Heisenberg and Bohr—Another View

IN HIS ARTICLE "LETTERS AVER PHYSICIST supported Nazi bomb" (News of the Week, 15 Feb., p. 1211), Adrian Cho repeats erroneous statements that have been cast into doubt by several writers (*1*). Werner Heisenberg never said that "he intended to subvert the Nazi bomb program from within." Nor is it true that "the Dane [Niels Bohr] abruptly ended … their long friendship." This can be seen from the warm tone used by Bohr in his unsent letters to Heisenberg (*2*). Also, after the war, the Bohr and Heisenberg families visited each other in their homes and spent their vacations together in Greece, and Bohr contributed an article to the Festschrift (i.e., a volume of essays to honor a scholar on a special anniversary) for Heisenberg's 60th birthday in 1961.

In 1939, German Army Ordnance had drafted Heisenberg to study the feasibility of atomic bombs so that the Allies would not be able to surprise Germany with them. By 1941, Heisenberg had found that such bombs would be feasible but technically so difficult to make that their construction would take many years. It seemed to him, therefore, that the then small international community of nuclear scientists might have time to reach an agreement not to build these weapons. Heisenberg decided that he should discuss the critical situation with his old friend Bohr, with whom he had solved so many tricky issues in the past. He risked his neck in doing so, because the nuclear project was secret. Heisenberg told me this when I asked him, in 1969, about his visit to Bohr in Copenhagen in 1941. I was then working under Heisenberg at the Max Planck Institute for Physics. Heisenberg said that he had not realized that the war had changed their formerly close relationship. In fact, Bohr was suspicious of the motives behind Heisenberg's unexpected visit (*2*). When Heisenberg mentioned the technical feasibility of nuclear weapons (still doubted at that point by Bohr), adding that he knew what he was talking about, Bohr apparently assumed, according to Bohr's unsent letters, that Heisenberg was working on the construction of bombs. He ended the conversation before Heisenberg could explain the true purpose of his visit.

In Germany, bomb construction was not attempted because it would have taken too much time and resources. A reactor for power production was given official support. Robert Jungk, in his book *Brighter Than a Thousand Suns*, which Cho mentions in his article, gave the erroneous impression that Heisenberg refrained, for moral reasons, from bomb-making. Heisenberg and his closest associate, Carl Friedrich von Weizsäcker, wrote letters (*3*) to Jungk criticizing his exaggerations

Heisenberg (left) and Bohr in 1934.

while appreciating his engaged research. Jungk published only the laudatory part of Heisenberg's letters. It seems clear that Bohr's drafted letters to Heisenberg do not aver Heisenberg's support for a Nazi bomb.

KLAUS GOTTSTEIN
Emeritus Professor, Max Planck Institute for Physics, Werner Heisenberg Institute of Physics, Föhringer Ring 6, D-80805 Munich, Germany. E-mail: Klaus.Gottstein@UniBw-Muenchen.de

References and Notes

1. See the postscript by Michael Frayn to his play *Copenhagen* [M. Frayn, *Copenhagen* (Anchor, New York, 2000)]; articles by T. Powers, C. Carson, and H. Rechenberg in a supplement to the German edition of *Copenhagen* [*Copenhagen* (Wallstein, Göttingen, Germany, 2001)]; and T. Powers, *Heisenberg's War* (Knopf, New York, 1993).
2. See drafts of unsent letters written by Borg to Heisenberg, which were recently released by the Niels Bohr Archive (www.nbi.dk/NBA/papers/introduction.htm).
3. See the article by Carson in the supplement to the German edition of *Copenhagen* (*1*).

Response

GOTTSTEIN WRITES THAT HEISENBERG KNEW that atomic weapons might be built, albeit with great difficulty, and that he realized that "the then small international community of nuclear scientists might have time to reach an agreement not to build these weapons." If Heisenberg intended to forswear work on atomic weapons while maintaining his position as leader of German nuclear research, did he not perforce intend to subvert Nazi ambitions to achieve such weapons?

Concerning the effect of the 1941 meeting on Bohr and Heisenberg's friendship, Gerald Holton, a physicist and historian of science at Harvard says, "It's a non-story in a way. Nothing happened except a friendship was broken." Holton may be mistaken, however. If Bohr and Heisenberg remained truly close after the war and until Bohr's death in 1962, then one can only wonder how the two failed to hash out their differences over the encounter that clearly meant so much to both of them.

Regardless of these considerations, one thing is clear: Bohr's letters explicitly and peremptorily state that in 1941 Heisenberg said that he had been working in earnest on atomic weapons for 2 years. Bohr may have misunderstood Heisenberg, but his letters speak for themselves and they certainly aver that Heisenberg supported the German bomb effort—precisely as the article says.

ADRIAN CHO

Survey of Foreign Recipients of U.S. Ph.D.'s

IN THE WAKE OF THE EVENTS OF SEPTEMBER 11, proposals have been made to regulate or restrict the number of students studying in the United States on temporary visas. In the interest of informing debate, we provide descriptive statistics on the number of temporary residents who received U.S. doctorates in science and engineering (S&E) between 1981 and 1999 (*1*). For the 1990s, we explore in more detail the country of citizenship of doctorate recipients. The data come from the Survey of Earned Doctorates (SED), a census of all doctoral recipients in the United States (*2*).

During the past 19 years, temporary residents have accounted for more than 50% of the growth in Ph.D. production in the United States. Permanent residents have provided for another 10%. A dramatic increase in the number of Ph.D. recipients holding temporary visas occurred from 1981 to 1992, followed by a decline during the next 7 years.

DOCTORATES AWARDED TO TEMPORARY RESIDENTS (1990–99) FROM 25 COUNTRIES TARGETED FOR MORE RIGOROUS SCREENING

Country	S&E	Percentage of all Ph.D.'s	Sensitive fields*
Afghanistan	s†	s	s
Algeria	185	0.100	18
Bahrain	16	0.009	s
Djibouti	s	s	s
Egypt	752	0.407	53
Eritrea	8	0.004	s
Indonesia	423	0.229	44
Iran	875	0.474	117
Iraq	112	0.061	14
Jordan	468	0.253	53
Kuwait	77	0.042	9
Lebanon	339	0.183	36
Libya	40	0.022	s
Malaysia	398	0.215	65
Morocco	151	0.082	15
Oman	14	0.008	s
Pakistan	726	0.393	73
Qatar	17	0.009	s
Saudi Arabia	383	0.207	27
Somalia	16	0.009	s
Sudan	86	0.046	7
Syria	102	0.055	9
Tunisia	194	0.105	14
United Arab Emirates	48	0.026	13
Yemen	39	0.021	s
Total	5469	2.960	583

*Sensitive fields include nuclear and organic chemistry; chemical and nuclear engineering; bacteriology; biochemistry; biotechnology research; microbiology; molecular biology; and neurosciences; and atomic, chemical, molecular, and nuclear physics.

†Suppressed (counts of five or fewer doctorate recipients during the period are not reported at the request of Science Resources Statistics, National Science Foundation).

In 1981, fewer than 2500 Ph.D. recipients in S&E held temporary visas (20% of all those receiving Ph.D.s in S&E); in 1992, the number stood at close to 7000 (38.4% of all Ph.D.'s in S&E that year). Since then, the number has decreased by about 1000, with temporary-visa recipients receiving slightly more than 32% of all Ph.D.'s awarded in S&E in 1999. The decrease relates in part to the passage of the Chinese Student Protection Act of 1992, which permitted Chinese nationals temporarily residing in the United States to switch to permanent-resident status.

Growth in Ph.D.'s awarded to temporary residents has been especially dramatic in the fields of biological and agricultural sciences (13% in 1981, 28% in 1992, and 26% in 1999) and math and computer sciences (23.5% in 1981, 46% in 1991, and 39% in 1999). The change in composition has been less dramatic in engineering, but the proportion of engineering doctorate recipients who are temporary residents is substantial, reaching a high of 50.5% in 1991 and closing the decade at 39.6%.

The geographical distribution of doctorate recipients with temporary visas is highly skewed. For the 1990s, almost 60% came from four countries in Asia: the People's Republic of China (21.0%), Taiwan (13.7%), India (12.2%), and South Korea (11.1%). The next most frequent countries (Canada, Brazil, Turkey, Greece, Germany, and Mexico) account collectively for less than 11%.

After the events of September 11, the State Department announced that it would impose more rigorous screening on men seeking visas from 25 designated countries (*3*). The number of temporary residents from these countries who received Ph.D.'s during the 1990s is given in the table. The 5469 degrees represent 8.8% of all degrees given during the period to temporary residents and 3.0% of all degrees awarded. The largest number of degrees was awarded in engineering. Fewer than 11% of the degrees were awarded in sensitive fields.

At the time of this writing, Congress is considering legislation that would "prevent the federal government from issuing student visas and other nonimmigrant visas to anyone from a country that the State Department lists as a sponsor of terrorism, unless federal officials first determine that the person does not pose a national security threat" (*4*). These countries are Cuba, Iran, Iraq, Libya, North Korea, Sudan, and Syria. Counts for five of these countries are given in the table. Counts for Cuba and North Korea are not reported because of the small number of observations (five or less) and restrictions on entry. The 1215 degrees received by individuals from these five countries represent 2.0% of all Ph.D.'s awarded to temporary residents during the decade of the 1990s and 0.7% of all degrees awarded. The largest number of degrees was awarded in engineering (56.5%), followed by the agricultural and biological sciences (22.4%).

Preventing individuals from countries that the United States considers to be sponsors of terrorism from studying in the United States would have but a small effect on U.S. Ph.D. production. The number of students coming from the 25 targeted countries is considerably larger, but still minimal, even if the new screening policy were to effectively limit entry. The larger question is whether the growth in Ph.D. production that has occurred, in large part because of non-U.S. citizens, is beneficial to the U.S. scientific enterprise.

PAULA E. STEPHAN,[1]* GRANT C. BLACK,[1] JAMES D. ADAMS,[2] SHARON G. LEVIN[3]

[1]Andrew Young School of Policy Studies, Georgia State University, Atlanta, GA 30303, USA. [2]Department of Economics, University of Florida, Gainesville, FL 32611, USA. [3]Department of Economics, University of Missouri–St. Louis, St. Louis, MO 63121, USA.

*To whom correspondence should be addressed. E-mail: Pstephan@gsu.edu

References and Notes

1. S&E includes the biological and agricultural sciences; earth, atmospheric, and ocean sciences; math and computer sciences; physical sciences; and engineering.
2. Survey of Earned Doctorates (Science Resources Statistics, Arlington, VA) (www.nsf.gov/sbe/srs/ssed/start.htm).
3. M. B. Sheridan, D. Eggen, *Washington Post*, 14 November 2001, p. A24.
4. S. Burd, S. Hebel, *Chronicle of Higher Education*, 11 January 2002, p. A30.

Letter of Appreciation

JOHN T. EDSALL WILL CELEBRATE HIS 100TH birthday in November 2002, and the Committee on Scientific Freedom and Responsibility (CSFR) of the American Association for the Advancement of Science (AAAS, the publisher of *Science*) would like to acknowledge the important role that he has played in its own establishment in 1976 and in the increasing recognition by scientists of their social and professional responsibilities. Edsall's many articulate statements over almost half a century of the rights and responsibilities of scientists have greatly focused these issues nationally and internationally. In particular, his 1975 article, "Scientific freedom and responsibility" (*1*), represents the seminal and still relevant presentation of the boundaries of these issues.

Questions about scientists' responsibilities and freedoms in the post–September 11 era have shown us how critical it is for scientists to reassess how they can best fulfill their social obligations while maintaining the integrity of science. In the year of Edsall's 100th birthday, CSFR reaffirms its role "to formulate and recommend principles and procedures to guide AAAS in a continuing review of issues that affect scientific freedom and scientific responsibility, and to search for means that will effectively bring these issues to the attention of both scientists and others."

AAAS COMMITTEE ON SCIENTIFIC FREEDOM AND RESPONSIBILITY

15 February 2002, Boston, Massachusetts

References and Notes

1. J. T. Edsall, *Science* **188**, 687 (1975). This article can be found on the CSFR node of the AAAS Web page at www.aaas.org/spp/dspp/sfrl/committ/csfr.htm.

Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 6 months or issues of general interest. They can be submitted by e-mail (science_letters@aaas.org), the Web (www.letter2science.org), or regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.