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Envisioning Scientific Innovation in Korea's Demilitarized Zone: A Step toward Economic Progress and Global Peace

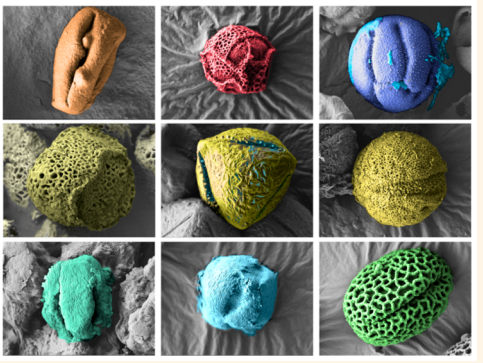
Jong-Lok Yoon,[†] Paul S. Weiss,[‡] and Nam-Joon Cho*[,§]

[†]Department of Computer Engineering, Gachon University, 1342 Seongnamdae-ro, Sujeong-gu, Gyeonggi-do, 13120, Korea

[‡]California NanoSystems Institute, Department of Chemistry and Biochemistry, and Department of Materials Science and Engineering, University of California, Los Angeles, Los Angeles, California 90095, United States

[§]School of Materials Science and Engineering, Nanyang Technological University, 50 Nanyang Avenue, Singapore 639798, Singapore

ABSTRACT: **Ongoing progress in inter-Korea relations suggests that a new era of peace could soon emerge on the Korean Peninsula. There is renewed hope for scientific cooperation between the two Koreas, along with broader engagements with other stakeholders. Key needs include managing the region's biodiversity and fostering economic progress with an eye toward potential unification. Herein, we introduce current efforts to preserve the biodiversity of the Demilitarized Zone (DMZ) through conservation efforts, while discussing how the DMZ question highlights a broader need to promote scientific innovation and economic development through mutual cooperation. Using the DMZ as an example, we discuss how sustainable natural resources, such as pollen grains present there, might serve as a catalyst to promote scientific cooperation, foster high-tech innovation, and generate economic impact. Looking forward, such efforts will hopefully lead to a bright future on the Korean Peninsula and global peace.**



The Korean War was one of the 20th century's deadliest military conflicts and resulted in the splitting of the Korean peninsula into two separated nations, South and North Korea. For more than 70 years, the division has had enormous geopolitical ramifications and been one of the defining issues of global diplomacy. At its heart lies the separation of the Korean people and the emotional toll that this separation carries. Families have been divided and the two Koreas have evolved along divergent developmental pathways. Today, South Korea is one of the world's richest and most technologically developed nations, while North Korea remains largely isolated and has endured major famines and political challenges.

One of the starkest reminders of this division is the Korean Demilitarized Zone (DMZ), which is a 4 km wide buffer zone that has separated the two nations since a ceasefire agreement was signed in 1953. Untold numbers of soldiers and weapons line each side of the DMZ, and military ordnance such as landmines is spread across its fields. It is a nearly impenetrable barrier that is a very real reminder that the two Koreas remain in a *de facto* state of war.

Remarkably, the DMZ also highlights the beauty of Korea and preserves its natural history (Figure 1). Comprising wetlands, forests, mountains, valleys, and fields, the DMZ and the neighboring civilian control zones constitute a protected sanctuary for many types of animals and plants.[1] It is estimated that there are over 100 species of fish, 1000 species of insects, 45 types of amphibians and reptiles, 1600 types of plants, and 300 species of mushrooms and fungi. It is home to endangered birds like the white-naped and red-crowned cranes, and there have been unconfirmed sightings of tigers, which were thought to have been extinct on the peninsula since the early 1900s.[2] What stands out most is that biodiversity in the DMZ has thrived while other parts of the peninsula have suffered environmental challenges. South Korea has faced explosive population growth and increasing urbanization, while North Korea has suffered from ineffective agricultural policies and widespread deforestation. Environmental issues are a common concern across the peninsula, and the DMZ represents one of the most pristine ecological sanctuaries on the peninsula and a harbinger of what peace may bring.

Even so, arguably the greatest threat to the DMZ and its biodiversity is not war but peace. The recently held talks between North Korea and South Korea (and other countries) open the door to the potential denuclearization of North Korea and a permanent peace agreement to end the Korean War.

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Figure 1. Modern-day picture of the Korean Demilitarized Zone (DMZ). The DMZ is a buffer zone that is approximately 260 km long and 4 km wide, and separates North Korea and South Korea. Photo Credit: Rex Wholster/Shutterstock.com image used under license from Shutterstock.com.

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With the first-ever summit meeting between the United States and North Korea to be held in the coming days, the prospects for peace on the Korean peninsula have rarely been brighter, and it has even been suggested that unification of the two Koreas might be possible. In turn, there is growing optimism for building stronger scientific cooperation between North Korea and the rest of the word, and working together on issues in public health and geology, among other possibilities.[3,4] At the same time, such progress would likely lead to rapid development of the DMZ, which sits directly in between the two nation's capital cities and which would erode its biodiversity.

In response to this potential environmental risk, there have been efforts to conserve the DMZ's ecological beauty through a variety of proactive measures. One example includes creating conservation areas and educating local farmers, and ecotourism has also been promoted in adjoining areas.[5] It has been proposed that the DMZ might eventually become a UNESCO-designated World Heritage Site. Importantly, some of these efforts have taken place in both Koreas and, in many cases, the two nations share aligned views for ecological conservation, highlighting opportunities for mutual cooperation.

Within this scope, it deserves attention that most scientific efforts involving the DMZ focus on ecological preservation. This is undoubtedly a critical issue, not only for preserving Korea's history but also for supporting biodiversity to benefit mankind and other life forms. At the same time, it must be emphasized that successful Korean unification would be one of the greatest social challenges of modern times. It would likely be significantly more costly than German reunification and estimated to reach into the trillions of dollars and take decades to achieve.[6] Under such circumstances, ecological preservation would ideally be tied together with an economic driving force in order to remain a high priority throughout the unification process. One possible motivation would be fostering the expansion of high-tech industries in South Korea, which are currently dominated by the information and communication technology (ICT) sector.[7]

Toward this goal, harnessing the natural resources of the DMZ in sustainable ways would provide significant value to foster prosperity, especially in areas where people from the two Koreas could work together. Indeed, collaborative efforts such as the ongoing Kaesong Industrial Complex where North Korean workers are employed by South Korean companies demonstrate the potential of inter-Korean cooperation.[8] Extending such efforts to a revitalized DMZ could lead to the utilization of high-value natural resources that have been shown to aid postconflict stabilization, spurring job creation and economic growth.[9] While high-value resources have been commonly associated with materials such as oil, gas, and minerals, realizing this potential with sustainable materials might facilitate ecological conservation and economic development while promoting scientific cooperation and technological innovation.[10]

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One example of a promising material fit for this task would be plant pollen grains, which are largely hollow biological microcapsules that play an important role in the reproduction

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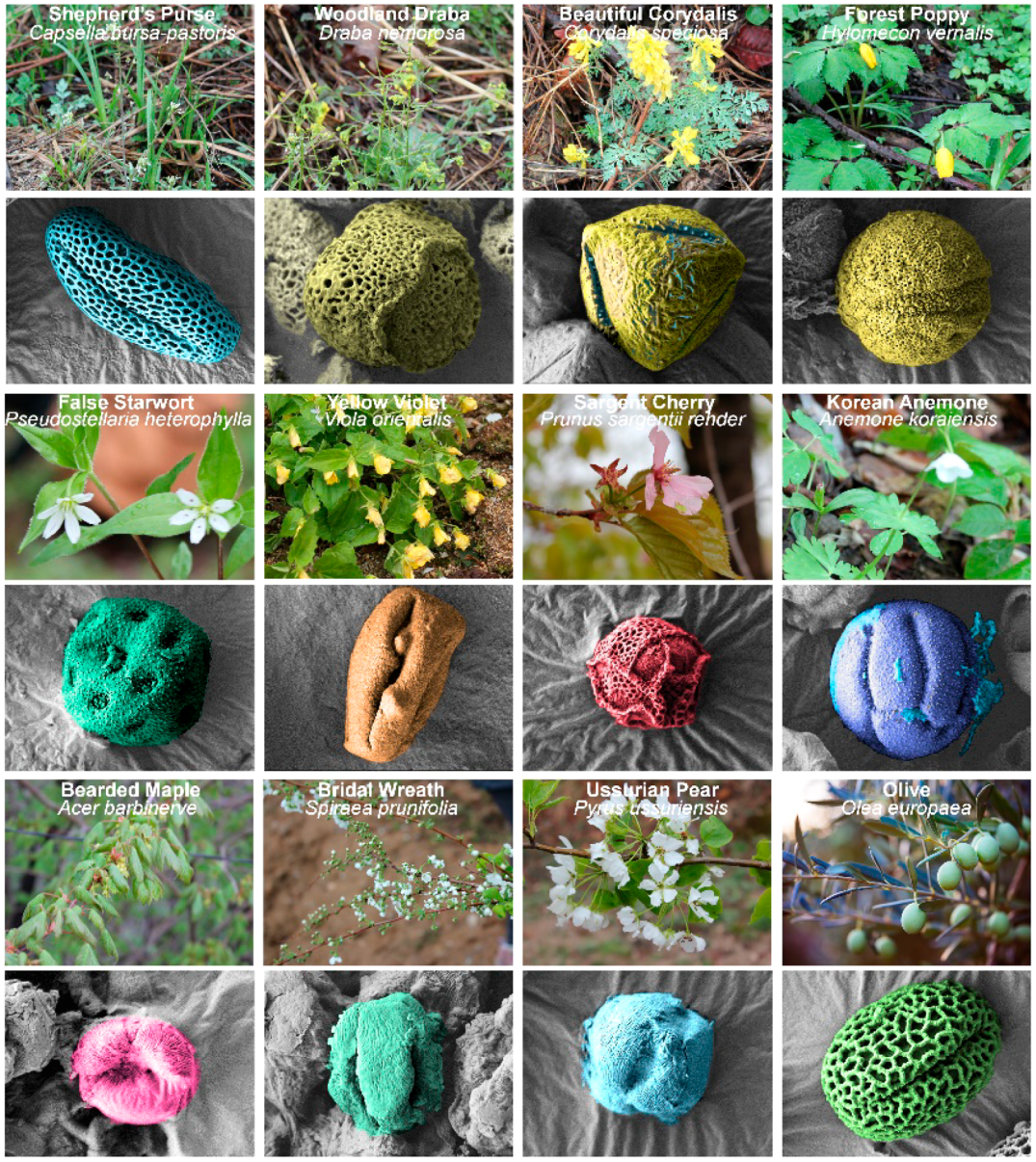

Figure 2. Biodiversity of plant species and pollen grains in the Korean Demilitarized Zone (DMZ). Optical images (top) and scanning electron microscopy (SEM) micrographs (down) are presented for flowering plants and defatted pollen particles, respectively, of various plant species found in the DMZ. The diameter of pollen grains is around 5 to 30 μm depending on the plant species. Photo Credit: Su Young Jung and Sang-Joon Cho.

of seed plants. Plant pollen is widely used in traditional medicine and is reported to have nutritional and health benefits.[11] Pollen has gained more recent attention as a material because pollen microcapsules have attractive properties for biotechnology and drug-delivery applications.[12] In particular, the outer shell of pollen microcapsules is composed of sporopollenin, which is considered the diamond of biopolymers, and demonstrates excellent chemical and physical stability.[13] Impressively, every species of seed plant renewably produces pollen microcapsules with unique architectural features and the particles are monodisperse, far exceeding synthetic production capabilities in terms of output and efficiency. We recently collected pollen samples from various plant species around the DMZ's Native Botanical Garden and identified that many of the pollen grains yield useful microcapsules that deserve further attention (Figure 2).

Moreover, in order to ensure successful reproduction, plants renewably produce vast excesses of pollen grains, and therefore they can be used sustainably in a wide range of applications where microcapsules are in high demand. Such possibilities might even help to address international scientific issues like the growing calls to stop using plastic microbeads, and pollen microcapsules could perhaps be an alternative, organic substitute.[14]

In terms of mutual cooperation, the field of pollen materials represents an ideal subject where a low-value, renewably abundant material can be converted into a high-value material with practical utility, highlighting the potential for working together across borders to promote innovation and economic growth (Figure 3). For example, pollen materials research is highly active in Singapore, and these efforts have uncovered simple and effective steps to make pollen grains commercially

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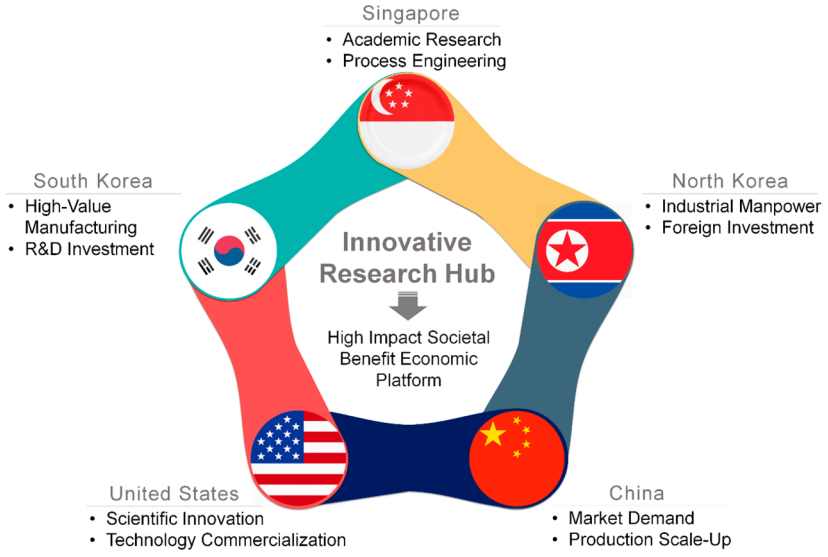

Figure 3. Conceptual illustration of how the two Koreas can work together with international partners to promote scientific innovation and economic impact.

useful across various applications. The processing steps by which pollen grains are made would fit well within the high-value manufacturing skills of South Korea together with the industrial manpower capabilities of North Korea. Scientific cooperation could also lead to the growth of different job sectors and spur industrial innovation. For example, in South Korea, the vast majority of graduates of medical and pharmaceutical schools enter service professions while there is a tremendous need for the growth of innovation-related opportunities in the medical, health, and pharmaceutical industries in order to foster international competitiveness for the long-term. It would also open the door to greater cooperation with other key nations such as China, where pollen is widely used in traditional medicine and there is already a large market, and the United States, which is one of the world's leaders in microencapsulation technologies. Although pollen materials are just one example, they highlight the potential that lies ahead for building new industries by harnessing the forestry of the DMZ in creative ways and creating win–win partnerships between nations. Ultimately, finding ways to promote economic innovation through science and nature will help provide tools for success in the exciting future that lies ahead on the Korean peninsula and the world peace that may come.

AUTHOR INFORMATION

Corresponding Author

*E-mail: njcho@ntu.edu.sg.

ORCID

Paul S. Weiss: 0000-0001-5527-6248

Nam-Joon Cho: 0000-0002-8692-8955

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