, "Imaginary Savior: the image of the nuclear bomb in Korea, 1945-1960," *International Journal of the History of Science Society of Japan* 19, no. 2 (2009): 105-18.

9 Joseph S. Bermudez Jr., "North Korea's Strategic Culture," October 31, 2006. https://irp.fas.org/agency/dod/dtra/dprk.pdf.

10 Lee Dong-hoon, "이승만, 1958년 미 전술핵 최초로 반입했다" [Syngman Rhee First Brought in U.S. Tactical Nuclear Weapons in 1958], *Weekly Chosun*, May 6, 2023. https://weekly.chosun.com/news/articleView.html?idxno=26165.

11 Kwon Yang-joo, ""북한의 대량살상무기 (WMD) 개발 관련 당-군 관계 조명" [Focusing on Party-Military Relations Related to North Korea's WMD Development], *Korea Institute of Defense Analysis*, April 29, 2013, 1–11.

From the very beginning of the Kim family regime, Kim Il-sung's teachings on nuclear development have taken priority over the welfare and human rights of the population. His approach to developing nuclear weapons was highly constrained by resource shortfalls, particularly with respect to expert personnel. Consequently, he began the nuclear program by training and educating personnel. Because of North Korea's highly centralized political system, Kim Il-sung could compel individuals to focus on relevant fields of study. The Kim regime uses the KWP to oversee every aspect of its nuclear program. In doing so, it controls all aspects of the lives of nuclear scientists and engineers.

The essence of North Korea's political structure is that the Supreme Leader (*Suryong*) leads the KWP, which controls the government. Kim Il-sung and Kim Jong-il both saw the WMD program as a means for regime security against real and perceived threats, particularly the United States and the Republic of Korea (ROK or South Korea).[12] Kim Jong-un, as Supreme Leader, leads both the KWP and the State Affairs Commission (SAC). The lives of the scientists and engineers involved in the WMD program, as well as that of their families, are impacted by both chains of authority.

The KWP is ultimately responsible for the recruitment, education, training, employment assignments, political life, and professional evaluation of North Korea's nuclear scientists and engineers. The SAC is responsible for the professional management of national defense. It determines goals and tasks for the WMD program, as well as areas that need to be prioritized by relevant personnel. While the KWP demands political participation and loyalty from the scientists, the government demands professional performance. Unsurprisingly, there is frequent conflict between these two demands.

For Kim Jong-un's part, he has expressed significant pride in the development of WMDs:

> *We will develop new strategic weapon systems, including atomic bombs, hydrogen and intercontinental ballistic missiles. Our defense industry and self-defense power has been enormously strengthened at an extraordinary speed, and our republic will become the world's strongest nuclear power and a military power. We will fight for it.*[13]

As he announced at a KWP Central Military Committee (CMC) meeting in April 2013, one of the goals of the regime's nuclear program is to develop five variants of nuclear weaponry—hydrogen bombs, nuclear-capable mobile inter-continental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), nuclear torpedoes, and nuclear backpacks. Kim also stated that he believes Americans will not want to engage in a nuclear conflict and that "the U.S. would rather go back home." Kim's intent is to increase North Korea's "striking power."[14] After the successful test of the Hwasong-15 ICBM on November 29, 2017, Kim and the Party Central Committee boasted that it had "achieved new great victories by vigorously leading the struggle for upgrading the nuclear force."[15]

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12 Joseph S. Bermudez Jr., "North Korea's Development of a Nuclear Weapons Strategy," *38 North*, 2015, 8. https://www.38north.org/wp-content/uploads/2015/08/NKNF_Nuclear-Weapons-Strategy_Bermudez.pdf.

13 Chris Kitching, "North Korea 'to launch another ballistic missile this weekend as it marks death of Kim Jong-un's dad'," *The Mirror*, December 16, 2017. http://www.mirror.co.uk/news/world-news/north-korea-to-launch-another-11704739.

14 Pak Jin-yo, "SLBM 손에 쥔 북, 다음 개발할 병기는 '핵어뢰'" [North Korea Has the SLBM in Its Hand, Next Weapons Development Is "Nuclear Torpedo"'], *Dailian*, September 1, 2016. http://www.dailian.co.kr/news/view/588016.

15 "On Report Made by Supreme Leader Kim Jong Un at Eighth Party Congress of WPK," *National Committee on North Korea*, January 25, 2021. https://www.ncnk.org/resources/publications/kju_8th_party_congress_speech_summary.pdf/file_view.

Human Rights Context

As the only state to withdraw from the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), North Korea has shown it has no intent to respect international norms.[16] To be sure, North Korea does not even follow its own rules. Although the Constitution of the DPRK guarantees a range of human rights, this is not implemented in the Kim regime's policies.[17] North Korea has signed or acceded to the International Covenant on Economic, Social and Cultural Rights (ICESCR), the International Covenant on Civil and Political Rights (ICCPR), the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW), the Convention on the Rights of Persons with Disabilities (CRPD), the Convention on the Rights of the Child (CRC), as well as the Optional Protocol to the Convention on the Rights of the Child on the Sale of Children, Child Prostitution and Child Pornography (CRC-OP-SC). However, it does not observe these covenants in practice.

Though relatively small in number, nuclear scientists and engineers play a significant role in North Korea. One estimate from 2010 put the total number of nuclear-related personnel at 6,000.[18] North Korea's nuclear scientists and engineers—the "slaves to the bomb"—are compelled from grade school until the end of their lives to serve the Kim regime's nuclear weapons program in any way they are directed. This includes studying nuclear program-related subjects, living where they are told, marrying who they are told, eating what they are provided, confessing weekly to their shortcomings relative to regime ideology and workplace performance, working in unsafe conditions, illegally proliferating nuclear technology, and even committing espionage.

While one would think that nuclear scientists and engineers hold a prestigious place in North Korean society due to their specialized skills and contributions to the regime's objectives, that is not the case. As such, the treatment of Kim's "slaves to the bomb" reflects the rigid structure of the North Korean regime and constitutes violations of international human rights law. This report argues that the regime's nuclear scientists and their families do not enjoy the rights and freedoms that North Korea is obligated to protect as a state party to the ICCPR and ICESCR.

The most unique aspect of North Korea's nuclear program is the KWP's oversight of the program. The KWP recruits, trains, employs, and controls all nuclear scientists and engineers in North Korea. Specifically, the KWP Science Education Department (SED) oversees recruitment and training, while the KWP Munitions Industry Department (MID) manages employment assignments, except for those in educational institutions. North Korea's nuclear scientists and engineers can only work on developing nuclear weapons or training personnel who will join the nuclear weapons program. The regime has not utilized these specialized personnel to harness nuclear energy for economic development, which would bring broader benefits for the North Korean people. Instead, the regime has focused on the production of weapons-grade plutonium and highly enriched uranium to create nuclear warheads. In every way, North Korea's nuclear weapons program reflects the regime's policy of human rights denial.

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16 Kongdan Oh and Ralph C. Hassig, "North Korea: A Rogue State Outside the NPT Fold," *The Brookings Institution*, March 1, 2005. https://www.brookings.edu/articles/north-korea-a-rogue-state-outside-the-npt-fold/.

17 "Socialist Constitution of the Democratic People's Republic of Korea (조선민주주의인민공화국 사회주의헌법)," *Naenara* (translated by *NCNK*, May 1, 2020). https://www.ncnk.org/sites/default/files/DPRK%20constitution%20%282019%29.pdf.

18 Hong Hee-jeong, "북한 핵 관련 전문 인력 6,000명" [6,000 Nuclear-related Personnel in North Korea], *KBS News,* March 16, 2010. https://news.kbs.co.kr/news/view.do?ncd=2063818.

SECTION 2: ORIGINS OF NORTH KOREA'S NUCLEAR PROGRAM

The history of North Korea's nuclear program begins during the Japanese occupation, prior to the founding of the DPRK in 1948. Japan embarked on a nuclear weapons program in April 1941, and its Institute of Physical and Chemical Research (RIKEN) was central to these efforts.[19] Japan built a graphite electrode factory in North Korea at Hamhung, where Japan built a major industrial center far from the front lines of World War II.[20] In Hamhung, they developed a graphite moderator using natural uranium and graphite, which are both abundant in North Korea's natural mineral ore deposits.[21]

After it surrendered, Japan immediately began dismantling all nuclear research facilities in Hamhung to avoid them falling into the hands of the Soviet Union. Japan also tried to ship 3–5 tons of 4% uranium ore through Incheon at the end of the war, but this was stopped by the United States. The Soviet Union eventually took advantage of Korea's ore deposits and shipped some of the ore back to the Soviet Union, and China did the same.[22] According to a declassified 1951 document from the U.S. Far East Command, the Soviet Union mined and took away 28,000 tons of monzonite, an important source of uranium, from North Korea between 1949 and 1950.[23]

North Korea's first recruitment efforts at finding key human assets in physics, mathematics, engineering, and chemistry took place immediately after the establishment of the Soviet military government in the northern half of the Korean Peninsula. During the Japanese occupation of Korea (1910–45), there were only around 500 Koreans who had pursued higher education in science and technology. A handful—approximately ten—of these students had majored in physics.[24] Before Korea's liberation from Japan, most scientific studies among Koreans had been conducted in the southern half of the peninsula. However, in the political chaos that followed liberation and the advent of the Korean War, many scientists moved north. These individuals laid the foundations of North Korea's science and technology sector, including the country's nuclear program.[25]

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19 RIKEN, "The RIKEN Story," accessed March 31, 2022. https://www.riken.jp/en/about/history/story/.

20 Robert K. Wilcox, *Japan's Secret War: How Japan's Race to Build Its Own Atomic Bomb Provided the Groundwork for North Korea's Nuclear Program* (New York: William Morrow & Co., 1985).

21 Some sources claim that Japanese scientists successfully tested an atomic bomb in Hamhung harbor as World War II neared its end, but the sourcing on this is questionable.

22 Lee Choon-kun and Jong-seon Kim, "Bukhan-ui haek mit rocket gisool gaebal-gwa hyanghu jeonmang" [Outlook on North Korea's Nuclear and Rocket Technology Development and Future], *STEPI Insight* 22 (May 2009). https://www.dbpia.co.kr/Journal/articleDetail?nodeId=NODE06285532; Bill Streifer, "Hungnam, North Korea: Delving into Pyongyang's Long Nuclear Past," *National Security News Service*, June 15, 2013. https://www.academia.edu/3813672/Hungnam_North_Korea_Delving_into_Pyongyang_s_Long_Nuclear_Past; and Wilcox, *Japan's Secret War*.

23 Shin Yoon-seok, "일제 개발 북한 광산서/구 소, 우라늄 대량 채굴" [The Soviet Union Mined Large Amounts of Uranium from Mines in North Korea Developed by Imperial Japan], *Hankook Ilbo*, August 8, 1996. https://www.hankookilbo.com/News/Read/199608080042067929.

24 Kang Ho-je, "도상록 - 북한 핵물리학의 아버지" [Do Sang-rok – Father of North Korea's Nuclear Physics], *North Korea's Science & Technology with Dr. Kang*, March 31, 2017. https://nktech.tistory.com/entry/3-%EB%8F%84%EC%83%81%EB%A1%9D%EB%B6%81%ED%95%9C%ED%95%B5%EB%AC%BC%EB%A6%AC%ED%95%99%EC%9D%98-%EC%95%84%EB%B2%84%EC%A7%80.

25 "북한 과학기술분야의 기초를 쌓은 사람들" [The People Who Laid the Foundations of North Korea's Science and Technology], *NK Tech*, August 1, 2003. http://www.nktech.net/inform/nkt_briefing/nkt_briefing_v.jsp?record_no=11.

The most notable members of this group include Do Sang-rok, Ri Sung-gi, and Han In-seok (see Annex I). They were recruited by Ri Hak-mun, a two-time national hero medal winner, who Kim Il-sung sent to southern Korea to recruit scientists to help with North Korea's severe lack of scientific talent.[26] Others include Kim Ji-jung in mathematics, Kim Yong-ho in chemistry, and Kim Ryang-ha in agriculture. Kim Ji-jung graduated from Tokyo Imperial University Science Department's Mathematics Section in 1935. He was eventually appointed as the Kim Il-sung University's Department Chair of Mathematics. Chong Jun-taek was a leader in the mining industry and was also designated a "Hero of the Republic" before dying of a heart attack in 1973. Choi Song-se, a leader in electricity and hydropower, was responsible for building these systems for Pyongyang. Kang Yong-sang made similar contributions in the metals industry.[27]

In particular, Do Sang-rok is considered the father of North Korea's nuclear program.[28] Do was born on October 13, 1903 in Hamhung, South Hamgyong Province. He graduated from high school in Okayama, Japan in 1925 and attended Tokyo Imperial University, where he graduated in 1930 with a degree in physics. In the early 1940s, Do taught at Shingyeong Engineering University in Manchuria. After liberation from Japanese colonial rule, Do became the Dean of the Engineering College at Kyongsong University, the predecessor to Seoul National University. However, he was dismissed from that position in June 1946 due to his involvement in a leftist movement as part of the *Gukdaean* incident.[29] He went to Pyongyang and met with Kim Il-sung on July 3, 1946, where he was appointed to the preparation committee for the establishment of Kim Il-sung University. Do established North Korea's first nuclear physics organization at the Kim Il-sung University Physics Department.[30] Do then became the Dean of the Physics and Math Department in 1946 and served there until he passed away in 1990.[31]

According to historians of Korea's science and technology, there were only about 200 scientists and engineers in Korea at the end of the Japanese occupation in 1945. Of these 200, 80 went north. The table below identifies these individuals.[32] These individuals came to form the core of North Korea's science and technology sector. They were deeply involved in the establishment of the country's first research institutions and engineering schools.[33]

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26 Streifer, "Hungnam, North Korea."

27 "The People Who Laid the Foundations of North Korea's Science and Technology," *NK Tech*.

28 Stephan Haggard, "History Lessons I: Walter Grunden on Japan's Nuclear Past," *Peterson Institute for International Economics*, August 15, 2013.
https://www.piie.com/blogs/north-korea-witness-transformation/history-lessons-i-walter-grunden-japans-nuclear-past.

29 *Gukdaean* is the Korean-language acronym for the "Plan to Establish a Comprehensive National University," which was announced by the U.S. Army Military Government in Korea (1945–48). Under this plan, Kyongsong University and several professional schools were to be combined into a single university. Many professors and students opposed the plan, including those with leftist ideological leanings. See Kim Tae-ho, "[구석구석 과학사] (17) 많은 과학자들이 남한을 떠난 까닭은" [Why Many Scientists Left South Korea], *Weekly Kyunghyang*, October 24, 2017.
https://weekly.khan.co.kr/khnm.html?mode=view&artid=201710161925221&code=116.

30 Im Gyong-sun, "해방 직후 대학의 물리학과" [Korea's Physics Departments Immediately After Liberation], *The Korean Physical Society Webzine* 12, no. 1/2 (January/February 2003): 38–39. https://webzine.kps.or.kr/inc/down.php?fileIdx=7886.

31 "The People Who Laid the Foundations of North Korea's Science and Technology," *NK Tech*.

32 This table is translated directly from Kim Yo-sep, "북한으로 간 80인의 과학기술자…사상으로 쇠락" [The 80 Scientists and Engineers Who Went North...Corrupted by Ideology], *Hello DD*, June 24, 2010.
https://www.hellodd.com/news/articleView.html?idxno=31486.

33 Ibid.

Table 1: College-Educated Scientists & Engineers Who Went to North Korea	
Major	**Name (University of Origin)**
Mathematics (7)	Kim Ji-jung, Yoo Chung-ho (Tokyo Imperial University); Jung Sun-taek, Choi Jong-hwan (Tohoku Imperial University); Hong Seong-hae (Kyushu Imperial University); Han Pil-ha (Osaka Imperial University); Lee Jae-gon (unidentified)
Physics (11)	Do Sang-rok, Lee Nak-bok (Tokyo Imperial University); Shin Keon-hee, Son Won-rok, Han Geon-ha (Kyoto Imperial University); Im Geuk-je, Han In-seok (Tohoku Imperial University); Jeon Pyeong-soo (Hokkaido Imperial University); Jeong Geun, Lee Yong-tae (Gyeongseong Imperial University); Lee Hong-guk (Gyeongseong University)
Chemistry (6)	Kim Yang-ha (Tokyo Imperial University, Ph.D.); Choi Sam-yeol, Kim Yong-ho (Tohoku Imperial University); Kim Nae-soo (Nagoya Imperial University); Lee Yong-gyu (University of Nebraska); Oh Tae-ho (Gyeongseong University)
Biology (2)	Han Hyung-ki (Tokyo Imperial University); Seon-u Gi (Hokkaido Imperial University)
Geology (3)	Joo Soo-dal (Kyoto Imperial University); Yoon Seok-gyu, Park Seong-wook (Gyeongseong University)
Chemical Engineering (13)	Lee Se-hun (Tokyo Imperial University); Lee Seung-gi (Ph.D.), Oh Dong-wook, Lee Jae-up, Lee Gye-soo, Kim Tae-yeol, Song Beop-seop, Lee Chang-jik (Kyoto Imperial University); Yoo Han-sang, Yeo Kyung-gu (Waseda University); Ma Hyung-wook (Taihoku Imperial University); Kim Seong-hee, Cho Dong-gyu (Gyeongseong University); Kim Hyun-bong (Tokyo Institute of Technology) Lee Si-hyun (Tokyo Imperial University); Choi Yoo-gil (Tokyo Institute of Technology); Kim Deok-mo, Choi Chang-ha, Sin Jong-lib, Hwang Deok-ro (Waseda University); Yoo Ki-yeon, Kang Young-chang (Ryojun College of Engineering); Kim Eun-seong, Lee Moon-hae , Hwang Gyu-hyuk (Gyeongseong Imperial University); Lee Byung-gu, Hwang Gyu-cheol (Gyeongseong University)
Electrical Engineering (14)	Choi Seong-se (Tokyo Imperial University); Jeong Se-kwan (unidentified); Bae Joon-ho, Yeo Byeong-yoon (Kyoto Imperial University); Kim Jae-do (Tokyo Institute of Technology); Lee Seong-do, Shin Taek-hee (Waseda University); Doo Soon-jong, Kim Doo-sam (Ryojun College of Engineering); Lee Yong-gyu, Lee Han-hee, Son Tae-sik (Gyeongseong Imperial University); Kim Young-dal, Lee Jong-doo (Gyeongseong University)
Civil Engineering (5)	Kim Si-on (Tokyo Imperial University); Seo Do-won (Kyoto Imperial University); Jeong Hyun-sook (Gyeongseong Imperial University); Choi Tae-hee (Tokyo Institute of Technology); Kim Woong-sang (Japanese University)
Mining & Metallurgy (8)	Kim Jae-eul (Kyoto Imperial University); Ryu Jong-geun (Hokkaido Imperial University); Yoo Sang-joon (Waseda University); Jung Jun-taek, Jeong Won-mo, Han Se-hwan (Ryojun College of Engineering); Lee Jae-byung (Gyeongseong Imperial University)

Soon after the founding of the DPRK in 1948, the North Korean regime established official institutions to oversee the administration of science and technology, as well as scientific research. This includes the State Science and Technology Committee (국가과학기술위원회), the Academy of Sciences (과학원), the National Planning Committee (NPC; 국가계획위원회), and the Second Academy of Natural Sciences (제2자연과학원).[34] In particular, the Academy of Sciences was established in December 1952, during the Korean War.[35] The KWP also established the Science Education Department to provide policy guidance for science and technology. These institutions divided duties and functions, but there is some natural friction between them.[36] From the start, Kim Il-sung emphasized KWP guidance over all aspects of science and technology.[37]

North Korea's interest in a nuclear program began in earnest during the Korean War. The Atomic Energy Research Institute was established under the Academy of Sciences in 1952.[38] Through this institute, North Korea began to develop the institutional capacity to train nuclear scientists and engineers.[39] In 1954, the Korean People's Army (KPA) established the Nuclear Weapons Defense Bureau. Kim Il-sung University began nuclear physics lectures at its Physics Department in 1955. The next year, the graduate school opened the Mathematics and Physics Research Institute and the Nuclear Physics Test Facility.[40]

In April 1955, the Nuclear Physics Research Institute (NPRI; 핵물리연구소) was established at the second meeting of the Academy of Sciences. Later that year, representatives of the Academy of Sciences attended an academic conference in the Eastern Bloc on the "peaceful use of nuclear energy."[41] In March 1956, the Soviet Union and North Korea signed a nuclear research agreement. Following this agreement, 30 North Korean scientists were sent to the Soviet Union's Joint Institute of Nuclear Research (JINR) in Dubna, outside Moscow, where they studied electronic physics, high-energy physics, radiochemistry, and radiation chemistry. Overall, more than 300 North Korean engineers and physicists eventually completed training courses at Soviet institutes, particularly at the JINR, the Moscow Engineering Physics Institute, and the Bauman Moscow State Technical University.[42]

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34 According to a 2017 *Yonhap News* article, this has been renamed to the Academy of National Defense Science (국방과학원). See Kim Hyo-jeong, "[단독]'北 무기개발기관 제2자연과학원, 국방과학원으로 개칭'" [North Korea's Weapons Development Agency, the 2nd Academy of Natural Sciences, Renamed the Academy of National Defense Science], *Yonhap News*, March 20, 2017. https://www.yna.co.kr/view/AKR20170320071700014.

35 Kang Ho-je, "4차 핵시험의 핵심: ③ 북한 핵물리학의 역사" [Key to the 4th Nuclear Test: History of N. Korea's Nuclear Physics], *Jajusibo*, February 24, 2016. http://www.jajusibo.com/26058.

36 Lee Choon-kun, *Bukhan haekmunje-ui gwahak gisuljeok e-hae* [Scientific and Technological Understanding of North Korea's Nuclear Issue] (Seoul: Science and Technology Policy Institute, 2003). https://www.dbpia.co.kr/journal/articleDetail?nodeId=NODE06286313.

37 Kim Il-sung, *Woorinara-ui gwahak gisool-ul baljeon sikil-de daehayo* [On Developing Our Country's Science and Technology] (Pyongyang: Korean Workers' Party Publishing Company, 1986), 444. In North Korea, Kim Il-sung's words carry the weight of law. His writings and statements are recorded in *Kim Il-sung's Works* by the KWP and are employed as guidance in every field of endeavor in the North Korean state, Party, military, and society. Violating or publicly opposing these words is subject to judicial or extrajudicial punishment.

38 Nuclear Threat Initiative, "North Korea: Atomic Energy Research Institute," accessed March 31, 2022. https://www.nti.org/education-center/facilities/atomic-energy-research-institute/.

39 Park Yong-chae, "관심 쏠린 원전기술 / 北발전설비 상당부분 국산화" [Focus on Nuclear Technology: the North Produces Most Electricity Themselves], *Kyunghyang Sinmun*, June 21, 1994.

40 Lee and Kim, "Outlook on North Korea's Nuclear and Rocket Technology Development and Future."

41 Choi Young-myeong et al., *A Study on the Status of Nuclear Development and Utilization in North Korea* (Daejeon: Korea Atomic Energy Research Institute, 1993), 39. https://inis.iaea.org/collection/NCLCollectionStore/_Public/26/012/26012129.pdf.

42 There are some reporting discrepancies on the total number, ranging from 250 to over 300. See Walter C. Clemens Jr., "North Korea's Quest for Nuclear Weapons: New Historical Evidence," *Journal of East Asian Studies* 10, no. 1 (April 2010): 129.

In 1957, North Korea's first Science and Technology Plan, entitled the "Science Development 10-Year Plan," included research into underground resources, including uranium. In 1959, North Korea and China signed a Nuclear Energy Agreement, and North Korea sent personnel to China to conduct basic research.[43] Upon the return of these scientists in 1962, North Korea established the Nuclear Energy Research Institute (원자력연구소) in Yongbyon and Pakchon. A few scientists also studied in East Germany, Canada, Japan, and China.

In 1959, the Soviet Union and North Korea signed an agreement on cooperation in the field of atomic energy, laying the foundation for joint nuclear activities. Referred to as the "Series 9559" contracts, the agreement led to the construction of a nuclear research center near Yongbyon on the Guryong River and the training of North Korean laborers. At the time, this facility was referred to by the code name "The Furniture Factory" by North Koreans.[44]

In 1962, the year that the Nuclear Energy Research Institute was founded in Yongbyon, Kim Il-sung University and Kim Chaek University of Technology (KCUT) both initiated their nuclear research programs to educate North Korea's next generation of nuclear physicists. North Korean leaders then began discussing their nuclear program in earnest.[45]

North Korea's first nuclear reactor was a 2-megawatt IRT-2000, built at Yongbyon with Soviet assistance in 1964–65. The design is based on a submerged active zone under light or heavy water, which enables the reactor to serve as a neutron reflector, moderator, coolant, and biological shield.[46] The reactor normalized operations by 1967 and provided North Korean nuclear scientists and engineers an excellent training platform, laying the foundation for North Korea's nuclear competency. In 1968, the Soviet Union provided a 0.1MWt small critical facility to the Yongbyon Complex that enabled the study of nuclear fission.[47] The Soviets also built the Yongbyon Nuclear Energy Research Institute. These efforts were critical in training and utilizing the capabilities of North Korea's new nuclear scientist corps.[48]

In the 1970s, North Korea developed an interest in graphite-moderated reactors due to their abundant underground reserves of both uranium and graphite. The regime began to expand research into developing a nuclear fuel conversion cycle, including uranium processing, conversion, and manufacturing. In 1975, it produced its first gram of plutonium. To expand the education of its scientists and engineers, Kim Il-sung University established a Nuclear Physics Section in its Physics Department and a Radiochemistry Section in its Chemistry Department. KCUT established a Nuclear Electrical Engineering Department and a Nuclear Reactor Engineering Department. Kim Il-sung University also began to translate foreign textbooks on

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43 Park, "Focus on Nuclear Technology: The North Produces Most Electricity Themselves"; Nuclear Threat Initiative, "North Korea Nuclear Overview," October 11, 2018. https://www.nti.org/analysis/articles/north-korea-nuclear/.

44 Clemens, "North Korea's Quest for Nuclear Weapons," 127–54.

45 Lee Choon-kun, "북한 핵개발의 역사와 논리 그리고 대책" [History of N. Korea's Nuclear Development: Logic and Countermeasures], *Chogabje.com*, April 3, 2013. http://chogabje.com/board/view.asp?C_IDX=50370&C_CC=AB.

46 Oleg Shcheka, "Could North Korea Suffer Its Own Chernobyl Disaster?," *The National Interest*, August 25, 2020. https://nationalinterest.org/blog/reboot/could-north-korea-suffer-its-own-chernobyl-disaster-167631.

47 Joseph S. Bermudez Jr., "Yongbyon Declassified Part V: Expansion Begins Across the Kuryong-gang," *Beyond Parallel*, September 25, 2019. https://beyondparallel.csis.org/yongbyon-declassified-part-v-expansion-begins-across-the-kuryong-gang/.

48 The International Institute for Strategic Studies, *North Korea's Nuclear Weapons Programme*, March 14, 2013. http://web.archive.org/web/20130314045542/http://www.iiss.org/publications/strategic-dossiers/north-korean-dossier/north-koreas-weapons-programmes-a-net-asses/north-koreas-nuclear-weapons-programme/.

nuclear science to increase the quality of its own textbooks. North Korea also founded a number of research centers at the Yongbyon Nuclear Complex during this time, enabling the training of specialized staff and technical workers. It enacted a Nuclear Energy Law in March 1974, and began to legally acquire related equipment after joining the International Atomic Energy Agency (IAEA).[49]

In the early-to-mid 1980s, North Korea shifted from research to production. At a national convention of scientists in 1981, there was an emphasis on using domestic resources with regards to nuclear power. North Korea started work on a graphite-moderated reactor using natural uranium and graphite. However, the key development of this period was that important educational and research institutions in applied sciences were relocated to Yongbyon. For example, KCUT moved its elite courses from the Physics Engineering and Applied Mathematics Departments to the newly established College of Physics in Yongbyon, where the Applied Science and Nuclear Electronics Departments were established.[50] This enabled nuclear scientists to centralize their knowledge and experience to enhance the training of current and future personnel. Moreover, the National Academy of Sciences (NAS) and the College of Science in Pyongsong, which performed basic research in applied science, also moved this function to Yongbyon.[51]

In 1986, with substantial Soviet assistance, North Korea completed the construction of a 5-Megawatt Reactor (5MWe) that enabled North Korea's scientists to develop weapons-grade plutonium. This was a major development in North Korea's nuclear program, and it highlighted the regime's technical capabilities. By this time, North Korea had developed a self-contained education and training complex for the community of engineers at Yongbyon that would provide the foundation for nuclear weapons development. In 1987, the Yongbyon nuclear facilities were placed under the control of the KWP Munitions Industry Department (MID), which provided overall management and political guidance.[52] North Korea conducted 130 high-explosive tests near Yongbyon from 1983 to 1993 in support of developing nuclear weapons.[53]

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49 Lee, "Scientific and Technological Understanding of North Korea's Nuclear Issue," 11-12; Lee and Kim, "Outlook on North Korea's Nuclear and Rocket Technology Development and Future."

50 Lee and Kim, "Outlook on North Korea's Nuclear and Rocket Technology Development and Future."

51 Ibid.

52 Lee Choon-kun, "북한의 핵무기 개발과 능력" [North Korea's Nuclear Development and Capabilities], *NAPSNet Special Reports*, May 11, 2015. https://nautilus.org/napsnet/napsnet-special-reports/%eb%b6%81%ed%95%9c%ec%9d%98-%ed%95%b5%eb%ac%b4%ea%b8%b0-%ea%b0%9c%eb%b0%9c%ea%b3%bc-%eb%8a%a5%eb%a0%a5/.

53 Kim Pil-jae, "북한 핵(核)무기 개발사... 극비리에 '해저 核시설' 건설" [History of North Korea's Nuclear Weapons Development...Secret Construction of Undersea Facilities], *Chogabje.com*, July 22, 2016. http://www.chogabje.com/board/view.asp?C_IDX=55731&C_CC=AB.

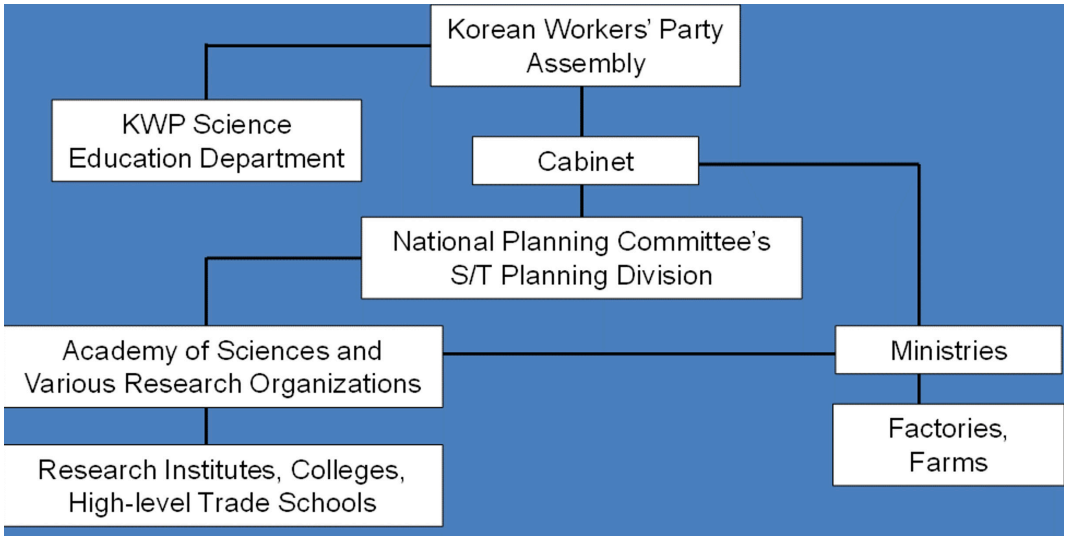
SECTION 3: STRUCTURE OF NORTH KOREA'S NUCLEAR PROGRAM

North Korea is under the absolute control of a single individual: the *Suryong* (Supreme Leader). Its byzantine political institutions overlay political control onto administrative jurisdiction. For every organization in North Korea, there is a lead department or ministry responsible for production or operations. The KWP controls these activities by funneling resources, decisions, and policy guidance to subordinate committees and commissions that exercise oversight over government ministries, departments, and agencies. The following chart depicts the Kim regime's authority structure.[54]

North Korea's governing apparatus is a Party-led structure committed to the Supreme Leader's dictatorial rule. There is little room for consensus-building. The regime's ideology dominates official decision-making and the daily lives of every North Korean, including that of the country's nuclear scientists and engineers.

The KWP exercises primary control over operational, fiscal, and personnel issues that impact cadres at all levels of the government, military, and Party-led organizations. The regime's leadership controls all three areas, thus complicating the decision-making structure from the perspective of the Supreme Leader. North Korea's WMD program is no different. All nuclear, missile, and bio-chemical weapons scientists, engineers, military personnel, and workers are subject to this oversight. Cadre at the mid-to-lower levels suppress initiative and creativity, placing political loyalty above all else. Every North Korean scientist and engineer is held accountable under this system and must carefully balance the regime's demands for political loyalty with national tasks. Political loyalty comes first in their lives, despite inadequate support from the regime for both their professional and personal lives.

54 Author's rendition of the Kim regime's authority structure.



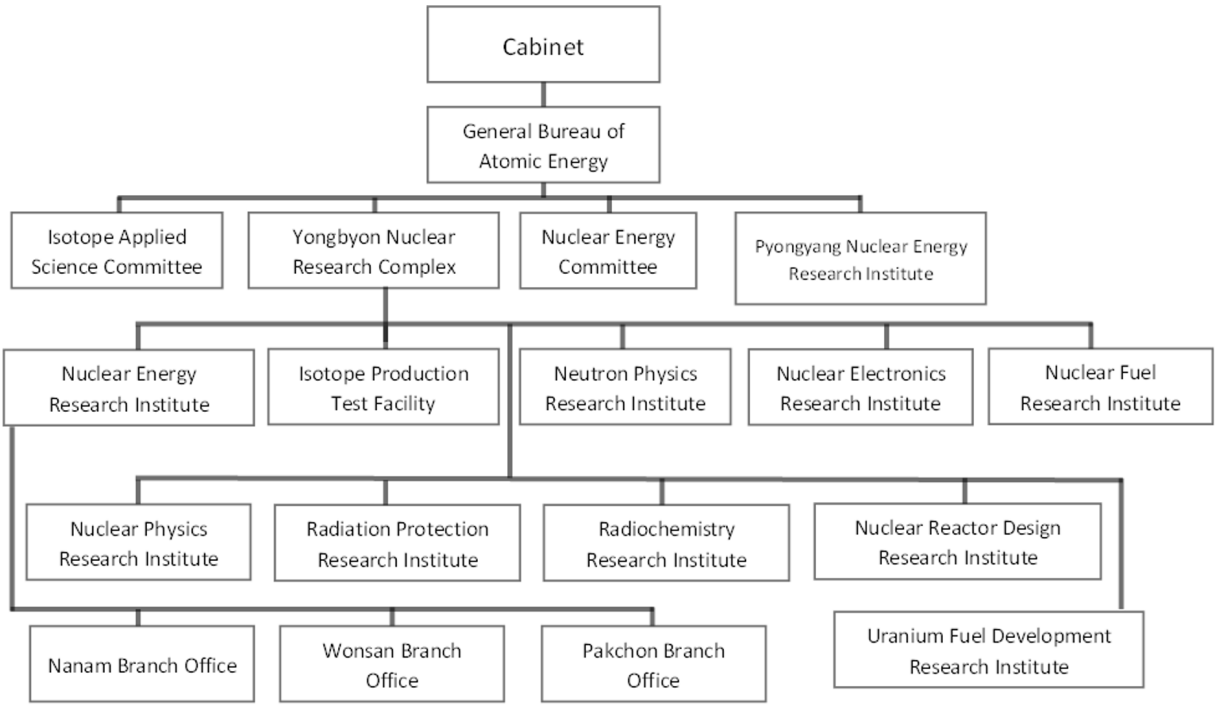
The KWP has a science/technology (S/T) policy guidance structure and the Science Education Department (SED), which exercises political supervision over all science and education programs in North Korea. The KWP SED takes its guidance from the KWP Central Committee. This department sets policy goals and standards for administrative supervision by the government, which is led by the DPRK Cabinet. Under the cabinet are the State Planning Committee (SPC) and its subordinate Science and Technology Planning Division. Subordinate to this is the National Academy of Sciences and its numerous research institutes, as well as universities and schools.

These entities divide duties and functions, but there is some natural friction among the various agencies. Kim Il-sung emphasized Party guidance over all of these organizations. The KWP SED implements North Korea's key S/T policies. After the KWP SED determines the overall policy direction, the SPC's S/T Planning Division drafts an overall plan and sends directives to each research institute, science academy, and government agency. In each government agency, there exists a technical guidance bureau that oversees quality control, new technology, and other related issues. These organizations reported to the S/T Committee before 1998. After 1998, they reported to the Academy of Sciences.[55]

55 Lee Choon-kun and Kim Gye-su, *Bukhan-ui gukga yeongu gaebal cheje-wa gwahak gisul illyeok yangseong cheje* [The National R&D System and S&T Human Resources Training System in N. Korea] (Seoul: Science & Technology Policy Institute, 2001), 58–59.

Nuclear Research: Key Institutions

The following chart shows the North Korean government's organization of its nuclear program.[56]



The Nuclear Energy Committee (원자력위원회) was founded as a result of the establishment of the Atomic Energy Research Institute (원자력연구소) in 1960. In 1986, the Nuclear Energy Industry Department (원자력공업부) was founded, and in 1987, it was subordinated to the KWP Munitions Industry Department (MID; 군수공업부). In 1994, the Nuclear Energy Industries Department was redesignated as the General Bureau of Atomic Energy (원자력총국). Nuclear research institutes are administratively supervised by the State Committee on Science and Technology.[57] Supreme People's Assembly (SPA) Decree No. 3111 of April 11, 2013 declared the General Bureau of Atomic Energy to be a government ministry entitled the "Ministry of Atomic Energy Industry."[58]

In the 1980s, Kim Il-sung moved the applied sciences, research, and development projects from Pyongyang to the Yongbyon Nuclear Complex. Most of the Academy of Science and KCUT personnel related to those programs were also moved to Yongbyon.[59] The Yongbyon Nuclear Energy Research Complex (영변 원자력연구단지) maintains a Uranium Resources Development Research Institute, a Nuclear Physics Research

56 Republic of Korea Ministry of Unification, "과학기술연구기관" [Science and Technology Research Organizations], July 20, 2010. http://unibook.unikorea.go.kr/?sub_num=51&recom=21&ord=2009&state=view&idx=122.

57 Lee, "Scientific and Technological Understanding of North Korea's Nuclear Issue."

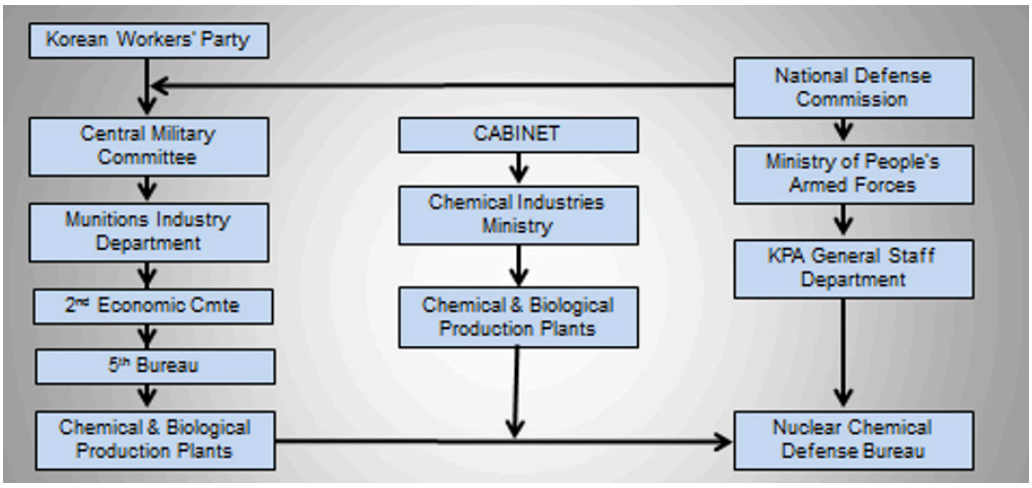
58 Alexandre Y. Mansourov, "Kim Jong Un's Nuclear Doctrine and Strategy: What Everyone Needs to Know", *NAPSNet Special Reports*, December 16, 2014.https://nautilus.org/napsnet/napsnet-special-reports/kim-jong-uns-nuclear-doctrine-and-strategy-what-everyone-needs-to-know/.

59 Lee Choon-kun, "North Korea's Nuclear Program: A History," *The Korea Herald*, June 15, 2009.

Institute, a Radiation Chemistry Test Facility, a Nuclear Materials Research Institute, a Nuclear Power Research Institute, an Isotope Production Research Institute, a Neutron Physics Research Institute, a Nuclear Reactor Design Research Institute, a Nuclear Electronics Research Institute, and a Radiation Protection Research Institute. Branch offices of the Nuclear Energy Research Institute are located in Ranam (Chongjin), Wonsan, and Pakchon.[60]

WMD Program: Key Institutions

North Korea is at a relatively low level in terms of training, education, and construction in terms of scientific research. Although Kim Jong-il emphasized state-of-the-art science during his rule, resources were not adequately prioritized to meet that commitment.[61] However, this is not the case with North Korea's nuclear, missile, or chemical and biological weapons programs. The following chart outlines the institutions that control and manage North Korea's WMD program, including the nuclear weapons program.[62]



Both Kim Il-sung and Kim Jong-il saw the WMD program as a means for regime security in the face of real and perceived enemies, particularly the United States and South Korea. The Supreme Leader, now Kim Jong-un, sits in the position of command for both the KWP and the State Affairs Committee (SAC). On the government side, administrative control over the development of the nuclear energy sector is exercised by the Ministry of Atomic Energy Industry. On the military side, all decisions are made at the KWP CMC.

The SAC is administratively responsible for the professional management of national defense, including WMD program goals and tasks, as well as worker priorities relevant to those goals and tasks. The Supreme Leader is also the Chairman of the KWP CMC, which is responsible for military policies and national defense tasks and priorities. WMD programs are among the North Korean leadership's highest priorities. The CMC directs policy to the KWP MID for direct political control over the North's WMD program development.

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60 Lee, "Scientific and Technological Understanding of North Korea's Nuclear Issue."

61 Lee Choon-kun, *Bukhan-ui gwahak gisool soojoon mit gwansim bunya bunseok* [Analysis of North Korea's Science and Technology and Related Fields] (Seoul: Ministry of Unification, 2009), 111.

62 Kwon Yang-joo, *The Comprehension of North Korean Military* (Seoul: Korea Institute for Defense Analysis, 2014), 224. Under Kim Jong-un, the National Defense Commission has been replaced by the State Affairs Commission (SAC). The Ministry of People's Armed Forces has been renamed the Ministry of Defense. KPA stands for Korean People's Army.

North Korea's nuclear and missile programs are under the direct supervision of the KWP MID. This is critical. Though both programs provide military capabilities, they are ultimately controlled by the Party apparatus. The convergence of Party, military, and government guidance on decisions and development are at the discretion of the Supreme Leader, who maintains overarching authority.

The following chart addresses North Korea's WMD production system tasks. The chart demonstrates how nuclear scientists and engineers are organized as a workforce.[63]

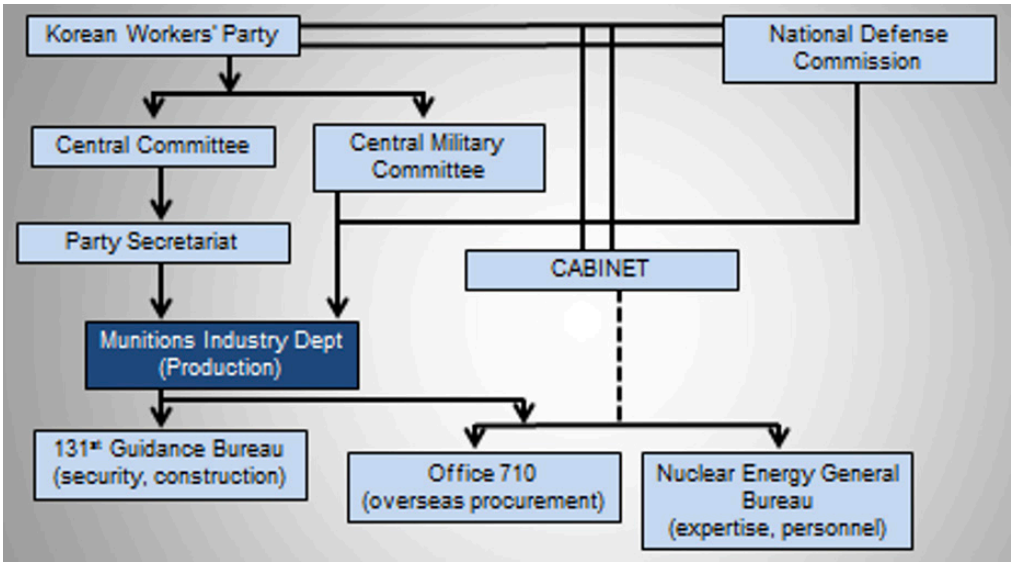
Element	Tasks
Ministry of Defense & KPA HQ	Reports requirements & needs Weapons testing
Central Military Committee (CMC)	Munitions Industry policymaking Overall program control Guidance to MID and other relevant cabinet ministries
Munitions Industry Department (MID)	Guidance and supervision to SEC & production facilities Supervision of nuclear weapons development
Second Economic Committee (SEC)	Weapons production & technical support Weapons R&D Oversight of weapons exports 4th Bureau: Missile production 5th Bureau: chemical, biological weapons production * *Not involved in nuclear weapons development or production*
First Academy of Natural Sciences	Basic research, e.g. regarding uranium milling
Second Academy of Natural Sciences	Reverse engineering & design development Engineering Research Institute: missile development Precision Machinery Institute: production of warheads, barrels * *Also has entities responsible for researching tanks, electronics*
Cabinet Ministries	Supplies raw materials and equipment for weapons production * Related organizations: General Bureau of Atomic Energy, Ministry of Electronics Industry, Ministry of Chemical Industry

The Second Economic Committee (SEC), which falls under the political supervision of the KWP MID, plays a central role in the production of WMDs. It manages 140 factories devoted to national defense production. By one estimate, the SEC-run economy is responsible for 70% of North Korea's total economic production.[64]

63 Kwon, *The Comprehension of North Korean Military*, 217. The Munition Industry Department was formerly called the Machine Industry Department. See Lee Bong-seok, "北핵개발 담당 '군수공업부' 명칭, 6년만에 등장" ['Munitions Industry Department,' Responsible for N. Korea's Nuclear Weapons Development, Appears Again], *Yonhap News*, January 7, 2016. https://www.yna.co.kr/view/AKR20160107192900014.

64 Kim Chol-hwan, "Bukhan-ui gukbang gwahak gisul-gwa haek munje" [North Korea's Science and Technology in National Defense and the Nuclear Issue], *Science & Technology Policy* 141 (2003): 67–68. https://www.dbpia.co.kr/journal/articleDetail?nodeId=NODE02477569.

The following chart specifically shows the entities involved in North Korea's nuclear weapons production.[65]



65 Kwon, *The Comprehension of North Korean Military*, 222. The National Defense Commission has been replaced by the State Affairs Commission (SAC).

SECTION 4: RECRUITMENT & EDUCATION

The KWP oversees every aspect of the nuclear program. In doing so, it controls all aspects of the lives of North Korea's nuclear scientists and engineers. Specifically, the KWP Science Education Department oversees the recruitment, education, and training of nuclear scientists and engineers. The KWP Munitions Industry Department and Cadre Department manages the employment of these personnel, except for those in educational institutions.

The Kim regime's nuclear scientists are among the best mathematical minds in the country—a distinction likely shared by North Korea's missile engineers and hackers. To support the nuclear weapons program, the most talented students are recruited from prestigious high schools at the county, province, and city levels to be educated at the top universities in the country. Some are even sent abroad to receive training from overseas institutions.

The nuclear scientists and engineers trained by the regime have no choice but to work for North Korea's nuclear program, which is focused on plutonium and highly-enriched uranium production. They are strictly committed to the workplaces and the tasks that the regime has assigned to them.

Early Recruitment of Talented Students

The fate of North Korea's "slaves to the bomb" are determined as early as elementary school. Recruitment begins in grade school, when teachers identify students who show exceptional promise in mathematics and science. These students are then channeled through educational and training institutions that will make these students valuable assets to the Party-state. They are provided with advanced teaching and instruction. Students who perform well are rewarded with benefits. In some cases, their families may be allowed to relocate close to the special schools that these students attend.

The brightest North Korean students are identified in sixth grade by local elementary school teachers. Those with the most potential are sent to the local "No.1 Middle School." After middle school, elite students attend "No.1 High Schools," although the brightest go straight to college. These No.1 schools are designed to foster gifted students in the fields of science, mathematics, and physics.

Located in Sinwon-dong, Pyongyang No.1 Middle School is North Korea's premier institution for gifted students. It was established in 1984, and it has around 1,000 students. In 1985, No. 1 Middle Schools were also created in each provincial capital. The teachers and teaching materials at Pyongyang No.1 Middle School are superior to those of other schools. Most of the students at this school are the children of Central Party and central government officials, anti-Japanese militants, descendants of military generals, or are from other wealthy families in Pyongyang. Those who transfer to Pyongyang No. 1 Middle School from other regions are selected based on skill, rather than family background.[66] Students from Pyongyang No. 1 Middle School also regularly participate in the International Math Olympiad.[67]

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66 "북한 최고의 엘리트 양성소 '평양1중학교'" [Pyongyang No. 1 Middle School, North Korea's Premier Institution for Training the Elite], *Daily NK*, October 19, 2007. https://www.dailynk.com/%5B%EC%A7%91%EC%A4%91%ED%95%B4%EB%B6%80%5D%EB%B6%81%ED%95%9C-%EC%B5%9C%EA%B3%A0%EC%9D%98%EC%97%98%EB%A6%AC%ED%8A%B8-%EC%96%91%EC%84%B1/.

67 Choi Young-jun, "북한은 숨은 '수학 강국'일까" [Is North Korea Truly a Mathematical Powerhouse?], *Dong-A Science*,

The other high-level high schools that focus on physics are Pyongyang High School of Physics and Kim Il-Sung High School of Physics. Bungang High School, located near the Yongbyon Nuclear Research Complex, educates the children of most of the nuclear scientists and engineers who work in the applied aspect of the nuclear program at Yongbyon.

After graduation from high school, the students who are destined to work in the nuclear program enter one of five universities: Kim Il-sung University (Pyongyang), KCUT (Pyongyang), National Defense University (Kanggye, Jagang Province), College of Physics (Bungang, South Pyongan Province), or University of Science (on the north-central edge of Pyongyang, formerly Pyongsong, South Pyongan Province).

Once these students show satisfactory academic performance in relevant fields of study, their personal and professional fates are sealed. They must work for the Kim regime as nuclear-related professionals. The only variances are place of employment, quality of housing, food, and quality of life. Many cannot choose whom to marry. Those who complain will be punished and deprived of the privileges their intellect awarded them.

These policies are inconsistent with the goal of the socialist system that the Kim regime initiated at the founding of the North Korean state. Originally, North Korea's education policies emphasized social equality over excellence. However, to achieve the national security objectives that the regime aspired to, the regime focused on nurturing students who could make important contributions to the regime's WMD programs.

Research & Training: Core Institutions

The core research organizations in the mathematics and mechanics fields in North Korea today are the Mathematics Research Institute of the National Academy of Sciences, Kim Il-sung University, KCUT, the University of Science, Kim Hyong-jik University of Education, the Railroad College, and the College of Machinery. Primary research areas include the applied aspects of condensed matter physics, nanotechnology, cluster physics, material science, lasers, engineering, acoustics, nuclear power, and spaceflight.[68]

Basic research in the nuclear field is conducted at Kim Il-sung University and KCUT in Pyongyang, and at the University of Sciences in northern Pyongyang. Applied research is conducted at the Yongbyon Nuclear Complex by the Academy of Sciences and the University of Physics.[69]

Kim Il-sung University opened its doors on October 1, 1946. It has around 12,000 students and 5,500 faculty members. It offers over 60 majors in 15 departments, including physics, nuclear energy, and computer science. Many of the North Korean regime's elite are Kim Il-sung University graduates.[70] Seats are assigned in all classrooms, so that anyone who is absent or shows shortcomings in their organizational life can be immediately identified.[71] A physics-mathematics department was established at Kim Il-sung University as the first academic entity that taught nuclear physics in North Korea, with Do Sang-rok as the head instructor.[72]

August 7, 2015. https://www.dongascience.com/news.php?idx=7785.

68 Lee, *Analysis of North Korea's Science and Technology and Related Fields*, 2.

69 Lee, "North Korea's Nuclear Program."

70 Republic of Korea Ministry of Unification, "김일성종합대학" [Kim Il-sung University], *North Korea Information Portal*, accessed November 7, 2023. https://nkinfo.unikorea.go.kr/nkp/term/viewNkKnwldgDicary.do?dicaryId=41.

71 "김일성종합대학" [Kim Il-sung University], *NK Chosun*, October 30, 2013. https://nk.chosun.com/bbs/view.html?idxno=3876&sc_category=.

72 Im, "Korea's Physics Departments Immediately After Liberation."

The **Kim Chaek University of Technology** is North Korea's leading institute of higher education in engineering and the sciences. Originally established as the Pyongyang School of Engineering in September 1948, it was later named after General Kim Chaek, a frontline KPA commander who died during the Korean War. In 2008, there were 13,000 undergraduate students, 1,500 Ph.D. students, and 1,350 professors. KCUT has multiple departments related to nuclear engineering.[73] Students from KCUT regularly participate in overseas competitions. In an international hacking contest held in May 2023, KCUT students placed first, third, and fourth. The second place student was from Kim Il-sung University.[74]

The **University of Science** trains many of North Korea's top scientists. It was founded in 1967 in Pyongsong, South Pyongan Province, just north of Pyongyang.[75] In November 1993, Pyongsong was merged into Pyongyang's Unjeong-guyok (Unjeong District), which is known as North Korea's Silicon Valley. This was intended to improve the welfare of North Korea's scientists, under Kim Il-sung's instructions. With about 1,500 students, this school has departments in nuclear physics, biology, mathematics, chemistry, and electrical engineering. Those who graduate from the nuclear physics department are "posted to the Yongbyon Nuclear Research Center or to nuclear facilities in [Pakchon County]."[76] This institution is unusual in that it emphasizes skill and ability over *songbun* in selecting students. Students undergo a seven-year program of studies, which includes a one-year dissertation period. Upon graduation, students are assigned to workplaces by the KWP Cadre Department. Most are assigned to the Academy of National Defense Science or the Academy of Natural Sciences to conduct further research.[77]

The **National Defense University** (NDU) is located in Kanggye, Jagang Province.[78] Its curriculum focuses on weapons engineering of all types. Its graduates are assigned as engineers to military factories, researchers at other research institutes, or instructors at the NDU. Its military code name is KPA Unit 852. Lee Ae-ran, a North Korean escapee, had a friend who was forced to attend NDU. Her friend wanted to attend another college, but the authorities decided otherwise because of her friend's skills in math and science.[79]

The **University of Physics** is located in Yongbyon, North Pyongan Province. Created in the 1980s, it was established to "train technicians to operate the nuclear reactors, reprocessing facility, fuel fabrication plants and other facilities at the Yongbyon Nuclear Complex." Students and alumni are "strictly controlled and isolated" due to the sensitive nature of their work. As of 2009, it was estimated that there were approxi-

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73 "김책공업종합대학" [Kim Chaek University of Technology], *Encyclopedia of Korean Culture*, accessed November 7, 2023. https://terms.naver.com/entry.naver?docId=553662&cid=46629&categoryId=46629.

74 "N. Korean Students Sweep Top Spots in Hacking Contest," *KBS World*, July 7, 2023. https://world.kbs.co.kr/service/news_view.htm?lang=e&Seq_Code=178963.

75 This institution is also referred to as the College of Science (리과대학); Pyongsong Institute of Science (평성리과대학); Pyongsong Scientific University; Pyŏngsŏng Scientific Institute; and College for Gifted Students (수재대학).

76 Nuclear Threat Initiative, "College of Science," May 29, 2012. https://web.archive.org/web/20151116092107/http://www.nti.org/facilities/759/.

77 "이공계 대학의 산실, '리과 대학'" [University of Science—the Cradle of North Korea's Scientific Research], *YTN Science*, March 4, 2008. http://www.ytnscience.co.kr/program/program_view.php?s_mcd=0101&s_hcd=01&key=200803041713315623.

78 Some sources indicate that the university has been moved to Pyongyang. For example, see Joo Seong-ha, "김정은국방종합대학" [Kim Jong-un National Defense University], *Dong-A Ilbo*, March 20, 2019. https://www.donga.com/news/Opinion/article/all/20190320/94639733/1.

79 Julian Ryall, "I was forced to marry a North Korean nuclear scientist and...," *South China Morning Post*, December 18, 2016. https://www.scmp.com/week-asia/society/article/2055300/i-was-forced-marry-north-korean-nuclear-scientist-and.

mately 1,500 students.[80] The university is organized into three departments—nuclear materials, nuclear electronics, and nuclear reactors. These departments are divided into ten sub-departments. All students receive practical training at facilities in Yongbyon, and students spend most of their last term in the program receiving hands-on education.[81] The college is located in Bungang, across the river and to the west of Yongbyon. Bungang is where the vast majority of Yongbyon Nuclear Complex employees live.

Overseas Training

For decades, North Korea has sent students overseas to study nuclear science and related academic fields to advance the Kim regime's nuclear program. After North Korean scientists return from studying abroad, many are assigned to defense-related projects. They are allowed to visit family after returning, but they are accompanied by official minders.[82]

Two institutions have played an important role in educating North Korea's nuclear scientists. The first is the **Joint Institute for Nuclear Research** (JINR) in Dubna, near Moscow. North Korean scientists began to participate in JINR in 1956, marking one of Pyongyang's first steps toward developing a nuclear program. However, due to international sanctions, North Korea's membership in JINR was terminated on November 21, 2015. There are no longer any North Koreans with a direct relationship with JINR, either as a student or as a joint committee representative.[83] Of the approximately 250 students that North Korea sent to JINR, only twenty-five defended their theses and two received a doctoral degree.[84]

The second is the **Harbin Institute of Technology** (HIT), one of China's premier engineering schools. After North Korea's first nuclear test in 2006, the UN imposed sanctions to stop Pyongyang from acquiring dual-use materials and funds. In response, the Kim regime increased its overseas knowledge acquisition by sending more graduate students overseas, with an emphasis on China. The number of students sent to China increased from approximately 380 in 2006 to 1,090 in 2015. In particular, HIT has collaborative agreements with Kim Il-sung University and KCUT. These two schools sent twelve doctoral and postdoctoral students to HIT in 2013 and twenty-eight in 2015. HIT also claimed in 2017 that nine students had downloaded 57,000 papers from its mechatronics department and other faculties. HIT's staff insisted that these students were North Korean. North Korean scientists, including Kim Young-geun (김영근), Kim Dong-seol (김동설), Ri Chol-nam (리철남), Kim Dae-jeong (김대정), Ok Chang-son (옥창선), Chu Kyong-sik (주경식), and O Se-hyok (오세혁), were eventually forced to leave HIT between 2013 and 2016 due to international sanctions.[85]

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80 Also formerly known as the Yongbyon Physics Junior College (영변물리학전문학교), Yongbyon Physics College (영변물리대학), and Yongbyon Nuclear Physics College (영변 핵물리대학). See Nuclear Threat Initiative, "Physics College," May 30, 2012. https://web.archive.org/web/20210516112019/https://www.nti.org/learn/facilities/775/.

81 Lee, "North Korea's Nuclear Development and Capabilities."

82 Natalie Wolf, "North Korea's scientists are hailed as national heroes in a country where science is king," *NZ Herald*, December 19, 2017. https://www.nzherald.co.nz/world/news/article.cfm?c_id=2&objectid=11962338.

83 Joint Institute for Nuclear Research, "Democratic People's Republic of Korea (DPRK): On Membership of DPRK in JINR," accessed December 3, 2020. http://www.jinr.ru/posts/map_maps/democratic-people-s-republic-of-korea/.

84 Alexander Zhebin, "A Political History of Soviet–North Korean Nuclear Cooperation," as cited in James Clay Moltz and Alexandre Y. Mansourov, eds., *The North Korean Nuclear Program: Security, Strategy, and New Perspectives from Russia* (New York: Routledge, 2000), 29–30.

85 Jeremy Page and Alastair Gale, "Behind North Korea's Nuclear Advance: Scientists Who Bring Technology Home," *The Wall Street Journal*, September 6, 2017. https://www.wsj.com/articles/behind-north-koreas-nuclear-advance-scientists-who-bring-technology-home-1504711605.

Despite international efforts to limit academic exchanges in areas with potential military applications, North Korea has continued to send its scientists abroad. In a February 2017 report, UN experts reported that North Korean students were studying physics in Italy and material science and engineering, as well as electronic communications in Romania. The report also found that thirty-four North Korean students studied at an "Indian space technology center" since 1996.[86] Moreover, Kim Il-sung University's Physics Department has cooperated with the International School for Advanced Studies, a university in Trieste, Italy. The school's International Centre for Theoretical Physics has awarded four North Korean students master's degrees in cosmology; the students were also enrolled in Ph.D. programs.[87]

As part of their overseas study, North Korean scientists have published papers in international journals. From 2011 to 2016, North Korean scientists published twenty-three papers in material science, twenty-three papers in physics, thirteen papers in electrical engineering, and eleven papers in metallurgical engineering. UN sanctions prohibit North Korean scientists from receiving "specialized teaching or training" in these fields.[88] Kim Il-sung University has claimed that North Korean scientists published 130 research papers in international scientific journals in 2020, covering physics, chemistry, and mathematics.[89]

86 Page and Gale, "Behind North Korea's Nuclear Advance"; see also Kim Young-kwon, "인도 우주연구센터, 북한 과학자 교육…유엔 제재 위반 논란" [North Korean Scientists Educated at India Space Research Center...Surprising Violation of United Nations Sanctions], *VOA*, June 22, 2016. https://www.voakorea.com/a/3385839.html.

87 Alison Abbott, "North Korean physicists forge rare exchange deal with Italian university," *Nature*, March 27, 2019. https://www.nature.com/articles/d41586-019-00990-5.

88 Page and Gale, "Behind North Korea's Nuclear Advance."

89 "N.K.'s top university published over 130 papers in int'l journals in past year: propaganda outlet," *Yonhap News*, March 10, 2021. https://en.yna.co.kr/view/AEN20210310002500325.

SECTION 5: NUCLEAR SCIENTISTS' ASSIGNMENT LOCATIONS

Under the KWP's direction, the North Korean state determines work assignments for all North Koreans, including scientists and engineers. North Korea's nuclear personnel are located across a range of settings, including universities, research institutes, nuclear facilities, and uranium milling facilities and mines.

The assignment location determines, for the most part, the quality of life for workers and their families. It is important to understand that nuclear scientists and engineers are preferentially assigned based on socio-political classification (*songbun*), just like everyone else in North Korea.[90] Scientists with lower *songbun* are assigned to positions and locations that offer a lower quality of life. This is a discriminatory practice that permeates North Korean society and violates the rights of North Koreans, including workers in the nuclear sector.

North Korea reportedly has 104 nuclear facilities, 40 of which are key facilities that must be addressed in any denuclearization plan. Among these forty are fifteen nuclear research and supervisory facilities, eight uranium mines, and five nuclear power plants and refineries.[91]

The bulk of North Korea's nuclear scientists and engineers work at the Yongbyon Nuclear Complex and live across the river in the town of Bungang. Those that are assigned to the KWP MID, the Ministry of Atomic Energy Industry, or universities in Pyongyang are provided with the most comfort and security in terms of nuclear safety and radiation exposure. At the other extreme, the Punggye-ri nuclear test site ranks at the lower end in terms of quality of life. Being assigned to Punggye-ri does not offer nearly the quality of life or comfort that is available to physics professors in Pyongyang, for example. A partial list of these sites is provided below.

90 See Robert Collins, *Marked for Life: Songbun, North Korea's Social Classification System* (Washington, D.C.: Committee for Human Rights in North Korea, 2012), 106-107. https://www.hrnk.org/uploads/pdfs/HRNK_Songbun_Web.pdf.

91 "KBS Secures List of N. Korea's Nuke Facilities," *KBS World*, March 29, 2019. https://world.kbs.co.kr/service/news_view.htm?lang=e&Seq_Code=144044.

Universities

Kim Il-sung University is located in Yongnam-dong, Daesong-gu, Pyongyang (39° 3'29.67"N, 125°46'5.80"E).[92]

KCUT is located on Younggwang Street, Gyogu-dong, Chung-guyok, Pyongyang[93] (39° 0'9.13"N, 125°44'47.41"E).[94]

92 Google Maps, "Kim Il-sung University (김일성종합대학)," accessed March 28, 2022. https://goo.gl/maps/oi81HWfA1hW1X8L77.

93 Nuclear Threat Initiative, "Kim Chaek University of Technology," June 26, 2012. https://web.archive.org/web/20150919221755/http://www.nti.org/facilities/757/.

94 Google Maps, "University of Technology," accessed March 28, 2022. https://maps.app.goo.gl/SaVBwrpPH8oeAC2g8.

The **University of Science** is located in Eunjeong District, which is at the northern edge of Pyongyang. Originally, the location was in Pyongsong City, South Pyongan Province, just north of Pyongyang. The administrative boundaries of Pyongsong were changed to include the university within the Pyongyang city limits, which would enable the students to receive better support.[95]

The **National Defense University** is located in Kanggye, Jagang Province. There have been some reports in recent years that it has been moved to Pyongyang. More than likely, this university was given the same status as Pyongyang in terms of preferential treatment.

The **University of Physics** is located in Bungang, across the river from Yongbyon, where the vast majority of Yongbyon Nuclear Complex employees live.

Leadership Organizations

The **First Academy of Natural Sciences** is located at the Academy of Sciences in Pyongyang. The facility is also known as the Natural Energy Institute of the State Academy of Sciences or the Institute of Natural Science at the Academy of Sciences (39°13'55.59"N, 125°52'2.77"E).[96]

95 Song Jeong-mi, "북한 과학기술의 요람 평양 '은정구역'" [Pyongyang's Eunjeong District, the Heart of North Korea's Science and Technology Sector], *Tongil News*, September 25, 2002. http://www.tongilnews.com/news/articleView.html?idxno=23318.

96 Google Maps, "39°13'55.6"N 125°52'02.8"E," accessed March 28, 2022. https://maps.app.goo.gl/LtmFdqpGQ7F8G7jZ8.

The **Second Academy of Natural Sciences** is located in Pyongyang (39°8'49.16"N, 125°46'1.06"E). It was established in 1960 as the National Defense Science Institute.[97] It develops nuclear weapons, missiles, and chemical weapons. The Academy director is designated as a four-star general and serves concurrently as a Vice Minister of Defense and the Deputy Director of the Second Economic Committee. This institute has a total of 15,000 researchers and 40,000 assistants and workers, selected from graduates with the highest grades from North Korea's most specialized schools.[98]

The **Yongbyon Nuclear Complex** is located in Bungang District, Yongbyon County, North Pyongan Province (39°47'49.77"N, 125°45'17.54"E).[99] Its official name is the Chosun Nuclear Energy Research Institute (조선원자력연구소). It was built with Soviet aid from 1961 to 1964, with additional construction through the 1990s. There are 390 buildings at the complex.[100] At the time of construction, it was referred to as the "Furniture Factory" to maintain secrecy. Demonstrating its importance to the Kim regime, the complex's administrative address is Chungsong-dong (충성동),[101] Chung-guyok, Pyongyang.[102] This provides privileges that are also given to those who live in Pyongyang or work for institutions based in Pyongyang.

97 Republic of Korea Ministry of Unification, "과학기술연구기관" [Science and Technology Research Organizations], July 20, 2010. http://unibook.unikorea.go.kr/?sub_num=51&recom=21&ord=2009&state=view&idx=122.

98 Kim So-jeong, "북 핵개발 알고보니 '101핵물리연구소'서 주도" [North Korea's Nuclear Program Led by the 101 Nuclear Physics Research Institute], *Dailian*, February 6, 2013. https://www.dailian.co.kr/news/view/325240.

99 Google Maps, "Yongbyon Nuclear Science and Weapons Research Center," accessed March 28, 2022. https://maps.app.goo.gl/D5KhdshkZ23L1jtM8.

100 "A Look into North Korea's Yongbyon Nuclear Complex," *Yonhap News*, September 19, 2018. https://en.yna.co.kr/view/AEN20180919012000315.

101 "Chungsong" means "loyalty" in Korean.

102 Nuclear Threat Initiative, "Yongbyon Nuclear Research Center," May 29, 2012. https://web.archive.org/web/20211201192259/https://www.nti.org/education-center/facilities/yongbyon-nuclear-research-center/.

The **216 Research Institute** is subordinate to the State Affairs Commission (SAC) in Pyongyang and is considered to be the control tower of North Korea's nuclear program. It has thirty researchers, all of whom enjoy a superior quality of life due to preferential treatment by the regime's leadership. One can ascertain from the name of the institute that it is a very important organization because February 16 is Kim Jong-il's birthday. The institute was reportedly established after a critical mistake relating to North Korea's first nuclear test on October 9, 2006. After the test, the emissions from the test leaked from the test tunnel without any filtering, demonstrating that North Korea's shielding technology was inadequate.[103] The United States was able to assess key information about the test by collecting these emissions. The leaders of the Nuclear Physics Research Center and the Radiation Protection Research Center, the core organizations that planned the test, were severely reprimanded. The need for a separate organization to build a more specialized process became apparent. This led to the establishment of the 216 Research Institute.[104] It is located in Changgwang-dong, Jung-guyok, Pyongyang at 39° 2'27.09"N, 125°42'54.01"E.[105]

The **Second Economic Committee** (SEC) is responsible for all military production in North Korea. It falls under the political supervision of the KWP MID. The SEC was originally established in 1961, and it was given its current designation at the Fifth Party Congress in 1970. According to *NK Leadership Watch*, the SEC is "responsible for the financing, planning, research, development, manufacturing, production and foreign acquisition of the DPRK's artillery, aviation, naval, missiles, strategic weapons and military communications and logistics."[106]

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103 Shielding technology refers to technology that prevents various gasses and other effluent components from escaping after a nuclear test.

104 Lee Yun-gol and Han Byong-kwan, "북한 핵개발 컨트롤타워 '216연구소' 실체" [The Control Tower of North Korea's Nuclear Development: 216 Research Institute], *Ilyo Sinmun*, October 20, 2016. https://www.ilyo.co.kr/?ac=article_view&entry_id=209003.

105 Google Maps, "39°02'27.1"N 125°42'54.0"E," accessed March 28, 2022. https://maps.app.goo.gl/4yrakuJSbFAHprNw8.

106 Michael Madden, "The Second Economic Committee," *North Korea Leadership Watch*, accessed May 2, 2024. http://nkleadershipwatch.files.wordpress.com/2009/10/thesecondeconomiccommittee.pdf.

Research Institutes

The **Nuclear Energy Research Institute** (원자력연구소) was established in December 1952 under the Academy of Sciences. It moved from Pyongyang to the Yongbyon Nuclear Complex in 1964. It has branches in Pakchon County (North Pyongan Province), Wonsan (Gangwon Province), and Ranam district in Chongjin (North Hamgyong Province).[107]

The **Radiation Protection Research Institute** (방사선방호연구소) is located inside the Yongbyon Nuclear Complex.[108]

The **Neutron Physics Research Institute** (중성자물리연구소) is located inside the Yongbyon Nuclear Complex.[109]

The **Isotope Production Laboratory** (동위원소이용연구소) is also known as the Isotope Production Research Institute, Isotope Processing Laboratory (동위원소가공실험실), Isotope Processing Research Institute (동위원소생산가공연구소), Radioactive Isotope Processing Laboratory, Radioisotope Use Institute, and the Radioisotope Utilization Research Institute.[110] It is located in the Yongbyon Nuclear Complex at 39°48'28.05"N, 125°45'8.94"E.[111]

107 Nuclear Threat Initiative, "Atomic Energy Research Institute," September 30, 2021. https://www.nti.org/education-center/facilities/atomic-energy-research-institute/.

108 Nuclear Threat Initiative, "Yongbyon Nuclear Research Center."

109 Mary Beth Nikitin, *North Korea Nuclear Weapons Program Open-Source History & Summary*, February 2013. https://web.archive.org/web/20140803132519/http://www.koreanconfidential.com/images/NorKor-NuclearWeapons-CRS-Feb13.pdf.

110 Nuclear Threat Initiative, "Isotope Production Laboratory," September 30, 2011. https://web.archive.org/web/20170706163448/https://www.nti.org/learn/facilities/749/.

111 Google Maps, "39°48'28.05"N, 125°45'8.94"E," accessed March 28, 2022. https://maps.app.goo.gl/R8nspH9MRp81yNQBA.

The **Nuclear Electronics Research Institute** (핵전자학연구소) is located inside the Yongbyon Nuclear Complex. The facility is also known as the Nuclear Electronics Institute (핵전자연구소) and the Nuclear Electronics Laboratory.[112]

The **Nuclear Materials Research Institute** (핵재료연구소) is located inside the Yongbyon Nuclear Complex.[113]

The **Nuclear Physics Research Institute** (핵물리연구소) is located inside the Yongbyon Nuclear Complex. It was established in 1964 and reorganized in 1982. This facility focuses on nuclear reactor physics and technology and nuclear fuel and materials. It is the primary institution for training nuclear engineers and physicists, with a focus on nuclear reactor operations. The facility is also known as the Yongbyon Nuclear Physics Research Institute, Nuclear Physics Institute, Atomic Energy Research Center, and College of Physics.[114]

The **Radiochemistry Research Institute** (방사화학연구소) was established in 1956 with the help of the Soviet Union. This institute maintains laboratories for neutron analysis, radiochemistry, spectroscopy, X-ray analysis, analytical chemistry, and radiation measurement. It is also known as the Radioactive Chemistry Research Institute, Radiochemistry Institute, Radiochemistry Laboratory, Radiochemical Laboratory, and the Radiochemistry Laboratory Complex. It is located inside the Yongbyon Nuclear Complex at 39°46'52.46"N 125°45'11.83"E.[115]

112 Nuclear Threat Initiative, "Nuclear Electronics Research Institute," June 26, 2012. https://www.nti.org/learn/facilities/761/.

113 Nikitin, *North Korea Nuclear Weapons Program Open-Source History & Summary*.

114 Nuclear Threat Initiative, "Nuclear Electronics Research Institute,"; see also Joseph S. Bermudez Jr., "Exposing North Korea's Secret Nuclear Infrastructure—Part Two," *Jane's Intelligence Review*, August 1999, 43.

115 Nikitin, *North Korea Nuclear Weapons Program Open-Source History & Summary*; Nuclear Threat Initiative, "Radiochemistry Research Institute," June 25, 2012. https://web.archive.org/web/20211013212230/https://www.nti.org/learn/facilities/763/. Image from Google Maps at https://maps.app.goo.gl/wAktNx5aFi17S6CQ6, accessed March 28, 2022.

The **Uranium Resources Development Institute** (우라늄자원개발연구소) is located inside the Yongbyon Nuclear Complex. This Institute is affiliated with the Uranium Enrichment Facility/Fuel Fabrication Complex, which is located at 39°46'9.63"N 125°45'1.57"E.[116] According a 2021 estimate by Siegfried Hecker, it is believed that North Korea operates 4,000 centrifuges at Yongbyon, which could produce "on the order of 175 kg" of highly enriched uranium per year.[117]

The **Nuclear Energy Research Institute** (원자력연구소) is located inside the Yongbyon Nuclear Complex. It is also known as the Atomic Energy Research Institute, Nuclear Research Institute, and Atomic Energy Research Center.[118]

The **Nuclear Reactor Design Research Institute** is located inside the Yongbyon Nuclear Complex. The facility is also known as the Reactor Design Research Institute (원자로설계연구소).[119]

The **101st Research Institute** is located in an underground facility in Gonggwi-ri near Kanggye City, Jagang Province. It is a high-security facility that is manned by approximately 300 personnel who are top-ranking graduates of NDU and Kim Il-sung University. Researchers from this institute reportedly go to the Yongbyon Nuclear Complex to participate in nuclear weapons development and preparations for nuclear testing.[120]

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116 Nikitin, *North Korea Nuclear Weapons Program Open-Source History & Summary*. Image from Google Maps at https://maps.app.goo.gl/4UpY3CRckUK6GSEJ6, accessed March 28, 2022.

117 "Estimating North Korea's Nuclear Stockpiles: An Interview With Siegfried Hecker," *38 North*, April 30, 2021. https://www.38north.org/2021/04/estimating-north-koreas-nuclear-stockpiles-an-interview-with-siegfried-hecker/.

118 Nikitin, *North Korea Nuclear Weapons Program Open-Source History & Summary*.

119 Ibid.

120 Kim, "North Korea's Nuclear Program Led by the 101 Nuclear Physics Research Institute."

Nuclear Reactors

The **Yongbyon 5MWe Reactor** is located in the Yongbyon Nuclear Complex at 39°47'51.04"N, 125°45'18.85"E.[121]

The **IRT-2000 Nuclear Research Reactor** (연구용 원자로) is located in the Yongbyon Nuclear Complex at 39°48'27.99"N, 125°45'3.55"E. Its construction was completed in 1965 with help from the Soviet Union after Pyongyang and Moscow signed an agreement in 1959 to cooperate on atomic energy.[122]

121 Nuclear Threat Initiative, "Yongbyon 5MWE Reactor," July 19, 2018. https://web.archive.org/web/20210330154016/https://www.nti.org/learn/facilities/766/. Image from Google Maps at https://maps.app.goo.gl/6suKh5Ndi1Gfmg9y9, accessed March 28, 2022.

122 Nuclear Threat Initiative, "IRT-2000 Nuclear Research Reactor," September 30, 2011. https://web.archive.org/web/20210126114408/https://www.nti.org/learn/facilities/767/. Image from Google Maps at https://maps.app.goo.gl/1shWsjN5c8U9W1GS8, accessed March 28, 2022.

An **Experimental 25-30 MWe Light Water Reactor** (LWR) is located within the Yongbyon Nuclear Complex at 39°47'44.87"N, 125°45'18.72"E.[123]

The **Taecheon 200MW Graphite-Moderated Reactor** (태천 200MW 흑연감속로) is located in Taechon County, North Pyongan Province at 39°55'40.13"N, 125°34'13.49"E. Its construction began in 1989, but it was abandoned in the 1990s. It is unknown whether any personnel are deployed at this facility.[124]

123 Nuclear Threat Initiative, "Experimental 25-30 MWE Light Water Reactor," September 30, 2012. https://web.archive.org/web/20211011162712/https://www.nti.org/learn/facilities/769/. Image from Google Maps at https://maps.app.goo.gl/NhcKb1WSmtXM8MvD8, accessed March 28, 2022.

124 Nuclear Threat Initiative, "Taecheon 200MW Graphite-Moderated Reactor," June 14, 2012. https://web.archive.org/web/20211012031630/https://www.nti.org/learn/facilities/764/. Image from Google Maps at https://maps.app.goo.gl/GJeCrdjocCc52sW86, accessed March 28, 2022.

The **Kumho District LWR Site** (금호지구경수로), also known as the Sinpo LWR, is located in Sinpo, Kumho County, South Hamgyong Province at 40° 5'42.75"N, 128°20'28.62"E. It was established pursuant to the 1994 Agreed Framework between the United States and North Korea. The Korean Peninsula Energy Development Organization (KEDO) was established in March 1995 to oversee the project. On May 31, 2006, the Executive Board of KEDO decided to terminate the LWR project at Kumho.[125] North Korea assigned more than 100 nuclear scientists to this facility in 2003 to learn how to operate a power-generating LWR facility. South Korean experts who were on site assessed the North Korean personnel as not having much knowledge of nuclear power generation. The housing built for the scientists was significantly better than that of the local population.[126]

125 Korean Peninsula Energy Development Organization, "Welcome: The Korean Peninsula Energy Development Organization," accessed January 6, 2021. http://www.kedo.org/index.asp.

126 Author email conversation with an on-site U.S. representative assigned to the Kumho LWR project. See also Nuclear Threat Initiative, "Kumho-jigu Light Water Reactor Site," September 30, 2011. https://www.nti.org/learn/facilities/768/. Image from Google Maps at https://maps.app.goo.gl/G96ncRb14snPYVx19, accessed March 28, 2022.

Enrichment Facilities

The **Bungang Uranium Enrichment Plant** is located in Bungang district, across the Guryong River and west of the Yongbyon Nuclear Complex. South Korean and U.S. intelligence officials have estimated that the plant maintains 10,000 centrifuges.[127]

There is a suspected enrichment facility at **Kangson**, west of Pyongyang, at 38°57'24.84"N, 125°36'42.41"E.[128] It was first reported as a "covert uranium enrichment site" in 2018,[129] but subsequent analyses have argued that it could instead be "a plant that could manufacture components for centrifuges."[130]

127 Jeong Yong-soo, Baek Min-jeong, and Shim Kyu-seok, "Secret enrichment plant is right next to Yongbyon: Sources," *Korea JoongAng Daily*, March 5, 2019. https://koreajoongangdaily.joins.com/2019/03/05/politics/Secret-enrichment-plant-is-right-next-to-Yongbyon-Sources/3060178.html.

128 Image from Google Maps at https://maps.app.goo.gl/1Vjp4fJq3ZZXXo5e9, accessed March 28, 2022.

129 Ankit Panda, "Exclusive: Revealing Kangson, North Korea's First Covert Uranium Enrichment Site," *The Diplomat*, July 13, 2018. https://thediplomat.com/2018/07/exclusive-revealing-kangson-north-koreas-first-covert-uranium-enrichment-site/.

130 Olli Heinonen, "New Evidence Suggests Kangson Is Not a Uranium Enrichment Plant," *38 North*, December 18, 2020. https://www.38north.org/2020/12/kangson201217/.

Uranium Milling Facilities

The **Pakchon Uranium Milling Facility** is located in Pakchon County, North Pyongan Province.[131]

The **Pyongsan Uranium Milling Facility** is located in Pyonghwa-ri, Pyongsan County, North Hwanghae Province at 38°19'4.05"N, 126°25'59.02"E.[132] It was reported that as of 1999, there were 1,500 workers at this facility, which produced 290 tons of yellowcake per year.[133] A 2021 satellite imagery analysis concluded that the facility remained operational.[134]

Uranium Mines

Pakchon Uranium Mine is located in Pakchon, North Pyongan Province. It is one of North Korea's primary uranium mines.[135] There are also uranium mines in Rajin (Rason Special Economic Zone), Hyesan (Ryanggang Province), Musan (North Hamgyong Province), Wiwon (Jagang Province), Hungnam (South Hamgyong Province), Gujang (North Pyongan Province), Cheolsan (South Pyongan Province), Seonchon (south of Pyongyang), and Kumchon (North Hwanghae Province).[136]

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131 Nuclear Threat Initiative, "Pakchon Uranium Milling Facility," June 1, 2005. https://web.archive.org/web/20211009084107/https://www.nti.org/learn/facilities/675/.

132 Google Maps, https://maps.app.goo.gl/RtnfGA1RNAChrDvWA, accessed March 28, 2022.

133 Nuclear Threat Initiative, "Pyongsan Uranium Milling Facility," June 1, 2005. https://web.archive.org/web/20211009084144/https://www.nti.org/learn/facilities/676/. Image from Google Maps at https://maps.app.goo.gl/xeK1SdGGT8EA7DPJ8, accessed March 28, 2022.

134 Joseph S. Bermudez Jr., Victor Cha, and Jennifer Jun, "Current Status of the Pyongsan Uranium Concentrate Plant (Namchon Chemical Complex) and January Industrial Mine," *Beyond Parallel*, November 8, 2021. https://beyondparallel.csis.org/current-status-of-the-pyongsan-uranium-concentrate-plant-nam-chon-chemical-complex-and-january-industrial-mine/.

135 Nuclear Threat Initiative, "Pakchon Uranium Mine," June 1, 2005. https://www.nti.org/learn/facilities/674/.

136 Jun Gyeong-woong, "북한 핵시설 28곳…생물학 무기 시설도 21곳" [North Korea has 28 Nuclear Sites and 21 Biological Weapons Sites], *New Daily*, March 5, 2019. https://www.newdaily.co.kr/site/data/html/2019/03/05/2019030500173.html.

Test Sites

The **Punggye-ri Nuclear Test Site** is located in Punggye-ri, Kilju County, North Hamgyong Province (41°16'16.77"N, 129° 5'45.55"E). Based on declassified satellite images, the test site appears to have been constructed in the mid 1980s.[137] It is located next to Camp 16, one of North Korea's political prison camps (*kwan-li-so*), and it is suspected that political prisoners may have been used to construct and maintain the facility. In 2023, HRNK identified a switchback road leading from the test site to the perimeter of Camp 16, stating that the road may have been used to transport forced labor.[138] All six of North Korea's nuclear tests to date (October 2006, May 2009, February 2013, January 2016, September 2016, September 2017) have been conducted at this facility.[139]

137 Joseph S. Bermudez Jr., Victor Cha, and Jennifer Jun, "Punggye-ri Declassified: Birth of North Korea's 'Northern Nuclear Testing Site'," *Beyond Parallel*, January 23, 2024.
https://beyondparallel.csis.org/punggye-ri-declassified-birth-of-north-koreas-northern-nuclear-testing-site/.

138 Jacob Bogle, Greg Scarlatoiu, and Raymond Ha, "Switchback: Evidence of a Connection between *Kwan-li-so* No. 16 and the Punggye-ri Nuclear Test Facility?," *HRNK*, October 17, 2023.
https://www.hrnk.org/uploads/pdfs/punggyeri_FINAL.pdf.

139 Nuclear Threat Initiative, "Punggye-ri Nuclear Test Facility," June 7, 2023.
https://www.nti.org/education-center/facilities/punggye-ri-nuclear-test-facility/.

SECTION 6: THE SUPREME LEADERS' TREATMENT OF SCIENTISTS

North Korean nuclear scientists and engineers faced a life of relative poverty under Kim Il-sung and Kim Jong-il. Although Kim Il-sung established "No.1" high schools to train students who were talented in science, those who worked in related fields were at an economic disadvantage. The regime did not provide special benefits, and they were not allowed to make a living at the *jangmadang* markets.[140] Under Kim Jong-il, North Korean propaganda showed scientists receiving preferential treatment, but the reality was quite different. According to one account, approximately 80% of scientists had to find work outside of their assigned job to support their families. The apartments in front of the Academy of Sciences were referred to as the "fermentation apartments," as residents produced alcohol products from corn and acorns for self-consumption and selling.[141]

One episode, however, suggests that Kim Jong-il's attitude toward nuclear scientists and engineers may have changed near the end of his rule. On May 25, 2009, at a private party to celebrate North Korea's second nuclear test, Kim congratulated the North's nuclear scientists and declared that they had saved the fatherland. At this gathering, Kim is reported to have said, "Truly, you comrades have saved our Party and our Fatherland. As the Supreme Commander, I thank you." The party was attended by members of the National Defense Commission (NDC), the KWP CMC, the KWP MID, and nuclear workers of the 2nd Natural Sciences Academy, and other high-level scientists. When leaving the party, Kim turned to the scientists and bowed 90 degrees as a sign of respect. Kim Jong-il never bowed to anyone in this way, except to Kim Il-sung.[142]

Kim Jong-un's treatment of North Korean scientists and engineers has been markedly different from that of his father. Thae Yong-ho, a former North Korean diplomat who was later elected to South Korea's National Assembly, stated in his autobiography that Kim Jong-un focused on the missile and nuclear programs to bolster his legitimacy and authority.[143] He has shown an understanding of the process of trial and error necessary for scientific progress.[144] The living conditions of nuclear scientists and engineers have improved dramatically under Kim Jong-un.[145] One of the ways Kim has demonstrated his interest in the work of his nuclear scientists is by visiting their work sites. From 1984 to the sixth nuclear test in 2017, North Korea's leaders conducted 119 on-site inspections related to the nuclear and missile programs. Of these visits, 83 were made by Kim Jong-un.[146]

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140 Moon Sung-hui, "북, 과학자에 파격 대우" [North Korea Gives Exceptional Treatment to Scientists], *RFA*, May 16, 2017. http://www.rfa.org/korean/in_focus/ne-ms-05162017085729.html.

141 Pak Mi-yong, "생계형 도둑이 되어가는 북한과학자들" [North Korea's Scientists and Denial of Livelihood], *North Korea Strategy Center*, January 23, 2008. http://www.nksc.co.kr/bbs/board_view.php?bbs_code=bbsIdx-2&num=988&page=189&keycode=&keyword=&sub_code=. [Page no longer maintained.]

142 Choi Kyong-seon, "김정일, 핵과학자들에게 큰 절 했다!" [Kim Jong-il Gives Deep Bow to Nuclear Scientists], *Konas.net*, January 3, 2012. http://www.konas.net/article/article.asp?idx=27478.

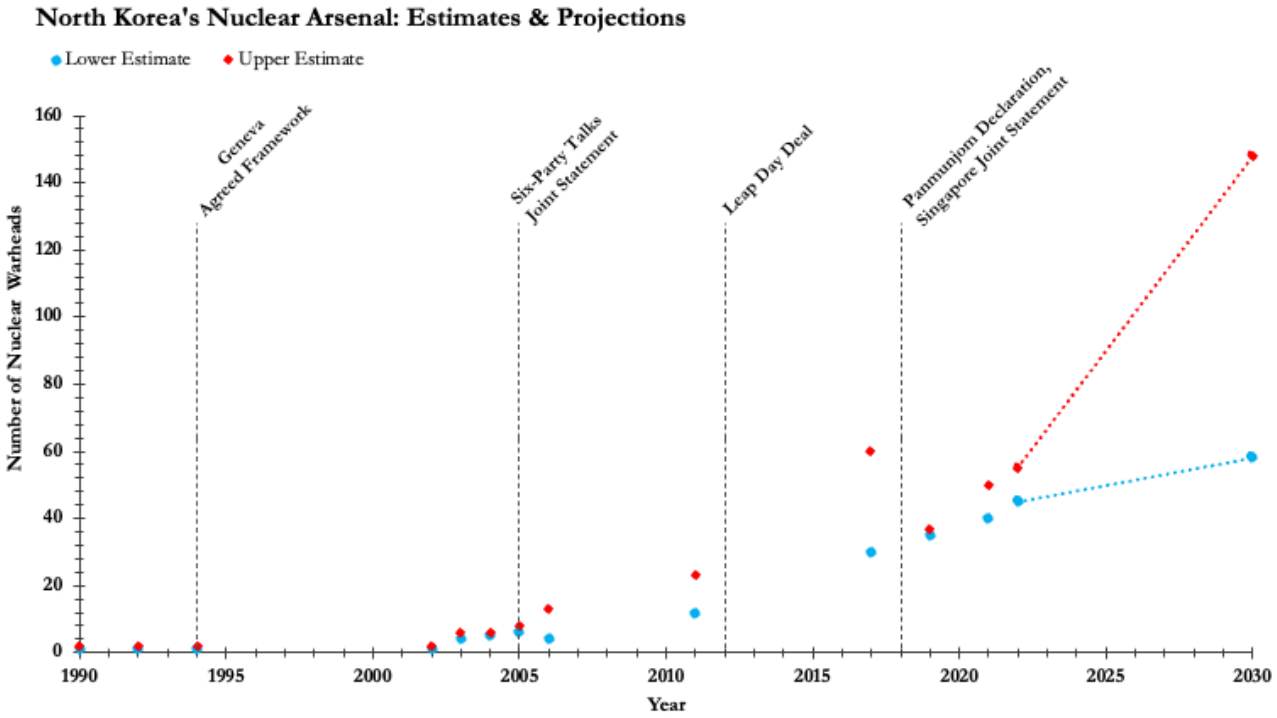
143 Thae Yong-ho, *3 cheung seogisil-ui amho* [*Passcode to the Third Floor Secretariat*] (Seoul: Guiparang, 2018), 518.

144 Wolf, "North Korea's scientists are hailed as national heroes in a country where science is king."

145 Byun Sang-jong, "김정은의 파격적 과학자 우대와 과학자들의 숙명" [Kim Jong-un's Exceptional Treatment of Scientists and Their Fate], *Institute for National Security Strategy*, December 2013.

146 Kim Ju-hwan, "북핵 전문 인력 3천여 명"...216연구소 주목" [North Korean Nuclear Experts Number 3,000...All Eyes on the 216th Research Institute], *YTN News*, October 17, 2017. http://www.ytn.co.kr/_ln/0101_201710072223287942.

The chart below, which shows estimates of the size of North Korea's nuclear arsenal, shows how the nuclear program has accelerated under Kim Jong-un.[147]



147 Sources: David Albright and Paul Brannan, "North Korean Plutonium Stock Mid-2006," *Institute for Science and International Security*. https://isis-online.org/publications/dprk/dprkplutonium.pdf; David Albright and Christina Walrond, "North Korea's Estimated Stocks of Plutonium and Weapon-Grade Uranium." *Institute for Science and International Security*, 2012. https://isis-online.org/uploads/isis-reports/documents/dprk_fissile_material_production_16Aug2012.pdf; Bruce W. Bennett et al., *Countering the Risks of North Korean Nuclear Weapons* (Santa Monica: RAND, 2021). https://www.rand.org/pubs/perspectives/PEA1015-1.html; "Estimating North Korea's Nuclear Stockpiles: An Interview with Siegfried Hecker," *38 North*, April 30, 2021. https://www.38north.org/2021/04/estimating-north-koreas-nuclear-stockpiles-an-interview-with-siegfried-hecker/; Siegfried S. Hecker,, Robert L. Carlin, and Elliot A. Serbin, "A Comprehensive History of North Korea's Nuclear Program: 2018 Update." *Center for International Security and Cooperation*, 2019. https://fsi-live.s3.us-west-1.amazonaws.com/s3fs-public/2018colorchartnarrative_2.11.19_fin.pdf; Hans M. Kristensen and Matt Korda, "North Korean Nuclear Weapons, 2021," *Bulletin of the Atomic Scientists* 77, no. 4 (2021): 222–36. https://doi.org/10.1080/00963402.2021.1940803; Hans M. Kristensen and Matt Korda, "North Korean Nuclear Weapons, 2022," *Bulletin of the Atomic Scientists* 78, no. 5 (2022): 273–94. https://doi.org/10.1080/00963402.2022.2109341; Hans M. Kristensen and Robert S. Norris, "North Korean Nuclear Capabilities, 2018," *Bulletin of the Atomic Scientists* 74, no. 1 (2018): 41–51. https://doi.org/10.1080/00963402.2017.1413062; Mary Beth Nikitin, "North Korea's Nuclear Weapons: Technical Issues." *Congressional Research Service*, 2013. https://sgp.fas.org/crs/nuke/RL34256.pdf; Larry A. Niksch, "North Korea's Nuclear Weapons Program," *Defense Technical Information Center*, January 27, 2005. https://apps.dtic.mil/sti/citations/ADA480434; "North Korean Nuclear Weapons: CIA Estimate for Congress; November 19, 2002," December 19, 2002. https://nuke.fas.org/guide/dprk/nuke/cia111902.html; "North Korea's Military Capabilities," *Council on Foreign Relations*, June 28, 2021. https://www.cfr.org/backgrounder/north-korea-nuclear-weapons-missile-tests-military-capabilities; Ankit Panda, "US Intelligence: North Korea May Already Be Annually Accruing Enough Fissile Material for 12 Nuclear Weapons," *The Diplomat*, August 9, 2017. https://thediplomat.com/2017/08/us-intelligence-north-korea-may-already-be-annually-accruing-enough-fissile-material-for-12-nuclear-weapons/; Stacie Pettyjohn and Jennie Matuschak. "Long Shadows: Deterrence in a Multipolar Nuclear Age," *Center for a New American Security*, May 18, 2022. https://www.cnas.org/publications/reports/long-shadows-deterrence-in-a-multipolar-nuclear-age; Sharon A. Squassoni, "North Korea's Nuclear Weapons: How Soon an Arsenal?," *Defense Technical Information Center*, May 12, 2005. https://apps.dtic.mil/sti/citations/ADA477931; Sharon A. Squassoni, "CRS Report for Congress North Korea's Nuclear Weapons: How Soon an Arsenal?," *Congressional Research Service*, August 1, 2005. https://www.everycrsreport.com/files/20050801_RS21391_fd30a44b151b03860bab602b65e825b8a791ff00.pdf.

Kim Jong-un's public statements and policy decisions have emphasized science and technology. On March 13, 2013, Kim declared his intent to pursue the strategic line of *byungjin* (parallel development) by expanding investment in science and technology.[148] In June 2016, he announced his "expectation and belief that the scientists, technicians, workers and officials in the sector of national defense science would perform fresh miracles and innovations in their scientific research for national defense and munitions production."[149] In his first public appearance of 2018, Kim visited the Academy of Sciences and stated that the scientists helped strengthen North Korea's strategic position.[150] The *Rodong Sinmun* stated in March 2020 that North Korea "must ensure that a portion of the profit made from the introduction of new technology actually goes to the scientists and institutions to invigorate scientific research and projects."[151]

Kim Jong-un has provided privileges and benefits to nuclear and missile scientists, including modern housing in Pyongyang. Mirae Scientists Street was built specifically for these scientists. Along with Unha Scientists Street, Space Scientists Housing Area, and the Ryomyong Street Housing Area, this area provides far better provisions for defense-related scientists than ever before and is referred to as "Pyonghattan."[152] The *Rodong Sinmun* reported on September 9, 2013 that Kim Jong-un had personally inspected the new housing complex for scientists. Located on Unha Scientists Street, the complex consists of twenty-one buildings with 1,000 units, with its own school, hospital, daycare facility, and other community service facilities.[153]

An additional apartment complex was completed in 2015 along the Taedong River for scientists residing in Pyongyang. On November 15, 2015, the regime's foremost cadre came to an apartment on Mirae Scientists Street to congratulate scientists and their families as they moved into their fully furnished homes. This included Pak Bong-ju (Cabinet Premier), Kim Ki-nam (Secretary for Propaganda), and Choe Thae-bok (Chair of the SPA Presidium).[154] Kim Ki-nam's presence was a clear indicator that the regime wanted to show gratitude to the scientists and emphasize its prioritization of the nuclear program. Such housing was designed as a reward to the scientists for their accomplishments, including the successful nuclear tests. Though these apartments are lavish by North Korean standards, the scientists "don't pay a dime of their own money" to live there.[155] A photo from the opening ceremony is shown below.[156]

148 Byun, "Kim Jong-un's Exceptional Treatment of Scientists and Their Fate," 2.

149 Michael Madden, "Kim Jong Un Attends Photo-op with Hwaso'ng 10 Personnel," *North Korea Leadership Watch*, June 29, 2016. https://nkleadershipwatch.wordpress.com/2016/06/29/kim-jong-un-attends-photo-op-with-hwasong-10-personnel/.

150 "Kim Jong-un visits science academy in his first inspection this year," *Yonhap News*, January 12, 2018. http://english.yonhapnews.co.kr/northkorea/2018/01/12/0401000000AEN20180112002600315.html.

151 "N. Korea's main paper calls for incentive system for scientists, engineers," *Yonhap News*, March 13, 2020. https://en.yna.co.kr/view/AEN20200313007100325.

152 Lee Yong-su, "공포통치 김정은, 유독 과학자엔 관대… '평해튼'까지 조성" [Scientists an Exception to Kim Jong-un's Politics of Fear], *Chosun Ilbo*, August 26, 2016. http://news.chosun.com/site/data/html_dir/2016/08/26/2016082600224.html.

153 An Yun-seok, "北 김정은 "교육과학부문 일꾼 살림집 건설에 힘쓰겠다" [Kim Jong-un States That North Korea Will Apply Every Effort to Build Homes For Educators and Scientists], *NoCut News*, September 9, 2013. http://www.nocutnews.co.kr/show.asp?idx=2609520&NewsCategoryCD=60100000.

154 "北 평양 53층아파트 어떻게 지어졌길래…'최고수준' 자찬" [How Did North Korea Build a 53-story Apartment in Pyongyang?], *Yonhap News*, November 17, 2015. https://www.yna.co.kr/view/AKR20151116185000014.

155 Elizabeth Shim, "North Korea scientists live in lavish apartments for free, Pyongyang says," *UPI*, November 17, 2015. http://www.upi.com/Top_News/World-News/2015/11/17/North-Korea-scientists-live-in-lavish-apartments-for-free-Pyongyang-says/2311447788717/.

156 Michael Madden, "Ceremony Opens Mirae Scientists' Street in Pyongyang," *North Korea Leadership Watch*, November 4, 2015. https://www.nkleadershipwatch.org/2015/11/04/ceremony-opens-mirae-scientists-street-in-pyongyang/. (Image

The remainder of this section briefly reviews how North Korea marked the nuclear tests that have been conducted under Kim Jong-un, illustrating the heightened status of nuclear scientists and engineers under the current Supreme Leader.

Third Test (February 2013)

After the third nuclear test, Kim Jong-un invited the relevant personnel to Pyongyang to congratulate them on their achievement. The scientists and engineers visited the Kumsusan Memorial Palace of the Sun, where they paid their respects to Kim Il-sung and Kim Jong-il, as well as to Kim Jong-suk—Kim Il-sung's wife and Kim Jong-il's mother—at the Revolutionary Martyrs' Cemetery in Pyongyang.[157]

from *Rodong Sinmun*, as published at cited source.)

157 Michael Madden, "Nuclear Test Personnel Visit Ku'msusan and Revolutionary Martyrs' Cemetery After Arriving in Pyongyang," *North Korea Leadership Watch*, February 21, 2013. https://nkleadershipwatch.wordpress.com/2013/02/21/nuclear-test-personnel-visits-kumsusan-and-revolutionary-martyrs-cemetery-after-arriving-in-pyongyang/. (Images from *KCNA*, as published at cited source.)

On February 21, the SPA Presidium conferred the title of "Hero of the Republic" on 100 individuals. Seventeen personnel received the Order of Kim Jong-il, nineteen received the Kim Jong-il Prize, and fifty received the Kim Jong-il Youth Honor Prize. Twelve received the title of People's Scientist, twenty-four received the title of Meritorious Scientist, and twenty received the title of Merit. In all, over 11,000 individuals were recognized for their contributions.[158] Kim Yong-nam, the President of the SPA Presidium, and Choe Yong-rim, the Cabinet Premier, visited the personnel at the Koryo Hotel to congratulate them.[159]

Fourth Test (January 2016)

Following the fourth nuclear test, Kim Jong-un praised the nuclear scientists and engineers as "the heroes of the heroes who will remain in history, and the patriots among patriots."[160] A crowd of 100,000 Pyongyang residents was mobilized to cheer for North Korean nuclear scientists and engineers as they arrived in Pyongyang.[161] On January 12, less than a week after the test, Kim Jong-un presented awards to nuclear scientists, engineers, construction workers, and other personnel who were involved in North Korea's first "hydrogen bomb" test. The awards were presented in the meeting room of the KWP Central Committee in Pyongyang. (The individual circled in red is Hong Yong-chil.)[162]

158 "北, 핵실험 유공자 1만1천여명에게 표창" [North Korea Presents Awards to 11,000 Personnel for Role in Nuclear Test], *Yonhap News*, February 23, 2013. https://www.yna.co.kr/view/AKR20130223052100014.

159 "Senior State Officials Visit Hotel for Contributors to Successful Third Underground Nuclear Test," *KCNA*, February 23, 2013.

160 Kim Min-so, "김정은 "핵무장력 질적으로 더욱 강화해야" [Kim Jong-un says "Nuclear armed forces should be further strengthened in quality"], *Segye Ilbo*, January 13, 2016. https://segye.com/view/20160113003753.

161 Park Young-hwan, "북한 '수소폭탄 실험' 핵과학자 영웅화…연일 '자강력 제일주의' 선전" [A Hero's Welcome for N. Korea's Nuclear Scientists after 'Hydrogen Bomb' Test, as Propaganda Hails Self-Reliance], *Kyunghyang Sinmun*, January 14, 2014. https://m.khan.co.kr/politics/north-korea/article/201601142221375.

162 "북한 '수소탄 시험 성공' 노동당 및 국가 표창 수여식" [KWP and State Honors Presented for North Korea's 'Successful Hydrogen Bomb Test'], *Chosun Ilbo*, January 13, 2016. https://www.chosun.com/site/data/html_dir/2016/01/13/2016011302535.html. (Image from *Rodong Sinmun*, as published at cited source.)

Fifth Test (September 2016)

Below is a photograph commemorating North Korea's fifth nuclear test in 2016, taken in front of the Kumsusan Memorial Palace of the Sun. There are a total of 500 personnel from the Nuclear Weapons Institute, the Second Academy of Natural Sciences, the Second Economic Committee, the KPA General Staff Department's Nuclear-Chemical Bureau, and the KWP MID.[163]

Sixth Test (September 2017)

The KWP Central Committee and the KWP CMC hosted a major ceremony in September 2017 for North Korea's nuclear scientists and engineers, congratulating them for their success in testing a hydrogen bomb. When entering the venue for the celebration, Kim Jong-un was seen walking arm-in-arm with Ri Hong-sop, the Director of the Nuclear Weapons Research Institute.[164] It is highly unusual for the leader of North Korea to show this kind of gesture toward a scientist.

At the celebration, Kim Jong-un said that "our robust economic foundations, our army of brilliant scientists, our people and our military, armed with the revolutionary spirit of Paektu, and our tradition of struggling for self-reliance all but assure the final victory of the Juche revolution."[165]

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163 Michael Madden, "KJU Poses for a Photo with Participants in the Fifth Nuclear Test," *North Korea Leadership Watch*, September 22, 2016. https://nkleadershipwatch.wordpress.com/2016/09/22/kju-poses-for-a-photo-with-participants-in-the-fifth-nuclear-test/. (Image from *KCNA/Rodong Sinmun*, as published at cited source.)

164 Eom Min-jae, "北 김정은, 핵무기연구소장 손잡고 팔짱 끼고…'애정·신뢰' 과시" [Kim Jong-un Holds Hands, Walks Arm-in-Arm with Director of Nuclear Weapons Research Institute, Showing Affection and Trust], *SBS News*, September 10, 2017. https://news.sbs.co.kr/news/endPage.do?news_id=N1004387048.

165 Cho Sung-won, "北김정은 '수소탄 폭음, 위대한 승리…최후승리는 확정적'" [Kim Jong-un Says Hydrogen Bomb Blast is Great Victory, Final Triumph is Assured], *KBS News*, September 10, 2017. https://news.kbs.co.kr/news/pc/view/view.do?ncd=3546695.

SECTION 7: FOREIGN ASSISTANCE, ESPIONAGE, PROLIFERATION

Kim Jong-un has claimed that North Korea's hydrogen bomb was built indigenously. According to *KCNA*, Kim stated, "All components of the H-bomb were homemade and all the processes ranging from the production of weapons-grade nuclear materials to precision processing of components and their assembling."[166]

This is highly debatable, however. North Korea has relied on educational, technical, and economic support from other countries to develop its nuclear program. North Korea's nuclear scientists and engineers have participated in education and training programs; acted as advisers on the legal and illegal acquisition of equipment and other resources; advised the nuclear programs of foreign governments; and utilized goods and resources received through illicit procurement networks.

Whether through foreign assistance, espionage, or proliferation activities, North Korea's nuclear scientists have conducted exchanges, both directly and indirectly, legitimately and illegitimately, with scientists and engineers from countries including the former Soviet Union, Brazil, Argentina, South Africa, Pakistan, and China.[167] North Korea's overseas espionage and proliferation efforts are substantial, and the KWP oversees these illicit activities.[168]

Getting to the point where the North Korean nuclear program could produce nuclear weapons took decades—much longer than in most other countries. There are several reasons for this, the most significant factors being internal politics, a lack of resources and technical know-how, and poor collaboration between different scientific specialties. North Korea's nuclear scientists did not have access to necessary supplemental technology, such as switches and relays.[169] North Korea's nuclear program would not have progressed without external assistance.

Foreign Assistance

Declassified diplomatic documents show North Korea's early interest in obtaining foreign assistance to develop a nuclear program. To initiate its nuclear weapons program, North Korea consistently pushed their communist counterparts in the Soviet Union, China, East Germany, Czechoslovakia, and Yugoslavia for assistance in building nuclear power plants as well as securing nuclear weapons.[170]

On August 26, 1963, the East German ambassador to North Korea told the Soviet ambassador to North Korea, Vasily Moskovsky, that "the Koreans, apparently on Chinese instructions, are asking whether they could obtain any kind of information about nuclear weapons and the atomic industry from German uni-

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166 Page and Gale, "Behind North Korea's Nuclear Advance: Scientists Who Bring Technology Home."

167 Oh Dong-yong, "북핵 과학자·기술자들 평화적 임무로 전환시켜라" [Turn N. Korean Nuclear Scientists and Engineers into a Peaceful Mission], *Weekly Chosun*, March 11, 2019. http://weekly.chosun.com/client/news/viw.asp?ctcd=C03&nNewsNumb=002548100010.

168 Lee Young-jong, "북핵 개발 주역은 '노동당 군수공업부" [KWP MID Leads N. Korea's Nuclear Development], *Sisa Press*, September 14, 2017. http://www.sisapress.com/journal/article/171260.

169 C4ADS provides excellent analysis of North Korea's involvement in proliferation activities, particularly clandestine acquisition channeled through China. See David Thompson, "Risky Business: A System-Level Analysis of the North Korean Proliferation Financing System, *C4ADS*, 2017. https://c4ads.org/reports/risky-business/.

170 Clemens, "North Korea's Quest for Nuclear Weapons."

versities and research institutes."[171] In 1967, North Korea attempted to convince East Germany to support their nuclear program through the provision of equipment and exchange of nuclear personnel, but East Germany referred them to the Soviet Union.[172]

In 1981, North Korea asked Hungary, East Germany, and Czechoslovakia to train North Korean graduate students in "nuclear energy and other topics," including "microelectronics, laser technology, enrichment facilities, reactive engine technology, protection of nuclear reactors, electronic equipment of nuclear reactors, and isotope separation." These requests were rejected. North Korea again asked Hungary in 1983 to train engineers to operate a nuclear power plant, but the request was denied once again.[173]

From the 1950s to the 1980s, North Korea relied heavily on the Soviet Union. Beyond training North Korea's nuclear scientists in the 1950s and 1960s, Moscow directly supported construction of the IRT-2000 research reactor and the 5MWe nuclear reactor at Yongbyon. According to Soviet and Russian reports, a total of 160 Russian nuclear scientists worked in North Korea in the late 1980s and early 1990s, and nine nuclear scientists and seventeen missile specialists were still there in 1994.[174] There are also reports that former East German and Russian nuclear scientists were in North Korea in the mid-1990s.[175]

The fall of the Soviet Union not only altered the regime's calculus on national security, but also forced Pyongyang to look elsewhere for assistance on its nuclear program. In particular, the role of Pakistani physicist A.Q. Khan is widely known. Former Pakistani President Musharraf also claimed in his autobiography that Khan "sold around twenty centrifuges to North Korea in the 1990s and visited North Korea to teach them how to install this equipment."[176] It has also been reported that North Korea may have "obtained information on uranium melting from Pakistan in the late 1980s."[177]

Espionage & Cyber Activities

North Korea has a long history of obtaining nuclear-related information outside of training and education programs. Choi Hak-keun, a Soviet-trained physicist, was twice sent to attend the IAEA's General Conference as North Korea's representative in the 1970s. During his visits, he is said to have photocopied nuclear reactor designs and other material from the IAEA's library to send to North Korea. An IAEA spokesperson responded that "scientific and technical documents provided in the library are not considered to be particularly sensitive." In 1986, Choi was appointed North Korea's Minister of the Atomic Energy Industry.[178]

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171 Clemens, "North Korea's Quest for Nuclear Weapons," 130.

172 Ibid., 132–33.

173 Ibid., 144–45.

174 Sergey Agafonow, "A Total of 160 Russian Nuclear Scientists and Missilemen Helped North Korea to Create a Nuclear Bomb," *Izvestia*, January 27, 1994; as cited in Young Whan Kihl and Hong Nack Kim, *North Korea: The Politics of Regime Survival* (New York: M E Sharpe, 2005), 98–99.

175 Larry A. Niksch, "North Korea's Nuclear Weapons Program," *Congressional Research Service*, August 1, 2006, 11. https://www.hsdl.org/?view&did=465815.

176 Oh, "Turn N. Korean Nuclear Scientists and Engineers into a Peaceful Mission."

177 Sharon Squassoni, "Closing Pandora's Box: Pakistan's Role in Nuclear Proliferation," *Arms Control Association*, April 1, 2004. https://www.armscontrol.org/act/2004_04/Squassoni#notes13.

178 Hong Deok-hwa, ""북 핵개발 리승기·도상록 등 월북과학자가 주도" [N. Korea's Nuclear Development Led by Scientists Who Went North, Including Ri Sung-ki and Do Sang-rok], *Yonhap News*, October 24, 2006. https://www.hani.co.kr/arti/politics/defense/166842.html.

In recent years, it appears that North Korea has used its cyber operatives to obtain nuclear-related information. A North Korean hacker group attempted to hack the Korean Atomic Energy Research Institute—a government-funded nuclear research institute in South Korea—in 2021. This followed an earlier cyberattack in 2014 that targeted South Korea's Korea Hydro & Nuclear Power Co. Ltd.[179] This kind of covert data collection by North Korean operatives likely contributed to its steady advancements in nuclear technology.

North Korea has also carried out similar activities with respect to missile technology. In 2017, it was reported that two North Korean nationals had been arrested in 2011 in Ukraine through a sting operation. Ryu Song-chol and Ri Tae-gil were arrested by the Ukrainian authorities for attempting to steal missile secrets from the Yuzhmash rocket factory. The information they sought to obtain related to the "uninterrupted flow of fuel" in rockets, which is critical to successfully launching ICBMs.[180] It was also reported that North Korean cyber operatives "secretly breached computer networks at a major Russian missile developer for at least five months" in 2022.[181]

Moreover, it should be noted that North Korea's cyber activities are aimed at more than just espionage. According to a public U.S. inter-agency advisory issued in 2022, individuals affiliated with North Korea's nuclear sector have been involved in raising funds for the Kim regime by posing as IT workers. This includes IT personnel associated with the Ministry of Atomic Energy Industry and the 313 General Bureau of the KWP MID, both of which play a critical role in North Korea's nuclear program. The advisory notes that North Korea's IT workers "generate revenue that contributes to its weapons of mass destruction (WMD) and ballistic missile programs."[182]

Procurement Networks

According to a 2013 piece in *The Atlantic*, a UN agency included the following locations in a watch list for monitoring North Korea's nuclear procurement network: Malaysia, the Cayman Islands, Cyprus, Liechtenstein, Greece, Taiwan, China, Philippines, Vietnam, Turkey, Mauritania, Thailand, Singapore, and the UAE.[183] The head of Germany's domestic intelligence agency stated in 2018 that North Korea's embassy in Berlin was involved in "acquiring equipment and technology for its nuclear and weapons programmes."[184]

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179 Hakyung Kate Lee, "North Korea attempted to hack South Korea's nuclear think tank, lawmaker says," *ABC News*, June 19, 2021. https://abcnews.go.com/International/north-korea-attempted-hack-south-koreas-nuclear-tank/story?id=78372452.

180 Andrew Higgins, "Two North Korean Spies, a Ukrainian Jail and a Murky Tale," *The New York Times*, September 28, 2017. https://www.nytimes.com/2017/09/28/world/europe/north-korea-ukraine-missiles.html.

181 James Pearson and Christopher Bing, "Exclusive: North Korean hackers breached top Russian missile maker," *Reuters*, August 7, 2023. https://www.reuters.com/technology/north-korean-hackers-breached-top-russian-missile-maker-2023-08-07/.

182 U.S. Department of the Treasury, "Guidance on the Democratic People's Republic of Korea Information Technology Workers," May 16, 2022. https://ofac.treasury.gov/media/923126/download?inline.

183 Mark Hibbs, "How North Korea Built Its Nuclear Program," *The Atlantic*, April 10, 2013. http://www.theatlantic.com/international/archive/2013/04/how-north-korea-built-its-nuclear-program/274830/.

184 "North Korea's Berlin embassy used to acquire nuclear tech, says spy chief," *Agency France-Presse*, February 4, 2018. https://www.theguardian.com/world/2018/feb/04/north-korea-berlin-embassy-nuclear-tech-germany-spy-chief.

North Korean efforts to conceal the sale or acquisition of goods and resources are nothing new. Pyongyang has one of the world's most sophisticated global procurement networks. In support of these operations, North Korea utilizes offshore jurisdictions with lax banking controls, shell companies, and foreign intermediaries to circumvent sanctions.[185]

There is also evidence that North Korea received significant assistance from ethnic Koreans in Japan who support the Kim regime. The Korean Association of Science and Technology (KAST, 재일본조선인과학기술협회), formed by pro-North Korean scientists in Japan, "has been an effective conduit for illicit procurement of material and access to know-how from Japan into North Korea."[186] According to a 2012 analysis, KAST is "under the direct control of the external relations division" of the KWP, and it has around 1,200 members across Japan.[187] In 2003, a Japanese company and an export agent "conspired to transport vacuum pump(s)," which are "useful for uranium enrichment," to North Korea.[188] A 2006 report by Japan's National Police Agency notes that it "made arrests in seven cases [for] the illegal export of WMD-related materials involving North Korea," including equipment that "can be used in uranium purification."[189]

The role of one KAST member has been reported in the press. In December 2006, the Japanese police arrested Seo Seok-hong and his wife Park Jong-soon for dispatching workers to companies without notifying the authorities, who suspected that Seo was seeking to acquire technological know-how from those companies. Seo, an expert on engines by training, was in North Korea during the launch of the Taepodong-1 missile in August 1998. He was believed to have been directly involved in the development of that missile, and in assisting the development of North Korea's nuclear weapons and missiles.[190]

Proliferation Activities

North Korean scientists and engineers have also been involved in the nuclear programs of other countries. South Korean intelligence authorities assessed that ten North Koreans died when Israel attacked a nuclear facility in Syria in September 2007. These individuals were affiliated with the KWP MID's Office 99, and their bodies were cremated and returned to North Korea one month later. Two or three North Koreans are believed to have survived the attack.[191] A 2010 report also raised the possibility that North Korean engineers "are helping to build a reactor in Burma."[192]

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185 Eda Erol and Leonard Spector, "Occasional Paper #35: Countering North Korean Procurement Networks Through Financial Measures: The Role of Southeast Asia," *James Martin Center For Nonproliferation Studies*, December 2017. http://www.nonproliferation.org/op35-countering-north-korean-procurement-networks-through-financial-measures-the-role-of-southeast-asia/.

186 James A. Russell and Jack Boureston, "Illicit Trafficking Challenges: Fighting the Good Fight Against Illicit Trafficking Networks," *Naval Postgraduate School* (Oct. 2012), 8. https://apps.dtic.mil/sti/tr/pdf/ADA571722.pdf.

187 Ibid.

188 Ibid., 9.

189 Japan National Police Agency, "North Korea Operations against Japan," December 2006. https://www.npa.go.jp/archive/keibi/syouten/syouten273/english/p02.html.

190 Cheon Gwang-am, "핵기술 북한에 제공 의혹 총련 산하단체 간부 체포" [Member of Chongryon-operated Organization Arrested for Allegedly Providing Nuclear Technology to North Korea], *Dong-A Ilbo*, January 30, 2007. https://www.donga.com/news/Politics/article/all/20070130/8401438/1.

191 Yang Jeong-ah, "시리아 핵시설 폭격시 북한인 10명 사망" [Ten North Koreans Die in Attack on Syrian Nuclear Facility], *Daily NK*, April 28, 2008. http://www.dailynk.com/korean/read.php?cataId=nk00900&num=55778.

192 Robert E. Kelley and Ali Fowle, "Nuclear Related Activities in Burma," *Democratic Voice of Burma* (2010), 27. https://www.washingtonpost.com/wp-srv/world/documents/060410.pdf.

There has been extensive cooperation between North Korea and Iran on nuclear technology. A 2011 *Yonhap News* report, citing a diplomatic source, states that "hundreds of North Korean nuclear and missile experts" work in Iran at more than ten locations, including Natanz and Qom. According to the IAEA, Natanz hosts a fuel enrichment plant.[193] The scientists rotate in and out of Iran every three to six months and are supervised by Office 99 of the KWP's MID.[194]

193 "北 핵 · 미사일 기술자 수백여명 이란서 근무" [Hundreds of North Korean Nuclear and Missile Engineers Working in Iran], *Yonhap News*, November 13, 2011. https://www.yna.co.kr/view/AKR20111111180000043.
194 Ibid.

SECTION 8: NORTH KOREA'S NUCLEAR LEADERS

The Supreme Leader has always been the ultimate leader of North Korea's nuclear program. Kim Il-sung, Kim Jong-il, and Kim Jong-un have all led the nuclear program through various periods of development. Kim Il-sung oversaw the development of intellectual capital that made the nuclear program possible, primarily by having 250 North Korean researchers study nuclear science in the Soviet Union. These scientists returned to North Korea in the 1960s and became known as the "red scientists." They formed the basis of North Korea's nuclear program, as they led nuclear research and trained additional personnel. This was critical to the program's expansion. Kim Jong-il focused on political loyalty and ideology among the scientists, which considerably slowed progress. However, Kim Jong-un has taken a more rational approach to managing the nuclear program, rewarding scientists and engineers for their achievements.

This section provides an overview of key individuals in North Korea's nuclear program, past and present, including KWP officials who have managed the program.

Current Leaders

Marshal Ri Byong-chol (리병철)

Ri is unique among Kim Jong-un's advisors. He has experience as a combatant commander in the KPA, and he has senior KWP experience from serving as a Member of the KWP Politburo Presidium and Vice-Chair of the KWP CMC.[195] Most importantly, Ri also served as the Director of the KWP MID, which oversees North Korea's nuclear and missile programs, as well as all other weapons development. Combined with his close access to Kim Jong-un, this makes him Kim Jong-un's most critical adviser, particularly in the event of a crisis. During a domestic crisis, Ri will serve as the primary balancer between the need for a military decision and the need to protect Kim Jong-un, the regime, and Pyongyang.

Ri has also served in the regime's most powerful entity—the KWP OGD.[196] Analysts reported in early 2015 that Ri had been appointed as a OGD first vice-director with responsibility for military affairs.[197] In this position, Ri had the power to directly impact Kim Jong-un's decision-making on weapons development. OGD first vice-directors oversee policymaking for consistency with Supreme Leader guidance and the careers of all senior leadership. After being moved from North Korea's Air Force to the OGD, Ri accompanied Kim Jong-un on inspections of North Korea's leading weapons development programs—nuclear weapons, long-range ballistic missiles, and SLBMs. The photo below, showing Kim Jong-un embracing Ri after a test-launch of the Musudan missile in 2016, illustrates the close personal relationship between the two.[198]

195 Photo from the ROK Ministry of Unification's *North Korea Information Portal*, accessed April 4, 2024. https://nkinfo.unikorea.go.kr/nkp/prsn/list.do.

196 Robert Collins, *North Korea's Organization and Guidance Department: The Control Tower of Human Rights Denial* (Washington, D.C.: Committee for Human Rights in North Korea, 2019). https://www.hrnk.org/uploads/pdfs/Collins_OGD_Web.pdf.

197 Choi Min-seok, "리병철 제1부부장 김정은 핵심실세" [First Vice-Director Ri Byong-chol: One of the Kim Regime's Core Elite], *RFA*, February 23, 2015. https://www.rfa.org/korean/in_focus/nk_nuclear_talks/powerman-02232015144824.html.

198 "北, 무수단 미사일 시험발사 '성공' 주장…김정은 환호" [North Korea Claims Successful Launch of Musudan Mis-

Ri was born in 1948 and attended the prestigious Mangyongdae Revolutionary School. He then attended and graduated from Kim Il-sung Military College. Ri rose through the ranks in the KPA Air Force to become the Second Air Division Commander in 1990 and was promoted to major general in 1992. He became the Commander of the KPA Air Force in April 2008 as a colonel general (three-star). In that capacity, he visited Russia, Cuba, and China as the head or a member of military delegations. He was promoted to a four-star general in April 2010. Ri has served as a Member of the 10th, 11th, 12th, 13th, and 14th SPA. He is also currently a Member of the KWP Central Committee. Ri was awarded the coveted Kim Jong-il Medal in 2012.[199] Ri has been sanctioned by the UN, U.S., UK, EU, and Japan.[200]

sile Test…Kim Jong-un Elated], *KBS News*, June 23, 2016. http://news.kbs.co.kr/news/view.do?ncd=3300240&ref=A. (Image from *Rodong Sinmun*, as published at cited source.)

199 Republic of Korea Ministry of Unification, *Bukhan juyo insa: inmuljeongbo 2023* [North Korea's Key Personnel: 2023] (Seoul: Ministry of Unification, 2023), 415–24. https://unikorea.go.kr/books/archive/archive/?boardId=bbs_0000000000000043&mode=view&cntId=47386.

200 Risk Advisory, "North Korea Sanctions List," accessed April 4, 2024. https://www.riskadvisory.com/sanctions/north-korea-sanctions-list/?page=3.

Hong Sung-mu (홍승무)

Hong is a First Vice-Director in the KWP MID.[201] In this capacity, he has working-level oversight of North Korea's nuclear and ballistic missile programs. He can be seen in North Korean media reports accompanying Kim Jong-un to testing and manufacturing sites. Hong has experience in the "production and manufacturing side" of North Korea's military and munitions industries, and he was also the former chief engineer at the 5Mwe reactor at Yongbyon.[202] Hong is a Member of the KWP Central Committee and the 14th SPA.[203] Hong has been sanctioned by the UK and the EU.[204]

Hong Yong-chil (홍영칠)

Hong, a life-long Party functionary, is a Vice-Director in the KWP MID.[205] In this position, he works with First Vice-Director Hong Sung-mu to oversee North Korea's munitions programs at the working level. He frequently accompanies Kim Jong-un to manufacturing sites, celebration events, and field demonstrations of North Korea's nuclear, missile, and other key munitions programs. In the photo below from *Rodong Sinmun*, Hong is seen accompanying Kim Jong-un on an inspection of a nuclear weapons facility (second from right, holding folded notebook).[206]

Believed to be in his 60s, Hong was designated as a Labor Hero in 2011. He was previously the KWP Committee Secretary at the Unsan Tools Factory and became a KWP Vice-Director in 2013.[207] He has been sanctioned by the UK and the EU.[208]

201 Photo from the ROK Ministry of Unification's *North Korea Information Portal*, accessed April 4, 2024.
202 Michael Madden, "Hong Sung Mu," *North Korea Leadership Watch*, April 9, 2016. https://nkleadershipwatch.wordpress.com/leadership-biographies/hong-sung-mu/.
203 Republic of Korea Ministry of Unification, *North Korea's Key Personnel: 2023*, 1063–64.
204 Risk Advisory, "North Korea Sanctions List," accessed April 4, 2024.
205 Photo from the ROK Ministry of Unification's *North Korea Information Portal*, accessed April 4, 2024.
206 Michael Madden, "Kim Jong Un Meets with Nuclear Weapons Personnel," *North Korea Leadership Watch*, March 8, 2016. https://nkleadershipwatch.wordpress.com/2016/03/08/kim-jong-un-meets-with-nuclear-weapons-personnel/. (Image from *Rodong Sinmun*, as published at cited source.)
207 Michael Madden, "Hong Yong Chil: Third generation munitions industry leader," *NK News*, October 24, 2013. http://www.nknews.org/2013/10/hong-yong-chil-third-generation-munitions-industry-leader/.
208 Risk Advisory, "North Korea Sanctions List," accessed April 4, 2024.

General Jang Chang-ha (장창하)

General Jang Chang-ha is the head of North Korea's Missile General Bureau. He previously served as the President of the Second Academy of Natural Sciences, which is responsible for weapons research and development.[209] Jang directly oversees the development of North Korea's missile programs at the working level and is present at missile tests.[210] Jang was appointed a Member of the KWP Central Committee at the Seventh Party Congress in May 2016.[211] Pursuant to Executive Order 13687, Jang was sanctioned by the U.S. Department of Treasury in December 2016 for his role in North Korea's WMD program.[212] He has also been sanctioned by the UN, UK, EU, and Japan.[213]

Ri Hong-sop (리홍섭)

Ri Hong-sop is the leading nuclear scientist in North Korea's nuclear weapons program. South Korea's Ministry of Unification identified him as the Director of the Nuclear Weapons Research Institute (NWRI) in 2023.[214] He was formerly the Director of the Yongbyon Atomic Energy Research Institute.[215] Ri was sanctioned by the UN in July 2009,[216] and by the United States in 2010.[217] Ri has also been sanctioned by the UK, EU, and Japan.[218] In 2017, Ri was seen wearing the insignia of a three-star general on his KPA uniform.[219]

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209 Photo from the ROK Ministry of Unification's *North Korea Information Portal*, accessed April 4, 2024.

210 Republic of Korea Ministry of Unification, *North Korea's Key Personnel: 2023*, 810–12; see also Ji Seong-rim, "북한 '미사일 1등공신'은 김정식…실무 책임자는 장창하" [Kim Jong-sik is the Number One Lead For North Korea's Missiles...Jang Chang-ha is the Working-level Officer], *Yonhap News TV*, September 21, 2016. https://www.youtube.com/watch?v=BJ6UeUKGCYU.

211 Cho Jung-hoon, "北 노동당 정무국 신설, 위원장 김정은 추대" [Korean Workers' Party Establishes Executive Policy Bureau, Appoints Kim Jong-un Chairman], *Tongil News*, May 10, 2016. http://www.tongilnews.com/news/articleView.html?idxno=116571.

212 Republic of Korea Ministry of Unification, *Bukhan gigwan-byeol inmyeongrok 2023* [Key Personnel in North Korea by Institution: 2023] (Seoul: Ministry of Unification, 2023), 321. https://unikorea.go.kr/books/archive/archive/?boardId=bbs_0000000000000043&mode=view&cntId=47386.

213 Risk Advisory, "North Korea Sanctions List," accessed April 4, 2024.

214 Republic of Korea Ministry of Unification, *Key Personnel in North Korea by Institution: 2023*, 321.

215 U.S. Senate Committee on Foreign Relations, *North Korea: Status Report on Nuclear Program, Humanitarian Issues, and Economic Reforms* (Washington, D.C.: U.S. GPO, 2004). https://www.govinfo.gov/content/pkg/CPRT-108SPRT92278/html/CPRT-108SPRT92278.htm.

216 UN Security Council, "Ri Hong-sop," October 29, 2014. https://www.un.org/securitycouncil/sanctions/1718/materials/summaries/individual/ri-hong-sop.

217 U.S. Department of the Treasury, "North Korea Executive Order / North Korea Designations / Non-proliferation Designations," August 30, 2010. https://ofac.treasury.gov/recent-actions/20100830.

218 Risk Advisory, "North Korea Sanctions List," accessed April 4, 2024.

219 "북한 핵개발 총책 홍승무, 상장->대장 진급" [Hong Sung-mu, Head of North Korea's Nuclear Weapons Program, Promoted to General], *Yonhap News*, September 7, 2017. https://www.yna.co.kr/view/MYH20170907006600038.

Cho Chun-ryong (조춘룡)

Cho Chun-ryong was the Director of the KWP MID.[220] He was formerly the Chair of the SEC, which directs North Korea's military-industrial complex and is responsible for administrative oversight of all WMD production facilities. In December 2023, he was appointed as a Member of the KWP Politburo and a Secretary of the KWP Central Committee. He was also seen accompanying Kim on inspections of munitions factories.[221] These appointments indicate both demonstrated loyalty to the regime and managerial capability.

Cho Yong-won (조용원)

Cho Yong-won is the Director of the KWP OGD,[222] a position he assumed in June 2022.[223] He is a long-time OGD official and has been one of Kim Jong-un's closest advisors. Cho has a B.S. in physics from Kim Il-sung University. He is reportedly a student of Do Sang-rok and Seo Sang-guk, the "fathers of nuclear science" in North Korea.[224] The OGD oversees the careers of all KWP leaders and the political life of every North Korean citizen, including every nuclear scientist. The OGD is critical to implementing Kim Jong-un's domestic policy of *byungjin*, which pursues the dual development of the economy and the nuclear program.

Past Leaders

Do Sang-rok (도상록)

Do Sang-rok received his education in physics at Tokyo University. Do was Kim Il-sung's first adviser for the nuclear program, and he is generally regarded as the "father of North Korea's nuclear program."[225]

Chon Byong-ho (전병호)

Chon Byong-ho built his career in the munitions industry, retiring as the KWP Secretary for the Munitions Industry in 2012. Chon played an instrumental role in advancing North Korea's nuclear program by overseeing the acquisition of equipment and technology from Pakistan. He was not trained as a nuclear scientist or engineer, however. Chon died in 2014.[226]

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220 Photo from the ROK Ministry of Unification's *North Korea Information Portal*, accessed April 4, 2024.

221 Hyun Hye-ran, "北박정천, 군사위 부위원장 복귀…'제재대상' 조춘룡, 당비서로" [Park Jeong-cheon Reinstated as CMC Vice Chair, as Cho Chun-ryong, Targeted by Sanctions, Appointed Party Secretary], *Yonhap News*, December 31, 2023. https://www.yna.co.kr/view/AKR20231231014400504.

222 Photo from the ROK Ministry of Unification's *North Korea Information Portal*, accessed April 4, 2024.

223 Republic of Korea Ministry of Unification, *North Korea's Key Personnel: 2023*, 871.

224 Choi Woo-seok, "北 실세 조용원, 7년 전부터 김정은 特命 전달 역할" [Cho Yong-won, a Powerful Figure in North Korea, Has been Kim Jong-un's Trusted Messenger for Seven Years], *Monthly Chosun*, March 2021. https://m.monthly.chosun.com/client/amp/viw.asp?ctcd=&nNewsNumb=202103100020.

225 Kang, "Do Sang-rok – Father of North Korea's Nuclear Physics."

226 Kim Joo-won, "핵무기 개발과 전병호" [Nuclear Weapons Development and Chon Byong-ho], *REA*, Janu-

Pak To-chun (박도춘)

Pak To-chun succeeded Chon Byong-ho as the KWP Secretary for Munitions Industry, exercising political oversight of North Korea's nuclear and missile programs. North Korea's state media reported in 2022 that he had been buried at the Patriotic Martyrs' Cemetery, but it is unclear when he died.[227] He previously served as the Jagang Province Party Committee Chairman from 2005 to 2010.[228] The province is known for having a high concentration of North Korea's munitions factories. He was appointed a four-star general in February 2012.[229]

Chu Kyu-chang (주규창)

Chu Kyu-chang was the First Vice Director of the KWP MID, where he played a critical role in overseeing North Korea's nuclear and missile programs.[230] He was a KCUT graduate and also served as the Director of the Second Academy of Natural Sciences. He died in 2018.[231]

Ri Myong-ha (리명하)

The South Korean press reported in 2009 that Dr. Ri Myong-ha, a scientist in his 70s who previously studied in the Soviet Union, played a critical role in North Korea's nuclear weapons development. At the time, Ri was serving as the Dean of the College of Physics at Yongbyon. He was known to be an expert in high explosives, which play a critical role in the detonation device for a nuclear warhead.[232] It was reported in 2016 that Ri was no longer directly involved in the nuclear program, but continued to exercise his influence over the appointment of key personnel.[233]

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ary 31, 2017. https://www.rfa.org/korean/weekly_program/ae40c528c77cac00c758-c228aca8c9c4-c9c4c2e4/hidden-truth-01312017095418.html.

227 Park Soo-yoon, "북, '핵 원로' 박도춘·사업가 신남철 애국열사릉에 안장" [Nuclear Leader Pak To-chun and Businessman Sin Nam-chol Buried in Patriotic Martyrs' Cemetery], *Yonhap News*, September 2, 2022. https://www.yna.co.kr/view/AKR20220902018500504.

228 Republic of Korea Ministry of Unification, "박도춘" [Pak To-chun], *North Korea Information Portal*, accessed April 17, 2023. https://nkinfo.unikorea.go.kr/nkp/prsn/view.do?menuId=PEOPLE_86&prsnMngNo=7443&prsnMngNo=7443.

229 Ibid.

230 "북한신문, 핵·미사일 개발 이끈 주규창 부각…억제력 강화 의지" [*Rodong Sinmun* spotlights Chu Kyu-chang, Who Led the Nuclear and Missile Programs], *Yonhap News*, August 18, 2020. https://www.yna.co.kr/view/AKR20200818074700504.

231 Park Gwang-soo, "北미사일 개발 이끈 주규창, 3일 사망…北 "커다란 손실" 추모" [Chu Kyu-chang, Who Led Missile Development, Dies – North Mourns 'A Great Loss'], *JoongAng Ilbo*, September 3, 2018. https://www.joongang.co.kr/article/22939584.

232 "더 세진 북핵…정보당국, 북한 70대 이명하 박사 주목" [North Korea's Nuclear Program Gains Strength, as Intelligence Authorities Focus on Dr. Ri Myong-ha], *Chosun Ilbo*, May 27, 2009. https://www.chosun.com/site/data/html_dir/2009/05/27/2009052700363.html.

233 So Mi-yeon, "[특집②북한 핵실험] 이명하→김정식, '충성경쟁'이 핵개발 원동력" [Ri Myong-ha to Kim Jeong-sik; Political Loyalty Drives the North's Nuclear Development], *Sisa Week*, September 12, 2016. https://www.sisaweek.com/news/articleView.html?idxno=78138.

SECTION 9: NUCLEAR SCIENTISTS & THE NORTH KOREAN MILITARY

On October 4, 2014, North Korea's Ministry of Foreign Affairs spokesman stated:

> *North Korea's nuclear force serves [as] a powerful treasured sword to protect the sovereignty of the country and the dignity of the nation and provides a sure guarantee for focusing efforts on preserving peace and security, building economy and improving the standard of the people's living.*[234]

To extend the analogy, North Korea's nuclear scientists are the treasured sword's swordsmith and the guarantor of North Korea's peace and security.

Senior KWP cadre generally enjoy greater trust from the regime's leadership than military leaders or nuclear scientists. However, when the regime plans and prepares for times of crisis, it is necessary to assign nuclear scientists and engineers to positions beyond research and development. Some of them must be assigned as technical advisers to senior military staff, as these scientists and engineers have the expertise and know-how to assure leaders of nuclear weapons performance and help plan the use of nuclear weapons.

From the beginning of the Kim regime, North Korea's nuclear scientists and engineers have been trained to serve the regime's national security strategy, which includes its nuclear strategy. The relationship between North Korean nuclear scientists and engineers and the North Korean military has grown substantially over the decades, particularly since the turn of the century. The roles and tasks of North Korea's technical experts have increased and become more specific as the country's nuclear weapons capability has grown. Today, these roles include the following:

- Developing the manufacturing process for producing nuclear warheads (tactical, operational and strategic);
- Designing nuclear warheads for short-range missiles, medium-range missiles, SLBMs, ICBMs, and also long-range artillery munitions;
- Managing technical aspects of all nuclear testing;
- Providing technical advice to the North Korean leadership, from the Supreme Leader down to major commands and nuclear-capable field units responsible for warhead delivery;
- Providing estimates of anticipated enemy nuclear attacks;
- Providing technical supervision for all nuclear warheads.[235]

These roles and tasks are executed under a system dominated politically and ideologically by the KWP, not by the state or the military. The diagram below depicts Kim Jong-un's view of the military situation in Northeast Asia, and, in particular, of U.S. bases in the region.[236] North Korea's nuclear scientists and engineers also operate from this strategic perspective.

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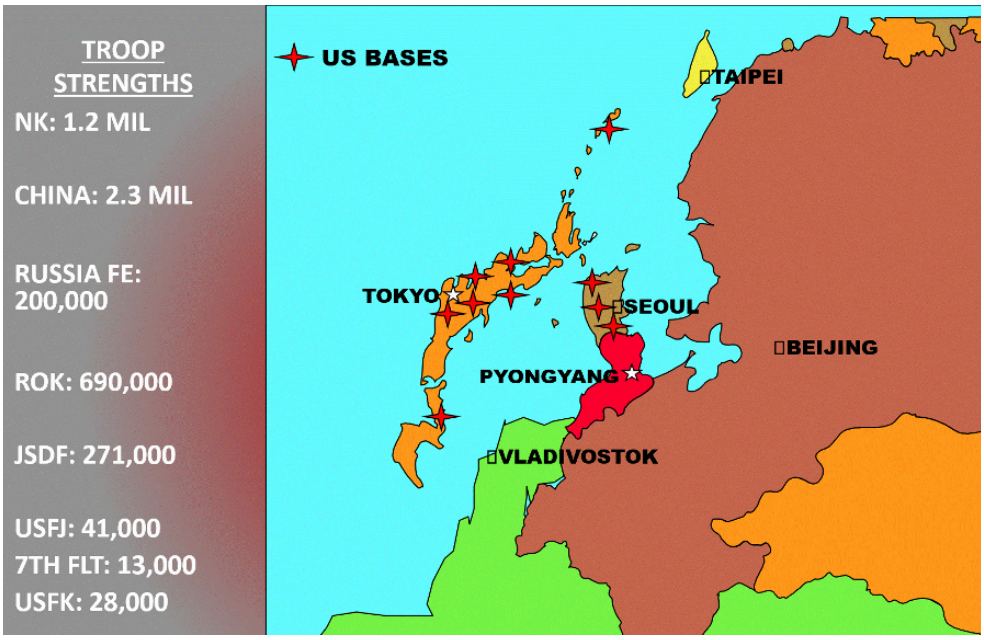
234 Mansourov, "Kim Jong Un's Nuclear Doctrine and Strategy."

235 Author's assessment.

236 Author's assessment. NK – North Korea; FE – Far East; JSDF – Japan Self-Defense Force; USFJ – U.S. Forces Japan; FLT – Fleet; USFK – U.S. Forces Korea.



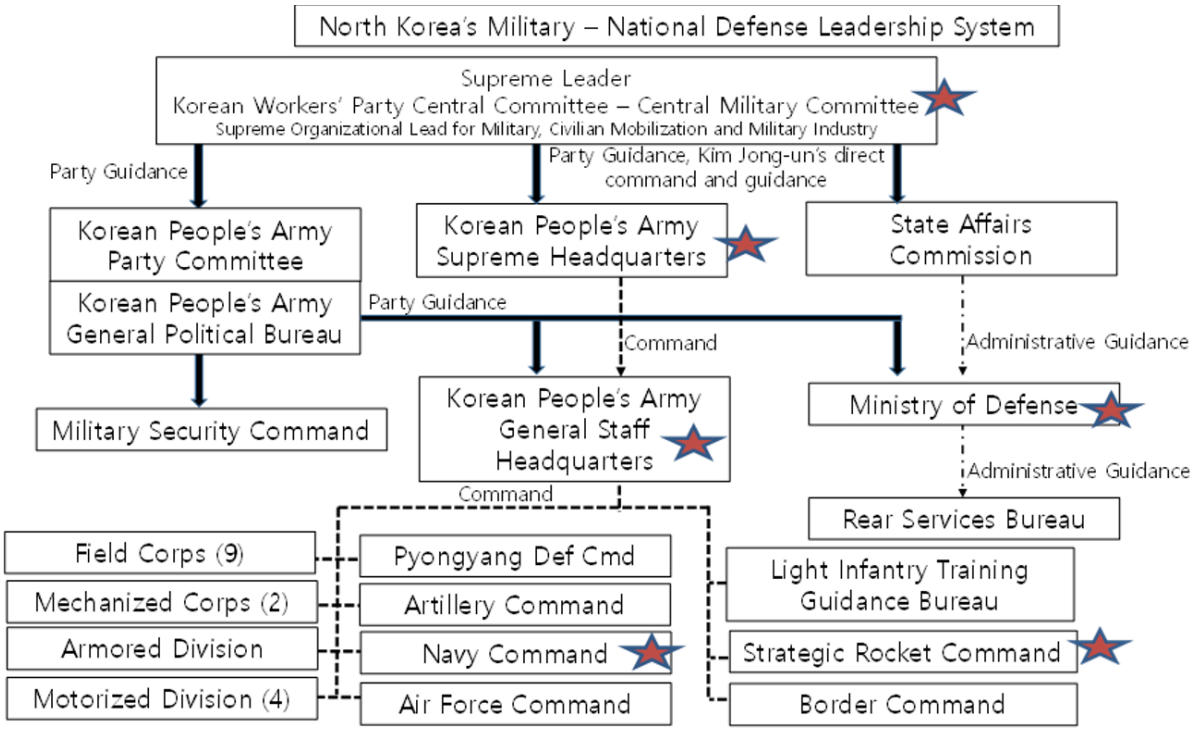
The KPA's Chains of Command-and-Control

The KPA has several chains of command: the KPA Supreme Commander, who exercises military leadership; the KPA General Staff, which directs all operational matters in the military; the State Affairs Commission, which exercises government control; the KWP Central Committee, which oversees policy implementation; the KWP CMC, which sets military policy; and the KPA General Political Bureau (GPB), which politically controls every KPA unit commander from the KPA General Staff down to the battalion level, including frontline DMZ companies.[237]

Every single organization and institution in North Korea is overseen by an embedded KWP committee. The KPA is no different. All KPA commanders from battalion level up through the KPA General Staff and the Ministry of Defense (MOD), including frontline companies along the DMZ, are flanked by a GPB officer who ensures compliance with directives delivered through that unit's embedded KWP committee. These directives originate from the Chairman of the KWP CMC, Kim Jong-un. Each unit commander is also flanked by a security officer of the KPA Military Security Command (MSC), who ensures there is no violation of mission intent. Most importantly, the MSC and its officers have counter-coup responsibility. The authorities of the political and security officers relegate the overall authority of the unit commander to little more than a glorified operations officer (G-3/S-3) in Western militaries.

237 Cheong Seong-Chang, *Bukhangun chongjeongchiguk-ui wisang mit yeokhal-gwa gwollyok seunggye munje* [The Status of the GPB and its Role in Power Succession] (Seoul: Sejong Institute, 2013).

The chart below provides an overview of the Kim regime's "control and command" system.[238] It portrays the dominance of KWP political control over all facets of national security command structures.[239] The Supreme Leader maintains absolute authority over all decision-making, military or otherwise, and the KWP facilitates the implementation of the Supreme Leader's decisions. In this process, the CMC provides military guidance and directives for the MOD and the KPA General Staff.



The inserted stars indicate the author's assessment of where nuclear scientists would be assigned as advisers for the conduct of nuclear warfare. During crises, the Supreme Leader, as the KPA Supreme Commander and the chairman of the KWP CMC, would frequently meet with two specialists who would serve as technical advisers in both structures: Hong Sung-mu (KWP MID) and Ri Hong-sop (Director of the NWRI).

Delegation of Nuclear Launch Authority

North Korea's nuclear arsenal is relatively new and far less developed than those of other nuclear powers. The same is true regarding North Korea's nuclear command and control system. Comparing the Kim regime's nuclear warfare decision-making to that of other countries is not helpful since no other nation's command and control system is remotely similar to that of North Korea.

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238 See Cheong Seong-Chang, *Contemporary North Korean Politics* (Seoul: Hanul Publishing, 2011), 375. Author has updated this chart.

239 Author's intent is to describe the North Korean military "command and control" system in terms of control *over* command due to the overwhelming political and ideological characteristics of the Kim regime's decision-making system.

The Kim regime's choice to employ nuclear weapons will not be based on rational choice, but on Kim Jong-un's desire to prolong the viability of the Kim regime.[240] Consequences for the general population of North Korea have always taken a back seat to regime survival and preservation.

Political dynamics within the Kim regime's control and command system directly impact the concept of nuclear launch authority. The "DPRK Law on Consolidating the Position of Nuclear Weapons State for Self-Defense" was codified by the 12th SPA on April 1, 2013.[241] It has been repealed in favor of a new law which the SPA passed in September 2022 regarding nuclear policy, "Laws of the Supreme People's Assembly of the Democratic People's Republic of Korea Regarding the Nuclear Forces Policy of the Democratic People's Republic of Korea." This law stipulates that "The Chairman of the State Affairs Commission of the Democratic People's Republic of Korea has the right to make all decisions regarding nuclear weapons."[242]

As a matter of public record, this 2022 law does not directly address the issue of delegation. Delegation of nuclear launch authority in other nations generally follows national defense security leadership lines.[243] Delegation is based on the presumption that the national leader may be suddenly incapacitated and thus unable to make a nuclear launch decision. The decision authority is then delegated to another official, either in the military or government, based on previously agreed arrangements. The 2022 North Korean law merely addresses under what conditions North Korea would see the use of nuclear weapons as justifiable. The closest the law comes to addressing delegation is in Article 3(3), which reads:

> *If the command and control system for the national nuclear force is in danger due to an attack by hostile forces, a nuclear strike to destroy the hostile forces—including the origin of the provocation and the command center—will be automatically and immediately executed according to a predetermined operational plan*.[244]

In other words, the law does not clearly specify who would be delegated the authority to launch nuclear weapons.

Despite the lack of public information about delegation for North Korea's nuclear weapons, it is still possible to assess plausible scenarios. First and foremost, any analysis of this issue must be based on an understanding of the Kim regime's profound emphasis on ideology, its inherent distrust of military leaders, and the role of GPB and MSC officers at the highest levels of the KPA. These political factors can create space for nuclear scientists to play a role in the use of nuclear weapons.

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240 See Hyeongpil Ham and Jaehak Lee, "North Korea's Nuclear Decision-making and Plausible Scenarios," *The Korean Journal of Defense Analysis* 25, no. 3 (September 2013): 399–413. This article explains in detail the concepts of rational deterrence theory and cognitive deterrence theory in the employment/non-employment of nuclear weapons.

241 Mansourov, "Kim Jong Un's Nuclear Doctrine and Strategy"

242 Kim Chi-kwan, "김정은 '절대로 먼저 비핵화란 없으며... 협상도 흥정물도 없다'" [Kim Jong-un: "There is absolutely no denuclearization...There is no negotiation or bargaining"], *Tongil News*, September 9, 2022. https://www.tongilnews.com/news/articleView.html?idxno=206114.

243 Amy F. Woolf, "Defense Primer: Command and Control of Nuclear Forces," *Congressional Research Service*, December 3, 2020. https://fas.org/sgp/crs/natsec/IF10521.pdf.

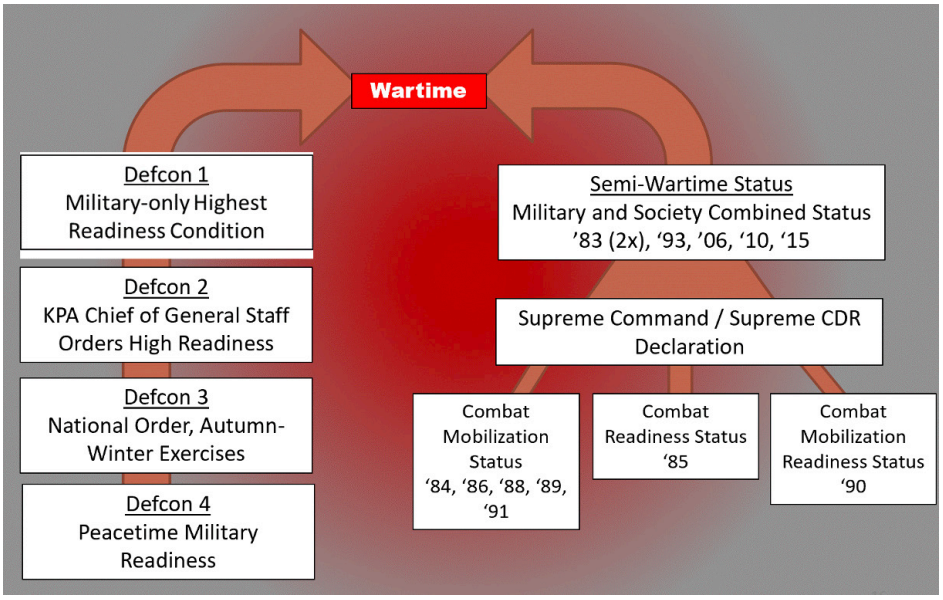
244 Kim, "Kim Jong-un: 'There is absolutely no denuclearization...there is no negotiation or bargaining.'"

The Kim regime's extreme paranoia about internal threats and its core ideology of the "Paektu bloodline," which requires Kim Il-sung's descendants to hold political power, complicate the delegation issue. Those who are not familiar with the Kim regime's ideology may dismiss the idea that Kim Yo-jong, Kim Jong-un's sister, could ever be in charge of using nuclear weapons. However, this would be consistent with the Kim regime's past practices of entrusting authority to family members. Because Kim Yo-jong has no experience in national defense and little to no understanding of nuclear warfare, she would need significant advice. While Hong Sung-mu and Ri Hong-sop can give technical advice, advice on national defense would most logically come from Marshal Ri Byong-chol. Ri is a Member of the KWP Politburo Presidium, oversaw WMD production as Director of the KWP MID, and is a former Air Force commander. If Kim Yo-jong is not the delegated authority figure, then Marshal Ri would be the most obvious choice. Given the Kim regime's focus on the KWP, Ri would likely be chosen even before the Minister of Defense or the Chief of the General Staff.

In the event that Kim Jong-un is incapacitated, it is also uncertain whether the regime's senior leadership would support an orderly transfer of power to a Kim family figure. Kim Yo-jong does not have a power base in the regime's military or internal security institutions, and would thus be unable to fill the power vacuum resulting from her brother's absence. Even if the regime has secret plans for the delegation of nuclear launch authority, these written plans will become meaningless if senior leaders attempt to seize political power. Whoever gains power after Kim Jong-un may decide to not use nuclear weapons against South Korean or U.S. forces.

Preparations for Nuclear Warfare

Preparation for warfare, especially nuclear warfare, is critical for the Kim regime. North Korea's nuclear scientists and engineers would play a prominent role in such preparations, including military exercises. The chart below depicts North Korea's defense readiness conditions, which are designed to enable the Kim regime to respond to crises.[245]



245 Adapted from Kim To-il, "북한 단계별 전투준비태세" [North Korea Combat Readiness Status By Stages], *Yonhap News*, August 21, 2015. https://www.yna.co.kr/view/GYH20150821001200044. CDR – Commander.

In general, defense conditions (DEFCON) are designed to prepare a country for war by defining readiness conditions and force deployments in a step-by-step process. The closer to DEFCON 1, the greater the readiness for war. The right side of the chart shows past North Korean national defense exercises that nuclear scientists and engineers would have participated in. Although there is no public information about where North Korea's nuclear scientists and engineers fit into this process, there are several likely possibilities.

First, it is logical to assume that nuclear scientists are consulted on the readiness of nuclear weapons during the elevation of DEFCON levels. Only the most senior and trusted nuclear scientists would provide input on this issue. Second, nearly all nuclear scientists and engineers would participate in non-military readiness measures, including the semi-wartime exercises depicted on the right side of the above chart. Their participation is essential in ensuring that North Korea's nuclear command-and-control system is functional.

Third, nuclear scientists and engineers would likely advise senior leadership about the damage that North Korea's nuclear weapons can inflict, as well as the damage North Korea could suffer in the event of an external attack. Lastly, the final injustice suffered by nuclear scientists and engineers is their deployment to field elements of nuclear warfare. These individuals had no choice over their careers and occupations. In the event of a war, they would be sent to key installations and facilities, where they may lose their lives.

SECTION 10: NUCLEAR SAFETY

Article 4 of North Korea's Nuclear Energy Law declares that "the state shall ensure safety in the construction and operation nuclear power plants and other nuclear facilities, in line with accepted international standards and the latest scientific and technical knowledge."[246]

However, the Kim regime's pursuit of a nuclear weapons program has been accomplished through the personal sacrifice of hundreds, if not thousands, of North Koreans who have worked at nuclear-related facilities. Kim Dae-ho, an escapee who worked at a uranium waste disposal site, stated that "North Korea's nuclear workers are being forced into uranium tanks and are working in spaces where uranium dust fills the air."[247]

The regime's violation of the workers' human rights and personal safety, especially in the form of radiation exposure, illustrates the regime's willingness to achieve its objectives at the expense of the health and safety of its citizens. North Korea has not observed international conventions and standards regarding the protection and safety of personnel working in nuclear facilities, and it has also disregarded the safety of the wider population or the health of the environment.

Progress over Safety

According to a U.S. nuclear engineer interviewed by the author, it is "hard to believe that people trained and educated to work in this field would not have sufficient knowledge to apply at least basic radiation safety measures to their work area." It mostly consists of good housekeeping, he explained: "Keep the area clean, put your sources away, keep some shielding between you and them, clean yourselves off afterwards."[248]

He added that the Kim regime's political goals would limit the personnel's ability to take adequate precautions. The regime would be unlikely to spend resources on enhancing worker safety. The equipment that is available may not be maintained well enough, and there may not be sufficient detectors to monitor radiation levels at work sites. Most importantly, personnel would be forced to work in dangerous environments for longer than is safe, in order to achieve the regime's goals as quickly as possible. This would prevent these personnel from taking prudent measures, such as staying in work sites for shorter periods of time.[249]

However, even if the hazard level is low, the effect of radiation exposure accumulates over time. Prolonged exposure to high doses of radiation can trigger leukemia, pulmonary cancer, thyroid cancer, skin cancer, and may also cause genetic mutations resulting in birth defects affecting the respective persons' children. Moreover, the chemicals involved in the nuclear field tend to be corrosive and toxic, and scientists may also be exposed to these chemicals. Finally, these personnel are under enormous stress but are not allowed to complain, and this could affect their mental health.[250]

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246 Unification Law Database, "원자력법" [Nuclear Energy Law], April 10, 2023, accessed April 17, 2024. https://www.unilaw.go.kr/bbs/selectBoardList.do?bbsId=BBSMSTR_000000000021&bbsSubId=007.

247 Jang Myeong-hwa, "핵실험 인근 주민들 불임, 기형아 증가" [Infertility, Birth Defects Increase Near Nuclear Test Site], *RFA*, February 12, 2013. https://www.rfa.org/korean/in_focus/nk_nuclear_talks/ne-mj-02122013120403.html.

248 Author interview with U.S. nuclear engineer.

249 Ibid.

250 Ibid.

Why do North Korea's nuclear scientists and engineers work under these conditions, even when they are aware of the risks? The bottom line is that safety considerations have been neglected to achieve progress on the nuclear program. In 2020, the Washington, D.C.-based Nuclear Threat Initiative ranked North Korea last out of twenty-two countries in terms of nuclear material security.[251] The tendency to prioritize progress over safety in North Korea is nothing new. For example, technical specialists from the Soviet Union who provided on-site assistance on "high-priority industrial facilities" in the 1960s "repeatedly noted [the] North Koreans' willingness to cut corners for the sake of construction speed."[252] Moreover, according to a 2017 report, as many as 200 individuals were reported to have died when a tunnel collapsed at the Punggye-ri Nuclear Test Site.[253]

Completing the Supreme Leader's orders takes priority over all other considerations. The KWP prioritizes and enforces Kim Jong-un's demands. There is an embedded Party committee at every reactor site, research facility, weapons development facility, program oversight and leadership agency, and every entity that plays even the smallest role in the nuclear program. The KWP committee chair may be a scientist, engineer, or a Party bureaucrat. These embedded KWP committees enforce ideological adherence to the Party, and they also monitor organizational effectiveness and dedication to assigned tasks and missions.

As noted in Section 3, the KWP MID manages the nuclear program. The MID sets goals and objectives for the program, which are then passed down to the KWP committee chair in each subordinate institution or agency. The committee chair must ensure that the scientists, engineers, and other staff comply with the standards established by the KWP MID. The chair reports up the MID's chain of control. There is also a committee vice-chair, who is always a professional KWP apparatchik, monitors progress on the MID's goals and objectives and directly reports to the OGD, which in turn reports to the Supreme Leader.[254]

Combined with an emphasis on achieving the Supreme Leader's goals and observing the KWP's ideological demands, the lack of appropriate resources inevitably leads to shortcuts, which contribute to poor adherence to safety standards. It is virtually impossible for scientists or engineers to voice their concerns about safety issues. Just like everyone else in North Korea, all scientists and engineers involved in the nuclear program must undergo weekly self-critique sessions (*saenghwal chonghwa*), where they must publicly confess to their professional and ideological shortcomings.[255] Complaining about lax safety standards would be tantamount to asking for direct political punishment.

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251 Yi Wonju, "N.Korea ranks worst in nuclear material security: report," *Yonhap News*, July 23, 2020. https://en.yna.co.kr/view/AEN20200723004500325.

252 Shcheka, "Could North Korea Suffer Its Own Chernobyl Disaster?"

253 "As many as 200 N. Koreans killed in tunnel collapse at nuclear test site: report," *Yonhap News*, October 31, 2017. https://en.yna.co.kr/view/AEN20171031012000315.

254 To understand the role of the KWP OGD's control over North Korean society, see Collins, *North Korea's Organization and Guidance Department*.

255 For an explanation of the self-critique system, see Robert Collins, *Denied From The Start: Human Rights at the Local Level in North Korea* (Washington, D.C.: Committee for Human Rights in North Korea, 2018), 78–85. https://www.hrnk.org/uploads/pdfs/Collins_Denied_FINALFINALFINAL_WEB.pdf.

Testimonies of Radiation Sickness

An indicator of the KWP's neglect of nuclear safety is the radiation sickness experienced by scientists, engineers, and workers. Below are testimonies of North Korean scientists, engineers, soldiers, and workers who suffered from radiation exposure. The scientists and engineers are undoubtedly aware of the risks, but they are under immense political pressure to work through the dangers and also lack the equipment to protect themselves. Moreover, the lack of adequate safety measures also harms the family members of nuclear scientists and engineers, as well as those living in proximity to nuclear facilities.

North Korean escapee Dr. Lee Ae-ran stated that she heard of "many cases of women forced into marriages with men who were put to work on the North's nuclear programs and consequently becoming victims of domestic violence," and escapee women testified that these nuclear workers suffered from physical and mental health issues.[256] Lee also said that students did not want to attend the NDU in Kanggye, Jagang Province, because they did not want to be exposed to radiation. Students knew that some scientists and engineers died before the age of forty. However, if they refused to attend the school, the Party authorities would question their commitment to the regime, and this would negatively impact their careers.[257] A former professor at Kim Il-sung University also testified that most students attending major universities were aware of poor safety standards in the nuclear program and did not want to study in programs related to nuclear science.[258]

There are several examples of radiation exposure at the Yongbyon Nuclear Complex. According to a North Korean escapee who worked at the Radiochemical Laboratory at Yongbyon as a radioactive chemicals analyst, most of the women who worked in his lab "could not conceive children while working at the factory."[259] Another escapee relayed that 100 graduates from the University of Physics in Bungang were sent to work at the Yongbyon Nuclear Complex, but "they died one by one." She knew of ten survivors, but "they all developed strange diseases and became mentally handicapped."[260] A resident of Bungang, near Yongbyon, noted that the local population is well aware of the dangers of radiation, including birth defects. This resident noted that local KWP cadre leave whenever they can to reduce exposure and pay bribes to get their children out of harm's way.[261]

Beyond North Korea's largest nuclear complex are uranium mining operations, where exposure to radioactive materials can have adverse health consequences. A North Korean escapee who worked at the Pyongsan Uranium Mine testified that there was evidence of lung cancer among the miners caused by inhalation of radon and derivative products.[262] U.S. analysts have warned that the Pyongsan Uranium Mine and enrichment site may leak radioactive waste into the adjacent Guryong River, which eventually flows into the West Sea.[263] According to a 2013 interview with a resident from North Hwanghae Province, the Pyongsan Mine

256 Ryall, "I was forced to marry a North Korean nuclear scientist and...."
257 Ibid.
258 Author interview with Dr. Hyun In-ae.
259 Shin Chang-Hoon, "Human Rights Abuses in North Korea's Nuclear Program," *Asan Institute*, 2014, accessed July 26, 2018. http://en.asaninst.org/contents/human-rights-abuses-in-north-koreas-nuclear-program/.
260 Ryall, "I was forced to marry a North Korean nuclear scientist and...."
261 Jang Seul Gi, "Radioactive decay from North Korean nuclear facility causes birth defects in Bungang," *Daily NK*, June 19, 2019. https://www.dailynk.com/english/deformed-babies-in-bungang-due-to-nuclear-radiation-residents-claim/.
262 Shin, "Human Rights Abuses in North Korea's Nuclear Program."
263 Cho Yi-jun and Yang Seung-sik, "Waste from N.Korean Uranium Factories 'Could Seep into Sea,'" *Chosun Ilbo*, August 19, 2019. http://english.chosun.com/site/data/html_dir/2019/08/19/2019081901197.html.

has almost 3,000 workers, who are "apparently exposed to radiation with minimal protection." The children of a Party official who was assigned to the mine were reportedly "born unable to walk or stand," and the miners' children were also born with birth defects.[264]

There is also evidence of radiation exposure related to the Punggye-ri Nuclear Test Site in Kilju County, North Hamgyong Province.[265] After arriving in South Korea, five former residents of Kilju County were found to have been exposed to 279–1,386 millisieverts. A 48-year-old woman who showed the highest exposure lived 14 miles away from Punggye-ri.[266] Choi Kyung-hee, the first North Korean escapee to earn a Ph.D. outside of the Korean Peninsula, interviewed twenty-one escapees from Kilju County and found that they had experienced hair loss, severe headaches, pain in the joints and bones, and low white blood cell count.[267] In addition, former Kilju County residents stated that Kilju residents were "not allowed to enter" Pyongyang after the sixth nuclear test, suggesting that the authorities wished to conceal the consequences of nuclear testing.[268] Due to the lack of notification or evacuation measures, the sixth nuclear test reportedly caused several local buildings, including a school, to collapse with citizens and students still inside.[269]

Concerns have also been raised about the transnational consequences of nuclear testing at Punggye-ri. A computer simulation by the Korea Institute of Ocean Science and Technology demonstrated that the meteorological conditions at the time of North Korea's sixth nuclear test could have carried radioactive materials into the atmosphere in a northeastern direction. This would have affected communities in North Hamgyong Province, as well as parts of Russia, the Kuril Islands, and the Japanese island of Hokkaido.[270] A 2023 report by the Transitional Justice Working Group states that contamination of groundwater near Punggye-ri could pose a threat to those in South Korea, China, and Japan due to "contaminated agricultural and marine products imported from North Korea."[271]

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264 Choi Song Min, "Evidence of Nuclear Harm Mounting," *Daily NK*, February 15, 2013. http://www.dailynk.com/english/read.php?cataId=nk01500&num=10321.

265 Chin Min-Jai, Jung Young and Mok Yongjae, "Living near North Korean nuclear test site caused health problems, escapees say," *RFA*, July 6, 2023. https://www.rfa.org/english/news/korea/radiation-07052023121346.html.

266 Kim Myong-song, "Defectors from Nuke Test Area Exposed to Heavy Radiation," *Chosun Ilbo*, October 2, 2019. http://english.chosun.com/site/data/html_dir/2019/10/02/2019100201289.html. This article notes that the typical amount of radiation a person is ordinarily exposed to in one year is 2.4 millisieverts.

267 Lee Mi-ah, "최경희 샌드연구소 대표 '북한 풍계리 주민 고통받는 삶부터 관심 가져야'" [Head of SAND Research Institute, Choi Kyong-hee: "We Should Pay Attention to the Suffering of Punggye-ri residents], *Korea Economic Daily*, November 21, 2017. https://www.hankyung.com/society/article/2017112146051.

268 Kim Myong-song, "N.Korean Nuclear Test Site 'Heavily Contaminated'," *Chosun Ilbo,* November 6, 2017. http://english.chosun.com/site/data/html_dir/2017/11/06/2017110601163.html.

269 Kim Myong-song, "Scores Dead as Houses Collapsed After N. Korean Nuke Test," *Chosun Ilbo*, November 24, 2017. http://english.chosun.com/site/data/html_dir/2017/11/24/2017112401312.html.

270 Sofia Lotto Persio, "North Korean Soldiers Are Being Treated for Radiation Exposure After Nuclear Test: Report," *Newsweek*, November 1, 2017. https://www.newsweek.com/north-korean-soldiers-being-treated-radiation-exposure-after-nuclear-test-698246.

271 Transitional Justice Working Group, *Mapping the Risk and Effect of Radioactive Contamination of Groundwater Sources from the Punggye-ri Nuclear Test Site in North Korea* (February 2023), 11. https://en.tjwg.org/mapping-project-north-korea/.

SECTION 11: WEAKNESSES, VULNERABILITIES, SHORTCOMINGS

North Korea's nuclear scientists and engineers are assigned to the nuclear program for their intellect, but they have no freedom in choosing how to apply their talents. Instead, the regime exploits their intellect to achieve its own objectives.

Ironically, the restrictions imposed by the regime on North Korea's nuclear scientists and engineers delayed the progress of the nuclear program. Kim Il-sung expressed interest in a nuclear program in the 1950s, but the first nuclear test was conducted in 2006. It took North Korea over five decades to accomplish what the United States achieved in three years with the Manhattan Project.[272]

The Kim regime's nuclear program suffers from chronic weaknesses. These include: an overwhelming emphasis on ideology, focusing on the Ten Principles of Monolithic Ideology (TPMI); regular self-criticism sessions to confess one's own failures and criticize the mistakes of colleagues; inability to exercise creativity or collaborate with others; poor safety standards; resource shortfalls; and strict political demands, especially from the MID.

Ideology

Ideology is unquestionably the most restrictive aspect of North Korea's nuclear program. To achieve professional success under the Kim regime, one must demonstrate support for the KWP's policies, practices, and daily propaganda messages. North Korean scientists must adhere to the regime's propaganda in conducting their research.

When publishing their work, they must praise the Supreme Leader before anyone else and state that their research is "an honorable, revolutionary task for the people."[273] Kim Heung-kwang, a North Korean escapee who was a professor of computer science in North Korea, said that ideological education—including classes on Kim Il-sung's revolutionary activities and the history of the KWP—consist about 30% of the curriculum even for scientists.[274]

Every member of North Korea's nuclear program is monitored for loyalty by the embedded KWP committee of each research institute, uranium mining enterprise, educational institution, and test site. Every one of these organizations, including those at the Yongbyon Nuclear Complex, maintains a Party cell for which membership is mandatory for every nuclear scientist and engineer. Each Party cell reports directly to the organization's embedded KWP committee. These embedded KWP committees are supervised by the KWP OGD, and the OGD controls every one of the over three million Party members nationwide. Within the OGD is the Party Life Guidance Section, which maintains an action officer responsible for monitoring the loyalty and effectiveness of the nuclear scientists and engineers.[275]

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272 Atomic Heritage Foundation, "The Manhattan Project," May 12, 2017. https://www.atomicheritage.org/history/manhattan-project.

273 Andrada Fiscutean, "What Science is Like in North Korea," *The Outline*, January 24, 2018. https://theoutline.com/post/2944/what-science-is-like-in-north-korea.

274 Yoo Byong-jun, "탈북 과학자에게 북한의 과학을 묻다" [Asking a North Korean Scientist about North Korea's Science Sector], *Daehak Sinmun*, April 12, 2009. http://www.snunews.com/news/articleView.html?idxno=7868.

275 Collins, *North Korea's Organization and Guidance Department*, 29-34.

There is a direct line of monitoring that connects every nuclear scientist and engineer to the Supreme Leader. This begins with the scientist or engineer's Party cell leader. Above the cell leader is the organizational secretary at the institute's Party committee. (The most threatening person in a nuclear scientist or engineer's life is the organizational secretary.[276]) This secretary is subordinate to the OGD's Party Life Guidance section officer for the KWP MID, who in turn reports to the director of the Party Life Guidance section. Finally, the section director reports to the OGD's overall director, who reports directly to the Supreme Leader. The Supreme Leader's directives are sent down to every scientist and engineer along the same chain of command.

The core element of every North Korean's ideological life, including that of nuclear scientists and engineers, is the TPMI. Every North Korean must adhere to these ten principles. The first principle, for instance, commands every North Korean citizen to "Fight, with all your strength, to make the whole society [a] Kimilsung-Kimjongilist one."[277] The TPMI are enforced through self-criticism sessions (*saenghwal chonghwa*). Every North Korean, including nuclear scientists and engineers, must participate in a regular self-critique session. These sessions are typically held every Saturday. At each session, everyone must publicly confess their failures to comply with the TPMI, and they must also criticize each other.[278]

By stifling creativity, productivity, and efficiency, the embedded Party committee at every nuclear facility and institute prevents scientists or engineers from contributing to their full capability. North Korean escapee Kim Hyeong-soo testified that "scientists don't believe what the propaganda feeds them, but they cannot discredit it either. You have to think what the Party tells you to think."[279] Furthermore, North Korea's nuclear scientists are "completely secluded and under strict supervision."[280] A foreign scientist who visited Pyongyang several times insisted that North Koreans are completely "driven by fear and operate in survival mode," and thus, "their creativity is stifled."[281]

Surveillance

Ideological and organizational security is a priority for the Kim regime. It seeks to ensure that all North Korean scientists and engineers remain loyal to the regime and to the objectives of the nuclear program. Although they undoubtedly have high intellectual capabilities, North Korea's scientists and engineers are also saturated with the regime's propaganda. Once they are on the job, it is too late to oppose the Supreme Leader's orders to advance the nuclear program. They are all bound by political loyalty to achieve the Party's goals. All other values and priorities, such as higher learning and contributing to society, are secondary.

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276 Collins, *North Korea's Organization and Guidance Department*, 29-34. In general, the organizational secretaries of local KWP committees—county-level and above and their institutional counterparts—are the most influential individuals within a given organization.

277 Fyodor Tertitskiy, "The party's 10 principles, then and now," *NK News*, December 11, 2014. https://www.nknews.org/2014/12/the-partys-10-principles-then-and-now/.

278 Collins, *Denied From the Start*, 78–85. According to interviews with North Korean escapees, the participants try to avoid being too harsh to each other during these sessions. This is to avoid inflicting irreparable harm to one another, as the Party cell leader must impose punishments for reported failures and mistakes.

279 Fiscutean, "What Science is Like in North Korea."

280 Ibid.

281 Ibid.

For entities involved in the nuclear program, there is usually a Ministry of State Security (MSS) officer who monitors the ideological loyalty of all personnel. (If the entity is military in nature, an officer from the MSC will play the same role.) If there are any violations, the officer will file a report up the MSS's chain of command. This report will also be forwarded to the OGD Party Life Guidance Section's officer responsible for the MSS, thus creating a parallel chain of reporting to the Supreme Leader. Failure to follow ideological guidelines results in disaster for personnel involved in the nuclear program. In January 2021, acting on the OGD's orders, the MSS reportedly investigated and arrested twenty scientists and engineers employed at Bureau 11 for viewing banned material from South Korea.[282]

The testimony of Park Choong-gwon, a North Korean escapee who was elected to South Korea's National Assembly in April 2024, is illustrative. While attending NDU as a student in the early 2000s, he was appointed as a section leader. In this role, Park was responsible for the ideological education of eighty students, and he was directly supervised by a security officer. He discovered that the officer had recruited eight students in his section to act as informants. These informants passed on detailed information about the other students, including any suspicious activity.[283]

Lack of Collaboration

North Korean scientists are forbidden to discuss their research with others. North Korean escapee Kim Hyeong-soo testified that one colleague with a Ph.D. in medicine told others what he was studying, and he and his family were subsequently arrested and became political prisoners. As a result, Kim says that North Korean scientists found life "absurd, sycophantic, isolated, and stressful."[284] A former employee at the Nuclear Energy Research Institute at the Yongbyon Nuclear Complex said that the rules there were extremely strict, and research laboratories could not collaborate with other organizations.[285]

Resource Shortages and Sanctions

The Kim regime's disproportionate focus on the military has distorted North Korea's economy. A former North Korean official who dealt with economic issues observed in 2011 that "the same economy that cannot produce a usable toothbrush is now armed to the teeth with nuclear weapons."[286] Due to economic constraints, North Korea has faced resource shortages in creating, sustaining, and advancing its nuclear program.[287] These difficulties have been compounded by international sanctions. Since 2006, the UN Security Council has passed eleven resolutions imposing sanctions on North Korea for its nuclear and missile

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282 Jang Tae Joo, "State security agency arrests key figures involved in North Korea's nuclear and missile development," *Daily NK*, January 8, 2021. https://www.dailynk.com/english/state-security-agency-arrests-key-figures-involved-north-korea-nuclear-missile-development/.

283 Kang Chan-ho, ""예쁜 여자에 4000달러 주면 평양 가" 이 말에 탈북 결심했다" ["I Decided to Escape After Discovering How Corrupt the Regime Was], *JoongAng Ilbo*, April 30, 2024. https://www.joongang.co.kr/article/25246344.

284 Fiscutean, "What Science is Like in North Korea,"

285 Bill Streifer and Nam Sang-so, "In a North Korean Nuclear Defector's Own Words," *KPA Journal* 2, no. 11 (November 2012). http://www.icasinc.org/2014/2014l/2014lbxs.html.

286 Kim Kwang-Jin, "The Defector's Tale: Inside North Korea's Secret Economy," *World Affairs* 174, no. 3 (September/October 2011): 35.

287 As explained in Section 7, North Korea extensively relied on other countries to train personnel and acquire key components for its nuclear infrastructure.

tests.[288] As noted in Section 8, key figures in the nuclear program have been personally subject to sanctions. There are also ongoing bilateral and multilateral efforts outside of the UN to disrupt the flow of resources that support Pyongyang's nuclear program.[289] These actions affect the ability of North Korean scientists and engineers to fulfill their missions, as well as the regime's ability to reward them with a comfortable lifestyle.

In an effort to circumvent these sanctions, the Kim regime created "a secret, invisible, firewalled financial system scavenging off the West."[290] North Korea utilizes offshore jurisdictions with lax banking controls, shell companies, and foreign intermediaries.[291] The Kim regime uses front companies and processes illicit profits through foreign banks. In 2019, for example, the United States identified three banks in China—China Merchants Bank Co., Bank of Communications Co., and Shanghai Pudong Development Bank Co., all among China's top ten banks by assets—that are used by the Kim regime.[292] The Kim regime also employs its significant cyber capabilities to conduct illicit activities that raise funds to support its nuclear program, among other priorities.[293]

A recent development at the UN Security Council will likely enhance North Korea's ability to evade UN sanctions. On March 28, 2024, Russia vetoed a resolution to extend the mandate of the Panel of Experts, a body which monitored and reported on violations of sanctions imposed on North Korea by the Security Council.[294] Ambassador Hwang Joon-kook, South Korea's Permanent Representative to the UN, strongly criticized the veto, stating that "this is almost comparable to destroying a CCTV to avoid being caught red-handed."[295] Although UN member states "will still be able to report violations to the Security Council," a former coordinator for the Panel of Experts stated that "without the panel's biannual reporting, dozens of global banks and insurance companies now lack the gold standard reports they once used to deny proliferation networks access to the global financial system."[296]

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288 Niniek Karmini and Hyung-jin Kim, "US, South Korea, Japan Seek to Curb North Korea's Illicit Cyber Activities," *The Diplomat*, December 14, 2022. https://thediplomat.com/2022/12/us-south-korea-japan-seek-to-curb-north-koreas-illicit-cyber-activities/.

289 U.S. Department of State, "Launching the U.S.-ROK Enhanced Disruption Task Force," March 26, 2024. https://www.state.gov/launching-the-u-s-rok-enhanced-disruption-task-force/.

290 Kim, "The Defector's Tale," 35.

291 Erol and Spector, "Countering North Korean Procurement Networks through Financial Measures."

292 Christian Berthelsen and Tom Schoenberg, "U.S. Is Investigating How North Korea Finances Its Nuclear Program," *Bloomberg*, August 6, 2019. https://www.bloomberg.com/news/articles/2019-08-06/u-s-is-investigating-how-north-korea-finances-nuclear-program.

293 Mathew Ha and David Maxwell, "Kim Jong Un's 'All-Purpose Sword' North Korean Cyber-Enabled Economic Warfare," *Foundation for the Defense of Democracies*, October 2018. https://s3.us-east-2.amazonaws.com/defenddemocracy/uploads/documents/REPORT_NorthKorea_CEEW.pdf.

294 Michelle Nichols, "Russia blocks renewal of North Korea sanctions monitors," *Reuters*, March 28, 2024. https://www.reuters.com/world/russia-blocks-renewal-north-korea-sanctions-monitors-2024-03-28/.

295 Song Sang-ho, "UNSC fails to extend mandate of expert panel monitoring N.K. sanctions enforcement," *Yonhap News*, March 29, 2024. https://en.yna.co.kr/view/AEN20240328009955315.

296 Michelle Ye Hee Lee and Min Joo Kim, "Russian veto ends U.N. panel monitoring North Korea sanctions," *The Washington Post*, March 29, 2024. https://www.washingtonpost.com/world/2024/03/29/russia-veto-brings-end-un-panel-monitoring-north-korea-sanctions/.

SECTION 12: HUMAN RIGHTS DENIAL OF NUCLEAR SCIENTISTS

The Kim regime has violated the human rights of not only the scientists and engineers who have built the bomb, but also the rights of their family members. Some of these consequences have already been outlined in Section 10. Moreover, the regime's headlong pursuit of nuclear weapons has affected the health and safety of the broader North Korean population. Those living in proximity to nuclear facilities have suffered the greatest cost. This section analyzes the human rights violations that have occurred as a result of North Korea's nuclear program, with reference to relevant international standards and agreements.

Health and Safety Rights

Legal Standard

As noted in Section 10, North Korea's nuclear scientists and engineers are subject to workplace conditions that violate international standards.[297] For example, Article 23(1) of the Universal Declaration of Human Rights (UDHR)[298] states, "Everyone has the right to work, to free choice of employment, to just and favourable conditions of work and to protection against unemployment."[299] In addition, Article 7 of the International Covenant of Economic, Social and Cultural Rights (ICESCR) provides that "[t]he States Parties to the present Covenant recognize the right of everyone to the enjoyment of just and favourable conditions of work, which ensure, in particular [...] (b) safe and healthy working conditions."[300] North Korea acceded to the ICESCR on September 14, 1981.

The UN Committee on Economic, Social and Cultural Rights (CESCR) defined "just and favourable conditions of work" in General Comment No. 23 with reference to Article 7 of the ICESCR.[301] Addressing Article 7(b)'s right to "safe and healthy working conditions," the CESCR noted that "[p]reventing occupational accidents and disease is a fundamental aspect of the right to just and favourable conditions of work and is closely related to other Covenant rights."[302]

In furtherance of Article 7(b), the CESCR urged States Parties to adopt "a national policy for the prevention of accidents and work-related health injury by minimizing hazards in the working environment and ensuring broad participation in the formulation, implementation and review of such a policy."[303] This policy

297 While the International Labour Organization (ILO) has set international labor standards through many conventions and treaties, North Korea is not a member state to the ILO and has not ratified any ILO conventions and treaties.

298 While the UDHR is not a binding legal document, it is a foundational text in international law and has been incorporated into subsequent international treaties and human rights instruments. It has become a part of customary international law and is a fundamental constitutive document of the UN and its member states, including North Korea.

299 UN General Assembly, *Universal Declaration of Human Rights*, 217 A (III), December 10, 1948. https://www.refworld.org/legal/resolution/unga/1948/en/11563.

300 UN General Assembly, *International Covenant on Economic, Social and Cultural Rights*, United Nations Treaty Series, vol. 993, p. 3, December 16, 1966. https://www.refworld.org/legal/agreements/unga/1966/en/33423.

301 UN Committee on Economic, Social and Cultural Rights, *General comment No. 23 (2016) on the right to just and favourable conditions of work* (article 7 of the International Covenant on Economic, Social and Cultural Rights), E/C.12/GC/23, April 7, 2016. https://www.refworld.org/legal/general/cescr/2016/en/122360.

302 Ibid. at para. 25.

303 Ibid.

should cover "all branches of economic activity" and "all categories of workers."[304] It should be comprehensive in addressing all areas and elements of the work and the workplace environment, while protecting employees from reprisal and retaliatory or disciplinary measures if health and safety incidents are monitored and reported.[305]

Moreover, the policy should also "include a mechanism, which might be a central body, for coordination of policy implementation and support programmes and with the authority to undertake periodic reviews."[306] The CESCR has noted that policies appropriate to uphold such principles should "incorporate appropriate monitoring and enforcement provisions, including effective investigations, and provide adequate penalties in case of violations, including the right of enforcement authorities to suspend the operation of unsafe enterprises. Workers affected by a preventable occupational accident or disease should have the right to a remedy, including access to appropriate grievance mechanisms, such as courts, to resolve disputes."[307]

Application

The information presented in this report shows that North Korea's treatment of its nuclear scientists and engineers violates their rights under Article 7(b) of the ICESCR in several ways.

First, North Korea is violating the right to be protected from occupational accidents and disease. Rather than preventing accidents or illnesses, the regime has shown a pattern of subjecting scientists and engineers to abject working conditions. Since the KWP maintains an embedded Party committee in every nuclear facility and strictly oversees all aspects of the program, political pressure overwhelms all other concerns. This directly impacts program development standards. Focused on the success of the nuclear program, the regime does not prioritize the health and safety of its scientists and engineers. This is supported by witness testimony that depicts severe shortcomings. Facilities are polluted with radioactive waste, and workers lack the equipment to protect themselves. There are testimonies of nuclear scientists and engineers dying at a young age and developing strange physical and mental diseases.

Second, while institutions responsible for ensuring nuclear safety exist on paper, they do little to enforce adequate health and safety standards in practice. For example, North Korea has a regulatory body responsible for nuclear safety and radiation protection—the State Nuclear Safety Regulatory Commission, which is tasked with performing inspections and issuing permits for nuclear-related projects.[308] In addition, the SPA enacted a law in April 2013 regarding cooperation with the international community on nuclear safety.[309] However, these institutions and laws are ineffective in reality. The April 2013 law explicitly makes the caveat that any cooperation would be dependent on the "improvement of relations with hostile nuclear weapons states,"[310] making nuclear safety cooperation contingent on North Korea's political objectives.

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304 UN Committee on Economic, Social and Cultural Rights, *General comment No. 23*, para. 26.

305 Ibid. at para. 27.

306 Ibid. at para. 28.

307 Ibid. at para 29.

308 Korean Peninsula Energy Development Organization, "KEDO: Promoting Peace and Stability on the Korean Peninsula and Beyond," accessed May 3, 2024. http://www.kedo.org/ns_dprk.asp#:~:text=The%20State%20Nuclear%20Safety%20Regulatory.

309 Matt Korda, "North Korean Nuclear Reactor Safety: The Threat No One is Talking About," *38 North*, December 14, 2017. https://www.38north.org/2017/12/mkorda121417/.

310 Ibid.

There is also reason to believe that no one in the nuclear program can openly complain about poor safety standards. Scientists and engineers must attend weekly self-critique sessions, where they must confess their "failures" to show ideological obedience and perfect loyalty to the regime. Needless to say, there does not appear to be any right to a remedy for violations, or penalties imposed upon facilities if they are found to be in violation of health and safety standards.

Third, in violation of their right to freely choose their employment, evidence shows that high school and university students are aware of the life-threatening dangers of being a nuclear scientist or engineer in North Korea. However, if they refuse to pursue their assigned path, the Party authorities will question their loyalty, resulting in negative repercussions for themselves and their families.

Fourth, the CESCR emphasizes that national policies pursuant to Article 7(b) should "take into account specific risks to the safety and health of female workers in the event of pregnancy."[311] Witnesses report that most women who worked as radioactive chemicals analysts in the Radiochemical Laboratory in Yongbyon were unable to bear children.

Fifth, the CESCR has explained that the protections of Article 7(b) are not limited to the workers themselves: State Parties are required to "ensure that workers suffering from an accident or disease and, where relevant, the depend[e]nts of those workers, receive adequate compensation, including for costs of treatment, loss of earning and other costs, as well as access to rehabilitation services."[312] As noted in Section 10, wives of nuclear scientists and engineers reported that their spouses suffered from physical and psychological issues due to their work, often resulting in domestic violence. There is also information to suggest that the children of workers in the nuclear sector are born with birth defects.

Additional Economic & Social Rights Violations

Legal Standard

The ICESCR also obligates North Korea to respect and protect, and not violate, the following:

- **The right to health** (ICESCR, Article 12 (1): "1. The States Parties to the present Covenant recognize the right of everyone to the enjoyment of the highest attainable standard of physical and mental health.")
- **The right to work** (ICESCR, Article 6 (1): "1. The States Parties to the present Covenant recognize the right to work, which includes the right of everyone to the opportunity to gain his living by work which he freely chooses or accepts, and will take appropriate steps to safeguard this right.")
- **Family rights** (ICESCR, Article 10 (1): "1. The widest possible protection and assistance should be accorded to the family, which is the natural and fundamental group unit of society, particularly for its establishment and while it is responsible for the care and education of dependent children. Marriage must be entered into with the free consent of the intending spouses." (ICCPR, Article 23 (3); Convention on the Elimination of All Forms of Discrimination against Women (CEDAW), Article 16(1)(b))
- **The right to education** (ICESCR, Article 13).

311 UN Committee on Economic, Social and Cultural Rights, *General comment No. 23*, para. 26.
312 Ibid. at para. 29.

Application

According to the World Health Organization, States Parties have three types of obligations regarding the right to health:

- **Respect**: This means simply not to interfere with the enjoyment of the right to health ("do no harm").
- **Protect**: This means ensuring that third parties (non-state actors) do not infringe upon the enjoyment of the right to health (e.g., by regulating non-state actors).
- **Fulfill**: This means taking positive steps to realize the right to health (e.g., by adopting appropriate legislation, policies, or budgetary measures).[313]

The CESCR defines "the right to health" to include "healthy occupational and environmental conditions, and access to health-education and information."[314] Under the ICESCR, North Korea must "recognize the right of everyone to the enjoyment of the highest attainable standard of physical and mental health" (Article 12). Conducting nuclear tests near a civilian population (e.g., residents of Kilju County, North Hamgyong Province) shows the regime's lack of respect for the right to health, given the considerable health and environmental dangers.

In addition, North Korea likely does not meet its obligations under the ICESCR by failing to provide specialized medical attention to those who work at or live near nuclear testing sites. If the right to health is indeed an "inclusive right" that extends even to the "underlying determinants of health," then North Korean citizens are clearly being deprived of their fundamental human rights.

Furthermore, hazardous working conditions at nuclear facilities and lack of safety equipment likely exacerbate the physical effects of radiation exposure for scientists and engineers, unquestionably increasing the likelihood of illness and even early death. Reports of local infrastructure collapsing as a result of nuclear testing suggest that the regime prioritizes the capabilities of its nuclear warheads over the lives and well-being of its own people.

North Korea also violates Article 13 of the ICESCR, which is the right to education. The article specifies States' obligations to respect and fulfill the right to education, which North Korea arguably does by providing an education for nuclear scientists. However, Article 1(1), in part, notes that States also "agree that education shall be directed to the full development of the human personality and the sense of its dignity, and shall strengthen the respect for human rights and fundamental freedoms." North Korea violates this article by forcing certain individuals identified by the regime to be pushed down a specific career path. The regime uses education to advance its political and military objectives. It certainly does not view education as a means to achieve "the full development of the human personality and the sense of its dignity."

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313 Office of the United Nations High Commissioner for Human Rights and World Health Organization, *The Right to Health: Fact Sheet No. 31* (June 2008), 25–28. https://www.ohchr.org/sites/default/files/Documents/Publications/Factsheet31.pdf.

314 UN Committee on Economic, Social and Cultural Rights, *General Comment No. 14: The Right to the Highest Attainable Standard of Health* (Art. 12 of the Covenant), E/C.12/2000/4, August 11, 2000 at para. 11. https://www.refworld.org/legal/general/cescr/2000/en/36991.

One way this is manifested is the violation of the right to work (ICESCR, Art. 6). The State has an obligation to fulfill, or take positive actions, towards the facilitation of the enjoyment of this right. North Korea does not allow individuals the opportunity to freely choose or accept their line of work in the nuclear field. Rather, workers are forced to work in the nuclear industry solely for the benefit of the regime.

Civil and Political Rights Violations

Legal Standard

North Korea is also a State Party to the International Covenant on Civil and Political Rights (ICCPR). The ICCPR identifies fundamental civil and political rights for individuals, which North Korea has an obligation to protect. This includes the right to life (Article 6), the right to self-determination (Article 1), the right to not be held in slavery or in servitude (Article 8), the right to liberty of movement (Article 12), and the right to freedom of expression (Article 19).[315]

Application

The most fundamental human right is the right to life. At the extreme end of rights denial in North Korea, scientists, engineers, and their family members may die because this right is not protected or respected. At times, it is even deliberately violated to pursue Kim Jong-un's objectives, as discussed above.

In pursuit of the Supreme Leader's goals, the regime has created a system in which individuals have almost no self-determination. This violates both the ICESCR (Article 1) and the ICCPR (Article 1). North Korea's nuclear scientists and engineers are unable to change their work assignments or express their opinions about their work. For fear of political punishment, they cannot communicate concerns they might have about inadequate safety precautions. The Kim regime controls all aspects of their lives, which violates the right to liberty of movement and the right to freedom of expression.

In line with this, North Korea intrusively violates family-related rights by forcing its scientists to enter into marriages in violation of the ICCPR, Art. 23 (2) and CEDAW, Art. 16(1) (b), sometimes with disastrous consequences for the physical and mental health of the family.

Finally, North Korea's nuclear scientists are arguably modern-day slaves. The traditional understanding of slavery has evolved to include contemporary forms of slavery.[316] North Korea's nuclear scientists and engineers are forced to work for the benefit of the regime. They are essentially owned and exploited by Kim Jong-un as modern-day slaves.

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315 UN General Assembly, *International Covenant on Civil and Political Rights*, United Nations Treaty Series, vol. 999, p. 171, December 16, 1966, https://www.refworld.org/legal/agreements/unga/1966/en/17703.

316 UN Office of the High Commissioner for Human Rights, "Special Rapporteur on contemporary forms of slavery," accessed April 24, 2024. https://www.ohchr.org/en/special-procedures/sr-slavery.

Environmental Concerns and Threat to Life

In addition to the egregious rights violations committed against nuclear scientists, engineers, and their family members, there are environmental concerns surrounding North Korea's nuclear program.

North Korea has carried out underground nuclear tests at the Punggye-ri test site, which borders the western perimeter of political prison camp (*kwan-li-so*) Number 16.[317] Underground testing typically limits radioactive exposure to local populations relative to atmospheric testing, but it does not necessarily eliminate the risk of exposure. It is possible for hazardous radioactive isotopes to "leak into the surrounding environment and atmosphere" as a result of underground testing, "posing potential risks to ecosystems and human health."[318] Following North Korea's first nuclear test in 2006, radioactive gases released into the atmosphere were detected as far away as Yellowknife, Canada, more than 4,500 miles away.[319]

The aforementioned testimonies from residents living near North Korea's nuclear research and production sites also suggest that there has been radioactive contamination beyond the confines of these facilities. It should be noted that radiation is "released during every stage of…nuclear weapon production."[320] Finally, concerns have been raised about the possibility of a nuclear accident in North Korea, especially since "North Korea's secretive nature would…hinder any kind of collective response" among neighboring states.[321]

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317 Bogle, Scarlatoiu and Ha, "Switchback."

318 Sulgiye Park and Rodney C. Ewing, "Environmental impacts of underground nuclear weapons testing," *Bulletin of the Atomic Scientists*, March 7, 2024. https://thebulletin.org/premium/2024-03/environmental-impacts-of-underground-nuclear-weapons-testing/.

319 Kevin Voigt, "What happens with an underground nuclear test?," *CNN*, February 19, 2013. http://www.cnn.com/2013/02/11/world/asia/north-korea-underground-explosion-explainer.

320 "Nuclear Disarmament and Ecological Impacts of Nuclear Weapons," *Geneva Environment Network*, July 25, 2023. https://www.genevaenvironmentnetwork.org/resources/updates/nuclear-disarmament-and-ecological-impacts-of-nuclear-weapons/.

321 Korda, "North Korean Nuclear Reactor Safety."

SECTION 13: THE FUTURE OF THE NUCLEAR PROGRAM

North Korea's nuclear scientists and engineers are one of the most important assets for Kim Jong-un in guaranteeing his own security. Indeed, some nuclear scientists and engineers are lavishly rewarded by the regime for their accomplishments. They lead comfortable lives in high-rise apartments in the heart of Pyongyang. However, the regime has shown little concern for the health, safety, and dignity of the vast majority of personnel involved in the nuclear program.[322]

These scientists and engineers are essentially enslaved starting in middle school. The KWP controls every aspect of their lives to achieve the Supreme Leader's political objectives. The work that these personnel are engaged in often presents serious threats not only to their own health and safety, but also to that of their spouses and children. In particular, it is an egregious human rights violation to knowingly expose the children of nuclear-related personnel to the risk of birth defects by failing to provide protective equipment or observing basic safety measures. A nuclear accident could have catastrophic consequences for North Korea's nuclear personnel and the population at large. Ideological obedience and political loyalty take precedence over everything else.

North Korea's nuclear scientists have no recourse except success. Kim Jong-un has been far more tolerant of research-related mistakes than his father or grandfather, but failure of any kind is still seen as disloyalty. Individual scapegoats are punished as demonstrations to other scientists and engineers. North Korea's nuclear scientists and engineers face a precarious future. The Supreme Leader is demanding ever-more sophisticated weapons, including nuclear warheads capable of being delivered via ICBMs to the continental United States. Ensuring the capability of these weapons will likely require additional underground testing, but there are concerns about the safety of the Punggye-ri nuclear test site.

The rapid advance of North Korea's nuclear program under Kim Jong-un has put him in a position to make credible nuclear threats. Analysts estimate that North Korea has produced up to ninety warheads.[323] Pyongyang has continued to develop its missile capabilities, successfully test-launching a solid-fuel ICBM in December 2023.[324] Following artillery drills in March 2024, North Korean state media claimed that it could mount tactical nuclear warheads on its "super-large multiple rocket launch systems."[325] As North Korea deploys its nuclear weapons, some nuclear engineers will be assigned to nuclear-capable units as part of a technical team for maintenance purposes. After all, who is to blame if a missile reaches its target but there is no nuclear explosion? A nuclear weapons delivery unit does not need a nuclear scientist past the point of a "physics package," but scientists can always check what engineers are prepared to do at launch.[326]

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322 North Korea's missile scientists live similar lives to those of North Korea's nuclear scientists, with few exceptions. The biggest difference, of course, is that they do not work in an environment where they are exposed to hazardous radiation.

323 Ha Chae-rim, "北 핵탄두 80~90여기 보유한 듯…목표 보유량은 300여기 추정" [N. Korea Estimated to Have 80-90 Nuclear Warheads, with a Goal of 300], *Yonhap News*, January 12, 2023. https://www.yna.co.kr/view/AKR20230112154500504.

324 Vann H. Van Diepen, "Third Successful Launch of North Korea's Hwasong-18 Solid ICBM Probably Marks Operational Deployment," *38 North*, December 21, 2023.https://www.38north.org/2023/12/third-successful-launch-of-north-koreas-hwasong-18-solid-icbm-probably-marks-operational-deployment/.

325 Chae Yun-hwan, "N.K. leader guides firing drills involving super-large multiple rocket launchers," *Yonhap News*, March 19, 2024. https://en.yna.co.kr/view/AEN20240319000652315.

326 Author interview with a U.S. nuclear engineer.

Testing nuclear warheads is vital to North Korea's nuclear program, since nuclear scientists and engineers must be able to assure their leadership that the weapons will work as intended. It was reported in March 2022 that North Korea was restoring its Punggye-ri nuclear test site, presumably to test tactical nuclear weapons.[327] However, the Kim regime's seismic analysts do not seem to have properly advised the Supreme Leader of the dangers of conducting multiple nuclear tests at the same site. South Korea has reported multiple minor earthquakes near the test site, when "the region isn't one where earthquakes naturally occur."[328] Experts have warned that the area is likely too unstable for further testing, and that further testing could trigger an eruption at Mount Paektu, sixty miles to the north.[329] Numerous aftershocks have damaged the test site, creating a "tired mountain syndrome."[330] A Chinese nuclear safety expert warned in 2017 that further testing could lead to a collapse of the mountain and the leakage of radioactive materials across the neighboring region.[331]

In preparing for possible contingencies on the Korean Peninsula, it is essential to consider the role of North Korea's nuclear scientists and engineers. If there is a war, nuclear scientists would be called upon to prepare nuclear weapons for use against South Korea, Japan, or the United States. Refusal to do so would not only result in the grave charge of disloyalty, but would also likely result in immediate execution of not only the nuclear scientist but also their family members. If there is a regime collapse, vying centers of power could view nuclear weapons and equipment as assets to be bartered. Rogue actors could exploit nuclear personnel to advance their own objectives, leading to proliferation risks.

What about denuclearization? Although it remains a diplomatic objective, the Kim regime's long-standing political strategy and objectives make it very unlikely that it will ever agree to complete, verifiable, and irreversible denuclearization. Kim Jong-un declared that he would seek to develop both the economy and the nuclear program, but he has sacrificed the former for the latter. It was estimated in 2013 that North Korea had spent approximately $3 billion on the nuclear program—enough to feed the population for three years.[332]

As long as the nuclear program remains a priority for Kim Jong-un, there is little hope that the human rights situation of North Korea's nuclear scientists, engineers, and their families will improve. Nevertheless, should the Kim regime ever agree to denuclearization, what would happen to the nuclear scientists? Any denucle-

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327 Josh Smith, "N.Korea May Be Preparing New Nuclear Tests to Improve Arsenal, U.S. And Allies Say," *Reuters*, April 1, 2022. https://www.reuters.com/world/asia-pacific/nkorea-may-be-preparing-new-nuclear-tests-improve-arsenal-us-allies-say-2022-04-01/.

328 Hyung-Jin Kim, "4th small quake detected since North Korea's nuclear test," *Associated Press*, October 13, 2017. https://apnews.com/general-news-95cd7d9e245e4657b7be680023541dbe.

329 Ibid.

330 "Why North Korea's Nuclear Test Is Still Producing Aftershocks," *BBC News*, December 11, 2017. http://www.bbc.com/news/world-asia-42305161; "Aftershocks Detected after North Korea Nuclear Test Moved Earth's Crust," *The Guardian*, December 10, 2017. https://www.theguardian.com/world/2017/dec/10/north-korea-nuclear-test-aftershocks-earth-crust; Anna Fifield, "After six tests, the mountain hosting North Korea's nuclear blasts may be exhausted," *The Washington Post,* October 20, 2017. https://www.washingtonpost.com/world/after-six-tests-the-mountain-hosting-north-koreas-nuclear-blasts-may-be-exhausted/2017/10/20/ccdfa016-b50d-11e7-9b93-b97043e57a22_story.html.

331 Kim Jin-bang and Ahn Seung-seop, "中연구팀 '북한 풍계리 핵실험장 붕괴 위험 있어'" [North Korea's Punggye-ri Test Site Could Collapse, Chinese Researchers Warn], *Yonhap News*, September 5, 2017. https://www.yna.co.kr/view/AKR20170905060451083.

332 "What Did N.Korea's Nuclear Program Cost?," *Chosun Ilbo*, February 13, 2013. http://english.chosun.com/site/data/html_dir/2013/02/13/2013021301335.html.

arization scheme will be a daunting task. According to Siegfried Hecker, a leading U.S. expert, dismantling the nuclear program will take fifteen years.[333] Experts have also advised that "human resources are the key to nuclear weapons technology, and the most troublesome problem in the process of denuclearization is the treatment of human resources."[334] It has been estimated that it will take up to 2,000 personnel to dismantle the Yongbyon facility alone.[335] What of the other 4,000? After the fall of the Soviet Union, nuclear scientists left Russia for jobs in countries that wanted to expand their nuclear program, including North Korea. Unless the international community secures employment opportunities for North Korea's nuclear scientists and engineers, they could contribute to proliferation elsewhere.

These steps may not be realized while the Kim family is in control of North Korea. However, the nuclear program must eventually be dismantled to secure the long-term peace and security of the Korean Peninsula. High-level KWP cadre and other key personnel must be held accountable for the human rights violations they committed in developing and testing nuclear warheads. The vast majority of nuclear scientists, engineers, and workers should be given the opportunity to apply their talents toward the peaceful use of nuclear energy. The "slaves to the bomb" must be liberated. These personnel and their family members should be provided with necessary medical care to address the consequences of radiation exposure and other health hazards. Finally, there should be a thorough assessment of the environmental damage caused by the nuclear program. Residents who lived in close proximity to nuclear facilities must be able to seek medical treatment and appropriate remedies for their suffering.

North Korea's nuclear weapons have helped perpetuate the Kim regime's brutal rule. Restoring the dignity and fundamental rights of the North Korean people will require a full accounting of the horrors inflicted by the Kim family's development of nuclear weapons.

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333 Hwang Joon-beom, "북비핵화 길면 15년…단계적 해법 불가피" [It Could Take Fifteen Years to Denuclearize North Korea... Step-By-Step Solution Is Inevitable], *Hankyoreh*, May 29, 2018. http://www.hani.co.kr/arti/international/international_general/846747.html.

334 Oh, "Turn North Korean Nuclear Scientists and Engineers into a Peaceful Mission."

335 Jungmin Kang, "Redirecting North Korea's Nuclear Workers," *Bulletin of the Atomic Scientists* 65, no. 1 (January 2009): 48–55.

ANNEX 1: NORTH KOREAN NUCLEAR SCIENTISTS

To effectively address North Korea's WMD programs, it is critical to identify the scientists and engineers behind those programs. North Korea deliberately hides information about its WMD programs, and the identity of their scientists is also well hidden. However, some key names have come to light through interactions with the international community. They are divided here into three categories—first generation, second generation, and third (current) generation.[336] Several individuals noted below are discussed in the body of the report. In these instances, some of the text is taken directly from the relevant sections.

First Generation Nuclear Scientists & Engineers

Chon Pyong-su (전평수) was born in North Gyeongsang Province (in present-day South Korea) in 1916. He graduated from Tokyo Physics School in 1939 and graduated from Hokkaido Imperial College in 1942. He then worked at Japan's Research Institute of Chemistry (이화학연구소). He went on to work at the Yajima Research Office of Kyongsong Imperial University.[337]

Chung Kun (정근) was one of the first people to study at Kyongsong Imperial University's Physics Department. Chung was later appointed to the faculty of Kyongsong University's Physics Department, but he defected to the North.[338] He then spent time in the Soviet Union studying the physics of nuclear reactors.[339]

Do Sang-rok (도상록, 1903–90) is widely regarded as the father of North Korea's nuclear program. Born in Hamhung, he graduated from high school in Okayama, Japan in 1925 and attended Tokyo Imperial University, where he graduated in 1930 with a degree in physics. In the early 1940s, Do taught at Shingyeong Engineering University in Manchuria. After liberation from Japanese colonial rule, Do became the Dean of the Engineering College at Kyongsong University, the predecessor to Seoul National University. However, he was dismissed in June 1946 due to his involvement in a leftist movement as part of the *Gukdaean* incident.[340] Do went to Pyongyang and met with Kim Il-sung on July 3, 1946, where he was appointed to the preparation committee for the establishment of Kim Il-sung University. He established North Korea's first nuclear physics organization at the Kim Il-sung University Physics Department.[341]

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336 For many of these individuals, there is insufficient information to reliably determine which generation they belong to. In these cases, they were classified based on the year that their research was published, or by the seniority of their position at the time they were identified by outside sources.

337 Im Gyong-sun, "Haebang jikhu daehak-ui moollihakgwa" [Korea's Physics Departments Immediately After Liberation], *The Korean Physical Society Webzine* 12, no. 1/2 (January/February 2003): 38–39. https://webzine.kps.or.kr/inc/down.php?fileIdx=7886.

338 "서울대학교 자연과학대학 물리학과" [History of the Physics Department at Seoul National University], *The Korean Physical Society*, December 2002. https://www.kps.or.kr/content/50years/html/kps223.htm.

339 Lee Sang-soo, "북한, 핵 기술·인력 어떻게 만들어졌나" [How N. Korea Acquired the Personnel and Equipment for its Nuclear Program], *Hankyoreh*, October 13, 2006. https://www.hani.co.kr/arti/politics/defense/164187.html.

340 *Gukdaean* is the Korean-language acronym for the "Plan to Establish a Comprehensive National University," which was announced by the U.S. Army Military Government in Korea (1945–48). Under this plan, Kyongsong University and several professional schools were to be combined into a single university. Many professors and students opposed the plan, including those with leftist ideological leanings. See Kim Tae-ho, "[구석구석 과학사] (17) 많은 과학자들이 남한을 떠난 까닭은" [Why Many Scientists Left South Korea], *Weekly Kyunghyang*, October 24, 2017. https://weekly.khan.co.kr/khnm.html?mode=view&artid=201710161925221&code=116.

341 Im, "Korea's Physics Departments Immediately After Liberation."

Do then became the Dean of the Physics & Math Department in 1946 and served there until he passed away in 1990.[342] Do wrote thirty textbooks and reference books on quantum mechanics, nuclear structure theory, and nuclear reactor physics.[343] He was also directly involved in establishing the foundations of nuclear research in North Korea, including the construction of an experimental reactor (with Soviet assistance) and a particle accelerator. In 1973, Do was awarded the Kim Il-sung Medal (North Korea's highest award), and in 1986 he was designated the "People's Scientist." He also received the "Hero of the Republic" award.[344] He is buried in the Martyr's Cemetery, which is reserved for national heroes.[345] Do worked closely with other scientists who defected to North Korea, such as **Han In-sok**, **Chung Kun**, **Chon Pyong-su**, and **Ryeo Chol-ki**.[346]

Han In-sok (한인석) was born in Kyonggi Province and studied in Germany and the Soviet Union.[347] He taught at Yonsei University in Seoul before defecting to the North, where he taught at Kim Il-sung University. After pursuing further studies in the Soviet Union, he published widely on nuclear physics in North Korea in the 1960s.[348]

Lee Si-gu (이시구) was born in 1926, in Uiseong County, North Gyeongsang Province (South Korea). He was a Korean-Japanese scientist who obtained a Ph.D. in theoretical physics from Osaka University in 1948. Lee was employed at Japan's Research Institute for Physics and Chemistry (RIKEN). Lee maintained significant ties to the Chosen Soren and allegedly passed key components of RIKEN's research on nuclear technology to North Korea.[349]

Ri Sung-ki (리승기; also spelled **Lee Sung-ki**) was born in 1905 in Damyang, South Cholla Province. He earned a Ph.D. in applied chemistry from Tokyo Imperial University in 1939 and served as the Dean of Seoul National University's College of Engineering after liberation. He defected to North Korea during the Korean War, and later served as the Director of the Yongbyon Nuclear Research Institute and the Hamhung Branch of the Academy of Sciences. He is believed to have made important contributions to the development of North Korea's implosion-type plutonium weapon.[350]

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342 "북한 과학기술분야의 기초를 쌓은 사람들" [The People Who Laid the Foundations of North Korea's Science and Technology], *NK Tech*, August 1, 2003. http://www.nktech.net/inform/nkt_briefing/nkt_briefing_v.jsp?record_no=11.

343 Choi Hyeon-seok, "'핵무력 위협' 북한, '핵이론 선구자' 도상록 부각" [N. Korea Spotlights Do Sang-rok Amidst Nuclear Threats], *Yonhap News*, March 20, 2023. https://www.yna.co.kr/view/AKR20230320094000535.

344 Kang Ho-je, "북한 핵개발 60년史…월북 물리학자 도상록이 주도" [Six Decades of N. Korea's Nuclear Program, led by Do Sang-rok, Who Defected to the North], *Pressian*, February 13, 2013. https://www.pressian.com/pages/articles/5884.

345 Choi, "N. Korea Spotlights Do Sang-rok Amidst Nuclear Threats."

346 Kang Ho-je, "도상록 - 북한 핵물리학의 아버지" [Do Sang-rok – Father of N. Korea's Nuclear Physics], *North Korea's Science & Technology with Dr. Kang*, March 31, 2017. https://nktech.tistory.com/entry/3-%EB%8F%84%EC%83%81%EB%A1%9D%EB%B6%81%ED%95%9C%ED%95%B5%EB%AC%BC%EB%A6%AC%ED%95%99%EC%9D%98-%EC%95%84%EB%B2%84%EC%A7%80.

347 Kim Jeong-seop, "北核두뇌 상당수가 남한출신" [Many of the Brains Behind N. Korea's Nuclear Weapons Are from the South], *Kyunghyang Sinmun*, April 20, 2003. https://m.khan.co.kr/politics/north-korea/article/200304201822211.

348 Lee, "How N. Korea Acquired the Personnel and Equipment for its Nuclear Program."

349 Lee Yun-gol and Han Byong-kwan, "[단독입수] '일본-북한 핵 커넥션' 담긴 조총련 문건 '일본 핵기술 조총련 거쳐 북으로'" [Exclusive: Chongryon Documents Show How Japan's Nuclear Technology was Leaked to N. Korea], *Ilyo Sinmun*, April 5, 2017. https://ilyo.co.kr/?ac=article_view&entry_id=240895.

350 Hong Deok-hwa, ""북 핵개발 리승기·도상록 등 월북과학자가 주도" [N. Korea's Nuclear Development Led by Scientists Who Went North, Including Ri Sung-ki and Do Sang-rok], *Yonhap News*, October 24, 2006. https://www.hani.co.kr/arti/politics/defense/166842.html.

Ryeo Chol-gi (려철기) was affiliated with the Physics Research Institute under the Academy of Sciences. He published a paper on the statistical-thermodynamics approach to second-order phase transition in non-equilibrium stationary states.[351]

Second Generation Nuclear Scientists & Engineers

Chang Won-hyok (장원혁) co-authored a paper with **Ri Kyong-su** (리경수) on neutron transport equations in 1991.[352]

Cho Byong-rae (조병래) was identified as a researcher affiliated with the Physics Research Institute (University of Science) and is an expert in maximum entropy for non-equilibrium thermodynamic systems.[353]

Choi Hak-keun (최학근) studied at the Dubna Nuclear Research Center in the former Soviet Union.[354] In 1975, he was sent to Vienna as a member of the North Korean delegation to the IAEA. During his time in Vienna, he is believed to have acquired blueprints and other technical information on reactor design from the IAEA's library. Choi served as the Director of the NPRI and the Minister of the Atomic Energy Industry.[355]

Choi Hung-do (최흥도) co-authored a paper with **Ri Sok-ham** (리석함) on atmospheric penetration of nuclear radiation in 1988.[356]

Choi Yong-chol (최용철) co-authored a paper entitled "Recovery and chemical protection from radiation injury" in 1977 with **Ryang Hong-kon** (량홍건), **Ri Man-u** (리만우), **Han Hong-jong** (한홍종).[357]

Chon Chi-bu has been identified as a scientist who worked at the Yongbyon Nuclear Complex. Chon reportedly led a team of North Korean nuclear scientists during a visit to Syria to negotiate the construction of a nuclear reactor identical to that at Yongbyon.[358]

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351 Lee Choon-kun and Kim Gye-su, *Bukhan-ui gukga yeongu gaebal cheje-wa gwahak gisul illyeok yangseong cheje* [The National R&D system and S&T Human Resources Training System in North Korea] (Seoul: Science & Technology Policy Institute, 2001), 224.

352 Hong Seong-beom, Im Deok-soon and Kim Gi-guk, *Bukhan gwahak gisul hyeonhwang mit jeongchaek donghyang bunseok* [Status of N. Korea's Science & Technology and Policy Trends] (Seoul: Science and Technology Policy Institute, 2002), 261. https://stepi.re.kr/common/report/Download.do?reIdx=289&cateCont=A0201&streFileNm=A0201_289&downCont=0.

353 Lee and Kim, *The National R&D System and S&T Human Resources Training System in N. Korea*, 223.

354 Donald Greenlees, "How North Korea fulfilled its nuclear quest," *International Herald Tribune*, October 23, 2006. https://www.nytimes.com/2006/10/23/world/asia/23iht-bomb.3257012.html.

355 Lee, "How N. Korea Acquired the Personnel and Equipment for its Nuclear Program."

356 Hong, Im and Kim, *Status of North Korea's Science & Technology and Policy Trends*, 261.

357 Ibid., 223.

358 Cho Eui-joon, "핵·미사일 중동 전파 막아라…이스라엘, 北과 '그림자 전쟁' 50년" [Fifty Years of N. Korea and Israel's Shadow War], *Chosun Ilbo*, October 22, 2019. https://www.chosun.com/site/data/html_dir/2019/10/22/2019102200112.html; see also "Oh What a Tangled Web They Weave: The Shadowy Half-Life of Syria's Supposedly Non-Existent Nuclear Reactor," *The Economist*, May 1, 2008. http://www.economist.com/node/11293979?story_id=11293979.

Hwang Sok-ha (황석하, 1943–) has been identified by the UN as a Director in the General Bureau of Atomic Energy. [359]

Jung Chung-ok (중정옥, 1955–) is one of the few known North Korean female nuclear scientists. She graduated from the University of Physics in 1974, and was assigned to Office 25 of the 304th Research Office of the Atomic Energy Science Committee until her dismissal on February 21, 1999. She defected in 2000.[360]

Kim Ha (김하) is affiliated with the Physics Research Institute (Academy of Sciences) and is an expert in Raman spectroscopy.[361]

Kim Il-kwang (김일광) is a particle physicist who published a paper entitled "The new model for the large distance mass-mass interaction and Higgs boson mass" in 1987.[362]

Kim Sung-il (김성일) was a researcher at the Yongbyon Nuclear Complex. His name came to light after it was reported in the South Korean press that Kim and his son, **Kim Seo-in**, a renowned mathematician, had been arrested for allegedly passing sensitive nuclear documents to a foreign power.[363]

Kim Yon-il (김연일) is affiliated with the Physics Research Institute (Academy of Sciences).[364]

Kim Yong-hek is affiliated with the Pyongyang Astronomy Observatory, and he has published a paper on the relationship between short-period solar activities and the variation of the solar neutrino flux.[365]

Kim Yong-jin (김영진) was identified as a Professor of Nuclear Physics at Kim Il-sung University.[366]

Kyong Won-ha (경원하) is a controversial figure due to conflicting reports about his personal history. He was originally from Sinuiju and taught at a university in Chuncheon, South Korea after the Korean War. Later, he went to Brazil and then to Canada to study at McGill University.[367] His master's degree thesis (1969) at McGill was on *A Numerical Description For Spherical Imploding Shock Waves*. His Ph.D. disserta-

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359 UN Security Council, "Sanctions: 1718 Sanctions Committee (DPRK)," accessed May 1, 2024. https://www.un.org/securitycouncil/sanctions/1718/materials.

360 Bill Streifer, "Hungnam, North Korea: Delving into Pyongyang's Long Nuclear Past," *National Security News Service*, June 15, 2013. https://www.academia.edu/3813672/Hungnam_North_Korea_Delving_into_Pyongyang_s_Long_Nuclear_Past

361 Lee and Kim, *The National R&D System and S&T Human Resources Training System in N. Korea*, 226.

362 Hong, Im and Kim, *Status of North Korea's Science & Technology and Policy Trends*, 261.

363 Lee Yun-gol and Han Byong-kwan, "[최초공개] 7년 만에 밝혀진 북한 천재 수학자 처형 비스토리" [Exclusive: Why a N. Korean Math Genius Was Executed], *Ilyo Sinmun*, December 29, 2017. https://ilyo.co.kr/?ac=article_view&entry_id=285608.

364 Lee and Kim, *The National R&D System and S&T Human Resources Training System in North Korea*, 221-22.

365 Ibid., 225.

366 "Buk haekmullihak-ul ikkeun hakjadeul – 1960 nyeondae soryeon-gwa injokgyoryu haekmullihak gisul supduk, il-lyeok yangseong" [The Scholars Who Led N. Korea's Nuclear Physics: Gaining Technology and Training Personnel through Exchanges with the Soviet Union in the 1960s], *Minjok21* 68 (November 2006): 84–85.

367 Choi Chang-soon and Sung Dong-gi, "서방 망명설 北 핵과학자 경원하박사 행적" [The Life of N. Korean Nuclear Scientist Dr. Kyong Won-ha, Rumored to Have Defected to the West], *Dong-A Ilbo*, September 29, 2009. https://www.donga.com/news/Politics/article/all/20030421/7936772/1.

tion (1972), also at McGill, was entitled *A Theoretical Study Of Spherical Gaseous Detonation Waves*.[368] Kyong also allegedly gained knowledge about nuclear reactors while in Canada. According to a fellow Korean student who knew Kyong at McGill, Kyong went to North Korea in 1972 to meet with his family. After returning to Canada, he was investigated by the authorities and lost his job. The extent and of Kyong's involvement in the nuclear program is unclear. He is rumored to have defected to the West in the early 2000s.[369]

Mun Yong-jin (문영진) was a contemporary of **Seo Sang-guk** and an expert in quantum mechanics.[370]

Nam Hong-u (남홍우) was identified in 2012 as the Director of the Physics Research Institute under the Academy of Sciences.[371] An article from 2002 notes that he was born in Osaka, Japan and has made important contributions to basic science research "for the past thirty years."[372]

Pak Kwan-o (박관오) was born in 1929 in Jagang Province. He studied in the Soviet Union and taught at Kim Il-sung University's Physics Department until the mid-1960s. Pak was appointed the Deputy Director of the Academy of Sciences in 1971, the Vice Chair of the National Atomic Energy Commission in 1978, and the Director of the Nuclear Power Research Institute in 1981. He then moved to the KWP Science Education Department before being appointed the President of Kim Il-sung University in 1987. He was awarded the Kim Il-sung Medal in 1992.[373]

Pyon Yong-rip (변영립, 1929–2016), who studied physics at Kim Il-sung University, served as the Director of the National Academy of Sciences from 2003 to 2009. He was an educator and a key administrator in science education. He also served as the Minister of Education (1999–2003), and the Chair of the Central Committee for the Korean Association of Science and Technology (2003–2010). Pyon was also a Member of the KWP Politburo and the Party's Central Committee.[374]

Ri Cha-bang (리자방) is a technocrat who began his career in the machine industry sector. He served as the head of the National Committee on Science and Technology (1985–2009) and the Chair of the Korean Association of Science and Technology (1985–2010). He was also elected as a Member of the Ninth SPA in 1990.[375]

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368 Search results obtained from https://escholarship.mcgill.ca/. Accessed April 29, 2024.

369 Kim Tae-gyeong and Son Byung-gwan, "'망명' 경원하 박사, '핵 과학자'인가" [Is Defector Dr. Kyong Won-ha a Nuclear Scientist?], *OhmyNews*, April 25, 2003. https://www.ohmynews.com/NWS_Web/view/at_pg.aspx?CNTN_CD=A0000119715.

370 "The Scholars Who Led N. Korea's Nuclear Physics: Gaining Technology and Training Personnel through Exchanges with the Soviet Union in the 1960s," *Minjok21* 68 (November 2006).

371 Republic of Korea Ministry of Unification, *2012 Bukhan juyo gigwan, danche inmyeongrok* [Individuals in N. Korea's Key Institutions and Organizations: 2012] (Seoul: Ministry of Unification, 2012), 304. https://www.korea.kr/archive/expDocView.do?docId=33190#expDoc.

372 "北과학원, 기초과학 연구과제에 박차" [N. Korea's Academy of Sciences Focusing on Basic Science Research], *Yonhap News*, February 13, 2002. https://nk.chosun.com/news/articleView.html?idxno=15139.

373 "북한 김일성종합대학 박관오 총장" [Pak Kwan-o, President of Kim Il-sung University], *Yonhap News*, April 26, 2001. https://www.tongilnews.com/news/articleView.html?idxno=6085.

374 Michael Madden, "Pyon Yong Rip (1929-2016)," *North Korea Leadership Watch*, November 19, 2016. https://nkleadershipwatch.wordpress.com/2016/11/18/pyon-yong-rip-1929-2016/; Republic of Korea Ministry of Unification, "변영립" [Pyon Yong-rip], *North Korea Information Portal*, accessed April 30, 2024. https://nkinfo.unikorea.go.kr/nkp/prsn/view.do;jsessionid=rRkR_F0fqALHH8S9uStP07vxhDIndObt3l-WPEpB.ins12?menuId=PEOPLE_86&prsnMngNo=7869.

375 Republic of Korea Ministry of Unification, "리자방" [Ri Cha-bang], *North Korea Information Portal*, accessed May 1,

Ri Je-son (리제선) is a former Director of the General Bureau of Atomic Energy and a former Minister of Nuclear Power Industry.[376] He is a Kim Il-sung University graduate and studied abroad in Russia. According to South Korean analysts, Ri was responsible for the management of nuclear tests and nuclear fuel, as well as the administration of research facilities in Pyongyang and Yongbyon.[377] Ri has been sanctioned by the UN Security Council since 2009.[378] Ri was also an Alternate Member of the KWP Central Committee, an indication of his importance within the regime.[379]

Ri Myong-ha (리명하) was noted by the South Korean press as a scientist in his 70s who previously studied in the Soviet Union and played a critical role in North Korea's nuclear weapons development. At the time, Ri was serving as the Dean of the College of Physics at Yongbyon. He was known to be an expert in high explosives, which play a critical role in the detonation device in a nuclear warhead.[380] It was reported in 2016 that Ri was no longer directly involved in the nuclear program, but continued to exercise his influence over the appointment of key personnel.[381]

Ri Myong-jin (리명진) was a contemporary of **Seo Sang-guk** and an expert in quantum mechanics.[382]

Seo Sang-guk (서상국, 1938–) is the leading figure among North Korean nuclear scientists who studied in the Soviet Union. He has also played a critical role in North Korea's ballistic missile program. Widely regarded as a genius, Seo earned his Ph.D. at the age of 28. The Soviet Union took notice of his talents and attempted to persuade him to stay. According to escapee testimony, Seo secretly met with Soviet officials and bragged to his friends in private that the Soviets had offered him a high-paying position. This was later reported to the North Korean authorities, who sent him to a countryside farm as punishment. Seo was reinstated after a Soviet physicist, responding to Kim Il-sung's request for help on rocket technology, inquired about Seo's whereabouts. Seo was later appointed the Chair of Kim Il-sung University's Physics Department, where he taught students and published widely on nuclear physics. At the same time, he was deeply involved in both the nuclear and missile programs. He is reported to have spent much of his time at the Yongbyon Nuclear Complex, and he leveraged his former Soviet connections to acquire materials and components for the nuclear program.[383]

2024. https://nkinfo.unikorea.go.kr/nkp/prsn/view.do;jsessionid=UY5oIBoqwqs0LM5OIKAoXQ2q8x_A3GnpXmLdo2yx.ins22?menuId=PEOPLE_86&prsnMngNo=23546.

376 Republic of Korea Ministry of Unification, "리제선" [Ri Je-son], *North Korea Information Portal*, accessed May 1, 2024. https://nkinfo.unikorea.go.kr/nkp/prsn/view.do;jsessionid=KS-2QsTfIoYG_tjHeO44MC2sF-AhmHTtFhIz7Y2t.ins12?menuId=PEOPLE_86&prsnMngNo=23583.

377 Kim Isaac, "모든 핵개발 실무 총괄 북한 원자력계의 대부" [The Godfather of N. Korea's Nuclear Sector], *Hankook Ilbo*, April 10, 2014. https://www.hankookilbo.com/News/Read/201404101833810684.

378 UN Security Council, "Sanctions: 1718 Sanctions Committee (DPRK)."

379 Republic of Korea Ministry of Unification, "Ri Je-son."

380 "더 세진 북핵…정보당국, 북한 70대 이명하 박사 주목" [N. Korea's Nuclear Program Gains Strength, as Intelligence Authorities Focus on Dr. Ri Myong-ha], *Chosun Ilbo*, May 27, 2009. https://www.chosun.com/site/data/html_dir/2009/05/27/2009052700363.html.

381 So Mi-yeon, "[특집②북한 핵실험] 이명하→김정식, '충성경쟁'이 핵개발 원동력" [Ri Myong-ha to Kim Jeong-sik; Political Loyalty Drives the North's Nuclear Development], *Sisa Week*, September 12, 2016. https://www.sisaweek.com/news/articleView.html?idxno=78138.

382 "The Scholars Who Led N. Korea's Nuclear Physics: Gaining Technology and Training Personnel through Exchanges with the Soviet Union in the 1960s," *Minjok21* 68 (November 2006).

383 "북한 핵개발의 대부는 김大 서상국 교수" [Prof. Seo Sang-guk of Kim Il-sung University is the Godfather of N. Korea's Nuclear Program], *Daily NK*, October 13, 2006. https://www.dailynk.com/%EB%B6%81%ED%95%9C-

Seo Seok-hong (서석홍), a Korean-Japanese scientist and a member of the Korean Association of Science and Technology in Japan, was arrested in 2006 by the Japanese authorities for his alleged role in assisting North Korea's nuclear and missile programs.[384]

Third Generation Nuclear Scientists & Engineers

Byeon Cheol-ho is a Korean-Japanese assistant professor at Kyoto University Research Reactor Institute who allegedly provided North Korea with information related to nuclear weapon miniaturization. Byeon visited North Korea seven times between 1992 and 2008. Both of his parents were members of the Chosen Soren.[385]

Choi Kil-man (최길만) was identified in 2004 as the Deputy Director of the Yongbyon Nuclear Scientific Research Center.[386]

Ho Il-mun (허일문) is a faculty member at Kim Il-sung University's Energy Science Department and has published several papers on light water reactor design.[387]

Ho Yong-hwan (허영환) has been identified as a researcher at Physics Research Institute (Academy of Sciences). He is an expert in chiral transformation and non-conservation of axial-vector current.[388]

Kang Jin-sok (강진석) is affiliated with the Pyongyang Astronomy Observatory, and he is an expert in the relationship between short-period solar activities and the variation of the solar neutrino flux.[389]

Kang Jin-u (강진우) is a faculty member in Kim Il-sung University's Physics Department. He obtained his Ph.D. in 2009 at the University of Munich, and has co-authored papers with scholars based in China, Germany, Italy, and Sweden.[390]

%ED%95%B5%EA%B0%9C%EB%B0%9C%EC%9D%98-%EB%8C%80%EB%B6%80%EB%8A%94-%EA%B9%80%E5%A4%A7-%EC%84%9C%EC%83%81%EA%B5%AD/; Jung Hye-yeon, "북한 核·미사일 개발의 배후 서상국의 실체" [Seo Sang-guk, the Man Behind N. Korea's Nuclear and Missile Programs], *Monthly Chosun*, January 2016. http://monthly.chosun.com/client/news/viw.asp?ctcd=&nNewsNumb=201601100022; Jang Jin-sung, "북한의 로켓기술은 서상국이 주도한다" [Seo Sang-guk Leads N. Korea's Rocket Development], *RFA*, December 11, 2012. https://www.rfa.org/korean/weekly_program/ae40c528-c77cac00c758-ac70c9d3acfc-c9c4c2e4/co-jj-12112012141930.html.

384 Cheon Gwang-am, "핵기술 북한에 제공 의혹 총련 산하단체 간부 체포" [Member of Chongryon-operated Organization Arrested for Allegedly Providing Nuclear Technology to North Korea], *Dong-A Ilbo*, January 30, 2007. https://www.donga.com/news/Politics/article/all/20070130/8401438/1.

385 Julian Ryall, "Are 'Nuclear Spies' in Japan Providing Pyongyang with Weapons Technology?," *Deutsche Welle*, April 3, 2017. http://www.dw.com/en/are-nuclear-spies-in-japan-providing-pyongyang-with-weapons-technology/a-38265685.

386 U.S. Senate Committee on Foreign Relations, *North Korea: Status Report on Nuclear Program, Humanitarian Issues, and Economic Reforms* (Washington, D.C.: U.S. GPO, 2004). https://www.govinfo.gov/content/pkg/CPRT-108SPRT92278/html/CPRT-108SPRT92278.htm.

387 Hyuk Kim, "North Korea's Artificial Intelligence Research: Trends and Potential Civilian and Military Applications," *38 North*, January 23, 2024. https://www.38north.org/2024/01/north-koreas-artificial-intelligence-research-trends-and-potential-civilian-and-military-applications/.

388 Lee and Kim, *The National R&D System and S&T Human Resources Training System in N. Korea*, 222.

389 Ibid., 225.

390 "Jin U Kang," *iNSPIRE-HEP*, accessed May 1, 2024. https://inspirehep.net/authors/1051315.

Kim Haik-soon (김핵순) was identified in 2004 as a senior researcher at the Yongbyon Nuclear Complex.[391]

Kim Jik-su (김직수) published a paper on solar proton events and their impact on spacecraft in 1996.[392] He also appears to have co-authored a paper in 2019 entitled "A Special Class of the Scalar-Tensor Gravity with Scalar-Matter Direct Coupling," in which he stated his affiliation with the Pyongyang Astronomical Observatory in the Academy of Sciences.[393]

Kim Kyong-chun (김경춘) was identified in 2019 as a Director in the Ministry of Atomic Energy Industry.[394] He was a member of North Korea's delegation in inter-Korean negotiations about nuclear issues in 1992.[395]

Kim Kyong-il (김경일) has published several papers on light water reactor design.[396]

Kim Kwang-bin (김광빈) has been identified as the former Director of the Nuclear Energy Research Institute under the General Bureau of Atomic Energy. A Japanese current affairs magazine reported in 2004 that he had defected to a third country.[397]

Kim Sung-du (김승두, 1958–) was identified in 2007 as the President of the College of Science (Pyongsong), a key institution in training scientists and engineers for the nuclear program.[398] He is a Member of the KWP Central Committee and was appointed the Minister of Education in November 2023.[399]

Paek Young-myong (백영명) co-authored a paper with **Ho Il-mun** and **Kim Kyong-il** in 2005 regarding issues in nuclear reactor design.[400]

Pak Chang-su was identified in 2004 as a researcher at the Yongbyon Nuclear Complex.[401]

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391 U.S. Senate Committee on Foreign Relations, *North Korea: Status Report on Nuclear Program, Humanitarian Issues, and Economic Reforms*.

392 Hong, Im and Kim, *Status of North Korea's Science & Technology and Policy Trends*, 261.

393 "Kim Jik-su," *iNSPIRE-HEP*, accessed May 1, 2024. https://inspirehep.net/authors/2527645.

394 Republic of Korea Ministry of Unification, *2019 Bukhan gigwan-byeol inmyeongrok* [Individuals in North Korea's Key Institutions: 2019] (Seoul: Ministry of Unification, 2019), 102. http://unibook.unikorea.go.kr/libeka/elec/20181200000000072.pdf.

395 "국가기록사진: 남북핵통제공동위원회 1차회의" [National Photo Archive: First Meeting of North-South Joint Nuclear Control Commission], *Korea TV*, accessed May 1, 2024. https://www.ehistory.go.kr/view/photo?mediaid=16294&mediasrcgbn=PT.

396 Kim, "North Korea's Artificial Intelligence Research," Appendix II.

397 Jeon Hyeon-il, "日월간지 '北 핵심 核과학자 제3國망명'" [Key N. Korean Nuclear Scientist Defects to Third Country, according to Japanese Magazine], *Segye Ilbo*, July 30, 2004. https://n.news.naver.com/mnews/article/022/0000044536.

398 Nuclear Threat Initiative, "College of Science," May 29, 2012. https://web.archive.org/web/20151116092107/http://www.nti.org/facilities/759/.

399 Republic of Korea Ministry of Unification, "김승두" [Kim Sung-du], *North Korea Information Portal*, accessed May 1, 2024. https://nkinfo.unikorea.go.kr/nkp/prsn/view.do;jsessionid=iFGG8mu9fs7t-g_1bQk6ii9L4DvFAPPji8jOTtfs.ins12?menuId=PEOPLE_86&prsnMngNo=14292.

400 Kim, "North Korea's Artificial Intelligence Research," Appendix II.

401 U.S. Senate Committee on Foreign Relations, *North Korea: Status Report on Nuclear Program, Humanitarian Issues, and Economic Reforms*.

Ri Chang-hyok (리창혁) is an expert in particle physics. In 2000, he published a paper entitled "State equation of quark matter."[402]

Ri Hong-sop (리홍섭) is the leading nuclear scientist in North Korea's nuclear weapons program. South Korea's Ministry of Unification identified him as the Director of the Nuclear Weapons Research Institute (NWRI) in 2023.[403] He was formerly the director of the Yongbyon Atomic Energy Research Institute.[404] Ri was sanctioned by the UN in July 2009,[405] and by the United States in 2010.[406] Ri has also been sanctioned by the UK, EU, and Japan.[407] In 2017, Ri was seen wearing the insignia of a three-star general on his KPA uniform.[408]

Ri Song-hwan (**Li Song-hwan**) was identified in 2004 as the chief engineer at the Yongbyon Nuclear Complex.[409]

Ri Yong-ho (**Li Yong-ho**) was identified in 2004 as the head of the safeguards section at the Yongbyon Nuclear Complex.[410]

Ri Yong-song (**Li Yong-song**) was identified in 2004 as the chief engineer of the Radiochemical Laboratory at Yongbyon.[411]

Ryom Yong (렴영) was identified in 2009 as a Director of the General Bureau of Atomic Energy.[412]

So Chol (서철) is a faculty member at Kim Il-sung University's Energy Science Department and has published several papers on light water reactor design.[413]

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402 Hong, Im and Kim, *Status of N. Korea's Science & Technology and Policy Trends*, 261.

403 Republic of Korea Ministry of Unification, *Key Personnel in North Korea by Institution: 2023* (Seoul: Ministry of Unification, 2023), 321.

404 U.S. Senate Committee on Foreign Relations, *North Korea: Status Report on Nuclear Program, Humanitarian Issues, and Economic Reforms*.

405 UN Security Council, "Ri Hong-sop," October 29, 2014. https://www.un.org/securitycouncil/sanctions/1718/materials/summaries/individual/ri-hong-sop.

406 U.S. Department of the Treasury, "North Korea Executive Order / North Korea Designations / Non-proliferation Designations," August 30, 2010. https://ofac.treasury.gov/recent-actions/20100830.

407 Risk Advisory, "North Korea Sanctions List," last accessed April 4, 2024. https://www.riskadvisory.com/sanctions/north-korea-sanctions-list/?page=3.

408 "북한 핵개발 총책 홍승무, 상장->대장 진급" [Hong Sung-mu, Head of N. Korea's Nuclear Weapons Program, Promoted to General], *Yonhap News*, September 7, 2017. https://www.yna.co.kr/view/MYH20170907006600038.

409 U.S. Senate Committee on Foreign Relations, *North Korea: Status Report on Nuclear Program, Humanitarian Issues, and Economic Reforms*.

410 Ibid.

411 Ibid.

412 "안보리, 北核 인물 제재 7-8명 사실상 합의" [UN Security Council Close to Consensus on 7–8 Individuals in N. Korea's Nuclear Program to Place on Sanctions List], *Yonhap News*, July 16, 2009. https://www.yna.co.kr/view/AKR20090716035800072.

413 Kim, "North Korea's Artificial Intelligence Research," Appendix II.

Other Key Personnel in North Korea's WMD Program

Choi Chun-sik (최춘식, 1954–) is the former Director of the Second Academy of Natural Sciences. He was presented with the Order of Hero of the Republic in 2012. Choi is believed to have played an important role in developing North Korea's long-range ballistic missiles.[414]

Chon Byong-ho (전병호) built his career in the munitions industry, retiring as the KWP Secretary for the Munitions Industry in 2012. Chon played an instrumental role in advancing North Korea's nuclear program by overseeing the acquisition of equipment and technology from Pakistan. He was not trained as a nuclear scientist or engineer, however. Chon died in 2014.[415]

Hong Sung-mu (홍승무) is a First Vice-Director in the KWP MID. In this capacity, he has working-level oversight of North Korea's nuclear and ballistic missile programs. He can be seen in North Korean media reports accompanying Kim Jong-un to testing and manufacturing sites. Hong has experience in the "production and manufacturing side" of North Korea's military and munitions industries, and he was also the former chief engineer at the 5Mwe reactor at Yongbyon.[416] Hong is a Member of the KWP Central Committee and the 14th SPA.[417]

Paek Se-bong (백세봉, 1938–) served as the Chair of the Second Economic Committee (SEC). In this role, he was responsible for overseeing the development of munitions and military equipment, including nuclear weapons and missiles. He is believed to have assumed this role in 2003.[418] He was appointed a three-star general in the KPA in February 2012,[419] and it was reported that he stepped down from the SEC around 2015.[420]

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414 Republic of Korea Ministry of Unification, "최춘식" [Choi Chun-sik], *North Korea Information Portal*, accessed April 30, 2024. https://nkinfo.unikorea.go.kr/nkp/prsn/view.do;jsessionid=qhhBZn5gqmwvAujV5LU5vFd-SiA16gOxtBTTlOsO3.ins22?menuId=PEOPLE_86&prsnMngNo=24341; Kang Mi-jin, "북한 장거리 미사일 개발 주역 최춘식은 중장" [Choi Chun-sik, Key to N. Korea's Long-Range Missile Development, is Major General], *Daily NK*, September 12, 2013. https://www.dailynk.com/%EB%B6%81%ED%95%9C-%EC%9E%A5%EA%B1%B0%EB%A6%AC-%EB%AF%B8%EC%82%AC%EC%9D%BC-%EA%B0%9C%EB%B0%9C-%EC%A3%BC%EC%97%AD-%EC%B5%9C%EC%B6%98/.

415 Kim Joo-won, "핵무기 개발과 전병호" [Nuclear Weapons Development and Chon Byong-ho], *RFA*, January 31, 2017. https://www.rfa.org/korean/weekly_program/ae40c528c77cac00c758-c228aca8c9c4-c9c4c2e4/hidden-truth-01312017095418.html.

416 Michael Madden, "Hong Sung Mu," *North Korea Leadership Watch*, April 9, 2016. https://nkleadershipwatch.wordpress.com/leadership-biographies/hong-sung-mu/.

417 Republic of Korea Ministry of Unification, *North Korea's Key Personnel: 2023*, 1063–64.

418 "北 군수전담 제2경제위원장은 백세봉 국방위원" [Chair of Second Economic Committee, Responsible for Munitions, is National Defense Commission Member Paek Se-bong], *Yonhap News*, January 13, 2008. https://www.yna.co.kr/view/AKR20080111148100014.

419 Republic of Korea Ministry of Unification, "Paek Se-bong."

420 Choi Won-gi, "2015 북한의 뜬 별과 진 별: '김여정 뜨고 최룡해 혁명화'" [Who Rose and Fell in N. Korea in 2015], *VOA*, December 5, 2015. https://www.voakorea.com/a/3088086.html.

Pak To-chun (박도춘) succeeded **Chon Byong-ho** as the KWP Secretary for Munitions Industry, exercising political oversight of North Korea's nuclear and missile programs. North Korea's state media reported in 2022 that he had been buried at the Patriotic Martyrs' Cemetery, but it is unclear when he died.[421] He previously served as the Jagang Province Party Committee Chairman from 2005 to 2010.[422] The province is known for having a high concentration of North Korea's munitions factories. He was appointed a four-star general in February 2012.[423]

Yun Ho-jin (윤호진, 1944–) was sanctioned by the UN Security Council in 2009 for his role in importing equipment necessary for North Korea's uranium enrichment program as the Director of the Namchongang Trading Corporation.[424] Together with **Chon Byong-ho,** Yun "played leading roles in North Korea's development and testing of atomic weapons."[425] Yun served as North Korea's representative to the IAEA and was directly involved in Pyongyang's discussions with the IAEA in the early 1990s. A German businessman was convicted in 2003 for "selling 22 metric tons of aluminum tubes" to Yun.[426] According to escapee testimony, Yun married Chon Byong-ho's second daughter and also facilitated negotiations with Syria regarding the construction of nuclear facilities.[427]

421 Park Soo-yoon, "북, '핵 원로' 박도춘·사업가 신남철 애국열사릉에 안장" [Nuclear Leader Pak To-chun and Businessman Sin Nam-chol Buried in Patriotic Martyrs' Cemetery], *Yonhap News*, September 2, 2022. https://www.yna.co.kr/view/AKR20220902018500504.

422 Republic of Korea Ministry of Unification, "박도춘" [Pak To-chun], *North Korea Information Portal*, accessed April 17, 2023. https://nkinfo.unikorea.go.kr/nkp/prsn/view.do?menuId=PEOPLE_86&prsnMngNo=7443&prsnMngNo=7443.

423 Ibid.

424 UN Security Council, "Yun Ho-Jin," October 29, 2014. https://www.un.org/securitycouncil/sanctions/1718/materials/summaries/individual/yun-ho-jin.

425 Jay Solomon, "North Korean Pair Viewed as Key to Secret Arms Trade," *The Wall Street Journal*, August 31, 2010. https://www.wsj.com/articles/SB10001424052748704741904575409940288714852.

426 Ibid.

427 Kim Joo-won, "전병호의 사위 윤호진" [Yun Ho-jin, Chon Byong-ho's son-in-law], *RFA*, February 7, 2017.https://www.rfa.org/korean/weekly_program/ae40c528c77cac00c758-c228aca8c9c4-c9c4c2e4/co-su-02072017082918.html.

ANNEX 2: NORTH KOREAN NUCLEAR SCIENTIST REPORTS

The list below shows the title of scholarly publications by North Korean scientists and their respective authors, as printed by the Science and Technology Publishing House between 1986 and 2013. Some of these individuals may be connected to the nuclear weapons program. The repetition of titles indicates collaboration.[428]

Name (ENG)	Name (KOR)	Title of Publication
(Titles printed 10 February 2013)		
Kim Jong-ho	김정호	Estimation of Standard Quartz Clock Frequency Stability by Using GPS Time Comparisons
Bak Kyong-il	박경일	Estimation of Standard Quartz Clock Frequency Stability by Using GPS Time Comparisons
Song Hak-jin	송학진	Creep Life Prediction of Steam Tube Materials for Power Plants
Jong Mun-chan	정문찬	Creep Life Prediction of Steam Tube Materials for Power Plants
Ri Il-myong	리일명	Chaos in an Array with Two Josephson Junctions
Kim Ha	김하	Chaos in an Array with Two Josephson Junctions
Kim Won-il	김원일	Distribution of Y2BaCuO5 (211) Particles with Power Melting Process
Hong Song-chol	홍성철	Distribution of Y2BaCuO5 (211) Particles with Power Melting Process
Tong Kum-chol	동금철	Physical Process of High Speed Turn-on Thyristor with Polycell Complex Structure
Li Hyo-myong	리효명	Physical Process of High Speed Turn-on Thyristor with Polycell Complex Structure
Ho Jin-ju	허진주	Finite Element Analysis Using Domain-Specific Language
An Yong-jun	안영준	Finite Element Analysis Using Domain-Specific Language
Ju Gum-ok	주금옥	Study on Spin-Polarized Transport in Ferromagnetic Ni Nanocontact by Non-Equillibrium Green's Function Method
Ri Kuk-chol	리국철	Study on Spin-Polarized Transport in Ferromagnetic Ni Nanocontact by Non-Equillibrium Green's Function Method
Jin Hak-son	진학선	End Processing of MAEAM Model Potentials, Making Model Parameters Precise and Calculating Phonon Dispersion for FCC Metals
Pang Myong-il	방명일	End Processing of MAEAM Model Potentials, Making Model Parameters Precise and Calculating Phonon Dispersion for FCC Metals
Cha Kuk-chol	차국철	Dynamical Mean-Field Theory of Effect of Electron-Phonon Interaction on Quasiparticle Effective Mass Near the Mott Transition
O Song-jin	오성진	Dynamical Mean-Field Theory of Effect of Electron-Phonon Interaction on Quasiparticle Effective Mass Near the Mott Transition
Kang Myong-jin	강명진	A Calibration Method for the Noncontact Shape Measurement
Pak Yong-su	박용수	A Calibration Method for the Noncontact Shape Measurement
Ri Kang-hyon	리강현	Thermionic Emission and Tunneling Effect of Carrier at Grain Boundary in Degenerate Polycrystalline Semi-Conducting Films
Kim Jun	김준	Thermionic Emission and Tunneling Effect of Carrier at Grain Boundary in Degenerate Polycrystalline Semi-Conducting Films
Jang Yong-song	장영성	Study on Polarization Property of TEM00Mode in He-Ne Laser with Inter-Cavity
Kim U-hyon	김우현	Study on Polarization Property of TEM00Mode in He-Ne Laser with Inter-Cavity

428 The romanization of names was not included in the source. It is provided here for ease of reference and pronunciation.

Kim Hyong-gil	김형길	Study on Polarization Property of TEM00Mode in He-Ne Laser with Inter-Cavity
Choe Kyon-gon	최견건	Research on Photograph Image in Laser Engraving with Optical Structure Layers
Kim Hun	김훈	Manufacture of Microlenses Formed on a Glass Plate by Using CO2 Laser
Ri Jun-yong	리준영	Manufacture of Microlenses Formed on a Glass Plate by Using CO2 Laser
(Titles printed 15 May 2013)		
Kim Kum-yong	김금용	Fast Cosine Fitting for Analysis of Fizeau Interference Fringe
Kim Cheol-woon	김철운	Effect of Emission ray Irradiation on Reverse Current and Reverse Breakdown Voltage of Semiconductor Junction
Kim Hyang-song	김향성	Improvement of Stability of pn Junction to Ionization Radiation Ray by Electron Beam Irradiation
Kim Won-hyok	김원혁	Weight Loss of Nano SiO2/Pentaphthal Vanish Composites by Thermal Aging
Han Seung-won	한승원	Weight Loss of Nano SiO2/Pentaphthal Vanish Composites by Thermal Aging
Jung Gwang-chol	정광철	Weight Loss of Nano SiO2/Pentaphthal Vanish Composites by Thermal Aging
Cha Soo-rim	차수림	Study on Matter-Antimatter Asymmetry in Framework of f(R)~Rn Gravity
Kang Jin-u	강진우	Study on Matter-Antimatter Asymmetry in Framework of f(R)~Rn Gravity
An Joo-seong	안주성	Growth of SiC One Dimension Nanocables Using PolyCrystal Silicon Powder
Kim Ryong-jin	김룡진	Growth of SiC One Dimension Nanocables Using PolyCrystal Silicon Powder
Choi Sam-hyuk	최삼혁	Growth of SiC One Dimension Nanocables Using PolyCrystal Silicon Powder
Pak Hyok-chol	박혁철	A Difference Scheme for Solar Dynamo Equation Using ADI Method
Kim Chol-jun	김철준	A Difference Scheme for Solar Dynamo Equation Using ADI Method
Pak Nam-il	박남일	Numerical Simulation of Phase Transformation and Microstructural Evolution During Liquid Phase Sintering
Kim Jong-chol	김정철	Numerical Simulation of Phase Transformation and Microstructural Evolution During Liquid Phase Sintering
Kwon Yong-hyok	권영혁	Detection of Carotenoid Antioxidant in Human Tissue Applying Shifted Excitation Resonance Raman Difference Spectroscopy
Ri Jong-hyok	리종혁	Detection of Carotenoid Antioxidant in Human Tissue Applying Shifted Excitation Resonance Raman Difference Spectroscopy
Song Hak-jin	송학진	Study on Isothermal and Thermocycling Creep Behavior of AlSi7 and AlSi18 Alloys
Jung Mun-chan	정문찬	Study on Isothermal and Thermocycling Creep Behavior of AlSi7 and AlSi18 Alloys
Yeo Hyon-chol	여현철	Study on Isothermal and Thermocycling Creep Behavior of AlSi7 and AlSi18 Alloys
Choi Won-gil	최원길	Investigation of Several Factors to Growth of ZnO Nanowires by Vertical Growth Method
Heo Yeong-min	허영민	Investigation of Several Factors to Growth of ZnO Nanowires by Vertical Growth Method
(Titles printed 10 February 2012)		
Hong Ryong-mun	홍룡문	Propagation of Strong Divergent Shock Wave in a-Dimension
Ri Chung-hyon	리충현	Propagation of Strong Divergent Shock Wave in a-Dimension
Ryu Pak-in	류박인	Propagation of Strong Divergent Shock Wave in a-Dimension
Ri Su-bok	리수복	Superconductivity Enhanced by Antifferromagnetic Spin Fluctuation and d-Density Wave
Ju Nam-chol	주남철	Superconductivity Enhanced by Antifferromagnetic Spin Fluctuation and d-Density Wave
Kim Ha	김하	Superconductivity Enhanced by Antifferromagnetic Spin Fluctuation and d-Density Wave
Kim Song-jin	김성진	Aberration Suppressing Method in Digital Holographic Microscopy by Numerical Process
Ri Jun-ho	리준호	Aberration Suppressing Method in Digital Holographic Microscopy by Numerical Process
Wi Chol-min	위철민	Measurement of Fluid Velocity by Using CCD Camera

Choi Il-su	최일수	Measurement of Fluid Velocity by Using CCD Camera
Kim Won-kyu	김원규	Dispersion of Photon Counting Data According Gate Time in Photon Correlation Spectroscopy
Pak Dong-hyon	박동현	Dispersion of Photon Counting Data According Gate Time in Photon Correlation Spectroscopy
Ri Chol-guk	리철국	Analysis of Acoustic Insertion Loss for Exhaust Muffler with Perforated Pipe and Plate
Kim Kyong-gi	김경기	Analysis of Acoustic Insertion Loss for Exhaust Muffler with Perforated Pipe and Plate
Ryu Kyong-il	류경일	Relation of Operation Deep and Transmission Frequency in Underwater Acoustic Log
Heo Seong	허성	Relation of Operation Deep and Transmission Frequency in Underwater Acoustic Log
Im Il-bin	임일빈	Redistribution of Impurity Concentration in Contact Face between Metal-Semiconductor with Double Diffusion Guard Ring Structure
Ri Min-won	리민원	Redistribution of Impurity Concentration in Contact Face between Metal-Semiconductor with Double Diffusion Guard Ring Structure
Pak Hak-gyong	박학경	Temperature Controlling Regime of Initial Crystal Growth Step in KTP Single Crystal Growth by TSSG
Chang Jae-sik	장재식	Temperature Controlling Regime of Initial Crystal Growth Step in KTP Single Crystal Growth by TSSG
Han Ryong-un	한룡운	Dependence of Derivative Specific Conductance on Magnetic Field in Quantum Dot Connected with Electrode of Magnetic Impurity
Kang Chol-jin	강철진	Dependence of Derivative Specific Conductance on Magnetic Field in Quantum Dot Connected with Electrode of Magnetic Impurity
Pak Yong-jin	박영진	Theoretical Analysis of Transient Process of Hydrogen Sorption Curve for Rare-Earth Alloy of Nd Series
Ri Yong-sop	리영섭	Mechanism of Cubic Boron Nitride Crystallization under Superhigh Pressure and High Temperature
Kim Su-gon	김수건	Mechanism of Cubic Boron Nitride Crystallization under Superhigh Pressure and High Temperature
(Titles printed 20 May 2012)		
Hong Ryong-mun	홍룡문	Propagation of Strong Imploding Shock Wave in a-Dimension
Ri Chung-hyon	리충현	Propagation of Strong Imploding Shock Wave in a-Dimension
Ryu Pak-in	류박인	Propagation of Strong Imploding Shock Wave in a-Dimension
Choi Hyon-chol	최현철	A First-Principle Method to Study Electron Transport Properties of Molecular Single-Electron Transistors
Kim Nam-hyok	김남혁	A First-Principle Method to Study Electron Transport Properties of Molecular Single-Electron Transistors
Kim Song-nam	김성남	Multicanonical Monte Carlo Algorithm and Structural Characteristics of Ala10 Polypeptide
Kim Yong-jin	김영진	Multicanonical Monte Carlo Algorithm and Structural Characteristics of Ala10 Polypeptide
Yeom Mun-chol	염문철	DPD Simulation using LAMMPS
Rim Ho-yong	림호영	DPD Simulation using LAMMPS
Um Chol-nam	엄철남	Implementation of Multiple Sources Localization by Hydrophone Linear Array
Nam Hyok-jin	남혁진	Application of FxLMS Algorithm for Active Noise Control
Kang Hyon-chol	강현철	Application of FxLMS Algorithm for Active Noise Control
Pak Seung-kyu	박승규	Effect of Nickel Impurities Affecting on Antiferromagnetic Nell Temperature
Kim Jong-yon	김정연	Effect of Nickel Impurities Affecting on Antiferromagnetic Nell Temperature
Chung Won-min	정원민	Numerical Simulation of Microstructural Evolution during Sintering of Silicon Nitride

Kim Jong-chol	김정철	Numerical Simulation of Microstructural Evolution during Sintering of Silicon Nitride
Ri Su-bok	리수복	DSC Orderparameter in Pseudogap Phase
Kim Ha	김하	DSC Orderparameter in Pseudogap Phase
Chung Un-ki	정은기	Maximally Localized Wannier Fundtion of Superconductor LaOFeAs and Calculation of Hubbard Model Parameters
Yoo Chol-jun	유철준	Maximally Localized Wannier Fundtion of Superconductor LaOFeAs and Calculation of Hubbard Model Parameters
Ri Yong-sop	리영섭	Nucleation of Cubic Boron Nitride in Presence of Mg-Al Alloy Catalyst under High Pressure and High Temperature
Kim Soo-gon	김수건	Nucleation of Cubic Boron Nitride in Presence of Mg-Al Alloy Catalyst under High Pressure and High Temperature
Choi Chol-su	최철수	Influence of Crystallographic Characteristics of Hexagonal Boron Nitride on Strength of Color Resin Pencil Core
Han Ok-son	한옥선	Influence of Crystallographic Characteristics of Hexagonal Boron Nitride on Strength of Color Resin Pencil Core
Cha Sang-jun	차상준	Influence of Crystallographic Characteristics of Hexagonal Boron Nitride on Strength of Color Resin Pencil Core
Sin Yong-je	신영제	Method for Eliminating Edge Effects of Capacitive Sensor for Micro Displacement Measurement
Kwon Chol-ho	권철호	Method for Eliminating Edge Effects of Capacitive Sensor for Micro Displacement Measurement
Chung Un-son	정은선	Study on Invariant Vectors's Set of L-Group
Kim Sung-won	김성원	Study on Invariant Vectors's Set of L-Group
(Titles printed 20 August 2012)		
Kwon Yong-nam	권영남	Analysis of Membrane Breakdown of Neuronal Cells in Nonuniform Electric Field Using Finite Element Method
Kim Yong-jin	김영진	Analysis of Membrane Breakdown of Neuronal Cells in Nonuniform Electric Field Using Finite Element Method
Bang Un-hyok	방은혁	GW Method for Calculation Screened Coulomb Interaction by Using only Occupied Electronic State
Pak Myong-chol	박명철	GW Method for Calculation Screened Coulomb Interaction by Using only Occupied Electronic State
Ri Jang-hun	리장훈	Estimating Chaotic Character of System Using CM Method
Choi Gyong-hyok	최경혁	Estimating Chaotic Character of System Using CM Method
Han Ryong-chol	한룡철	Research on Interface Electrical Property of Carbon Nanoparticle and Its Action in Lead Battery
Choi Hee-ung	최희웅	Research on Interface Electrical Property of Carbon Nanoparticle and Its Action in Lead Battery
Choi Sung-hyok	최성혁	Measurement of Sub-Pixel Displacement in Digital Image Correlation
Kim Won-do	김원도	Measurement of Sub-Pixel Displacement in Digital Image Correlation
Kim Gwang-il	김광일	Influence of Various Parameters for Output Character in SBS Cell
Kim Joo-song	김주성	Accounting for Photoresponse Nonuniformity of Ultra-Violet CCD in Spectrum Study
Choi Il-su	최일수	Accounting for Photoresponse Nonuniformity of Ultra-Violet CCD in Spectrum Study
Kim Se-nam	김세남	Luminescent Properties and Long Afterglow Characteristic of Y2O2S:EEu3+, Mg2+, Ti1+ Phosphor

Ri Su-hyon	리수현	Luminescent Properties and Long Afterglow Characteristic of Y2O2S:EEu3+, Mg2+, Ti1+ Phosphor
Choi Yong-chol	최용철	Luminescent Properties and Long Afterglow Characteristic of Y2O2S:EEu3+, Mg2+, Ti1+ Phosphor
Pak Yong-myong	박영명	Preparation of a Long-Afterglow Phosphor and Spectroscopic Characterization
Hwang Chan-sung	황찬성	Preparation of a Long-Afterglow Phosphor and Spectroscopic Characterization
Kim Jung-hak	김정학	Quality Improvement of 5.1 Stereosonics Reproduction
Hwang Un-ha	황운하	Quality Improvement of 5.1 Stereosonics Reproduction
Seo Dae-sung	서대성	Investigation of Isoscalar-Factors by Eigenvalue of Casimir Operator and One-Photon f-f Transition
Choi Chang-nam	최창남	Optimal Size of Fluorescent Organic Glass Plate in Silica-Photo-Cell Structure to Detect Visible Light
Kim Yong-bin	김영빈	Optimal Size of Fluorescent Organic Glass Plate in Silica-Photo-Cell Structure to Detect Visible Light
(Titles printed 20 November 2012)		
Choi Kyong-jin	최경진	Influence of Spin-Orbit Interaction on Band Structure in Two-Dimensional Electron System interacting with Screened Coulomb Interaction
Kim Ha	김하	Influence of Spin-Orbit Interaction on Band Structure in Two-Dimensional Electron System interacting with Screened Coulomb Interaction
Ri Chang-won	리창원	Watermarking of Printing Materials Based on Holographic Principle
Kim Chol-su	김철수	Watermarking of Printing Materials Based on Holographic Principle
Ri Kyong-il	리경일	Study on Development of Profile of XP8843 Resist by using ATHENA/OPTOLIT
Ri Son-guk	리선국	Study on Development of Profile of XP8843 Resist by using ATHENA/OPTOLIT
Han Soon-ok	한순옥	Modification of Multi-Walled Carbon Nanotubes by Dielectric Barrier Discharge
Hong Hyon-gil	홍현길	Modification of Multi-Walled Carbon Nanotubes by Dielectric Barrier Discharge
Kim Won-soon	김원순	Modification of Multi-Walled Carbon Nanotubes by Dielectric Barrier Discharge
Kim Su-rim	김수림	Method of Plating on a Diamond Powder by the Centrifugal Stirring
Kim Ho-nam	김호남	Method of Plating on a Diamond Powder by the Centrifugal Stirring
Kim Kwang-hyon	김광현	Ultrafast Nonlinear Optical Response of Metal-Dielectric Nanocomposites
Sin Jun-sik	신준식	Investigation on Limitations of the WKB Approximation in the Field Emission Theory
Choi Hyon-chol	최현철	Investigation on Limitations of the WKB Approximation in the Field Emission Theory
Ri Chung-su	리정수	Study on Improvement of Mechanical Intensity of PZT Ceramics by Nanocompounding
Pak Myong-chol	박명철	New Discrete Method for Calculating Delectric Tensor and Born Effective Charge Tensor in Electric Field by Using Berry Phase and Gauge Invariance
Ma Kwang-jin	마광진	Study on Using of Fabry-Perot etalon for Choice of Laser Longitudinal Mode
Kim U-hyon	김우현	Study on Using of Fabry-Perot etalon for Choice of Laser Longitudinal Mode
Ri Chol-won	리철원	Study of One Method for Taking Account of Frequency Depedence of Two-Particle Vertex in Non-Equilbrium Functional Renormalization Group Method
Chung Kum-hyok	정금혁	Study of One Method for Taking Account of Frequency Depedence of Two-Particle Vertex in Non-Equilbrium Functional Renormalization Group Method
Mun Sang-hyok	문상혁	Study on Manufacture of Boron Nitride Nano Tube and Its Character
Han Nam-su	한남수	Study on Manufacture of Boron Nitride Nano Tube and Its Character
Chung Myong-guk	정명국	Study on Influence of Aperture and Pixel Sampling of CCD to Reconstruction Image of Digital Hologram

Ri Jun-ho	리준호	Study on Influence of Aperture and Pixel Sampling of CCD to Reconstruction Image of Digital Hologram
(Titles printed 20 February 2011)		
Ri Jong-hyok	리종혁	Expressions of Spin Probability Partial Function in Classical Ising Model
Kim Ri-hun	김리훈	Estimation of Errors of Measuring the Absorption Coefficient Due to Deviation of the Starting Point of Signal Recording Time, When Measuring the Absorption in Kundt Tube with Single Microphone
Won Kyong-su	원경수	Estimation of Errors of Measuring the Absorption Coefficient Due to Deviation of the Starting Point of Signal Recording Time, When Measuring the Absorption in Kundt Tube with Single Microphone
Ri Chol-hyok	리철혁	Calculation of Short Range Order Parameters of Binary Alloys by Monte Carlo Method
Ryang Se-hun	량세훈	Calculation of Short Range Order Parameters of Binary Alloys by Monte Carlo Method
Kang Dong-hun	강동훈	Analytic Method for Radiativity in Two-Components (SiC-Si3N4) Series Far-Infrared-Radiative Coating in Dependent with the Component Ratio
Kim Yoo-yong	김유영	Analytic Method for Radiativity in Two-Components (SiC-Si3N4) Series Far-Infrared-Radiative Coating in Dependent with the Component Ratio
Kim Yong-chun	김영춘	Analytic Method for Radiativity in Two-Components (SiC-Si3N4) Series Far-Infrared-Radiative Coating in Dependent with the Component Ratio
Choi Yong-su	최영수	Crystal Structure of Li2B4O7 by Powder X-Ray Diffraction
Kim Gwang-hyok	김광혁	A Method for the Ultrafast Quantum Kinetical Coulomb Potential Screening
Choi U-il	최우일	The investigation of correlation functions in the normal metal/superconductor junction
Yun Il-jin	윤일진	Properties of wBN-based super hard sintered composite with diamond inclusions
Han Ok-sun	한옥선	Properties of wBN-based super hard sintered composite with diamond inclusions
Kim Sung-gol	김성걸	Influence of the heat treatment regime of the powders on the production of Mn-Zn ferrites
Ju Se-il	주세일	Influence of the heat treatment regime of the powders on the production of Mn-Zn ferrites
Kan Hyong-nam	간형남	Research on manufacturing and characteristics of silicon semiconductor temperature sensor by using p-type diffusion resistant
Kim Kyong-gi	김경기	Research on manufacturing and characteristics of silicon semiconductor temperature sensor by using p-type diffusion resistant
Pyon Kwang-jin	변광진	Study on measurement of atomic emission spectrum and data processing method
Chon Kyong-ho	전경호	Theoretical study on the characterize of phase transition in Pd1-xCaxTiO3 solid solution
Kim Il-hwan	김일환	Theoretical study on the characterize of phase transition in Pd1-xCaxTiO3 solid solution
Pak Sung-deok	박성덕	Study on capacitance of the Piezoelectric hollow sphere transducer
Ryeo In-gwang	려인광	Study on capacitance of the Piezoelectric hollow sphere transducer
Choi Yong-chol	최영철	Collective variable theory of electron-Plasmon-Phonon System
Chang Hyon-il	장현일	Study on complex mode superposition method
Yun Song-won	윤성원	Study on complex mode superposition method
An Chung-hun	안정훈	Spin Reorientation theory in ultra-thin ferromagnetic films, using generalized Callen Approximation
Yun Chol-song	윤철송	Spin Reorientation theory in ultra-thin ferromagnetic films, using generalized Callen Approximation
Ryu Ryong-hyok	류룡혁	Numerical research on scattering characteristics of the acoustic wave by dummy head
Won Kyong-su	원경수	Numerical research on scattering characteristics of the acoustic wave by dummy head

(Titles printed 20 May 2011)		
Kim Ha	김하	High-temperature superconductivity induced by the feedback of antiferromagnetic spin fluctuation and d-charge density
Ri Su-bok	리수복	High-temperature superconductivity induced by the feedback of antiferromagnetic spin fluctuation and d-charge density
Son Song-il	손성일	Synthesis of SiC one-dimensional nanostructure by pyrolysis of ethanol
Kim Kum-hyok	김금혁	A method for data modeling of flicker fluctuation
Yun Hyon-il	윤현일	Prediction of the transmission loss in expansion muffler by using ANSYS
Oh Sung-jin	오성진	fRG study of magnetic and superconducting instabilities in the high-Tc Cuprates
Cha Chung-jik	차충직	Study on the effect of permutation of Sr on the microwave dielectric properties of BaTiO3 system ferroelectric
Chung Ju-hyok	정주혁	Manufacture of two-dimensional flexible hinges nanopositioning stage and study on its characteristics
Kwon Chol-ho	권철호	Manufacture of two-dimensional flexible hinges nanopositioning stage and study on its characteristics
Kim Song-chol	김성철	Vibration characteristic of the piezoceramic disk by AC impulse
Ri Kyong-chol	리경철	Vibration characteristic of the piezoceramic disk by AC impulse
Ryang Ryong-mo	량룡모	Geometric optical consideration on the misalignment characters versus the curvature radius of tumed reflectors at a folder resonator
Kim Rye-chol	김례철	Study on recrystallization property of Cu-Fe-Ni alloy
Cha Sang-jun	차상준	Study on recrystallization property of Cu-Fe-Ni alloy
Kim Yong-song	김용성	The effect of Sn on the properties of (V1-xCrx)2O3 Series thermistor
Yun Sung-ok	윤성옥	The effect of Sn on the properties of (V1-xCrx)2O3 Series thermistor
Hwang Chan-ki	황찬기	The effect of Sn on the properties of (V1-xCrx)2O3 Series thermistor
Kim Ri-hun	김리훈	Turbulent effect of sound field due to mounting the microphone in Kundt tube
Won Kyong-su	원경수	Turbulent effect of sound field due to mounting the microphone in Kundt tube
Ri Chol-nam	리철남	Study on the electron transport in quantum dots coupled to normal metal and superconductor leads
Ri Guk-chol	리국철	Study on the electron transport in quantum dots coupled to normal metal and superconductor leads
Mun Ri-hyon	문리현	Evaluation of equivalent circuit of low frequency underwater acoustic sensor composed of three vibrometer
Chang Pyong-nam	장평남	The evaluation of accuracy in Situ measurement of absorption coefficients of materials using two microphones
Won Kyong-su	원경수	The evaluation of accuracy in Situ measurement of absorption coefficients of materials using two microphones
Pyon Sung-jin	변성진	Study on the G0W0 algorithm combined with all-electron calculation method of DFT
Kim Nam-hyok	김남혁	Study on the G0W0 algorithm combined with all-electron calculation method of DFT
Kim Hak-chol	김학철	Study on the Amplification Process of Laser impulse with the time shorter than longitudinal relaxation time
Kim U-hyon	김우현	Study on the Amplification Process of Laser impulse with the time shorter than longitudinal relaxation time
An Kyong-il	안경일	The theoretical research of a focalizing limit of the plane wave
Kim Seung-hyok	김승혁	The influence of the input density on the generated power of the cross flow type CO2 laser and the stabilization of the generated

Kim U-hyon	김우현	The influence of the input density on the generated power of the cross flow type CO2 laser and the stabilization of the generated
Chon Sin-hyok	전신혁	A method of first-principles calculation for the exchange interaction energy of many-electron system
Jung Chol	정철	A method of first-principles calculation for the exchange interaction energy of many-electron system
Ri Kyong-chol	리경철	Study on the Careen Angle and quality improvement of receive property in the depth measurement
Kim Kye-chil	김계칠	Study on the Careen Angle and quality improvement of receive property in the depth measurement
Mun Kyong-mi	문경미	MHD research on plasma focus phenomena
Choi Yun-sik	최윤식	MHD research on plasma focus phenomena
(Titles printed 20 August 2011)		
Kang Seung-ho	강승호	Study of the Magnetization Characteristic of the semi-hard magnetic material in the low magnetic field
Choi Chang-ho	최창호	Study of the Magnetization Characteristic of the semi-hard magnetic material in the low magnetic field
Chang Yeo-guk	장여국	Study of the Magnetization Characteristic of the semi-hard magnetic material in the low magnetic field
Cho Hong-chol	조홍철	Analysis of fast turn-on process of the semiconductor pn-Junction and improvement of the characteristics
Kim Kyong-gi	김경기	Analysis of fast turn-on process of the semiconductor pn-Junction and improvement of the characteristics
Kwon O-sung	권오성	Crystalline particle size of precipitation in preparation of ZrO2 nano powder in the heating process of alcohol aqueous solution
Chung Kum-hyok	정금혁	Study on the relation between green's function and vertex function in non-equilibrium functional Keldysh formalism
Ri Chol-won	리철원	Study on the relation between green's function and vertex function in non-equilibrium functional Keldysh formalism
Sin Ho-seok	신호석	Calculation of wave field for computer generated rainbow hologram (CGRH) by region partition method
Choi Yong-hun	최영훈	Calculation of wave field for computer generated rainbow hologram (CGRH) by region partition method
Ri Song-chol	리성철	Influence of sintering temperature on magnetization and room-temperature magnetoresistance of double Perovskite Sr2FeMoO6
Kim Yong-sik	김영식	Study on the magnetic properties of nanocrystal a-Fe(Si) by Using Ab-initio molecular dynamics
Yun Song-guk	윤성국	Study on the magnetic properties of nanocrystal a-Fe(Si) by Using Ab-initio molecular dynamics
Ju Hye-song	주혜성	Study on the magnetic properties of nanocrystal a-Fe(Si) by Using Ab-initio molecular dynamics
Sin Kwang-seok	신광석	Analysis of the non-equilibrium phase transition phenomenon due to external fluctuations field by using fractional Fokker
Pak Song-jin	박성진	A research on the weak signal detection in nonlinear oscillating system
Hong Sun-chol	홍순철	A research on the weak signal detection in nonlinear oscillating system
Kim Ryong-jin	김룡진	The synthesis of SiC-SiO2 nanocables decorated with C nanoparticles and investigation of the Raman and PL characteristics

Son Sung-il	손성일	The synthesis of SiC-SiO2 nanocables decorated with C nanoparticles and investigation of the Raman and PL characteristics
Yang Il-hyun	양일현	New method of detecting wave shape in digitalizing the seismic signal
Jung Chol	정철	New regularization method for the calculation of one-loop scattering amplitude of open strings in type IIB orientifold string theory
Kang Jin-u	강진우	New regularization method for the calculation of one-loop scattering amplitude of open strings in type IIB orientifold string theory
Hong Bok-nam	홍복남	Synthesis of nano-scale ZnO powder by low temperature combustion
Kim Jung-soo	김정수	Synthesis of nano-scale ZnO powder by low temperature combustion
Seo Chol	서철	Simulation and design of parameters for surge current generator circuit
Mun Chol-ho	문철호	Simulation and design of parameters for surge current generator circuit
Sin Nam-chol	신남철	Study on image blurring by holographic plate shift in the emulsion superposition reflection holography
Choi Yong-hun	최영훈	Study on image blurring by holographic plate shift in the emulsion superposition reflection holography
Chang Pyong-nam	장평남	Study on the error limit in measurement of sound absorption measuring device in-Situ
Won Kyong-su	원경수	Study on the error limit in measurement of sound absorption measuring device in-Situ
Choi Sin-hyok	최신혁	Study on the Grain Size distribution character of WC-Co nano composite powder by made of planet ball milling
Chang Jae-sik	장재식	Study on the Grain Size distribution character of WC-Co nano composite powder by made of planet ball milling
Kwak Chong-il	곽청일	Study on hybrid continuum and molecular dynamics simulation system
Ri Un-hee	리은희	Study on the 3-dimensional shape measurement by extraction of projected knife-edge on continuous wavelet transformation
Kim Chol-su	김철수	Study on the 3-dimensional shape measurement by extraction of projected knife-edge on continuous wavelet transformation
Heo Yong-min	허영민	Field Emission property of CNT-ZnO nanomaterial
Ryang Ryu-chol	량류철	Effect of some factors on the characteristics of thermoelectromotive force of YBCO film
Kim Su-yong	김수영	Effect of some factors on the characteristics of thermoelectromotive force of YBCO film
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Ri Sang-ryol	리상렬	*Ab initio* Study of Growth Mechanisms at Wurtzite GaN (0001) Surface
Ri Guk-sop	리국섭	Dimerized Phase in Frustrated Spin Ladder Model
Heo Chol-ju	허철주	Kondo Effect in Electronic Transport through a QD taking account of electron-phonon interaction when AC bias is applied
Ri Guk-chol	리국철	Kondo Effect in Electronic Transport through a QD taking account of electron-phonon interaction when AC bias is applied
Kim Kyong-hwa	김경화	Determination of permittivity in linear absorbing dielectrics using microscopic approach
Kim Tae-hyok	김태혁	Determination of permittivity in linear absorbing dielectrics using microscopic approach
Ji Song-il	지성일	Evaporation characteristics of ZnO-TiO2-La2O3 composite powder in atmospheric DC arc plasma flow
Kim Ju-hyok	김주혁	Film formation process based on Stochastic processes and film structure
Choi Chang-ho	최창호	Film formation process based on Stochastic processes and film structure
Ri Chung-song	리청송	A robust reconstruction method of super-resolution
Kang Yong-rim	강영림	A robust reconstruction method of super-resolution

Kim Un-chol	김은철	Calculation of TM010 mode microwave cylindrical resonator for excitation of longitudinal discharge CO2 laser
Ri Chang-soon	리장순	Calculation of TM010 mode microwave cylindrical resonator for excitation of longitudinal discharge CO2 laser
Kang Ho-nam	강호남	A method of determining length of divided anode plate along to gas flow in transverse flow CO2 laser with tube-plate electrodes
Ri Chang-soon	리장순	A method of determining length of divided anode plate along to gas flow in transverse flow CO2 laser with tube-plate electrodes
Seo Yun-kyong	서윤경	Cross section profilometry of object and method of its modeling
Pak Yong-su	박용수	Cross section profilometry of object and method of its modeling
Kang Hye-song	강혜성	A method for phase profile reconstruction in digital on-line hologram
Ri Jun-ho	리준호	A method for phase profile reconstruction in digital on-line hologram
Kim Yong-gil	김영길	Influence of laser engraving on quality of laser beam and position of laser focus
Bang Chol-su	방철수	Influence of laser engraving on quality of laser beam and position of laser focus
Jung Chol-su	정철수	Influence of surrounding atmospheric temperature affected to output power of He-Cd+ Laser
Kim Hyon	김현	Influence of surrounding atmospheric temperature affected to output power of He-Cd+ Laser
Ri Kang-jin	리강진	Influence of several additives on magnetic properties of Mn-Zn ferrites
Kim Sung-gol	김성걸	Influence of several additives on magnetic properties of Mn-Zn ferrites
Ri Hyon-il	리현일	Fabrication and Characteristics of CeO2 buffer layer on Ni substrate for YBa2Cu3Ox superconducting wire
Ri Yong-min	리영민	Effect of hydric titanium additive in synthesis of cubic boron nitride
Sin Ung-gil	신웅길	Effect of hydric titanium additive in synthesis of cubic boron nitride
Chon Yun-gil	전윤길	Interaction and wetting of diamond and CBN with glass melt
Choi Hung-kyun	최흥균	Interaction and wetting of diamond and CBN with glass melt
Yun Kwang-jin	윤광진	Adding effect of ultrafine diamond on the lubricating properties of the tribological pair
Han Wok-guk	한원국	Adding effect of ultrafine diamond on the lubricating properties of the tribological pair
Min Il-chon	민일천	Estimation of centre time in several halls based on measurement of impulse response
Won Kyong-su	원경수	Estimation of centre time in several halls based on measurement of impulse response
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Pak Jung-ok	박정옥	A new model of order parameters relative to symmetry breaking in Pb1-xCaxTiO3 solid solution
Chon Kyong-ho	전경호	A new model of order parameters relative to symmetry breaking in Pb1-xCaxTiO3 solid solution
Kim Sung-hyon	김성현	Study on a new method of time-delay estimation in the dispersive material using Hamon-Hannan estimator
Ri Un-sun	리운선	Study on a new method of time-delay estimation in the dispersive material using Hamon-Hannan estimator
Pyo Ik-sun	표익선	The influence of growth rate on occurrence of the cloud-like striations in Li2B4O7 monocrystal growth by the CZ method
Ryang Ho-kil	량호길	The influence of growth rate on occurrence of the cloud-like striations in Li2B4O7 monocrystal growth by the CZ method

Kim Chol-yong	김철용	Simulation of the interaction between magnetic gyroscope and electromagnetic field
Kim Yong-jin	김영진	Simulation of the interaction between magnetic gyroscope and electromagnetic field
Kim Chang-il	김창일	A study on electron spin-magnetic impurity spin correlation function in a quantum dot under external magnetic field
Kang Chol-jin	강철진	A study on electron spin-magnetic impurity spin correlation function in a quantum dot under external magnetic field
Kim Chol-jun	김철준	Study about manufacturing and characteristics of ZnO varistor by a method of citric acid gel
Mun Chol-ho	문철호	Study about manufacturing and characteristics of ZnO varistor by a method of citric acid gel
Ri Jung-hyok	리정혁	The study of on character of the magnetic pinning force in HTSC
Mun Kwang-il	문광일	The study of on character of the magnetic pinning force in HTSC
Ri Hyon-suk	리현석	The study on white light encoding method in real color coding of rainbow hologram
Choi Yong-hun	최영훈	The study on white light encoding method in real color coding of rainbow hologram
Kim Seung-chol	김승철	Study on the directivity of the fundamental mode of the non-spherical resonator
Kim Yong-chol	김영철	Study on the directivity of the fundamental mode of the non-spherical resonator
Kim Ryo-myong	김려명	Study on the directivity of the fundamental mode of the non-spherical resonator
Ri Chol	리철	Phase conjugation mirror using the SBS cell
Ri Jin-hyok	리진혁	Phase conjugation mirror using the SBS cell
Pak Kwang-il	박광일	Simulation of fluid slip at hydrophobic microchannel by the Lattice Boltzmann method
Choi Kwang-ho	최광호	Simulation of fluid slip at hydrophobic microchannel by the Lattice Boltzmann method
Kim Yong-jin	김영진	The influence of the structure parameters on the threshold of a photonic crystal laser
Kim Nam-hyok	김남혁	The influence of the structure parameters on the threshold of a photonic crystal laser
Chae Chung-hyok	채충혁	Study on the micro-displacement measurement using 24bit capacitance-to-digital converter
Wu Dong-hyok	우동혁	Study on the micro-displacement measurement using 24bit capacitance-to-digital converter
Ko Chung-hyok	고정혁	Analysis for spatial directivity of hydro-acoustic array antenna
Kim Ki-dok	김기덕	Analysis for spatial directivity of hydro-acoustic array antenna
Kim Suk-chol	김석철	Analysis for spatial directivity of hydro-acoustic array antenna
Chon Kwang-sung	전광성	Coercive force of nanocrystal composite rare earth permanent magnets
Kim Kyong-gi	김경기	Coercive force of nanocrystal composite rare earth permanent magnets
Bang Hak-hyon	방학현	Spin Structure factor in zigzag-type crystal
Pak Hak-chol	박학철	Spin Structure factor in zigzag-type crystal
Ri Su-bok	리수복	Competition of superconductivity and d-density wave in high-tc superconductor
Kim Ha	김하	Competition of superconductivity and d-density wave in high-tc superconductor
An Yong-nam	안영남	A method of implementing source localization in shallow underwater by inversion
Ri Un-sun	리운선	A method of implementing source localization in shallow underwater by inversion
Kim Yon-il	김연일	Non-equilibrium transport process through single quantum dot
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Chung Un-son	정은선	Computational Group Theoretical study for identifying the space groups of the Landau symmetric phase
Kim Sung-won	김성원	Computational Group Theoretical study for identifying the space groups of the Landau symmetric phase
Kim Il-chol	김일철	Study on resonance absorption of laser light by plasma
Choi Yun-sik	최윤식	Study on resonance absorption of laser light by plasma
Ri Hyo-min	리효민	Study on resonance absorption of laser light by plasma
Kim U-hyon	김우현	Study on high-couple, high-quality materials of Pb(Mn1/3Nb2/3)O3-PZT
Cho Jung-ae	조정애	Study on high-couple, high-quality materials of Pb(Mn1/3Nb2/3)O3-PZT
Kim Sang-ok	김상옥	Study on high-couple, high-quality materials of Pb(Mn1/3Nb2/3)O3-PZT
An Yong-nam	안영남	Study on classification of underwater sound by ICA method
Sun U-hyok	선우혁	Study on the dependence of the Quasiparticle current and supercurrent on the strength of the interfacial barrier and temperature
Kim Sung-gon	김성건	A study on the operation in TEA-N2 laser pumped with two-stage Blumlein circuit
Yang Hak-chol	양학철	A study on the operation in TEA-N2 laser pumped with two-stage Blumlein circuit
Choi Chang-sun	최창선	Improvement of magnetic characteristics by magnetic field annealing in Co69Fe4.1Ni1. 4Mo1.5Si12B12 amorphous magnetic
Sin Kwang-chol	신광철	Improvement of magnetic characteristics by magnetic field annealing in Co69Fe4.1Ni1. 4Mo1.5Si12B12 amorphous magnetic
Ju Hye-song	주혜성	Improvement of magnetic characteristics by magnetic field annealing in Co69Fe4.1Ni1. 4Mo1.5Si12B12 amorphous magnetic
Cho Chang-hyok	조창혁	Research on the energy spectrum of quantum bose liquid used the soft sphere potential
Kim Ha	김하	Research on the energy spectrum of quantum bose liquid used the soft sphere potential
Pak Chung-il	박충일	The study of synthesizing and formation shape of CNT
Kim Gwang-il	김광일	The study of synthesizing and formation shape of CNT
Pak Jin-song	박진성	Study on the mechanical alloying of W-Cu series mixed powder
Ju Deok-yong	주덕영	Vertical scaling of STM device of constant current mode
Choi Ho	최호	Vertical scaling of STM device of constant current mode
Seok Chol-nam	석철남	Vertical scaling of STM device of constant current mode
Ri Chol-nam	리철남	Preparation of Mn-Zn ferrite powder by the low-temperature combustion synthesis process
Kim Sung-gol	김성걸	Preparation of Mn-Zn ferrite powder by the low-temperature combustion synthesis process
O Kwang-yong	오광영	Symmetrical magneto-impedance effect by DC-bias current in Co-base amorphous alloy ribbons
Pak Dong-hyon	박동현	Measurement of asymmetry coefficient the single crystal LiNbO3 by the Raman spectroscopy
Chung Se-yong	정세영	Measurement of asymmetry coefficient the single crystal LiNbO3 by the Raman spectroscopy
Jung Chol-min	정철민	Relation between Dielectric constant and dielectric loss for matching electromagnetic wave in ferroelectric substances
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Kim Hyon-chol	김현철	Study on a Semi-empirical potential of carbon
Chon Kwang-il	전광일	Study on a Semi-empirical potential of carbon
Ri Myong-ha	리명하	Generalized theory of electro-dynamics
Sin Sun-ae	신순애	Magnetic field of sunspot in NOAA AR 10330 by Stokes parameters
Pak Hye-yeong	박혜영	Magnetic field of sunspot in NOAA AR 10330 by Stokes parameters
Ri Yong-chol	리영철	Influence of sintering temperature on Curie temperature and magnetoresistance of Ba2FeMoO6
An Ung-bom	안웅범	Influence of sintering temperature on Curie temperature and magnetoresistance of Ba2FeMoO6
Cha Chol-jun	차철준	Study on the manufacture of a-Al2O3 Nano powder by Sol-Gel Method
Kim Bong-ju	김봉주	Study on the manufacture of a-Al2O3 Nano powder by Sol-Gel Method
Ri Sung-gon	리성건	A study of the S/N Ratio in Photon correlation spectroscopy
Chung Se-yong	정세영	A study of the S/N Ratio in Photon correlation spectroscopy
Chung Ryong-il	정룡일	Effect of laser beam quality on marking in a glass body
Pak Il-myong	박일명	Effect of laser beam quality on marking in a glass body
Kim Yong-gil	김영길	Effect of laser beam quality on marking in a glass body
Pak Su-il	박수일	Dependence of spin injection efficiency on the magnetic field
Pak Hak-chol	박학철	Dependence of spin injection efficiency on the magnetic field
Kim Ji-won	김지원	Generation of ultrashort Nd: YAG laser pulse with the use of saturable absorber
Kim Chol	김철	Generation of ultrashort Nd: YAG laser pulse with the use of saturable absorber
Kim Dae-ryong	김대룡	Efficiency characteristic owing to Bragg's effect on the phase modulation holographic diffraction grating made by GS-I photoplate
Kim Hyon-jun	김현준	Research on the random anisotropy effects in spin reorientation transition of ultra thin ferromagnetic film
Ryang Se-hun	량세훈	Research on the random anisotropy effects in spin reorientation transition of ultra thin ferromagnetic film
Pak In-ho	박인호	A higher order FDTD method for consideration on the influence of electron collision frequency to radar stealth characteristics in non-uniform plasma layer
Hong Hyon-gil	홍현길	A higher order FDTD method for consideration on the influence of electron collision frequency to radar stealth characteristics in non-uniform plasma layer
O Chung-il	오충일	Study on the structure designing for the sandwiched film transmission window with the metal film
Choi Chang-ho	최창호	Study on the structure designing for the sandwiched film transmission window with the metal film
Ri Il-jin	리일진	Study on frequency-output characteristic change of ultrasonic motor
Ri Ki-song	리기성	General theory on shock wave
O Kil-bang	오길방	General theory on shock wave
Pak Song-chol	박성철	Manufacture and magnetoresistance near room temperature of LaNaMnO3 nano powder by Sol-Gel method
Hwang Bol	황벌	Manufacture and magnetoresistance near room temperature of LaNaMnO3 nano powder by Sol-Gel method
Ri Kyong-su	리경수	Study on the magnetic susceptibility of L2BaNiO5 material
Rim Un-sok	림은셕	Thermodynamical phase diagram of ternary system Ga-As-Sb
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Jung Kwang-hyok	정광혁	The method of determining the local spatial period of the fringe-pattern by the continuous wavelet transform
Kim Chol-su	김철수	The method of determining the local spatial period of the fringe-pattern by the continuous wavelet transform
Ri Chol-hyok	리철혁	Effect of vacancy concentration on order-disorder critical temperature in binary alloys
Ryang Se-hun	량세훈	Effect of vacancy concentration on order-disorder critical temperature in binary alloys
Ri Yong-sun	리영선	The influence of the quantum Dot's energy level on the intensity of the RKKY interaction
Kim Sung-hyok	김성혁	The influence of the quantum Dot's energy level on the intensity of the RKKY interaction
Pak Chun-ok	박춘옥	Influence of the size of air gap on the magnetic shielding characteristics in Bi based High-Tc superconductor and ferromagnetism superimposed type magnetic field shielding cylinders
O Sun-ok	오순옥	Influence of the size of air gap on the magnetic shielding characteristics in Bi based High-Tc superconductor and ferromagnetism superimposed type magnetic field shielding cylinders
Chon Kwang-sung	전광성	The manufacture and property of Nd-Fe-B/a-Fe systems nanocrystal composite plastic magnets
Kim Kyong-gi	김경기	The manufacture and property of Nd-Fe-B/a-Fe systems nanocrystal composite plastic magnets
Kim Sung-won	김성원	Irreducible representations of the wave vector channel groups of crystals of the rhombohedral and hexagonal systems
Chung Un-son	정은선	Irreducible representations of the wave vector channel groups of crystals of the rhombohedral and hexagonal systems
Myong Kwang-ryol	명광렬	CFD study on Orifice's optimization in GM type orifice pulse tube cooler
Kim Kwang-sun	김광선	CFD study on Orifice's optimization in GM type orifice pulse tube cooler
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Kang Jin-u	강진우	Study on the Hamiltonian quantization of new Ekpyrosis theory
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Choi Yong-chol	최영철	Hamiltonian of Electron liquid-optical phonon system
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Ri Chang-ryong	리창룡	Energy band structure of carbon nanotube
Ri Un-chol	리은철	Energy band structure of carbon nanotube
O Sung-jin	오성진	Functional renormalization group study of the effective interaction of the 2D single band Hubbard model
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Pak Hyok-nam	박혁남	Finite Element Analysis for Vibration Mode of Piezoelectric micropump
Ri Sung-chon	리성천	Finite Element Analysis for Vibration Mode of Piezoelectric micropump
Kim Chung-sung	김정성	Effect of the length of the slit on the parallel flow in the ultrasonic liquid whistle
Kim Myong-jin	김명진	Effect of the length of the slit on the parallel flow in the ultrasonic liquid whistle
Kim Chol-yong	김철영	Study on the deformation of 3-in Silicon wafer by substitution of the diffusion impurity atoms
Kim Chol	김철	Synthesis of Carbon nanospheres by CVD method

Chang Sang-hyon	장상현	Synthesis of Carbon nanospheres by CVD method
Ri Song-gon	리성건	Manipulation of Optical unit for enhancement of signal detectivity in a photo-correlation spectrometer
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Heo Chol-u	허철우	Design Method of Tilting Head Acoustic Transducer by Using Neural Network
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Pak Myong-il	박명일	Design Method of Tilting Head Acoustic Transducer by Using Neural Network
Ri Un-kwang	리은광	Characteristics of Scattering Body by Spectral Analysis of Echo Signal
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Seo Chol-ung	서철웅	Vibrator Characteristics of Traveling Wave Type Ultrasonic Motors
Ri Chol-su	리철수	Vibrator Characteristics of Traveling Wave Type Ultrasonic Motors
Yang Sang-chol	양상철	Decision of Position of Light Spot and Light Strength at Exit of Hollow Bending Wave Guide
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Choi Il-su	최일수	Spectral Analysis of Mn Element in Steel by Fuzzy Information Processing
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Kim Kyong-gi	김경기	Exciton Absorption of Oxide Semiconductor Nanoparticles
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Choi Chang-ho	최창호	Tunneling of an Electron in Fe/Cr/Fe Nano-Multifilm
Yun Chol-song	윤철송	Dependence of Spontaneous Magnetization on Temperature and Carrier Concentration in 2DAF System
Kim Jung-yon	김정연	Dependence of Spontaneous Magnetization on Temperature and Carrier Concentration in 2DAF System

Hong Ryo-myong	홍려명	Heat Collecting Property of Nonmetal Solar Collector
Kang Yong-hwan	강영환	Heat Collecting Property of Nonmetal Solar Collector
Ri Hyon-ung	리현웅	Chaos Control Method of Low Dimensional Nonlinear Systems Based on Random Perturbation of Control Parameter
Ri Kwan-ho	리관호	Chaos Control Method of Low Dimensional Nonlinear Systems Based on Random Perturbation of Control Parameter
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Choi Myong-il	최명일	Influence of Electron-Phonon Interaction on Kondo Effect in Single Quantum Dot
Kim Yon-il	김연일	Influence of Electron-Phonon Interaction on Kondo Effect in Single Quantum Dot
Kim Chang-il	김창일	Influence of Magnetic Field on Electron Transport Passing through a Quantum Dot with Magnetic Impurity Dopped
Kang Chol-jin	강철진	Influence of Magnetic Field on Electron Transport Passing through a Quantum Dot with Magnetic Impurity Dopped
Ri Yu-chol	리유철	Dependency of Spin Correlation Function on Carrier Density in Strong Correlated Electronic System
Pak Hak-chol	박학철	Dependency of Spin Correlation Function on Carrier Density in Strong Correlated Electronic System
Ri Chun-hyok	리춘혁	Method of Receiving Seabed Echo Signal Based on Digital Multi-Beamforming in Side-Scan Sounder
Kang Hyon-chol	강현철	Method of Receiving Seabed Echo Signal Based on Digital Multi-Beamforming in Side-Scan Sounder
Ri Un-kwang	리은광	A Method for Estimating Direction of Arrival of Acoustic Signal
Won Jung-ung	원정웅	A Method for Estimating Direction of Arrival of Acoustic Signal
Kim Chol-hyok	김철혁	Prediction of Early Decay Time in Space with Two Kinds of Absorptive Structure by Diffusion Model
An Jung-hyok	안정혁	Prediction of Early Decay Time in Space with Two Kinds of Absorptive Structure by Diffusion Model
Cho Yong-hee	조영희	Prediction of Early Decay Time in Space with Two Kinds of Absorptive Structure by Diffusion Model
Ri Su-jin	리수진	Simulation of a Traveling Wave-Type Ultrasonic Linear Motor
Ri Chol-su	리철수	Simulation of a Traveling Wave-Type Ultrasonic Linear Motor
Pak Yong-su	박용수	A Method for Centre-Positioning of Projected Laser Light-Line Having Subpixel Accuracy
Hong Hae	홍해	A Method for Centre-Positioning of Projected Laser Light-Line Having Subpixel Accuracy
Kim Chol-hyon	김철현	Optimal Electrode Structure for Phase Velocity Matching in Traveling Wave-Type Modulator for Laser-Beam Intensity
Yun Du-hon	윤두헌	Optimal Electrode Structure for Phase Velocity Matching in Traveling Wave-Type Modulator for Laser-Beam Intensity
Ryu Kyong-ho	류경호	Relationship between Laser Light Spot Diameter and Heat-Influenced Zone in Heat Treatment by Laser
Ri Song-kwon	리성권	A Method of Determining Parameters of Cross-Flow Fan Used for Gas Laser Device and Improving its Capacity
Heo Sung	허성	Spontaneous Deformation Characteristics in Monoclinic Ferroelectric Ceramics near Tetragonal-Rhombohedral Phase

Pak Sung-dok	박성덕	Spontaneous Deformation Characteristics in Monoclinic Ferroelectric Ceramics near Tetragonal-Rhombohedral Phase
Rim Un-hyok	림은혁	Investigation on Thermodynamical Phase Diagram of Ga-As-P Ternary System
Han Ju-myong	한주명	Investigation on Thermodynamical Phase Diagram of Ga-As-P Ternary System
Kim Un-chol	김은철	Specification of Optimal Structure for PhotoIC
Kim Chang-bum	김창범	Specification of Optimal Structure for PhotoIC
Ri Son-guk	리선국	Specification of Optimal Structure for PhotoIC
Choi Kyong-il	최경일	On Fabrication of Optical Probe by Chemical Etching of Single Mode Fiber with GeO2-Dopped Core
Kim Yu-jung	김유정	On Fabrication of Optical Probe by Chemical Etching of Single Mode Fiber with GeO2-Dopped Core
Kim Chol-jin	김철진	Structural and Optical Properties of ZnO: Al Films Prepared by Ultrasonic Spraying Pyrolysis
Ri Chung-ho	리충호	Structural and Optical Properties of ZnO: Al Films Prepared by Ultrasonic Spraying Pyrolysis
Chang Yong-su	장용수	Selection of Rational Material upon Electrical Properties in PEC Solar Cell
Ri Chung-ho	리충호	Selection of Rational Material upon Electrical Properties in PEC Solar Cell
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Gil Chan-won	길찬원	Synthesis of Carbon Nano Tubes by the Floating Catalytic Pyrolyzing Method
Yoo Ju-hyun	유주현	Synthesis of Carbon Nano Tubes by the Floating Catalytic Pyrolyzing Method
Pak Kwang-hak	박광학	A Method of Improving Current Pulse Characteristic of MFCG
Kim Kyong-chol	김경철	A Method of Improving Current Pulse Characteristic of MFCG
Kim Chol	김철	A Method of Improving Current Pulse Characteristic of MFCG
Pak Ji-myong	박지명	Study on Resonator Consisting of Quantized Spherical Mirror and Plane Mirror
Kim Yong-chol	김영철	Study on Resonator Consisting of Quantized Spherical Mirror and Plane Mirror
Pak Kum-sung	박금성	A Research on the Influence of Mg Oxides in the Relaxor Ferroelectrics 0.9Pb (Mg1/3Nb2/3) O3-01PbTiO3
Ri Kun-nam	리근남	A Research on the Influence of Mg Oxides in the Relaxor Ferroelectrics 0.9Pb (Mg1/3Nb2/3) O3-01PbTiO3
Kim Hyon-jun	김현준	The Method of Cluster Analysis by Access of Recursion Function and its Application to the Some Systems of Chemical Compounds
Ryang Se-hun	량세훈	The Method of Cluster Analysis by Access of Recursion Function and its Application to the Some Systems of Chemical Compounds
Yun Chan	윤찬	Efficiency for Coupling Super Luminescent Diode (SLD) to Single Mode Fiber (SMF) and Coupling Structure
Kim Chang-hae	김창해	Synthesis of Ultra-Fine Si3N4 Powders by the Self-Propagating High-Temperature Synthesis (SHS) Process Adding Si(NH)2+NH4Cl
Heo Chung-won	허정원	Synthesis of Ultra-Fine Si3N4 Powders by the Self-Propagating High-Temperature Synthesis (SHS) Process Adding Si(NH)2+NH4Cl
Ra Myong-chon	라명천	Fractal Characteristics of Granularity Distributions of Aqueous Clay
Chang Gwang-hyok	장광혁	Fractal Characteristics of Granularity Distributions of Aqueous Clay
Sin Chang-rim	신창림	Research on Phase Diagram of t-J Model
Kim Sung-guk	김성국	Research on Phase Diagram of t-J Model
Kim Ha	김하	Superconducting Transition from Pseudogap State in High-Temperature Superconductors
Ri Su-bok	리수복	Superconducting Transition from Pseudogap State in High-Temperature Superconductors

Chung Sun-gon	정순건	Research on Excitation of Muscle by Nonequilibrium Thermodynamics
Ri Kwan-ho	리관호	Research on Excitation of Muscle by Nonequilibrium Thermodynamics
Kye Hyok-il	계혁일	Propagation Characteristics of Normal Wave in Radial Direction in Medium with Sol-id-Solid Cylindrical Boundary
Ri Un-sun	리운선	Propagation Characteristics of Normal Wave in Radial Direction in Medium with Sol-id-Solid Cylindrical Boundary
Ri Hyok	리혁	Method for Determining Temperature of High-Temperature High-Dense Pinch Plasma
Kim Il-chol	김일철	Method for Determining Temperature of High-Temperature High-Dense Pinch Plasma
Cha Ki-ung	차기웅	Tracking Mode of GPS Satellites on GDOP
Pak Mun-hyok	박문혁	Influence of Optical Parameters on SPR-Angular Spectrum
Ri Jun-yong	리준영	Influence of Optical Parameters on SPR-Angular Spectrum
Yun Sung-guk	윤성국	*Ab initio* Study of Magnetocrystalline Anisotropy in 3*d* Transition Metals
Ri Ki-hak	리기학	*Ab initio* Study of Magnetocrystalline Anisotropy in 3*d* Transition Metals
Ri Ki-sop	리기섭	Influence of Mn Oxide on Initial Permeability of Mn-Zn Ferrite
Hwang Bol	황벌	Influence of Mn Oxide on Initial Permeability of Mn-Zn Ferrite
Heo Kwang-sop	허광섭	Influence of Mn Oxide on Initial Permeability of Mn-Zn Ferrite
Pak Chol-jin	박철진	Preparation a-Fe2O3-SnO2 Nano Thin Films by Sol-Gel Method and Gas Sensing Properties
Kim Kye-chil	김계칠	Preparation a-Fe2O3-SnO2 Nano Thin Films by Sol-Gel Method and Gas Sensing Properties
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Won Chol-mi	원철미	Study on Proton Exchange Membrane Fuel Cell Power
Sin Yun-sop	신윤섭	Study on Proton Exchange Membrane Fuel Cell Power
Paek Kwang-chol	백광철	Study on Proton Exchange Membrane Fuel Cell Power
Kim Il-hwan	김일환	Phenomenological Theory of the Phase Transitions in Pb-Based Piezoelectric Solid-Solutions
Chang Gum-ok	장금옥	Phenomenological Theory of the Phase Transitions in Pb-Based Piezoelectric Solid-Solutions
Kim Il-hun	김일훈	Phenomenological Theory of the Phase Transitions in Pb-Based Piezoelectric Solid-Solutions
Kim Yun-hyon	김윤현	Piezoelectric and Ferroelectric Properties of the Ceramic/Polymer 1-3 Composites
Ri Sang-kil	리상길	Piezoelectric and Ferroelectric Properties of the Ceramic/Polymer 1-3 Composites
Hwang Jun-chol	황준철	Simulation on the Fluid Flow through Microscale Fractal-Like Branching Channel Net-works
Kim Yong-jin	김영진	Simulation on the Fluid Flow through Microscale Fractal-Like Branching Channel Net-works
Pak Kwang	박광	A Simulation Method for the 3D Characteristic Surfaces in the BAW and the Propagation of the SAW in Crystals
Han Chol-du	한철두	A Simulation Method for the 3D Characteristic Surfaces in the BAW and the Propagation of the SAW in Crystals
Pak Dong-hyun	박동현	Emission Spectra of Long UV-Excited Phosphor
Ri Ju-hyun	리주현	Emission Spectra of Long UV-Excited Phosphor
Ri Mun-hyok	리문혁	*Ab Initio* Study of the Microscopic Structure of Salen-Manganese Complex EUK-134
Kim Nam-hyok	김남혁	*Ab Initio* Study of the Microscopic Structure of Salen-Manganese Complex EUK-134
Ri Kyong-jun	리경준	Research of Nonlinear Dynamic Characteristic of Mutual Optoelectronically Coupled Semiconductor Laser and Suppression of Chaos
Kim U-hyon	김우현	Research of Nonlinear Dynamic Characteristic of Mutual Optoelectronically Coupled Semiconductor Laser and Suppression of Chaos

Ri Kwang	리광	A Study on the Effect of Spin Polarization of an Electron in Compton Scattering
Kim Sung-bok	김성복	A Study on the Effect of Spin Polarization of an Electron in Compton Scattering
Ryeo In-kwang	려인광	Phase Equilibrium Coposition in Ferroelectric Material near MPB
Pak Song-dok	박성덕	Phase Equilibrium Coposition in Ferroelectric Material near MPB
Ri Ung-ho	리웅호	Dispersion Properties of Photonic Crystal Fiber
Kim Hyon-guk	김현국	Measurement of Arc Temperature Using CCD Camera
Kim Chol-sun	김철순	Measurement of Arc Temperature Using CCD Camera
Pae Hak-mun	배학문	Temperature Dependence of GaAs Semiconductor-Transmission Type Optical Fiber Temperature Sensor on Incident Signal Light
Ha Chol-jin	하철진	Temperature Dependence of GaAs Semiconductor-Transmission Type Optical Fiber Temperature Sensor on Incident Signal Light
Cha Nam-hyok	차남혁	Synthesis of Metallic High-Temperature Superconductor MgB2
Han Sang-sol	한상설	Synthesis of Metallic High-Temperature Superconductor MgB2
Ri Jong-hyok	리정혁	A Model of Distribution of Magnetic Flux of II Type Superconductor
Mun Kwang-il	문광일	A Model of Distribution of Magnetic Flux of II Type Superconductor
Ri Chol	리철	Simulation of Q-Switch Operation Using Phase Conjugation Mirror
Kim Won-pil	김원필	Simulation of Q-Switch Operation Using Phase Conjugation Mirror
Chung Myong-chol	정명철	Influence of Attitude of Low Orbit Craft on External Heat Flux
Chang Sun-ho	장순호	Influence of Attitude of Low Orbit Craft on External Heat Flux
Yang Hak-chol	양학철	Selecting Absorption Coefficient of Media in Stabilizing Output Power Using Thermal Lens Effect
Kim Sung-gon	김성건	Selecting Absorption Coefficient of Media in Stabilizing Output Power Using Thermal Lens Effect
Ryu Chol-bom	류철범	Application of Quantum Network Method in Solving Multi-Dimension Schrodinger Equation of the Quantum Multi-Particle
Kim Nam-chol	김남철	Application of Quantum Network Method in Solving Multi-Dimension Schrodinger Equation of the Quantum Multi-Particle
Kim Sung-guk	김성국	Application of Quantum Network Method in Solving Multi-Dimension Schrodinger Equation of the Quantum Multi-Particle
Kil Chan-il	길찬일	Zero-Point Stabilization of Piezoelectric Vibratory Gyroscope
Kwon Yong-bom	권용범	Zero-Point Stabilization of Piezoelectric Vibratory Gyroscope
Choi Hyon-chol	최현철	Zero-Point Stabilization of Piezoelectric Vibratory Gyroscope
Chon Ryong-un	전룡은	Simulation on Aggregation-Dissociation of Nanoparticles in Nanoliquids
Kim Yong-jin	김영진	Simulation on Aggregation-Dissociation of Nanoparticles in Nanoliquids
An Jong-hyok	안정혁	Predicting IACC of Great Theatre with Suspensed Reflectors
Won Kyong-su	원경수	Predicting IACC of Great Theatre with Suspensed Reflectors
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Kim Chol-ae	김철애	Dispersion Relation of 2D Photonic Crystals
Ri Kyong-chun	리경춘	Dispersion Relation of 2D Photonic Crystals
Ri Un-chol	리은철	Electronic Structure in PbTe Cylindrical Quantum Dots of Taking Account for Effect of Band Anisotropy
Ri Guk-chol	리국철	Electronic Structure in PbTe Cylindrical Quantum Dots of Taking Account for Effect of Band Anisotropy
Han Chol-gyu	한철규	Damping Factor Calculation by Dynamic Linear Response

Yun Sung-ro	윤성로	Damping Factor Calculation by Dynamic Linear Response
Jung Gwang-chol	정광철	Damping Factor Calculation by Dynamic Linear Response
O Ju-ok	오주옥	A Method for Determining Noise Level in Chaotic Time-Series
Son Sung-nam	손성남	A Method for Determining Noise Level in Chaotic Time-Series
Kim Chol-jin	김철진	A Method for Solution to Nonlinear Wave Couple Equation with Absorption
Yun Du-hon	윤두헌	A Method for Solution to Nonlinear Wave Couple Equation with Absorption
Ri Chol-man	리철만	A Method for Solution to Nonlinear Wave Couple Equation with Absorption
Ri Yong-guk	리영국	Influence of Some Factors on Stability of Discharge in Volume Discharging Cross-Convection kW CO2 Laser
Ri Sung-kwon	리성권	Influence of Some Factors on Stability of Discharge in Volume Discharging Cross-Convection kW CO2 Laser
Kim Hyon-u	김현우	A Method of Synthesizing 3D Hologram by computer Simulation
Yun Du-hon	윤두헌	A Method of Synthesizing 3D Hologram by computer Simulation
Kim Kum-chol	김금철	A Method of Synthesizing 3D Hologram by computer Simulation
Han Yong-won	한영원	Anticounterfeiting of Holograms by Using Computer-Generated-Holograms Reconstructing Multi-Images on Diffraction Axis
Kim Kwang-hyon	김광현	Anticounterfeiting of Holograms by Using Computer-Generated-Holograms Reconstructing Multi-Images on Diffraction Axis
Ryang Un-suk	량은숙	Two-Step Recording Method of Rainbow Holograms by Using Striped Parallel Beam
Kim Kwang-hyon	김광현	Two-Step Recording Method of Rainbow Holograms by Using Striped Parallel Beam
Kim Chol-sam	김철삼	Relation between Gas Pressure and DC Electric Field of Target in RF Sputtering
Han Yong-su	한영수	Relation between Gas Pressure and DC Electric Field of Target in RF Sputtering
Paek Kwang-un	백광은	Relation between Melting Point in YBCO High-Temperature Superconductor and Size of Particles
Mun Kwang-il	문광일	Relation between Melting Point in YBCO High-Temperature Superconductor and Size of Particles
Kim Myong-song	김명성	Relation between Melting Point in YBCO High-Temperature Superconductor and Size of Particles
Ri Yong-sun	리영순	Character of Ethanol Gas Sensor of Porous Silicon (PS)
Pak Ho-nam	박호남	Character of Ethanol Gas Sensor of Porous Silicon (PS)
Han Yong-sun	한영순	Character of Ethanol Gas Sensor of Porous Silicon (PS)
Kil Chol-min	길철민	Processing of Scanning Probe Image by DFT
Choi Kyong-su	최경수	Processing of Scanning Probe Image by DFT
Ju Dok-yong	주덕영	Processing of Scanning Probe Image by DFT
Gung Myong-jin	궁명진	Temperature-Dependent of Absorption and Radiation Properties in Inhomogeneous Composites
Pak Song-il	박성일	Temperature-Dependent of Absorption and Radiation Properties in Inhomogeneous Composites
Hong Ryong-il	홍룡일	Influence of Covergage Factor of Diamond - Metal on Mechanical Property of Diamond Polishing Tools Combinating with Plastic
Choi Hong-kyun	최홍균	Influence of Covergage Factor of Diamond - Metal on Mechanical Property of Diamond Polishing Tools Combinating with Plastic
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Han Mun-won	한문원	Tunnel Transition and Energy Levels of Magnetization in Ferromagnetic Nanoparticles

Kim Won-chung	김원청	Tunnel Transition and Energy Levels of Magnetization in Ferromagnetic Nanoparticles
Kang Chol-bom	강철범	Noise-Induced Phase Transition in Genetic Model
Sin Chol-nam	신철남	Optical Confinement Characteristics of GaAs/AlGaAs Single Quantum Well Laser
Han Un-ok	한은옥	Optical Confinement Characteristics of GaAs/AlGaAs Single Quantum Well Laser
Kim Chol-song	김철성	Method for Applying Fractal Compression Technique to EEG Signal
Ri Kwan-ho	리관호	Method for Applying Fractal Compression Technique to EEG Signal
Cho Sun-kwon	조순권	Characteristics of 0-3 Connectivity Piezoelectric Polymer Composites
Ri Chung-hyok	리충혁	Characteristics of 0-3 Connectivity Piezoelectric Polymer Composites
Hong Il-su	홍일수	Influence of Moving Medium on Elementary Particle Reaction
Ko Yong-hae	고영해	Influence of Moving Medium on Elementary Particle Reaction
Kim Ki-chol	김기철	Calculation of Linear Absorption Spectrum by Time Dependent (TD)-Density Functional Theory (DFT)
Song Kum-sung	송금성	Calculation of Linear Absorption Spectrum by Time Dependent (TD)-Density Functional Theory (DFT)
Paek Chol	백철	Physical Theory of s-Shockwave (Com. 2)
Ri Myong-ha	리명하	Physical Theory of s-Shockwave (Com. 2)
Jung Hyok-chol	정혁철	Properties of Fluorescence Spectrum of Rhodamine 6GH of Using as Active Medium of Dye Laser
Kim U-hyon	김우현	Properties of Fluorescence Spectrum of Rhodamine 6GH of Using as Active Medium of Dye Laser
Chang Yong-guk	장영국	Influence of Gaseous Composition Ratio of Composite Gas on Reflective Index of AlN Thin Film under Condition of Minimum Ionization Voltage of Ar Atoms
Choi Chang-ho	최창호	Influence of Gaseous Composition Ratio of Composite Gas on Reflective Index of AlN Thin Film under Condition of Minimum Ionization Voltage of Ar Atoms
Seo Chol-ung	서철웅	Influence of Gaseous Composition Ratio of Composite Gas on Reflective Index of AlN Thin Film under Condition of Minimum Ionization Voltage of Ar Atoms
Kang Hyon-kwang	강현광	Optimal Design Method of Amplitude-Quantized Computer-Generated Holograms Optimal Design Method of Amplitude-Quantized Computer-Generated Holograms
Kim Kwang-hyon	김광현	Collimation Testing Method of Using Diffraction Pattern of Light in Circle Aperture and Determination of Focus Length of Lens
Ri Kwang-chol	리광철	Collimation Testing Method of Using Diffraction Pattern of Light in Circle Aperture and Determination of Focus Length of Lens
Choi Kwang	최광	Collimation Testing Method of Using Diffraction Pattern of Light in Circle Aperture and Determination of Focus Length of Lens
Kim Yu-jung	김유정	Collimation Testing Method of Using Diffraction Pattern of Light in Circle Aperture and Determination of Focus Length of Lens
Kang Chol	강철	Pb, FeO, CaO, ZnO, SiO2 Analysis in Slag by CCD Camera
Choi Kwang	최광	Pb, FeO, CaO, ZnO, SiO2 Analysis in Slag by CCD Camera
Kim Kwang-ryul	김광률	Analytical Line Selection for Analysis of Cu in Copper Alloy
Kan Jung-nam	간정남	Analytical Line Selection for Analysis of Cu in Copper Alloy
Hong Jin-guk	홍진국	Binding Energy of Exciton in Spherical Quantum Dot of Considering Dielectric Confinement Effect
Ri Guk-chol	리국철	Binding Energy of Exciton in Spherical Quantum Dot of Considering Dielectric Confinement Effect
Kim Kwang-il	김광일	Tidal Force of Planets to the Earth's Surface

Chae Jung-sok	채중석	Tidal Force of Planets to the Earth's Surface
Pak Chong-il	박정일	Tidal Force of Planets to the Earth's Surface
Seo Hyok	서혁	Manufacture of Infrared Reflection Multilayer Films and Its Optical Characteristics
Choi Kyong-il	최경일	Calculation of Thickness of Each Film at Ultraviolet Rays Cutting off Multilayer Film by Monte-Carlo Method
Kim Hyon-guk	김현국	Calculation of Thickness of Each Film at Ultraviolet Rays Cutting off Multilayer Film by Monte-Carlo Method
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Ri Chong-hyok	리종혁	Relation between Partition Function and Free Energy
Choi Yung-su	최영수	Relation between Partition Function and Free Energy
Pak Kwang-myong	박광명	A Method on Solution to Time Dependent Schrodinger Equation for Deciding Tunnel Transmission Probability
Choi Sun-chol	최순철	A Method on Solution to Time Dependent Schrodinger Equation for Deciding Tunnel Transmission Probability
Kim Sung-hee	김성희	Renormalization of Fermion Operator in Boson-Fermion Model
Ryeo Se-jong	려세종	Renormalization of Fermion Operator in Boson-Fermion Model
An Chung-hyok	안충혁	Analyzing Propagation Modes of Photonic Crystal Fibers by Using Plane Wave Expansion Method
Im Sung-jin	임성진	Analyzing Propagation Modes of Photonic Crystal Fibers by Using Plane Wave Expansion Method
Kim Yung-chol	김영철	1D Non-Spherical Resonator with Profile of Fourth Power Function
Han U-yong	한우영	1D Non-Spherical Resonator with Profile of Fourth Power Function
Kim U-hyon	김우현	1D Non-Spherical Resonator with Profile of Fourth Power Function
Ri Un-byol	리은별	Synthesis and Reconstruction of Two-Channel Computer-Generated Holograms
Yun Du-hon	윤두헌	Synthesis and Reconstruction of Two-Channel Computer-Generated Holograms
Heo Jin-song	허진송	Theoretical Research on Phenomena of Double Resonance in Ferrite Medium
Ri Ki-sop	리기섭	Theoretical Research on Phenomena of Double Resonance in Ferrite Medium
Pak Yong-su	박용수	Theoretical Research on Phenomena of Double Resonance in Ferrite Medium
Kim Jong-chol	김정철	Microwave Absorption Property of Nano Hexagonal Ferrite Composite
Kim Won-chong	김원청	Microwave Absorption Property of Nano Hexagonal Ferrite Composite
Ryu Hyon-ju	류현주	Manufacturing Substrate of CO2 Laser Light Wave Guide of Using Dielectric Material
Roh Sok-bong	로석봉	Manufacturing Substrate of CO2 Laser Light Wave Guide of Using Dielectric Material
An Kil	안길	Manufacturing Substrate of CO2 Laser Light Wave Guide of Using Dielectric Material
An Myong-ho	안명호	Measurement of Ocular Refractive Power by Eye-Collimating Optical System
Ri Chung-ho	리충호	Change in Size of Crystal Particle and Magnetic Property of W-Type Ba Hexagonal Ferrite Powder Prepared by Sol-Gel Method
Kim Jong-chol	김정철	Change in Size of Crystal Particle and Magnetic Property of W-Type Ba Hexagonal Ferrite Powder Prepared by Sol-Gel Method
Rim Chol-san	림철산	Magnetic Field Distribution around Magnetic Code Drum of Magnetic Rotary Encoder
Ji Sang-ho	지상호	Magnetic Field Distribution around Magnetic Code Drum of Magnetic Rotary Encoder
Choi Chol-jin	최철진	Magnetic Field Distribution around Magnetic Code Drum of Magnetic Rotary Encoder
Han U-yong	한우영	Thermal Characteristics of Natural Cooling RF Excited CO2 Laser
Kim Yong-chol	김영철	Thermal Characteristics of Natural Cooling RF Excited CO2 Laser

Kim Il-yong	김일영	Influence of Starting Materials-Mixing Process on Quality of WBN Compacts
Cha Sang-jun	차상준	Influence of Starting Materials-Mixing Process on Quality of WBN Compacts
Han Ok-sun	한옥선	Influence of Starting Materials-Mixing Process on Quality of WBN Compacts
Heo Suk-hee	허숙희	Optimization by Genetic Algorithm in He-Ne Laser Resonator
Kim Hyong-kil	김형길	Optimization by Genetic Algorithm in He-Ne Laser Resonator
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Ri Byong-il	리병일	The "Overunity" Principle and Extracting Energy
Pak Kwang-myong	박광명	The *Ab initio* Study of BaTiO3 (001) Surfaces
Ri Ki-hak	리기학	The *Ab initio* Study of BaTiO3 (001) Surfaces
Choi Ju-yong	최주영	Investigation on Lepton Reaction, Taking Account of Charge and Proper Magnetic Moment
Ko Yong-hae	고영해	Investigation on Lepton Reaction, Taking Account of Charge and Proper Magnetic Moment
Yun Song-guk	윤성국	First-Principles Calculation to Effective Hamiltonian Expansion Parameters of BaTiO3
Ri Chung-ho	리충호	First-Principles Calculation to Effective Hamiltonian Expansion Parameters of BaTiO3
Kim Sung-hee	김성희	Calculation of Fermion Spectral Function in Different Temperature Region Using Flow Equation Method
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U Sung-min	우성민	Method for Monte-Carlo (MC) Simulation of Time Dependent Schrodinger's Equation (TDSE) on Quantum Spin System
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Kim Yong-myung	김용명	Image Processing of SEM by Computer
Song Seok	송석	Image Processing of SEM by Computer
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Kim Ha	김하	Electronic Structure of CuO2 Plane of High-Tc Superconductors by Linear Combination of Atomic Orbitals (LCAO) Method
Chung Un-sun	정은선	On Irreducible Representations of 230 Space Groups (2)
Kim Sung-won	김성원	On Irreducible Representations of 230 Space Groups (2)
Ri Kwang-sun	리광선	On Irreducible Representations of 230 Space Groups (2)
Kim Chol-jun	김철준	Effective Potential of Quintescense (the 5th Element) Field of Causing Accelerating
Paek Chang-ryong	백창룡	Effective Potential of Quintescense (the 5th Element) Field of Causing Accelerating
Kim Kwang-il	김광일	Linear Spectrum of Density Perturbations in CHDM-Cosmological Model
Kim Jik-su	김직수	Linear Spectrum of Density Perturbations in CHDM-Cosmological Model
Jung Chol-sam	정철삼	Dependence of the Average Size of Clusters on Temperature and Growth-Time in Infinite Stokes Number Regime

Kim Sun-chol	김순철	Dependence of the Average Size of Clusters on Temperature and Growth-Time in Infinite Stokes Number Regime
Kim Sung-guk	김성국	Polynomial Time Algorithm for Factorization
Sin Chang-rim	신창림	Polynomial Time Algorithm for Factorization
Chon Yong-hyok	전영혁	Evaluation of Entropy of Fusion of Transition Metals by Artificial Neural Network
Choi Yong-nam	최영남	Evaluation of Entropy of Fusion of Transition Metals by Artificial Neural Network
Choi Kyong-hyok	최경혁	Analysis of Space-Time Signal Spectrum Using New Wavelet Functions
Kim Yong-jin	김영진	Analysis of Space-Time Signal Spectrum Using New Wavelet Functions
Hong Sung-il	홍성일	Charging Model of Electrophotographic Photoreceptor
Bang Chol	방철	Charging Model of Electrophotographic Photoreceptor
Jung Tong-chol	정동철	Charging Model of Electrophotographic Photoreceptor
Pak Yong-su	박용수	Precise Profilometry of Object by Optical Projection and Digital Image Processing
Kim Kwang-hyon	김광현	Precise Profilometry of Object by Optical Projection and Digital Image Processing
Kang Hak-ju	강학주	Design, Manufacturing and Diffraction Efficiency of Kinoform by Using FFT
Ryang Seok-myong	량석명	Design, Manufacturing and Diffraction Efficiency of Kinoform by Using FFT
Ri Hyo-sung	리효성	Resolution of Hybrid Digital Holographic Microscopy
Choi Kwang	최광	Resolution of Hybrid Digital Holographic Microscopy
Cha Sang-jun	차상준	Synthesis and Property of Diamond Compacts
Kim Il-kwang	김일광	Synthesis and Property of Diamond Compacts
Min Won-jun	민원준	Breakdown Voltage of Photodiode
Rim Suk-yong	림숙영	Breakdown Voltage of Photodiode
Ri Nam-hu	리남후	Breakdown Voltage of Photodiode
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Chang Sung-ku	장성구	Nanoparticle Formation Process by Homogeneous Nucleation Theory in Preparation in Nanomaterial Production by Arc Plasma
Choi Kyong-il	최경일	Nondestructive Testing of Diffusely Reflecting Object by Digital Speckle Pattern Interferometry
Kim Chol-su	김철수	Nondestructive Testing of Diffusely Reflecting Object by Digital Speckle Pattern Interferometry
Son Sung-nam	손성남	Nonlinear Noise Reduction in Chaotic Time-Series Data by Local Projecting Method
Ri Kwan-ho	리관호	Nonlinear Noise Reduction in Chaotic Time-Series Data by Local Projecting Method
Rim Chol-san	림철산	Multi-Pole Magnetization of Magnetic Drum for Magnetic Rotary Encoder
Kim Yung-yu	김영유	Multi-Pole Magnetization of Magnetic Drum for Magnetic Rotary Encoder
Ri Hyon	리현	Research on the Microdefect of Silicon Semiconductor Crystal with X-ray Section Topography
Cho Sun-hee	조선희	Research on the Microdefect of Silicon Semiconductor Crystal with X-ray Section Topography
Kim Kyong-gi	김경기	Measurement of Electric Current by Magnetic Field Compensation Method
Ri Il-chol	리일철	Measurement of Electric Current by Magnetic Field Compensation Method
Kim Chol	김철	Generation of a Few Nanoseconds Nd: YAG Laser Pulse with Use of Saturable Absorber, BDN
Ryu Myong-su	류명수	Generation of a Few Nanoseconds Nd: YAG Laser Pulse with Use of Saturable Absorber, BDN

Yun Hyok-chol	윤혁철	A Control Technique for Chaos Dynamics Given to a Scalar Time Series
Ri Kwan-ho	리관호	A Control Technique for Chaos Dynamics Given to a Scalar Time Series
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Kim Ha	김하	Spin Fluctuation-Indeed-dx2-y2-Wave Superconductivity and Nearest-Neighbor Coulomb Interaction in High-Tc Superconductors
Jang Chol-su	장철수	Spin Fluctuation-Indeed-dx2-y2-Wave Superconductivity and Nearest-Neighbor Coulomb Interaction in High-Tc Superconductors
Kim Yong-jin	김영진	Investigation to Formation Mechanism of Nano-Scale Porous Silicon by a Random Walk Model
Kang Yong-rim	강영림	Investigation to Formation Mechanism of Nano-Scale Porous Silicon by a Random Walk Model
Choi Yong-gil	최영길	Acoustical Field for Branch-Cut Integral of Longitudinal Wave and Transversal Wave within Solid Bar with the Solid-Porous Media Boundary
Ri Un-sun	리운선	Acoustical Field for Branch-Cut Integral of Longitudinal Wave and Transversal Wave within Solid Bar with the Solid-Porous Media Boundary
Ri Song-yi	리송이	Calculation of the Acoustic Field Taking into Consideration the Influence of the Surface and Bottom of the Sea
Hwang Sung-chol	황성철	Calculation of the Acoustic Field Taking into Consideration the Influence of the Surface and Bottom of the Sea
Ri Song-yi	리송이	Change Characteristics of the Acoustic Field in the Shallow Sea
Chung Hyung-sok	정형석	Change Characteristics of the Acoustic Field in the Shallow Sea
Choi Sang-chol	최상철	Strain of Optical System and Reconstruction Image in Lensless Fourier Holography for Digital Holography
Ryeo In-kwang	려인광	Strain of Optical System and Reconstruction Image in Lensless Fourier Holography for Digital Holography
Choi Sung-in	최성인	Analysis of Optical System and Reconstruction Image in Lensless Fourier Holography for Digital Holography
Choi Il-su	최일수	Analysis of Optical System and Reconstruction Image in Lensless Fourier Holography for Digital Holography
Ri Il-hyok	리일혁	Calculation of Discrete Fresnel Diffraction Field in the Case of Different Lengths of Object and Image
Choi Il-su	최일수	Calculation of Discrete Fresnel Diffraction Field in the Case of Different Lengths of Object and Image
Choi Sung-in	최성인	Deformation Measuring of Difusely Reflecting Object by Digital Holography
Song Kum-hyon	송금현	Deformation Measuring of Difusely Reflecting Object by Digital Holography
Kong Jin-hyok	공진혁	Characteristics of Y-Optical Fiber Probe for the Surface Inspection of Metal
Ha Chol-jin	하철진	Characteristics of Y-Optical Fiber Probe for the Surface Inspection of Metal
Kong Myong-nam	공명남	Preparation of Pyroelectric Infrared Alarm Device with PLT Thin Film Sensors
Choi Chun-sik	최춘식	Preparation of Pyroelectric Infrared Alarm Device with PLT Thin Film Sensors
Yoo Yong-ju	유영주	Preparation of Pyroelectric Infrared Alarm Device with PLT Thin Film Sensors
Chang In-gol	장인걸	Microwave Response Feature of Y-System High Tc Superconducting Thin Film Electromagnetic Wave Sensor
Kang Yong-kwan	강용관	Microwave Response Feature of Y-System High Tc Superconducting Thin Film Electromagnetic Wave Sensor
Ko Il-ho	고일호	Microwave Response Feature of Y-System High Tc Superconducting Thin Film Electromagnetic Wave Sensor

Kim Sun-chol	김순철	Parameters Controlling the System of Cluster Generation and Deposition
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Choi Ryu-sung	최류성	Automatic Balance Type Microwave Power Meter
Cho Sung-il	조승일	Automatic Balance Type Microwave Power Meter
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Cha Yong-jin	차영진	Optical Efficiency of Broad Area IRED
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Han Jung-ho	한정호	Effect of Thermal Annealing on UV and Visible Emitting Properties of ZnO Thin Films
Pak Ho-nam	박호남	Effect of Thermal Annealing on UV and Visible Emitting Properties of ZnO Thin Films
Kim Sang-ryong	김상룡	Growing of SnO2 <F> Film by PECVD Method and Its Feature
Han Myong-ok	한명옥	Growing of SnO2 <F> Film by PECVD Method and Its Feature
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Ju Duk-yong	주덕영	Effect of AC Frequency on Etching Property of STM W-Tips
Kim Myong-chon	김명천	Effect of AC Frequency on Etching Property of STM W-Tips
Choi Kyong-su	최경수	Effect of AC Frequency on Etching Property of STM W-Tips
Yun Chol-min	윤철민	Prediction of Products' Constitution in High Pressure High Temperature Reacting System
Kim Su-gon	김수건	Prediction of Products' Constitution in High Pressure High Temperature Reacting System
Han Nam-su	한남수	Prediction of Products' Constitution in High Pressure High Temperature Reacting System
Kim Kyong-il	김경일	Performance Evaluation of Blind Channel Indentification Methods for the Dereverberation of the Underwater Acoustic Signal
Kim Sok-chol	김석철	Performance Evaluation of Blind Channel Indentification Methods for the Dereverberation of the Underwater Acoustic Signal
Kim Myong-jin	김명진	A Result of Analysis of 3D Diffuse Acoustic Field
Cho Yong-hee	조영희	A Result of Analysis of 3D Diffuse Acoustic Field
Pae Myong-hee	배명희	A Method for Feature Extracting of Underwater Acoustic Signal by Using Wavelet Packet Transform
Chon Yong-su	전용수	A Method for Feature Extracting of Underwater Acoustic Signal by Using Wavelet Packet Transform
Heo Ryong-hak	허룡학	Beat Series Recognition of Music
Kim Ju-yong	김주영	Beat Series Recognition of Music
Kang Won-kil	강원길	Stochastic Resonance of Hodgkin-Huxley System
Ri Kwan-ho	리관호	Stochastic Resonance of Hodgkin-Huxley System
Pae Jin-sung	배진성	Estimating Situation of Non-Linear System by the Structural Feature of Strange Attractor
Kim Kyong-chol	김경철	Analysis of Sunspot Activity by Non-Stationarity Time Series Model
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Ri Yong-il	리영일	Calculation of the Artificial Satellite's Orbit by a Numerical Integral Method
Seo Sung-ryol	서승렬	Ground Motion Synthesis by Stochastic Simulation Method
Chung Song-su	정송수	Ground Motion Synthesis by Stochastic Simulation Method
Kim Jong-chol	김정철	Time-Change of Tidal Stress Field
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Mun Sung-chol	문성철	Time-Change of Tidal Stress Field
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Kim Ha	김하	Theory of d-Density Wave Induced by Antiferromagnetic Spin-fluctuations in High-Tc Superconductor
Kim Hyok-chol	김혁철	Influence of Interband Charge Density Excitation on Raman Scattering Spectrum of Cuprate High-Tc Superconductors
An Chung-kwan	안정관	Influence of Interband Charge Density Excitation on Raman Scattering Spectrum of Cuprate High-Tc Superconductors
Han Mun-won	한문원	A Study on Quantum Tunneling Phenomenon in Ferromagnetic Nanoparticles
An Chung-hoon	안정훈	A Study on Quantum Tunneling Phenomenon in Ferromagnetic Nanoparticles
Kim Myong-sun	김명선	An Electronic Structure Calculation Based on Wavelet Bases
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Kim Myong-sun	김명선	Comparison Between Method Based on Plane-wave Base and a New Method Based on Wavelet Base for Two-atomic Molecules
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Kim Jung-chol	김정철	Information-theoretic Consideration on Quantum Cryptography Using POVM
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Ham Sok-chon	함석천	Dispersion of Rayleigh Wave Propagating along the Generating Line on Circular Cylindrical Surface and an Optimum Exciting by Plane Oscillator
Ryu Sung-muk	류승묵	Dispersion of Rayleigh Wave Propagating along the Generating Line on Circular Cylindrical Surface and an Optimum Exciting by Plane Oscillator
Song Sung-chol	송승철	Three-dimensional Coordinates Measurement of a Small Object by Digital Camera
Kang Un-sil	강은실	Three-dimensional Coordinates Measurement of a Small Object by Digital Camera
Ji Yu-sung	지유성	Method of Calculation on the Main Parameters of a Diffusion-cooled RF (radio frequency) Discharge CO2 Laser Design
Ri Chang-sun	리장순	Method of Calculation on the Main Parameters of a Diffusion-cooled RF (radio frequency) Discharge CO2 Laser Design
Ri Kum-chol	리금철	Quasi-CW Discharge of Xe Lamp and Effect on Oscillation of Nd3+:YAG Laser
Kim U-hyon	김우현	Quasi-CW Discharge of Xe Lamp and Effect on Oscillation of Nd3+:YAG Laser
Choi Un-hwa	최은화	State Change of Dyeing Solution in Magnetic Field
Kim Kyong-gi	김경기	State Change of Dyeing Solution in Magnetic Field
Ji Chol-ryong	지철룡	Growth of YBCO High-Tc Superconducting Thin Film on MgO/Si (111) Substrate
Chang In-gol	장인걸	Growth of YBCO High-Tc Superconducting Thin Film on MgO/Si (111) Substrate
Kim Sung-ho	김성호	Manufacture of the Thermoelectrical Element PbTe by the Method of Powdered Alloy and Its Properties
Han Ryong-chol	한룡철	Manufacture of the Thermoelectrical Element PbTe by the Method of Powdered Alloy and Its Properties
Choi Hyon-sung	최현성	Growing of Band-type Single Crystal by the Method of Pulling the Melting Liquid
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Han Yong-won	한영원	Thermodecompose Kinetic of Binary Compounds Ca2CuO3, Sr2CuO3 of Bi-system High-Tc Superconductor

Choi Yun	최윤	Thermodecompose Kinetic of Binary Compounds Ca2CuO3, Sr2CuO3 of Bi-system High-Tc Superconductor
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Pak Chi-bong	박치봉	Method Determining the Geothermal Field from Geothermal Data
Im Sung-jin	임성진	Timing Jitter Reduction Using Decision Function in Dispersion Managed Fiber Transmission
Kim Il-kwang	김일광	Timing Jitter Reduction Using Decision Function in Dispersion Managed Fiber Transmission
Ri Il-hyok	리일혁	Spectral Analysis by Digital Camera
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Ri Ho-nam	리호남	Flexible Vibration of Piezo-Electric Ceramic Stick
Kim Sung-kyu	김승규	Nonrelativistic Calculation for the Electronic States of Atoms without Central Field Approximation
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Seo Yong-won	서영원	The 3-D Distribution of Particles by Digital Holography
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Kim Jae-hwa	김재화	Computation for the Radiation Impedances of Acoustic Transducers on a Perfectly Resilient Infinite Planar Baffle by Boundary Element Method
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Ryu Sung-muk	류승목	A Design Method of Underwater Acoustic Transducer Used of the Width Direction Vibration of Rectangular Piezo-ceramic Vibrator
Kim Kyong-gi	김경기	Manufacture of Nd Bond Magnets by HDDR Method
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Ri Sung-bom	리성범	Calculation of Order Parameters of Binary Alloys with Vacancy Migration by Monte Carlo Computer Simulation
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Kim Jik-su	김직수	3-Dimensional Theory of the Non-stationary Radiative Transfer
Han Nam-su	한남수	3-Dimensional Theory of the Non-stationary Radiative Transfer
Ri Gwi-chol	리귀철	Effect of Carrageenan on the Dispersion of Piezo-Electric Ceramic Powder and the Preparation of Membranes

Chae Chol-ung	채철웅	Effect of Carrageenan on the Dispersion of Piezo-Electric Ceramic Powder and the Preparation of Membranes
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Ri Myong-kyu	리명규	Counting of Relax Time in High Temperature Plasma-Heating by Relativistic Charged Particle Beam
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Seo Hak-bong	서학봉	Characteristics of Al Alloys for Metal-Air Battery
Kim Hae-ryong	김해룡	Characteristics of Al Alloys for Metal-Air Battery
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O Jin-wi	오진위	Effect of Electrolytic Liquid Specific Gravity on Output Characteristics of Microbend Optical Fibre Sensor
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Ri Un-sun	리운선	Propagation of Acoustical Wave through Infinite Cylindrical Solid Bar Surrounding by Fluid-Porous Media
Choi Yong-jo	최영조	Propagation of Acoustical Wave through Infinite Cylindrical Solid Bar Surrounding by Fluid-Porous Media
Kim Hyon-chol	김현철	An Azimuth Tracing System of Sound Source Used of Sound Intensity
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Nam Sok-chon	남석천	Magnetic Reconnection as a Reason of Disappearance of Filament in Solar Atmosphere
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Kim Sung-ki	김성기	Ferroelastic Phase Transition in Cristobalite-SiO2
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Kim Jik-su	김직수	Energy Release of Scalar Fields and Explosive Phenomena on Cosmic Scale

Jung Chol-myong	정철명	Temperature Dependence Estimation of Some Magnet Characteristic Quantities in R2Fe11B Compounds with Monte Carlo Method
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Kim Song-il	김송일	Calculation of the Critical Temperature of Ising Ferromagnetic System Based on the Spin Cluster Analysis
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Ri Yong-hwan	리영환	Site Symmetry and Symmetry Coordinates of the Crystal with Space Groups, D1ah3, D174h
Kim Il-hwan	김일환	Site Symmetry and Symmetry Coordinates of the Crystal with Space Groups, D1ah3, D174h
Ri Chol-san	리철산	Thermal Effect of Composite Material of Metal Oxides
O Sung-il	오성일	Thermal Effect of Composite Material of Metal Oxides
Kim Kwang-hyon	김광현	Improvement of the Quality of Reconstructed Image in CGH
Seo Yong-won	서영원	Improvement of the Quality of Reconstructed Image in CGH
Cho Kum-ho	조금호	Distribution of the Dislocation of GaAs Crystal in Plastic Deformation
Pak Chung-hwan	박정환	Distribution of the Dislocation of GaAs Crystal in Plastic Deformation
Ri Yong-sok	리영석	Orientation of Domains in Piezoelectric Ceramics, Pb
Ryeo In-kwang	려인광	Orientation of Domains in Piezoelectric Ceramics, Pb
Kim Kum-sok	김금석	Dynamo a--Effect in Production of Magnetic Helicity of Solar Atmosphere
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O Ri-chol	오리철	Influence of Several Factors on the Crystal Growth of TiO2 Nanoparticle in Liquid Phase
Kim Kwang-hyon	김광현	Optimal Design of CGH with Continuous Phases and Generation of Hologram with Reconstructive Multi-Images on Diffraction
Ri Kil-son	리길손	Dissociation of CO2 Molecules in Sealed-off CO2 Laser Active Medium
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Kim Jun	김준	Frequency Mixing Characteristics of Josephson Junction
Kim Kyong-gi	김경기	Frequency Mixing Characteristics of Josephson Junction
An Ung-bom	안응범	Effect of Magnetic Field on Hydrogen Bond
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Han Sung-won	한승원	Study on Rotational Spectra of Diatomic Molecules by Nonlinear SU (2) Symmetry
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Choi Il-su	최일수	Reconstruction of Virtual Image in Digital Holography
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Ji Jang-ju	지장주	Iron Oxide Magnetic Powder for Magnetic Recording
Kim Yong-ki	김용기	Iron Oxide Magnetic Powder for Magnetic Recording

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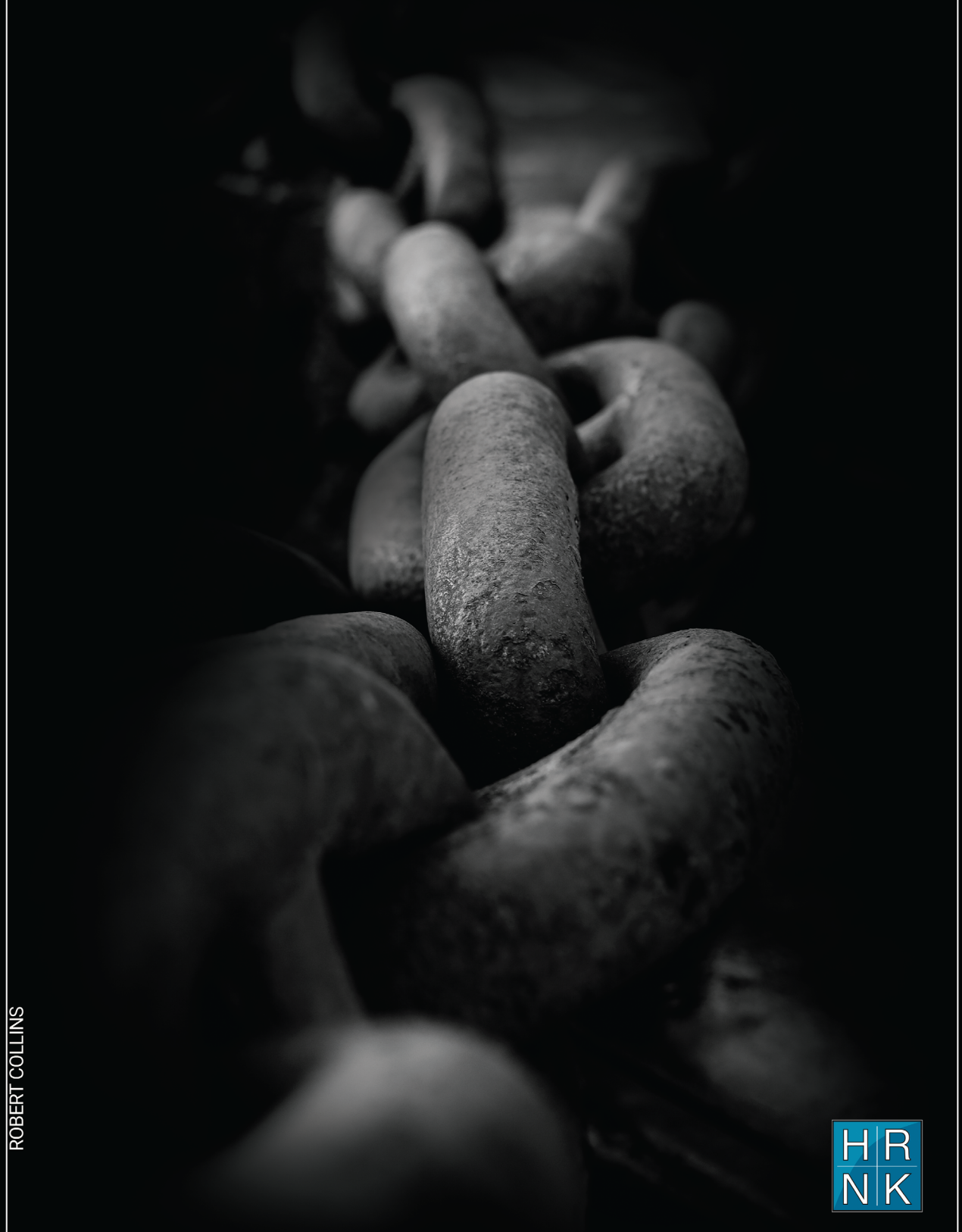

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