Evolution of chromosomes and genomes

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Chromosome rearrangements

Additional question: when these occur they are rare in a population: how do they spread?
Chironomus banded chromosomes

Fig. 41. The four polytene elements from a salivary gland nucleus of *Chironomus thummi*, showing the banding. Small arrows indicate the approximate positions of the centromeres. The shortest chromosome has its longer arm largely heterochromatic and the other three elements have short heterochromatic regions at the tips. From Bauer (1935).
Paracentric and pericentric inversions

A Paracentric Inversion

A B C D E F G H I J

A B C D E F G H I J

A B F E D C G H I J

A B F E D C G H I J

A B C E F G H I J

A B C I J

E F G H D

A B C I J

E F G H D

A B C D E F G H I J

A B C D E F G H I J

A B C H G F E D I J

A B C H G F E D I J
Pairing in a paracentric inversion heterozygote
Crossover in a paracentric inversion heterozygote
These two chromosomes did not cross over
This one did. How will it segregate?
This one did too. How will it segregate?
Pairing in a pericentric inversion heterozygote
Crossover in a pericentric inversion heterozygote
These two products didn’t undergo crossing-over
One that did. Is anything deleted? Duplicated?
The other one that did. Anything deleted, duplicated?
A translocation

Before

Breaks

Rearrangement

After
Segregation of translocation heterozygote

at first division of meiosis metaphase

A pair of translocated chromosomes
pairs with a pair of untranslocated chromosomes
Adjacent segregation in translocations

... Leads to deletions and duplications.
Alternate segregation in translocations

... Leads to euploid (normal gene complement) gametes
Banding pattern changes

in two species of Chironomus midges

Fig. 11.12. Comparison of the banding pattern in chromosome arm II' of Chironomus piger (left) and C. thummi (right) in the hybrid between them. Bands C2.11 and C2.4 show a two-fold increase in DNA content in thummi, band C2.12 shows a four-fold increase, bands C2.2, C2.1 and C1.9 show the same amount. In the case of bands C2.3, C1.11, C1.8, C1.7 and B5.28 the increase is variable. From Keyl (1968).
Polytene Drosophila chromosomes
Chromosome phylogeny of Drosophila pseudoobscura etc.

**FIGURE 5.2**
Phylogenetic relationships of the gene arrangements in the third chromosomes of Drosophila pseudoobscura, D. persimilis, and D. miranda.
Chromosome phylogeny of Hawaiian Drosophila
Formation of the Hawaiian islands

plate

hot spot
Geology of the Hawaiian islands

A chain of seamounts leads northwest back across the Pacific as far as the Kamchatka peninsula of Siberia, an estimated 85 million years.
Inferred migration events on the Hawaiian islands

Figure 5.—Geographical summary of the proposed founder events invoked to explain the origin of the fauna of each island. The width of the arrows is proportional to the number of proposed founders. The number of species found on each island is given in parentheses.
When a tetraploid mates with a diploid

A tetraploid

An ordinary diploid

Gametes

Triploid offspring

Evolution of chromosomes and genomes – p.26/36
The gametes are aneuploid

a tetraploid

an ordinary diploid

gametes

triploid offspring

gametes

Evolution of chromosomes and genomes – p.27/36
And so are the offspring

a tetraploid

an ordinary diploid

gametes

triploid offspring

gametes

the resulting aneuploid offspring
Polyploid evolution in Clarkia
The fern Ophioglossum, high number champion

Highest number is in this genus, about 1440 chromosomes, or 720 pairs.
The ant Myrmecia, low chromosome number champion

Fig. 1. Chromosomes from prepupal cerebral ganglia. (A) Worker prometaphase chromosomes. Identical C-banding provides evidence for homology of the two chromosomes. (B) Male prometaphase chromosome. Chromosomes consistently display a large centromeric C-band on the short arm and a smaller centromeric C-band on the long arm. Most of the short-arm C-band is not immediately adjacent to the centromere, though a very small portion of the short-arm C-band is centromeric. Arrows indicate position of centromere.
Distribution of chromosome numbers in mammals
Karyotypes of Drosophila species

Fig. 11. Male karyotypes of some members of the subgenus Sophophora of Drosophila. Several different karyotypes have been reported for montium and tahashii. Based on various authorities.
Karyotypes of gymnosperms

Fig. 4.12  Karyotypes of various genera of gymnosperms. (a) *Pinus*, showing the symmetrical karyotype characteristic of the families Pinaceae, Cupressaceae, and most genera of Taxodiaceae. (b), (c), Moderately asymmetrical karyotypes of *Amentotaxus argyrotetania* (Taxaceae) and *Stangeria paradoxa* (Cycadaceae). (d), (e), (f), Strongly asymmetrical karyotypes of *Podocarpus nivalis* (Podocarpaceae), *Ginkgo biloba* (Ginkgoaceae), and *Welwitschia mirabilis* (Welwitschiaceae). (a) from Bowden; (b) from Chuang and Hu; (c) from Marchant; (d) from Hair and Beuzenberg; (e) from Lee; (f) from Khoshoo and Ahuja.
Human and mouse genomes compared
Human and chimp karyotypes compared