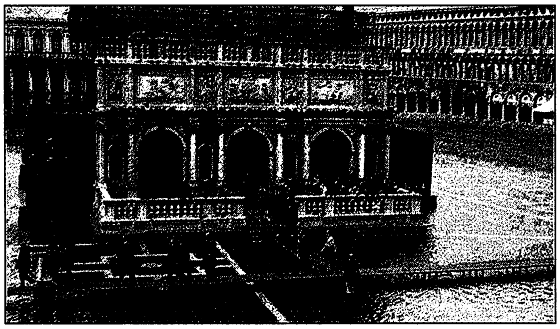
peak tides (higher than 100 centimeters above the 1897 datum), with consequent hydrological and ecological problems.

Although the geologically and anthropologically induced subsidence of Venice is well established (*1, 2*), several points should be noted. During the peak years of groundwater withdrawal (1950s to 1970s), relative sea level rose by 4 millimeters per year as compared with the 20th century average trend of ~2.5 millimeters per year (*2*). Between 1952 and 1969/70, the industrial zone due north of Venice subsided about 13 centimeters. Additional subsidence was negligible after groundwater pumping stopped (*3*). However, almost 85% of the subsidence that has already occurred is irreversible and its effects still remain. Furthermore, although human-induced subsidence has essentially stopped in the historic center of Venice, it still continues along the barrier island bounding the Venetian lagoon (*3*). This continued subsidence not only threatens the future survival of the barrier islands, but also that of Venice itself, placing the historic city at increasing risk to flooding from storm surges. The proposed floodgates can be closed during exceptionally high tides, but they will not prevent overtopping of the islands by extreme surges.



**The Piazza San Marco in Venice during an exceptionally high tide.**

Ammerman and McClennen argue that the proposed system of floodgates is unsatisfactory. An alternative solution for saving Venice might be that used by the Dutch: surround the city by a continuous series of dikes interrupted by locks to permit boats to enter, but only at low tide. Increased loading by dikes would be a secular phenomenon that could be met by periodically raising the dikes to compensate for the subsidence and sea level rise, as is done in the Netherlands.

**Vivien Gornitz**
**Rhodes W. Fairbridge**
Goddard Institute for Space Studies and Columbia University Center for Climate Systems Research, 2880 Broadway, New York, NY 10025, USA

**References**

1. A. J. Ammerman *et al.*, *Antiquity* **73**, 303 (1999).
2. P. A. Pirazzoli, *J. Coastal Res.* **7**, 231 (1991).
3. L. Carbognin *et al.*, in *Land Subsidence*, F. B. J. Barends *et al.*, Eds. (Balkema, Rotterdam, 1995), pp. 129–137.

### *Response*

Certainly the lagoon hydraulics and land elevation have been modified by human intervention, as Gornitz and Fairbridge point out. The centuries-old diversion of the Brenta and Sile rivers shunted fresh waters into the Adriatic Sea, sharply reducing deltaic sedimentation and through-flow flushing of the lagoon, while simultaneously causing an increase of lagoon salinity. Venice's fresh water, drawn from the same dolomite region, is now substantially enriched with organics before being discharged into the lagoon as urban sewage wastewater. Lagoon aquatic life thrives or is inhibited by changes in these various hydraulic factors, as well as by associated nutrient supplies, pollutants, toxins, and biological oxygen demand.

Overtopping of the barrier islands and spits will certainly become more frequent with continuing subsidence and sea-level rise. Caution is needed, however, in making comparisons between observations of land surface subsidence around the lagoon and those made in Venice that are based on fixed points on buildings. The building foundations rest on wooden poles driven down through 4 to 5 meters of lagoon sediments to the much firmer prelagoonal river floodplain sediments (*1*). This relationship, known by Venetians for centuries, has been confirmed by archaeological fieldwork at the Basilica of San Marco and the church of San Lorenzo (*2*) and is what has made it possible to build large, stable structures in the marsh island areas of the lagoon. In contrast, the benchmarks established on the barrier and lagoon ground surfaces are subject to disturbances and the instability of salt marshes, natural tidal channel deposits, anthropic fills, and silty lagoon sediments that have accumulated over the last 6000 years. So land surface benchmarks can produce different elevation histories than those observed on large buildings. This difference in the two types of elevation markers might explain some of the variability in reported subsidence values (*3*). The ongoing installation of high-precision Global Positioning System (GPS)–based survey markers in Venice will provide the basis for new data and evaluation over the next few decades.

Any Dutch solution must deal with the urban sewage effluent as well as the added load and any local subsidence caused by such a massive dike structure. With the lagoon depths typically less than 1 meter (except in the 5- to 20-meter deep channels), the 60- to 80-centimeter tidal cycle currently provides substantial twice-daily flushing through the three Adriatic Sea inlets. Any enclosure in this Mediterranean climate with high summer temperatures and low precipitation generates ecological management challenges. An examination of engineering options will demonstrate that major improvements in reducing levels of pollution entering from agriculture, the petrochemical complex at Porto Maghera, and the city itself are essential to the existence of a healthy lagoon ecology. Moreover, there will have to be a clean-up of the chemical wastes, including dioxins, that the Maghera plants pumped into the lagoon between 1984 and 1997. The estimated clean-up cost is $8 to $40 billion (*4*). Thus, decades of industrial mismanagement, the local climate, and the need for tidal flushing of urban waste make the Dutch solution for saving Venice more complicated than its successful use in the Netherlands.

**Albert J. Ammerman**
**Charles E. McClennen**
Colgate University, 13 Oak Drive, Hamilton, NY 13346–1398, USA. E-mail: aammerman@mail.colgate.edu and cmcclennen@mail.colgate.edu

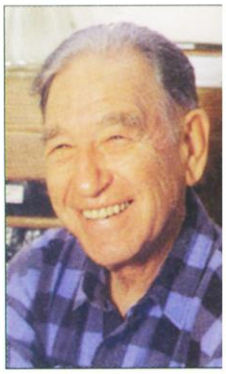
**References and Notes**

1. C. E. McClennen, A. J. Ammerman, S. G. Schock, *J. Coastal Res.* **13**, 745 (1997).
2. A. J. Ammerman *et al.*, *Antiquity* **73**, 303 (1999). We have collected further data that confirm and extend the previous findings in Venice (A. Ammerman *et al.*, in preparation).
3. L. Carbongnin, L. Tosi, in *Land Subsidence*, F. B. J. Barends *et al.*, Eds. (Balkema, Rotterdam, 1995), pp. 129–137.
4. *Venezia La Nova*, 5 October 2000, p. 3, and 15 October 2000, p.15.

## The Other Stanley Cohen

In the timeline accompanying the Pathways of Discovery essay "Neuroscience: breaking down scientific barriers to the study of brain and mind" by E. R. Kandel and L. R. Squire (10 Nov., p. 1113), there are photos that are labeled to be of Rita Lévi-Montalcini (my thesis advisor) and her collaborator Stanley Cohen (my friend). Perhaps the photo that the legend indicates is Stan Cohen is instead that of another Stanley Cohen? My photos of Stan Cohen of nerve growth factor/epidermal growth factor fame show a good head of hair, even at age 62.

**Ruth Hogue Angeletti**
Department of Developmental & Molecular Biology, Albert Einstein College of Medicine of Yeshiva University, Bronx, NY 10461, USA. E-mail: angelett@aecom.yu.edu



### *Editor's note*

The photo in the Pathways essay was indeed of "another Stanley Cohen," a researcher well known for his pioneering role in genetic engineering. The Stanley Cohen referred to in the Pathways essay, a co-recipient of the Nobel Prize in Physiology or Medicine in 1986 and professor of biochemistry at Vanderbilt University, is pictured here.

CREDIT: (LEFT) A. J. AMMERMAN; (RIGHT) VANDERBILT UNIVERSITY