

Take notes while watching the following video tutorials to prepare for the "Nucleic Acids Activity".

# Nucleic Acids Part 1: Introduction and Nucleotides (The Basic Building Blocks)

DNA:

RNA:

Function of  
DNA

RNA

Supporting Cast:  
Ribosomes

Red Blood Cells

RBCs are produced from stem cells in the bone marrow. When RBCs mature, they discard their DNA to make room for more hemoglobin. Thus, they have no nucleus, no DNA, and do not divide. They produce energy through glycolysis, so RBCs do not have mitochondria.

What is glycolysis?

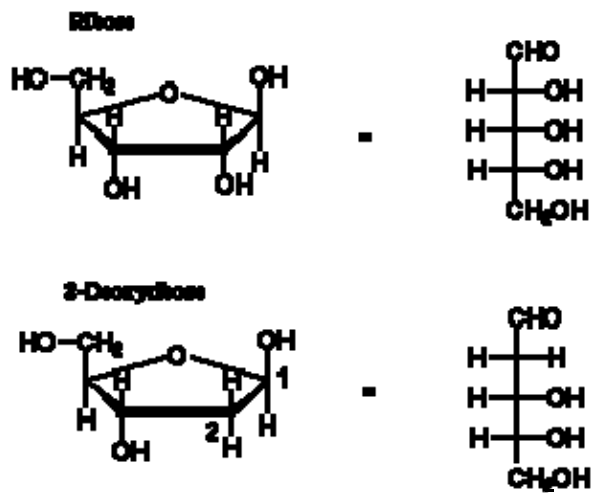
What important biochemical reactions occur in mitochondria?

# Nucleotides

Nucleoside:

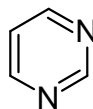
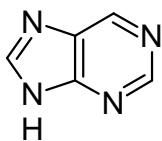
Nucleotide:

## The Monosaccharide Component

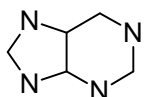
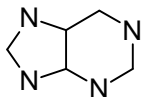


# The Nitrogen Base

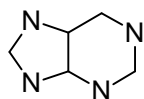
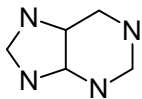
## Derivatives of purine and pyrimidine



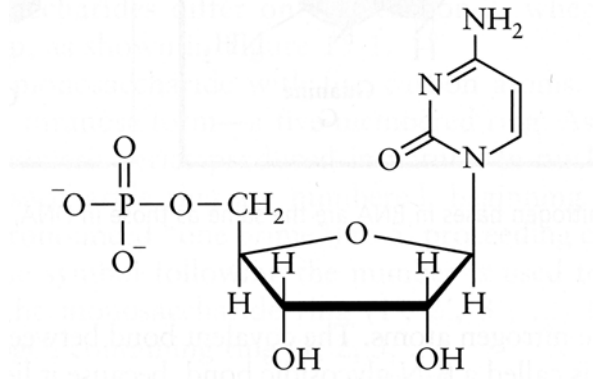
## DNA Bases



## RNA Bases



## The Phosphate Group



Point an arrow to the bond that links the ribose to the phosphate group.

What type of bond links the phosphate group to the sugar?

Other important nucleotides

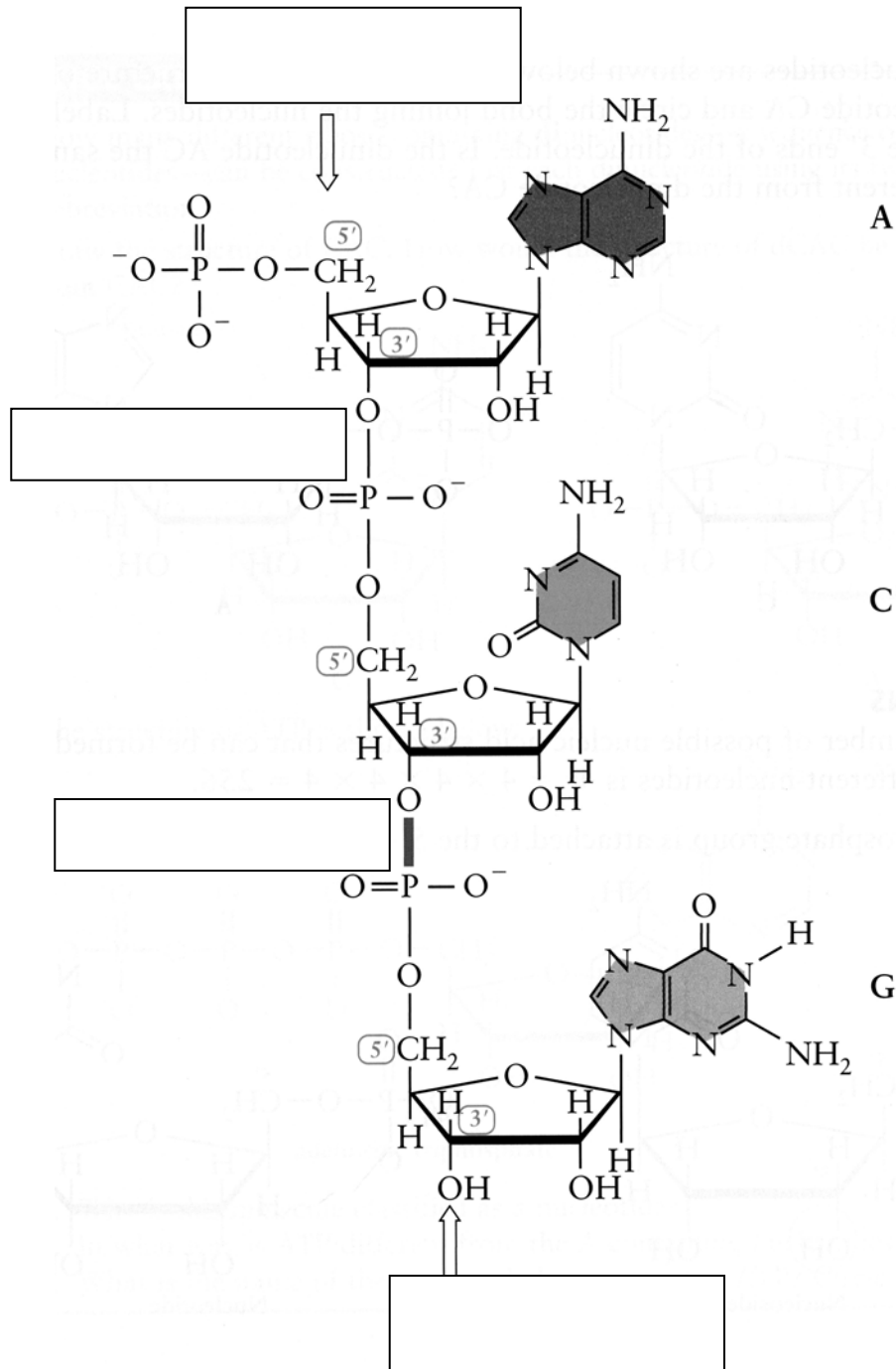
Construct AMP from its 3 basic parts: phosphate, adenine, & deoxyribose.

## Nucleic Acids Part 2: DNA

### Nucleic Acids

Nucleotides are joined when the phosphate of one nucleotide joins with the 3' alcohol the other nucleotide to form a phosphate ester bond.

Example – the trinucleotide ACG



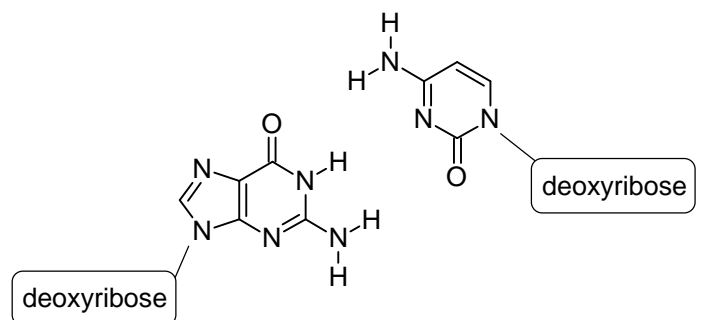
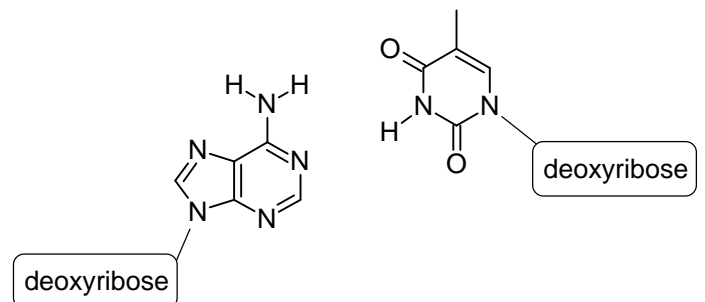
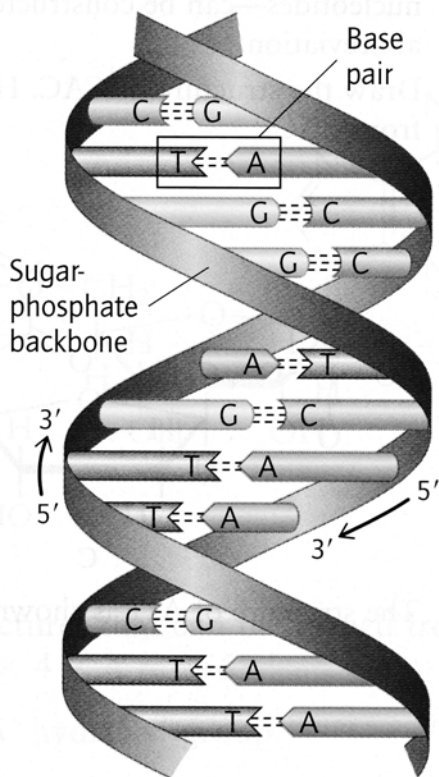
The number of nucleic acids that can be formed from 4 different nucleotides is  $4^n$ . For example, only 3 nucleotides creates  $4^3 = 64$  different possible nucleic acids. DNA is composed of millions of nucleotides creating astronomical possibilities.

## DNA

DNA consists of two nucleic acid molecules twisted around each other to form a double helix.

Hydrophilic Backbone:

Hydrophobic Base Pairs:



## Chromosomes: Higher Order DNA Structure

DNA is packaged into chromosomes found in the nucleus of cells

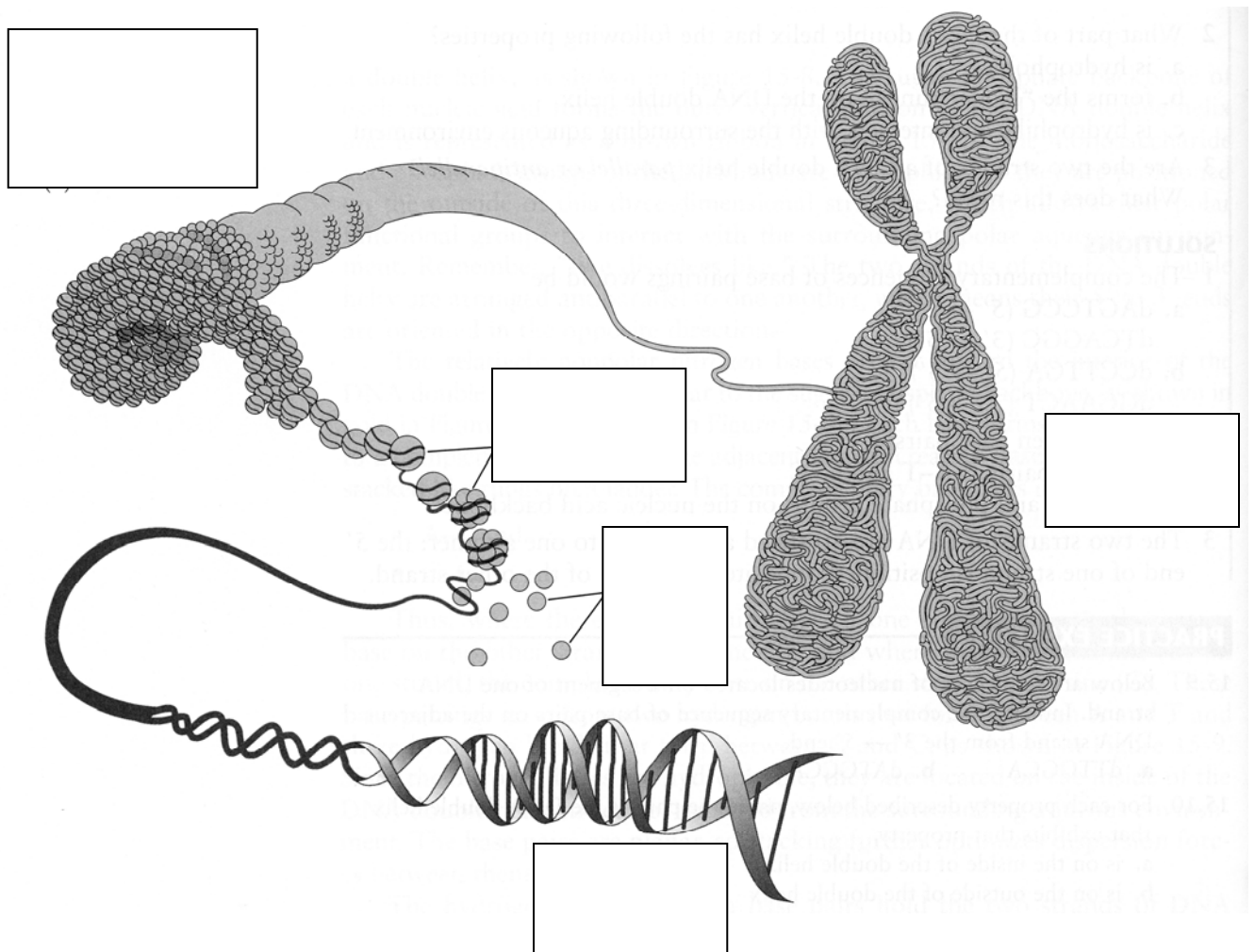
Chromosomes: highly compact structures containing DNA & proteins

Histones: proteins found in DNA

Nucleosomes: DNA wrapped around histones

Chromatin fiber: nucleosomes coiled upon themselves

Label the diagram below





# Genes and the Human Genome

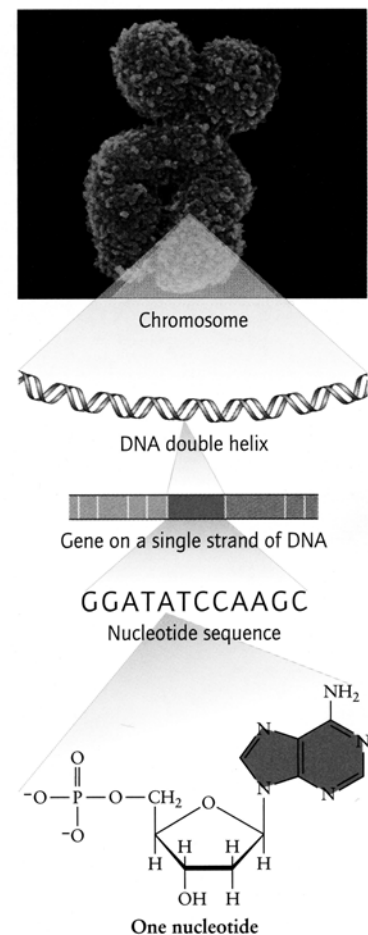
Genome: the complete sequence of bases in DNA distributed over 46 chromosomes

Gene: a segment of DNA that contains the instructions for making a protein

## Chromosome 6

Iridogoniodysgenesis	Multiple myeloma oncogene
Anterior segment mesenchymal dysgenesis	Orofacial cleft
Rieger anomaly	Leukemia, acute nonlymphocytic
Axenfeld anomaly	Fanconi anemia, complementation group E
Coagulation factor XIII	Ankylosing spondylitis
Keratitis palmoplantaris striata	Stickler syndrome, type II
Spinocerebellar ataxia	OSMED syndrome
Schizophrenia susceptibility locus	Weissenbacher-Zweymuller syndrome
Maple syrup urine disease, type Ib	Deafness, nonsyndromic sensorineural
Bare lymphocyte syndrome, type I	Dyslexia
Atrial septal defect, secundum type	Hemochromatosis
Adrenal hyperplasia, congenital	Porphyria variegata
Renal glucosuria	Pemphigoid, susceptibility to
Beryllium disease, chronic, susceptibility to	Immune suppression to streptococcal antigen
Leukemia, pre-B-cell transcription factor	Sialidosis, types I and II
Tumor necrosis factor (cachectin)	Panbronchiolitis, diffuse
Malaria, cerebral, susceptibility to	Psoriasis susceptibility
Retinitis pigmentosa	Ehlers-Danlos-like syndrome
Platelet-activating factor	Cone dystrophy
Asthma and atopy, susceptibility to	Polycystic kidney and hepatic disease, autosomal recessive
Peroxisomal biogenesis disorder	Retinal degeneration, slow (peripherin)
Anemia, hemolytic, Rh-null, suppressor type	Ritinitis pigmentosa, peripherin-related and punctata albens
Methylmalonicaciduria, mutase deficiency type	Macular dystrophy
Hemolytic anemia	Butterfly dystrophy, retinal
Char syndrome	Cleidocranial dysplasia
Gluten-sensitive enteropathy (celiac disease)	Dental anomalies, isolated
Cone-rod dystrophy	Nystagmus, autosomal dominant
Inflammatory bowel disease	Bullous pemphigoid antigen 1
Mixed polyposis syndrome, hereditary	Pelviureteric junction obstruction
Leber congenital amaurosis, type V	Stargardt disease, autosomal dominant
Serotonin receptors	Epilepsy, juvenile myoclonic
Macular dystrophy, retinal, North Carolina type	Brain-specific angiogenesis inhibitor
Obesity, severe	Diazepam-binding inhibitor
Diabetes mellitus, insulin-dependent	Schizophrenia susceptibility locus
Muscular dystrophy, congenital merosin-deficient	Salla disease
Arthropathy, progressive pseudorheumatoid, of childhood	Sialic acid storage disorder, infantile
Rhizomelic chondrodysplasia punctata, type 1	Chorioretinal atrophy, progressive bifocal
Deafness	Melanoma, absent in
Cardiomyopathy, dilated, autosomal dominant	Metaphyseal chondrodysplasia, Schmid type
Human immunodeficiency virus type I susceptibility	Spondylometaphyseal dysplasia, Japanese type
Epilepsy, myoclonic, Lafora type	Hepatic fibrosis susceptibility
Opioid receptor	Oculodentodigital dysplasia (Syndactyly type III)
Estrogen receptor	Hereditary persistence of fetal hemoglobin, heterocellular
Breast cancer	Argininemia
Estrogen resistance	Leukemia
Insulin-like growth factor-2 receptor	Immune interferon, receptor for
Hepatocellular carcinoma	Mycobacterial infection, atypical, familial disseminated
Tumorigenicity, suppression of	BCG infection, generalized familial
Loss of heterozygosity, ovarian	Tuberculosis, susceptibility to
Ovarian cancer, serous	Diabetes mellitus, transient neonatal
Myeloid/lymphoid or mixed-lineage leukemia	Pleomorphic adenoma (ZAC tumor suppressor)
Pancreatic beta cell, agenesis of	Parkinson disease, juvenile, type 2
uniparental disomy	Plasminogen Tochigi disease
Conjunctivitis, ligneous	Thrombophilia, dysplasminogenemic
Coronary artery disease, susceptibility to	Plasminogen deficiency, types I and II
Complex neurologic disorder	
Xeroderma pigmentosum, variant type	

## Chromosome Structure

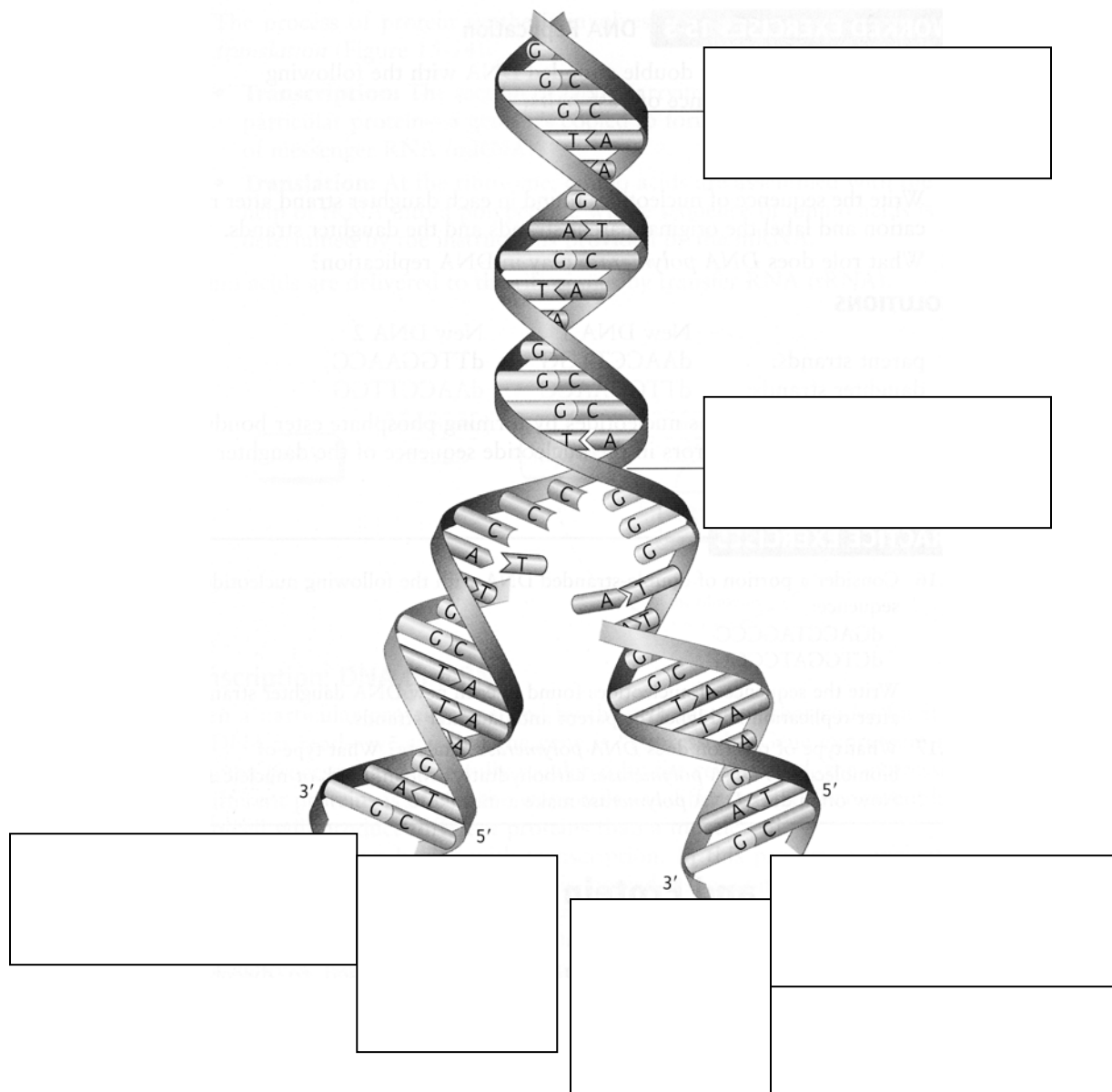


## DNA Replication

Every person starts life as a fertilized egg (zygote) which contains the entire human genome. This single cell grows and divides to become a human being with one trillion cells – each with same genome as the zygote from which it originated.

DNA replication is an anabolic biochemical process.

- 1) Unravel super-coiled DNA to expose double helix
- 2) Each of the two strands is copied



## Nucleic Acids Part 3: RNA and Protein Synthesis

The genes in DNA hold the instructions for how to synthesize proteins.

The actual synthesis of the proteins requires RNA and ribosomes.

RNA – 3 Major Forms for 3 different jobs

rRNA

mRNA

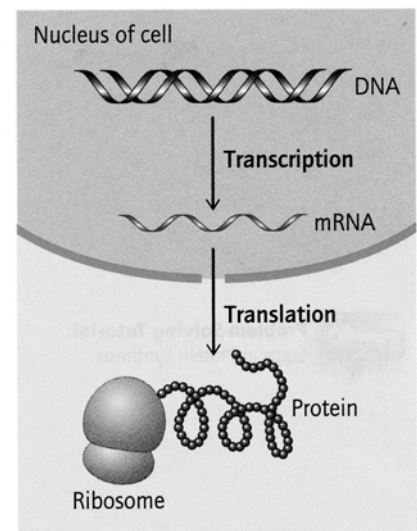
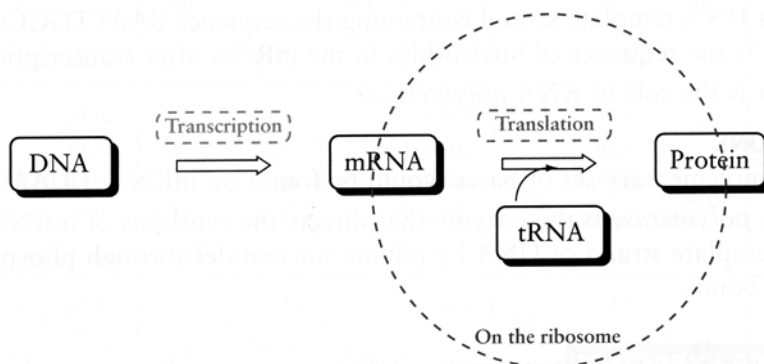
tRNA

RNA is a single-stranded nucleic acid.

Ribosomes are the protein-making factories of the cell.

Transcription: Instructions from a section of DNA are copied to mRNA

Translation: tRNA delivers amino acids to the ribosome for protein synthesis



## Transcription & mRNA

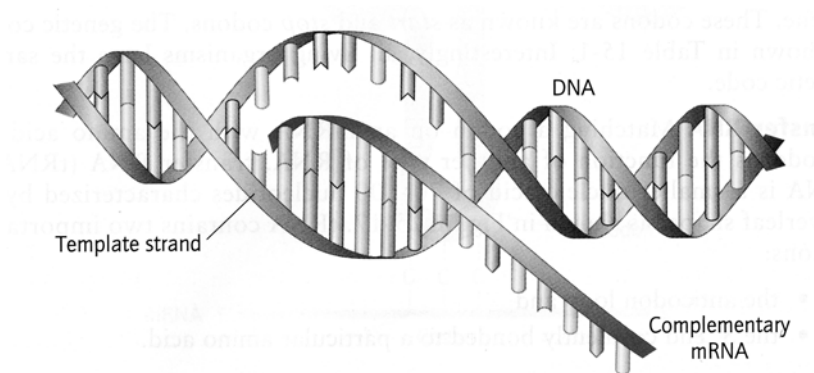
A segment of DNA unravels to expose the nucleotide sequence on the template strand of DNA so that RNA polymerase can build a complimentary nucleotide sequence of mRNA.

DNA returns to its double helix structure and mRNA is exported out of the nucleus and to the ribosomes in the cytoplasm.

Gene expression: a gene's DNA is used as a template for synthesis of a specific protein

Gene expression begins with transcription.

- 1) DNA must be unraveled to expose the nucleotide sequence.
- 2) Copying begins at nucleotides called "start codons".
- 3) DNA refolds and mRNA is exported out of the nucleus and into the cytoplasm where the ribosomes are located

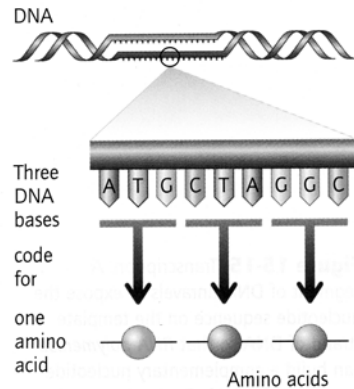


What is the complimentary mRNA sequence for a DNA sequence of GATCAT?

## Translation: mRNA, tRNA & Protein Synthesis

Ribosomes are the cellular structures where the nucleotide sequence of the mRNA is read and a polypeptide is built by linking amino acids.

**Codon:** every group of three nucleotides on an mRNA molecule is known as a codon because it codes for one of the 20 amino acids.



Since there are 64 possible codons and only 20 amino acids, each amino acid has more than one codon.

**Genetic Code:** the key for the codons and their amino acids

		Second letter				
		U	C	A	G	
First letter	U	UUU } Phe UUC } UUA } Leu UUG }	UCU } UCC } Ser UCA } UCG }	UAU } Tyr UAC } UAA Stop UAG Stop	UGU } Cys UGC } UGA Stop UGG Trp	U C A G
	C	CUU } CUC } Leu CUA } CUG }	CCU } CCC } Pro CCA } CCG }	CAU } His CAC } CAA } Gln CAG }	CGU } CGC } Arg CGA } CGG }	U C A G
	A	AUU } AUC } Ile AUA } AUG Met/ Start	ACU } ACC } Thr ACA } ACG }	AAU } Asn AAC } AAA } Lys AAG }	AGU } Ser AGC } AGA } Arg AGG }	U C A G
	G	GUU } GUC } Val GUA } GUG }	GCU } GCC } Ala GCA } GCG }	GAU } Asp GAC } GAA } Glu GAG }	GGU } GGC } Gly GGA } GGG }	U C A G

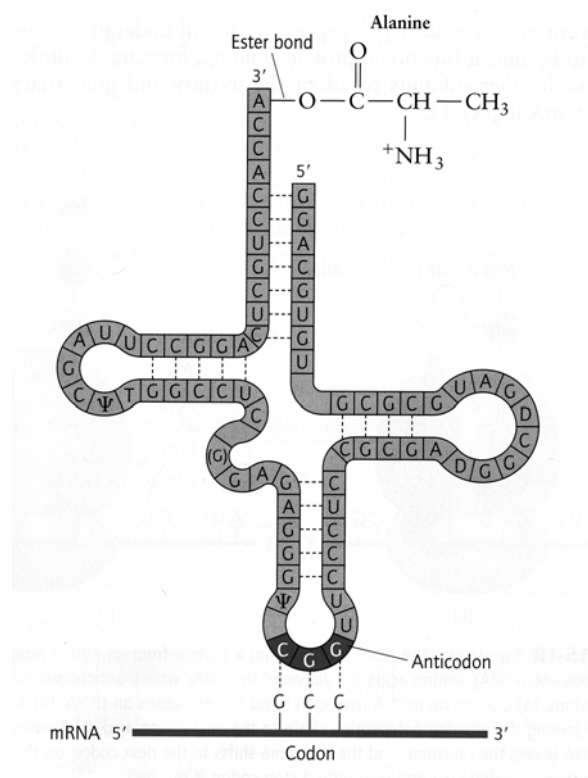
tRNA – a closer look

tRNA matches the codon on an mRNA with the corresponding amino acid

the cloverleaf shaped tRNA has two important regions

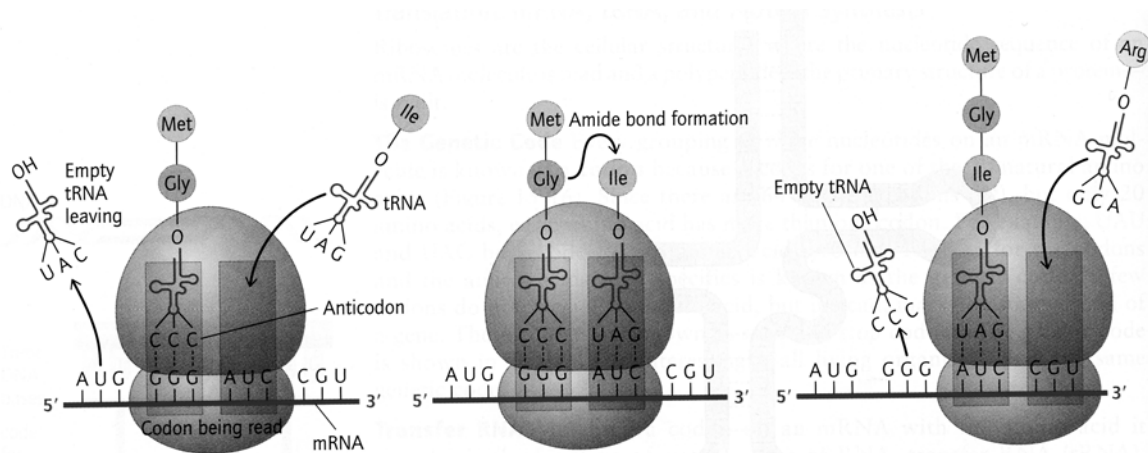
1) anticodon loop

2) 3' end covalently bonded to the amino acid corresponding to the anticodon

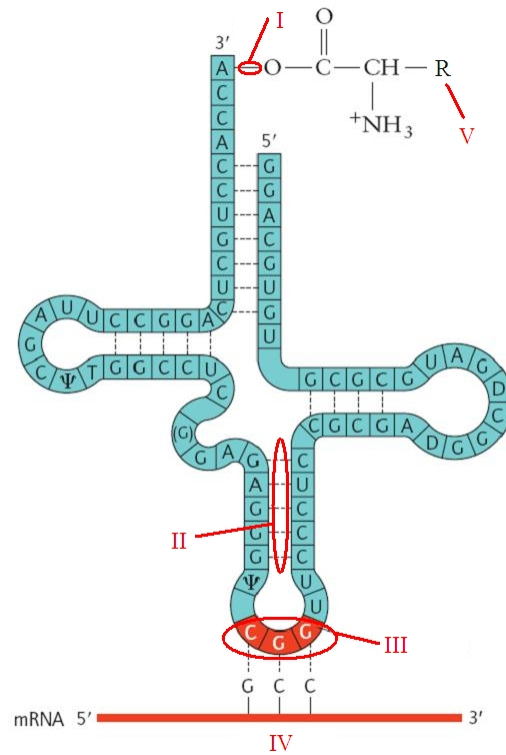


## Translation – Building a Protein

- 1) At the ribosome, an mRNA codon is read and a matching tRNA molecule arrives with the corresponding amino acid.
- 2) Base pairs H-bond temporarily between the anticodon on tRNA and the codon on mRNA.
- 3) The next tRNA arrives with its amino acid. The tRNA base pairs H-bond with the adjacent codon so that an amide bond can form between the two adjacent amino acids on the two adjacent tRNA molecules.
- 4) As the first tRNA is released the next codon on the mRNA is read and another tRNA molecule is recruited.
- 5) The process continues until a 'stop codon' is reached.
- 6) A polypeptide must undergo additional modifications to create the 2°, 3°, and possibly 4° structure to become a protein.



Use the genetic code table to identify the amino acid attached to this tRNA.



		Second letter				
		U	C	A	G	
First letter	U	UUU } Phe UUC } UUA } Leu UUG }	UCU } Ser UCC } UCA } UCG }	UAU } Tyr UAC } UAA Stop UAG Stop	UGU } Cys UGC } UGA Stop UGG Trp	U C A G
	C	CUU } Leu CUC } CUA } CUC }	CCU } Pro CCC } CCA } CCG }	CAU } His CAC } CAA } Gln CAG }	CGU } Arg CGC } CGA } CGG }	U C A G
	A	AUU } Ile AUC } AUA } AUG Met/ Start	ACU } Thr ACC } ACA } ACG }	AAU } Asn AAC } AAA } Lys AAG }	AGU } Ser AGC } AGA } Arg AGG }	U C A G
	G	GUU } Val GUC } GUA } GUG }	GCU } Ala GCC } GCA } GCG }	GAU } Asp GAC } GAA } Glu GAG }	GGU } Gly GGC } GGA } GGG }	U C A G



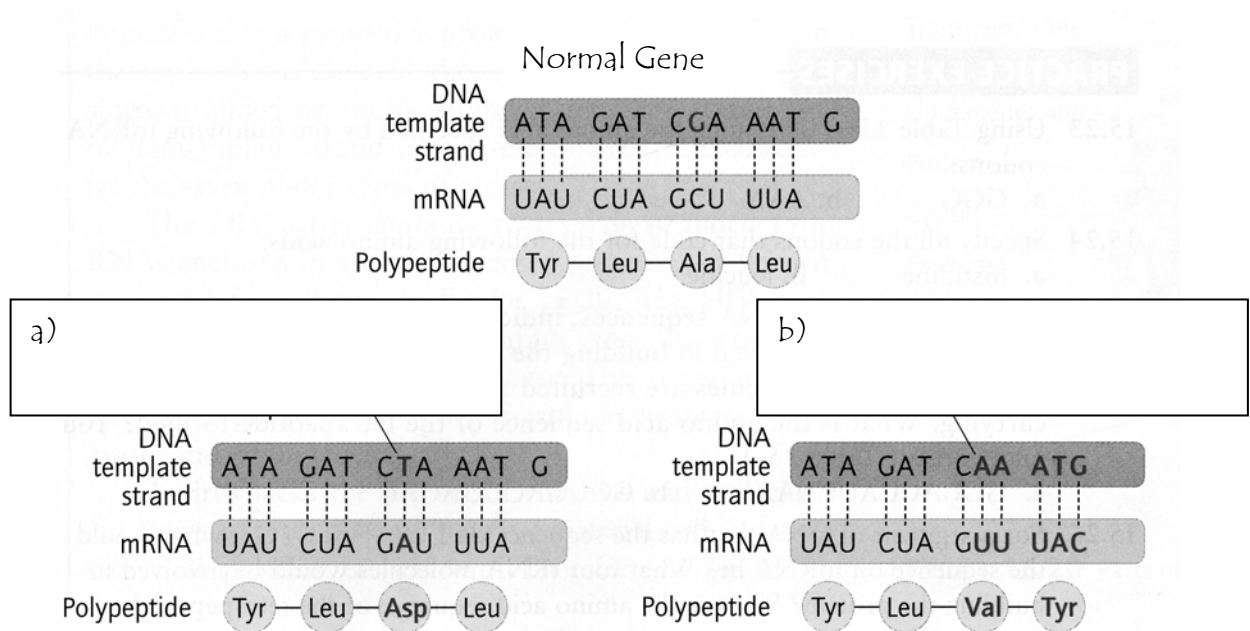
## Nucleic Acids Part 4: Genetic Mutations

Any permanent chemical change at one or more nucleotides in the DNA sequence that affects the primary structure of a protein

Substitution: a mutation caused by the substitution of a nucleotide

Frameshift: a mutation caused by the deletion of a nucleotide

Compare the altered genetic codes to the Normal Gene below and classify them as Substitution or Frame Shift.



Effects of DNA mutations are minimized by the fact that there is more than one codon for most amino acids.

DNA mutations can create defective enzymes.  
Some we can live with.

Some we can not.

Mutations are caused by a variety of factors: genetics, certain chemicals, high energy light (UV, X rays & gamma rays)

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