of interstellar molecules. My article was meant to be a review of the current state of the subject and not a discussion of the history of this field. I regret the use of the word "accidental" in my introduction to describe the detection of the first interstellar molecules since it does a great disservice to those who spent years of effort searching for the first interstellar molecules.

As Barrett *et al.* point out, the impression that early developments in molecular line astronomy were in part due to "accidents" and in part due to improvements in instrumentation is derived from developments at millimeter wavelengths, which now produce most of our information about the cold phase of the interstellar medium. In this field, the last 15 years has been marked by dramatic improvements in receiver performance, antenna surface accuracy, and systems integration. Many of the observed spectral lines and new phenomena were unexpected. The discovery of X-ogen (later identified to be HCO^{+}), giant molecular clouds in CO, and bipolar outflows are but a few examples of surprising new finds.

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Subseabed Waste Disposal

Eliot Marshall, in his article "Thirty ways to temporize on waste" (News & Comment, 7 Aug., p. 591), refers to the support of Senator Chic Hecht (D–NE) for continued research on "putting nuclear waste in the deep seabed" as "proposing something new." This is not the case. Subseabed disposal of radioactive waste is not a "new" idea (*1*). The United States and nine other nations have been investigating subseabed disposal for more than 10 years, and research results to date indicate that subseabed disposal can be conducted without proposing unacceptable risks to human health or the marine environment. In 1986, however, the Department of Energy (DOE) terminated U.S. participation in the international subseabed disposal research effort "purely on the basis of near term budget priorities," according to a DOE statement of 5 January 1986.

Senator Hecht's bill, the "Subseabed Nuclear Waste Disposal Research Act of 1987" (S. 1428), would authorize continuation of U.S. research on subseabed disposal. Rather than proposing something new, the bill reasserts the wisdom of section 222 of the Nuclear Waste Policy Act of 1982 (NWPA), which mandates continued research on alternative disposal methods. A bill proposed by Senator Daniel Evans (R–WA), the "High-Level Radioactive Waste Storage Act of 1987" (S. 1266), contains similar provisions for reauthorizing research on subseabed disposal. In light of the problems facing land-based disposal, it seems prudent to keep our options open rather than abandon the only credible backup to deep geologic repositories.

We should heed the lesson of the *Challenger* accident, which left NASA without alternative launch capability because it had abandoned its expendable rocket program. It is unwise to put all one's eggs in a single basket, especially when the possibilities and consequences of failure are significant and the cost of maintaining a backup is relatively low. For less than 5% of the land repository program budget, the United States could keep the subseabed option open. Senators Hecht and Evans have good reasons for supporting continued development of subseabed disposal. If one of their states is selected for a repository site, and if the site turns out to be flawed technically, having an alternative available would provide a significant safeguard.

Subseabed disposal is also a significant potential international disposal option. The United States is not the only nation encountering severe problems in siting a land-based repository. In fact, only the Soviet Union claims to have developed a permanent repository for high-level waste. For small nuclear nations, the land-based option may be foreclosed altogether. For developing country nuclear nations the cost of building a deep geologic repository on land would severely strain resources even if the country possessed the capability to design and construct reliable facilities. These problems would be significantly reduced if an internationally chosen, constructed, regulated, and monitored site were to be developed.

Such a site would, in addition, provide a significant boost to U.S. nonproliferation policy objectives, since it could also safely accommodate spent fuel. This would verifiably close the back end of the nuclear fuel cycle without raising the issue of the United States having to accept foreign wastes. Continued research and development of the subseabed disposal option would, therefore, serve both domestic and foreign policy objectives of the United States. Moreover, if the U.S. program were to be continued, it would ensure the continuation of the cooperative international program within the Nuclear Energy Agency of the Organization of Economic Cooperation and Development. This would permit the United States to realize the full benefits of this program for only a fraction of its total cost.

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TMI and Chernobyl

The article "Nuclear power after Chernobyl" by John F. Ahearne (8 May p. 673) contains some disturbing inconsistencies.

Ahearne states that among the similarities between the accidents at Three Mile Island (TMI) and Chernobyl is the fact that "both reactors are very sensitive," yet he notes that at Chernobyl the operators had only seconds to react, while at TMI there were hours. The Chernobyl accident involved a reactivity excursion, something that did not happen at TMI, nor could it have, given the entirely different neutronic characteristics of that reactor.

Ahearne states that in both instances the operators "took a series of steps that were deliberate and that defeated the safety systems." At Chernobyl the operators did deliberately violate their procedures by turning safety systems off; but at TMI the operators, faced with a situation in which different procedures posed irreconcilable requirements depending on which instrument readings they believed, and because of their ignorance at the time that the PORV (a pressure relief valve at the top of the pressurizer) was stuck open, chose what was in retrospect the wrong response and shut off the safety injection of water into the reactor vessel to prevent what they believed to be the imminent danger that the system would go "solid," that is, lose the necessary steam "bubble" in the top of the pressurizer. Thus they acted after the accident had begun and did what they believed their procedures called for, while at Chernobyl the procedure violations occurred before the onset of the event (in fact caused it) and were indeed deliberate.

It is indeed true that containment overpressure capabilities in U.S. light-water reactors range from about 2 to 5 kilograms per square centimeter, but this says nothing about their protective capabilities without information about the volume within the pressure boundary, which determines how large a pressure rise would accompany a given release into the containment-confinement volume. U.S. plants have either large dry-volume containments or somewhat smaller volumes supplemented with ice-water systems to condense vapor and thus reduce the pressure increase; they are designed to withstand a complete break of the largest pipe in the system. Chernobyl's RBMK-1000 confinement systems design, on the other hand, has a much smaller volume and is in fact designed to accommodate at most the rupture of only one of the more than 1600 small pipes passing through the graphite stack that constitutes the core.

Ahearne does not compare releases and health effects. The TMI containment performed its design function: virtually no radioactivity (other than noble gases, which contribute little to population exposure) was released, and the offsite health effects were virtually negligible. By now, the severe radiological impacts of Chernobyl are well known. This difference reflects the radical differences in design and safety philosophies that underlie the features of the two reactors and profoundly affected the consequences of the two accidents.

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Response: Silver is correct that the Chernobyl RBMK reactor is far more sensitive than the TMI reactor. However, as I stated in my article (p. 677), the TMI "design is well known within the U.S. nuclear reactor industry as being more responsive to perturbations than other U.S. reactors." Nuclear Regulatory Commission studies after TMI showed that for some accident scenarios involving this type of reactor, operator reaction times would have to be much less than 2 hours.

With regard to the TMI operators' ignorance of the status of the PORV, the operator interpretation was complicated by the operating staff's willingness to allow a violation to go uncorrected. That PORV had been leaking for weeks (1, p. 46). Company instructions called for the block valve to have been closed under those conditions (1, p. 116). But it had not. This was a violation of required procedures (2). Very early in the accident an operator read that temperature downstream of the PORV was 50°F higher than the maximum allowable, indicating the valve was stuck open (3, p. 14). Over the next 3 hours, the operators disregarded additional warnings and misinterpreted indications, such as rise in containment pressure (3, pp. 17 and 18). However, when the Babcock & Wilcox technical support person was briefed over the phone on what was happening, he immediately figured out that the block valve should be closed, and the replacement shift supervisor took only 20 minutes to reach the same conclusion (3, p. 19). The TMI crew did take deliberate actions, even if misguided: "the operators override the emergency system and sharply reduce flow from the HPI [high pressure injection] pumps" (3, p. 17). "There is no question that operators erred when they interfered with the automatic operation of the high pressure (HPI) system even though conditions that initiated the system (low pressure) persisted . . ." (3, p. 102). It is also true that the operators had not been trained to handle the events that were developing at TMI: "It is a human intervention in the automatic chain of events not inconsistent with the operators' training . . ." (3, p. 17). One major review concluded: "First, the operators on duty had not received training adequate to ensure that they would be able to recognize and respond to a serious accident . . . Second, neither the operating crew nor their supervisors . . . possessed the necessary combination of technical competence and familiarity with the plant . . ." (3, p. 103). Nevertheless, "these operating personnel made some improper decisions, took some improper actions and failed to take some correct actions, causing what should have been a minor incident to develop into the TMI-2 accident" (1, p. 27).

I agree there were major differences in design and safety philosophy. However, complacency, lack of understanding, inadequate training, and poor management were not that different, unfortunately.

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Erratum: In the issues of 21 August (p. 816) and 28 August (p. 956), the volume number (237) was incorrectly given as 238 in the Table of Contents heading.