Less closely linked P elements can be mobilized to remove the targeted gene through flanking deletions. Such deletions have been recovered by selection for marker loss, but with sporadic success. A more systematic procedure to generate deletions is the "hybrid element insertion" process (*10*), which has been successful at several loci. Here, the left end of a P element joins with the right end of its twin copy on the sister chromatid. The resulting "hybrid element" can then insert into the homolog to yield a pair of recombinant chromosomes—one bearing a duplication and the other a deficiency of flanking sequences. The lack of meiotic recombination in *Drosophila* males makes screening for these recombinants easy. These deletion-based methods have two principal limitations: the variable frequencies for different P elements, and the potential for "collateral damage" or loss of other nearby or interstitial genes.

In Rong and Golic's new approach, most of the work is done by a pair of site-specific DNA-modifying enzymes from yeast. One is a recombinase whose action is to loop out a circular copy of the gene of interest. This copy comes from a transposon that was previously constructed and placed at a random site in the genome. The second enzyme is an endonuclease that opens the circle by cutting within the gene. This linear fragment can now find the targeted gene and recombine with it to produce a mutation.

There are some surprising aspects to Rong and Golic's results. The first is that their method works at all, given that another group (*11*) has recently tried a similar approach without success. The second is that two-thirds of the structures produced by Rong and Golic's method are not of the expected integration class, that is, they are not structures in which the linearized fragment is inserted into the targeted gene [see Fig. 4 in (*2*)]. A third surprise is that the frequency of mutations is much higher in females than in males.

The authors suggest possible reasons for these surprises, but there are alternative explanations that should be considered. A single exchange between the free DNA fragment and the chromosomal gene could lead to a double-strand break (see the figure). Repair of that break could make use of the homologous chromosome, especially if the event occurred before chromosome replication, when no sister chromatid is available for the job. This would explain the male-female difference, because the targeted gene (*yellow*) lies on the X chromosome and would have only one copy in males. Furthermore, *yellow* lies near the tip of the X chromosome, suggesting that the break could be repaired by "breakage-induced replication," as previously observed in yeast (*12*). In breakage-induced replication, a broken end is restored by synthesis from the homologous template all the way to the chromosome end. That would explain most of the structures observed by Rong and Golic (see the figure) as well as the lack of success in previous attempts where the targeted gene was not near a chromosomal tip (*11*).

The breakage-induced replication explanation can be readily tested. It implies that most mutational events are accompanied by recombination for outside markers, and that genes far from the telomere (end of the chromosome) would be refractory to mutation. If breakage-induced replication proves to be involved, Rong and Golic's findings will provide a valuable way to study this interesting repair pathway in *Drosophila*. Unfortunately, another implication is that the technique is unlikely to provide a broadly applicable approach to reverse genetics, because most *Drosophila* genes are not close to telomeres. On the other hand, if Rong and Golic's interpretation is correct and breakage-induced replication does not occur, then *Drosophila* geneticists will have a powerful and universal tool for reverse genetics at hand.

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13. I thank C. Flores for helpful discussions.

PERSPECTIVES: ECOLOGY

Weather Ruins Winter Vacations

Bernt-Erik Sæther

Our world is warming up (*1*). Climate models predict that this increase in mean annual temperature will continue for the rest of the 21st century (*2*). Whatever the reasons for the temperature increase, there is accumulating evidence that climate change may have a stronger impact on ecological processes than previously realized (*3*). Further evidence now comes from the report of Sillett *et al.* (*4*) on page 2040 of this issue. They show that large-scale regional variations in climate have a twofold effect on the demographics of a migratory bird species, affecting both its survival in the tropics as well as its reproductive performance in the north. One frightening consequence of these findings is that they illustrate how difficult it will be to reliably predict the effects of large-scale regional climate change on ecological systems.

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The El Niño Southern Oscillation (ENSO)—a quasi-periodic annual variation in global atmospheric and oceanic circulation patterns—influences rainfall worldwide (*5*). A quantitative measure of ENSO is provided by the Southern Oscillation Index (SOI), which is a standardized measure of the difference in atmospheric pressure between Tahiti in the South Pacific and Darwin in Australia. El Niños, assigned a low (negative) SOI value, generate milder and drier winters in the Southern Hemisphere. In contrast, high (positive) SOI values indicate La Niña conditions with more rainfall.

There has been an alarming decline in many migratory bird species that travel long distances to their tropical wintering grounds (*6*). It is well established that climate conditions at the wintering grounds may affect population fluctuations in long-distance migrant bird species. For instance, the size of the Dutch population of the purple heron, which winters in West Africa, is directly related to the annual variation in water discharges of the Senegal and Niger rivers (*7*). Small heron populations predominate after dry years when the rivers have little water. Another example is the British population of the sedge warbler. This increased after several winters of heavy rain in their West African wintering grounds, most likely because of higher survival rates among adult birds owing to an increase in the food supply (*8*). Such evidence suggests that unfavorable climate conditions at wintering grounds may explain the decline in many long-distance migratory bird species. The study of Sillett *et al.* (*4*) provides the first evidence that the demographics of a migrant bird, the black-throated blue warbler, may be strongly influenced by large-

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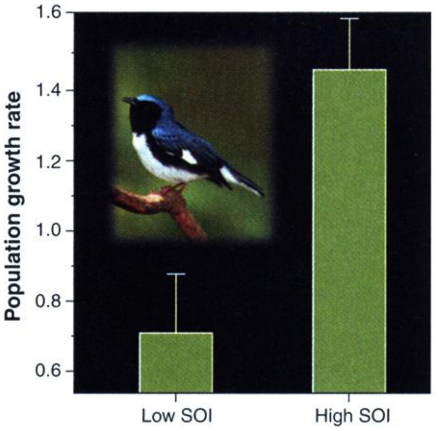

Fly away. The predicted population growth rate (mean ± SD) of the black-throated blue warbler, a migratory bird species, under El Niño conditions (low SOI; 1992 to 1994) and in three La Niña years (high SOI; 1988,1989, and 1996). Estimates of adult survival rates at the warbler's Jamaican wintering site have been combined with estimates of their reproductive rate at the New Hampshire breeding site (*4*). (It is assumed that the survival rate among juveniles is half the adult survival rate) (*10*).

scale climate changes affecting not only survival in southern wintering grounds but also reproductive performance in northern breeding areas.

The black-throated blue warbler is a migrant songbird that breeds in forests in eastern North America and winters primarily in the Greater Antilles (in the Caribbean). Sillett and co-workers took advantage of a long-term data set (1986 to 1998) from Hubbard Brook Experimental Forest in New Hampshire, USA (the warbler's breeding ground), and from northwest Jamaica in the West Indies (the warbler's winter quarters). With the Hubbard Brook data set they were able to show that the fecundity rate was lower under El Niño conditions than in La Niña years. They attributed this to an effect on the body mass of the fledglings, which is closely associated with the probability of first-year adult survival in many small songbird (passerine) species. Often the fecundity rate of small passerines is limited by food availability. Accordingly, Sillett *et al.* showed that, under El Niño conditions, there was a reduction in the biomass of lepidopteran larvae, the favorite food of the warbler. As a consequence, El Niño (with a low SOI value) resulted in a decrease in the number of new yearlings entering the New Hampshire population the following year.

With the Jamaica data set Sillett and colleagues were able to study the relation between ENSO and warbler winter survival. They noticed that there was a positive correlation between the number of juveniles in the study site in October and the SOI value, indicating that the pattern recorded in New Hampshire was not just a local phenomenon. Thus, in both study sites, low annual recruitment of first-year birds was related to El Niño conditions. The demographic consequences of El Niño years were further supported by a positive correlation between annual survival at the Jamaican wintering grounds and SOI.

The consequences of climate effects on animal population dynamics may be considerable. For example, consider predicting the warbler population growth rate by combining survival in the Jamaican study site with the reproductive rate at the breeding grounds in New Hampshire (see the figure). Assuming no effects of population density on population fluctuations, the population growth rate will be more than twice as high in La Niña years as in El Niño years (see the figure). Obviously, changes in the probability of an El Niño event (for example, because of the effects of global warming) are likely to strongly affect the population dynamics of this species (as predicted for other passerines) (*9*).

The Sillett *et al.* analysis provides another illustration of the need for detailed long-term studies to determine the many complex effects of global warming on animal populations.

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PERSPECTIVES: MATERIALS SCIENCE

Deformations in Extreme Matter

Roderic Lakes

Most materials, when stretched, become narrower in cross section, as can be observed by stretching a rubber band or a piece of sponge rubber. This narrowing is represented by Poisson's ratio, ν, which is defined as the negative transverse strain of a stretched or compressed body divided by its longitudinal strain. For most solids (*1*), ν is between 0.25 and 0.33; for rubber, it approaches 0.5. Because it is easy to change the shape of rubbery materials (they have a small shear modulus) but much more difficult to change their volume (they have a much higher bulk modulus), they are called incompressible. On page 2018 of this issue, Baughman *et al.* (*2*) examine unusual lateral deformations in matter with cubic structure and reach the surprising conclusion that a negative Poisson's ratio may occur naturally in several forms of matter with extremely high or extremely low density.

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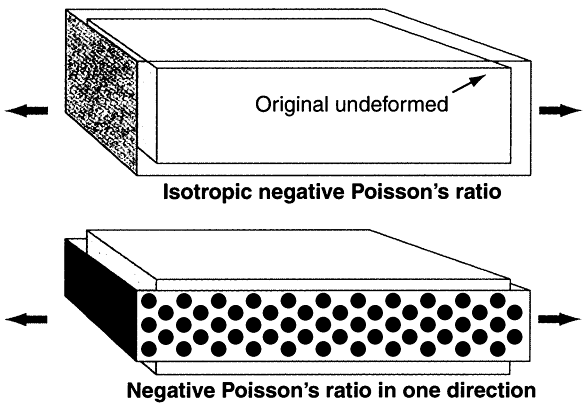

An unusual stretch. Stretching of materials with a negative Poisson's ratio causes an unexpected transverse expansion. This is unlike rubber and other common materials. If the material is isotropic, the expansion is in both transverse directions (**top**). Stretching cubic extreme matter can cause expansion in one direction and contraction in another direction at constant volume (**bottom**).

The limits for stability of an isotropic continuum (in which properties are independent of direction) suggest that ν can be between −1 and 0.5. The reason is that for the material to be stable, the bulk and shear stiffnesses (moduli) must be positive. These stiffnesses are interrelated by formulas that incorporate Poisson's ratio. Materials with a negative Poisson's ratio become fatter when stretched—a counterintuitive property (top panel in the first figure). For many years, negative