

# Lecture Notes for INF281 Basics of Bioinformatics Sequence Analysis

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# Part I

## 1 Introduction

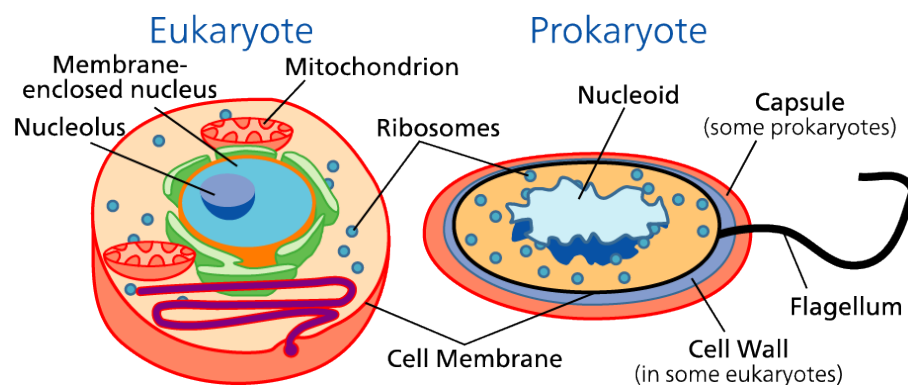
### 1.1 Introduction to Molecular Biology

Molecular biology is the study of biology focusing on organisms and cells at the molecular level.

#### Five essential facts about cells

##### 1. Two primary types of cells - eukaryotes and prokaryotes

- Eukaryote: animals & plants
- Prokaryote: bacteria & archaea



**Figure 1.1:** Eukaryotic and prokaryotic cells (source: Wikipedia)

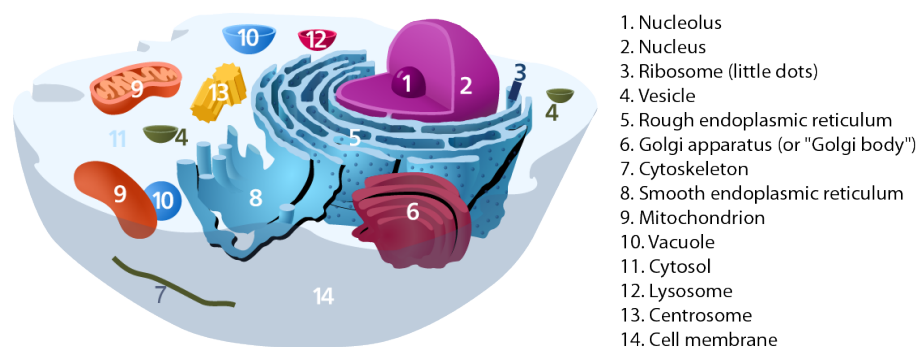
##### 2. Cell size - around 1 to 100 micrometers

- Cell Size and Scale: <http://learn.genetics.utah.edu/content/cells/scale>

##### 3. The number of cells

- Prokaryotes: 1 cell
- Human: Estimate of 15 trillion cells

##### 4. An animal cell and cell organelles



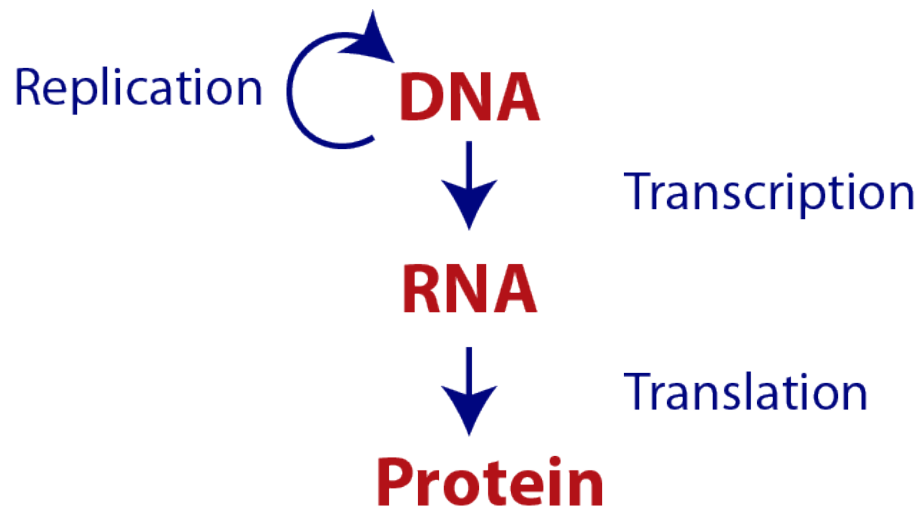
**Figure 1.2:** An animal cell and organelles (source: Kelvinsong, Wikipedia)

## 5. Cellular processes

- Cell growth, cell development, cell signaling,
- Example: <http://www.nature.com/nrg/multimedia/rnai>

### Central dogma of molecular biology

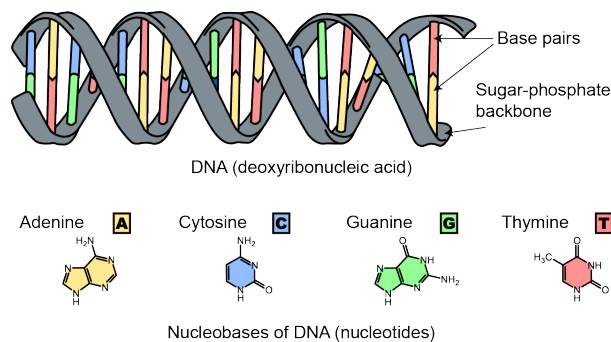
It describes the information flow within a cell.



**Figure 1.3:** Central dogma of molecular biology

### DNA (deoxyribonucleic acid)

DNA stores genetic information. It has four different bases: cytosine (C), guanine (G), adenine (A), and thymine (T).



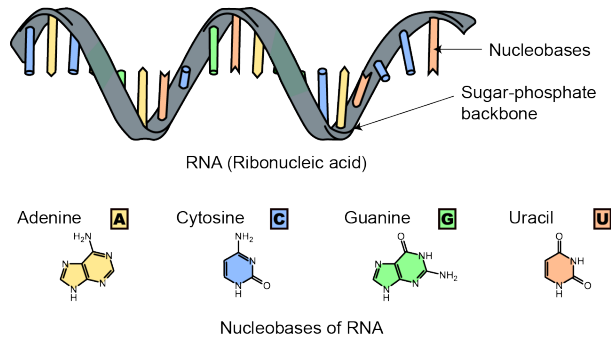
**Figure 1.4:** DNA double helix and base pairs (modified from the original version by Sponk, Wikimedia Commons)

**Base pair matching (Watson-Crick base pair)** Adenine (A) pairs with thymine (T), whereas cytosine (C) pairs with guanine (G).

```
DNA strand1: ACGT
              ||||
DNA strand2: TGCA
```

## RNA (Ribonucleic acid)

RNA has various biological roles and several sub-classes. Messenger RNAs (mRNAs) convey genetic information. It has four different bases: cytosine (C), guanine (G), adenine (A), and uracil (U).



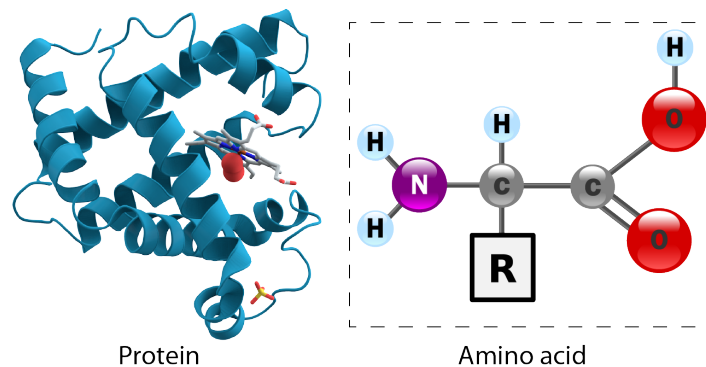
**Figure 1.5:** Single strand RNA (modified from the original version by Sponk, Wikimedia Commons)

## Transcription: mRNAs are transcribed from DNAs

DNA: ACGT -----> RNA: ACGU  
Transcription

## Protein

Proteins are large molecules consisting of amino acids. There are 20 common amino acids.



**Figure 1.6:** Protein 3D structure and amino acids (sources: AzaToth, Wikimedia Commons), YassineMrabet, Wikimedia Commons)

## Translation: Amino-acids are translated from mRNAs

mRNA: GUC -----> AA: Valine  
Translation

**Universal genetic code** A codon consists of three nucleic acids. Single-letter or three-letter names can be used for amino acids.

Gentic code				Amino acids			
				<div>Basic</div>	<div>Acidic</div>	<div>Polar</div>	<div>Nonpolar (hydrophobic)</div>
2nd base							
		U	C	A	G		
1st base	U	UUU (Phe/F) Phenylalanine	UCU (Ser/S) Serine	UAU (Tyr/Y) Tyrosine	UGU (Cys/C) Cysteine		
		UUC (Phe/F) Phenylalanine	UCC (Ser/S) Serine	UAC (Tyr/Y) Tyrosine	UGC (Cys/C) Cysteine		
		UUA (Leu/L) Leucine	UCA (Ser/S) Serine	UAA Ochre (Stop)	UGA Opal (Stop)		
		UUG (Leu/L) Leucine	UCG (Ser/S) Serine	UAG Amber (Stop)	UGG (Trp/W) Tryptophan		
	C	CUU (Leu/L) Leucine	CCU (Pro/P) Proline	CAU (His/H) Histidine	CGU (Arg/R) Arginine		
		CUC (Leu/L) Leucine	CCC (Pro/P) Proline	CAC (His/H) Histidine	CGC (Arg/R) Arginine		
		CUA (Leu/L) Leucine	CCA (Pro/P) Proline	CAA (Gln/Q) Glutamine	CGA (Arg/R) Arginine		
		CUG (Leu/L) Leucine	CCG (Pro/P) Proline	CAG (Gln/Q) Glutamine	CGG (Arg/R) Arginine		
	A	AUU (Ile/I) Isoleucine	ACU (Thr/T) Threonine	AAU (Asn/N) Asparagine	AGU (Ser/S) Serine		
		AUC (Ile/I) Isoleucine	ACC (Thr/T) Threonine	AAC (Asn/N) Asparagine	AGC (Ser/S) Serine		
		AUA (Ile/I) Isoleucine	ACA (Thr/T) Threonine	AAA (Lys/K) Lysine	AGA (Arg/R) Arginine		
		AUG (Met/M) Methionine	ACG (Thr/T) Threonine	AAG (Lys/K) Lysine	AGG (Arg/R) Arginine		
	G	GUU (Val/V) Valine	GCU (Ala/A) Alanine	GAU (Asp/D) Aspartic acid	GGU (Gly/G) Glycine		
		GUC (Val/V) Valine	GCC (Ala/A) Alanine	GAC (Asp/D) Aspartic acid	GGC (Gly/G) Glycine		
		GUA (Val/V) Valine	GCA (Ala/A) Alanine	GAA (Glu/E) Glutamic acid	GGA (Gly/G) Glycine		
		GUG (Val/V) Valine	GCG (Ala/A) Alanine	GAG (Glu/E) Glutamic acid	GGG (Gly/G) Glycine		

**Figure 1.7:** Universal genetic code (modified from the original version by Häggström, Wikimedia Commons)

## Cellular functions of proteins

- Enzymes: catalyze chemical reaction
- Cell signaling: hormone (e.g. insulin), antibodies,
- Structural: collagen, cartilage, keratin,

## Exercises 1.1

1. Draw a simple diagram of the central dogma of molecular biology and briefly explain the information flow of the molecules.
2. What are the DNA sequences of the opposite strand for the following DNA sequences?

Seq1 CCGATT  
Seq2 TTACGC  
Seq3 ACGCGC

3. What are the mRNA sequences transcribed from the following DNA sequences?
4. What are the polypeptide sequences translated from the following mRNA sequences? Answer them with both one-letter and three letter names.

Seq1 AUGUUUUAA  
Seq2 GCAGCAAAA