not begin until about 180 years ago, according to their best interpretation of the ages of the ice samples. This was about the time that world population began skyrocketing, they point out. Craig and Chou, on the basis of fewer samples and a different interpretation of ice core ages, have reported that the increase began about 400 years ago.

Except for the suggestion of population-related environmental pressures, researchers still do not know what is behind the methane increase. If the strongly oxidizing atmosphere of Earth had its way, there would be no methane at all, but bacteria-mediated fermentation of organic matter under low oxygen conditions manages to produce hundreds of millions of tons of this reduced form of carbon each year. The problem for researchers is that such fermentation goes on everywhere from termite guts (there may be more termites with increased forest clearing), to rice paddies (which have been expanded to feed a larger population), cows' stomachs, and natural wetlands. Biomass burning and natural gas leakage contribute as well. Part of the methane increase could even be a response to its reduced removal from the atmosphere by hydroxyl radical, whose abundance might be decreased by reaction with pollutants. All these mechanisms—both those that can add more methane and those that can slow its removal—are plausible and are now behaving so as to increase methane, so most researchers suspect that a combination of them is responsible.

The causes of the increase remain obscure, but at least one of its effects seems clear. Craig and Chou have calculated that, to the extent that any estimates of greenhouse warming are reliable, the methane increase has warmed the atmosphere "0.23°C over the past 400 years, and at the current rate of increase the warming due to methane is about 38 percent of the carbon dioxide warming effect." Methane's greenhouse effect is beginning to rival the collective effect of the chlorofluorocarbons (second behind the effect of carbon dioxide), and the cumulative effect of all trace gases is thought to equal that of carbon dioxide (*Science*, 24 June 1983, p. 1364). Ironically, the additional methane may be helping to protect stratospheric ozone from destruction by chlorofluorocarbons.—**RICHARD A. KERR**

**Additional Reading**


1. H. Craig and C. C. Chou, *Geophys. Res. Lett.* **9**, 477 (1982).
2. M. A. K. Khalil and R. A. Rasmussen, *Chemosphere* **11**, 877 (1982).
3. R. A. Rasmussen and M. A. K. Khalil, *J. Geophys. Res.*, in press.


# Frog Genes Jump Species

The discovery a year ago (*1*) of populations of a species of European mouse, *Mus musculus*, whose cells contained the mitochondrial DNA of a neighboring species, *Mus domesticus*, constituted a warning to biologists that an organism's genetic package might not always be what is reasonably expected of it. A second clear example of this type of mixing of genomes has now been brought to light, again in Europe, this time among species of water frogs (*2*). The warning becomes yet more intense that systematists who utilize molecular data to reconstruct genealogies must exercise extreme caution in selecting their raw material.

Mitochondrial DNA has a number of peculiarities, some of which are responsible for this occasional aberrant state of genomic affairs. These include being present in many copies per cell, evolving five to ten times faster than chromosomal DNA, and being maternally inherited. When male and female gametes meet they each contribute half of the chromosomal DNA, but only the egg contains mitochondria that become established in the developing embryo. The high rate of evolution of mitochondrial DNA makes it very useful in molecular tracing of genealogies, especially in the short term. But the mode of inheritance clearly restricts available information to maternal lineages. It is also the maternal mode of inheritance that can, under the right circumstances, lead to the introgression of one species' mitochondrial DNA into the cells of another.

When populations of different but related species are geographically contiguous, a hybrid zone sometimes arises, in which cross-species reproduction gives rise to more or less viable hybrids. In the case of the above-mentioned mice, it is postulated that the present-day *musculus* individuals that contain *domesticus* mitochondria arose from the mating of a female *domesticus* and a male *musculus*, the offspring of which backcrossed with *musculus* mates, thus diluting out the *domesticus* chromosomal genome while the mitochondrial genome was retained (through the female line at least). The Central European water frog case, which is reported by Christina Spolsky and Thomas Uzzell of the Academy of Natural Sciences of Philadelphia, is similar but has important differences that arise from the special biology of these animals.

Spolsky and Uzzell analyzed by restriction enzyme fragmentation the mitochondrial DNA from two water frog species, *Rana ridibunda* and *R. lessonae* from Poland. Although 59 percent of *R. ridibunda* individuals had typical *ridibunda* mitochondrial DNA, designated type A, 41 percent had a distinctly separate mitochondrial genome, type B, which differed by about 8 percent of its nucleotide sequence. The mitochondrial DNA in *R. lessonae*, type C, was virtually identical to *R. ridibunda*'s type B, differing by 0.3 percent of sequence, and seemed to be the source of it. The question was, how did this arise?

Natural hybrids between the two species produce a third species, *R. esculenta*, which nearly always has *lessonae* mitochondria and has the peculiarity of producing only *ridibunda* gametes; the *lessonae* genome is always lost. This process is known as hybridogenesis and is a form of clonal reproduction. Mating between two *esculenta* will therefore produce offspring that are *ridibunda* in their chromosomal genomes and probably *lessonae* in their mitochondria. Although this is one way in which the chromosomal/mitochondrial hybrids observed by Spolsky and Uzzell might arise, they often suffer from deleterious effects of recessive genes that are otherwise masked. *Rana ridibunda* individuals with *lessonae* mitochondria more likely arise through the crossing of a male *ridibunda* with a female *lessonae*. Because the *ridibunda* type B mitochondrial DNA has detectably diverged from *lessonae* type C, Spolsky and Uzzell guess that the event that led to the establishment of the chromosomal/mitochondrial genomic hybrid occurred either some while ago or geographically distant from where they sampled the populations.—**ROGER LEWIN**

**References**


1. S. Ferris *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* **80**, 2290 (1983).
2. C. Spolsky and T. Uzzell, *ibid.* **81**, 5802 (1984).