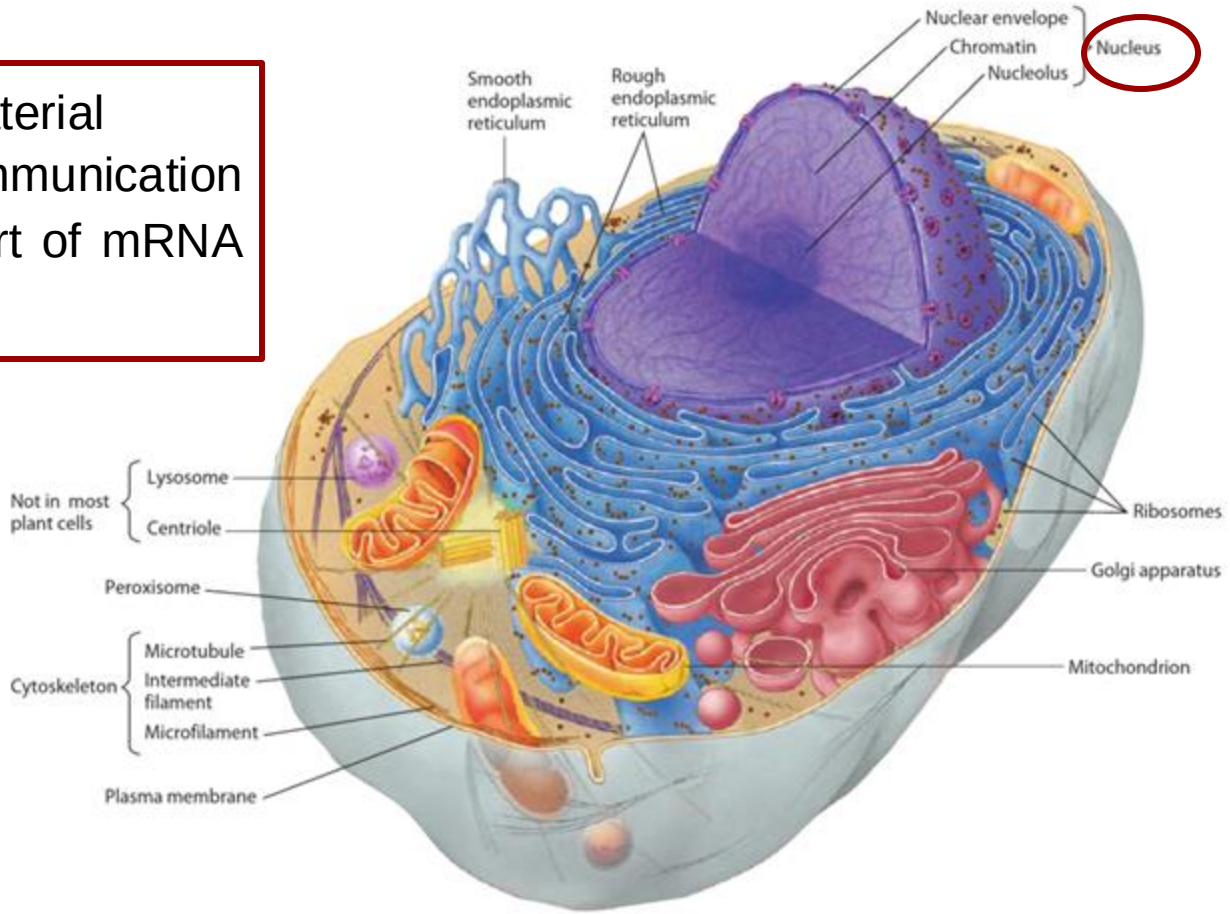
Summary- Week 1

Building blocks of the cell

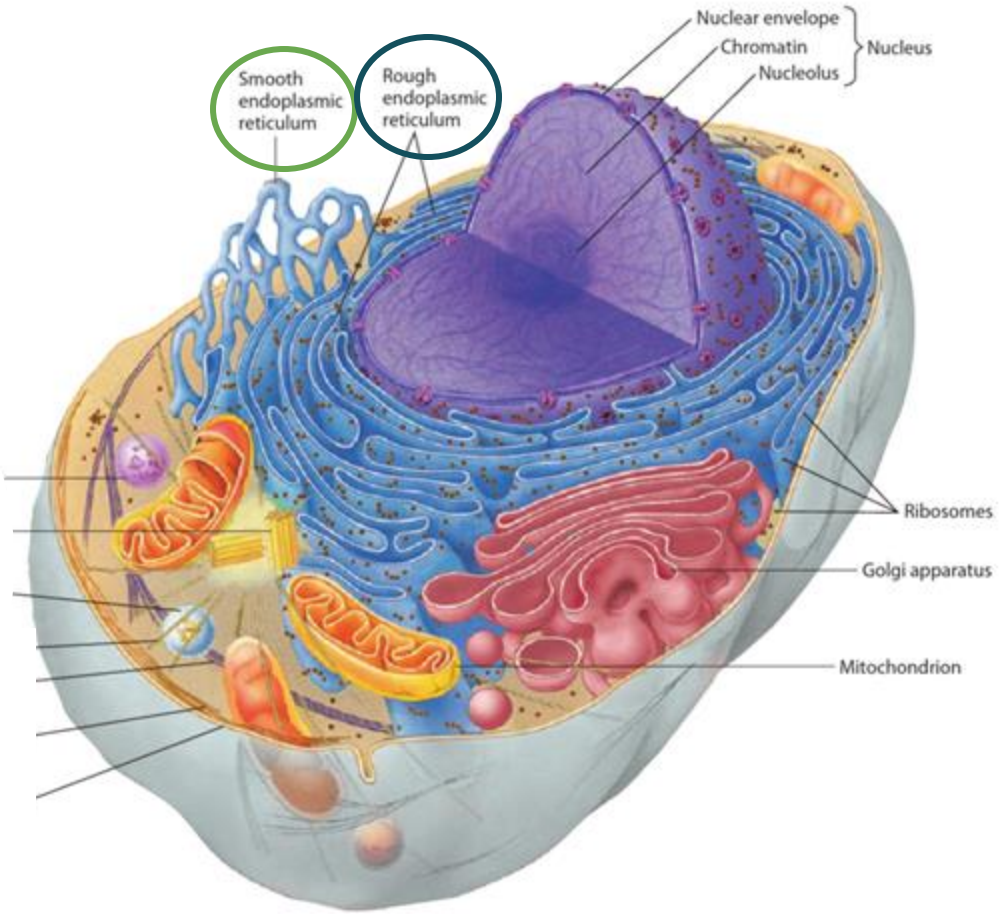
Storage of the genetic material
Nuclear pores allow communication and the export and import of mRNA and proteins.



Building blocks of the cell

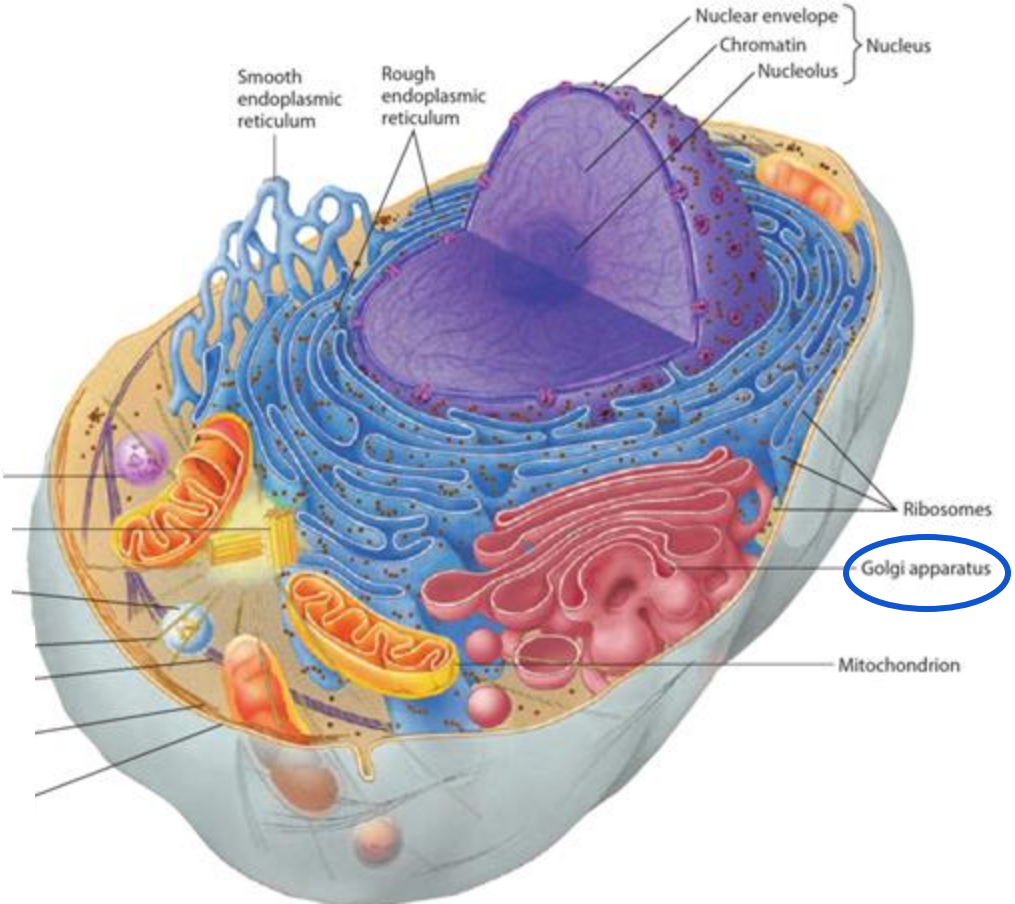
The smooth ER is a storage place for calcium. It is also involved in lipid biosynthesis and detoxification.

mRNA exported from the nucleus is translated into protein by the ribosomes that are bound or freely floating around the rough endoplasmic reticulum.



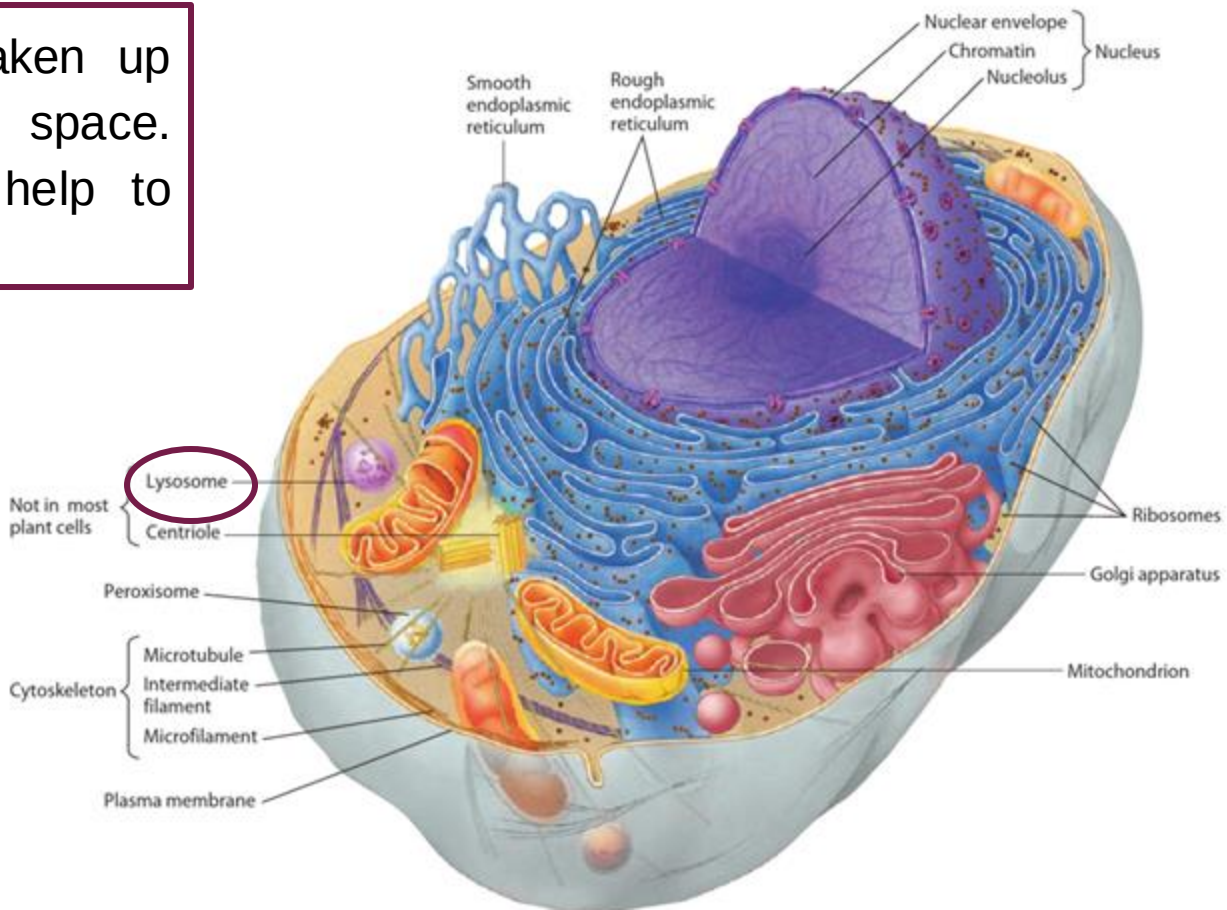
Building blocks of the cell

The Golgi is the packaging center of the cell. It receives proteins from the ER and adds chemical modifications (sugar, phsophate, sulfates). Takes care of sorting and sending to a destination (membrane, lysosome, secretion)



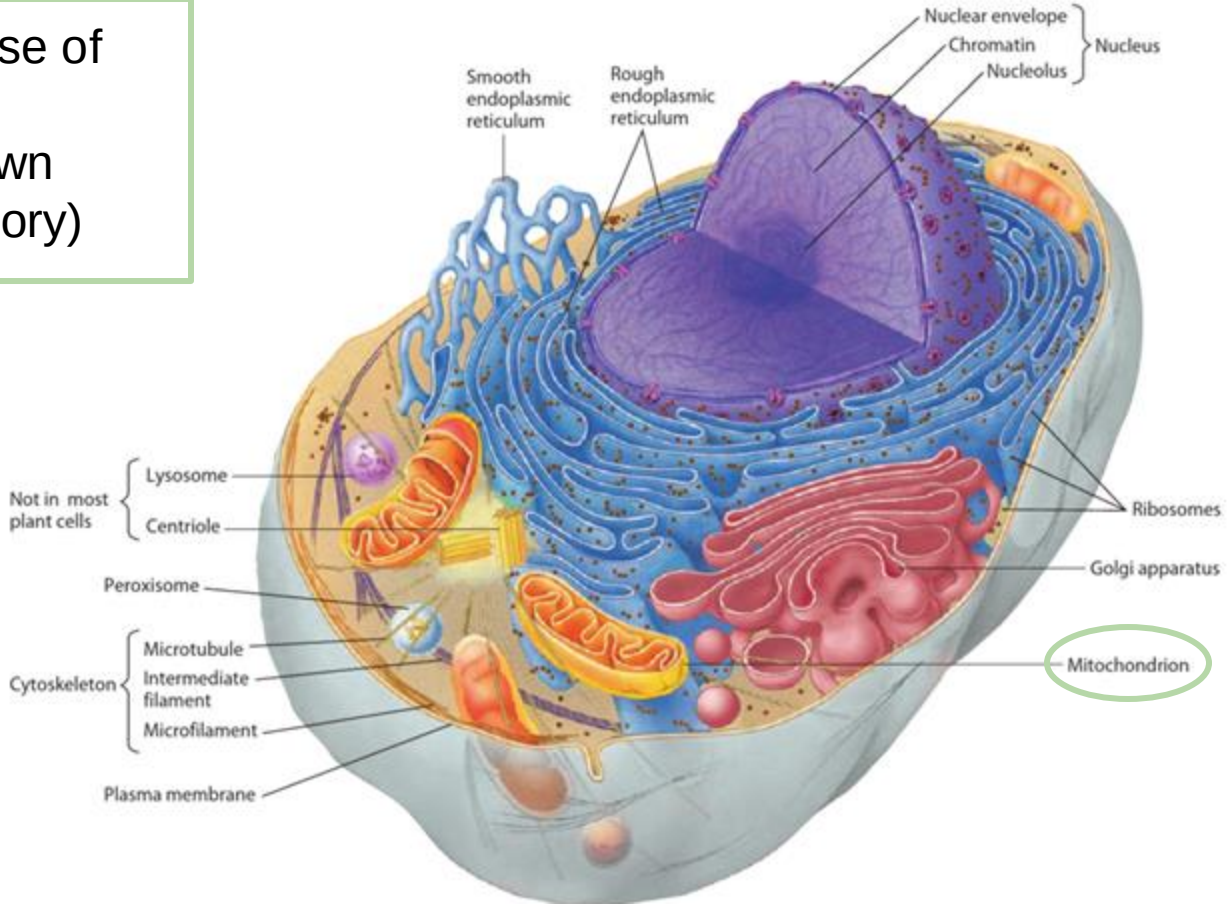
Building blocks of the cell

Digestion of molecules taken up from the extracellular space. Clearing organelles and help to renew the cell (autophagy).



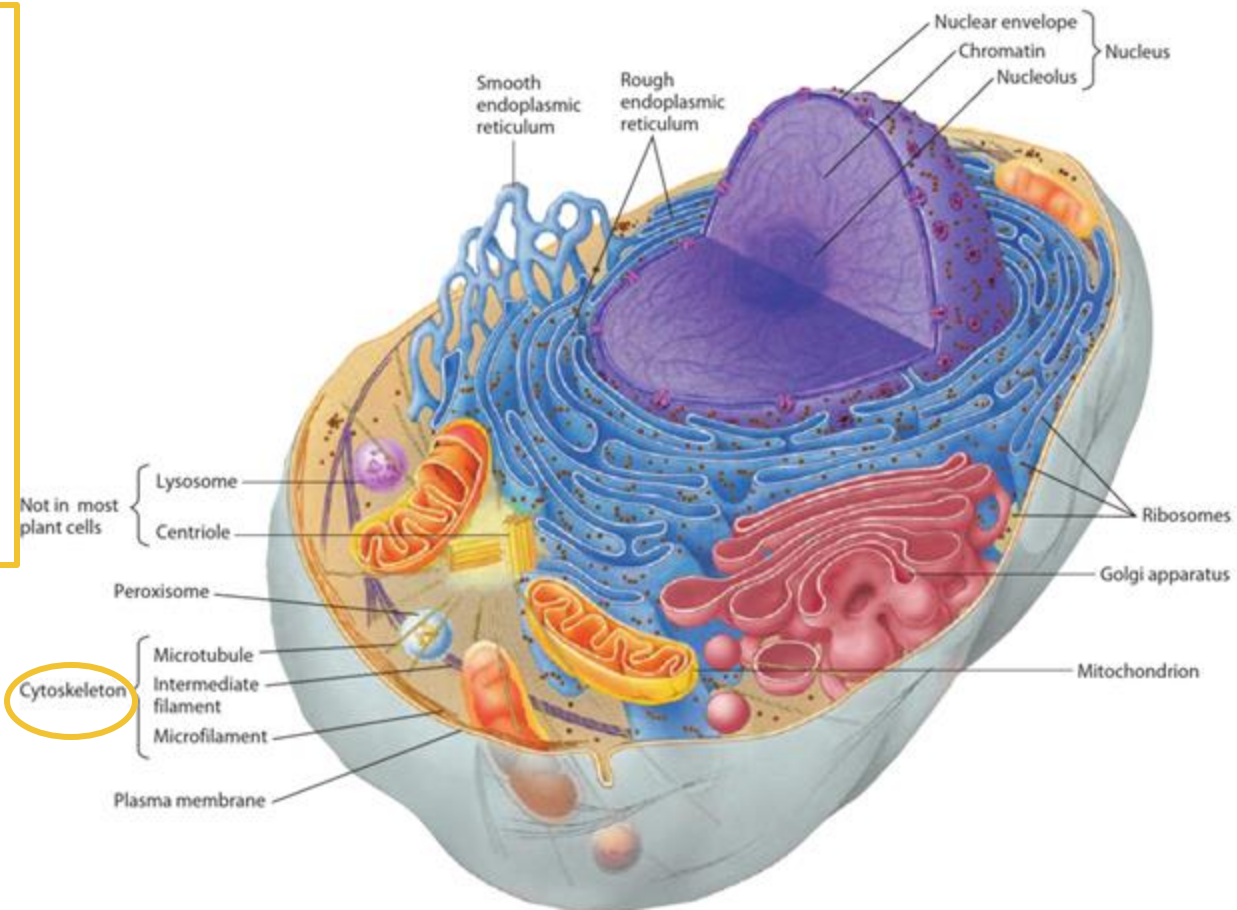
Building blocks of the cell

Produce energy (powerhouse of the cell)
Has two membranes and own genome (endosymbiont theory)

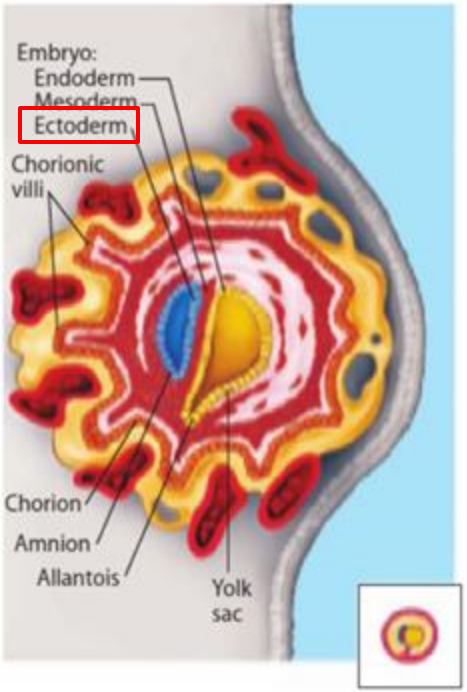


Building blocks of the cell

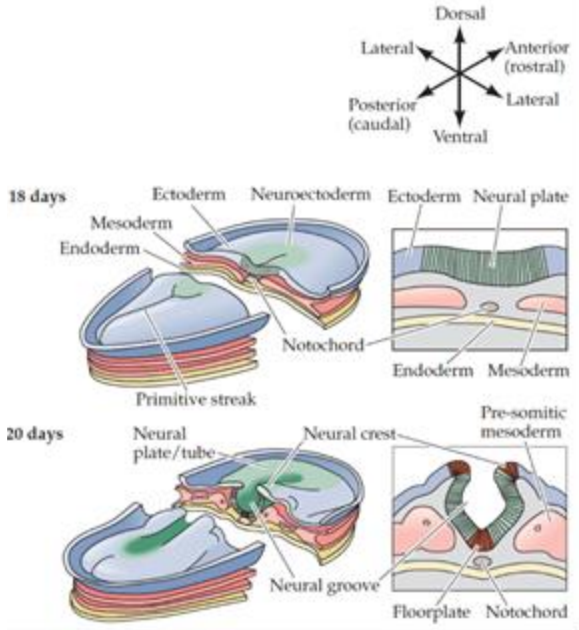
Segregate chromosomes in cell division, intracellular transport, cell motility
Mechanical support of the cell shape
Mechanical support of cell shape in movement, cell division and muscle contraction

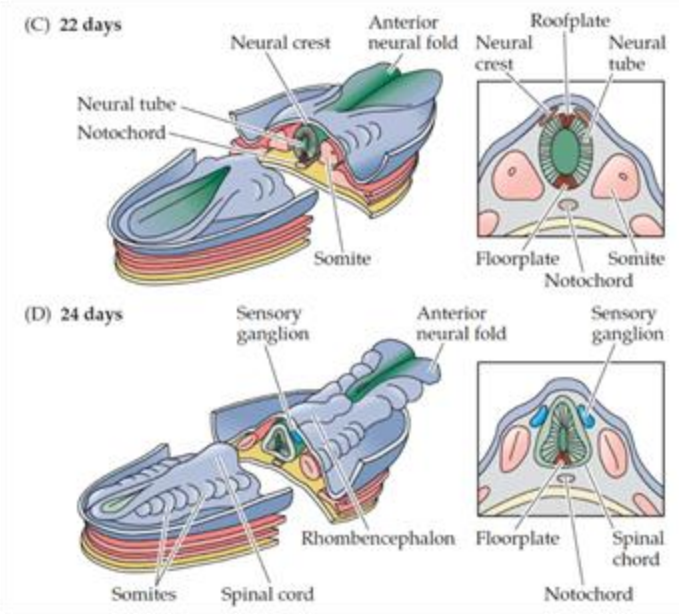


Development of the embryo and the brain

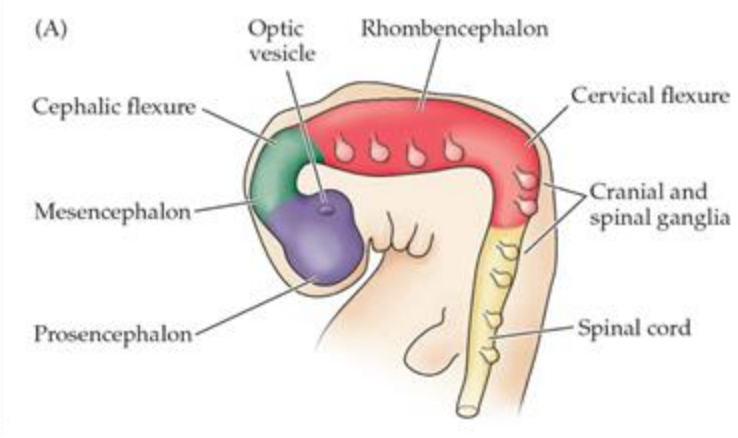


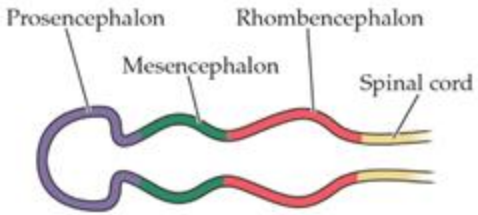
▲ **Figure 15E** Three-layered embryo and four extraembryonic membranes (16 days)

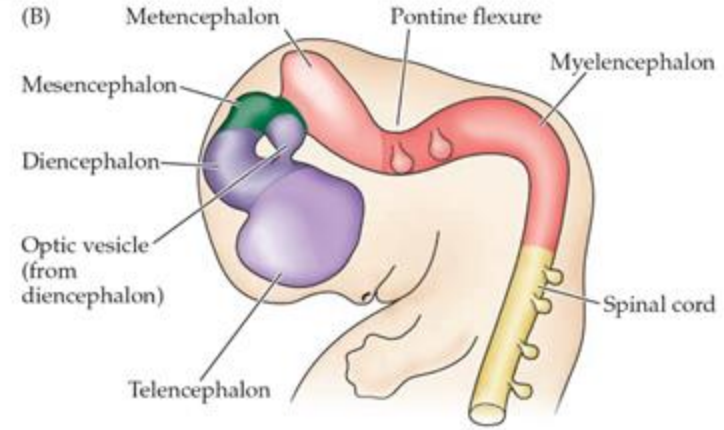


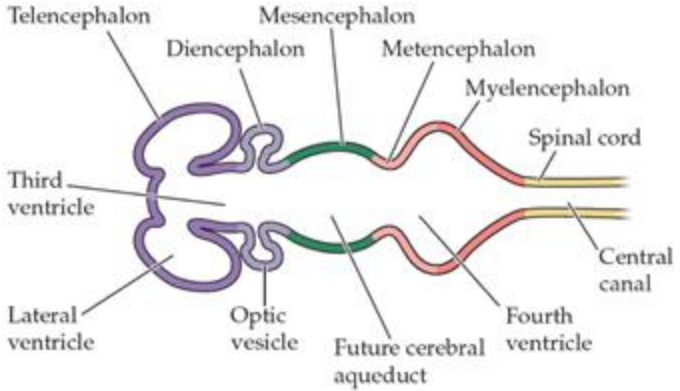


Parts of the developing brain

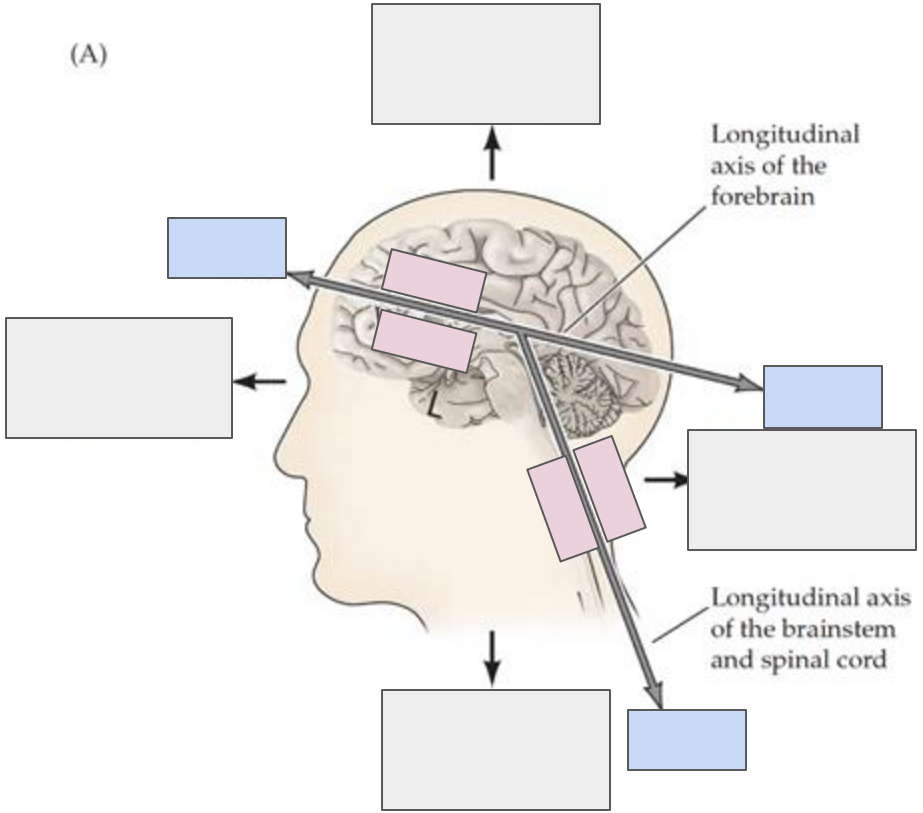


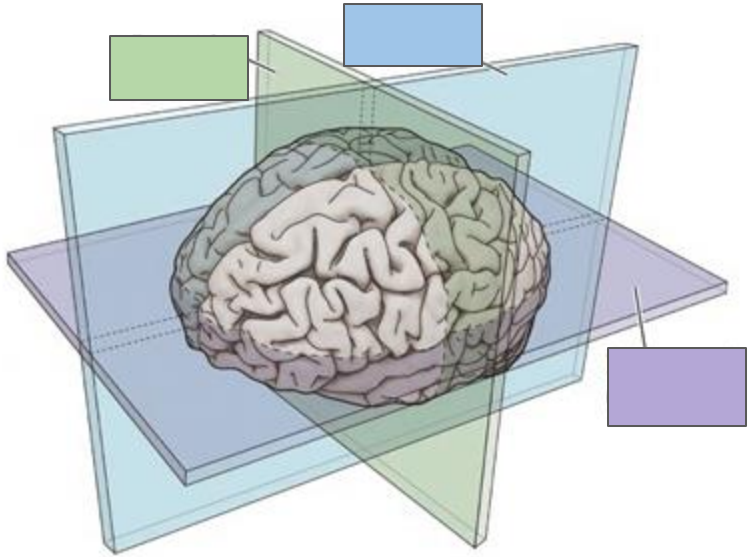




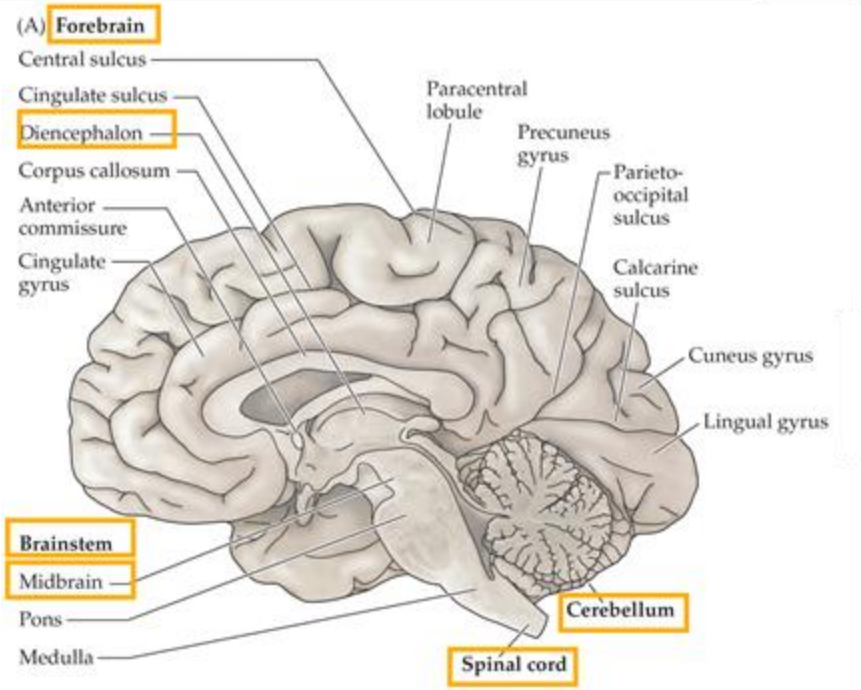


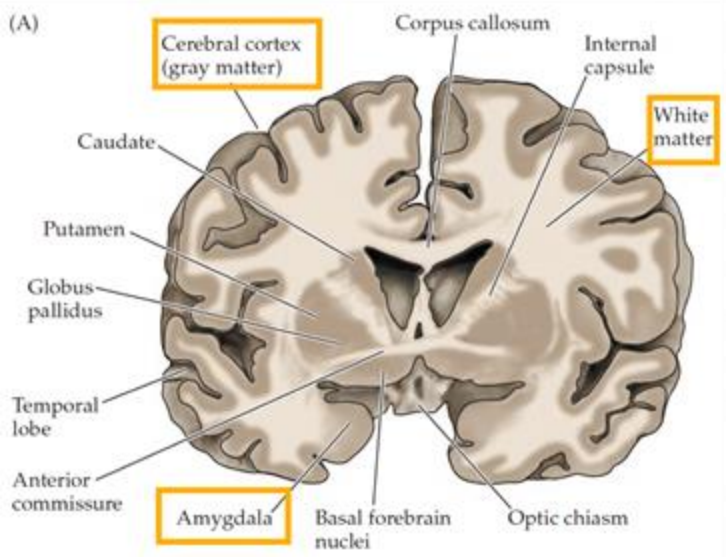
Important axes of the brain

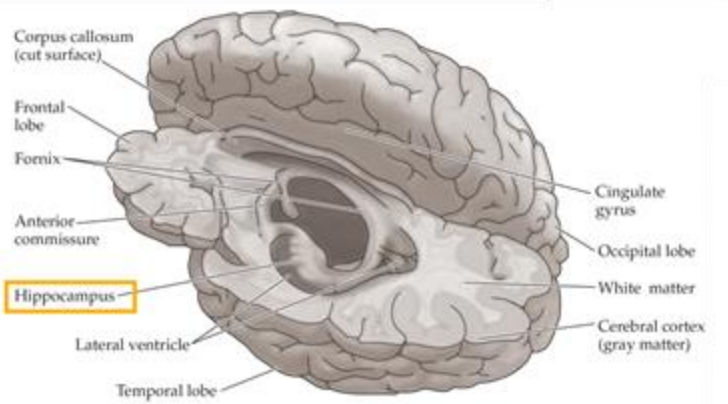




Important brain regions







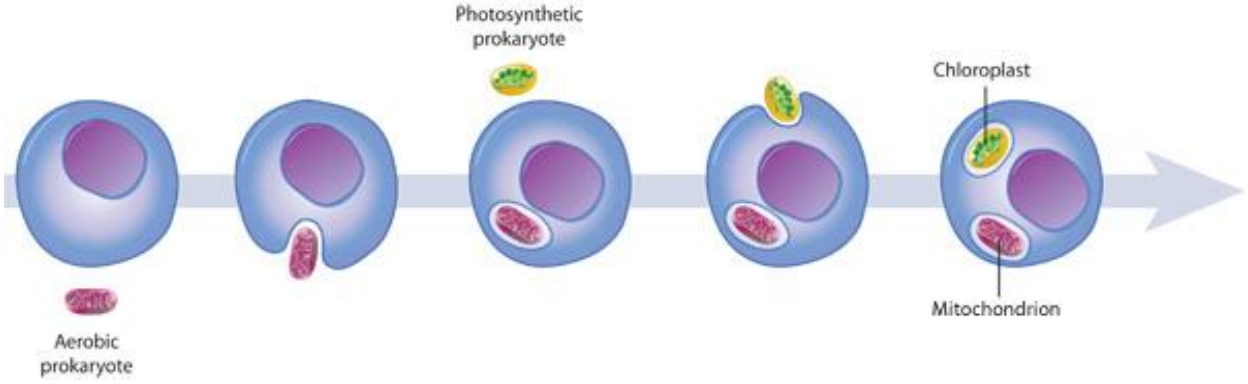
Exercise Questions - Lecture 1

1- In eukaryotic cells, which organelles contain DNA?

Nucleus, mitochondria and chloroplast

2- Briefly explain what endosymbiont theory is.

Oxygen-metabolizing (aerobic) bacteria, which was ingested by an anaerobic cell. The bacteria evolved in symbiosis with the cell and its progeny by generating power for the host cell while receiving nourishment and shelter.



Exercise Questions - Lecture 1

3- What would be an argument against the endosymbiont theory? (short discussion)

Exercise Questions - Lecture 1

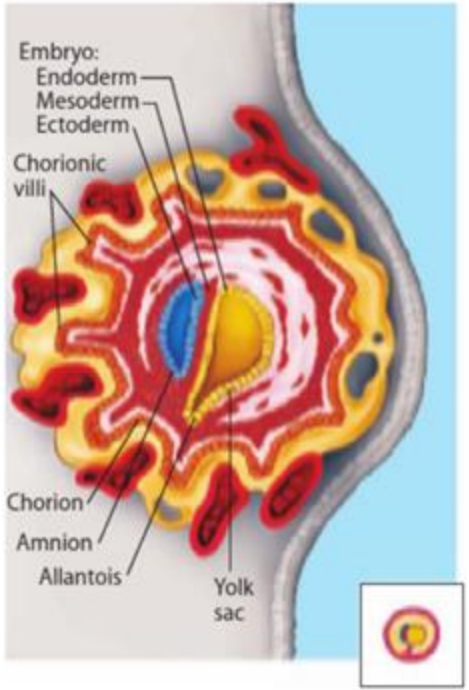
4- What are the functions of the nucleus?

Storage of genetic information (chromatin→ DNA + structural elements), DNA replication, RNA synthesis, regulate gene expression

Exercise Questions - Lecture 1

5- What are the three embryonic layers in development?

Endoderm, mesoderm and ectoderm

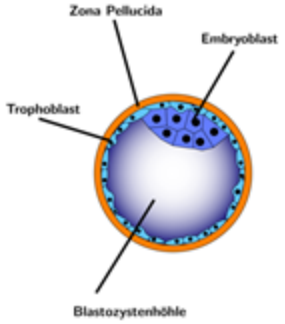


▲ **Figure 15E** Three-layered embryo and four extraembryonic membranes (16 days)

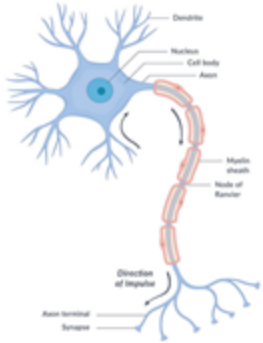
Exercise Questions - Lecture 1

6- What do we mean by totipotency of a cell? Would you classify the following cells as totipotent?

Zygote



Trophoblast

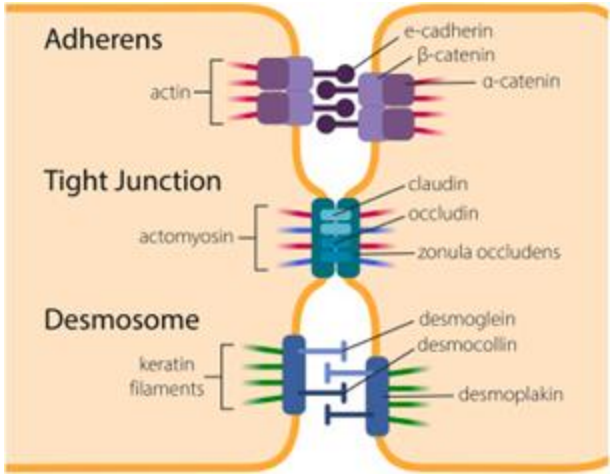


Neuron

Exercise Questions - Lecture 1

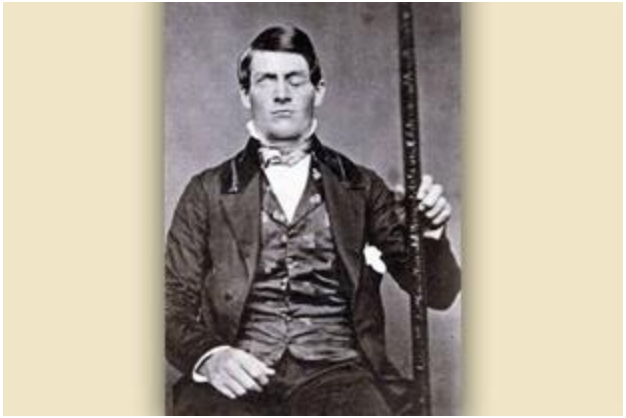
7- What enables cells to stick together and form a tissue and an organ, rather than just falling apart?

- ***Cell adhesion molecules, cell junctions and extracellular matrix.***

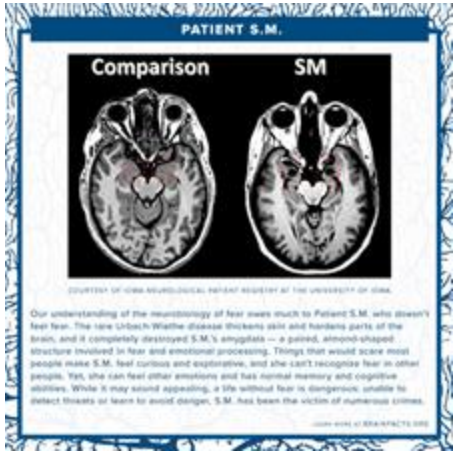


Exercise Questions - Lecture 1

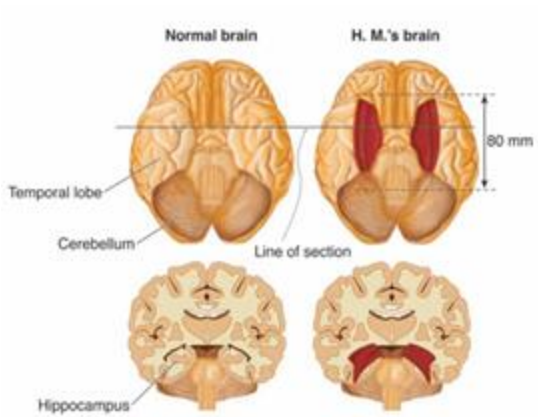
8- How did we find out about most functions of different brain regions, for example that the frontal lobe is important for higher cognitive functions?



Phineas Gage (frontal lobe)



Patient S.M. (amygdala)



Patient Henry Molaison (hippocampus).

Exercise Questions - Lecture 1

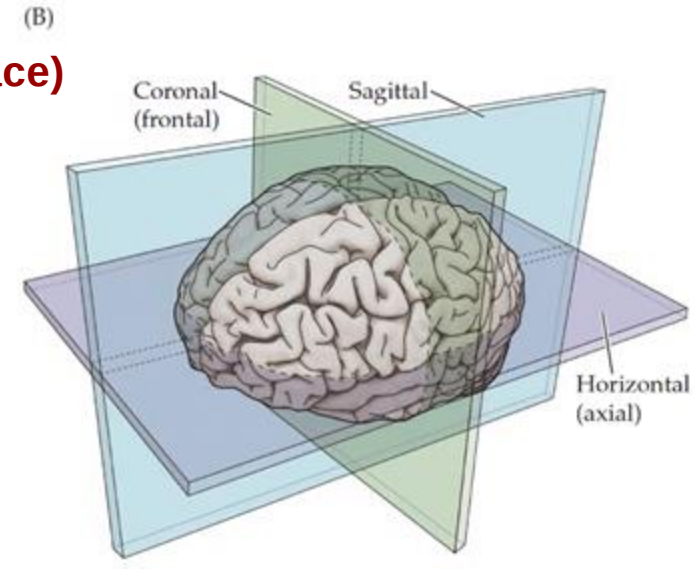
9- Which embryonic layer gives rise to the developing brain?

Ectoderm

Exercise Questions - Lecture 1

10- What are the three anatomical axes used to study the brain's anatomy?

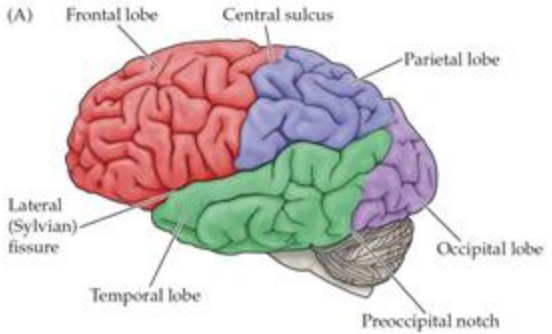
a. Sagittal (divides two hemispheres)
b. Coronal (frontal, in the plane of the face)
c. Axial (horizontal)

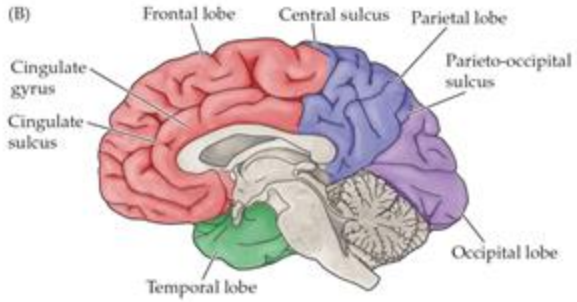


Exercise Questions - Lecture 1

11- What are the lobes of the cerebral cortex? What are the associated functions with each lobe?

a. Frontal – higher level executive functions such as planning, reasoning, emotional regulation,
b. Occipital – visual processing
c. Parietal – integrating sensory information, touch, temperature, pressure
d. Temporal – integrating sensory information, memory formation, understanding language

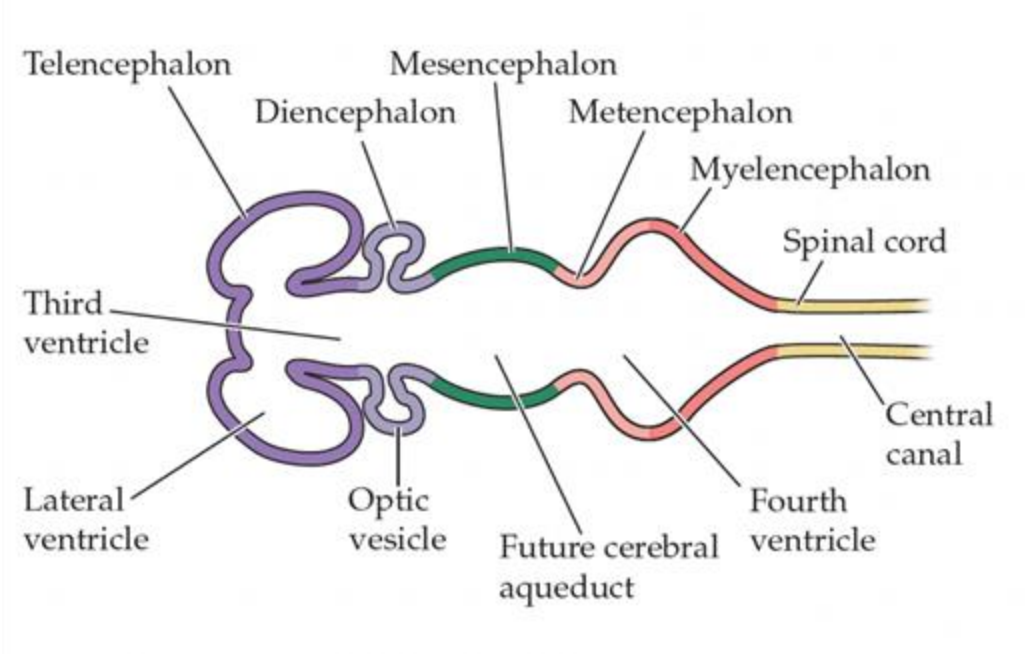




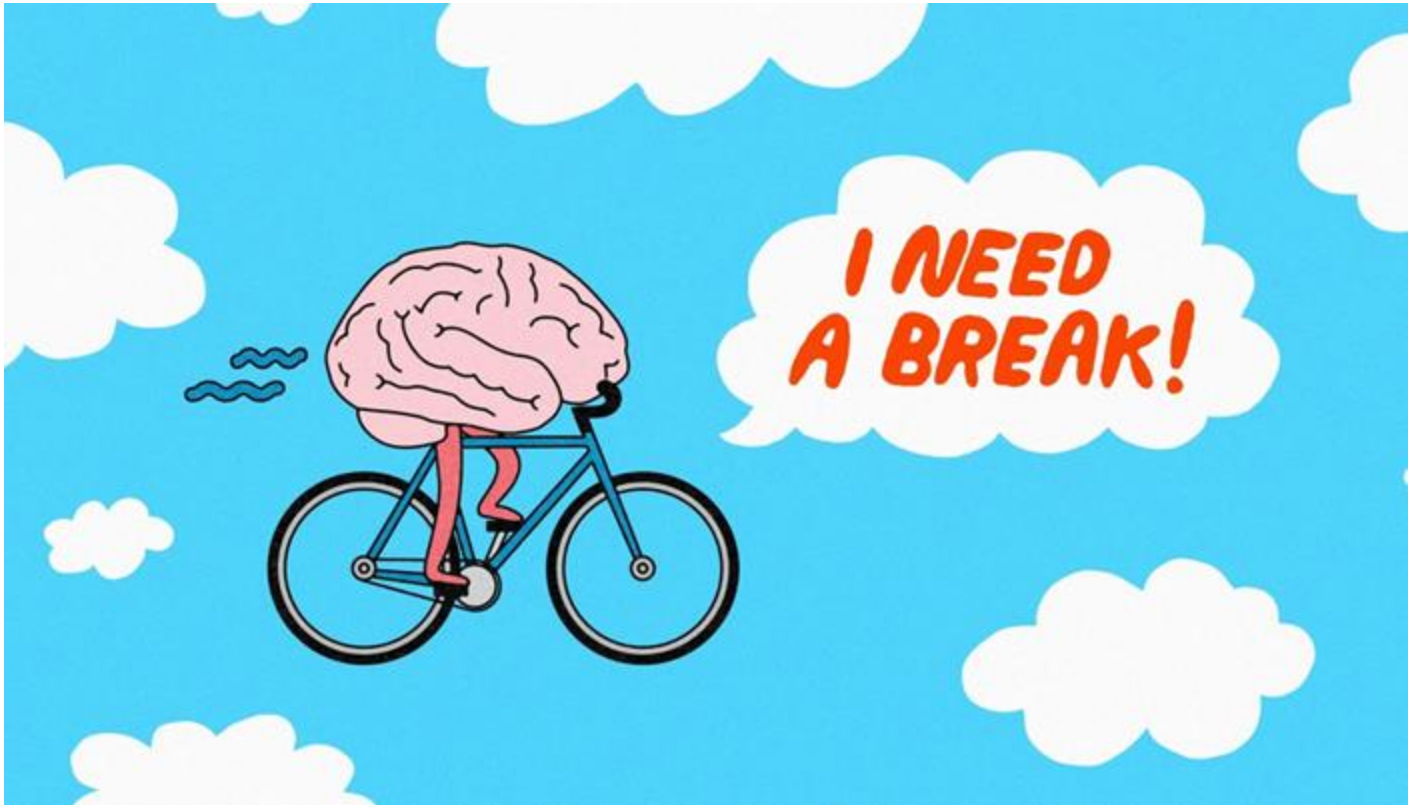
Exercise Questions - Lecture 1

12- What are the five vesicles of the developing neural tube?

a. Telencephalon
b. Diencephalon
c. Mesencephalon
d. Metencephalon
e. Myelencephalon



15 min break

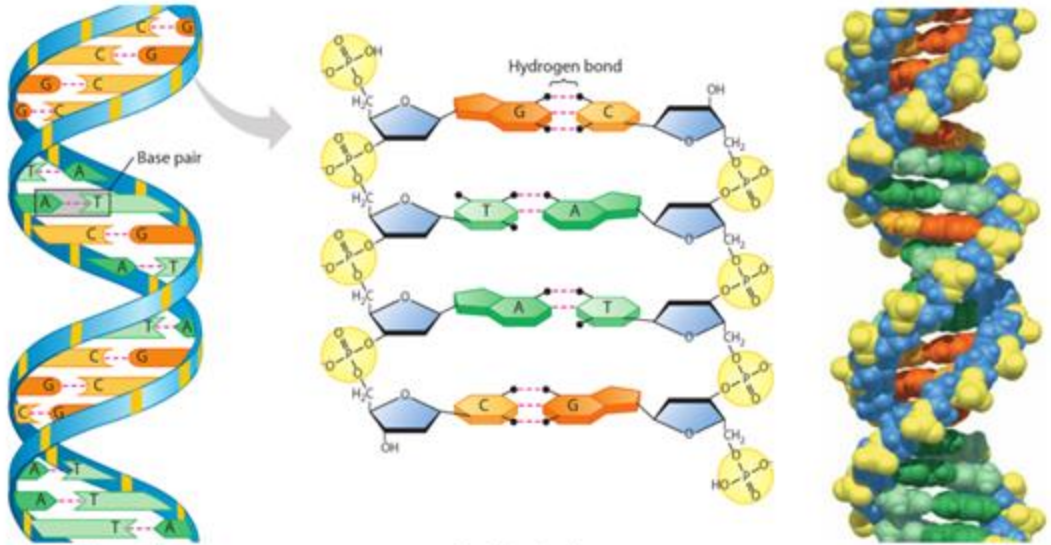


Structure of the DNA

The structure of the DNA is a double helix.

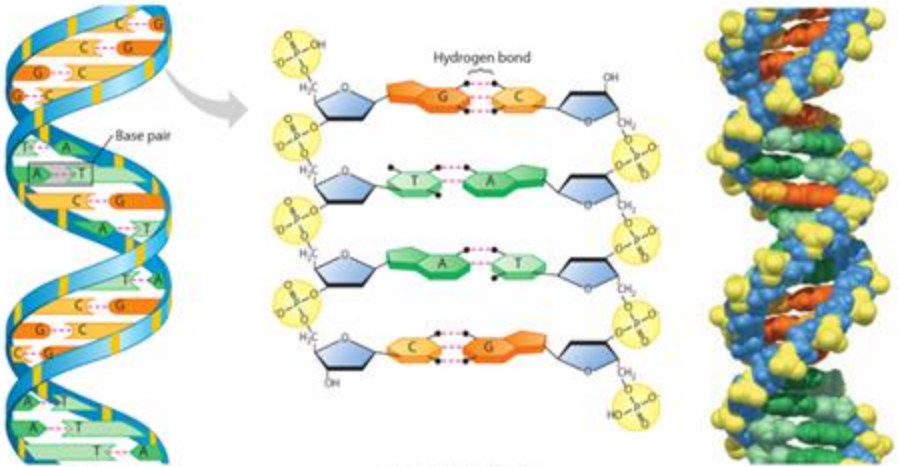
It is composed of 4 different bases bound to sugar phosphate molecule: Adenine (A), Thymine (T), Guanine (G) and Cytosine (C)

DNA replication is a semi-conservative process due to one strand being conserved.



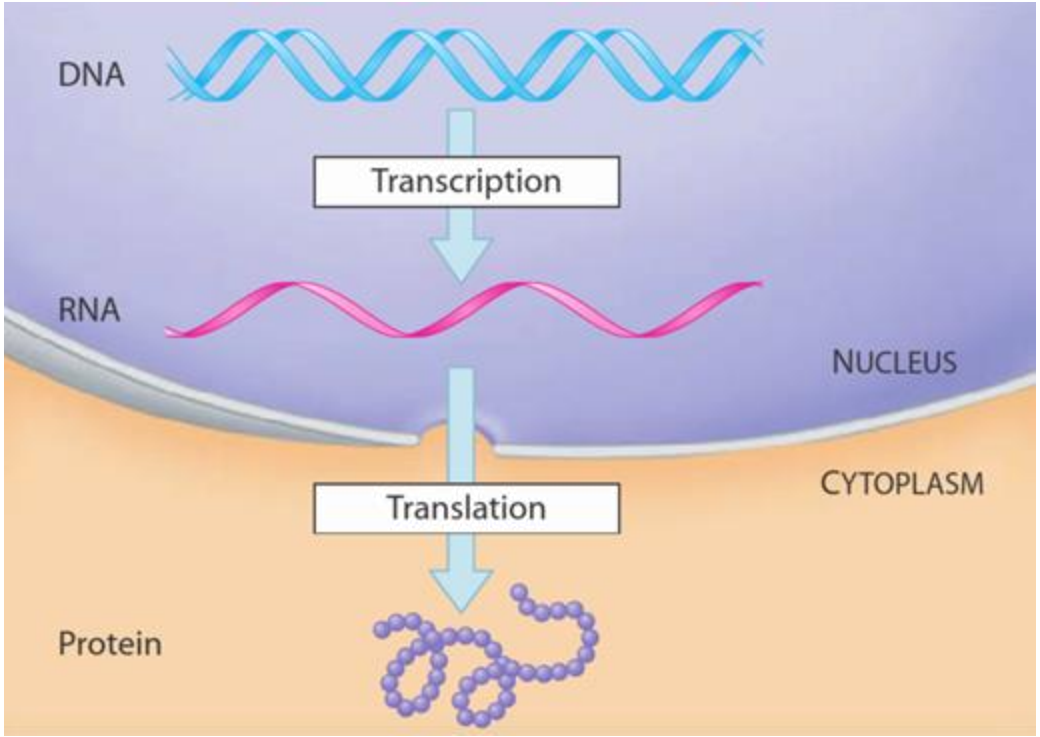
▲ Figure 3D Three representations of DNA

Discussion question: in the lab, we often need to move DNA fragments on a gel. What could allow for this movement of DNA molecules? Take a close look at the molecule.



▲ Figure 3D Three representations of DNA

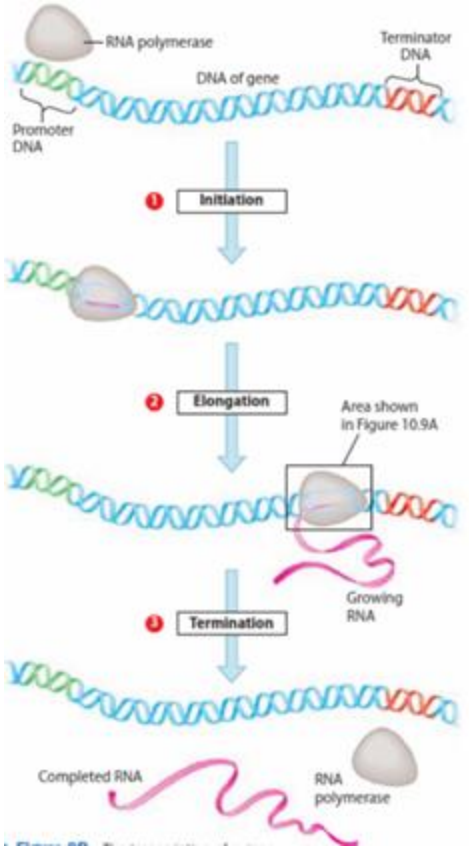
Central dogma of molecular biology



Discussion question:

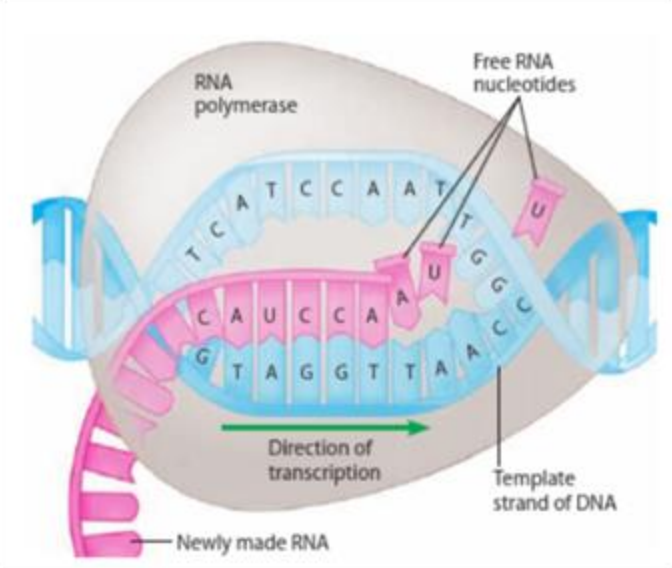
Once a peptide is made - is it ready to start performing its function?

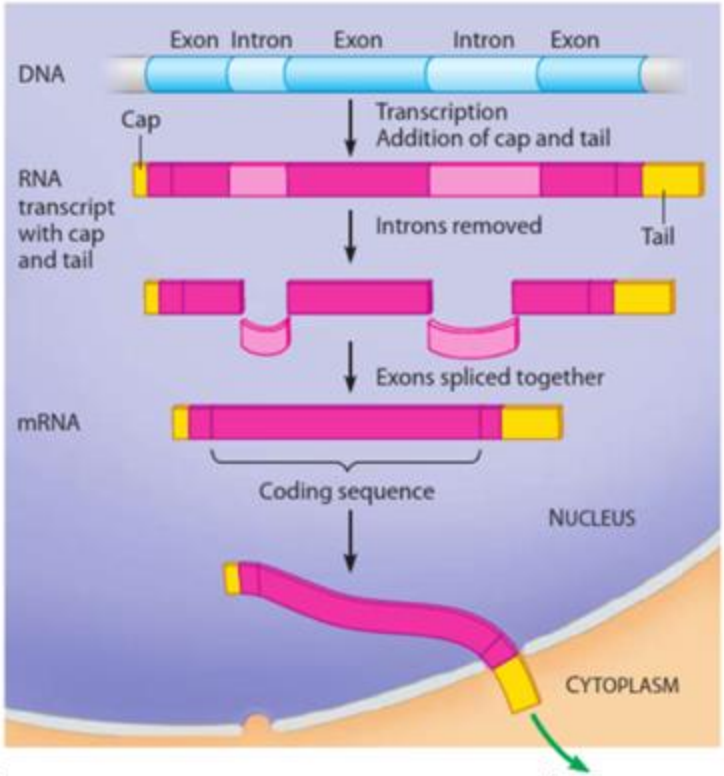
Transcription



Inside the **nucleus** DNA is transcribed into RNA by RNA Polymerase II and then exported to the **cytoplasm**

RNA polymerase recognizes the promoter of a gene



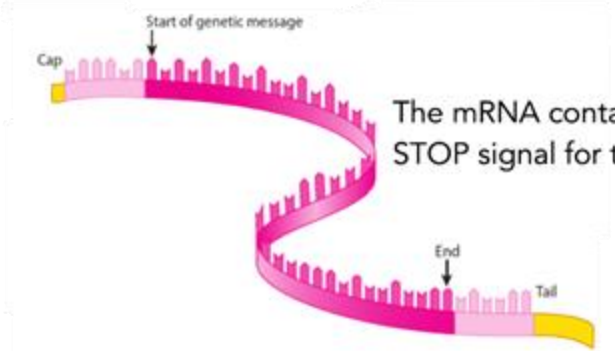


Genes of eukaryotes are structured into intron and exons (Nobel Prize 1993)

The pre-mRNA contains the introns which are removed in a process called splicing

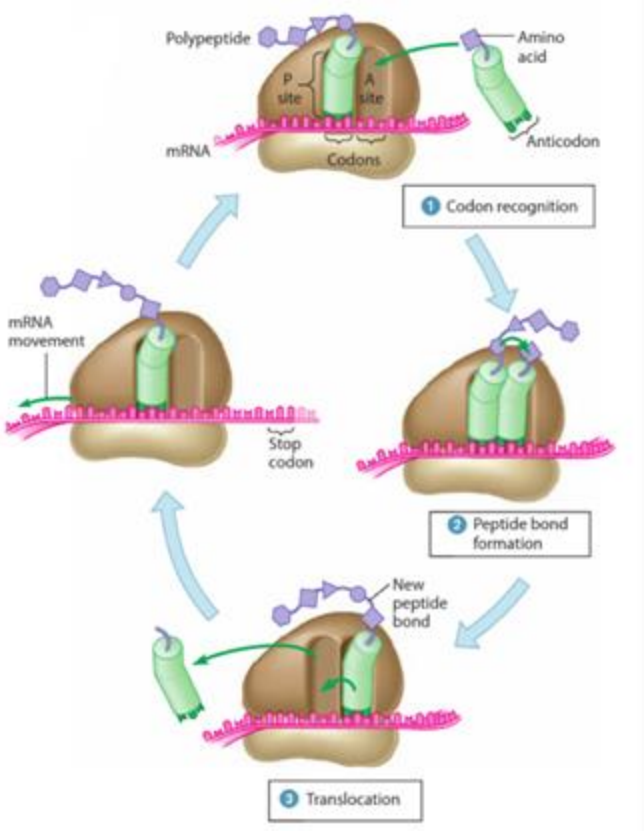
The mRNA is protected by a 5′ Cap and a 3′ polyA tail

The mature mRNA is transported into the cytoplasm



The mRNA contains a START and STOP signal for translation

mRNA to protein

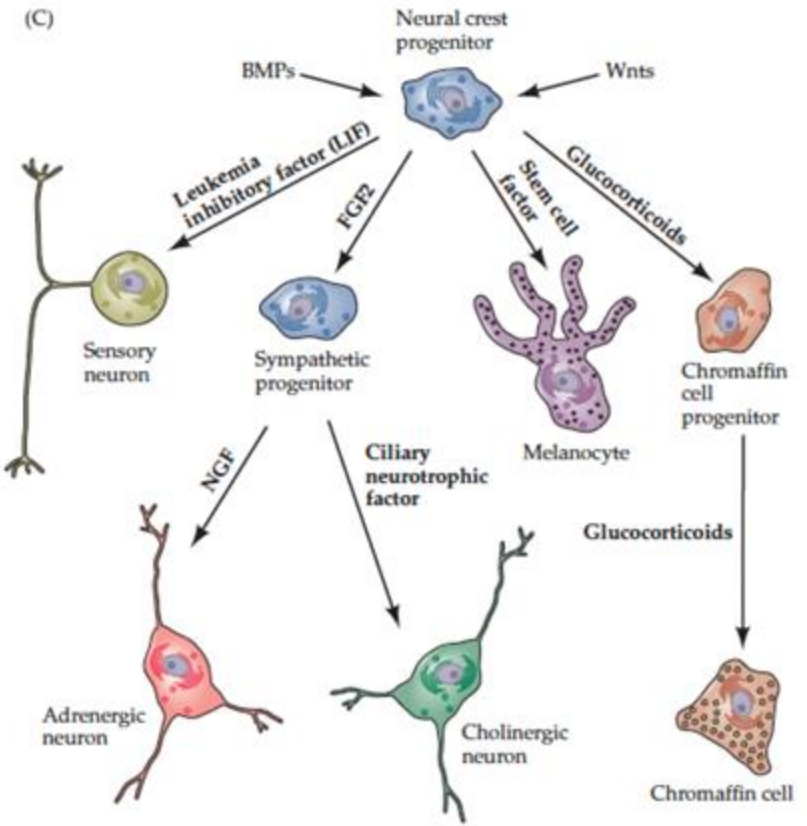


tRNAs read the mRNAs and the ribosome connects individual amino acids to form a peptide chain

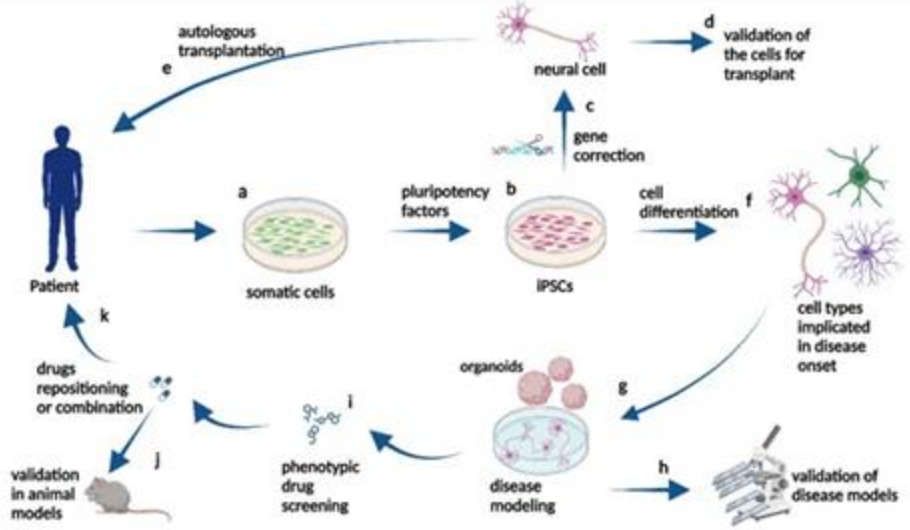
Peptide chains will resume secondary and tertiary structures and build proteins

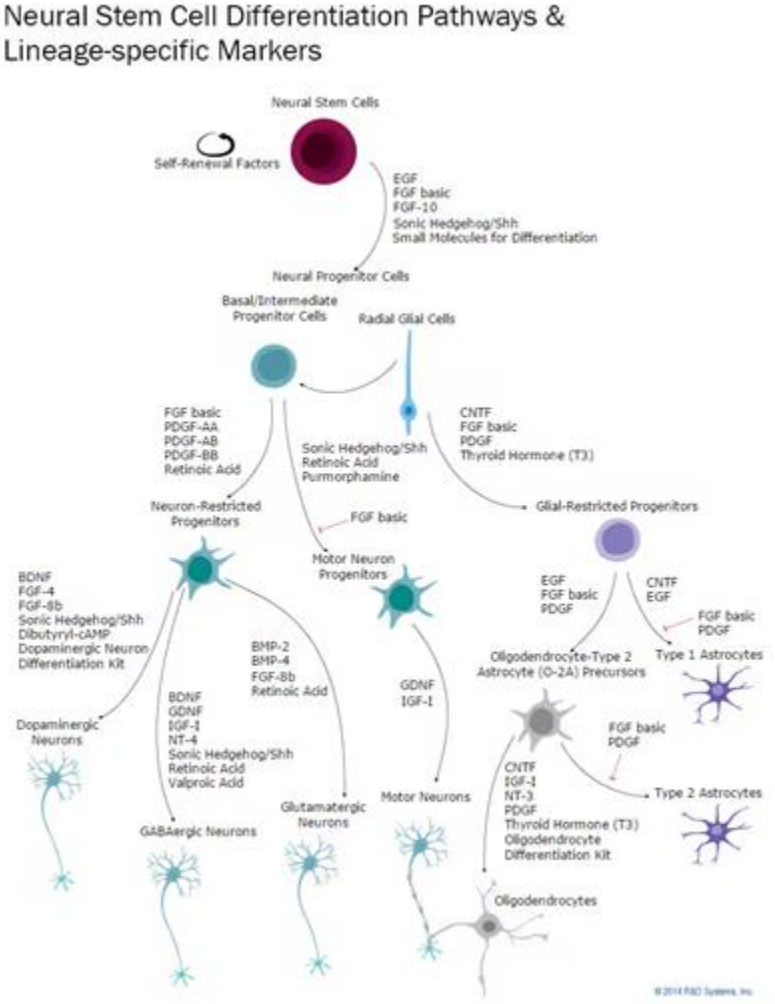
Cell fate transitions

Neural crest progenitors can produce a wide variety of different cell types depending on the signalling molecules they encounter. Remember, signalling molecules bind their receptors, which can translocate into the cell and induce transcription factors to regulate a gene.



Example of cell fate transitions in neuroscience research





Exercise Questions - Lecture 2

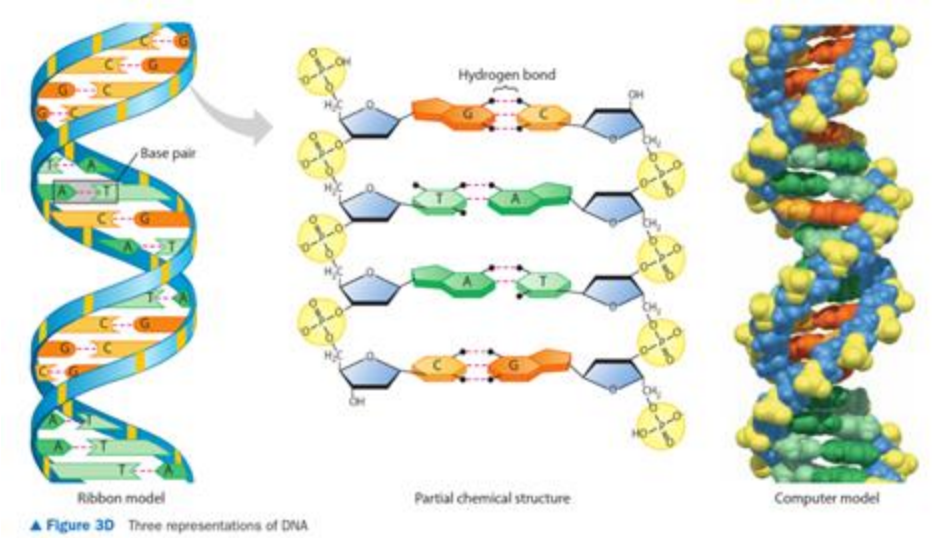
1- What is the structure of the DNA?

Double helix

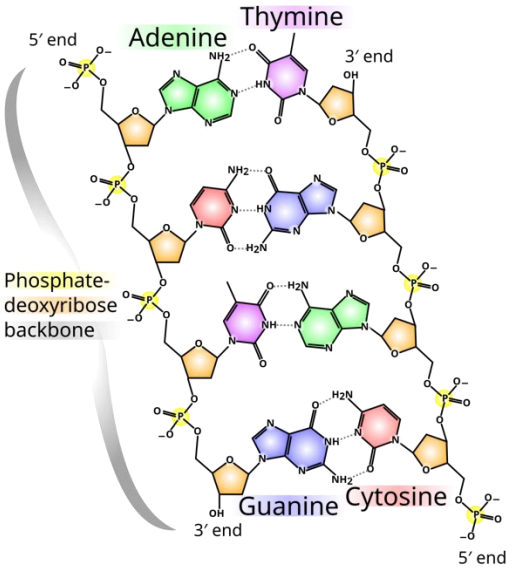
2- What is the direction of DNA replication? Briefly describe the process of DNA replication.

5’ to 3’. DNA replication starts at the origin of replication with the helicase opening up the DNA at the replication fork. DNA polymerase catalyzes nucleotide polymerization. On the lagging strand, short DNA fragments are made using a short RNA primer later to be replaced with DNA.

Discussion question: what does 5’ to 3’ refer to in DNA? Take yet another close look at the molecule.



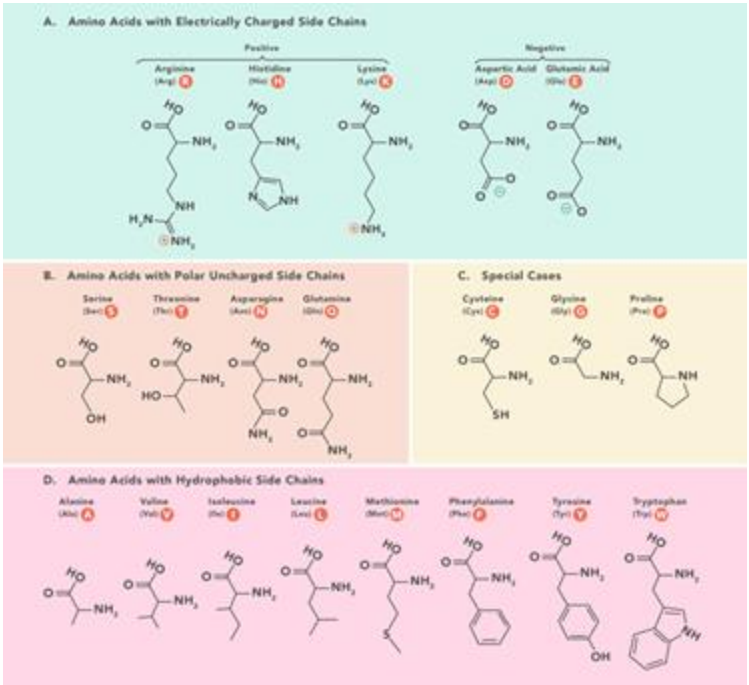
▲ Figure 3D Three representations of DNA



Exercise Questions - Lecture 2

3- How many naturally occurring amino acids are there?

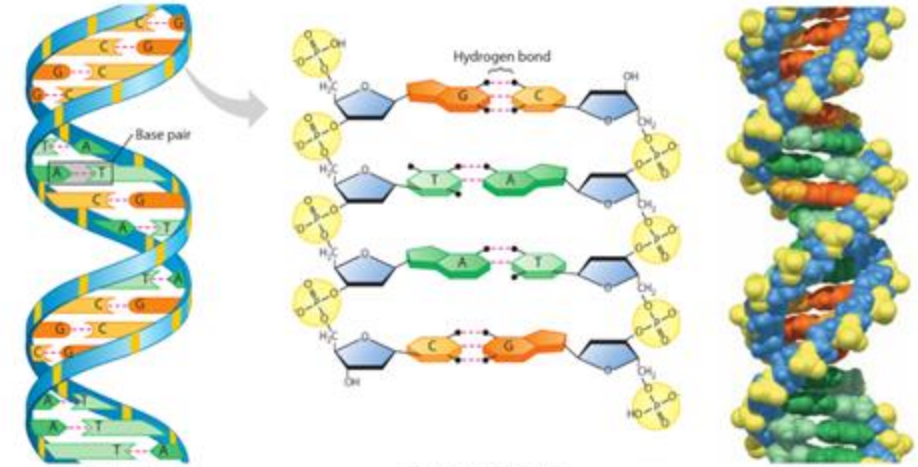
20



https://www.technologynetworks.com/applied-sciences/articles/essential-amino-acids-chart-abbreviations-and-structure-324357

Exercise Questions - Lecture 2

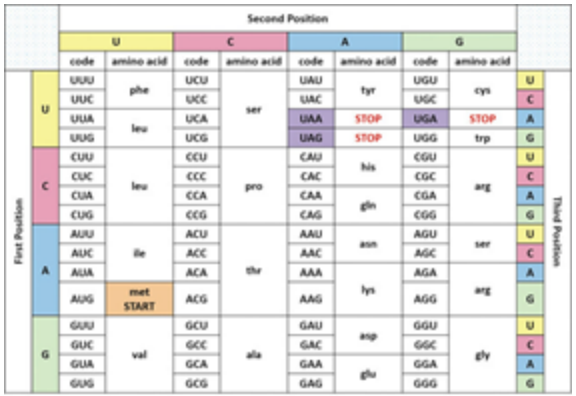
4- In DNA, nucleotides bind in a specific way, A to T, and C to G. Provide some reasoning for this. What kind of a bond is this? Take a look at the molecule - again!



▲ Figure 3D Three representations of DNA

Exercise Questions - Lecture 2

5- Triplets of nucleotides can serve to start or finish transcription (start codons and stop codons). Which ones start and which ones stop transcription? Why do these particular combinations serve for starting or stopping transcriptions and not others?

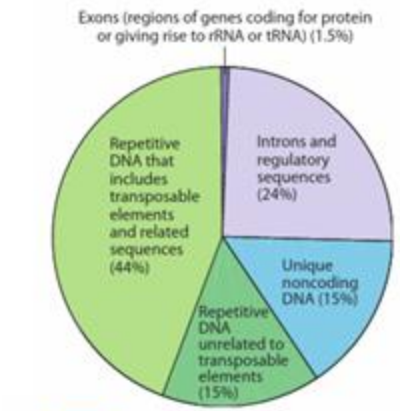


First Position	Second Position: U code	U amino acid	C code	C amino acid	A code	A amino acid	G code	G amino acid	Third Position
U	UUU	phe	UCU	ser	UAU	tyr	UGU	cys	U
	UUC		UCC		UAC		UGC		C
	UUA	leu	UCA		UAA	STOP	UGA	STOP	A
	UUG		UCG		UAG	STOP	UGG	trp	G
C	CUU	leu	CCU	pro	CAU	his	CGU	arg	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	gln	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	ile	ACU	thr	AAU	asn	AGU	ser	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	lys	AGA	arg	A
	AUG	met START	ACG		AAG		AGG		G
G	GUU	val	GCU	ala	GAU	asp	GGU	gly	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	glu	GGA		A
	GUG		GCG		GAG		GGG		G

You don't have to know all the codes, but it's good to know start and stop codons and why they serve that function

Exercise Questions - Lecture 2

6- What percentage of DNA codes for proteins?



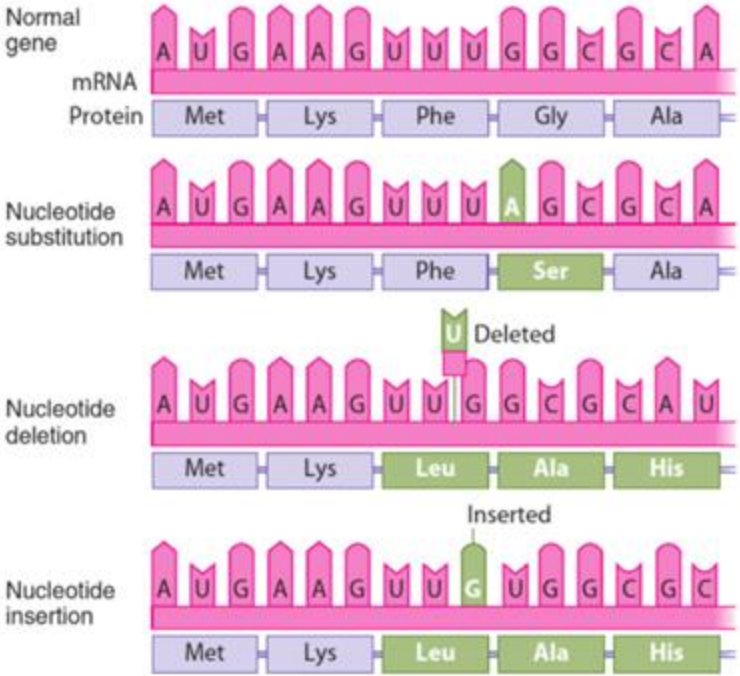
▲ Figure 18 Composition of the human genome

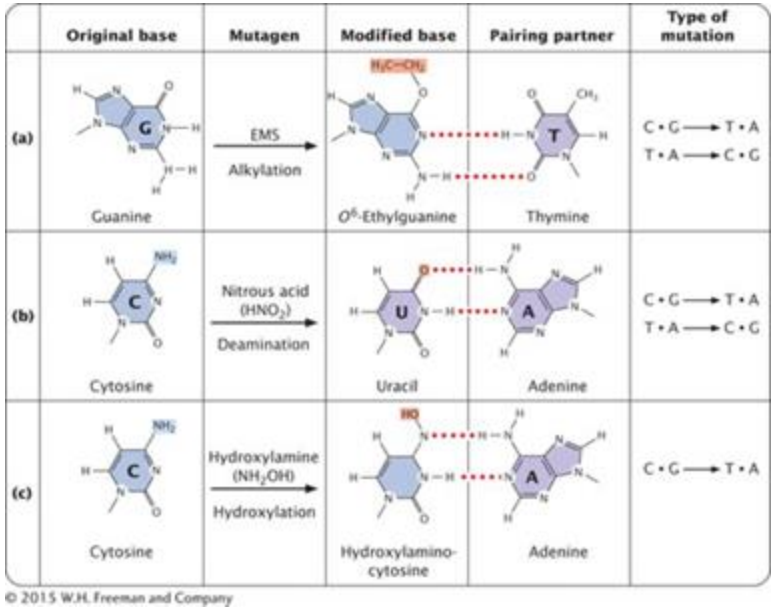
7- Within genes, there are coding parts of DNA and non-coding parts. What does the non-coding DNA do?

A lot of the non-coding fraction of the genome comprises regulatory regions that help control the expression of genes.
These regulatory elements help to turn on genes in cell types specific fashion.

Exercise Questions - Lecture 2

8- How can mutagens lead to changes in the DNA?





Exercise Questions - Lecture 2

8- How can mutagens lead to changes in the DNA?

Herman Muller was the first to show that X-ray irradiation causes high levels of mutations - work done in fruit flies. On the right - not one of his mutants, but an interesting mutation causing the fly to gain another pair of wings (ultrabithorax).

Exercise Questions - Lecture 2

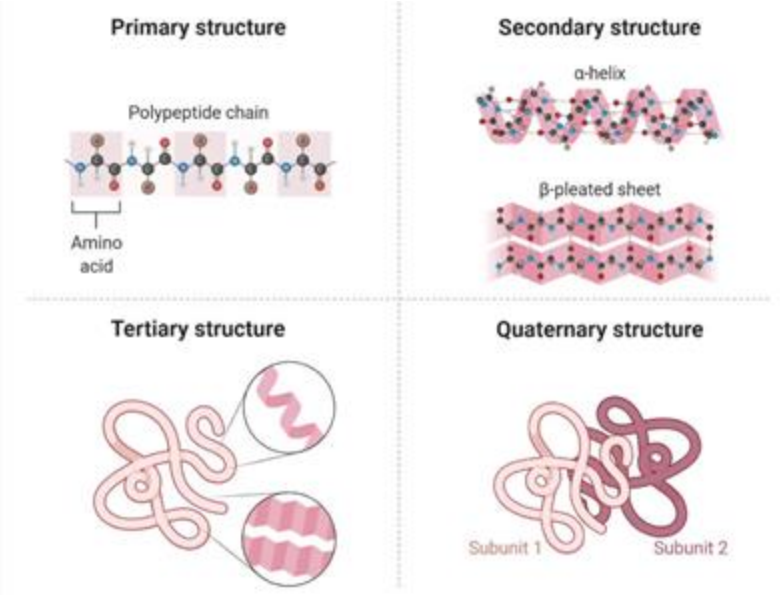
9- What are the different types of RNAs that play a role in protein synthesis, and what are their roles?

mRNA → Codes for proteins
tRNA → Central to protein synthesis as adaptors between mRNA and amino acids
rRNA → Forms basic structure of ribosome and catalyze protein synthesis

Exercise Questions - Lecture 2

10- What are the different levels of protein structure?

Primary structure → Chain of amino acids
Secondary structure → Non-covalent interactions between amino acids from both the polypeptide backbone and side chains provide folding, two main folding forms : α-helix and β-sheet
Tertiary structure → Arrangement of secondary structures into functional domains
Quaternary structure → Assembly of different polypeptide chains



Exercise Questions - Lecture 2

11- What are the functions of transcription factors?

Regulating gene expression by controlling transcription such as activating or repressing transcription of genes.

Exercise Questions - Lecture 2

12- Describe alternative splicing. Why is this process important?

Alternative splicing allows to generate different RNA molecules (and proteins) from the same gene. This process contributes to high complexity and diversity of transcriptomes.

Exercise Questions - Lecture 2

13- What is cell fate and differential gene expression? Explain briefly.

Cell fate describes what a group of cells will develop into. Differential gene expression refers to the differences between different cells due to different gene activity leading to synthesis of different proteins.