

Between Fraud and Hope: Stem Cell Research in Korea after the Hwang Affair

Myungsim Kim, Jongyoung Kim, and Hee-Je Bak

Received: 7 March 2016 / Accepted: 27 April 2017
© 2017 Ministry of Science and Technology, Taiwan

Abstract This study analyzed the influence of the Hwang scandal on the stem cell research community and research governance systems in South Korea. In contrast to the claims of some critics that the fraud scandal might raise doubts about Korean stem cell science, the impact of the Hwang scandal on publications by Korean stem cell researchers in international scientific journals proved limited, with only a temporary halt in research and publications. On the one hand, Korea's scientific community has moved toward the ethical turn through which the Korean government tightened its research-ethics standards and regulations. On the other hand, the government and scientific community remain hopeful about stem cell research. Consequently, the politics of hope have led to the quick recovery of Korean stem cell science from the potential damage caused by the Hwang scandal. The scandal accelerated the South Korean government's efforts toward research ethics reform: it mandated universities and research institutes to create and strengthen institutional review boards and other research-integrity committees. In addition, the Korean government, maintaining its optimism about the economic value of stem cell science, continued to fund stem cell research. Despite the seemingly prompt recovery from the scandal, however, stem cell research governance systems in Korea face a serious new challenge: the ethical and safety concerns associated with the rapid commercialization of stem cell science. Therefore, this article views the changes in the scientific community as a process of conflict and negotiation between the accountability crisis in the Korean scientific community and the politics of hope in science.

M. Kim
Center for Science, Technology, and Society, Kyung Hee University, Republic of Korea
e-mail: shann12@khu.ac.kr

J. Kim
Department of Sociology and Center for Science, Technology, and Society, Kyung Hee University, Republic of Korea
e-mail: jkim24@khu.ac.kr

H.-J. Bak
Department of Sociology and Center for Science, Technology, and Society, Kyung Hee University, Republic of Korea
e-mail: hbak@khu.ac.kr

Keywords ethical modernization · Hwang scandal · politics of hope · science governance · stem cell science

It has been a decade since a case of scientific misconduct in Seoul, South Korea, became a worldwide scandal. The scientific fraud perpetrated by Woo-Suk Hwang and his group at Seoul National University (SNU) is one of the most notorious in recent medical history. Hwang's publications in the field of human embryonic stem cell (hESC) science—in particular, two papers published in *Science* in 2004 and 2005—attracted international attention because they were considered landmark articles that contained breakthrough research in one of the most competitive fields of biomedical research. These two papers were seen as showing the enormous potential for further progress in research and industrial applications. Hwang was hailed as a national hero, who, with his extravagant claims about the benefits of stem cell treatments, would propel South Korea to the forefront of stem cell research. But soon the party was over: his alleged breakthroughs were shown to be cases of brazen scientific fraud. The investigative committee established by SNU announced in its final report that the data in the 2005 paper were an intentional fabrication (Gottweis and Kim 2010; Kang, Kim, and Han 2006; Seoul National University Investigation Committee 2006).

In this article, we examine the ramifications of this international scandal by looking at what happened in stem cell science and science governance systems in Korea after the Hwang affair. Our research differs from conventional research on scientific misconduct in two ways. First, we view the research misconduct as embedded in Korea's social and cultural environments. According to the conventional view of science, which has long attributed scientific misconduct to the lack of individual ethical integrity or personal motivations (Broad and Wade 1982), the Hwang scandal is merely another single case of scientific fraud. However, scholars of scientific misconduct have tended to see scientific fraud as intertwined with larger contexts, such as the characteristics of a specific field, institutional and cultural systems of science (including reward structure and collaboration culture), and the politics of science. For instance, Mary Fox and Catherine Faver (1984) have claimed that, as scientific research became more complex and was carried out by teams of researchers with different types of expertise, the peer monitoring system in science became increasingly ineffective and the opportunities for scientific fraud increased significantly. Along the same lines, noting that the Hwang scandal was linked to political interests, hierarchy in disciplines, national research culture, nationalism in Korea, and above all a weak scientific governance system in Korea that lags behind the global standard (Gottweis and Kim 2009, 2010; Gottweis and Triendl 2006; Kang, Kim, and Han 2006; Kim 2007; L. Kim 2008; T.-H. Kim 2008; Kim 2009; Kim and Park 2015), we pay attention to how the scandal, after the misconduct was revealed, has interacted with these social and cultural environments and, in so doing, has affected stem cell science in Korea.

Second, we analyze the consequences of research misconduct. Research on scientific misconduct, whether it has emphasized the ethics of individual scientists or a larger social context, has centered on why and how the misconduct happened. It has mostly ignored, save for a few passing remarks, the impact of scientific misconduct on, for instance, the discipline, national research governance systems, and public support for science. The literature is unsatisfactory, particularly when researchers look only at

the social contexts that foster scientific misconduct, because from this perspective the effective response to scientific misconduct should entail changing those cultural and social environments.

The present study examines what has transpired in stem cell research and the efforts to reform scientific ethics governance in Korea since the Hwang scandal. While some commentators had predicted that the scandal would have a significant impact on Korea's stem cell research community and its research governance systems, given the celebration of Hwang as a national hero and the massive support for his research by the Korean government (Gottweis and Triendl 2006), there have been few empirical studies of the impact of the fraud scandal on stem cell science and research governance systems in Korea.

Of course, the Hwang scandal has always been linked to many other factors, including the responses of the stem cell research community and the Korean government. The efforts to reform scientific ethics governance, for example, were under way in Korea before the Hwang scandal broke out. Nevertheless, the scandal might have had a significant effect on the breadth, depth, and speed of these efforts. The impact could be seen through concerns expressed in the stem cell research community and science policy circles in Korea that such a highly publicized instance of scientific misbehavior could lead to assumptions from outside the scientific community about the state of science in Korea and its standards of science ethics. The Hwang scandal should be understood, therefore, as a conditional influence more than as a direct causal effect.

We conceptually understand the changes in the scientific community after the Hwang affair as back-and-forth movements between the ethical turn or ethical modernization and the politics of hope in science. By *ethical turn*, we mean that the Korean scientific community underwent an accountability crisis and had to raise its ethical standards in the wake of an embarrassing scientific fraud. The self-regulation of the scientific community failed in the Hwang affair, and the government and civil society forced it to strengthen its regulations. Ethical modernization does not mean that all types of scientific misconduct disappeared or that the scientific community became fully accountable. Instead, ethical modernization designates a normative direction that drives and motivates ethical changes in scientific practices. Consequently, in this article, we present contradictions between introductions of formal regulations and actual practices. The ethical turn does not function smoothly, but it should be embedded in daily scientific cultures. The Korean scientific community has suffered from lack of trust for a long time because of its cliquish and heteronomous closures and cutthroat competition. To scientists, the ethical turn is a reluctant one because they must confront several onerous new regulations. The government had to enact new laws and regulations under pressure from Korean civil society and beyond, but at the same time it cannot give up the hope and promise of stem cell research. Because of the research's potential industrial benefits, the government resumed heavy investment in stem cell research after the Hwang affair. Ethical modernization is a process of conflict and negotiation between the accountability crisis in the Korean scientific community and the politics of hope in science, which have generated diverse contradictions in the reform of scientific community in Korea after the Hwang affair.

By *politics of hope*, we mean a phenomenon in which political decisions about whether or not to support scientific research are based upon unproved expectation and optimism that it will substantially benefit the society in the future. A hope technology

generates collective promise that it would bring technological miracles and progress (Franklin 1997: 203). Stem cell therapy, as one of the most important emerging hope technologies, has attracted public and government support even after the Hwang affair (Kim 2009). In the politics of hope, an unrealized future with collective hope, expectation, and promise constructs the present's policies. The far-reaching effects of expectations and promises on technological development have long been noted in the sociology and history of technology (Borup et al. 2006; Brown and Michael 2003; Schatzberg 1999). For example, engineers and stakeholders may want to develop a specific technology not because of its technical merit or practical utility, which is not yet demonstrated, but because of their belief in its promise, which is discursively mobilized. In contrast, the public may resist technological development out of fear that it may be harmful. Using the concept of the politics of hope, however, we emphasize the role of expectations in the political decisions at the state level. That is, our focus is on the ways in which expectations in a science or technology form the vision and prospects that serve as the basis for future investment by the government. In particular, biotechnology is a field that has taken shape under the overwhelming influence of hope and fear among political decision makers (Mulkey 1993; Rajan 2006; Rose 2007). A study of hESC research in South Korea has claimed that the Korean government's passionate support for biotechnology is a product of the collective vision of national sociotechnical imaginaries that articulate the role of science and technology in relation to the survival and well-being of the nation (Kim 2014). It is similar to the mass media's response to stem cell research in Japan that has emphasized keywords related to national promotion, which became more pronounced after the Nobel Prize was awarded to Japanese biologist Shinya Yamanaka, following the appearance of human induced pluripotent stem (iPS) cells (Shineha 2016).

Through these conceptual lenses of the ethical turn and the politics of hope, this study examines how the Hwang affair has affected stem cell science and science governance systems in Korea. We approached this study from two angles. First, we examined changes in the scientific governance system in Korea, especially the efforts to reform research ethics after the Hwang scandal. In addition to the literature review, we conducted in-depth interviews with twenty interviewees: ten prominent researchers in Korean stem cell science, four ethicists, two nongovernmental organization activists, and four business people, to understand the details of policy change and reactions among the research community (see the [appendix](#) for a description of respondents).

Second, we examined whether the Hwang scandal was followed by changes in the publication records of Korean scientists in the stem cell field and the Korean government's financial support for stem cell research. We used the Web of Science database (version 5.13; Thomson Reuters) to compile a list of 5,945 stem cell publications from 2000 to 2013 by Korean scientists in the stem cell field and classified them based on four key phrases: embryonic stem cell (ESC), adult stem cell, hESC, and iPS cell. We also examined documents from the Korean government for changes in its R&D funding for stem cell research.

After presenting our results, we discuss their implications. Scientific misconduct constitutes a major challenge for university administrators and policy makers. They must be able to limit the impact of such scandals on the reputation of their universities and on their national science system. In that sense, the policy lessons drawn from how

the South Korean government and the Korean scientific community responded to the scientific misconduct are more important than Hwang's scandal per se.

1 Research Misconduct in the Hwang Affair and Ethical Modernization

From today's vantage point, we can clearly see the details of misconduct in the Hwang affair. SNU's investigation and the prosecutor's investigation show the full picture of what happened on Hwang's research team and with his diverse collaborators. A Seoul National University Investigation Committee report (2006) reveals that Hwang's two science papers were fabricated, indicating that no stem cell lines were derived from the somatic cell nuclear transfer (SCNT) method (which involves denucleation of a human egg and insertion of a nucleus from an ordinary somatic cell). Meanwhile, the [Seoul Central District Prosecutor's Office \(2006\)](#) investigated hundreds of people who were connected with Hwang's scientific, political, economic, and academic networks. Shortly after the investigation, SNU fired Hwang, and the government barred him from conducting human stem cell research.¹

The blatant misconduct of Hwang and his team shocked Korean society. Hwang and his five collaborators were indicted and spent the next nine years going through the court system. The Korean Supreme Court found Hwang guilty of embezzling research funds and of acquiring eggs illegally. It also upheld Hwang's firing from SNU. After the Hwang affair, additional scandals and misconduct on the part of social notables came to light. Many actors and influential figures in the entertainment sector were found to have faked their degrees, and the Korean public was disturbed by their lies. Government ministers who came from academia had their research scrutinized. Some were found to have violated research ethics and consequently resigned. [Jongyoung Kim and Kibeom Park \(2013\)](#) argued that the Hwang affair exerted abrupt and enormous moral pressures on not only the scientific community but also the social realms, leading Korean society to ethical modernization. Ethical modernization means that economic development should be corrected by a trust-based society and that Korean society should achieve moral progress in the public realm. Serious doubt was cast upon the growth-centered and results-first mentality and culture that dominated Korea's social realms. Ethical modernization as a social remedy is a general trend that the Hwang affair generated. Although Kim and Park's concept of ethical modernization tends to generalize Korea's ethical reforms, actual practices and implementation after new regulations require close examinations, the goal of our study.

¹ Hwang was fired from his position at SNU in 2006, but he filed a lawsuit to regain his position. In 2014 the Korean Supreme Court decided that SNU's action was legitimate. Though his political alliances had almost collapsed, Hwang's patrons and supporters contributed to the founding of his new laboratory, Soom Biotech Research Institute. His research team received major news coverage for the commercial cloning of dogs. In addition, a joint mammoth-cloning project with a Russian team received international attention that was the topic of a National Geographic program titled "Mammoth: Back from the Dead." Although the Hwang saga itself has ended, it continues to have ramifications. For example, the Korean film *The Whistle Blower* (2014) detailing the Hwang affair was seen by approximately 1.5 million people. (Young-Jun Ryu was the whistleblower in Hwang's lab who came forward with the truth about Hwang's research.) The reaction of the media and the public to the film suggests that the Hwang scandal has helped Korean society become more democratic and mature in its public engagement in science and politics.

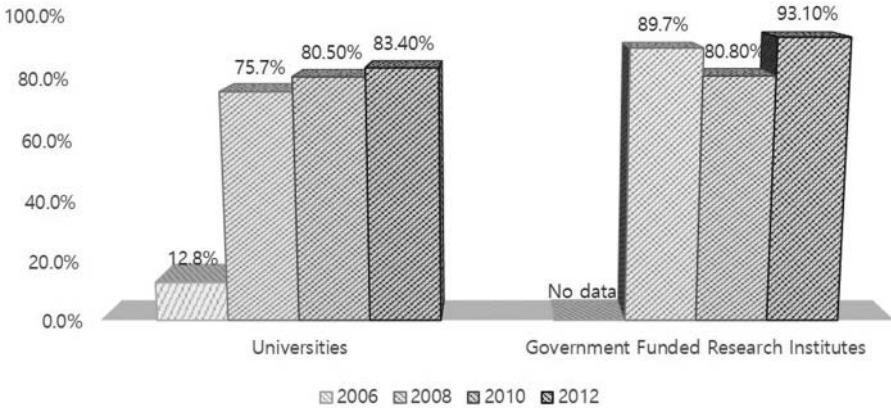


Fig. 1. Percentages of universities and government-funded research institutes having research ethics committees (including institutional review boards), by year. Sources: Analysis on the Results of Research Ethics Activities and the Improvement Plan of Research Ethics in Korea (Lee, forthcoming), Biotech Policy Research Center (2007, 2011).

In response to the research misconduct revealed in the Hwang affair, the Korean government, universities, and academic organizations enacted new regulations. The Hwang scandal was manifold: the fabrication of results in published articles, the unethical collection and use of human embryos, embezzlement of research funds, gift authorship, and exploitation of graduate students’ labor. Consequently, enacting new regulations required complex debates but included broad definition of misconduct and corresponding regulations. The [Korean Ministry of Science and Technology \(2007: 1\)](#) defined six categories of research misconduct: fabrication, falsification, plagiarism, inappropriate authorship, activities that interfere with a research ethics committee’s examination, and activities that go beyond generally acceptable norms in the scientific community. The first four categories focus on the publication process, and the last category makes a blanket reference to types of misconduct in scientific activities.

The Korean government revised its Bioethics and Safety Act twice, in 2008 and again in 2012.² This act stipulated that ESC research should be regulated by the government; as a result, ESC research has stagnated but iPS and adult stem cell research gained momentum. The government also pushed universities and research associations to establish their own research-integrity committees and suggested how to operate them. [Figure 1](#) shows the percentages of research-integrity committees in universities and government-funded research institutes after the Hwang affair, which increased dramatically between 2006 and 2008 and then leveled off. In the second major revision of the Bioethics and Safety Act the Korean government extended institutional review board (IRB) procedures to cover all human subjects research. Previously, social scientists in Korea were not required to take IRB training, but the law now requires them to pass IRB training before conducting research on human subjects in any way. Through taking a leading role in ethical reform in science, the Korean government responded

² For the legislative process and the nature of the Bioethics and Safety Acts in Korea, refer to [Hwang and Sleeboom-Faulkner 2014](#); [Kim 2014](#); and [Yoon, Cho, and Jung 2010](#).

immediately to the heated debate over the nation's poor research ethics and bioethics prompted by the Hwang scandal.

The stem cell scientific community also welcomed this ethical reform, although it insisted that Hwang's misconduct was an isolated, individual case that had nothing to do with overall research activities. Most of our interviewees, while emphasizing that Hwang's affair was an individual fraud rather than something that the whole scientific community should be blamed for, agreed that the Hwang affair had had a positive effect on the stem cell community and that the appropriate reaction of the government to the scandal helped with recovery from the crisis.

Interviewee D: Hwang's affair has strengthened ethical awareness. . . . I think that's what we learned from the Hwang affair, by wasting a lot of money. If we did not do that, Korea would not have grown up.

Interviewee G: The scientific community and the [Korean] government attempted to have some protection for research ethics. They would not have established laws unless they did not care about the ethics regulations on research. Korea, as a member country of the OECD, needed the ethics regulations, in particular, institutional bases to regulate research ethics such as IRBs at least. They are the requirement at a minimum from the international scientific community.

However, creating ethics regulations is one thing; abiding by them is another. There have been tensions between regulations and actual practices in laboratories. Unlike the general direction of the ethical modernization model, in Korea research ethics reforms are fraught with contradictions and negotiations. Not all scientists agreed that the government-led regulation was successful. The comments of two scientists reflect this disagreement:

Interviewee D: The consciousness on research ethics was strengthened. I don't see the Hwang affair totally negatively. It was a good lesson that we paid a lot for. Without the Hwang affair, we would not have grown up.

Interviewee B: The present form of research ethics is not about following it but rather about checking it off our lists. Research ethics was developed in institutionalized form but not actually in scientists' practices in real situations.

The tensions between research ethics institutionalization and actual practices have increased. For instance, two prominent stem cell scientists in Hwang's former department were later accused of research misconduct (Chosun Ilbo 2012). In the following, we discuss these tensions in relation to Korea's distinctive research culture.

2 Research Culture, Commercialization, and Contentious Regulations

Has ethical modernization achieved its goals? Has it permeated the Korean scientific community that received so much criticism after the Hwang affair? Interestingly, as revealed in 2012 (Chosun Ilbo 2012), two faculty members who worked in the same department (veterinary medicine) as Hwang were also charged with research misconduct. A whistle-blower submitted evidence that Soo-Kyung Kang and Kyung-Sun Kang, critics of Hwang, were themselves guilty of similar ethical violations. The irony is that

while Kyung-Sun Kang was criticizing Hwang in 2005, he was also under investigation for misconduct. The research-integrity committee of SNU concluded that those two professors had manipulated data in fourteen scientific papers published in international journals. How can we explain these repeated violations (Lee 2015)? To answer this question, we need to understand the culture of Korea's scientific community.

Leo Kim and Woo Park (2015) argue that the Hwang affair should be interpreted not as an individual case of fraud but as emblematic of failures in collaborative culture. Scientific collaboration requires shared labor, credibility, material and technical resources, and symbolic and social capital (Hackett 2005: 671). Stem cell research demands collaboration, which is seldom obtained because "cooperative mind-sets and underlying cultural elements were too weak to sustain any interdisciplinary collaboration" (Kim and Park 2015: 236). In the Hwang affair, Hwang's team worked in veterinary science, a field that has been traditionally disregarded by medical researchers. There were strong authoritative and epistemological barriers between veterinary medicine and human medicine. Hwang needed expertise from researchers in the medical field, but he failed to communicate effectively with them. Researchers from MizMedi Hospital, who were major partners of Hwang's team, were pressured by Hwang to make stem cells, and they deceived him by claiming that they had succeeded in making particular stem cell lines. Then they conspired to make sham cell lines. Hwang did not know the exact technology performed by his colleagues, which led to a misjudgment on his part. The importance of trust in scientific community tells us that regulations are not enough for ethical research, because mistrust generates miscommunications and may lead to unrecognized errors and manipulations and finally unintentional misconduct.

After the Hwang affair, regulations were made stricter, but trust in the stem cell scientific community did not progress as expected. For instance, we also found a lack of trust between medical doctors and scientists, which blocks collaboration. A stem cell scientist in a major Korean hospital blames disciplinary barriers and especially doctors' prejudice against scientists: "We [scientists and medical doctors] don't have a [collaborative] mind-set. Instead, we have a great gap. There is no hierarchy between PhDs and MDs in the United States, especially in research fields. But the situation in Korea is the opposite. MDs have the strong prejudice that they earn money for hospitals but PhDs spend money for research. As a result, MDs think that they should take upper positions and PhDs should take lower positions" (interviewee M).

Korean academic and intellectuals are notorious for their cliquish and heteronomous closures (J. Kim 2015). Their interactions are also strongly influenced by a Confucian culture in which age hierarchy and male domination prevail. These asymmetrical human relationships prevent open and flexible communication among researchers, and they generate mistrust and unproductive exchanges of knowledge. Academic closure leads to the monopolization of valuable resources, regarding other groups as ineligible and illegitimate contenders for such resources. In this context, one sees intense competitions among stem cell researchers who vie for limited government funding, without using a collaborative mind-set.

In addition to the conflicts related to research culture, more serious conflicts and concerns within the stem cell scientific community have arisen due to uncoordinated visions, practices, and expertise among government, biotech companies, and researchers. Though the Hwang affair brought a temporary setback in stem cell research, the

research funding has increased because of the promise of large economic returns for stem cell research. The biotechnology field needs to embrace the vision of the future (Rajan 2006). The triple helix of government, biotech, and the scientific community does not give up the promising vision with which they collectively pursue the economization of stem cell research.

But the major problem arises when the politics of hope collides with the reality of weak processes for creating effective regulations, on the one hand, and the lack of expertise and experience among the Korean government, biotech companies, and scientific community, on the other. For instance, Korea was the first country in the world to allow stem cell therapies. Pharmicell, a Korean biotech company, introduced Hearicellgram, the first stem cell therapy for the mass market, in 2011 (Joongang Ilbo 2011). This drug is designed to cure patients with acute myocardial infarction. This aggressive development in Korea is related to the pursuit of economization and, paradoxically, the lack of expertise in stem cell commercialization. The following is taken from an interview with the CEO of Pharmicell:

Interviewer: Despite the Hwang Affair, why has the Korean government increased funding for stem cell research?

Interviewee T: The major agenda was the industrialization of stem cells. The Korean government wants us to be at the forefront of development. . . . The weakness of the government is that there are few experts in it. And then, they don't take responsibility for the results.

The combination of the zeal for development of stem cell therapies and the lack of expertise in the government led to lax regulations in the commercialization of stem cells. After the first stem cell therapies, the Korea Food and Drug Administration (KFDA) approved three more stem cell therapies by 2015: Medipost's Cartistem (2012), Anterogen's Cupistem (2012), and Corestem's Neuronata-R (2014). Thus, four out of a total of five stem cell therapies worldwide have been developed in Korea.

Here, three parties—the Korean government, the scientific community, and the stem cell industry—worked together once again to actualize the hope of stem cell technologies through industrialization. Our interviewees revealed that they are in an awkward dance between regulations and hope. Interviewee O, who was involved in industrial regulations on stem cells, said that scientists and business people heavily contributed to making them. She stated that it would be wrong to assume that the government sets the rules and the scientific community and stem cell industry follow them. When the government attempted to create commercialization rules, they worked together, considering the ethical and industrial dimensions that they could not always easily reconcile.

Consequently, the quick commercialization of stem cells by Korean biotech companies came under immediate attack at home and abroad. D. Yvette Won (2012: 329) criticized the hasty approvals by KFDA, essentially shouting “show me the data.” Won pointed out that those therapies lacked peer-reviewed data, and the approvals were rushed through, unlike the stricter and slower processes that the standards of other countries' regulatory agencies required. An activist and expert in health movement also criticized the Korean government's reckless approvals, arguing that those therapies needed more experimental and clinical data to ensure safety and efficacy (Ohmynews

2014). While Korean academics and scientists have attempted to build up IRBs and offices of research integrity, the processes of commercialization also deserve attention. Kyuin Choi (interviewee R), a longtime bioethicist, describes this situation: “Bioethics in Korea is still too shabby, and bioethicists stick to IRBs too much. They are obsessed with IRBs. Bioethics has moved away from real situations and become too abstract. It is abstract bioethics, and bioethicists are unconcerned about this problem [of abstract bioethics].”

The Korean scientific community has established several organizations that regulate research integrity. But as Choi observed, the implementation of research ethics foundered because, as the STS literature has suggested, having a rule is not the same as following it. In other words, a rule itself is not sufficient to enhance research ethics because rules are embedded in culture, and the lack of trust and collaborative spirit in the Korean scientific community achieved only formal research ethics guidelines. Especially, these organizations lack oversight of the commercialization of stem cell research, even as they cooperate with the Korean government for its development. Nationalism in Korean science has not gone away, and it has strong bonds with the government and the scientific community. More important, stem-cell scientists depend on funding from the government, and the decisive factor in determining their laboratory’s trajectory is their relationship with top government officials.

In this contentious situation, *Mainichi Daily* in Japan accused R&L Bio of Korea, a biotech company, of providing stem cell therapies in Fukuoka. It reported that R&L Bio illegally sent five hundred patients every month from Korea to Japan ([HanKyung Business Magazine 2013](#)). This company also has been known to recruit and send Korean patients to China. In response to regional concerns about stem cell therapies, the Korean government warned the Korean public that R&L Bio’s therapies were not permitted and, consequently, were illegal. But R&L Bio paid for a big advertisement in *Chosun Daily*, a national newspaper with the largest circulation in Korea, insisting that its stem cell therapies were safe and effective and that the Korean government should allow them. The Seoul Southern District Prosecutor’s Office investigated R&L’s possible illegal activities, including nonlicensed production of stem cell therapies, and later arrested R&L’s CEO ([HanKyung Business Magazine 2013](#)). This well-known incident shows the dilemmas and ambitions that the Korean government, biotech companies, and the scientific community confront.

The stem cell research community, the Korean government, and biotech companies have been caught between fraud and hope, which generates contradictions and tensions. Regulations and formal ethical guides are not enough to ensure ethical research behavior in labs. Government’s and biotech’s vision and strategies are still short-sighted because they are in a hurry to control global stem cell markets. The Korean government and scientific community did not achieve mature progress in research ethics but has started to recognize the importance of culture, trust, and practice in the scientific community.

3 Impact on the Publications of Stem Cell Research in Korea

While the Hwang scandal was a key driver in the acceleration of research ethics reform by the Korean government and the scientific community, it remains to be seen whether

the scandal has influenced journal publications by Korean scientists and government funding for stem cell research. Certainly academic publications and research funds are the main concerns of scientists; therefore, any change in these areas would have a great impact on stem cell science in Korea.

After the Hwang affair, the most significant change in South Korea's stem cell research was the diversification of ESCs. The Korean government supported Hwang's projects by appointing Hwang to head the new World Stem Cell Hub in 2005. In 2004 and 2005 many Korean media outlets enthusiastically supported Hwang as the builder of a Korea that might garner the greatest worldwide share of biotechnology and its associated profits (Kim 2011). This fantasy, however, ended with the revelation of Hwang's scientific misconduct. Many researchers inside and outside of the stem cell research community looked with suspicion on the results of stem cell research, and the government was expected to change policies involving ESC research. ESC researchers therefore recognized that their research environment was markedly less supportive because of Hwang's research misconduct. The circumstances surrounding stem cell research changed overnight. "The Hwang affair brought stem cell fields into highlight, so people realized that there was not only embryonic stem cell research but also adult stem cell research. Thus, the Hwang affair provided an opportunity to direct attention to adult stem cell research, which was overshadowed by embryonic stem cell research" (interviewee F). This statement suggests that the Hwang affair generated a momentum in which stem cell science in Korea accelerated research on cell types other than ESCs. At the same time, the researchers noted the change in their research environment. They were apparently unsettled by the Korean government's response, which reinforced bioethics, regulated research, and provided at best lukewarm support for their research. Furthermore, from 2005 to 2009, termed the dark ages by a few Korean stem cell scientists, it was difficult to regain the trust of their international peers. One of our interviewees, a leading member of the Twenty-First-Century Frontier R&D Program, recalled the period as a painful time for stem cell researchers, arguing that there was a "cynical atmosphere" among Korean scientists, especially because scientists who did not work on stem cell research were claiming stem cell researchers were fabricating research outcomes, so such research was regarded with suspicion.

Some scientists commented that during this period their papers were more likely to be rejected than before. They argued that, after the Hwang scandal, reviewers or editors outside of Korea tended to ask for outrageously detailed information and clarifications of their studies. Because of the mistrust of Korean scientists and their work, these scientists claimed, their papers took much longer to publish. "When we try to publish a paper, certain questions about the methodology can be raised [in the journal review process]. When we are established, however, they [reviewers] don't care about that usually. But those types of questions were raised by the individuals [reviewers] and from the journals [editors]. It feels as though they are suspicious. Another interviewee, a prominent researcher in clinical trials who is known for producing some of the best academic papers in the cardiovascular field, said that one of his papers was rejected five times, and it took almost a year for it to be published. "The final reason for the rejection was very shocking. Reviewers recommended that I use stem cell lines certified in the United States instead of experimenting with ones in the South Korea. It hurt my pride" (interviewee F).

Table 1 Numbers of Science Citation Index journal papers published by South Korean scientists, 2000–2013

Year	Stem cell	Embryonic stem cell	Adult stem cell	Human embryonic stem cell	Induced pluripotent stem cell
2000	59	0	10	0	0
2001	65	5	22	0	0
2002	92	3	24	0	0
2003	175	8	56	0	0
2004	247	30	88	1	0
2005	309	42	100	7	0
2006	335	44	126	8	0
2007	488	71	226	8	0
2008	589	79	263	11	0
2009	706	77	337	6	5
2010	833	112	387	15	18
2011	932	119	457	27	25
2012	1,115	134	506	9	36
2013	1,026	104	577	17	33

Source: Web of Science database (version 5.13; Thomson Reuters), [Biotech Policy Research Center \(2007, 2011\)](#).

Data are number of research papers that include the corresponding keyword. Some papers are listed in more than one category.

Of course, not all interviewees perceived that they were at a disadvantage from the international community or colleagues. Some of our interviewees thought that they had recovered from Hwang's scandal, and they did not feel any bias in manuscript selection and publication. Although they found that reviewers did request more detailed information and more supporting data than before, these interviewees tended to recognize this kind of request as a legitimate part of the peer-review process for verifying a study.

These contrasting responses raise a question of whether or not the Hwang scandal really prompted closer scrutiny of Korean stem cell science among the international scientific community, or was the claim merely a defensive overreaction among some Korean stem cell researchers? To better understand the impact of the Hwang scandal, we analyzed the number of publications on stem cell research written by South Korean scientists after the Hwang affair. If the scandal had damaged the international credibility of Korean stem cell science, as claimed by some stem cell scientists we interviewed, it might also have affected the patterns of publication by Korean stem cell researchers.

Table 1 shows the numbers of publications on stem cells by South Korean scientists in 2000–2013, as listed on the Web of Knowledge database. The publications of the ESC field stagnated for a few years after 2005, suggesting of the fallout from the Hwang crisis. Immediately after the scandal, for example, the number of publications on ESCs written in Korea remained almost the same (only a 4.8 percent increase from 42 in 2005 to 44 in 2006). In contrast, over the same period the number of publications on adult stem cell research increased by 26 percent (from 100 in 2005 to 126 in 2006). We can view the stagnation in publications as an abrupt standstill, suggesting an impact of the Hwang scandal, because ESC research publications had increased rapidly every year before 2006. The number of ESC research publications jumped again in 2007 and remained at the same level until 2009.

Of course, stem cell research in Korea was also influenced by research trends in the international stem cell scientific community. Overall, the growth rates in the United States, Japan, and the United Kingdom were more stable than the growth rate in Korea over the period and have slowed since 2005. In contrast, from 2003 to 2005 the publications produced by Koreans increased dramatically but then stopped in 2006 when the Hwang scandal broke out. The standstill in 2006 may therefore reflect both the impact of the Hwang scandal and the general research trend in international stem cell science whereby researchers became more interested in adult stem cells and iPS while ESC research began to slow.

Finally, the standstill can be also associated with the Korean government's diminished support for stem cell science. The number of publications on ESCs increased markedly in 2010, after the South Korean government announced its Plan for Revitalizing Stem Cell Research in 2009 and the subsequent spike in its support for stem cell research, including ESC research. In part, the South Korean government's ongoing support for stem cell research appears to explain the trend in stem cell research publications. The next section examines the trend in government support for stem cell research.

4 Impact on State Support for Stem Cell Research

Given the turmoil caused by the Hwang scandal in Korea, the most serious impact of the scandal could be on the South Korean government's support for stem cell research. Although most interviewees agreed that the government did tighten regulations on bioethics, there was substantial disagreement over whether the Korean government reduced financial support for stem cell research. Some scientists claimed that the government did reduce its support for stem cell research and changed its priorities from ESCs to adult stem cell research. In particular, researchers in the ESC field tended to express concern about the stricter regulations and less supportive atmosphere.

However, the Korean government has consistently supported stem cell research since the launch of the Biotech 2000 program, the long-term R&D plan established in 1994 (Yoon et al. 2010). Therefore, most of the scientists we interviewed said that they did not experience a serious reduction in government support outside of the dark ages from 2006 to 2009. "Policy is a very systematic decision. It's not influenced by a single scandal. It's not made by one person. This is systematic . . . We made a national plan at the time [Comprehensive Implementation Plan on Stem Cell Research] to support stem cell research continuously. But it didn't work well for a while, because as I said, there was cynical atmosphere" (interviewee B).

In line with this opinion, our findings did not provide evidence of a reduction in financial support from the government. Figure 2 indicates that government funding for stem cell research, including ESC research, was quite stable from 2005 to 2009. Although this funding declined in 2006, the decline was moderate and short-lived. As one interviewee told us, the allocation of government research funding has been done through a long-term national plan, so that it could not be seriously affected by a single case of individual misconduct. Indeed, in May 2009 the South Korean government announced that it would triple its funding for stem cell research over the next five years, from KRW 40.2 billion (USD 34.8 million) to KRW 120 billion (USD 103.9 million) won in 2015, through its national Implementation Plan for Stem Cell Research. The plan to support stem cell research allowed limited somatic cell cloning while reinforcing

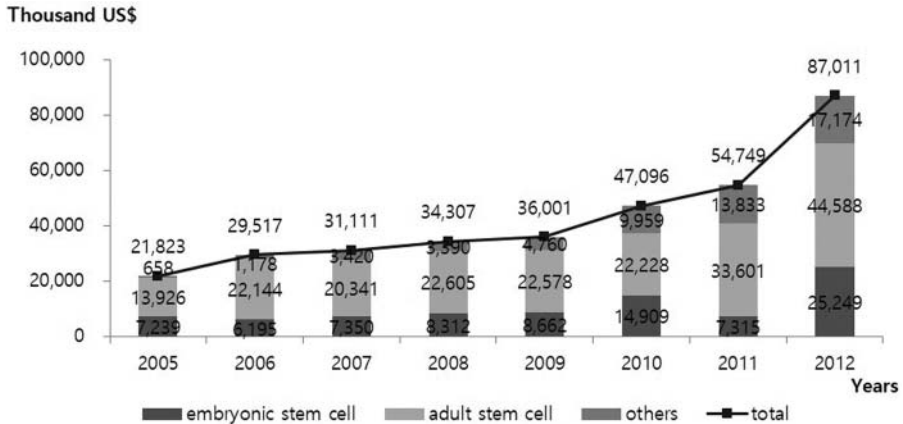


Fig. 2. Korean government-funded stem cell R&D expenditures by type, converted to 2012 USD ($\text{₩}1126.87 = \$1$ (per <http://ecos.bok.or.kr>). Sources: Korean Ministry of Education, Science, and Technology 2006–11, Biotech Policy Research Center (2007, 2011).

bioethics regulation by investing 2 percent of total stem cell R&D expenditures on bioethics programs. Overall, science policy in Korea is still geared toward promotion and development.

Unlike total R&D expenditures for stem cell research, which has continuously increased, the amount of funding for ESC research decreased during the period of the Hwang scandal, dropping by 14 percent between 2005 and 2006. This decrease contrasts sharply with the 59 percent increase in adult stem cell R&D expenditures over the same period. In addition, other R&D expenditures, which are mainly for bioethics, have increased since 2006. Considering Hwang's misconduct in hESC research, such a policy change was not surprising. In fact, funding for stem cell research in South Korea focused on ESC before the Hwang affair, but priorities changed directly after the incident. For some time, the Korean government stayed away from ESC research, despite the increased funding for stem cell research in general. The total amount of R&D expenditures never declined (see Fig. 2); between 2009 and 2010, government funding increased by 31 percent, signifying a recovery of stem cell research in Korea. At the same time, the increased government support for stem cell research fell short of the increase in funding for biotechnology, suggesting a harmful impact of the Hwang scandal. Whereas the total governmental support for biotechnology increased by 87 percent from 2005 to 2009, its support for stem cell research increased by only 65 percent in that period.

For these reasons, a few leading scientists involved in policy making pressured the government to establish a national plan and to support stem cell research for national competitiveness. These scientists have emphasized the increasing necessity of stem cell research and Korea's lack of international competitiveness.

Interviewee B: The government was very enthusiastic to support this stem cell research. But the Hwang scandal made the government reconsider him and his colleagues. . . . We persuaded the government that this is the chance to risk investing further to reorganize the whole area of research and bioethics, and that's the reason they revised the bioethics guidelines in 2009.

Interviewee A: Not only professors in Seoul National University but also all professors in the stem cell research fields made efforts to gain the government's support. I mean . . . it was an important point that the US invested \$200 billion on the stem cell research as soon as President Obama signed the Stem Cell Bill in 2009. It surprised our government, and we were able to persuade it to boost funding for stem cell research, which could be a new growth engine.

In March 2009 the new Obama administration in the United States signaled its increased support for stem cell research by overturning a Bush administration policy that restricted federal funds for hESC research. With such a global movement, the South Korean government also began to accelerate its support for stem cell research. In July 2009 the South Korean government announced its Plan for Revitalizing Stem Cell Research, pointing out the stalled support for stem cell science compared to that for other biotechnology fields and in the global competitiveness of Korean stem cell science. The plan included investing KRW 53 billion (USD 45.9 million) in stem cell research, an increase of 21.9 percent over 2008 (Korean Ministry of Education, Science, and Technology 2011). In September 2011 the Korean government reiterated that it would increase support for stem cell research, with much emphasis on the development of clinical therapies using stem cells. These leaps in government support in 2010 and 2012 (see Fig. 2) reflect such political decisions.

The new national plan to support stem cell research showed the strong desire of the South Korean government to invest in the biotechnology sector. Many Korean scientists in the stem cell field welcomed the government's actions in the hope that it might promote stem cell research, especially in ESCs, which had been in crisis after 2005. Most of all, the government's actions suggested that the state was very much interested in winning the international competition for the commercialization of stem cell research. Therefore, the resumption of stem cell research in South Korea should be understood as the result of the state's reaction to the competitive global environment of stem cell research in the belief that it was essential to enhance Korea's international competitive power.³

In our interviews, some of the leading scientists in South Korea insisted that government rather than industry or academia has sustained Korean stem cell research, emphasizing the government's role in financial support for biotechnology. It seemed that stem cell research in Korea has weathered the crisis and welcomed an opportunity to make another leap forward with the rigorous yet hasty support by the Korean government.

5 Discussion

5.1 Concerns about the Negative Impacts of the Hwang Affair on Stem Cell Science in Korea

Because the Hwang affair involved not only Hwang and his laboratory colleagues but also politicians, government agencies, medical scientists, journalists, and the public,

³ The turnaround in ESC research in 2010 was found in other countries as well. Note that, in all countries shown in Figure 2, the growth rates of the publications on ESCs increased significantly in 2010, which might demonstrate international expectations and competition in this field.

it may have far-reaching effects on stem cell science in Korea. The responses of stakeholders to the Hwang scandal were closely related to the concern that Hwang's fraud might raise suspicions about all stem cell research in Korea and thus impede the development of stem cell science in the country (Gottweis and Triendl 2006). Indeed, the history of scientific misconduct reveals that fraud perpetrated by a leading figure in a discipline can threaten the authority of the discipline itself by casting public suspicion on its veracity (Gieryn and Figert 1986). In such cases, scientists tended to attempt to salvage the authority of science by denouncing the scientist who committed the fraud. That is, through this boundary-making tactic, scientific fraud was attributed to personal character rather than to weakness of the science or discipline (Broad and Wade 1982; Gieryn and Figert 1986). Some of our interviewees made similar responses, arguing that such a concern went too far, given that it was a problem only of one scientist.

However, from the point of view of East Asian STS, perhaps a more distinct feature of the Hwang fraud case is that it raised concerns about the state of science in a particular country, which is involved with the same boundary-making strategy against scientific fraud. Jenny Kitzinger (2008) has asserted that proponents of ESC research attempted to rehabilitate the field after the Hwang scandal by adopting a boundary-making strategy. To promote the potential of ESC science, proponents of ESC research have disseminated the utopian vision of ESC science as a medical breakthrough. Hwang's articles in *Science*, which were later determined to be fraudulent, had been cited as evidence to validate the promise of therapeutic cloning. Once the scandal broke, however, the stem cell research community had to draw a line between Hwang's work and stem cell science in general. An interesting finding is that proponents of the ESC research drew national boundaries. In addition to attributing Hwang's fraud to his personal faults, they tried to distinguish the scientific culture, national social conditions, and research governance systems in Korea from those of conventional powerhouses of science (Kitzinger 2008: 427). Such boundary making can be appealing, since Hwang's research came from a country outside the scientific mainstream.

These contexts suggest that it was a plausible concern among scientists that the international scientific community, because of the Hwang scandal, might question all stem cell research coming out of Korea. In addition to anecdotes in our interviews, the slowdown in the number of publications and the halt in state-funded R&D expenditures for ESC research that Korea experienced right after the Hwang scandal indicate the validity of this concern. Therefore, the concern that the Hwang scandal might significantly slow Korean stem cell science should not be shrugged off as an exaggeration. Moreover, many stakeholders in Korea, including the stem cell research community and the Korean government, appeared to share this concern, although to quite different extents, as noted by our interviewees.

However, we suggest that such fears did not come true. Although Korean stem cell research was temporarily stalled, Korean stem cell science continued to grow without the big trouble some critics predicted. How could Korean stem cell science recover so quickly from this crisis? What were the limitations in the recovery? By examining what happened in stem cell science in Korea after the Hwang affair, this article may answer some of these questions and offer lessons for research policy.

5.2 Government-Led Research Ethics Reform and Its Limitations

The Hwang scandal was a wake-up call for Koreans and brought strong pressure for ethical modernization on the scientific community from society and the Korean government. Here, the critical role of the Korean government in responding to Hwang's fraud deserves special attention. Traditionally, as a developmental state, the South Korean government has mobilized science and technology for economic purposes (Bak 2014). Thus, the Korean government has long been a loyal supporter of scientific research with commercial potential. In the aftermath of the Hwang scandal, however, the Korean government realized that Korean scientific governance systems had fallen below the global standard and strengthened its role as a regulator: it mandated prompt and sweeping reforms of research ethics in response to research misconduct after the Hwang affair.

The rapid institutionalization of research ethics should be considered a positive impact of the Hwang affair, as many of our interviewees claimed. Without the Hwang scandal, it is unlikely that the Korean government or the Korean scientific community would have felt the urgent need to reform research ethics in Korea, and the institutionalization of research ethics would have been much slower and more limited in scope. At the same time, without the state's influence, the Hwang scandal alone cannot explain the prompt and far-reaching ethics reform. Most organizations for research integrity, such as IRBs and offices of research integrity, in Korean universities, research institutes, and professional scientific associations were established by law soon after the Hwang affair.

Therefore, the response of the Korean government to the Hwang scandal demonstrates that the state should not hesitate to assume the role of regulator when its country is involved in international research misconduct. The growing number of controversial cases of scientific misconduct brought into question whether the scientific community is able to police itself; thus, the state, which should protect societal investment in scientific research, has increasingly taken on more of the responsibility for policing science (Bird and Dustira 1999). With support from civil society, the Korean government was willing to take responsibility quickly, instead of leaving ethical reform in the hands of the scientific community; this made the ethical reform prompt and far-reaching. In turn, the swift institutionalization of research ethics helped stem cell science regain the state's support and the international scientific community's trust.

While the Korean government's active intervention demonstrated to the Korean public and the international scientific community that the government was working to improve research practices, these policy engagements left much to be desired. Above all, many critics, especially ethicists and social scientists, have emphasized the tensions between regulations and actual research practices. The tensions might result partly because the Korean government and the scientific community have focused on building up organizations for research integrity as a response to the Hwang affair. In other words, they have largely failed to link the Hwang affair with the broader hierarchical and authoritative culture among scientists, the lack of a collaborative culture for interdisciplinary research, and the collusion of science with politics that discouraged organized skepticism and made Hwang's fraud possible. The introduction of organizations for research integrity was necessary, but it was only a first step. As the recent

newspaper report on scientific misconduct among even critics of Hwang suggests, the cultural change will be difficult and slow (Yang 2012).

In part, the slower change in research culture and actual research practices can be associated with the rather passive roles of the Korean scientific community in addressing the Hwang scandal. Of course, we do not deny the important roles of the Korean scientific community in managing the Hwang scandal. For example, after Hwang's fraud came to light, the SNU investigation committee immediately investigated the allegation. Such prompt action helped control the damage caused by the Hwang scandal, thereby protecting the reputation of the university. Stem cell scientists were also able to persuade the Korean government to continue its support for stem cell research in the aftermath of the Hwang scandal. However, the Korean scientific community, while it did tend to follow the government's initiative, failed to resolve problems in research culture and so could not take a leading role in research ethics reform. On the contrary, it tended to claim that the Hwang scandal was a case of individual misconduct and attempted to isolate it from its own research activities. Needless to say, changes in research culture require active participation by scientists, since research culture is constituted by the norms and research practices of scientists themselves. Therefore, for more effective reform in research ethics governance, the Korean government and universities should have paid more attention to developing science policies to create an environment in which scientists would be encouraged to reflect on their own research practices and take the initiative in research ethics reform.

Another important limitation of the ethical reforms taken by the Korean government is that they were not sufficient to regulate the emerging commercialization of stem cell research. In the last ten years, the commercial applications of stem cell research have become a reality. Because much research has been done on the commercial applications of stem cells, ethical concerns related to stem cell therapies have also arisen. Focusing on setting up organizations for research integrity, however, the government's research ethics reform has failed to pay sufficient attention to ethics problems involved in the commercial applications of stem cell research. In addition, due to the lack of expertise in the stem cell therapies, the Korean government has tended to rely on bioindustry in setting up regulations on the commercialization of stem cell research. Thus, bioindustry has been simultaneously a player and a regulator in the commercial applications of stem cell, which was likely to loosen the regulations on stem cell therapies.

5.3 The Politics of Hope and Continuing Support for Stem Cell Science

In addressing the Hwang affair, the Korean government remained a crucial supporter of stem cell science. The Hwang case reveals that government support of scientific research may shy away from areas of research that are seen as controversial or in cases where the reputation of the scientists has been tarnished. However, the Korean government, like the stem cell research community and biotech industry, has never lost confidence in the promise of stem cell research. As only a temporary decline in funding for ESC research in 2006 demonstrated, the government continued supporting stem cell research, including ESC research. It would be difficult to understand the rapid recovery in the number of publications by Korean stem cell scientists without considering the ongoing government support for stem cell research, as well as the stakeholders'

confidence in its promise. The Korean case may show that a broad approach to the management of scientific fraud cases not only brings swift action and damage control but also can accompany material and symbolic support for the affected community.

The concept of the politics of hope may help us understand such responses of both the Korean government and the stem cell research community. Despite the Hwang scandal, the government, biotech industry, and the stem cell research community in Korea did not discard the promise of large economic returns for stem cell research and made haste to commercialize stem cell research. Indeed, continued support for stem cell research reflected their efforts to realize this promise. Note that both the Implementation Plan for Stem Cell Research and the Plan for Revitalizing Stem Cell Research, national plans to support stem cell science after the Hwang scandal, have focused on expediting commercialization of stem cell research such as the development of clinical therapies using stem cells.

However, while the politics of hope led the Korean government to be a continued supporter of stem cell science, it was also affected by the Hwang affair. We may understand the politics of hope as a constant factor in major scientific or technological breakthroughs. But the government's and the scientific community's approach to it might differ depending on how involved actors interpret, agree, and disagree with it. To explain how the Korean government and the scientific community mobilized hope and vision differently after the Hwang affair, we should distinguish celebratory hope from cautious hope. Before the Hwang affair, without challenges and resistances from civil society, the government and the scientific community overstated the promise and potential of stem cell research. Consequently, they celebrated Hwang's false achievement and promoted a rosy future in which stem cell research would bring wealth and health to the Korean nation (Kang, Kim, and Han 2006; T.-H. Kim 2008). For instance, a government report predicted that Hwang's research would bring USD 300 billion in economic benefit (Ha 2005). After the Hwang affair, however, the Korean government and the scientific community became more cautious about mobilizing this type of rosy future. Instead, they emphasized the value of stem cell research by citing competing countries' support for it (M. Kim 2015). Their politics of hope had to be cautious not only because the government and scientific community failed to maintain it after the Hwang affair but also because Korean civil society, including the media, became critical and suspicious of exaggerated claims about stem cell research.

As we discussed, strong interest and confidence in the economic value of stem cell research were behind the policy decisions to continue support for it, which became a decisive factor in the quick recovery of Korean stem cell science. The same politics of hope, however, may pose a serious challenge to the Korean government and the stem cell scientific community in Korea. There has been growing criticism both nationally and internationally that, motivated by the economic promise of stem cell research, Korea has failed to fully address ethical and safety concerns. In particular, observers have expressed concern about the rapid commercialization of stem cell therapies in Korea, noting that the Korean government has relaxed regulations on investigative stem cell therapies to expedite the commercialization of stem cell research (M. Kim 2015).

The Hwang scandal taught Korean society a costly lesson that hasty and unrealistic expectations in an emerging field of science, without laws and a research culture regulating research activities, are likely to cause havoc. We noted that inadequate

regulation of the emerging commercialization of stem cell research is a serious weakness of research ethics reform in Korea. The Korean government, stem cell researchers, and bioindustry should therefore be more cautious about the commercialization of stem cell therapies and continue their research ethics and bioethics reform for the new challenge. By striking a balance between the hope for research progress and the need for ethical research practices, Korea may demonstrate to the world that it indeed has learned its lesson from the Hwang affair.

References

- Bak, Hee-Je (2014). "The Politics of Technoscience in Korea: From State Policy to Social Movement." *East Asian Science, Technology and Society* 8, no. 2: 159–74.
- Biotech Policy Research Center (2007). "BioVision 2016." Daejeon, South Korea: Biotech Policy Research Center.
- Biotech Policy Research Center (2011). "2010 Biotechnology Major Statistics Collection." Daejeon, South Korea: Biotech Policy Research Center.
- Bird, Stephanie J., and Alicia K. Dustira (1999). "Misconduct in Science: Controversy and Progress." *Science and Engineering Ethics* 5: 131–36.
- Borup, Mad, Nik Brown, Kornelia Konrad, and Harro van Lente (2006). "The Sociology of Expectations in Science and Technology." *Technology Analysis and Strategic Management* 18, nos. 3–4: 285–98.
- Broad, William, and Nicholas Wade (1982). *Betrayers of the Truth: Fraud and Deceit in the Halls of Science*. New York: Simon and Schuster.
- Brown, Nik, and Mike Michael (2003). "A Sociology of Expectations: Retrospecting Prospects and Prospecting Retrospects." *Technology Analysis and Strategic Management* 15, no. 1: 2–18.
- Chosun Ilbo (2012). "Hwang Wu suk gong-gyeok-a-deon gyo-su-ga jul-gi-se-po non-mun 14pyeon jo-jak" 황우석 공격하던 교수가 줄기세포 논문 14 편 조작 (The Professor Who Had Blamed Hwang Wu Suk Fabricated the Fourteen Stem Cell Papers). 5 December.
- Franklin, Sarah. (1997). *Embodied Progress: A Cultural Account of Assisted Conception*. London: Routledge.
- Fox, Mary F., and Catherine A. Faver (1984). "Independence and Cooperation in Research: The Motivation and Costs of Collaboration." *Journal of Higher Education* 55, no. 3: 347–59.
- Gieryn, Thomas F., and Anne E. Figert (1986). "Scientists Protect Their Cognitive Authority: The Straus Degradation Ceremony of Sir Cyril Burt." In *The Knowledge Society: The Growing Impact of Scientific Knowledge on Social Relations*, edited by Gernot Böhme and Nico Stehr, 67–86. Dordrecht: Reidel.
- Gottweis, Herbert, and Byoungsoo Kim (2009). "Bionationalism, Stem Cell, BSE, and Web 2.0 in South Korea: Toward the Reconfiguration of Biopolitics." *New Genetics and Society* 28, no. 3: 223–39.
- Gottweis, Herbert, and Byoungsoo Kim (2010). "Explaining Hwang-gate: South Korean Identity Politics between Bionationalism and Globalization." *Science, Technology, and Human Values* 35, no. 4: 501–24.
- Gottweis, Herbert, and Robert Triendl (2006). "South Korean Policy Failure and the Hwang Debacle." *Nature Biotechnology* 23: 141–43.
- Ha, Taekyung. (2005). "Hwanguseok yeonguseonggwau gyeongjejeok gachi mit sisajeom" 황우석 연구성과의 경제적 가치 및 시사점 (Economic Value and Implications of Hwang Woo Suk's Research Achievement). *Innovation Policy Brief* 4: 3–27.
- Hackett, Edward J. (2005). "Introduction to the Special Guest-Edited Issue on Scientific Collaboration." *Social Studies of Science* 35, no. 5: 667–72.
- Hankyung Business Magazine (2013). "Ui-ryo-gye-ui hat issue, jul-gi-se-po chi-ryo-ui bit-gwa geu-rim-ja" 의료계의 핫이슈, 줄기세포 치료의 빛과 그림자 (Hot Issue in the Medical Profession: Light and Shadows of Stem Cell Therapy). 7 February.
- Hwang, Seyoung, and Margaret Sleeboom-Faulkner (2014). "Bioethical Governance in South Korea: Tensions between Bottom-Up Movement and Professionalization and Scientific Citizenship." *East Asian Science, Technology and Society* 8, no. 2: 209–28.
- Joongang Ilbo (2011). "Sim-jang hyeol-gwan-e jul-gi-se-po chi-ryo-je neo-eo sim-geun-gyeong-saek go-chin-da" 심장 혈관에 줄기세포 치료제 넣어 심근경색 고친다 (Myocardial Infarction Is Treated by Injection of Stem Cell into the Cardiovascular System). 25 June.

- Kang, Yang-gu, Byungsoo Kim, and Jaegak Han (2006). *Chim-muk-goa yeol-guang: Hwang Wu-suk satae 7nyeon-eui go-rok* 침묵과 열광: 황우석 사태 7년의 기록 (*Silence and Enthusiasm: A Record of Seven Years in the Hwang Scandal*). Seoul: Humanitas.
- Kim, Guenbae (2007). *Hwang Wu-suk shinhwaowa daehanminguk guahak* 황우석 신화와 대한민국 과학 (*The Myth of Hwang Woo-suk and Science in Korea*). Seoul: Yuksawoa Bi-pyung.
- Kim, Jongyoung (2009). "Public Feeling for Science: The Hwang Affair and Hwang Supporters." *Public Understanding of Science* 19, no. 6: 670–86.
- Kim, Jongyoung (2015). *Jji-bae-ban-neun Ji-bae-ja* 지배받는 지배자 (*Dominated Dominators: US Degrees and the Birth of Korean Elites*). Paju, Korea: Dolbegae.
- Kim, Jongyoung, and Kibeom Park (2013). "Ethical Modernization: Research Misconduct and Research Ethics Reforms in Korea following the Hwang Affair." *Science and Engineering Ethics* 19: 355–80.
- Kim, Leo (2008). "Explaining the Hwang Scandal: National Scientific Culture and Its Global Relevance." *Science as Culture* 17, no. 4: 397–415.
- Kim, Leo (2011). "Media Framing of Stem Cell Research: A Cross-National Analysis of Political Representation of Science between the UK and South Korea." *Journal of Science Communication* 10, no. 3: 1–16.
- Kim, Leo, and Woo Park. (2015). "Diagnosing 'Collaborative Culture' of Biomedical Science in South Korea: Misoriented Knowledge, Competition, and Failing Collaboration." *East Asian Science, Technology and Society* 9, no. 3: 233–52.
- Kim, Myungsim (2015). "Hangook Julgi-sepo-yeon-gu jung-chaek-eui tek-sung" 한국 줄기세포연구정책 거버넌스의 특성 (Characteristics of Stem Cell Governance in Korea). *Gua-hak gi-sul-hak yeon-gu* 과학기술학연구 (*Journal of Science and Technology Studies*) 15, no. 1: 181–214.
- Kim, Sang Hyun (2014). "The Politics of Human Embryonic Stem Cell Research in South Korea: Contesting National Sociotechnical Imaginaries." *Science as Culture* 23, no. 3: 293–319.
- Kim, Tae-Ho (2008). "How Could a Scientist Become a National Celebrity? Nationalism and Hwang Woo-Suk Scandal." *East Asian Science, Technology and Society* 2, no. 1: 27–45.
- Kitzinger, Jenny (2008). "Questioning Hype, Rescuing Hope? The Hwang Stem Cell Scandal and the Reassertion of Hopeful Horizons." *Science as Culture* 17, no. 4: 417–34.
- Korean Ministry of Education, Science, and Technology (2006–13). "Julgisepoyeongu-sihaenggyehock" 줄기세포연구시행계획 (Implementation Plan for Stem Cell Research). Seoul: Korean Ministry of Education, Science, and Technology.
- Korean Ministry of Science and Technology (2007). "Government Order 236: Guides for Securing Research Ethics." 8 February. Seoul: Korean Ministry of Science and Technology.
- Lee, In Jae (2015). "Yeon-gu-yul-li, hu-toe-han geon-nil-kka" 연구윤리, 후퇴한 것일까? (Research Ethics: Moving Backward?). *Hangukdaehaksinmun*, 20 December.
- Lee, In Jae (forthcoming). *Yeon-gu-yul-li seonggwabunseog mich gaeseonbangan yeongu* 연구윤리 성과분석 및 개선방안 연구 (*Analysis on the Results of Research Ethics Activities and the Improvement Plan of Research Ethics in Korea*). Daejeon, South Korea: National Research Foundation of Korea.
- Mulkay, Michael (1993). "Rhetoric of Hope and Fear in the Great Embryo Debate." *Social Studies of Science* 23, no. 4: 721–42.
- Ohmynews (2014). "Im-sang-shi-höm bat-tön 18se so-nyön, wae sa-hül-man-e ju-gö-sül-kka" 임상시험 받던 18세 소년, 왜 사흘만에 죽었을까 (Why Did Eighteen-Year-Old Boy in Clinical Trial Die in Three Days?). 30 September.
- Rajan, Kaushik Sunder (2006). *Biocapital: The Constitution of Postgenomic Life*. Durham, NC: Duke University Press.
- Rose, Nikolas (2007). *The Politics of Life Itself: Biomedicine Power and Subjectivity in the Twenty-First Century*. Princeton, NJ: Princeton University Press.
- Schatzberg, Erick (1999). *Wings of Wood, Wings of Metal: Culture and Technical Choice in American Airplane Materials, 1914–1945*. Princeton, NJ: Princeton University Press.
- Seoul Central District Prosecutor's Office (2006). "Jul-gi-se-po non-mun jo-jak sa-geon su-sa-gyeol-gwa" 줄기세포 논문 조작 사건 수사결과 (Criminal Investigation Report on the Fabrication of Stem Cell Research). 12 May.
- Seoul National University Investigation Committee (2006). "Hwang Woo-suk gyosu yeon-gu euihoak guanryun josa gyulguoa bogoseo" 황우석 교수 연구의혹 관련 조사결과 보고서 (Final Report on Professor Woo-suk Hwang's Research Allegations). Seoul: Seoul National University Investigation Committee.
- Shineha, Ryuma (2016). "Attention to Stem Cell Research in Japanese Mass Media: Twenty-Year Macro-trends and the Gap between Media Attention and Ethical, Legal, and Social Issues." *East Asian Science, Technology and Society* 10, no. 3: 229–46.

- Won, D. Yvette (2012). "Korea Okays Cell Therapies Despite Limited Peer-Reviewed Data." *Nature Medicine* 18, no. 3: 329.
- Yang, Seung-sik (2012). "Professor Who Had Blamed Hwang Woo-suk Fabricated Fourteen Stem Cell Papers." *Chosun Ilbo* 5 December.
- Yoon, Jeong-Ro, Sung Kyum Cho, and Kyu Won Jung (2010). "The Challenge of Governing Biotechnology in Korea." *East Asian Science, Technology and Society* 4, no. 2: 353–48.

Myungsim Kim is a research fellow in the Center for Science, Technology, and Society, Kyung Hee University, Seoul, South Korea. Her main research interests are the structure of scientific community, stratification and inequality in science and technology, and the biocapital and ethical issues in stem cell.

Jongyoung Kim is associate professor of sociology at Kyung Hee University in Seoul, South Korea. He holds a PhD in sociology from the University of Illinois at Urbana-Champaign. His main research interests are knowledge politics and social movements, education and globalization, and scientific construction of traditional medicine. He has published various articles in the fields of STS, sociology of education, and medical anthropology.

Hee-Je Bak is professor of sociology and director of the Center for Science, Technology, and Society, Kyung Hee University, Seoul, Korea. His main research interests are public understanding of science and technology, social controversies over technological and environmental risks, the structural transformation of universities, and the Korean scientific community.

Appendix List of interviewees

No.	Interviewee	Date	Gender	Field /status
1	A	13 July 2010	M	Stem cell scientist, university professor
2	B	14 July 2010	M	Stem cell scientist, university professor
3	C	10 Nov. 2011	M	Stem cell scientist, university professor
4	D	9 Nov. 2011 31 July 2014	F	Stem cell scientist, university professor
5	E	8 Nov. 2011	M	Stem cell scientist, university professor
6	F	21 Nov. 2010 10 Nov. 2014	M	Stem cell scientist, university professor
7	G	24 Sept. 2012	M	Ethicist, government-funded research institute research fellow
8	H	18 Oct. 2012	M	Ethicist, university professor
9	I	8 Aug. 2012	M	Ethicist, university professor
10	G	9 Aug. 2012	M	Activist, nongovernmental organization
11	K	14 Aug. 2012	M	Ethicist, university professor
12	L	12 Aug. 2014	M	Stem cell scientist, university professor
13	M	2 Sept. 2014	F	Stem cell scientist, university professor
14	N	21 Aug. 2014	M	Stem cell scientist, university professor
15	O	19 Aug. 2014	F	Industry, chief of laboratory
16	P	26 Aug. 2014	M	Industry association, director
17	Q	26 Aug. 2014	F	Industry association, assistant manager
18	R	27 Oct. 2014	M	Activist, nongovernmental organization
19	S	18 Dec. 2014	M	Stem cell scientist, university professor
20	T	21 Jan. 2015	M	CEO, industry