nitrogen isotope results reported by Brown *et al.* also hint at a great abundance of interstellar grains in the Tagish Lake meteorite, which will likely spur a flurry of studies of those components. Petrologists and cosmochemists will be interested in this meteorite because it seems to have some chemical and textural properties transitional between highly primitive CI chondrites and the more processed CM group and may shed light on problems such as chondrule and refractory-inclusion formation and chemical fractionations in the solar nebula.

It seems likely that the Tagish Lake meteorite will be the most important recovered fall since the Allende (Mexico) and Murchison (Australia) events, both in 1969, touched off a revolution in our understanding of meteorites and what they tell us about the early solar system.

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PERSPECTIVES: PALEOCLIMATE

The Younger Dryas: Cold, Cold Everywhere?

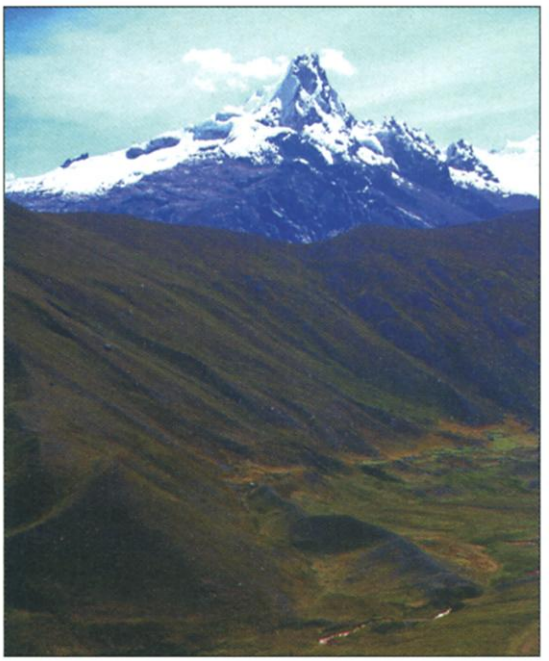
Donald T. Rodbell

During the Younger Dryas (YD) period, climatic conditions returned to near full glacial conditions for about 1000 years, midway through the transition from the last glacial period to the present interglacial. This event has fascinated Earth scientists because it demonstrates a relatively recent instability in regional and possibly global climate. Evidence for this event was first documented in glacial deposits and pollen records from Scandinavia (*1*), which revealed a reexpansion of ice and a brief return of *Dryas octopetala*, a cold-tolerant flower, to the landscape. Subsequent marine and ice-core evidence has demonstrated a YD cooling in and around much of the North Atlantic (*2*).

On page 325 of this issue, Bennett *et al.* (*3*) report results of a study of fossil pollen grains preserved in lake sediments in maritime southern Chile that indicate that no such cooling took place in that region nor, they assert, elsewhere in the Southern Hemisphere. These conclusions are sure to generate passionate discussion among paleoclimatologists. Numerous workers have endeavored to document the global extent of the YD cooling, and few climate records have produced more conflicting results than those from South America.

Most evidence for the YD comes from regions in and around the North Atlantic, and this has led to speculation that its origin lies in the North Atlantic Ocean. One leading hypothesis (*4*) holds that the event was a climatic accident driven by an abrupt change in the flow of the melt water from the waning ice sheet that covered much of North America during the glacial period. According to this hypothesis, the melt water first took a route through the Mississippi River, but this changed to one that carried melt water to the North Atlantic, thereby upsetting the salinity balance of the North Atlantic so much that it briefly shut down the ocean circulation patterns that moderate regional climate. In the last decade, it has become clear (*5*) that the YD was but one of a series of millennial-scale cold snaps that punctuated the climate of the North Atlantic region over at least the past 50,000 years or so. YD-like events are thus far more common than previously appreciated, but both their cause and their geographic extent remain elusive.

If we knew to what extent these rapid climatic oscillations were felt in regions far from the North Atlantic, this may help to identify oceanic and atmospheric teleconnections that linked regional climates during glacial-interglacial cycles. Of the many cold snaps, the YD is most likely to be recorded in mid- and low-latitude lakes and glacial deposits because most lakes were formed during the last deglaciation and deposits from older glacial advances are commonly obliterated by subsequent advances. One exception is found in the Chilean Andes, about 300 km north of the area studied by Bennett *et al.* (*3*), where glaciers advanced in near lockstep with the predecessor cold snaps of the YD in the North Atlantic region, and another in New Zealand, where a similar pattern of glacial advance includes an advance contemporaneous with the onset of the YD in the North Atlantic (*6*). Synchroneity does not necessarily reflect a common cause, however, and climate change during the YD in some areas far from the North Atlantic has been very different from the cooling that occurred around the North Atlantic (*7*).



Traces of millennial-scale climatic change. Regional climate history can be inferred from proxy climate indicators such as the age of glacial landforms. Features such as the small moraine ridge (above) that crosses part of a valley floor in the Cordillera Blanca in the northern Peruvian Andes indicate that many glaciated regions of the world experienced unstable climatic conditions throughout the last deglaciation, but the evidence for a YD cooling in the Southern Hemisphere remains equivocal.

Many proxy climate indicators from both South and North America reveal climatic reversals of some kind during the last glacial-interglacial transition. Some of these appear to fit neatly into the North Atlantic climate template, but in many cases, dating is insufficient to rigorously

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establish synchroneity. Glacial records from two areas in the central Andes, where deposits are well dated, demonstrate that glacial advances once thought to be of possible YD age are, in fact, older than the YD by several centuries; glaciers in these regions were rapidly retreating during the YD (*8*).

Bennett *et al.* make a compelling case for the absence of a YD cooling based on sediment cores from four lakes on the Taitao peninsula and Chonchos archipelago, southern Chile. Each core, dated by radiocarbon, spans the last deglaciation and includes the critical YD interval. They note the progressive southward migration of decreasingly cold-tolerant trees through the last deglaciation with no evidence of a reversal at any time. The steady temperature rise through this climatic transition implied by these data is consistent with results from several other paleobotanical studies from southern South America (*9*) yet is in striking contrast with records of Southern Hemisphere glacier advances (*6*, *8*), isotope paleotemperature data from ice cores from maritime Antarctica and the central Andes (*10*), and other paleobotanical data from elsewhere in South America (*11*).

These apparent discrepancies cannot easily be explained. It is possible that the aforementioned glacier advances reflect episodic increases in precipitation and only small decreases in temperature—too small to impact the southward spread of cold-intolerant tree species on the landscape. On the other hand, if the location of the Bennett *et al.* study area was not close to a boundary between trees of different cold tolerance at the time of the onset of a cool event, such as the YD, one would not expect to see a strong pollen signature of the cooling. One thing is certain: Much remains to be learned about the timing, geographic extent, and causes of millennial-scale climatic variability.

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PERSPECTIVES: PHOTOCHEMISTRY

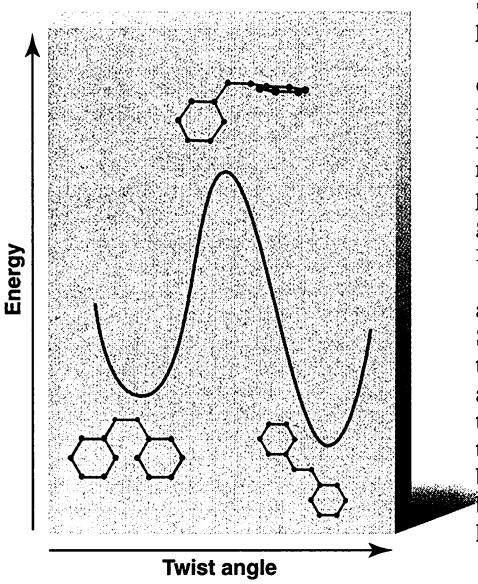
Twist and Fluoresce

John I. Brauman

The immune system is an immensely powerful apparatus capable of making proteins that bind other molecules with great strength and selectivity. Its normal function is to make proteins (antibodies) that sequester "foreign" substances. This molecular recognition has recently been used to create proteins that act as catalysts (catalytic antibodies) by making them bind to molecules with structures similar to that of the transition state of the reaction. The underlying view is that of enzyme catalysis as transition state binding. Combined with the ability to make monoclonal antibodies, it is now possible to use the immune system to engineer new catalysts (*1*).

On page 307 of this issue, Simeonov *et al.* (*2*) report the application of this approach to a new area, namely photochemical processes and reactions. Antibodies have been made that exhibit extraordinary photochemistry. They bind *trans*-stilbene, and, when irradiated, the stilbene does not isomerize but instead exhibits intense fluorescence.

To understand why this is remarkable, we have to look at the usual photochemistry of stilbene, which has been studied extensively (*3*). Stilbene readily undergoes photochemical trans → cis isomerization and shows only weak fluorescence. This behavior can be understood in the context of the ground- and excited-state potential energy surfaces. In the ground state, a 90° rotation around the C-C double bond costs roughly 45 kcal/mol (the energy of the π bond that has been broken). In contrast, the orbital to which the electron is photoexcited has antibonding character in the double bond, and the excited state has a minimum at 90°. When *trans*-stilbene absorbs a photon, the excited state rapidly twists to 90° and then undergoes a radiationless transition to the ground-state surface, ending up somewhere near the ground-state potential energy maximum. Subsequent rotation produces the isomeric product, *cis*-stilbene.



Ground-state potential surface for *cis*- (left) and *trans*-stilbene (right).

The time required for twisting in the excited state is short compared with the fluorescence lifetime, so relatively little fluorescence emission is observed. If the rate of rotation is slowed, for example, by placing stilbene in a viscous medium or by geometrically preventing the rotation, then fluorescence is observed (*4*).

Some of the features of the stilbene-antibody photochemistry observed by Simeonov *et al.* (*2*) can be explained on the basis of these previous studies. For example, it is not particularly surprising that the antibodies inhibit stilbene isomerization. As Simeonov *et al.* show for one stilbene-antibody complex (*2*), the antibody binds the *cis*-stilbene only weakly and inhibits isomerization.

Nevertheless, much of the observed photochemistry is still unexpected. Stilbenes that are constrained from rotational isomerization are known to fluoresce, but the spectra of the stilbene-antibody complexes are clearly different from that of stilbene itself. Moreover, a study of the time and temperature dependence of the fluorescence emission reveals that the process leading to the fluorescence is rather complex. Much of the fluorescence is quenched at low temperature, but at temperatures above 250 K, the fluorescence occurs with two separate time scales: a very fast one characteristic of isolated stilbene, followed

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