Evolution of the Sexes: What a Fungus Can Tell Us

January 9 2008

Fungi don't exactly come in boy and girl varieties, but they do have sex differences. In fact, a new finding from Duke University Medical Center shows that some of the earliest evolved forms of fungus contain clues to how the sexes evolved in higher animals, including that distant cousin of fungus, the human.

A team lead by Joseph Heitman, M.D. has isolated sex-determining genes from one of the oldest known types of fungi, Phycomyces blakesleeanus, findings which appear in the Jan. 10 issue of *Nature*.

Fungi do not have entire sex chromosomes, like the familiar X and Y chromosomes that determine sexual identity in humans. Instead, they have sex determining sequences of DNA called "mating-type loci."

Mating-type loci have been found in a number of higher-level fungal species, and exhibit an unusual amount of diversity. These differences occur even among similar fungal species leading scientists to wonder how they evolved.

Heitman's group hypothesized that the sex-determining arrangement found in one of earliest forms of fungi might reveal the ancestral structure of mating-type loci, serving as a sort of molecular fossil.

"Fungi are good model systems for the evolution of human sexual differentiation because the genetic sequences responsible for sex are smaller versions of chromosomal sex-determining regions in people,"

Heitman said.

To identify the mating-type loci in Phycomyces, the researchers used a computer search to compare known mating-type loci in the genomes of other fungal lineages and then genetic mapping. "We employed a usual-suspects approach, comparing proteins between fungal types before identifying a candidate that appeared related in all lineages," says Heitman.

Within this stretch of DNA, they were able to isolate two versions of a gene that regulates mating, which they dubbed sexM, (sex minus) and sexP (sex plus). Strains of fungi with opposite versions of the sex genes are able to mate with each other.

Both versions of the gene, sexM and sexP, encode for a single protein called a high mobility group (HMG)-domain protein that leads to sex differentiation through an unknown process. This protein is very similar to one encoded by the human Y chromosome, called SRY, that when turned on leads a developing fetus to exhibit male characteristics. Heitman said this similarity suggests that HMG-domain proteins may mark the evolutionary beginnings of sex determination in both fungi and humans.

Heitman's team proposes that sexM and sexP were once the same gene that went through a mutation process called inversion. The new versions then evolved into two separate sex genes. The same process is most likely responsible for the evolution of the male Y chromosome, Heitman suggests.

Heitman hopes to next identify the sex region in another fungus, Rhizopus oryzae in order to better understand how HMG-domain proteins control sex determination in fungi. Rhizopus' genes can be cultured and chemically altered in a way that Phycomyces' sex genes can

not.

"Rhizopus can be used to understand the influences of certain genes in lesser studied fungi much in the way we use mice to understand genetic effects in humans," explained Alexander Idnurm, Ph.D., the primary author on the study and recently appointed assistant professor at the University of Missouri-Kansas City.

Another troubling mystery for Heitman is that certain younger fungal species lack HMG-domain proteins. He proposes that these proteins have been replaced with alternative transcription factors, which are proteins that turn genes on and off.

Source: Duke University