

Chapter 28: Chromosomes

Chromatin describes the state of nuclear DNA and its associated proteins during the interphase (between mitoses) of the cell cycle.

A chromosome is a discrete unit of the genome carrying many genes.

Each chromosome consists of a very long molecule of duplex DNA and an approximately equal mass of proteins.

It is visible as a morphological entity only during mitosis.

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Eukaryotic DNA Has Loops and Domains Attached to a Scaffold

- A chromosome **scaffold** is
 - a proteinaceous structure
 - Not made up of histone proteins.
- A **matrix attachment region (MAR)** is
 - a region of DNA that attaches to the proteinaceous scaffold.
 - It is also known as a scaffold attachment region (SAR).
- MARs are A · T-rich but do not have any specific consensus sequence.
 - Usually contain consensus sequence for topoisomerase II
 - Many transcription factors also bind to MARs or adjacent to MARs

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The length of nucleic acid is much greater than the dimensions of the surrounding compartment.

DNA is highly compressed in all types of genomes				
Compartment	Shape	Dimensions	Type of nucleic acid	Length
TMV	Filament	0.008 × 0.3 μm	1 single-stranded RNA	2 μm = 6.4 kb
Phage fd	Filament	0.006 × 0.85 μm	1 single-stranded DNA	2 μm = 6.0 kb
Adenovirus	Icosahedron	0.07 μm diameter	1 double-stranded DNA	11 μm = 35.0 kb
Phage T4	Icosahedron	0.065 × 0.10 μm	1 double-stranded DNA	55 μm = 170.0 kb
<i>E. coli</i>	Cylinder	1.7 × 0.65 μm	1 double-stranded DNA	1.3 μm = 4.2 × 10 ³ kb
Mitochondrion (human)	Oblate spheroid	3.0 × 0.5 μm	~10 identical double-stranded DNAs	50 μm = 16.0 kb
Nucleus (human)	Spheroid	6 μm diameter	46 chromosomes of double-stranded DNA	1.8 m = 6 × 10 ⁶ kb

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Chromatin Is Divided Into Euchromatin and Heterochromatin

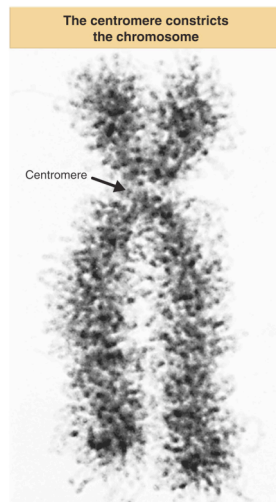
- **Euchromatin** composes all of the genome in the interphase nucleus except for the heterochromatin.
- The **euchromatin** is less tightly coiled than heterochromatin, and contains the active or potentially active genes.
- **Heterochromatin** describes regions of the genome that are highly condensed, are not transcribed, and are late-replicating.
- **Heterochromatin** is divided into two types, which are called constitutive and facultative.

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Chromatin

- Complex of DNA, histones, and non-histone proteins
- Two broad classes of chromatin:
 - **Euchromatin:**
 - Majority chromatin is in its extended (decondensed) state during interphase
 - only condenses during mitosis.
 - **Heterochromatin:**
 - Remains highly condensed even in interphase.
 - Accounts for the dark staining regions seen in interphase chromatin.
 - **Constitutive:** always inactive and condensed:
 - e.g. repetitive DNA, centromeric DNA
 - **Facultative:** can exist in both forms.
 - e.g.: Female X chromosome in mammals.

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28.5

Chromatin Is Divided Into Euchromatin and Heterochromatin

- Individual chromosomes can be seen only during mitosis.
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- During interphase, the general mass of chromatin is in the form of euchromatin,
 - which is less tightly packed than mitotic chromosomes.
- Regions of heterochromatin remain densely packed throughout interphase. (constitutive)

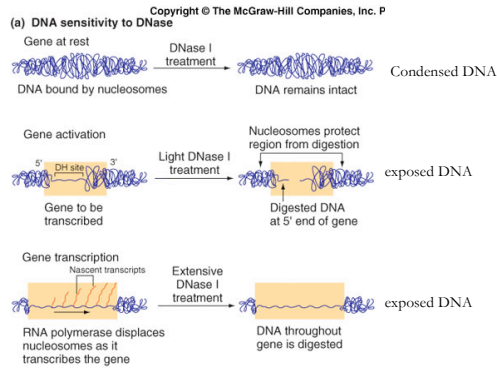
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How chromosomal packaging influences gene activity

- Decompaction precedes gene expression
 - Boundary elements delimit areas of decompaction
 - Nucleosomes in the decompacted area unwind to allow initiation of transcription
 - Transcription factors (nonhistone proteins) unwind nucleosomes and dislodge histones at 5' end of genes
 - Unwound portion is open to interaction with RNA polymerase which can recognize promoter and initiate gene expression

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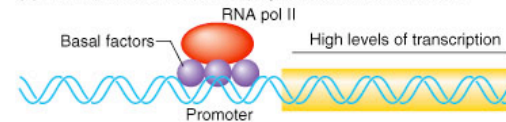
Studies using DNase identify decompacted regions



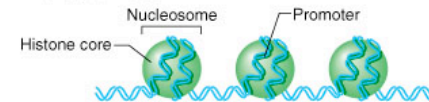
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Normal chromatin structure slows transcription

The McGraw-Hill Companies, Inc. Permission required for reproduction (a) Naked promoter binds RNA polymerase and basal factors.

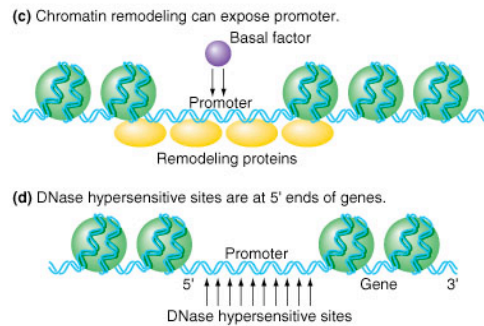


(b) Chromatin reduces binding to basal factors and RNA pol II to very low levels.



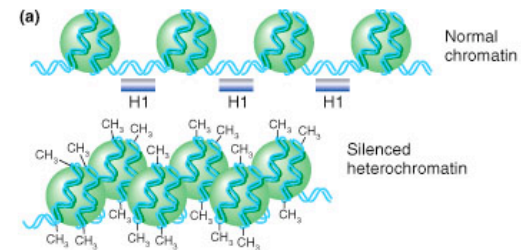
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Remodeling of chromatin mediates the activation of transcription



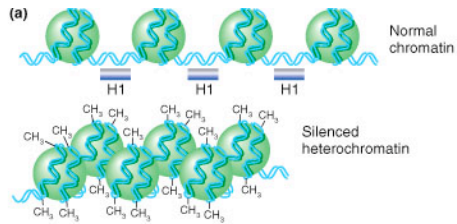
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Hypercondensation over chromatin domains causes transcriptional silencing



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Genomic imprinting



- Results from Heterochromatinization that selectively silences genes inherited from one parent
- Genes found in heterochromatin are not available to the transcription machinery
- Are not transcribed

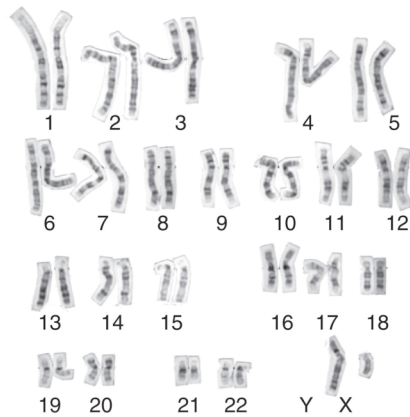
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28.6 Chromosomes Have Banding Patterns

- **G-bands** are
 - generated on eukaryotic chromosomes by staining techniques
 - appear as a series of lateral striations.
 - They are used for karyotyping
 - (identifying chromosomal regions by the banding pattern).
- Certain staining techniques cause the chromosomes to
 - have the appearance of a series of striations called G-bands.
- The bands are lower in G · C content than the interbands.
- Genes are concentrated in the G · C-rich interbands.
- Mammalian DNA is ~40% G-C

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Every chromosome has a distinct G-banding pattern



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