Common ground for X, Y chromosomes

The major difference between a female and a male mammal's cell is the chromosome composition. The female cell has a pair of X chromosomes, one of which is usually curled up in an inactive form, while the male cell has only one X chromosome and one, much smaller, Y chromosome. Scientists have hypothesized that these dissimilar chromosomes must share some of their genetic information — the X and Y are thought to have evolved from a common ancestral sex chromosome, and they still pair at every cell division, lining up the ends of their shorter arms. Now researchers are identifying genes that are carried on both of the sex chromosomes, Larry J. Shapiro of the Harbor-UCLA Medical Center in Torrance, Calif., reported in Los Angeles at the meeting of the American Association for the Advancement of Science.

At least two genes now appear to reside on both X and Y chromosomes of at least some mammalian species. Previously more than 100 genes had been assigned to the X chromosome, often on the basis of there being no matching gene in male cells. Only a few genes had been assigned to the Y chromosome — most of which relate to sex determination and thus have no counterpart on the normal X.

A gene located on both the X and Y mouse chromosomes was reported in the May 16 NATURE by scientists at the University of Washington in Seattle. This gene, called STS, affects the activity of an enzyme, steroid sulphatase. There had previously been confusion over whether the gene is on the X or one of the non-sex chromosomes. Elisabeth Keitges, Stanley M. Gartler and their colleagues also report that during meiosis, the cell division that produces sperm and eggs, the X and Y chromosomes can break and recombine so that they exchange the STS genes. In humans there appears to be no functional STS gene on the Y chromosome.

Another gene was reported to be shared by the human X and Y chromosomes. It encodes a cell surface molecule, called 12E7, found on most human tissues. Peter Goodfellow and his colleagues at the Imperial Cancer Research Fund in London, England, reported in 1983 that the gene is on the tip of the short arm of the human X chromosome and also on the short arm of the Y chromosome.

The genes of the tip of the X chromosome escape X-chromosome inactivation, Shapiro says. Three human genes have been mapped to this region: STS, 12E7 and the gene encoding a surface molecule, called Xg, found on red blood cells. In female cells, when the other known genes are inactivated on one of the two X chromosomes, these genes remain active. Shapiro speculates that the reason for their activity has an evolutionary origin.

The X and Y chromosomes must pair at meiosis so that they are properly distributed to the eggs and sperm. Therefore, some region of the chromosomes must be similar enough for the two chromosomes to line up properly. It now appears that the genes in this region act like genes on the non-sex chromosomes. They are not inactivated and they are able to recombine during meiosis.

Together, the recent findings offer a new view of the evolution of sex chromosomes. "Most people feel that the X and Y chromosomes were once homologous," Shapiro says. The only difference was that the Y chromosome carried a block of genes that determined male characteristics. Because it was necessary that the entire set of "maleness" genes be inherited intact, recombination between these genes and genes of the X chromosome came to be suppressed, Shapiro suggests. He proposes that the same process that suppressed this recombination also produced the inactivation of the X chromosome in female cells. Often, scientists explain the basis for X-inactivation to be the need of male and female cells to produce the same levels of proteins whose genes are on the X chromosome, although the male cells have only one copy and the female cells have two copies. But according to Shapiro's theory, this dosage-compensation effect would be just a by-product of a more basic phenomenon.

Shapiro also sees recombination suppression as a possible source of the size discrepancy between the X and Y chromosomes. Recombination is the process thought to continually monitor the similarity between paired chromosomes, so that they do not become too dissimilar. Shapiro says that once recombination between the X and Y was suppressed, they were free to drift apart evolutionarily. "Whenever a cell [except a sperm] has a Y chromosome, it always also has an X, so the Y is free to mutate and delete sequences, because the loss of information is always covered by the genes on the X."

—J. A. Miller

Hybrid grass roots out soil salinity

Soil salinity, the bane of irrigated agriculture, is poisoning an increasing number of croplands throughout the world (SN: 11/10/84, p. 298). But an Agricultural Research Service soil scientist has stumbled onto a low-cost reclamation scheme for affected soils: Plant them with a special hybrid forage grass.

Though salt can usually be leached out of the soil and washed away by applying enough water onto the top of an affected field, that may not be sufficient to restore crop productivity, explains Charles Robbins of the Agriculture Department's Snake River Conservation Research Center in Kimberly, Idaho. "If you remove the bulk salts from the soil without replacing the sodium," he points out, "you could destroy the soil structure." Such compacted soils lose their permeability to air and water, making it tough growing for roots.

One way to prevent soil collapse is to substitute calcium for sodium in the soil. And while measuring the respiration of crop roots last year, Robbins and his colleagues identified a commercially available forage grass that will aggressively promote such a calcium substitution because of the unusually high carbon dioxide (CO_2) output of its roots.

Roots take in oxygen and give off CO_2. In moist soil, the CO_2 will combine with water to form carbonic acid (H_2CO_3). Robbins points out that the acid dissolves any lime (calcium carbonate) in the soil, making its calcium available for sodium substitution. Though he studied a brand-name forage-grass hybrid of sorghum and sudangrass, Robbins says any hybrid of those grasses should yield a similar CO_2 production rate from its roots.

When growing vigorously in moist soil, the hybrid produced roughly two to three times as much CO_2 as did cotton, barley or alfalfa. More important, there was twice as much sodium in drainage exiting the instrumented growing pots in which the hybrid had been raised as from those in which either alfalfa or barley had been grown, and three to four times more sodium from the hybrid than from cotton.

To reclaim saline soils in some areas, farmers now add between 10 and 50 tons per acre of gypsum, a mineral form of calcium sulfate. The $65 to $70 per ton it costs farmers to buy this soil amendment doesn't account for the costs of transporting or applying it, Robbins says. Moreover, he notes that with gypsum, a growing season might also be lost while farmers wait for it to become adequately dispersed through the root zone of the soil. In contrast, Robbins says, seeds for this hybrid grass might cost only $3 or $4 per acre, the fertilizer another $20 to $30. Yet at the end of the growing season, farmers could have a harvestable crop worth $300 to $500 per acre, he says.

In a limited "worst-case" trial in south central Idaho last year, the hybrid grass was planted in soil so saline it would support neither corn nor barley. "And we got 25 tons an acre" of the grass, Robbins reports. This year, he says, sodium removal tests are being conducted under more typical field conditions.

In the laboratory, he plans to delve deeper into the operant chemistry. It is possible, he says, that formic and acetic acids — which can also form when the grass grows — are even more effective than carbonic acid at liberating calcium for sodium substitution, and hence at helping reclaim saline soils. *— J. Raloff*