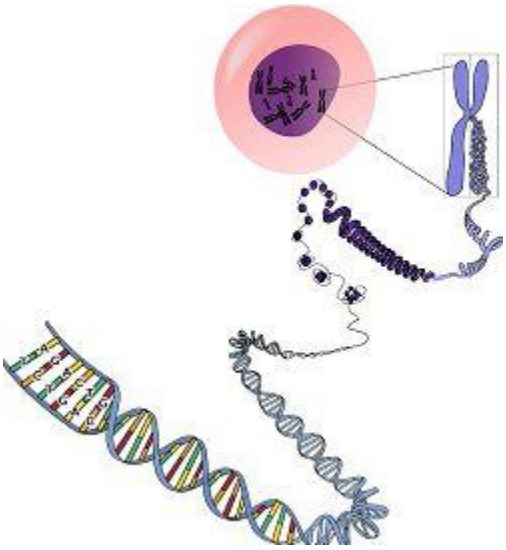
Difference Between Heterochromatin and Euchromatin



The major difference between heterochromatin and euchromatin is that **heterochromatin** is such part of the chromosomes, which is a firmly packed form and are **genetically inactive**, while **euchromatin** is an uncoiled (loosely) packed form of chromatin and are **genetically active**.

When the non-dividing cells of the nucleus were observed under the light microscope, it exhibited the two regions, on the ground of concentration or intensity of staining. The **dark stained** areas are said as heterochromatin and **light stained** areas are said as euchromatin.

Around **90%** of the total human genome is euchromatin. They are the parts of chromatin and participate in the protection of DNA in the genome present inside the nucleus. **Emil Heitz** in the year 1928, coined the term Heterochromatin and Euchromatin.

By focussing on the few more points, we will be able to understand the difference between both types of chromatin. Given below is the comparison chart along with the brief description of them.

Content: Heterochromatin Vs Euchromatin

Comparison Chart

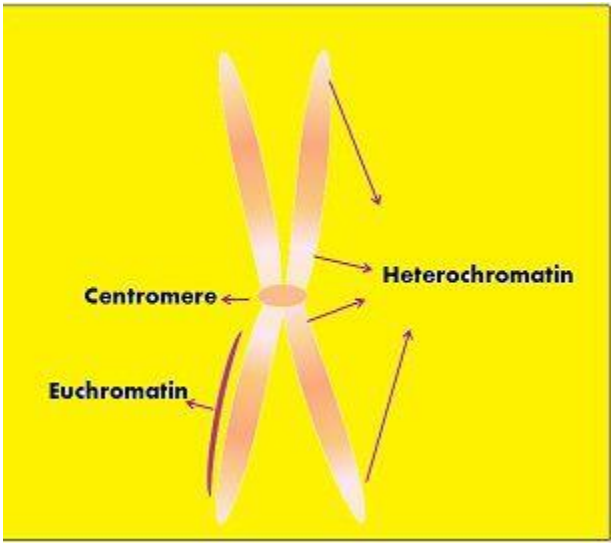
BASIS FOR COMPARISON	HETEROCHROMATIN	EUCHROMATIN
Meaning	The tightly packed form of DNA in the chromosome is called as heterochromatin.	The loosely packed form of DNA in the chromosome is called as euchromatin.
DNA density	High DNA density.	Low DNA density.
Kind of stain	Stained dark.	Lightly stained.
Where they are present	These are found at the periphery of the nucleus in eukaryotic cells only.	These are found in the inner body of the nucleus of prokaryotic as well as in eukaryotic cells.
Transcriptional activity	They show little or no transcriptional activity.	They actively participate in the process of transcription.
Other features	They are compactly coiled.	They are loosely coiled.
	They are late replicative.	They are early replicative.
	Regions of heterochromatin are sticky.	Regions of euchromatin are non-sticky.
	Genetically inactive.	Genetically active.
	Phenotype remains unchanged of an organism.	Variation may be seen, due to the affect in DNA during the genetic process.

BASIS FOR COMPARISON	HETEROCHROMATIN	EUCHROMATIN
	It permits the gene expression regulation and also maintains the structural integrity of the cell.	It results in genetic variations and permits the genetic transcription.

Definition of Heterochromatin

The area of the chromosomes which are **intensely stained** with DNA-specific strains and are relatively condensed is known as **heterochromatin**. They are the **tightly packed** form of DNA in the nucleus.

The organization of heterochromatin is so highly compact in the way that these are inaccessible to the protein which is engaged in gene expression. Even the chromosomal crossing over is not possible due to the above reason. Resulting them to be transcriptionally as well as genetically inactive.



Heterochromatin is of two types: Facultative heterochromatin and constitutive heterochromatin. The genes which get silenced through the process of **Histone methylation or siRNA** through **RNAi** are called as **facultative heterochromatin**. Hence they contain inactive genes and is not a permanent character of every nucleus of the cells.

While the **repetitive and structurally functional genes** like telomeres or centromeres are called as **Constitutive heterochromatin**. These are the continuing nature of the cell's nucleus and contains no gene in the genome. This structure is retainable during the interphase of the cell.

The **main function** of the heterochromatin is to protect the DNA from the endonuclease damage; it is due to its compact nature. It also prevents the DNA regions to get accessed to proteins during gene expression.

Definition of Euchromatin

That part of chromosomes, which are **rich in gene** concentrations and are loosely packed form of chromatin is called as **euchromatin**. They are active during transcription.

Euchromatin covers the maximum part of the dynamic genome to the inner of the nucleus and is said that euchromatin contains about **90% of the entire human genome**.

To allow the transcription, some parts of the genome containing active genes are loosely packed. The wrapping of DNA is so loose that DNA can become readily available. The structure of euchromatin resembles the nucleosomes, which consist of histones proteins having around 147 base pairs of DNA wrapped around them.

Euchromatin actively participates in transcription from DNA to RNA. The **gene regulating mechanism** is the process of transforming euchromatin into heterochromatin or vice versa.

The active genes present in euchromatin gets transcribed to make mRNA whereby further encoding the functional proteins is the **main function** of euchromatin. Hence they are considered as genetically and transcriptionally active. **Housekeeping** genes are one of the forms of euchromatin.

Key differences between Heterochromatin and Euchromatin

Following are the substantial points to differentiate among heterochromatin and euchromatin:

1. The tightly packed form of DNA in the chromosome is called as **heterochromatin**, while the loosely packed form of DNA in the chromosome is called as **euchromatin**.
2. In heterochromatin, the **density of DNA** is **high** and are **stained dark**, whereas in euchromatin the density of DNA is **little** and are **lightly stained**.
3. Heterochromatin is **found** at the periphery of the nucleus in eukaryotic cells only, and Euchromatin is **located** in the inner body of the nucleus of prokaryotic as well as in eukaryotic cells.
4. Heterochromatin shows little or **no transcriptional activity** as well they are **genetically inactive**, on the other hand, Euchromatin **actively** participates in the process of transcription and are **genetically active** also.
5. Heterochromatin is **compactly coiled** and is **late replicative**, whereas Euchromatin is **loosely coiled** and **early replicative**.
6. **Regions** of heterochromatin are sticky, but the areas of Euchromatin are non-sticky.
7. In Heterochromatin part, the **phenotype** remains unchanged of an organism, though variation may be seen, due to the effect in DNA during the genetic process in the Euchromatin.
8. Heterochromatin permits the **gene expression regulation** and also maintains the structural integrity of the cell though Euchromatin results in **genetic variations**, and allows the genetic transcription.

Conclusion

From the above information regarding chromatin – their structure and types. We can say that only Euchromatin is vigorously involved in the transcription process although heterochromatin and its types do not play such significant role.

Constitutive heterochromatin contains the satellite DNA, and it surrounds the centromere, and facultative heterochromatin is disbanded. So apparently it can be said that the eukaryotic cells and their inner structure are relatively complex.

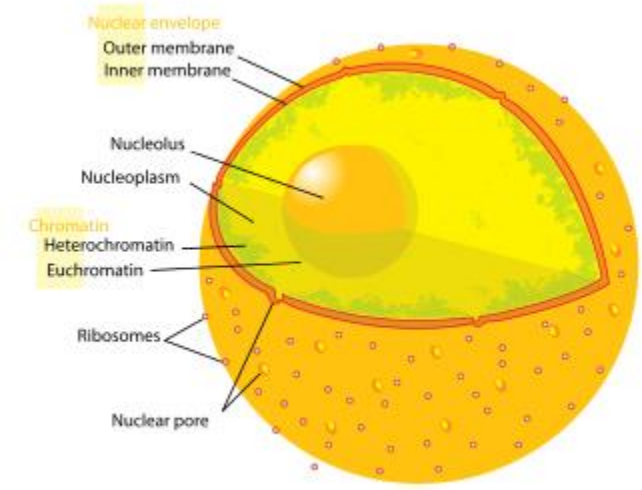
Heterochromatin

Heterochromatin is a tightly packed form of DNA or *condensed DNA*, which comes in multiple varieties. These varieties lie on a continuum between the two extremes of **constitutive heterochromatin** and **facultative heterochromatin**. Both play a role in the expression of genes. Because it is tightly packed, it was thought to be inaccessible to polymerases and therefore not transcribed, however according to Volpe et al. (2002),[1] and many other papers since,[2] much of this DNA is in fact transcribed, but it is continuously turned over via RNA-induced transcriptional silencing (RITS). Recent studies with electron microscopy and OsO_4 staining reveal that the dense packing is not due to the chromatin.[3]

Constitutive heterochromatin can affect the genes near itself (e.g. position-effect variegation). It is usually repetitive and forms structural functions such as centromeres or telomeres, in addition to acting as an attractor for other gene-expression or repression signals.

Facultative heterochromatin is the result of genes that are silenced through a mechanism such as histone deacetylation or Piwi-interacting RNA (piRNA) through RNAi. It is not repetitive and shares the compact structure of constitutive heterochromatin. However, under specific developmental or environmental signaling cues, it can lose its condensed structure and become transcriptionally active.[4]

Heterochromatin has been associated with the di- and tri-methylation of H3K9 in certain portions of the genome.[5] H3K9me3-related methyltransferases appear to have a pivotal role in modifying heterochromatin during lineage commitment at the onset of organogenesis and in maintaining lineage fidelity.[6]



The nucleus of a human cell showing the location of heterochromatin

Note that the informal diagram shown here may be in error as to the location of heterochromatin. An inactivated X-chromosome (a.k.a. Barr body) migrates to the nuclear membrane alone, leaving the active X and other chromosomes within the nucleoplasm (away from the membrane in general). Other heterochromatin appear as

particles separate from the membrane, "Heterochromatin appears as small, darkly staining, irregular particles scattered throughout the nucleus ...".[7]

Contents

Structure[edit]

Chromatin is found in two varieties: euchromatin and heterochromatin.[8] Originally, the two forms were distinguished cytologically by how intensely they stained – the euchromatin is less intense, while heterochromatin stains intensely, indicating tighter packing. Heterochromatin is usually localized to the periphery of the nucleus. Despite this early dichotomy, recent evidence in both animals[9] and plants[10] has suggested that there are more than two distinct heterochromatin states, and it may in fact exist in four or five 'states', each marked by different combinations of epigenetic marks.

Heterochromatin mainly consists of genetically inactive satellite sequences,[11] and many genes are repressed to various extents, although some cannot be expressed in euchromatin at all.[12] Both centromeres and telomeres are heterochromatic, as is the Barr body of the second, inactivated X-chromosome in a female.

Function[edit]

Heterochromatin has been associated with several functions, from gene regulation to the protection of chromosome integrity;[13] some of these roles can be attributed to the dense packing of DNA, which makes it less accessible to protein factors that usually bind DNA or its associated factors. For example, naked double-stranded DNA ends would usually be interpreted by the cell as damaged or viral DNA, triggering cell cycle arrest, DNA repair or destruction of the fragment, such as by endonucleases in bacteria.

Some regions of chromatin are very densely packed with fibers that display a condition comparable to that of the chromosome at mitosis. Heterochromatin is generally clonally inherited; when a cell divides, the two daughter cells typically contain heterochromatin within the same regions of DNA, resulting in epigenetic inheritance. Variations cause heterochromatin to encroach on adjacent genes or recede from genes at the extremes of domains. Transcribable material may be repressed by being positioned (in *cis*) at these boundary domains. This gives rise to expression levels that vary from cell to cell,[14] which may be demonstrated by position-effect variegation.[15] Insulator sequences

may act as a barrier in rare cases where constitutive heterochromatin and highly active genes are juxtaposed (e.g. the 5'HS4 insulator upstream of the chicken β-globin locus,[16] and loci in two *Saccharomyces* spp.[17][18]).

Constitutive heterochromatin[edit]

Main article: Constitutive heterochromatin

All cells of a given species, package the same regions of DNA in constitutive heterochromatin, and thus in all cells, any genes contained within the constitutive heterochromatin will be poorly expressed. For example, all human chromosomes 1, 9, 16, and the Y-chromosome contain large regions of constitutive heterochromatin. In most organisms, constitutive heterochromatin occurs around the chromosome centromere and near telomeres.

Facultative heterochromatin[edit]

The regions of DNA packaged in facultative heterochromatin will not be consistent between the cell types within a species, and thus a sequence in one cell that is packaged in facultative heterochromatin (and the genes within are poorly expressed) may be packaged in euchromatin in another cell (and the genes within are no longer silenced). However, the formation of facultative heterochromatin is regulated, and is often associated with morphogenesis or differentiation. An example of facultative heterochromatin is X chromosome inactivation in female mammals: one X chromosome is packaged as facultative heterochromatin and silenced, while the other X chromosome is packaged as euchromatin and expressed.

Among the molecular components that appear to regulate the spreading of heterochromatin are the Polycomb-group proteins and non-coding genes such as Xist. The mechanism for such spreading is still a matter of controversy.[19] The polycomb repressive complexes PRC1 and PRC2 regulate chromatin compaction and gene expression and have a fundamental role in developmental processes. PRC-mediated epigenetic aberrations are linked to genome instability and malignancy and play a role in the DNA damage response, DNA repair and in the fidelity of replication.[20]

Yeast heterochromatin[edit]

Saccharomyces cerevisiae, or budding yeast, is a model eukaryote and its heterochromatin has been defined thoroughly. Although most of its genome can be characterized as euchromatin, *S. cerevisiae* has regions of DNA that are transcribed very poorly. These loci are the so-called silent mating type loci (HML and HMR), the rDNA (encoding ribosomal RNA), and the sub-telomeric regions. Fission yeast (*Schizosaccharomyces pombe*) uses another mechanism for heterochromatin formation at its centromeres. Gene silencing at this location depends on components of the RNAi pathway. Double-stranded RNA is believed to result in silencing of the region through a series of steps.

In the fission yeast *Schizosaccharomyces pombe*, two RNAi complexes, the RITS complex and the RNA-directed RNA polymerase complex (RDRC), are part of an RNAi

machinery involved in the initiation, propagation and maintenance of heterochromatin assembly. These two complexes localize in a siRNA-dependent manner on chromosomes, at the site of heterochromatin assembly. RNA polymerase II synthesizes a transcript that serves as a platform to recruit RITS, RDRC and possibly other complexes required for heterochromatin assembly.[21][22] Both RNAi and an exosome-dependent RNA degradation process contribute to heterochromatic gene silencing. These mechanisms of *Schizosaccharomyces pombe* may occur in other eukaryotes.[23] A large RNA structure called RevCen has also been implicated in the production of siRNAs to mediate heterochromatin formation in some fission yeast.[24]

See also[edit]

- Centric heterochromatin

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repetitive DNA, which usually doesn't contain genetic information. If evolution makes sense only in the context of the regulatory control of genes, we propose that heterochromatin, which is the main form of chromatin in higher eukaryotes, is positioned to be a deeply effective target for evolutionary change. Future investigations into assembly, maintenance and the many other functions of heterochromatin will shed light on the processes of gene and chromosome regulation.

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