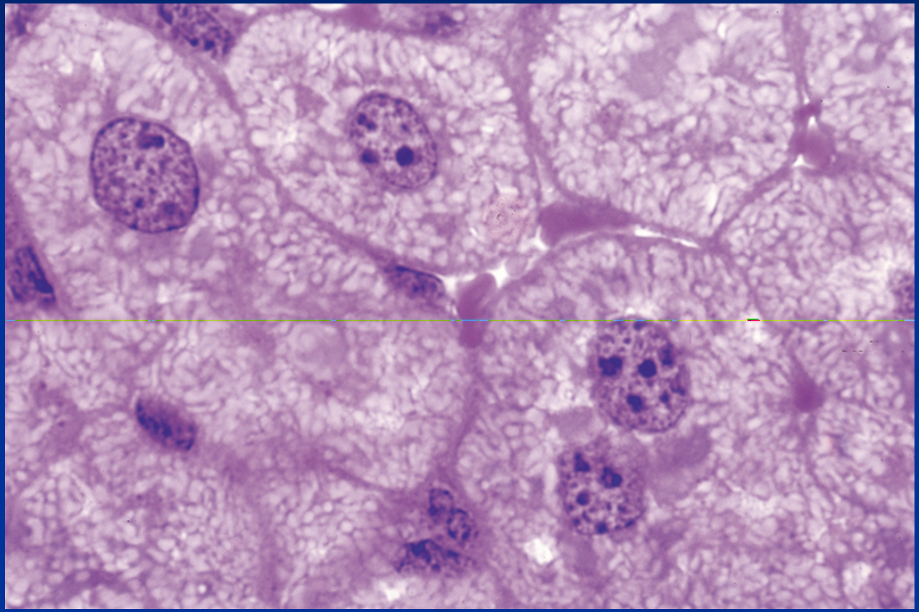
NUCLEUS

- There are hundreds of different types of cells inside your body. They have different shapes and roles in keeping you healthy and growing, but every cell inside you has one thing in common:

- Much like your brain, the nucleus is the control center of the cell. It helps the cell move, absorb nutrients, and reproduce (create new cells).

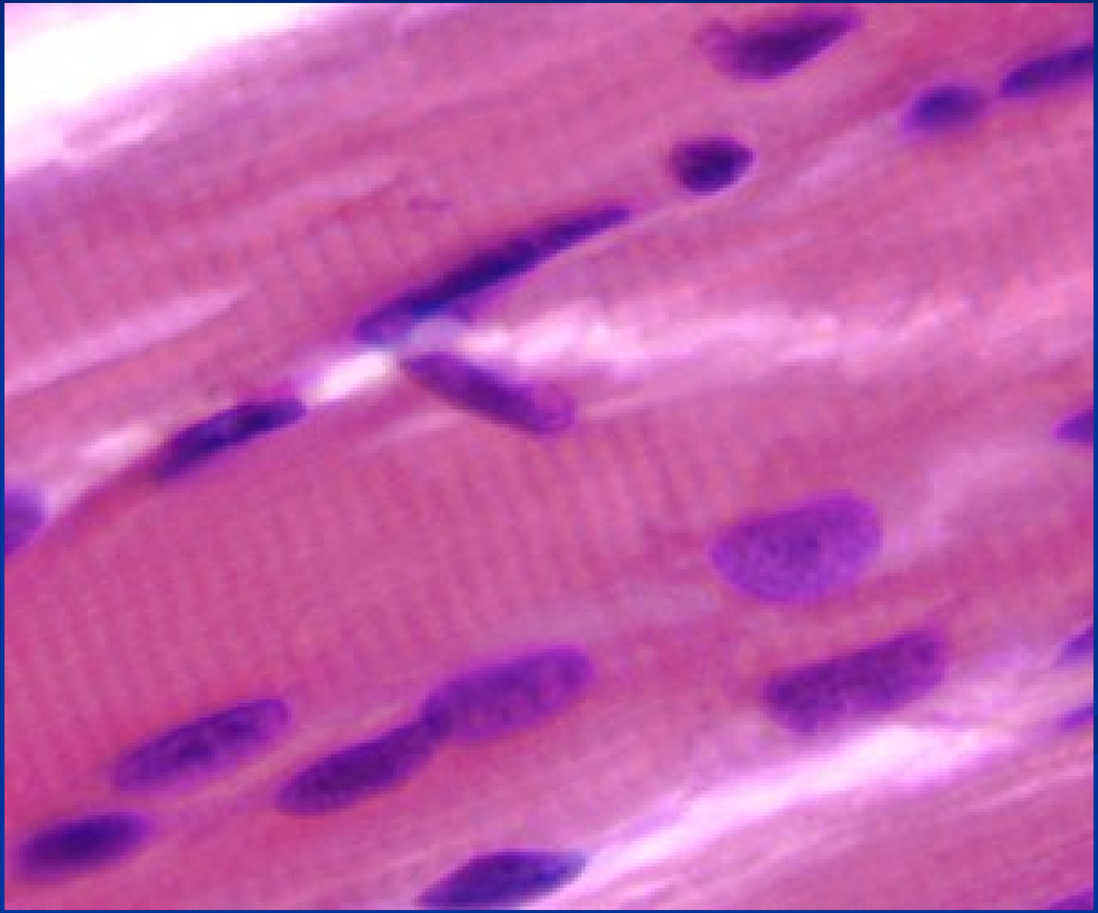
- The nucleus is the largest organelle of most eukaryotic cells.
- It is a membrane-limited compartment that contains the genetic material and proteins in eukaryotic cells.
- Prokaryotic cells don’t have a nucleus



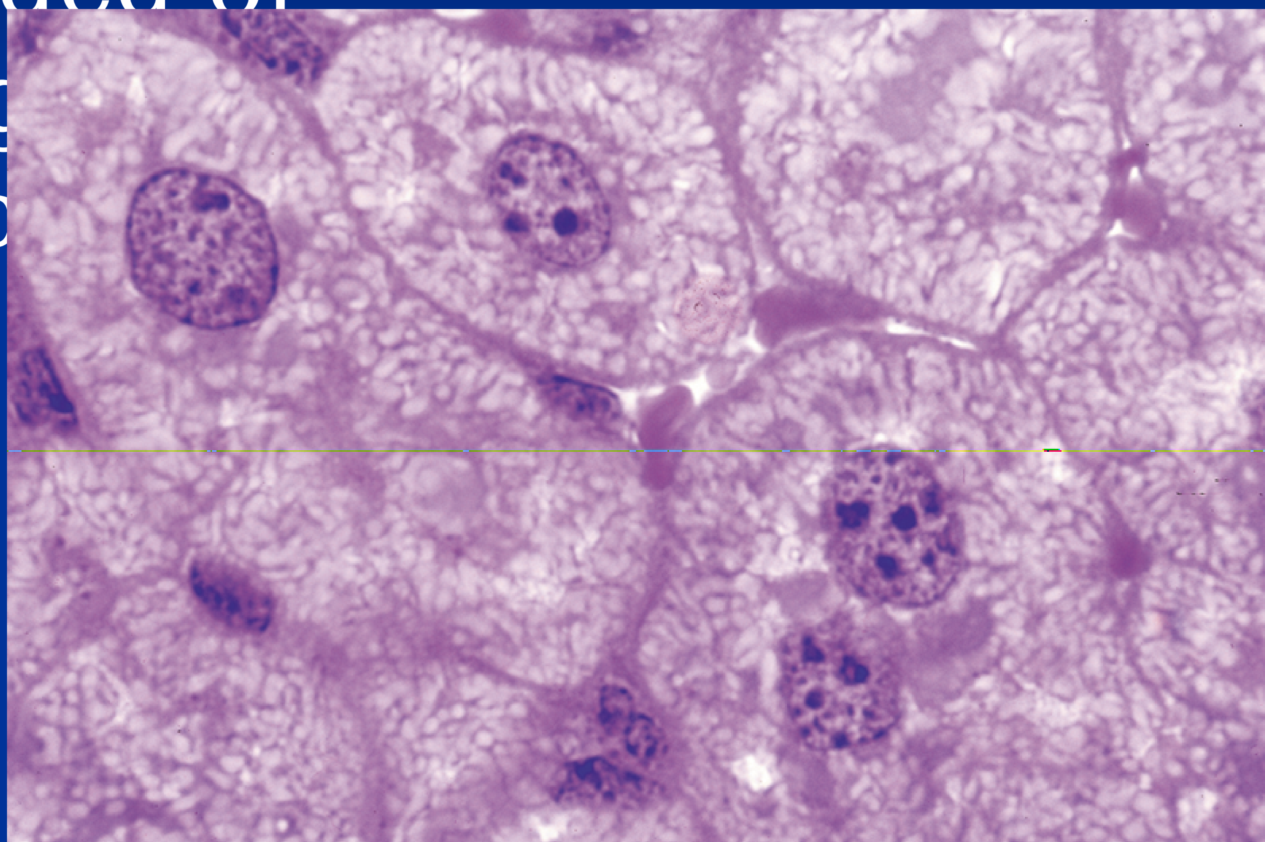
- The shape of the nucleus is variable and is usually adapted to the morphology of the cell.

- The localization of the nucleus is normally in the center of the cell, but it can also be found in more peripheral locations.
- For example, secretory cells have their nucleus located in the basal part,

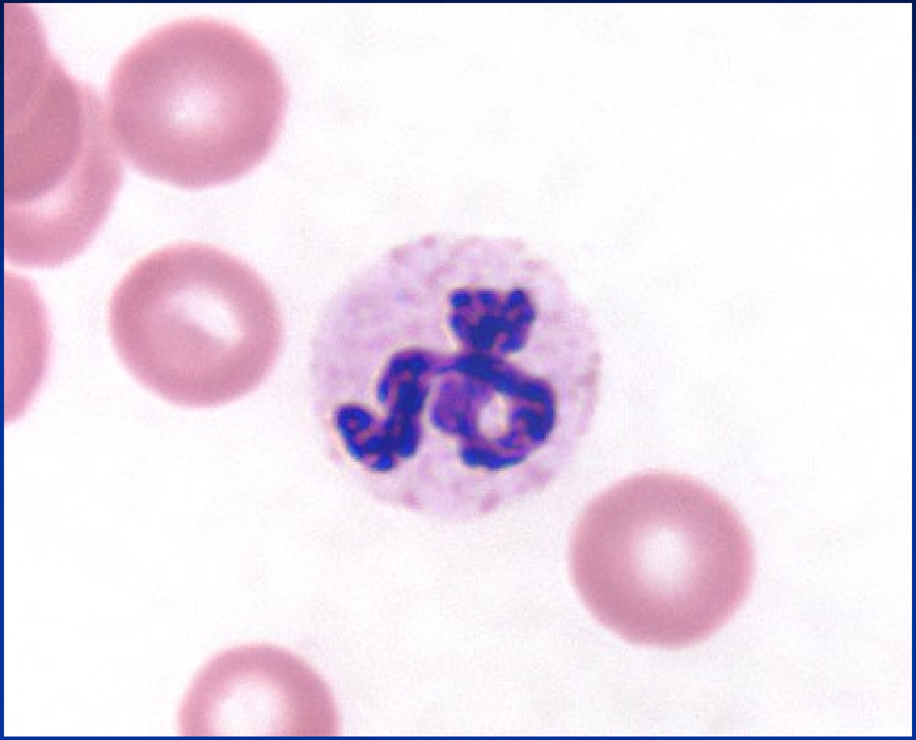
- and skeletal muscle fibers have their nuclei close membrane.



Nucleus frequently appears as a rounded or elong struc

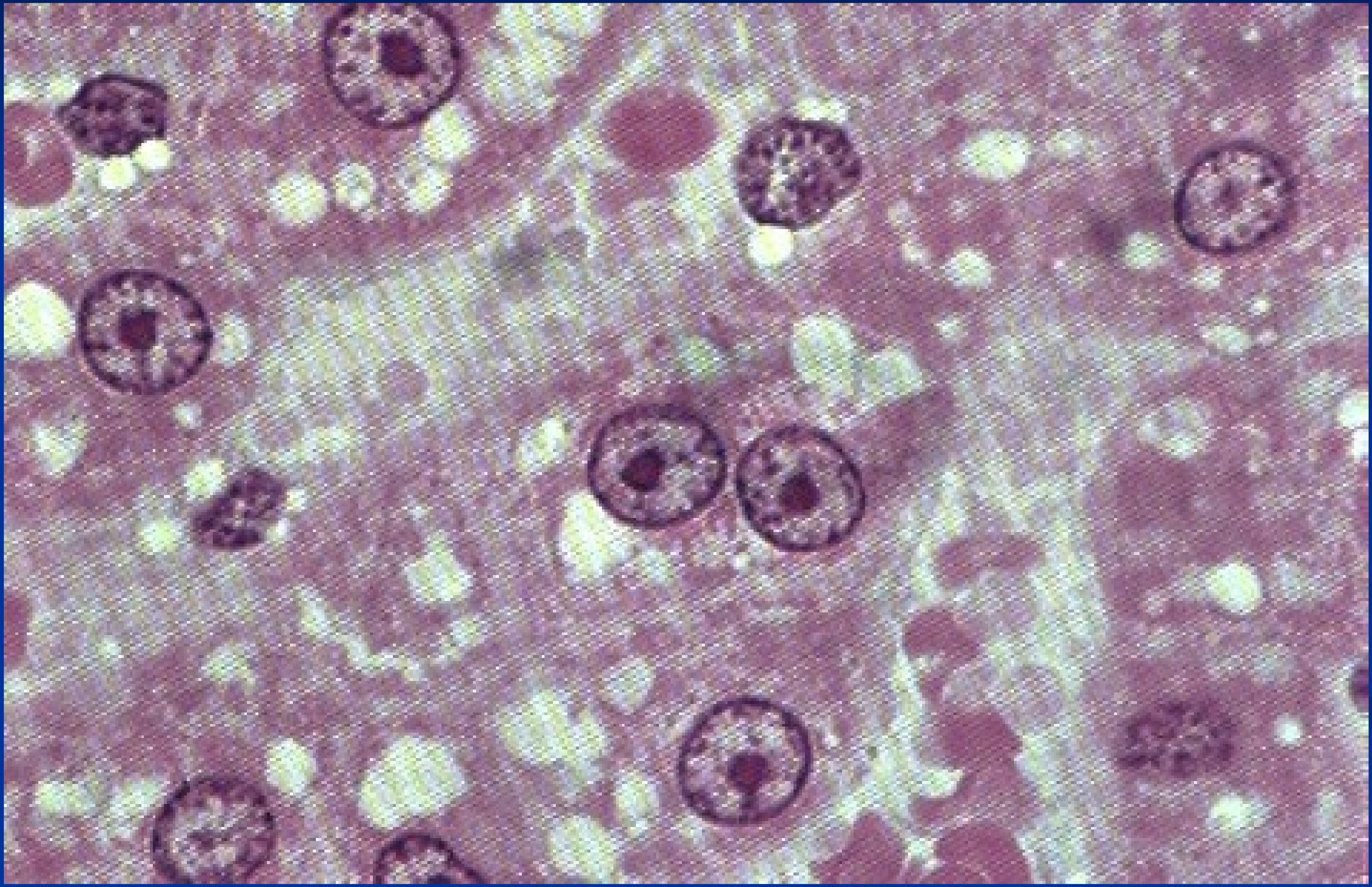


- but other forms are also found. Example, neutrophils have a multi-lobed nucleus. The lobes are separated by a thin strand. Because of the shape of the nucleus, neutrophils are also called "polymorphonuclear neutrophils".

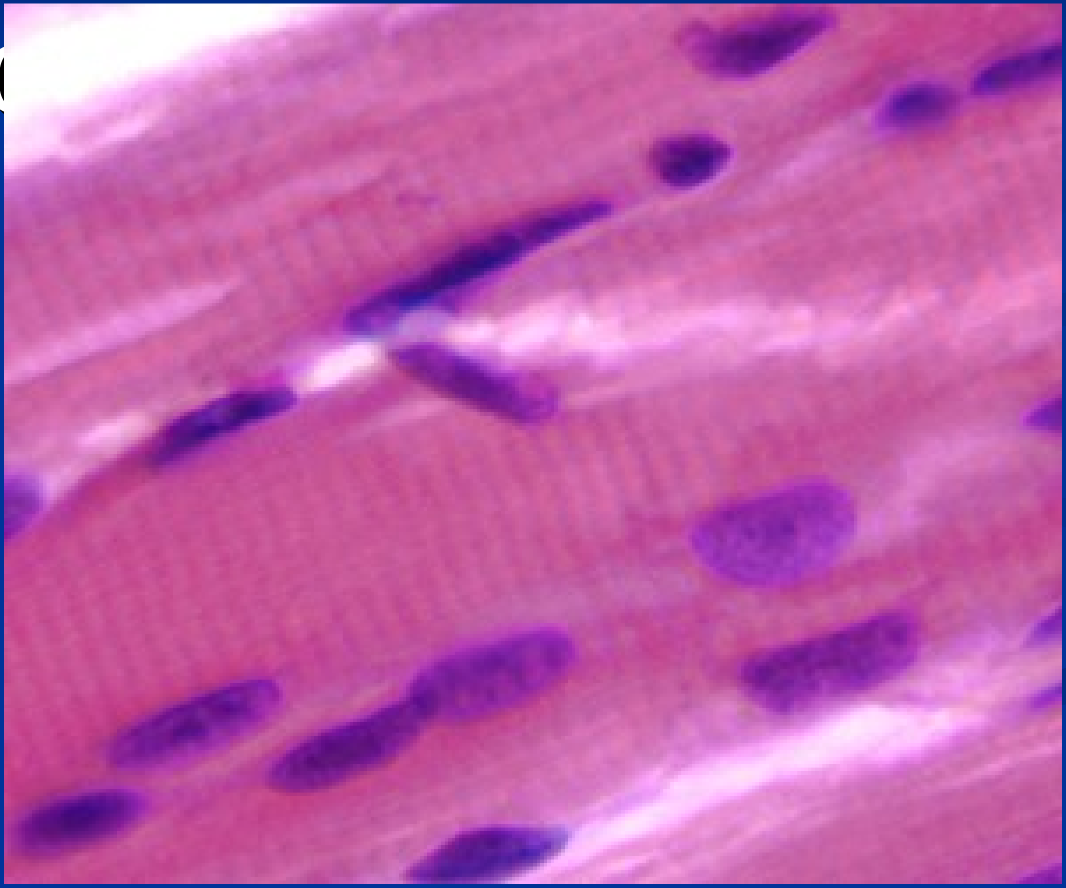


- All the cells in an eukaryotic organism have a single nucleus. The cells which have high metabolism have double or more nucleus.

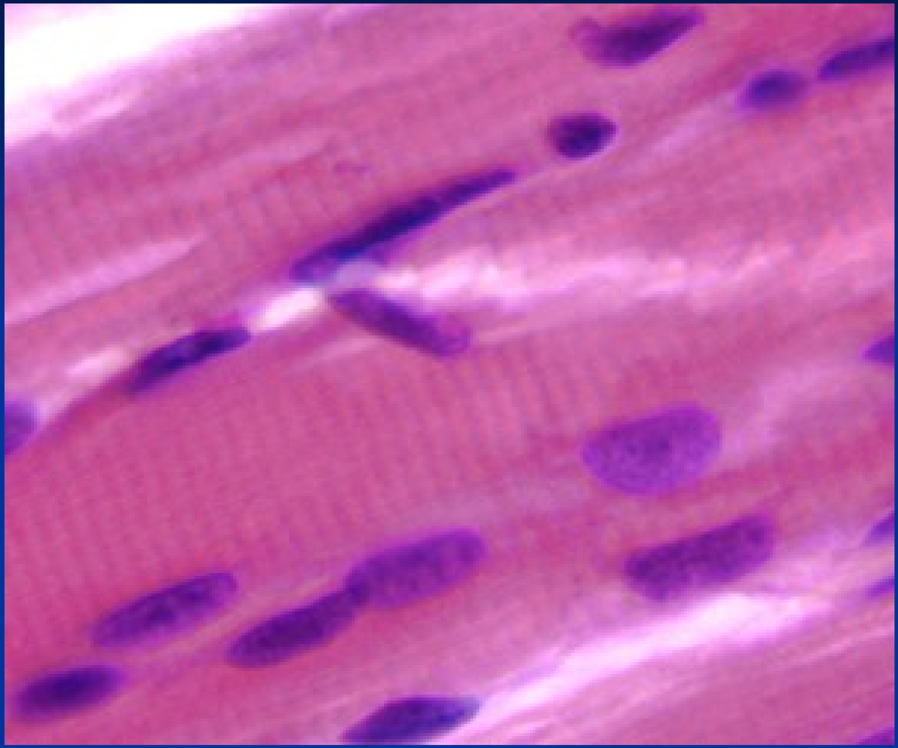
- Example (liver epithelial cell- hepatocyte).



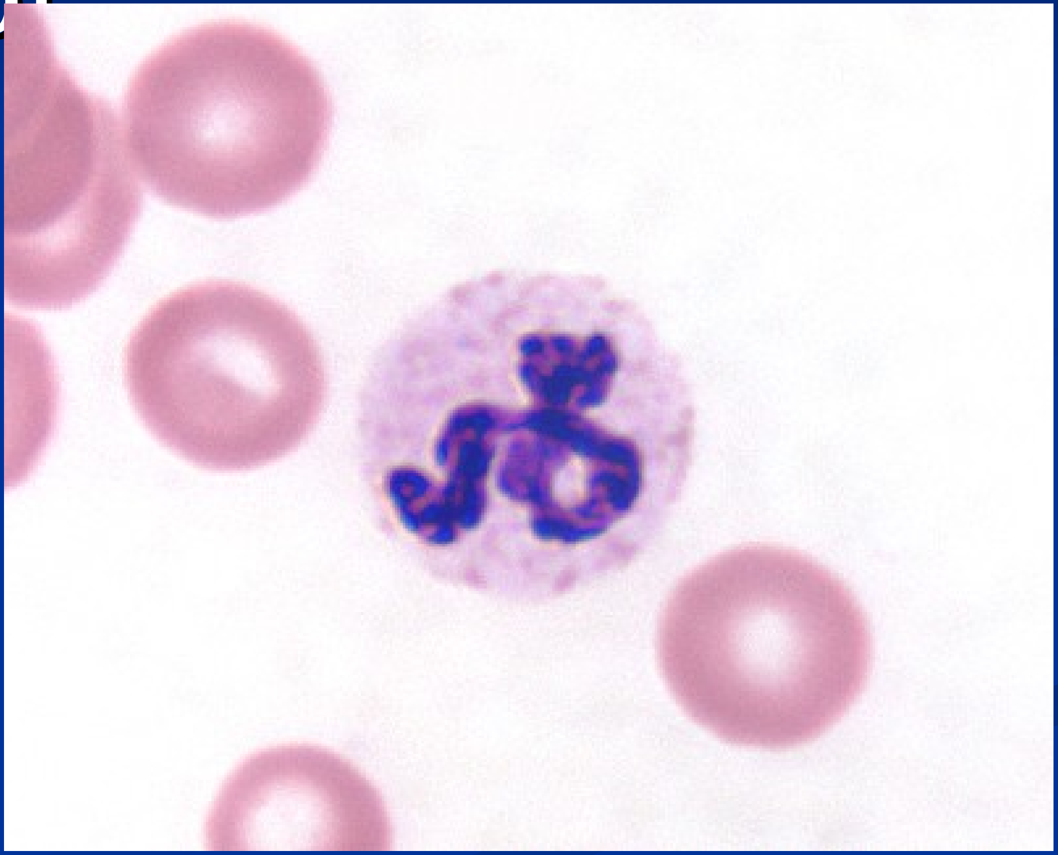
Osteoclasts, skeletal muscle fibers. Osteoclast is found in the bo



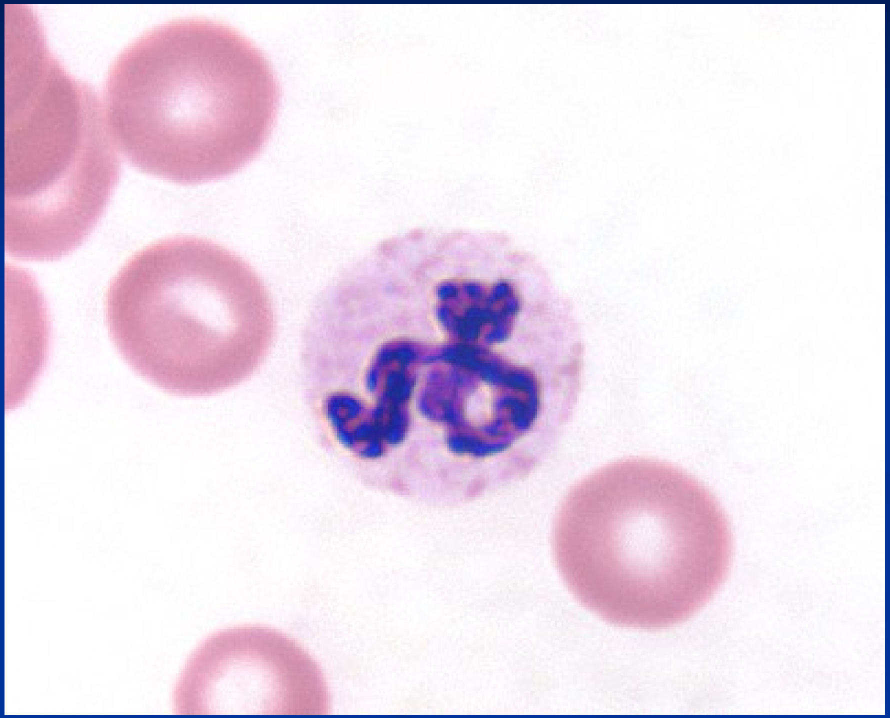
- Muscle cells and muscle fibers have many nuclei because these cells arise from a fusion of myoblasts. Before being fused the myoblasts each have their own nucleus. After being fused together, the multiple myoblasts become a muscle fiber that has multiple nuclei.



- Mammalian red blood cells do not contain nuclei.



- Red blood cells are initially produced in the bone marrow with a nucleus. Then they undergo a process known as enucleation in which their nucleus is removed. Enucleation occurs roughly when the cell has reached maturity.



- The absence of a nucleus is an adaptation of the red blood cell for its role. It allows the red blood cell to contain more hemoglobin and, therefore, carry more oxygen molecules.
- However, since little is known about the genes the enucleation, it is still not a fully understood process.

- The size and morphological features of nuclei in a specific normal tissue tend to be uniform.
- In contrast, the nuclei in cancer cells have an irregular shape, variable size, and atypical chromatin patterns.

- What is the importance of the nucleus?
- 1.It is a carrier of the gene that determines inherited characteristics.
- 2. Cytoplasmic synthesis is possible with ribonucleic acids given to cytoplasm from nucleus.

- Its main components are;
- the **nucleus envelope,**
- **chromatin**,
- **nucleolus** and
- **nuclear matrix.**

- 1. Nucleus envelope:
- Nucleus is separated from the rest of the cell organelles with a nuclear envelope or nuclear membrane.
- It protects the DNA molecules and other genetic material against various mechanical forces in the cytoplasm.

A <u>Nuclear Membrane</u> is like…

… your *skull*

because it protects your brain like the nuclear membrane protects the nucleus.

- The nuclear envelope consists of two cellular membranes.
- There is a perinuclear cisternal space between them.
- It separates the nucleoplasm from the cytoplasm.

- The nuclear envelope completely encloses the nucleus and separates the cells genetic material from the surrounding cytoplasm, serving as a barrier to prevent macromolecules from diffusing freely between the nucleoplasm and the cytoplasm.

- There are pores on the nuclear membrane.

- Nuclear pores are formed from the fusion of the inner and outer membranes of the nuclear envelope.

- This picture shows an electron micrograph of a nucleus.
- The short white arrows are pointing to nuclear pores. Note the appearance of euchromatin and heterochromatin, and the nucleolus. Heterochromatin stains more densely than euchromatin, but they are both forms of chromatin.

- The nuclear envelope is impermeable to ions and molecules of all sizes. The exchange of substances between the nucleus and the cytoplasm is made only through the nuclear pores.
- The number of nuclear pores varies greatly from cell to cell.

- Nuclear pores mediate the active transport of proteins, ribonucleoproteins and RNAs between the nucleus and cytoplasm.

- Ions and molecules with a diameter up to 9 nm pass freely through the nuclear pore without consuming energy. But molecules and molecular complexes larger than 9 nm are transported by an active process which uses energy from adenosine triphosphate (ATP).

- Ribosomes are attached to the outer membrane surface facing the cytoplasm.

Second component;

2. Chromatin: Chromatin is the most abundant substances found in the nucleus. It is a complex DNA and proteins (histones).

According to the degree of chromosome condensation, two types of chromatin can be distinguished with both the light and electron microscopes .

- **Heterochromatin** is electron dense and it appears as coarse granules in the electron microscope and as basophilic clumps in the light microscope.

- Euchromatin is the loosely coiled portion of the chromosomes, visible as a finely dispersed granular material in the electron microscope and as basophilic areas in the light microscope.

The intensity of staining of the chromatin is frequently used to distinguish and identify different tissues and cell types in the light microscope.

- Heterochromatic regions are settled the periphery of the nucleus and around the nucleolus.

- Three-dimensional representation of a cell nucleus showing the distribution of the nuclear pores, the heterochromatin (dark regions), the euchromatin (light regions), and a nucleolus.
- Note that there is no chromatin closing the pores.

- Chromatin is formed by DNA molecules.

- Therefore, the DNA molecules also called as chromatin fibers.

- Each DNA molecule consists of 2 thin filaments which wrapped around each other along a common axis and interconnected with side arm. Thus, double stranded molecule occur.

- DNA molecule that is simple in prokaryotes, but it is compounds with histone protein (deoksiribonükleoprotein) in eukaryotes.

- The length of DNA in the nucleus is far greater than the size of the compartment in which it is contained. To fit into this compartment the DNA has to be condensed in some manner.
- Therefore, it take some preventions in order to fit into the nucleus.

- Firstly, DNA wraps around histone molecules (it is called octamer).
- Thus, it is formed nucleosomes.

- An octamer and DNA molecules are surrounded around this octamer which form a **nucleosome**.

- The length of the DNA molecule is shortens 5-7 times to generate nucleosomes ; so, normally 2 nm thickness is reaches around 10 nm.

- DNA molecules make the secondary spirals in the peripheral parts of the nucleus and around the nucleolus.
- Thus it reduce their size 40 more times.
- Heterochromatic regions more concentrated.

- The DNA molecule is still longer than the diameter of the nucleus; They have to repeatedly folds to fit into the nucleus.
- Higher order coiling and supercoiling also help package the chromatin inside the nucleus.

- Generally it is believed that the heterochromatic regions are inactive.
- It is believed to be synthesized the RNA molecules in euchromatic regions.

- Before starting cell division RNA synthesis stops and DNA synthesis begins.
- This situation continues until the DNA molecules is doubled (This situation is called DNA replication).
- After they return to chromosomal DNA molecules come together in twos. This situation would be as follows:

- The length of a DNA molecule in the interphase is longer 5000 to 10000 times according to the length of a chromosome.
- This means that the DNA molecule must be 5000-10000 times shorter to fit into the chromosome.

- DNA molecule was shortened length 200-280 times to fit into nucleus in interphase.

- DNA molecules be shortened to fit into the chromosome 20-50 times once again.
- The DNA molecule is still longer than the diameter of the nucleus. They have to repeatedly folds to fit into the nucleus.
- Non-histone proteins fills spaces of folds.

- Chromosomes show constriction in one or two points.

- The one of these constriction is called primary, the other is called the secondary constriction. Primary constriction are found in all chromosomes.

- Secondary constriction located on a small number chromosome. It is located near one end of the chromosome (satellite chromosome). A satellite chromosome has a chromosome segment that is separated from the main body of the chromosome by such a secondary constriction.

- Chromatin fibers which are shortened and thickened enough to fit into the chromosome are called chromonema.
- Chromonema pair forming a chromosome is held together by a primary constriction contained in the centromere.
- The two identical copies—each forming one half of the replicated chromosome—are called chromatids. (two identical sister chromatids).

- Before replication, one chromosome is composed of one DNA molecule. Following replication, each chromosome is composed of two DNA molecules; in other words, DNA replication itself increases the amount of DNA but does *not* increase the number of chromosomes.

- There are four main types of chromosomes: metacentric, submetacentric, acrocentric, and telocentric.

- Metacentric chromosomes have the centromere in the center, such that both arms are of equal length.

- In submetacentric chromosome, the centromere so placed that it divides the chromosome into two arms of unequal length.

- In acrocentric chromosome, the centromere is located quite near one end of the chromosome.
- Humans normally have five pairs acrocentric chromosomes.

- In telocentric chromosome, the centromere is at the very end of the chromosome.

- Humans do not possess telocentric chromosomes but they are found in other species such as mice.

- Chromosome map is obtained by referring these types of features (karyotype). A **karyotype** is the number and appearance of chromosomes in the nucleus of a eukaryotic cell.

- Chromosomes other than the sex chromosomes are similar to each other in shapes and sizes. These are called homologous chromosomes.
- A human cell contains 23 pairs of homologous chromosomes: 22 of them are autosomes and 1 homologous pair of sex chromosomes.

- Females have two X chromosomes, whereas males have one X and one Y chromosome.

DNA molecules consist of two strands coiled around each other to form a double helix

- DNA molecules have a very important function in synthesis incidents in the nucleus and cytoplasm. Although, mRNA molecules determine the protein type which will occur in the cytoplasm, DNA molecules gives this information to the RNA molecule. DNA stores biological information.
- But unlike DNA, RNA molecules are found a single-strand. RNA molecules, as compared with DNA molecules is very short.
- Their longest is mRNA.

The molecular structure of nucleic acids

- Nucleic acids (which include DNA and RNA) consist of nucleotides.
- Each nucleotide has three components:
- a purine or pyrimidine nucleobase
- Pentose sugar
- A phosphate group

- Nucleic acids
  consist of long chains of polynucleotides
  .
- In polynucleotides, nucleotides are joined to one another by covalent bonds between the phosphate of one and the sugar of another. These linkages are called phosphodiester linkages. Phosphodiester linkages form the sugar-phosphate backbone of both DNA and RNA.

- Thus, such millions of nucleotides, by means of polymerase enzyme, are arrayed a long strand (nucleic acid) form.

- Nucleic acid types differ in the structure of the sugar in their nucleotides. DNA contains deoxyribose sugar while RNA contains ribose sugar.

- Also, the nucleobases found in the two nucleic acid types are different: adenine, cytosine, and guanine are found in both RNA and DNA, while thymine occurs in DNA and uracil occurs in RNA.
- DNA consists of the four nitrogenous bases: **adenine (A), guanine (G), cytosine (C), and thymine (T)**.

- Purin bases: adenine+ guanine
- Primidin bases: thymine+cytosine+urasil
- If the sugar is deoxyribose, the polymer is DNA. If the sugar is ribose, the polymer is RNA.
- When all three components are combined, they form a nucleic acid.

Nucleotides are not arranged according to a certain rule in the DNA and RNA. Therefore, chromosomes in terms of structure and functionality is different according to species.

- In double stranded DNA, adenine pairs with thymine **(A-T)** and guanine pairs with cytosine (**G-C)**. Bases provide reciprocal link with the H-bridge.

- A-T, G-C DNA
- A-U, G-C RNA

- Nucleotides are one of the main components of nucleic acids while nucleic acids themselves are the building blocks of life.

- While sugar and phosphate molecules help with the organization of the DNA molecule, the nitrogenous bases carry the genetic information.

- Three types RNA molecules is required passage from nucleus to the cytoplasm for the realization of protein synthesis in the cytoplasm
- Therefore, chromatin fibers in the interphase nucleus synthesize new RNA molecules continuously, according to the activity status of the cells.

- This is called transcription.
- Simply , transcription is the synthesis of RNA from a DNA template.

- DNA strands get rid of the spiral through DNA helicase enzyme. RNA molecules are synthesized along only a single one of these strands.
- During transcription, guanine pairs with cytosine **(G-C)** and adenine pairs with uracil **(A-U)**.

- Particles which synthesizes RNA along the DNA strands is called gene. GENOM is all of the genes in the chromosomes of an organism.
- The longest genes synthesize mRNA molecules. Medium length synthesizes rRNA molecules. The shortest also synthesizes tRNA molecule..

- rRNA genes expressing of DNA molecules are collected in the nucleolus. This is called the nucleolus organizer regions. So, NORs include active rRNA genes.
- Genes are located at intermittently on DNA molecules as seen and only those parts are active. In this case, a small part of of each DNA molecule makes the transcription.

- The synthesized RNA molecules is attached to the DNA strand temporarily.
- The enzymes providing to bind of nucleotides in the RNA molecule called RNA polymerase.

DNA replication

- **DNA replication** is the process of producing a new DNA molecule from one original DNA molecule.
- This biological process occurs in all living organisms and is the basis for biological inheritance.

- All molecules participate this synthesis during DNA synthesis.
- DNA helicase enzyme also solves spirals.
- Each strand synthesizes a new strand.

- During replication, guanine pairs with cytosine **(G-C)** and adenine pairs with thymine **(A-T)**.

- The enzymes providing to bind of nucleotides in the DNA molecule called DNA polymerase.

- Thus, the synthesized new strand spiral with synthezing himself with old strand generate a new DNA molecule.

Sex chromatin

- When soma cells of female mammals examined, granule larger than chromatin observed mostly sitting on the inner face of the nuclear membrane, and sometimes in karyoplasm (Barr body-sex chromatin). This chromatin clump is the sex chromatin and this is one of the two X chromosomes is present in female cells.

- In blood smears, the sex chromatin appears as a drumstick like in nuclei of the neutrophilic leukocytes

Evidence suggests that the sex chromatin is genetically inactive.

- This is important in the early detection of sex. It is important in terms of forensic medicine.

Nucleolus

- The nucleolus is a spherical structure that is rich in rRNA and protein. This is the largest structure in the nucleus of eukaryotic cells. With the electron microscope, the nucleolus consists of three distinct components:

- (1) From one to several pale-staining regions are composed of **nucleolar organizer DNA** sequences of bases that code for rRNA . In the human genome, five pairs of chromosomes contain nucleolar organizers.

- (2) Closely associated with the nucleolar organisers are densely packed 5- to 10-nm ribonucleoprotein fibers that comprise the **pars fibrosa,** which consists of primary transcripts of rRNA genes.

- (3) The **pars granulosa** consists of 15- to 20-nm granules.
- Proteins, synthesized in the cytoplasm, become associated with rRNAs in the nucleolus; ribosome subunits then migrate into the cytoplasm.

- Heterochromatin is often attached to the nucleolus (**nucleolus-associated chromatin**), but the functional significance of the association is not known.

- Nucleolus are not continuous formations. It losts in the prophase stage of mitosis and meiosis and appear again towards the end of telophase.

Nuclear matrix

- The nuclear matrix is the component that fills the space between the chromatin and the nucleoli in the nucleus. It is composed mainly of proteins (some of which have enzymatic activity), metabolites, and ions.

- When its nucleic acids and other soluble components are removed, a continuous fibrillar structure remains, forming the **nucleoskeleton.**

- The fibrous lamina of the nuclear envelope is part of the nuclear matrix. The nucleoskeleton probably contributes to the formation of a protein base to which DNA loops are bound.