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## Nucleus

Study Guide — Cell Organelles

Pre-Med practice questions about the nucleus, chromatin, and nuclear components

8 items — Study Guide with Answers

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1 What is the primary function of the nucleolus in a eukaryotic cell?

- A Replication of chromosomal DNA before mitosis.
- B Synthesis and processing of ribosomal RNA and assembly of ribosomal subunits.** ✓
- C Storage of mRNA molecules before translation.
- D Degradation of misfolded nuclear proteins.
- E Attachment of chromosomes to the nuclear envelope.

► **Explanation:** The nucleolus is the site of rRNA transcription and assembly of ribosomal subunits, which are then exported to the cytosol.



2 Which statement about the nuclear envelope of a typical eukaryotic cell is correct?

- A It consists of a single phospholipid monolayer surrounding the nucleus.
- B Its outer membrane is continuous with the rough endoplasmic reticulum.** ✓
- C Nuclear pore complexes permit only RNA, but not proteins, to pass.
- D The nuclear lamina is composed of microtubules attached to the inner membrane.
- E It remains completely intact and unchanged throughout mitosis in all eukaryotic cells.

► **Explanation:** The nuclear envelope has two membranes; the outer one is continuous with the rough ER and shares its ribosomes.



3 Which of the following molecules requires active, signal-mediated transport through a nuclear pore complex to enter the nucleus from the cytosol?

- A Carbon dioxide.
- B A 10-kDa ion such as  $\text{Na}^+$ .





- C A 70-kDa transcription factor containing a nuclear localization signal. ✓
- D Water.
- E Ribose and deoxyribose sugars.

► **Explanation:** Large proteins (over ~40-60 kDa) require a nuclear localization signal and receptor-mediated transport, whereas small molecules diffuse freely through nuclear pores.

4 In a non-dividing cell that is actively transcribing genes, nuclear DNA is predominantly found as:



- A Highly condensed metaphase chromosomes aligned on the spindle.
- B Circular DNA molecules attached to the plasma membrane.
- C Heterochromatin tightly packed and transcriptionally silent throughout the nucleus.
- D Euchromatin that is relatively decondensed and accessible to transcription machinery. ✓
- E Single-stranded DNA molecules to allow rapid transcription.

► **Explanation:** In interphase, active genes are found in decondensed euchromatin, which is accessible to RNA polymerase and other transcription factors.

5 Which feature distinguishes eukaryotic nuclear DNA from prokaryotic chromosomal DNA?



- A Eukaryotic nuclear DNA is always circular, whereas prokaryotic DNA is linear.
- B Eukaryotic nuclear DNA is associated with histone proteins to form nucleosomes. ✓
- C Prokaryotic chromosomal DNA is enclosed by a nuclear envelope.
- D Prokaryotic DNA is found exclusively in multiple chromosomes.
- E Only prokaryotic DNA contains genes for ribosomal RNA.





► **Explanation:** Eukaryotic nuclear DNA is packaged with histones in nucleosomes, whereas prokaryotic chromosomal DNA is usually circular and not organized into nucleosomes.

**6** A small molecule strongly activates histone acetyltransferases (HATs) in a population of eukaryotic cells. Which of the following is the most direct effect on chromatin and transcription?



- A** Increased positive charge on histone tails, tighter DNA binding, and global transcriptional repression.
- B** Decreased acetylation of histones, leading to conversion of euchromatin into heterochromatin.
- C** Neutralization of positive charges on histone tails, loosening nucleosome–DNA interactions, and increased transcription of many genes. ✓
- D** Degradation of histones in lysosomes, leaving naked DNA that cannot be transcribed.
- E** Conversion of nuclear DNA to circular form, enhancing transcription efficiency.

► **Explanation:** Histone acetylation neutralizes lysine side chains, reducing electrostatic attraction between histones and DNA, which opens chromatin (more euchromatin) and generally promotes transcription.

**7** A transcription factor contains a functional DNA-binding domain but acquires a point mutation that destroys its nuclear localization signal (NLS). The mutant protein is expressed at normal levels. Which outcome is most likely?



- A** It accumulates in the cytosol and fails to activate transcription of its target genes. ✓
- B** It accumulates in the nucleus because nuclear pores import all proteins by passive diffusion.
- C** It enters mitochondria instead, where it binds mitochondrial DNA.
- D** It is degraded immediately by lysosomes because it lacks an NLS.
- E** It still shuttles normally between cytosol and nucleus because exportins recognize any protein above a size threshold.





► **Explanation:** Large proteins require an NLS and importin-mediated transport to enter the nucleus; without the NLS, the transcription factor remains in the cytosol and cannot reach its DNA targets.

**8** In eukaryotic cells, the directionality of nuclear import and export cycles through nuclear pore complexes depends critically on:



- A** The orientation of phospholipids in the nuclear envelope.
- B** A gradient of Ran-GTP and Ran-GDP across the nuclear envelope. ✓
- C** Higher calcium concentration in the nucleus than in the cytosol.
- D** Continuous ATP generation by mitochondrial ATP synthase located in the nuclear envelope.
- E** Proteolytic cleavage of importins after each transport cycle.

► **Explanation:** Ran-GTP is enriched in the nucleus and Ran-GDP in the cytosol; this gradient drives the binding and release cycles of cargo-importin and cargo-exportin complexes, giving nuclear transport a defined direction.

