Concerted evolution

Genomes are comprised of single copy sequences, moderately and highly repetitive sequences.

Observation that members of repeated sequence family are often more similar to each other within species than across species led to research on concerted evolution.

Concerted evolution: members of gene family generally do not evolve independently - repeat copies exchange sequence information!

How could copies in one species be more similar than their corresponding ortholog in another species?

Species 1          Species 2
1. Constraint
2. Recent duplication
3. Concerted evolution

Need to take a phylogenetic approach to demonstrate concerted evolution.

Gene conversion

How does concerted evolution occur?

Several mechanisms can occur including unequal crossing over, but we will focus on:

Gene conversion: nonreciprocal recombination where one sequence is “converted” to the other.

Amount of DNA involved in conversion can range from several bps to several thousand.

Gene conversion

There are many sub-types of gene conversion (fig 6.28) but most important distinction for us:

Unbiased gene conversion: sequences have equal chances of converting each other.

Biased gene conversion: probability of conversion is directional - “master” copy and “slave” copy.
Gene conversion
Gene conversion is surprisingly common, detected in nearly every species and in every gene family examined in detail.
Further, biased gene conversion appears to be more common than unbiased conversion.

Rates of concerted evolution
Rates of concerted evolution are affected by:
1) Number of repeats: fewer conversion events needed if have fewer repeats
2) Arrangements of repeats: repeats in tandem are easier to convert than highly dispersed repeats
3) Structure of repeats: difficult to maintain similarity if large or numerous non-coding regions (because they evolve quickly)
4) Functional requirements: concerted evolution higher in constrained genes (eg: dose repetition in rRNAs vs diversity in immune function genes)
5) Population processes: population size, drift, selection all still matter!
Evolutionary implications of concerted evolution
Spread of advantageous mutations
"horizontally" across members of a gene family

Evolutionary implications of concerted evolution
Retardation of paralogous gene divergence -
divergence of duplicate genes may proceed
more slowly than expected

Evolutionary implications of concerted evolution
Allows for "gene flow" between genes not just
between populations

Evolutionary implications of concerted evolution
Can blur the distinction between genes and
pseudogenes
Pseudogenes can be “resurrected” by gene
conversion from functional gene copies
Similarly, genes can be “killed” by nearby
non-functional copies

Concerted evolution recap
“master” and “slave” has been updated
(thankfully) to “donor” and “acceptor”

Mechanisms of gene conversion

Chen et al 2007
Concerted evolution
Gene conversion can happen between:
- Alleles at same locus on sister chromatids
- Alleles at same locus on homologous chromosomes
- Paralogous sequences on same chromatid
- Paralogous sequences on different chromosomes

Concerted evolution
Gene conversion can have positive, negative or no functional effects

Many examples of gene families that show adaptive concerted evolution
- Opsin genes
- Olfactory receptor genes
- Immune function genes

Concerted evolution
But recent work also shows that gene conversion can cause disease in humans
Can be due to transfer of genetic info from non-functional pseudogenes to functional relatives but also can be due to functional "donors" with deleterious mutations
- neural tube defects
- persistence of fetal haemoglobin
- polycystic kidney disease
- cancer