LETTERS

Acid Rain: U.S.–Canadian Negotiations

Eliot Marshall's article on air pollution (News and Comment, 17 Sept., p. 1118) needs a little correction.

Strictly speaking the Canadian government did not accept the advice of the joint committee of the National Academy of Sciences and the Royal Society of Canada, although it has supported the joint venture strongly (with money as well as good wishes). When it became apparent that the two governments would not use the joint committee for the peer reviews of the Memorandum of Intent documents, the Canadian Minister of the Environment asked the Royal Society to carry out a Canadian review. The Society appointed the expert panel to which Marshall refers. It has only one member in common with the joint committee, although it does have the same Canadian chairman, myself, and the same scientific officer, Andrew Forester. This panel's reviews will be referred to the joint committee for comment.

A little Byzantine? Certainly; but needs must if nothing more straightforward will work.

I am the provost of Trinity College in the University of Toronto, not of the university itself. And the Royal Society of Canada is a freestanding body of scholars that is not really the counterpart of the National Academy of Sciences. It was the nearest thing, and the Academy generously assumed that we had as much experience in such matters as they had.

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Trauma Research

The organization of the National Institutes of Health and the creation of additional institutional divisions are indeed subjects that merit discussion (News and Comment, 13 Aug., p. 610). I would like to call attention to a major health problem that has yet to be addressed in an effective, nationally coordinated manner.

Trauma and injury are the leading cause of death after heart disease, cancer, and stroke and represent the major cause of death and disability in individuals below the age of 40. Monetary costs exceed $20 billion yearly plus the loss to society of young individuals in the prime of life. The funding of trauma research, especially accident prevention and injury minimization, is miniscule, estimated at less than 0.04 percent of the annual cost of injury. Existing organizations have not obtained significant increased funding or been able to muster public or congressional support for important preventive measures.

For those reasons, it seems timely to urge consideration of a National Institute of Trauma. Our modern society exacts a high price in injury, disability, and death. The public and those who care for trauma victims must unite to confront this health problem.

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Damascus Steel-Making

In a recent letter (16 Apr., p. 242), Cyril Stanley Smith discusses an article by Thomas H. Maugh II (Research News, 8 Jan., p. 153) about our work on ultrahigh carbon (UHC) steel and on Damascus steel. It was a pleasure to read Smith's review of the history of Damascus steel. We disagree, however, when he states, "The secret of Damascus steel was well known in the 19th century." We believe this statement is incorrect because none of the 19th-century metallurgists (for example, Bréant, Anossoff, or Faraday) ever documented a procedure that would allow ready reproduction of the damask (surface markings) characteristic of Damascus steels. In our work (*1, 2*), a precise procedure for making the damask has been described. We demonstrate here the inadequate detail of previous descriptions (*3, 4*) in the work of 19th-century metallurgists.

It has been generally accepted that the methods of manufacture of Damascus swords are insufficiently understood. In our initial research into their history, we came to the same conclusion. In fact, in American patent law it is stated (*5*) that the swords of Damascus are among a number of ancient arts which remain to be rediscovered and are a prime example of a patentable discovery. Smith credits the French metallurgist, Bréant (*6*) as having been the first to unravel the secret of Damascus swords. To support the claim that Damascus sword-making is well understood, Smith states in his letter, "He [Bréant] saw that a good structure originated in the very coarse duplex crystals formed by slow solidification from the liquid state, and this was contorted by subsequently forging the blade at a low temperature" (*7*). No further detail can be found in Smith's other works (*3, 4*). We suggest that the brief procedural statement given by Smith is quite insufficient, even for one knowledgeable in the art, to manufacture Damascus steel. For example, the statement "the very coarse duplex crystals formed by slow solidification," in addition to being questionable (*7*), neglects the influence of cooling rate after solidification, a factor that is of paramount importance in developing the desired damask. In UHC steels, only by slow cooling from high temperatures (for example 10°C per hour) will the required precipitation of proeutectoid cementite, in the form of thick plates, occur at the grain boundaries of the coarse-grained austenite. This condition is required in order that the final damask be visible to the naked eye. Furthermore, the statement "forging the blade at a low temperature" has no meaning unless the temperature of forging and the strain imparted during forging are specified. Our own experience (*2*) has shown that a deformation, typically a 5 to 1 reduction, imparted by forging in a narrow range of temperatures—from 750°C (cherry color) to 800°C (bright cherry color)—will lead to the desired damask observed in Damascus swords. This damask consists of stringers of spheroidized proeutectoid carbides in a matrix of eutectoid composition steel. A further important factor not discussed by Smith or Bréant is the heat treatment of the final product. In order to obtain the desired strength and toughness while retaining the damask, it is necessary to heat the forged sword in a narrow temperature range (that is, to a cherry color) followed by appropriate quenching (*1, 2*).

In our reviews on Damascus steel (*1, 2*), we carried out the above specified procedure and described it for a 1.7 percent carbon steel in the manufacture of a damask. This damask is identical in appearance to those in the photomicrographs taken by Zschokke (*8*) and others (*3, 9*) of original Damascus swords.

There is no doubt that Bréant and his colleagues made swords having a pattern. Since a Damascus-type blade was made, it is necessary to ask, Why did he not describe its processing in the necessary detail? The answer may, in fact, lie in Smith's own description of Bréant's activities in Damascus steel-making (*4*). "Bréant's success raised a difficult question. The Society [sponsoring his work] was dedicated to the dissemination of information to help the nation's industry, yet it realized that publishing Bréant's process would help foreign competition.

It was, therefore, decided to withhold full details of the discovery for 2 years, but full information would be released to any French manufacturer who intended to make use of it. . . . As it turned out, secrecy was broken within a year. . . . Bréant's paper finally appeared in the August, 1823, issue of the *Bulletin*." One may speculate that, in spite of the ability to publish, Bréant was asked only to discuss the metallurgy of his Damascus steel discovery in general terms. Thus in his papers, Bréant taught some of the metallurgy of UHC steels but may have purposely avoided teaching the detailed know-how of making a damask in such steels. In contrast, we have taught both the metallurgy and the know-how of Damascus steel-making.

We do not claim that the above discussion of our work represents a complete account of the metallurgy of Damascus swords. On the contrary, it is reasonable to speculate that many different procedures were used to obtain swords with exceptional mechanical properties. For example, steels having a composition identical to Damascus steel can be readily manufactured in such a way that no damask is present. Such steels have been shown to possess excellent formability, strength, and toughness (*1, 2, 10*). Perhaps the best of the Damascus swords, ironically, would have been those that did not possess a damask. This conclusion would be supported by modern metallurgical concepts about the influence of size, distribution, and volume fraction of hard particles on the mechanical properties of crystalline solids.

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References and Notes

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4. ______, *1963 Lecture on Outstanding Research* (American Society for Testing and Materials, Philadelphia, Pa., 1963).
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6. J. R. Bréant, *Bull. Soc. Encour. Ind. Nat.* 22, 222 (1823); *Ann. Philos.* 8, 267 (1824).
7. We were not able to find equivalent statements by Bréant in our review of his work (*6*). Smith's quotation, however, is a summary of his own teachings in 1963 on the processing of Damascus swords (*4*, p. 18). When Smith states that "duplex crystals formed by slow solidification," we believe he is of necessity considering the case for white cast iron of a composition range of between 2.1 and 4.3 percent carbon. For such compositions, eutectic carbides and austenite will be present on solidification giving the "duplex crystals." Bréant, on the other hand, considered principally UHC steels in the composition range from about 1 to 2.1 percent carbon, where no eutectic carbides will form on solidification since only a single phase (austenite) is obtained. In this case, no "duplex crystals" can appear upon solidification. The metallurgy, microstructural features, and mechanical properties of UHC steels and white cast irons are quite dissimilar [J. Wadsworth and O. D. Sherby, *Foundry Met. Treat.* **106**, 59 (1978); J. Wadsworth, L. E. Eiselstein, O. D. Sherby, *Mater. Eng. Appl.* 1, 143 (1979).
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Synthetic Muramyl Peptides

In the article "Sleep-promoting factor isolated" (Research News, 25 June, p. 1400), Thomas H. Maugh II attributes to me the synthesis of "more than 300 muramyl peptides in a search for immunostimulants that could serve as adjuvants or potency increasers for vaccines."

The work on MDP (muramyl dipeptide) is the result of an extensive collaborative effort of several teams. The identification in 1974 of MDP as the smallest adjuvant active unit of bacterial cell walls was the result of work at the Institut de Biochimie (Université de Paris-Sud, Centre d'Orsay) by Arlette Adam, Rita Ciorbaru, Farielle Ellouz, and Jean-François Petit. The first synthesis of MDP was performed by Pierre Sinaÿ and Claude Merser at the Institut de Biochimie of the Université d'Orléans, who followed our suggestions and used a protected dipeptide prepared by Pierre Lefrancier of Laboratoires Choay, Montrouge. The synthetic muramyl dipeptide being fully active (*1*), Pierre Lefrancier, Jean Choay, and their group have, since 1974, synthesized more than 200 analogs.

The biological properties of these compounds have been extensively studied by Louis Chedid with Françoise Audibert and Monique Parant at the Pasteur Institute in Paris. For recent reviews, see (*2*).

Japanese workers Shozo Kotani and Tetsuo Shiba of Osaka and Ichiro Azuma of Sapporo have also made important contributions to this field.

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Nuclear Proliferation Concerns

In his discussion (Letters, 17 Sept., p. 1082) of laser isotope separation (LIS), David Albright, while bringing attention to some proliferation concerns, does not mention several important points. France is already a nuclear-weapons state, and West Germany has long had the materials and capability to manufacture nuclear weapons if it so chose. Denial of isotope-separations technology to them would add little toward nonproliferation of nuclear weapons. More to the point is that LIS knowledge should not be transferred to any of the other dozen or so nations that are at the nuclear-weapons threshold and have not agreed to international safeguards under the Non-Proliferation Treaty (NPT). Nuclear-weapons states must rigorously control their own development and export of shortcuts to fissile materials.

Albright also does not note that there are many more potential national actions and self-restraints that would be more effective than technology control in discouraging proliferation. For example, continued development, testing, production, and deployment of nuclear weapons—coupled with the absence of arms-control treaties—give nations such as India excuses for not becoming adherents to the NPT. Termination by the Reagan Administration of comprehensive test-ban negotiations and the lack of Senate ratification of the Threshold Test-Ban Treaty, the Peaceful Nuclear Explosives Treaty, and SALT II are very detrimental to nonproliferation.

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Erratum: In the report "Single-neuron labeling in the cat auditory nerve" by M. C. Liberman (11 June, p. 1239), in lines 24 and 25 of the legend to figure 2 (p. 1240), the words "CF's above 15 kHz" should have been "CF's below 15 kHz."

Erratum: In the report "Hair-cell innervation by spiral ganglion cells in adult cats" by N. Y. S. Kiang *et al.* (9 July, p. 175), in lines 14 and 17 of the legend to figure 2 (p. 176), the unit "mm" should have been "μm."

Erratum: In the article "Alternative energy futures: The case for electricity" by Umberto Colombo (20 Aug., p. 705), the label on the abscissa for figure 4 on page 708 should have read: "Increase in kWh per capita, 1972 to 1978 (%)."