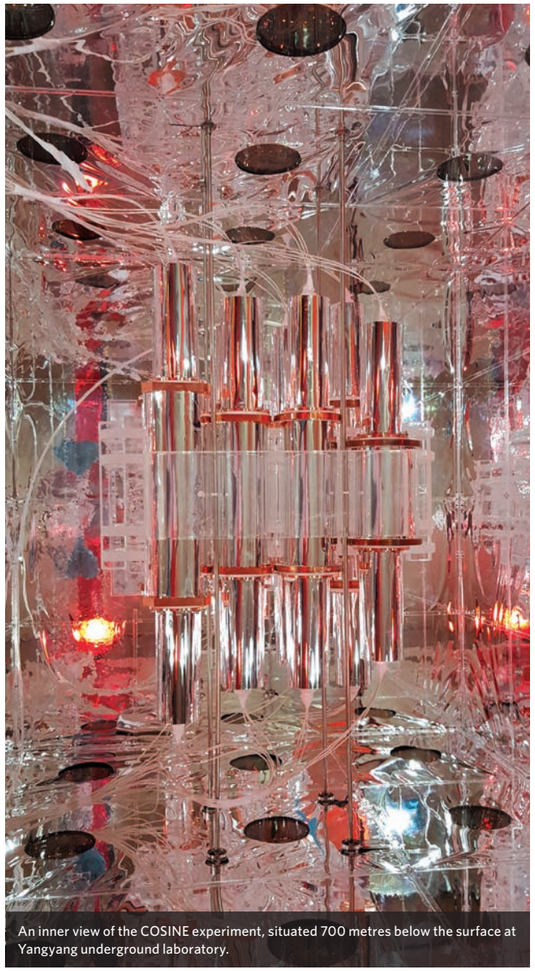
From basic to breakthrough

In fewer than 10 years the Institute for Basic Science has evolved from an idea to A MULTI-DISCIPLINARY WEB OF 30 RESEARCH CENTRES TACKLING some of the most fundamental scientific questions of our time.



An inner view of the COSINE experiment, situated 700 metres below the surface at Yangyang underground laboratory.

South Korea's first institute dedicated to pure basic research, the Institute for Basic Science (IBS), was established in 2011 with the aim of generating the types of fundamental 'breakthrough' discoveries that could propel the country to the global stage and be a new driver of economic and social development.

"IBS HAS GIVEN US ALL THE OPPORTUNITY TO LEARN SOMETHING COMPLETELY NEW, AND TO CREATE A NEW SCIENTIFIC LANDSCAPE."

The IBS created an entirely new research system from the ground up, bringing together the essential components for a fertile research environment; substantial state funding, research autonomy, and a commitment to long-term, large-scale, open-ended research institutes in exploratory and speculative science.

From its headquarters in the hub city of Daejeon, an hour south of Seoul, the IBS has established 30 research centres covering themes as diverse as cognition and sociality, underground physics, RNA, catalytic hydrocarbon functionalizations, artificial low dimension electron systems, neuroscience imaging, climate physics and quantum nanoscience, and is adding new centres every year.

IBS's particular strength in the physical sciences is reflected in its place in the top 100 global academic institutions in physical sciences in the 2020 Nature Index Annual Tables. This research is facilitated by the institute's large-scale facilities, such as the Yemilab.

Searching for dark matter

"We know that dark matter must be five times more abundant in the universe than the visible matter we can see, but we still don't know what it is. It is one of the most critical unknowns in our understanding of the structure and history of the Universe," says Yeongduk Kim, director of the IBS Center for Underground Physics.

It is thought that the particles possibly making up dark matter — weakly interacting massive particles (WIMPs) — could be detectable by flashes of light produced when they hit a scintillating crystal medium. As other forms of ionizing radiation such as cosmic rays also cause these flashes, scientists house these crystals in lead boxes deep underground to shield the detector from anything but WIMPs.

"We are constructing Yemilab, a deep underground laboratory, at Jeongseon-kun, to continue our search for evidence of dark matter," says Kim.

The Center for Underground Physics used another underground laboratory, the Yangyang Laboratory, to conduct the 'COSINE-100' dark matter experiment, with results recently published in *Nature*. "COSINE-100 is a pioneering experiment set up to challenge the DAMA experiment in Italy," says Kim. DAMA is a renowned experiment that has detected a regular annual periodicity in scintillations over the past 20 years, thought to be due to the relative motion of the Earth's orbit around the Sun. But the result has not been able to be replicated elsewhere, shedding doubt on the observation's interpretation.

"Our results have been useful, but not definitive, due to background noise. We have designed the COSINE-200 experiment at Yemilab, based on our long experience at Yangyang, using a much larger mass of ultra-low-radiation crystals which we also produce here. We expect this next experiment to have a much lower background and so will be able to verify the DAMA claims definitively."

Climate change and human evolution

At the other end of the scientific spectrum, and illustrative of IBS's research diversity, is the climate modelling being undertaken by the IBS Center for Climate Physics.

"As the only Earth science centre in the IBS, we are expanding the frontiers of Earth system science by linking our understanding of past climate evolution with projections of future climate change including impacts on the hydrological cycle, ice sheets, sea level and regional processes," says the centre's founding director, Axel Timmermann.

"When I started the centre in 2017, we designed a new supercomputing system that would be optimally suited for extremely long and high spatial resolution climate model simulations," says Timmermann. "This system is now one of South Korea's flagship supercomputers, which enables our extremely data- and computing-intensive research."

"One of our research themes is a multi-disciplinary study of how past climate changes have influenced human evolution, where we develop computer models to simulate early human dispersals, gene flow and adaptation strategies in the presence of fluctuating glacial climate and vegetation environments," he adds.

Results recently published by Timmermann's team in *Nature* show that early human migration events did not occur randomly, but were probably paced by astronomically induced changes in climate and vegetation.

A global player

It is work such as this on dark matter and climate modelling that has led to IBS's number 3 position in the 2020 Nature Index Annual Tables in South Korea and its rank within the top 20 global government institutions.

The institute's role as a global player is further reflected by its research output in the natural sciences. On a normalized basis, IBS competes with the world's top institutions in terms of the proportion of its high-quality research output (as measured by Nature Index) within its overall article output in natural sciences (as measured by Dimensions).

IBS's research achievements, combined with its investments in infrastructure, leadership by outstanding scientists, and early-career researchers — through its IBS's Young Scientist Fellowship — demonstrate that supporting basic science will ultimately help foster fundamental breakthroughs.

It is a philosophy that suits Timmermann: "The IBS offers an amazing research environment, which has given us all the opportunity to learn something completely new, and to create a new scientific landscape," he says. ■

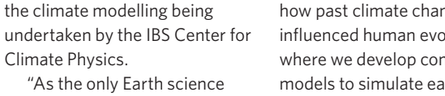
IBS IN THE NATURE INDEX

THE INSTITUTE FOR BASIC SCIENCE has performed particularly well in physical science, as indicated by its output in the Nature Index 2020 Annual Tables.

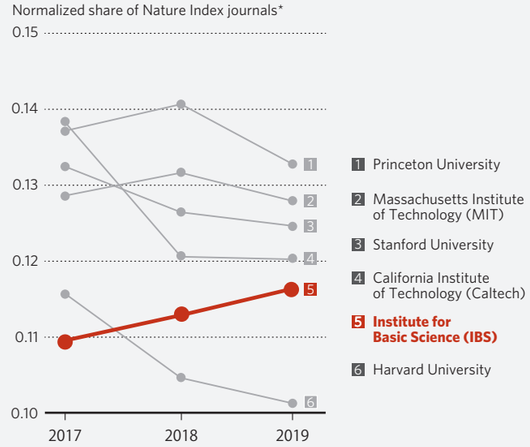
2020 ANNUAL TABLES (SHARE 2019)

RANKED	TOP	RANKED
#3	100	#17
in South Korea	globally in physical science	government institution globally

SHARE PER YEAR FROM 2015 TO 2019



NORMALIZED ARTICLE OUTPUT BETWEEN 2017 AND 2019



*Output has been normalized by article counts in Dimensions, for Natural sciences articles.

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