Overview of Chromosome Structure

A. Viral Chromosomes

Small; ss / ds; DNA / RNA; linear / circular
Generally 1 copy per virion; hundreds sequenced
Small size – few genes present – rely on host cell
Variety of replication strategies and pathways
Some require RNA-dependent RNA polymerases
Replication pathways: Targets for drug action

B. Bacterial Chromosomes

ds DNA; circular; nucleoid region
Generally 1 copy per cell; ~30 sequenced
Several thousand genes; most single copy
Circular DNA is supercoiled
No centromeres or telomeres

C. Chromosomes in Mitochondria and Chloroplasts

Similar to bacterial chromosomes but much smaller

Human mitochondrial DNA: ~ 17 kb
Plant chloroplast DNA: ~100 - 200 kb

Genes Encode: tRNAs; rRNAs; some mRNAs
Many organelle proteins imported from cytoplasm

Organelle genes exhibit "Non-Mendelian" inheritance

Multiple copies of chromosome per organelle
Good female transmission (present in egg)
Poor male transmission (absent from sperm)

D. Eukaryotic Chromosomes

>1 per cell; highly condensed; localized in nucleus

Histones: Abundant nuclear proteins

Repetitive DNA sequences common

Some tandemly duplicated (centromeric; telomeric)
Others dispersed throughout chromosome
Some correspond to transposable elements

> 10,000 genes / genome

Several model eukaryotic genomes have been sequenced:

Saccharomyces cerevisiae (yeast)
Caenorhabditis elegans (nematode)
Drosophila melanogaster (fruit fly)
Arabidopsis thaliana (mustard plant)
Homo sapiens (humans)

Centromeres: Essential for chromosome maintenance

Characteristic nucleotide sequence
Assemble kinetochore proteins
Attach to spindle; allow chromosome movement
Late replication in mitosis
No replication during meiosis I

Many genes contain intervening sequences (introns)

Transcribed but later removed from RNA
Do not code for protein (not translated)
Coding regions known as exons

Many genes are members of multigene families

Related in sequence and function
Different chromosome locations
Often active in different tissues
Gene redundancy beneficial to organism

E. Morphology of Eukaryotic Chromosomes

Interphase: *Chromosomes partially uncoiled*
Chromatin: DNA + protein
Nucleolus: rRNAs; ribosomal proteins; rRNA genes

"S" phase: *DNA replication – formation of chromatids*

Mitotic prophase to Metaphase:

Chromosomes condense and become visible / distinct
Karyotype: Pictures of stained chromosomes
Identify by size, centromere location, banding pattern
Chromosome aberrations detected at this stage

Meiotic Prophase I:

Homologs paired; recombination occurs
Appear larger than in mitosis (less condensed)
Heterochromatic regions (more condensed)

Synaptonemal complex:

Composed of DNA and protein
Located between paired homologs
Facilitates pairing of homologs; recombination
Absent in Drosophila males (no recombination)

Polytene Chromosomes:

Giant chromosomes; multiple chromatids
Present only in certain specialized cells
Salivary glands of Drosophila larvae
DNA replication without centromere division
Chromosomes uncoil, enlarge; Homologs paired
Widely used in Drosophila cytogenetics
~5,000 transverse bands: visible landmarks

Molecular Structure of Eukaryotic Chromosomes

Overview: *DNA associated with histone proteins*

Nucleosome: *Basic unit of chromosome structure*

Histones: *Abundant nuclear proteins*
Ubiquitous, highly conserved
General repressors of gene expression
5 major types (H1, H2A, H2B, H3, H4)
Basic; rich in (+) lysine, arginine
Bind to (-) phosphates in DNA
Binding independent of DNA sequence
Acetylation alters chromatin structure
Makes DNA accessible for transcription

Nucleosome Structure:

Core: *2 molecule each of H2A, H2B, H3, H4*
150 bp DNA wrapped around histones

Spacer: *1 molecule H1 + 20 bp DNA*

Coiling: *Nucleosomes condense to produce chromatin fiber*
Fibers condense at prophase; chromosomes visible

Many other proteins are associated with chromosomes

Nuclear scaffold proteins (chromosome mechanics)
Transcription factors (gene expression)

Features of Eukaryotic Chromosomes

Homologous Chromosome Pair

Each Chromatid Composed of ds DNA

Associated Histone Proteins

Nucleosomes: Fundamental Unit

Genes (Exons / Introns)

Repetitive DNA Sequences

Transposable Elements

Heterochromatic Regions

Origins of Replication

Centromere

Telomeres

Sequence Polymorphisms