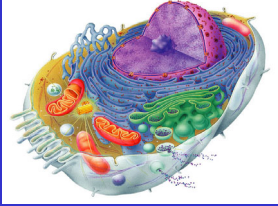


## NURSING

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### Science Lectures



**Prof Peter O'Donoghue**

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## LEARNING OBJECTIVES

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### Lecture 3: Overview of Cells (Cell Biology)

- understand functions of cell membranes and organelles
- relate DNA to proteins (transcription/translation)
- examine processes of cell division (mitosis/meiosis)

cellular basis of all life

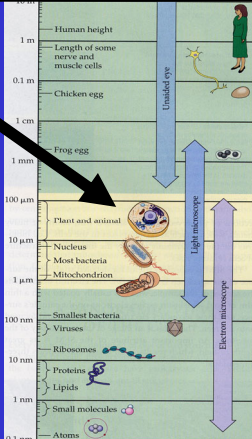
2

## CELLS

size:  
microscopic  
high surface-to-volume ratio

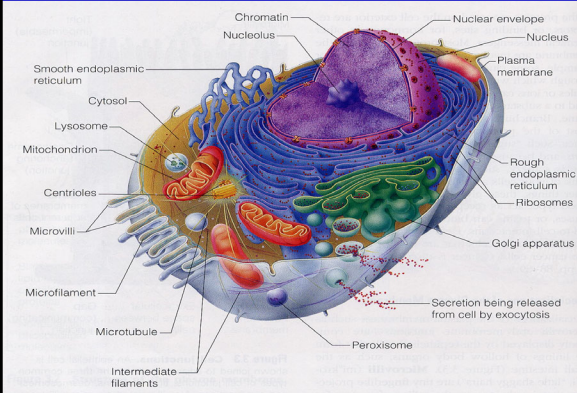
measurements (metric)

m = meter  
cm = centimeter =  $10^{-2}$ m  
mm = millimeter =  $10^{-3}$ m  
 $\mu$ m = micrometer =  $10^{-6}$ m  
nm = nanometer =  $10^{-9}$ m



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## Eukaryotic animal cell



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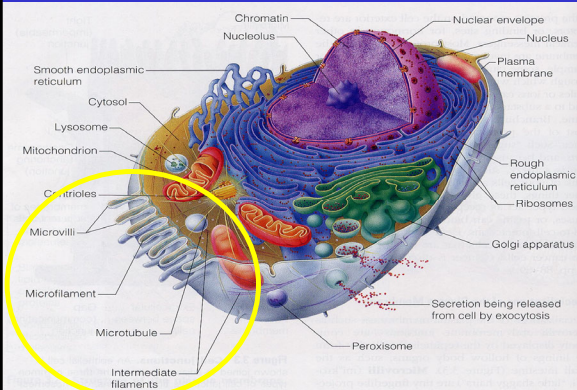
## Outside-in approach

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<p>cell membrane</p> <ul style="list-style-type: none"> <li>- phospholipid layer</li> <li>- cytoskeleton</li> </ul>	}	structural integrity
<p>organelles</p> <ul style="list-style-type: none"> <li>- mitochondria</li> <li>- endomembranes</li> </ul>	}	process energy
<p>nucleus</p> <ul style="list-style-type: none"> <li>- DNA</li> <li>- RNA</li> </ul>	}	process information

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## MEMBRANE



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### Membrane functions

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structural

- delimiting boundary
- semipermeable barrier
- intercellular joining
- attachment to cytoskeleton and ECM

biochemical

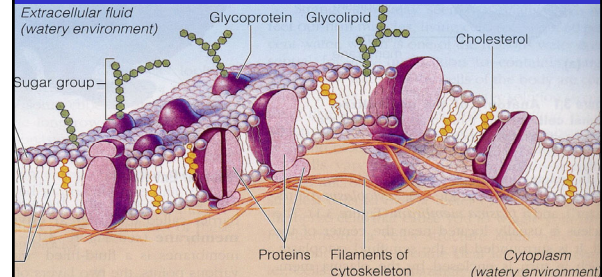
- receptors for signal transduction
- cell-cell recognition
- enzymatic activity
- molecular transport

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### Membrane structure

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- phospholipid bilayer – polar molecules
- embedded/attached proteins
- supporting filaments



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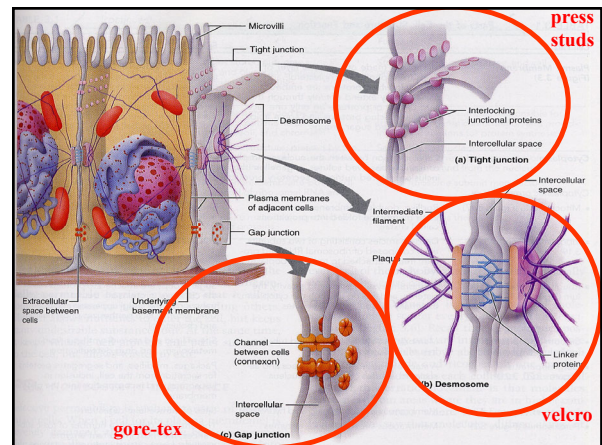
### Cell membrane connections

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Metazoa = multicellular animals  
→ mandates cell junctions (three types)

- tight junctions  
(complete seal, esp. between delimiting epithelia)
- desmosomes  
(cell adhesion linker molecules joining cells)
- gap junctions  
(small intercellular connecting channels)

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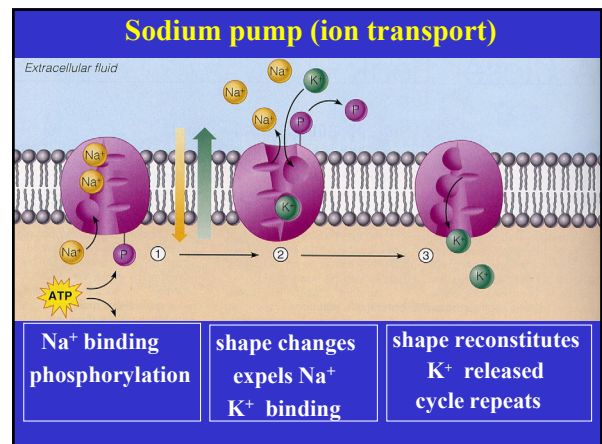
### Substances move across membrane by:

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- diffusion  
(random movement down concentration gradient)
- osmosis  
(diffusion across semi-permeable membrane)
- passive transport  
(facilitated diffusion through specific channels)
- active transport  
(energy-dependent movement against concentration gradient using carrier protein/transporter/pump)

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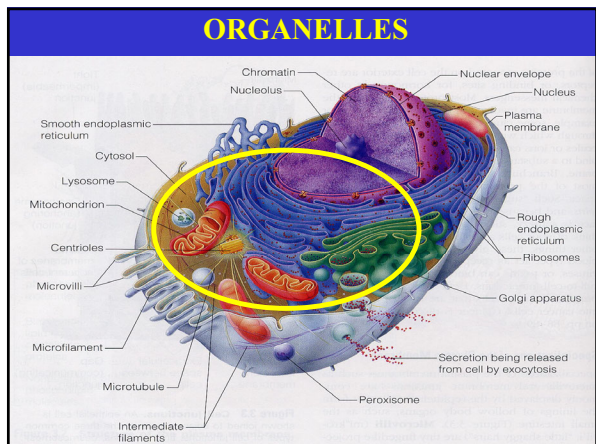
### Sodium pump (ion transport)



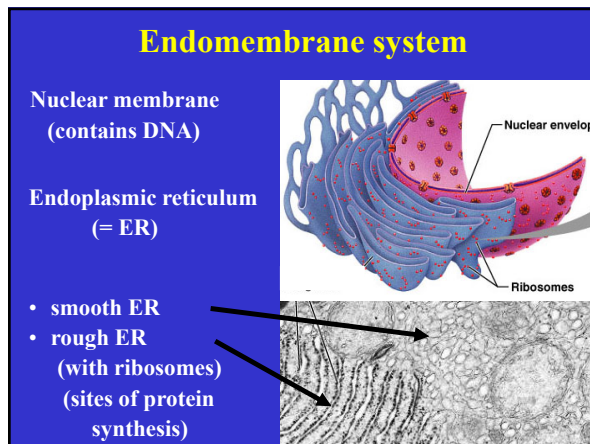
Na <sup>+</sup> binding phosphorylation	shape changes expels Na <sup>+</sup> K <sup>+</sup> binding	shape reconstitutes K <sup>+</sup> released cycle repeats
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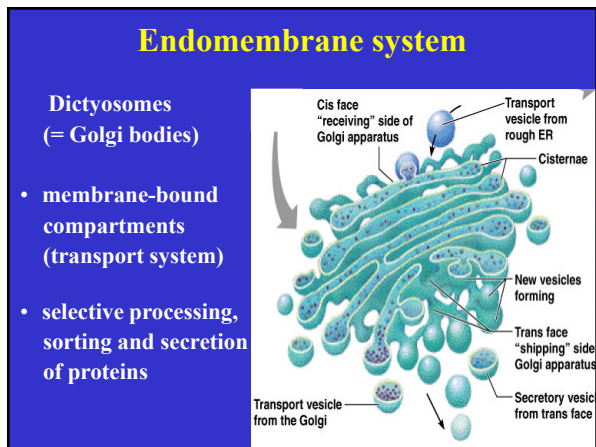




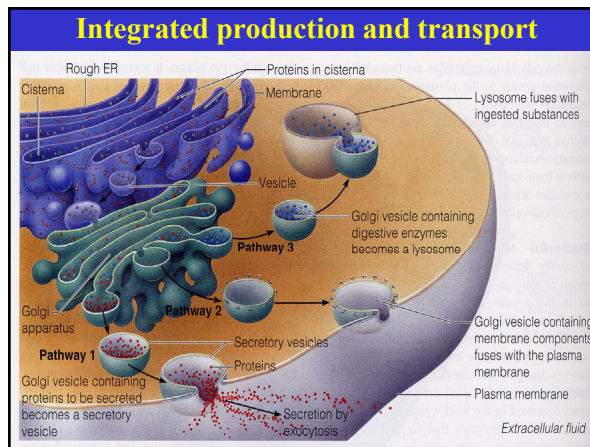
13



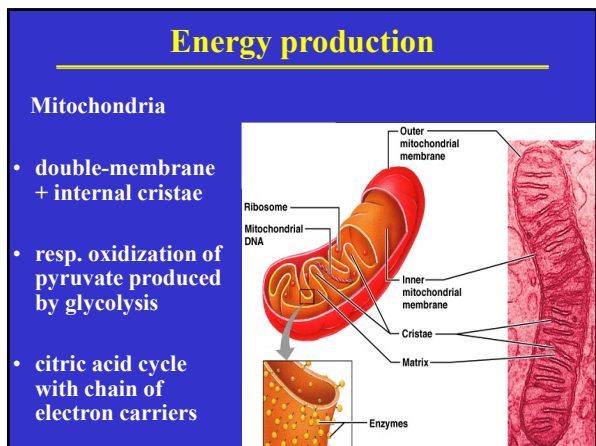
14



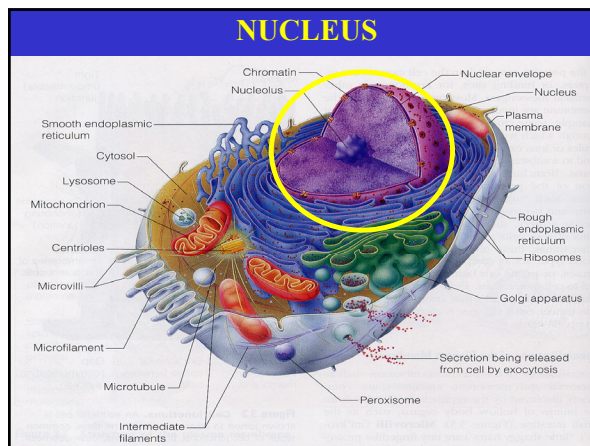
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### Cellular basis of life

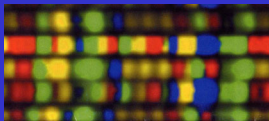
**Central dogma:**

- flow of genetic information is unidirectional

DNA  $\xrightarrow{\text{transcription}}$  RNA  $\xrightarrow{\text{translation}}$  Protein

↓ replication

DNA



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### What is DNA?

deoxyribonucleic acid

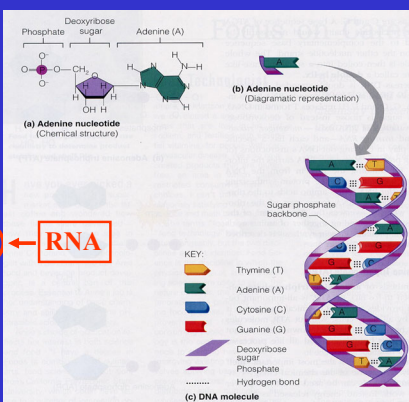
linear polymer of 4 nucleotides

- purines
  - adenine A
  - guanine G
- pyrimidines
  - cytosine C
  - thymine T (uracil U)

complementary bases

- G - C
- A - T

double helix



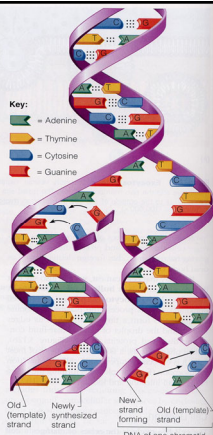
20

### DNA replication

double strand unfolds (unzip weak H bonds)

new strands assembled using single strands as templates for replication proteins & DNA polymerases

⇒ like mirror-image processing



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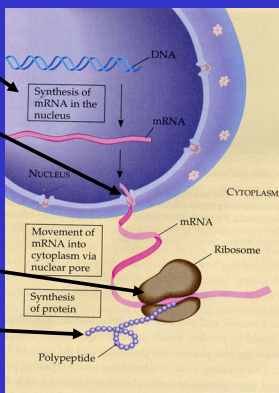
### Protein synthesis

mRNA synthesis in nucleus

movement to cytoplasm

ribosomes read RNA triplets encoding for specific amino acids (total of 20)

protein synthesis (initiation, elongation, termination)



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### Transcription & Translation

**DNA**

5' TTT GTT AAT CAG CAT CTT 3'

3' AAA CAAT TAG TCG TAG A 5'

**TRANSCRIPTION**

**RNA**

5' UUU GUU AAU CAG CAU CUU 3'

**TRANSLATION**

**Protein** H<sub>2</sub>N- Phe Val Asn Gln His Leu -COOH

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### 20 amino acids

Ala	alanine	SECOND BASE			
Arg	arginine	U	C	A	G
Asn	asparagine	UUU	UCU	UAU	UGU
Asp	aspartic acid	UUC	UCC	UAC	UGC
Cys	cysteine	UUA	UCA	UAA Stop	UGA Stop
Glu	glutamic acid	UUG	UCG	UAG Stop	UGG Trp
Gln	glutamine	CUU	CCU	CAU	CGU
Gly	glycine	CUC	CCC	CAC	CGC
His	histidine	CUA	CUA	Pro	CGA
Ile	isoleucine	CUG	CCG	CAG	CGG
Leu	leucine	AUU	ACU	AAU	AGU
Lys	lysine	AUC	ACC	AAC	AGC
Met	methionine	AUA	ACA	AAA	AGA
Phe	phenylalanine	AUG Met or Start	ACG	AAG	AGG
Pro	proline	GUU	GCU	GAU	GGU
Ser	serine	GUC	GCC	GAC	GGC
Thr	threonine	GUA	GCA	GAA	GGA
Trp	tryptophan	GUG	GCG	GAG	GGG
Tyr	tyrosine				
Val	valine				

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**DNA sequences**  
*make up*  
**genes**  
*make up*  
**chromatids**  
*make up*  
**chromosomes**  
*make up*  
**chromatin**  
*make up*  
**nuclei**

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**CELL DIVISION**

Two processes to generate new cells

- **Mitosis:** asexual multiplication
- **Meiosis:** sexual reproduction

Need to understand concept of ploidy

- **Diploid:** normal to have duplicated chromosomes (2n in humans = 46)
- **Haploid:** gametes only have one set (n = 23)

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**Cell cycle**

two phases

- interphase (growth)
- mitotic phase (division)

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**Asexual division = MITOSIS**

mitotic division occurring all the time

variable rate depending on cell longevity and turnover

- e.g. gut lining 7-14 days
- e.g. replace skin every 25-45 days

daughter cells inherit a copy of every chromosome

process essentially:  
 chromosomes duplicate then separate

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**MITOSIS**

four step process from interphase:

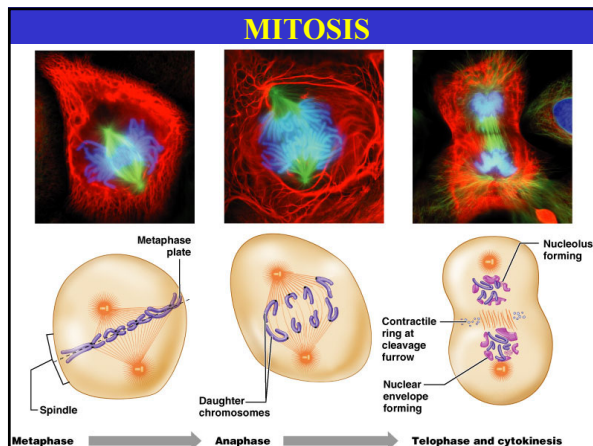
- prophase: DNA replication
- metaphase: chromosome alignment
- anaphase: chromatids separation
- telophase: cytokinesis, cell division

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**MITOSIS**

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### Sexual division = MEIOSIS

meiotic division only occurs in gonads

variable rate between male and female  
 e.g. oocyte production every 28 days  
 e.g. sperm production 64 days

daughter cells inherit one chromatid only  
 (haploid gametes)

process essentially:  
 chromosomes duplicate, divide in 2, divide in 2

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### MEIOSIS

two divisions involving four steps each:

- Meiosis I (unique reduction division)
  - prophase I: DNA replication + synapsis (tetrads)
  - metaphase I: tetrad alignment
  - anaphase I: dyad separation
  - telophase I: cytokinesis, cell division
- Meiosis II (like mitosis)
  - prophase II: but no DNA replication
  - metaphase II: chromosome alignment
  - anaphase II: chromatid separation
  - telophase II: cytokinesis, cell division (produces 4 haploid gametes)

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### Meiosis I

DNA replication, chromosomes duplicate  
 synapsis, form pairs (tetrads)  
 dyad separation (reduction division)  
 (daughters have haploid chromosome number  
 but diploid DNA)

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### Meiosis II

similar to mitosis  
 but no DNA replication  
 chromatid separation  
 four haploid daughters

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### Heredity

karyotype - diploid genome ( $2n = 46$ )  
 2 sex chromosomes (XX = F, XY = M)  
 44 autosomes

chromosomes paired, genes paired  
 inherit 2 copies of every gene (= alleles)

- homozygous (same alleles)
- heterozygous (different alleles)

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### Expression

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- dominant inheritance (widow peak, detached earlobes)
- recessive traits (albinism, cystic fibrosis)
- incomplete dominance (sickle cell anaemia)
- multiple allele inheritance (ABO blood groups)
- sex-linked inheritance (maleness)
- polygene inheritance (skin pigmentation)




carrier recognition

- pedigree tracing
- foetal testing (karyotyping via amniocentesis, chorionic villus sampling)

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### Karyotyping


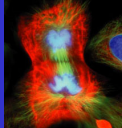
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mitotic cell	chromosome pairs matched by computer	resultant karyotype
		

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### SUMMARY

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cellular basis of life		
- membranes	provide structure	
- organelles	process energy	
- nuclei	process information	
cell division		
- mitosis	asexual, diploid daughters	
- meiosis	sexual, haploid gametes	
- heredity	genetic recombination	

**GO FORTH AND DIVIDE!**

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