



JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

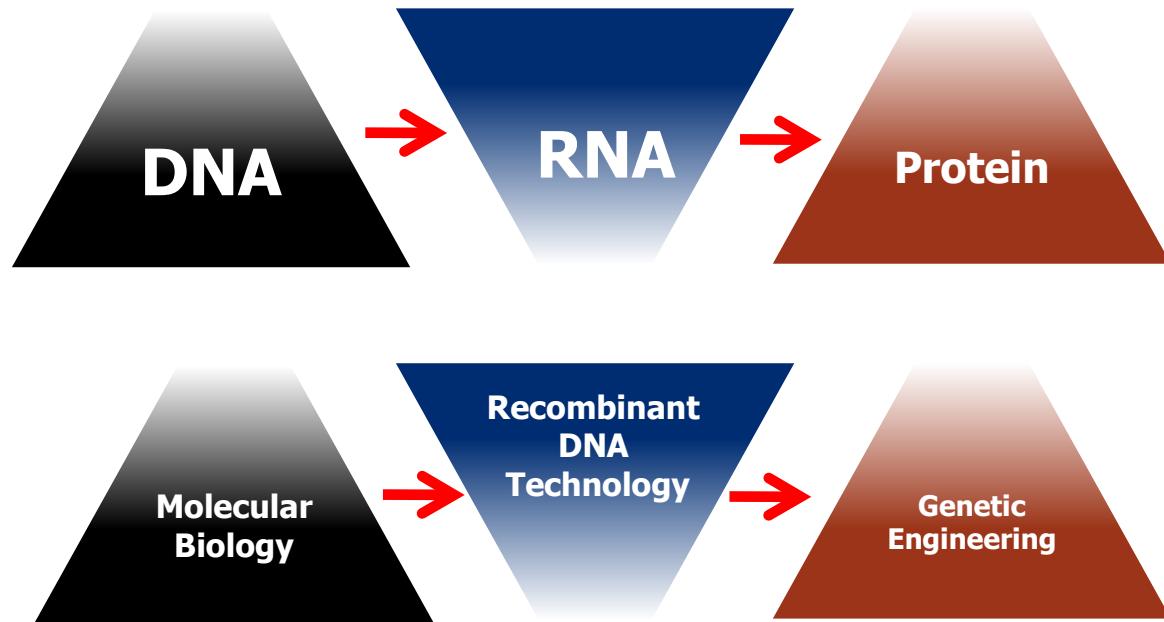
Cell and Tissue Engineering

Quantum Information Processing and Genetic Engineering, Part 1

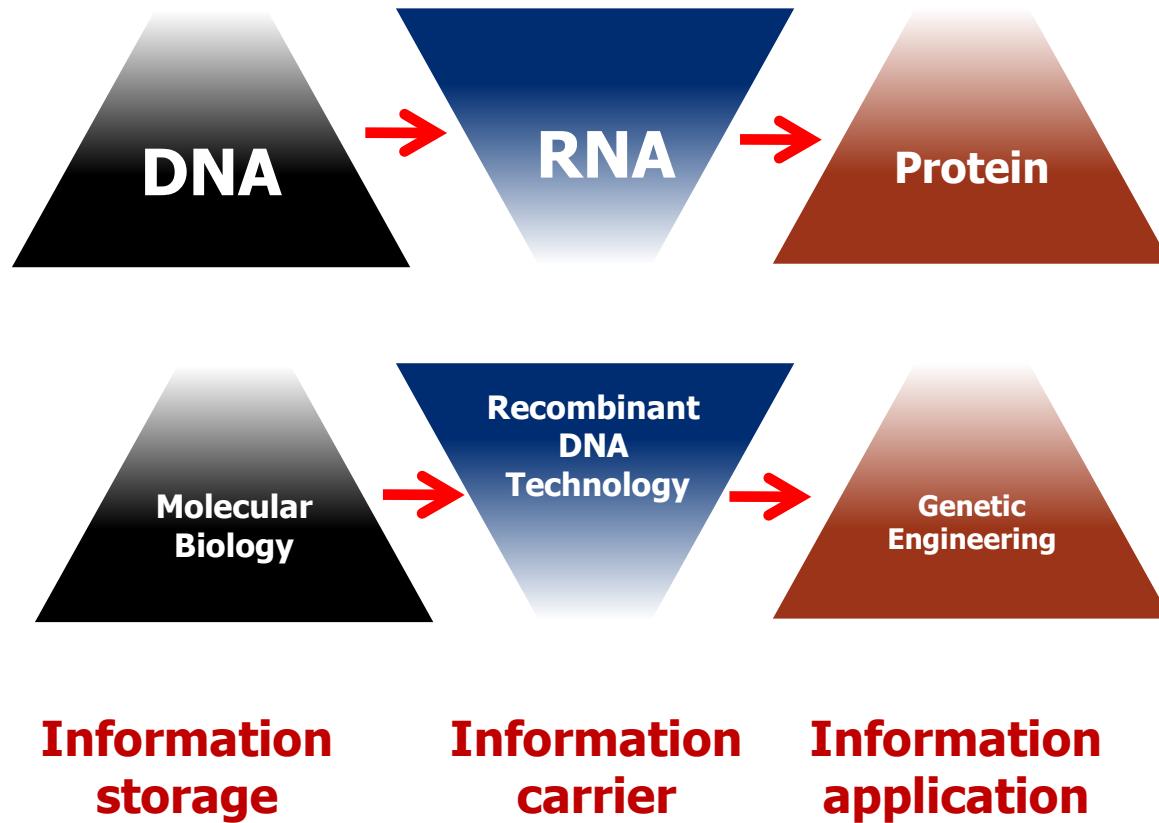
Central dogma of Molecular Biology



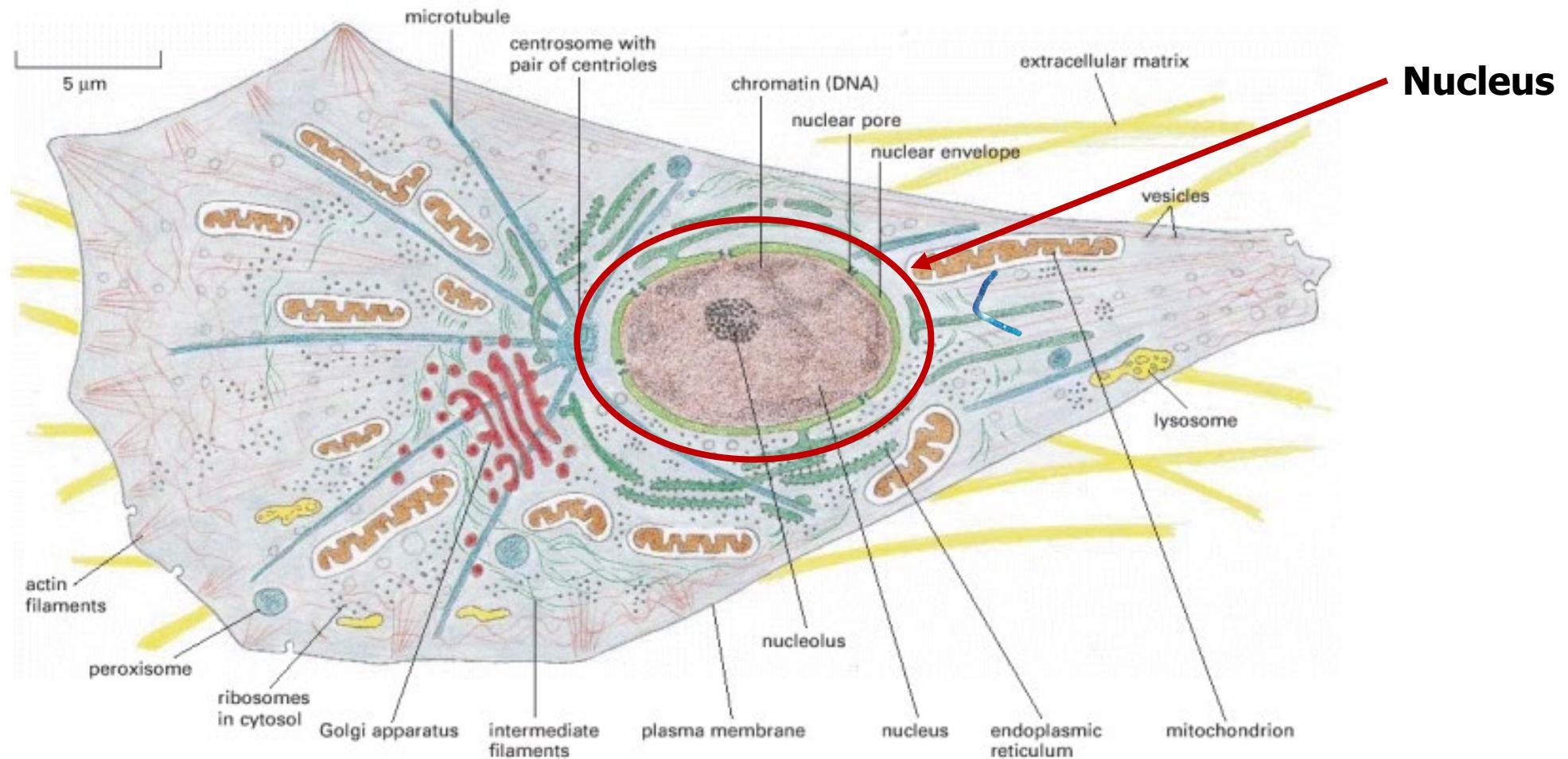
Central dogma of Molecular Biology



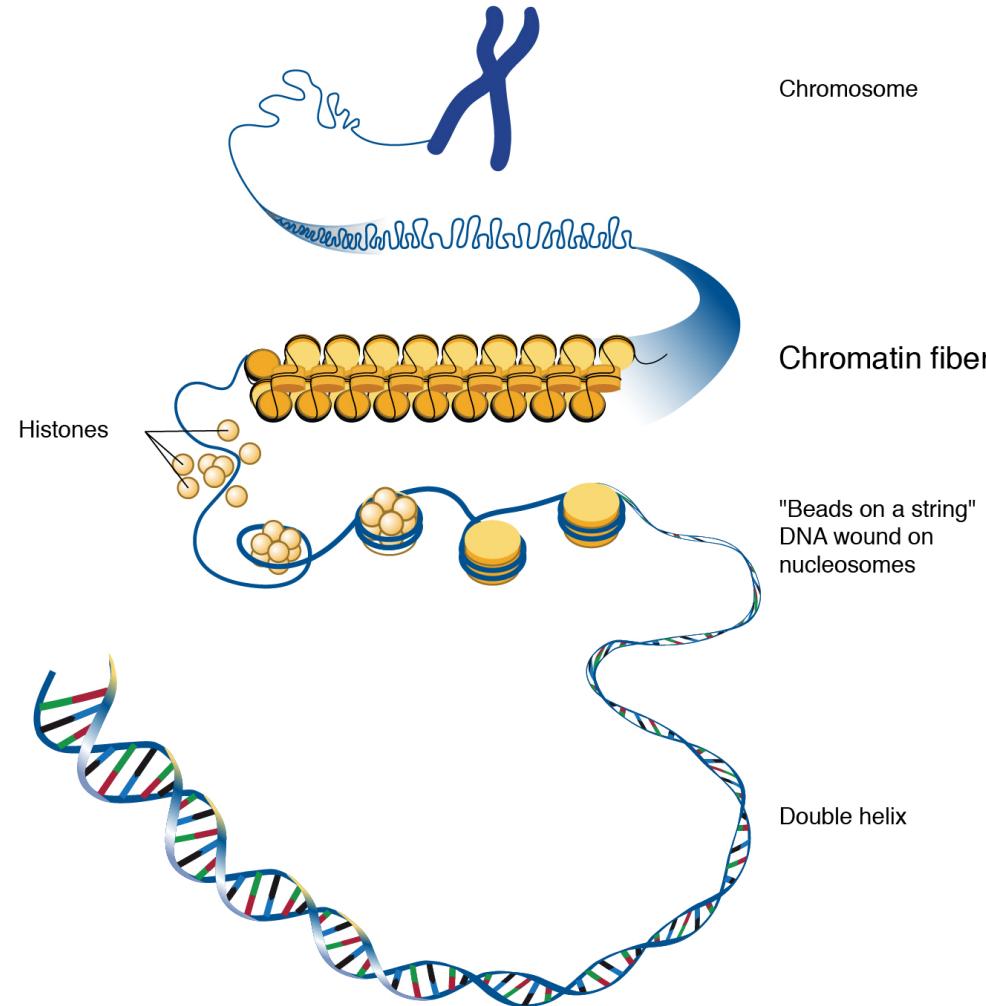
Central dogma of Molecular Biology



DNA level - the Eukaryotic cell

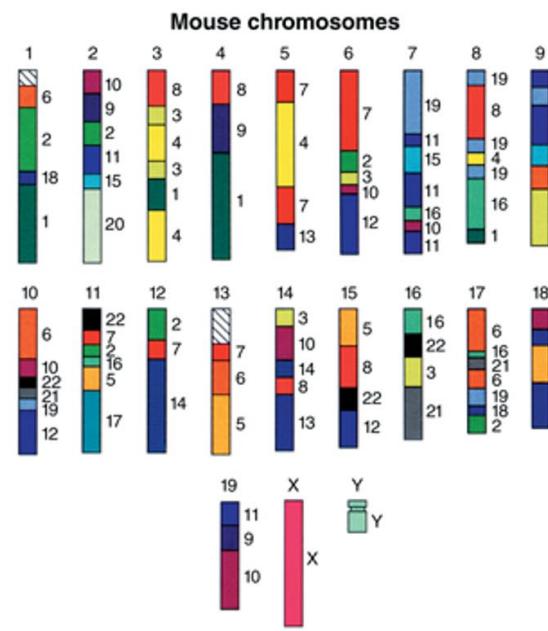
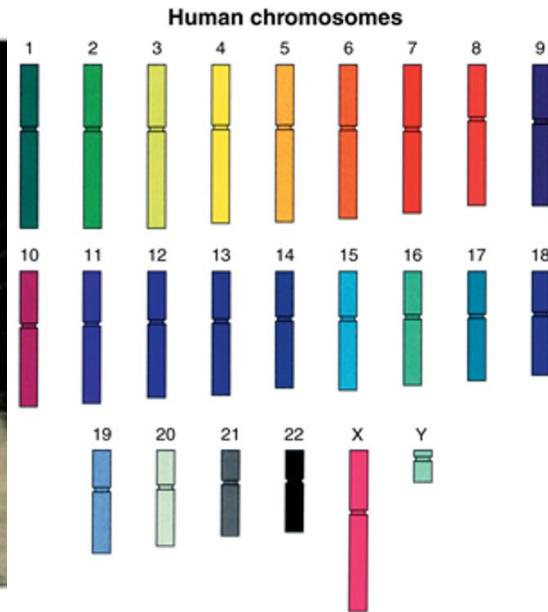


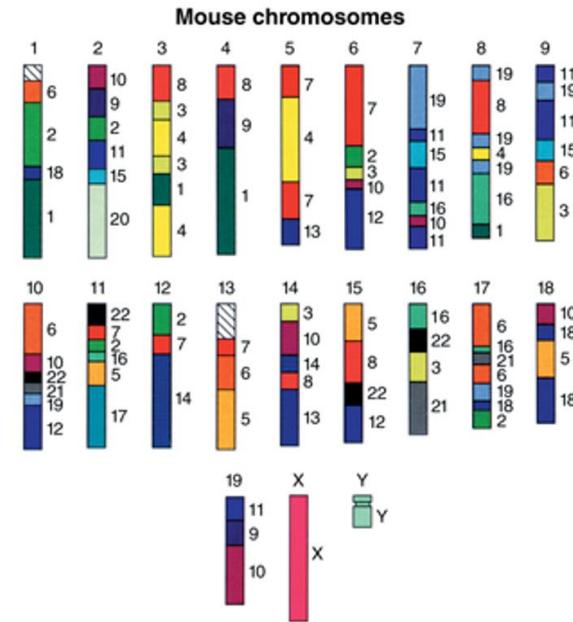
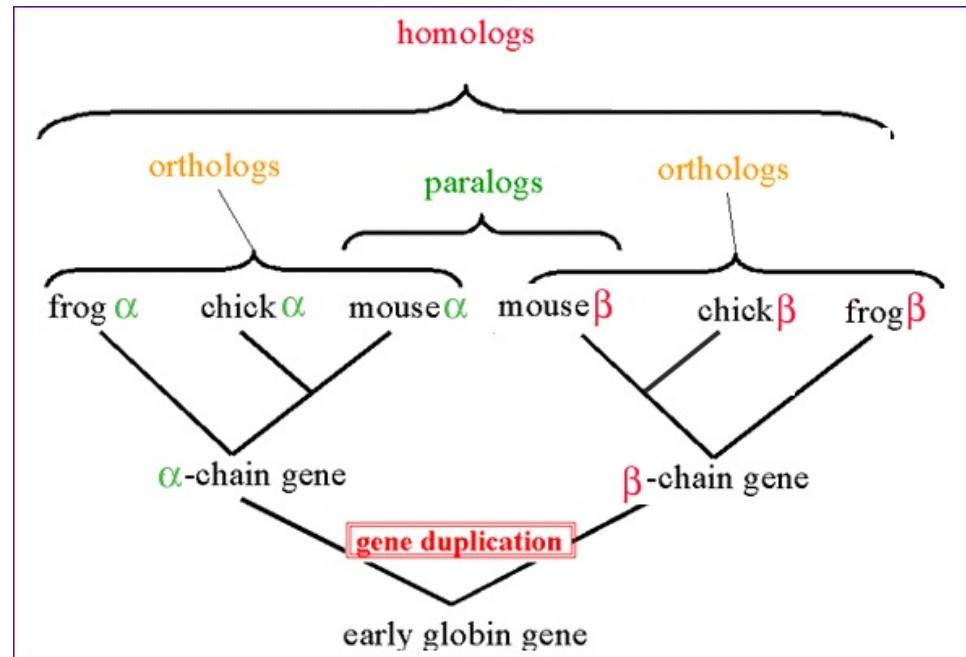
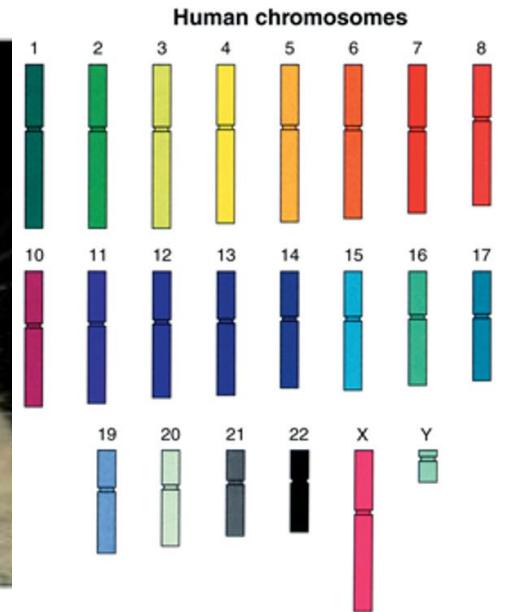
DNA within nucleus



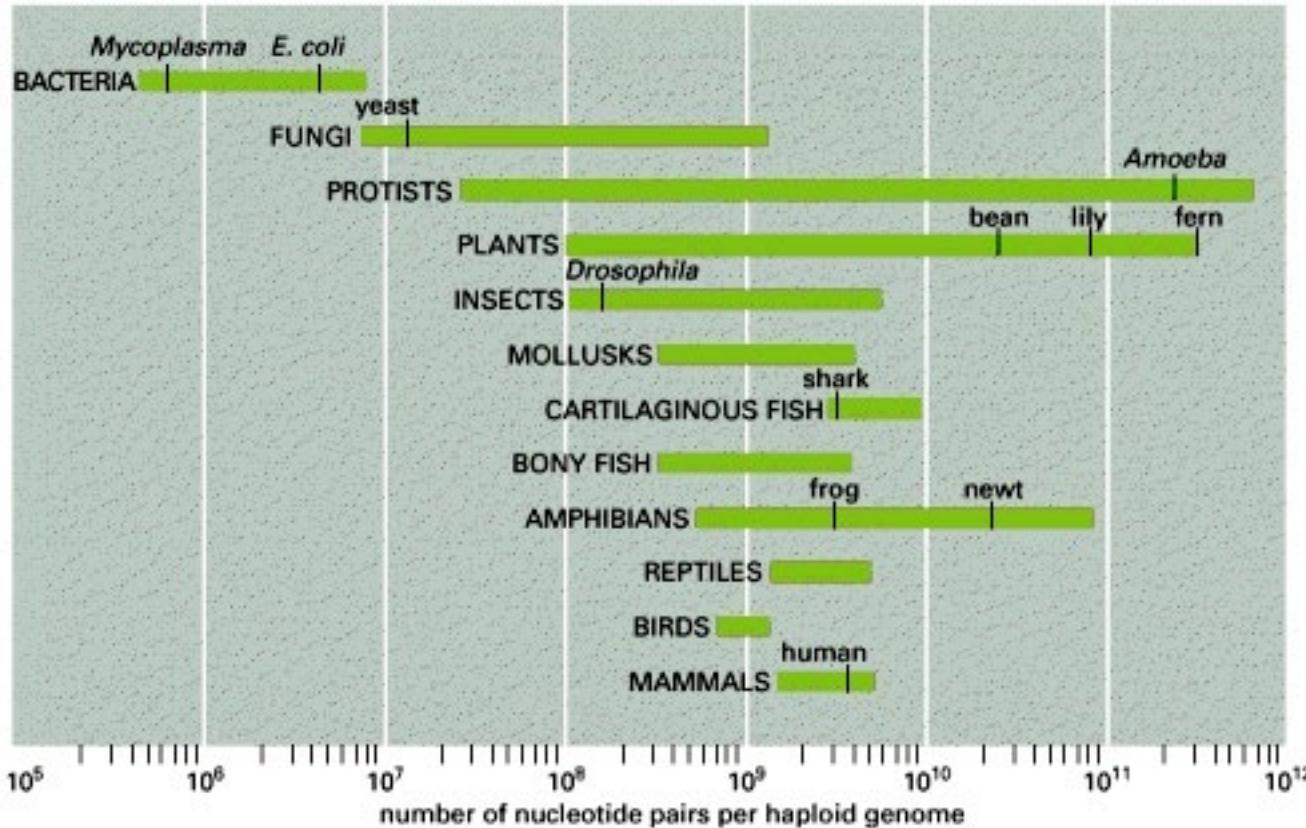




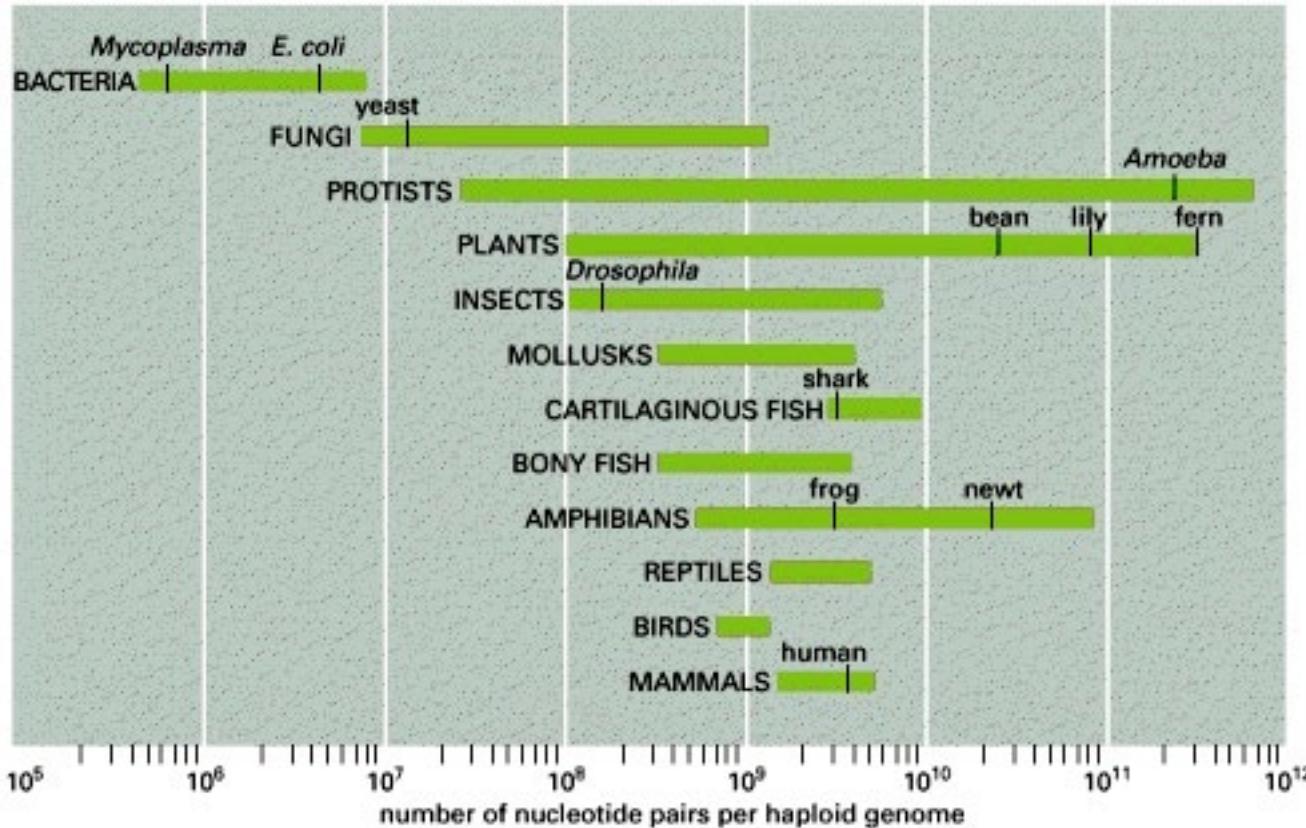




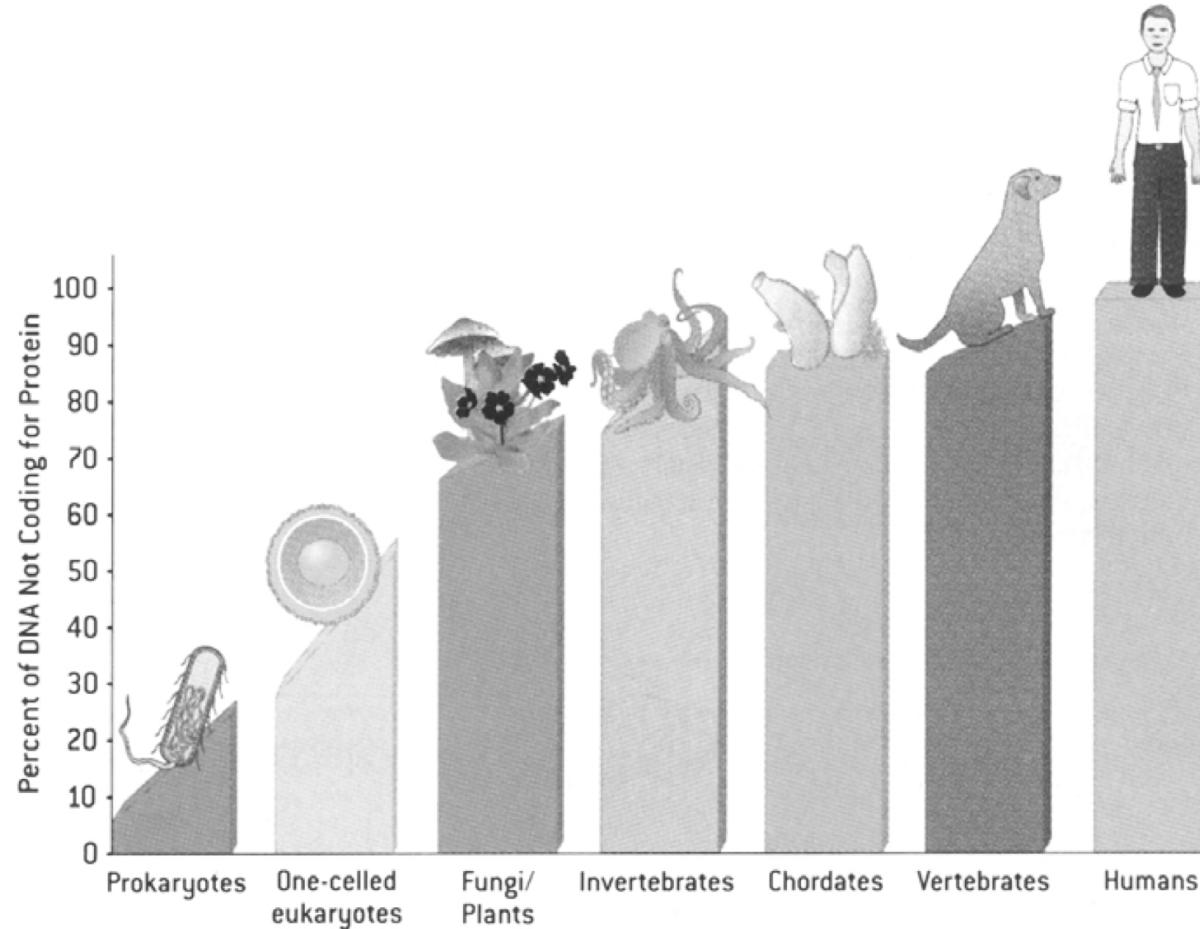
Genome size doesn't correlate with organism complexity



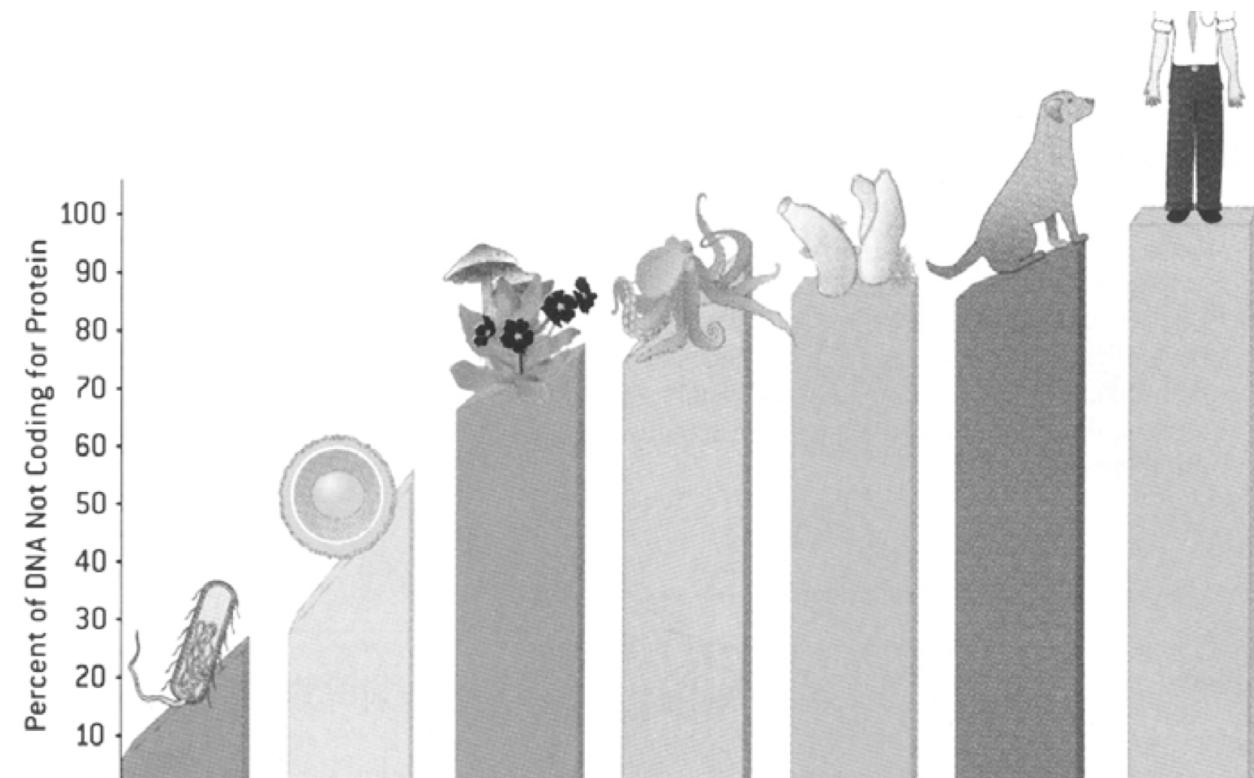
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Coding and non-coding DNA



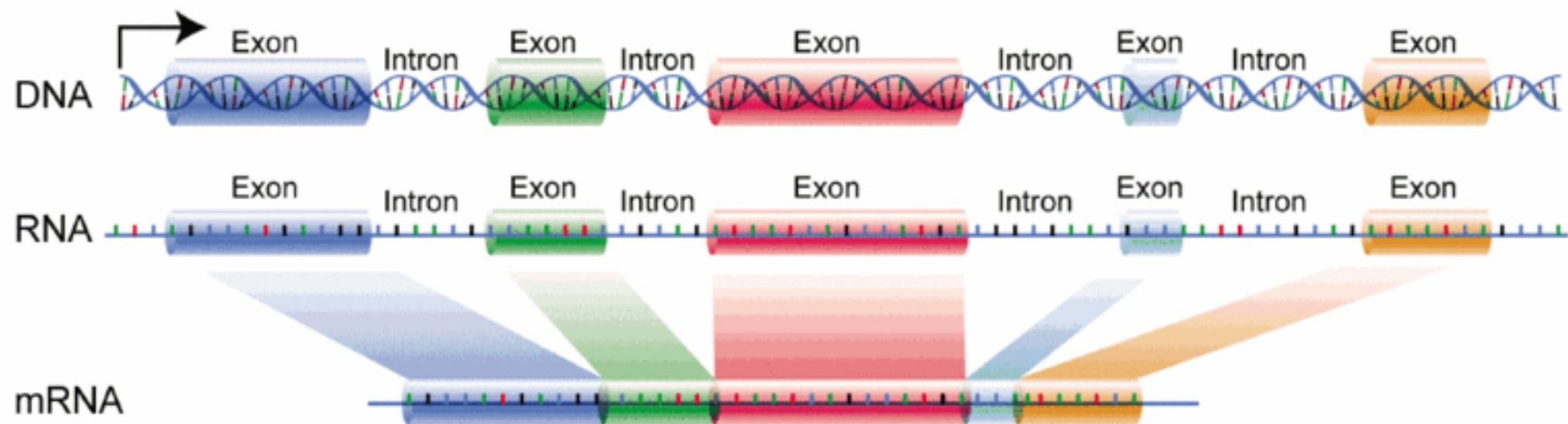
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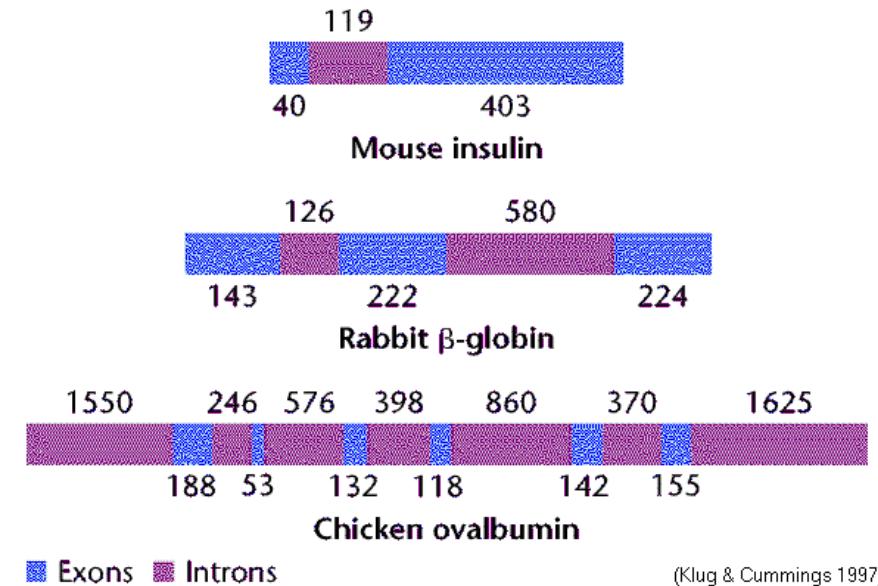
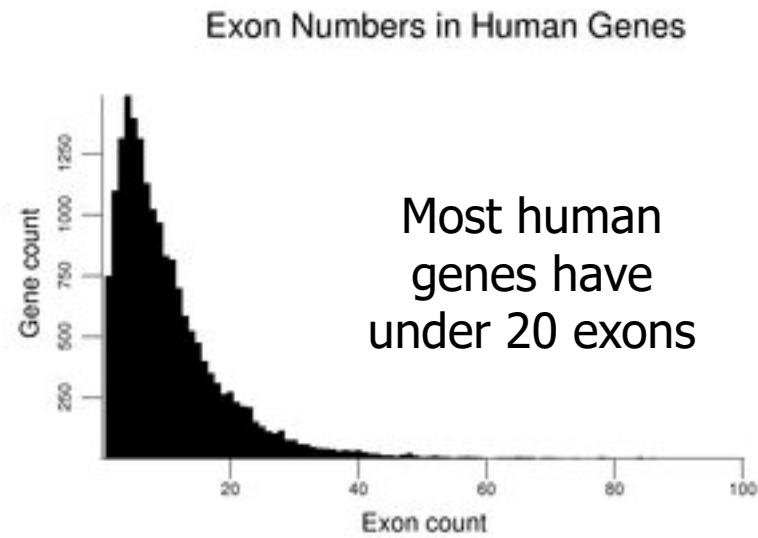
98.5% of the human genome is non-coding

Compared with 11% for bacterium *E. coli*

Coding and non-coding DNA



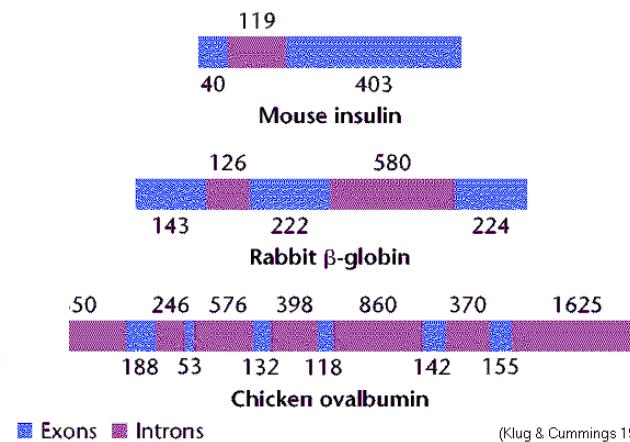
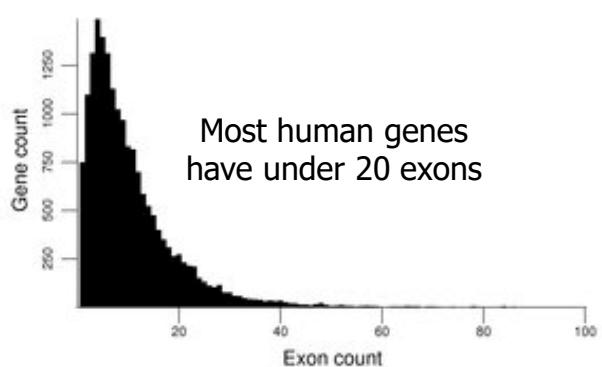
Coding and non-coding DNA



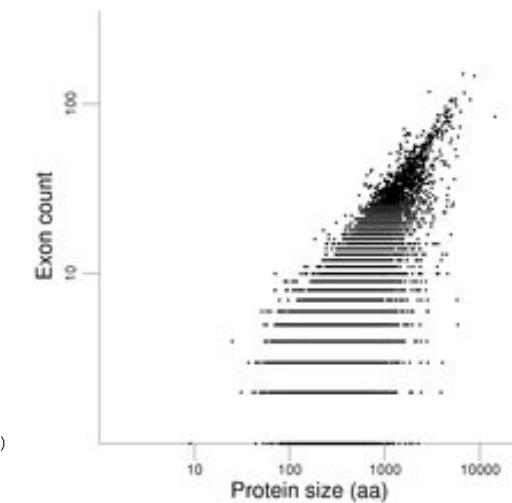
(Klug & Cummings 1997)

Coding and non-coding DNA

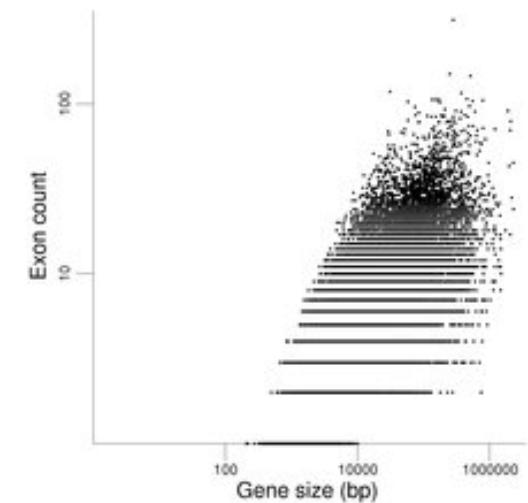
Exon Numbers in Human Genes



Exon Number vs Protein Size



Exon Number vs Gene Size



Genotype and Phenotype

Genotype

Genetic make-up

Genotype and Phenotype

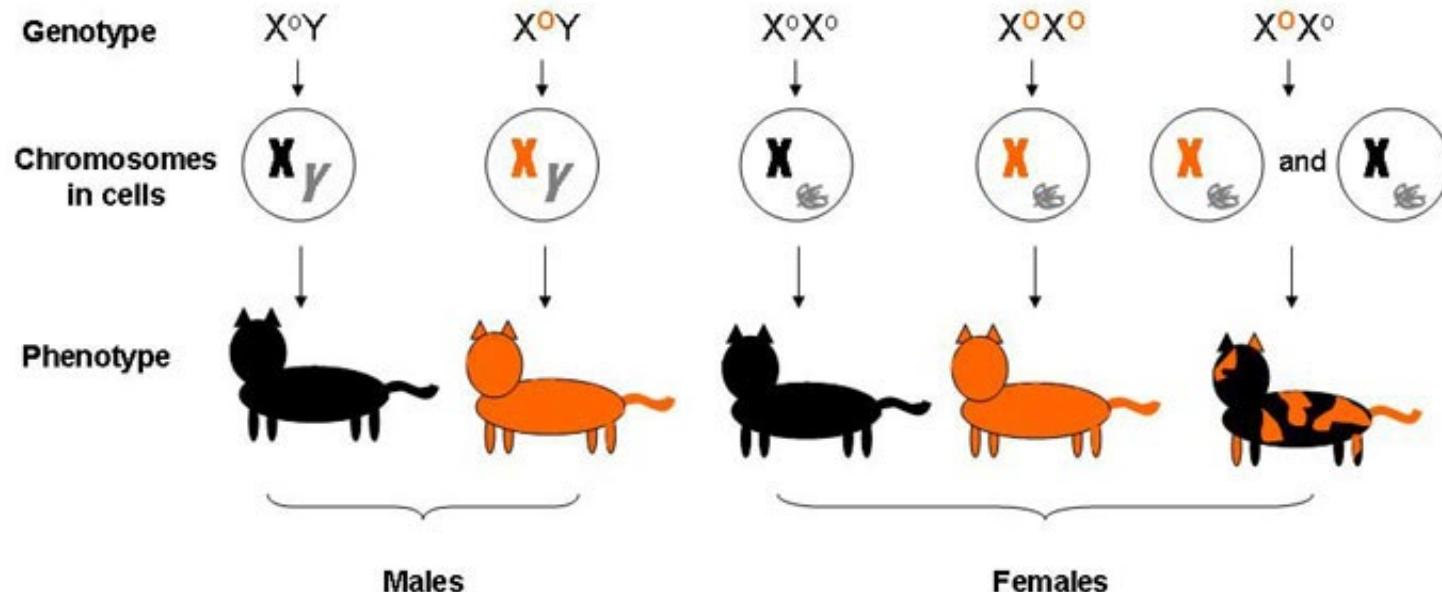
Regulation

Genotype + Environmental Factors → Phenotype

Genetic make-up

Function, characteristics,
Traits, behavior

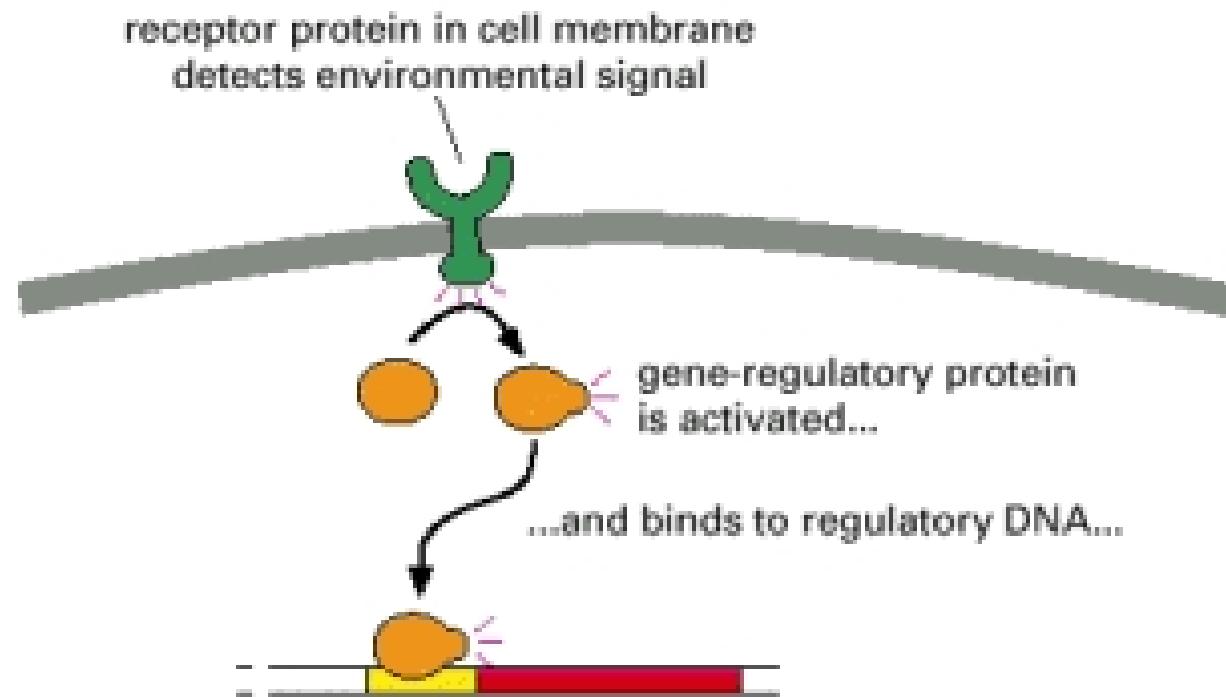
Genotype and Phenotype



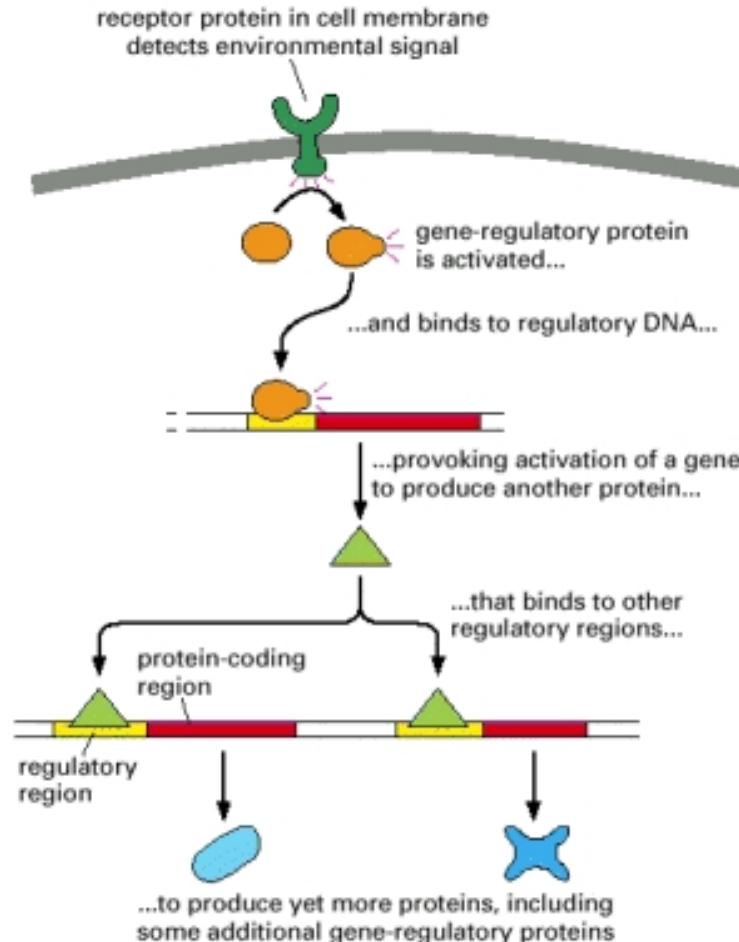
Regulation
Genotype + Environmental Factors → Phenotype

 = inactivated X chromosome, also called a Barr body

Gene regulation



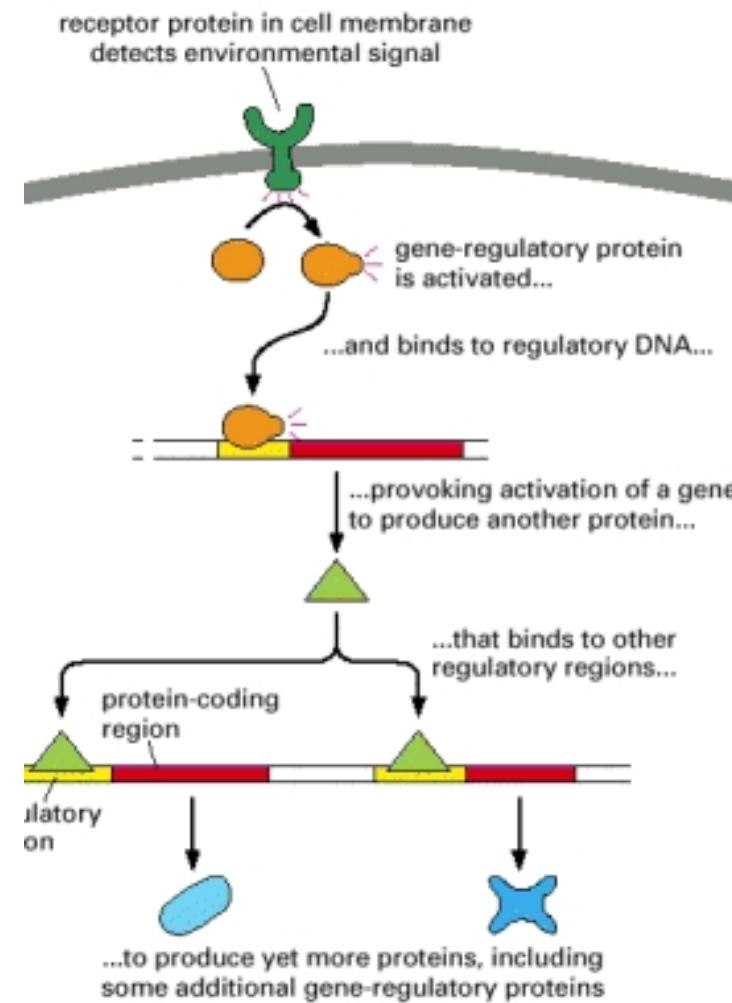
Gene regulation



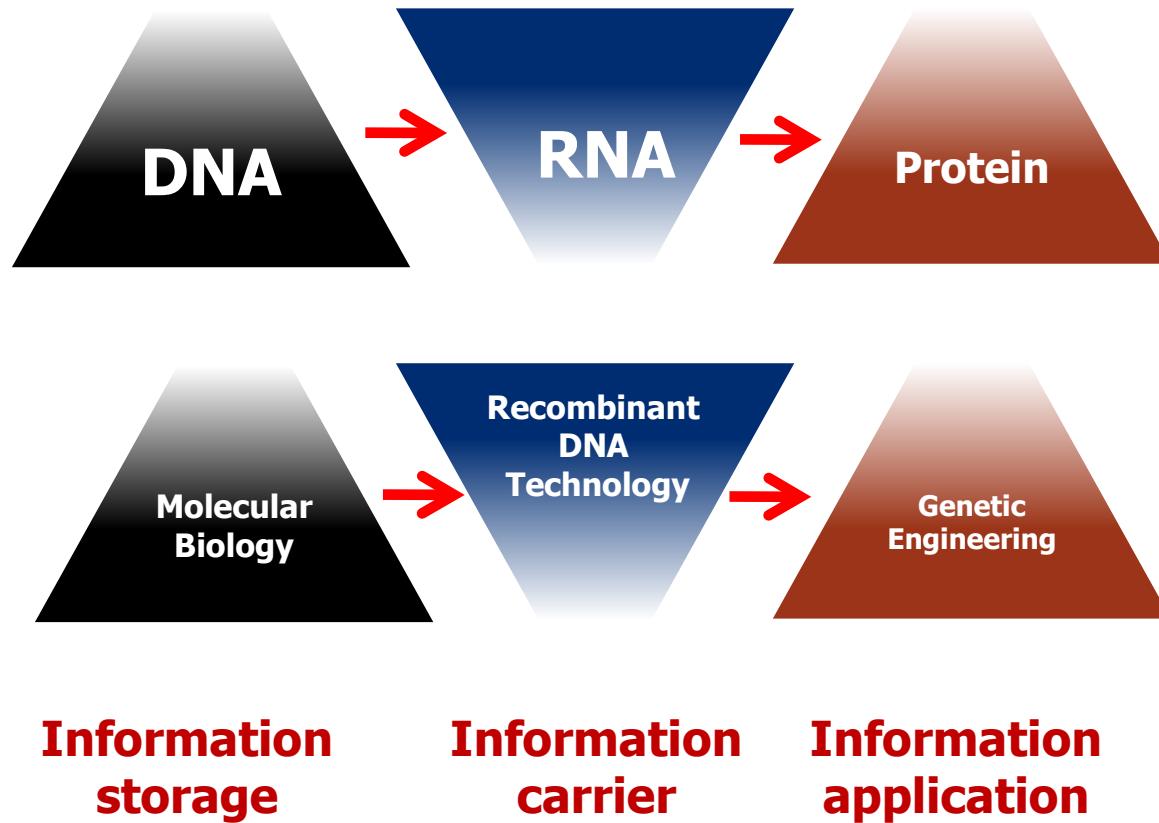
Gene regulation

Levels of regulation

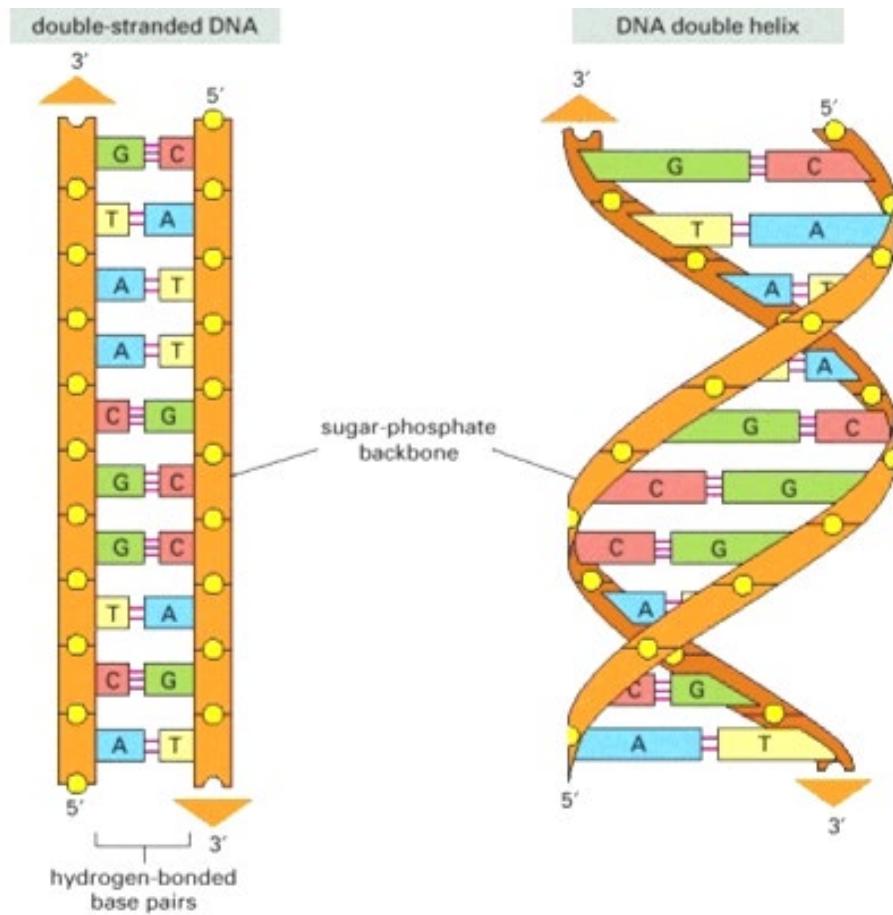
- Evolutionary or Genomic Level (species)
- Individual level (genotype)
- Chromosomal level (open or closed, transcription factors)
- mRNA Level (regulated initiation, splicing, degradation)
- Protein Level (regulated initiation, modifications, sorting, degradation)
- Composite Outcome + environment (phenotype)



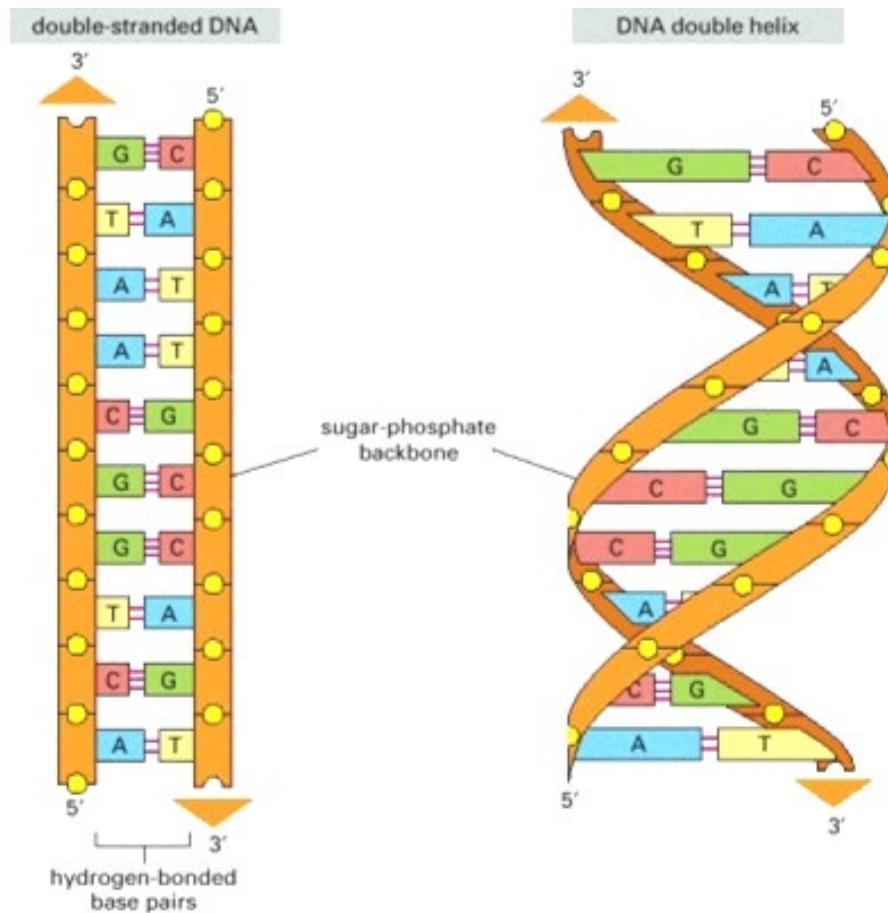
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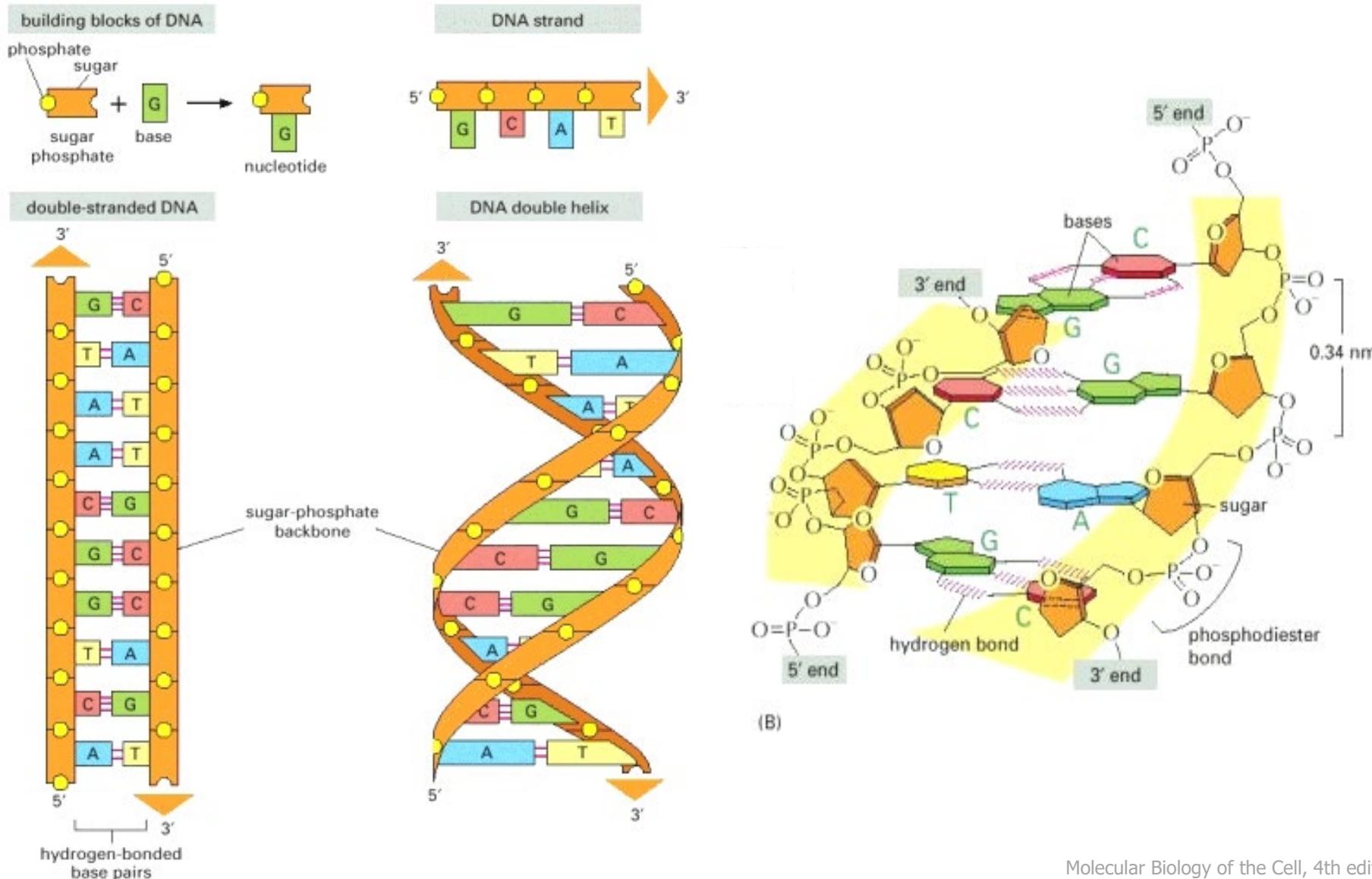
DNA structure and function



DNA structure and function



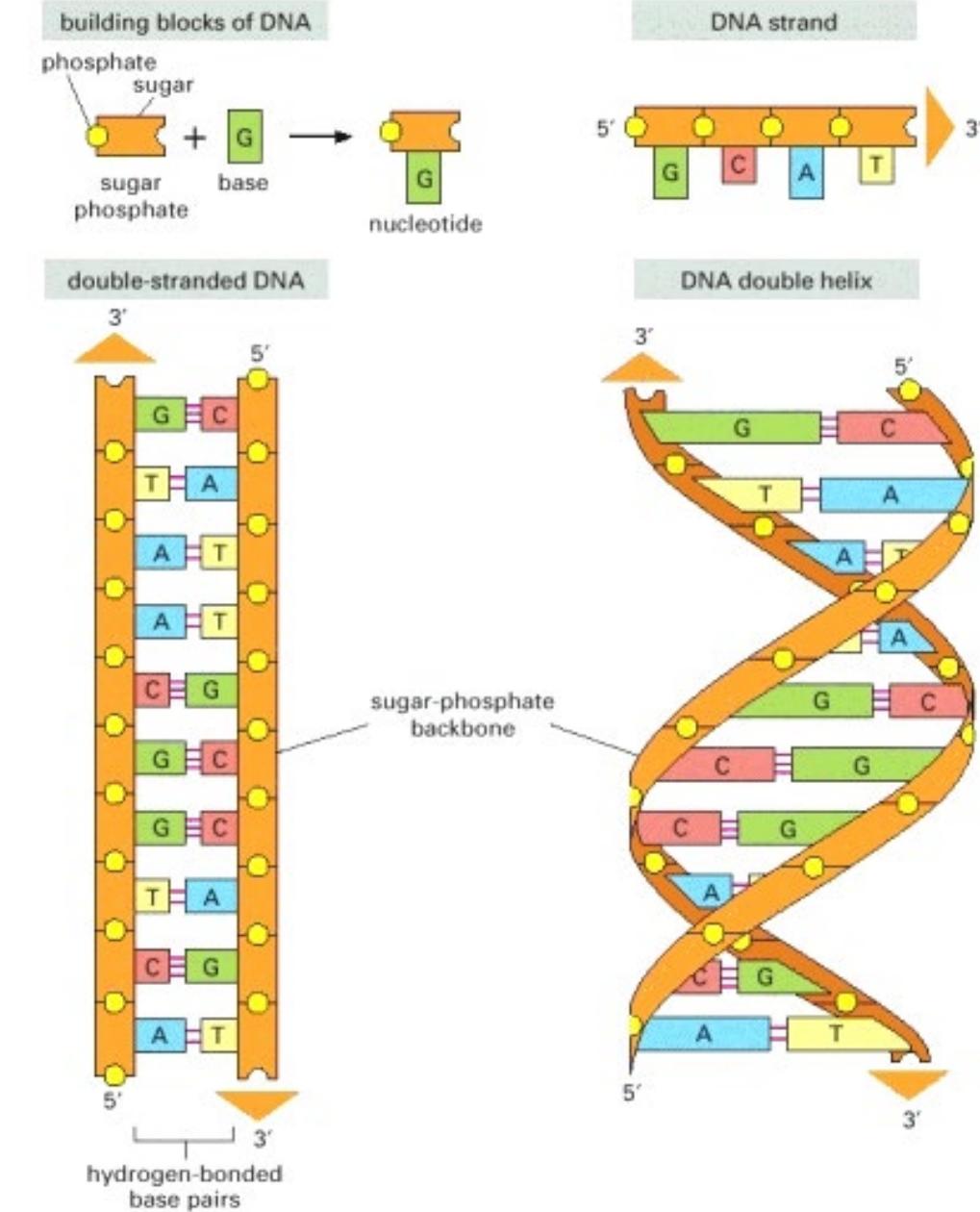
DNA structure and function



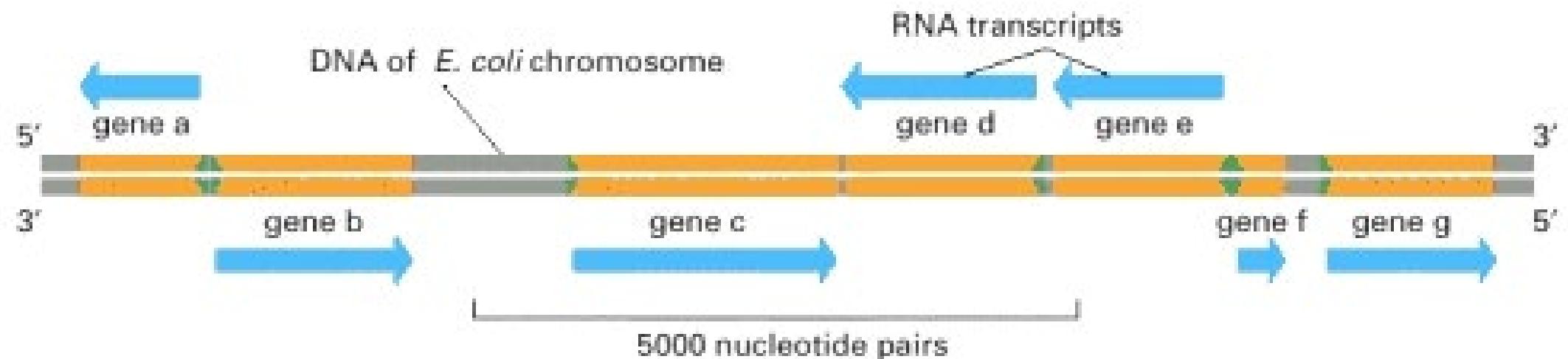
DNA structure and function

4 types of nucleotides

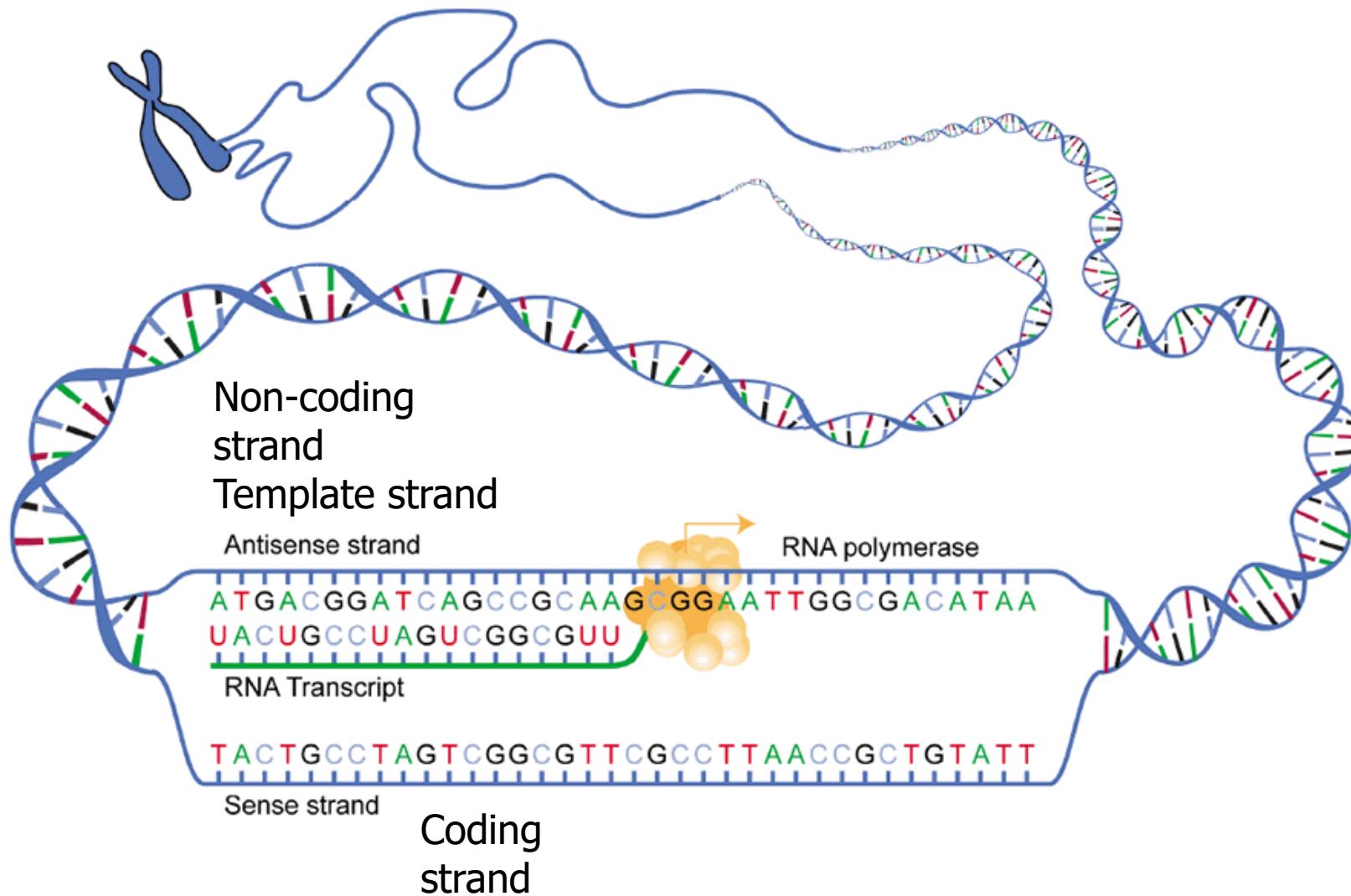
- Adenine
- Cytosine
- Guanine
- Thymine



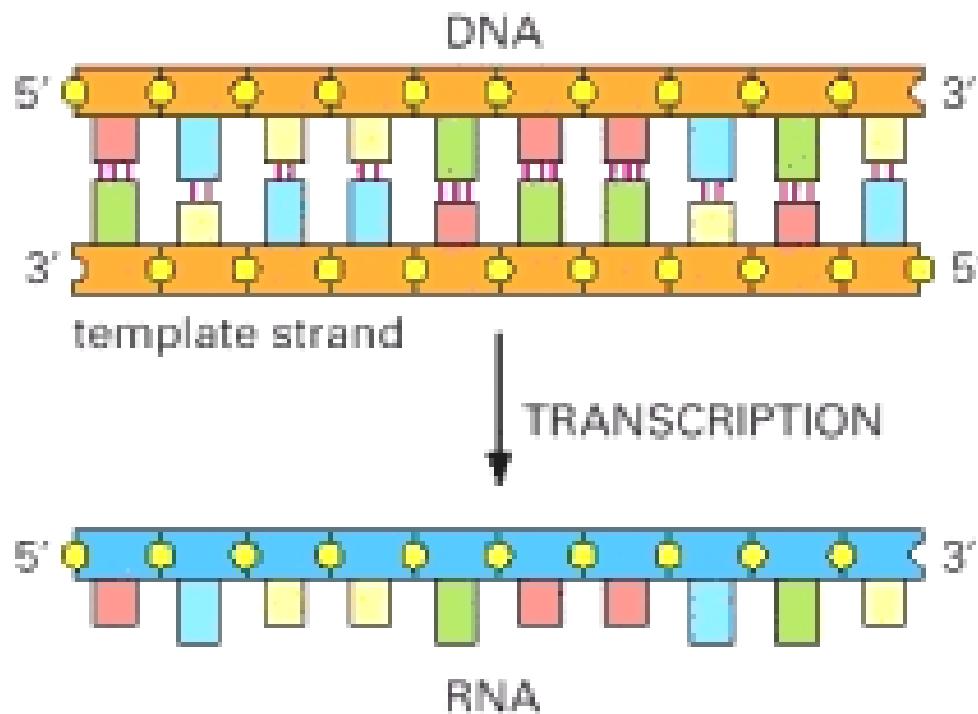
Cracking the code



Cracking the code - Transcription



Cracking the code - Transcription

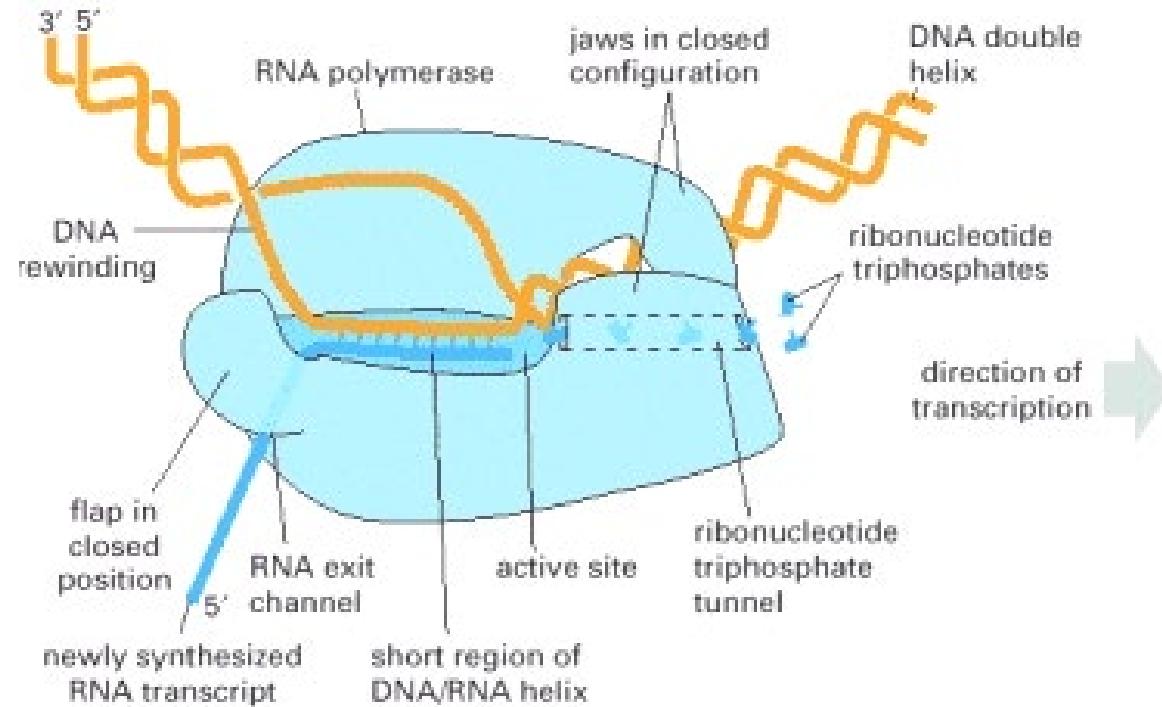


Sense, Coding strand

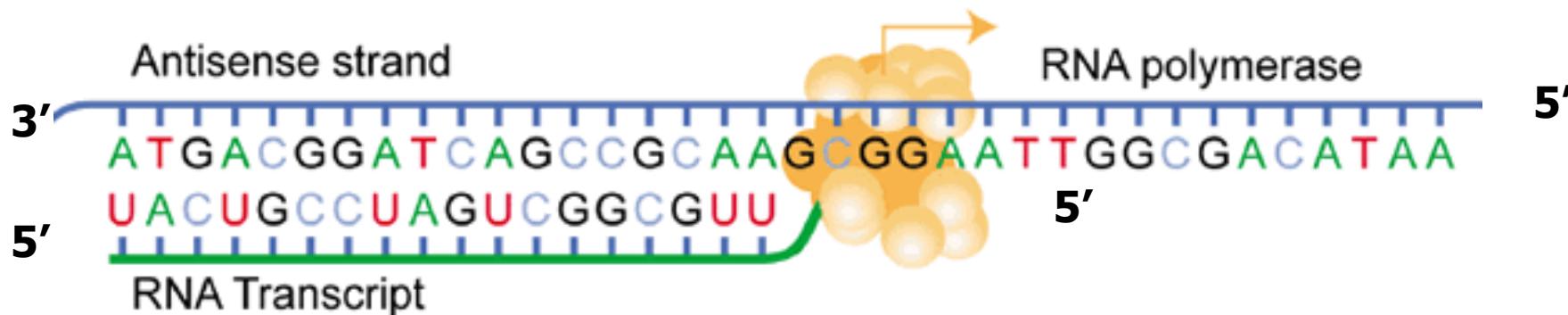
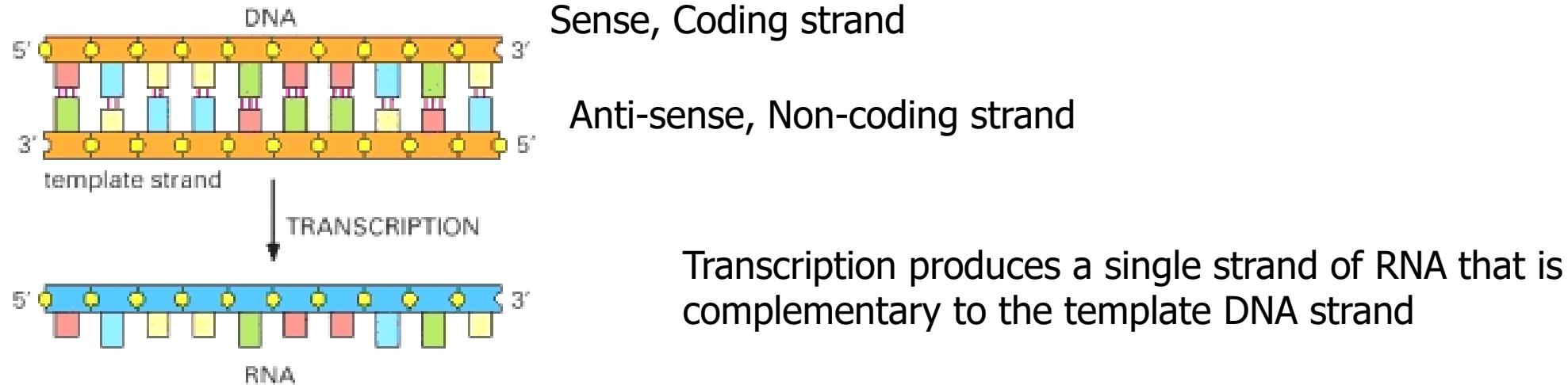
Anti-sense, Non-coding strand

Transcription produces a single strand of RNA that is complementary to the template DNA strand

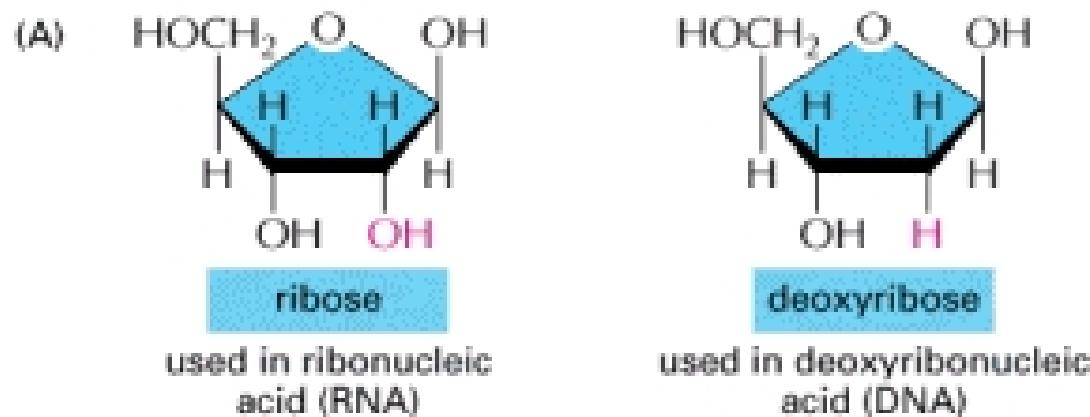
Process of transcription



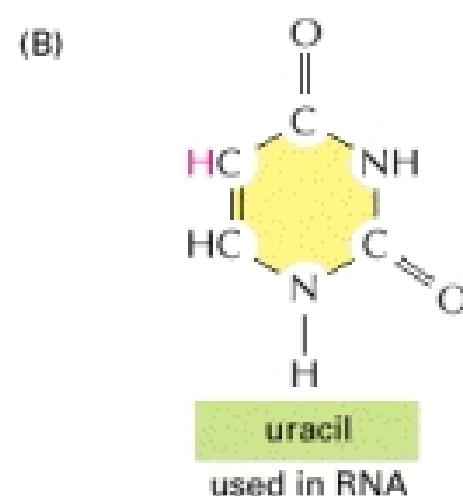
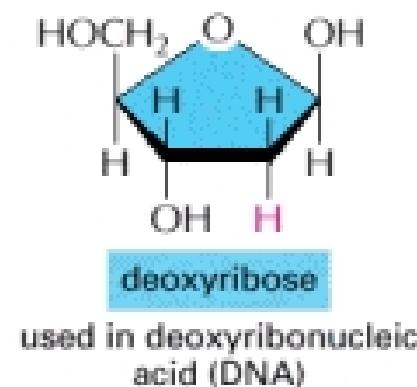
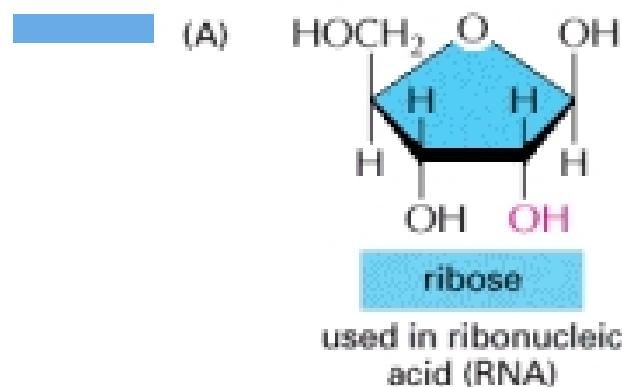
Cracking the code - Transcription



RNA structure and function

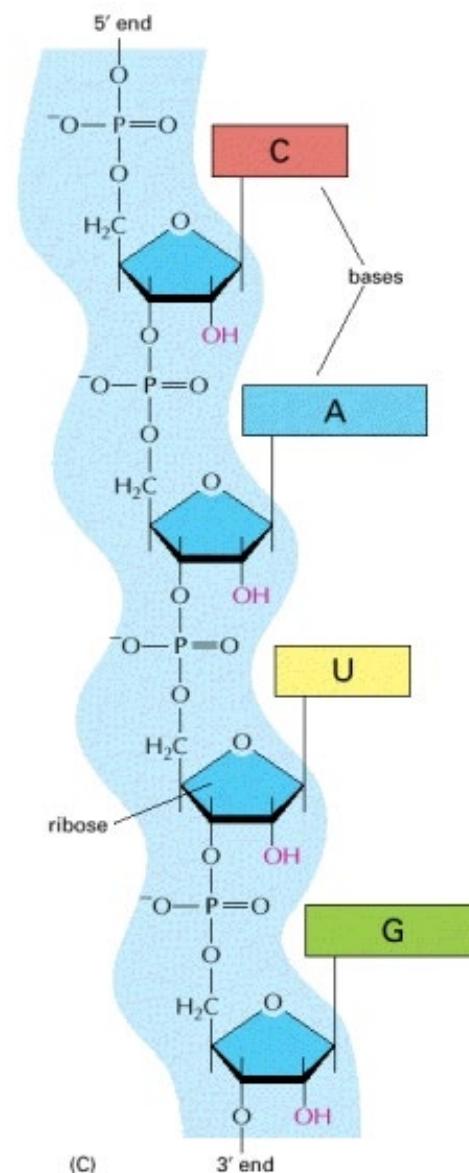


RNA structure and function



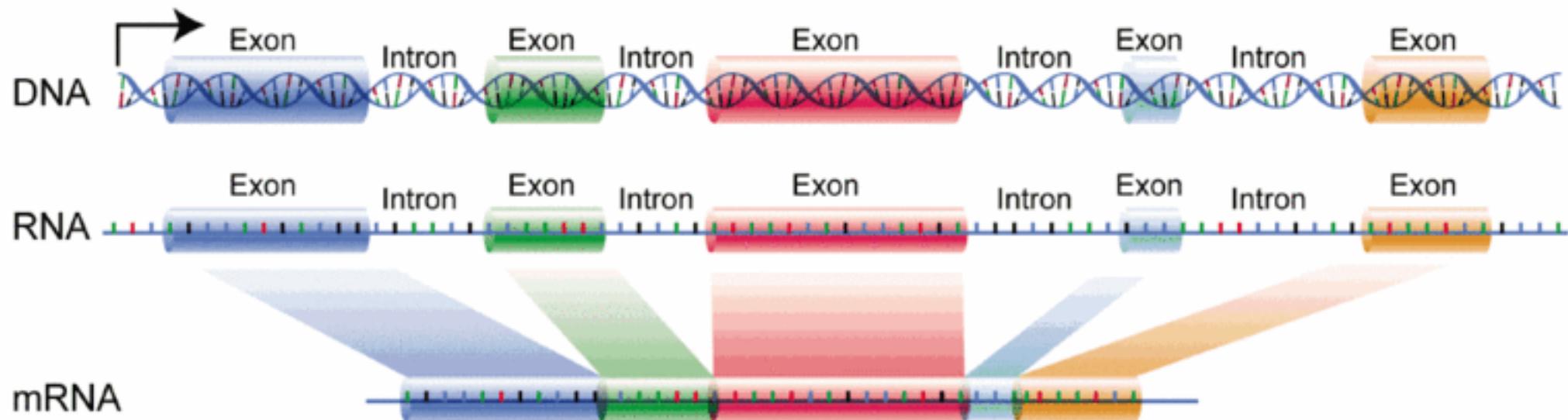
A, C, G, U

A, C, G, T



RNA structure and function

A direct RNA transcript undergoes splicing to become mRNA



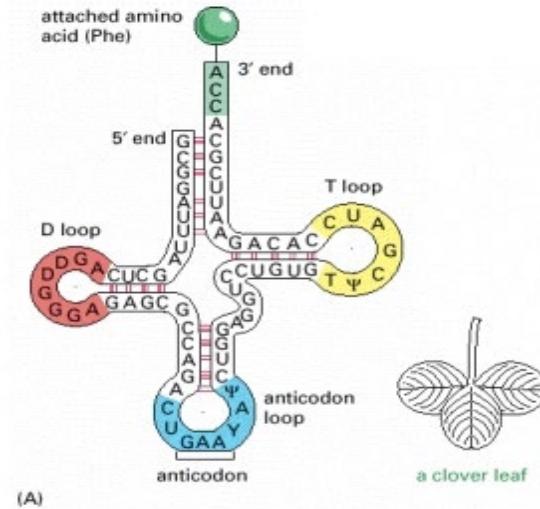
Types of RNA

Type	Function
mRNA	Messenger RNA, codes for protein
rRNA	Ribosomal RNA, forms ribosome and catalyzes protein synthesis
tRNA	Transfer RNA, adapter between mRNA and amino acids during protein synthesis
snRNA	Small nuclear RNA, multi-functional (slices pre-mRNA)
snoRNA	Small nucleolar RNA, processes and modifies rRNA
Other non-coding RNA	Diverse functions

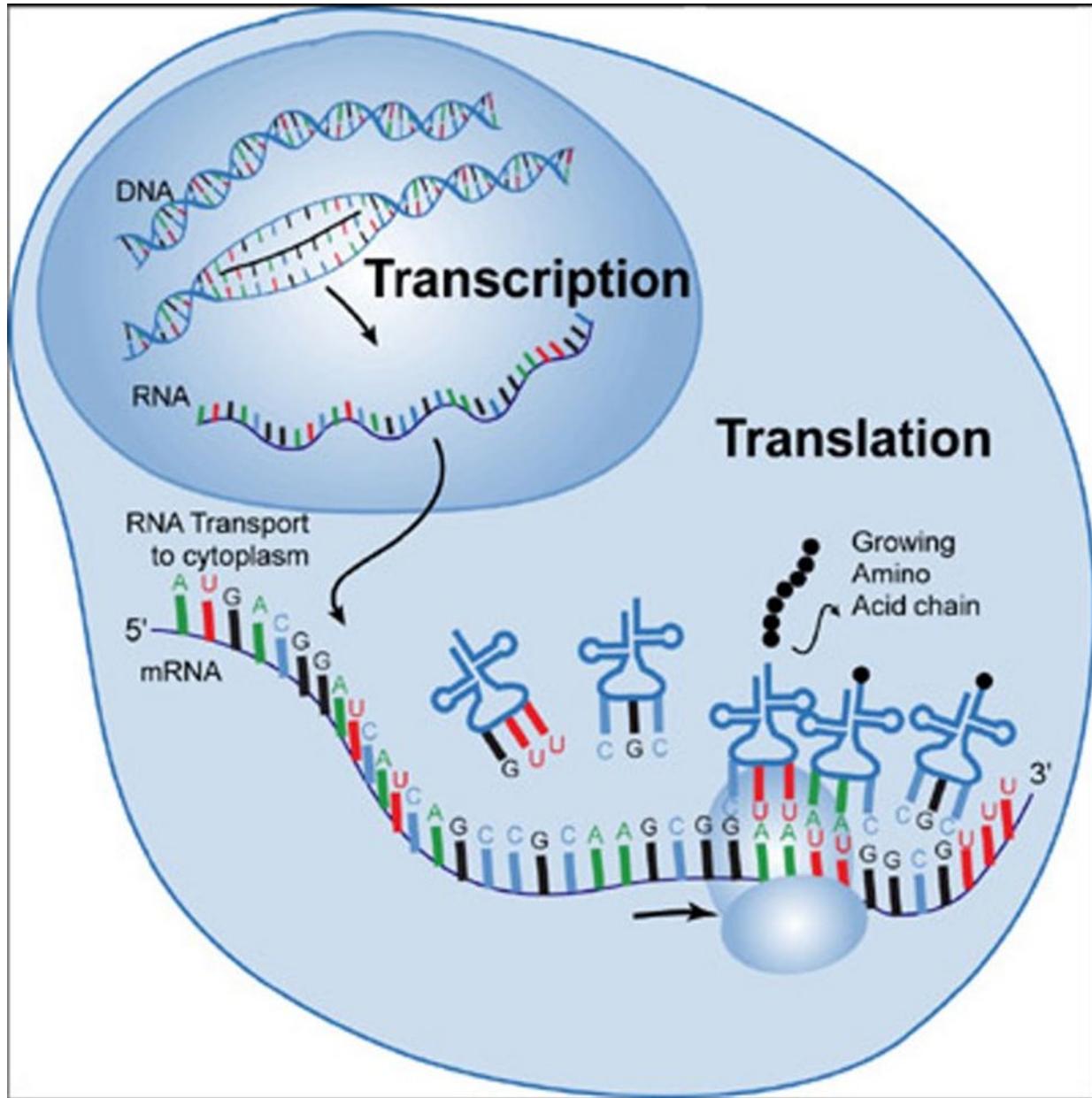
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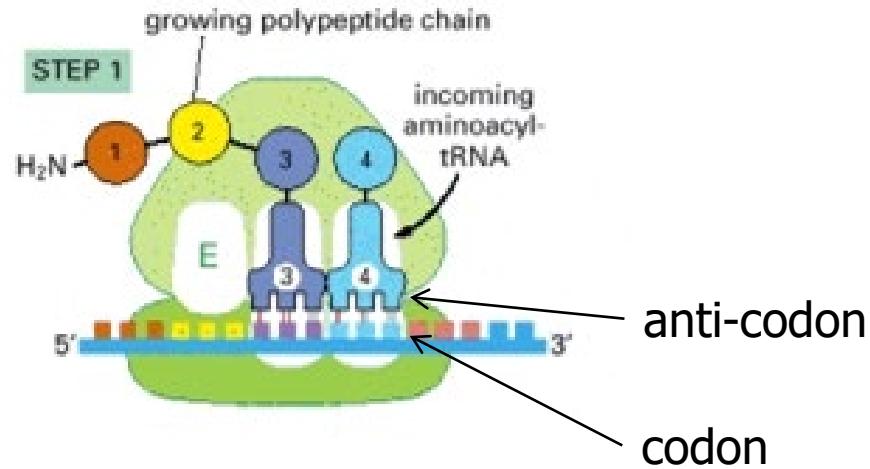
From RNA to protein



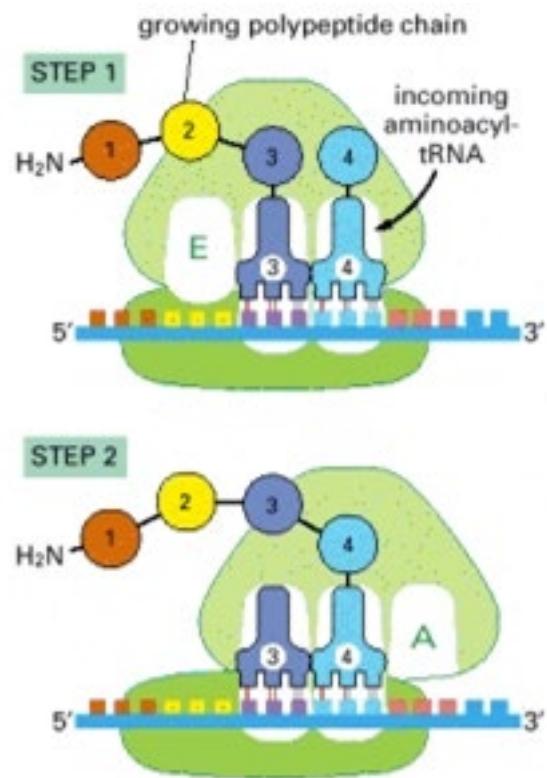
(A)



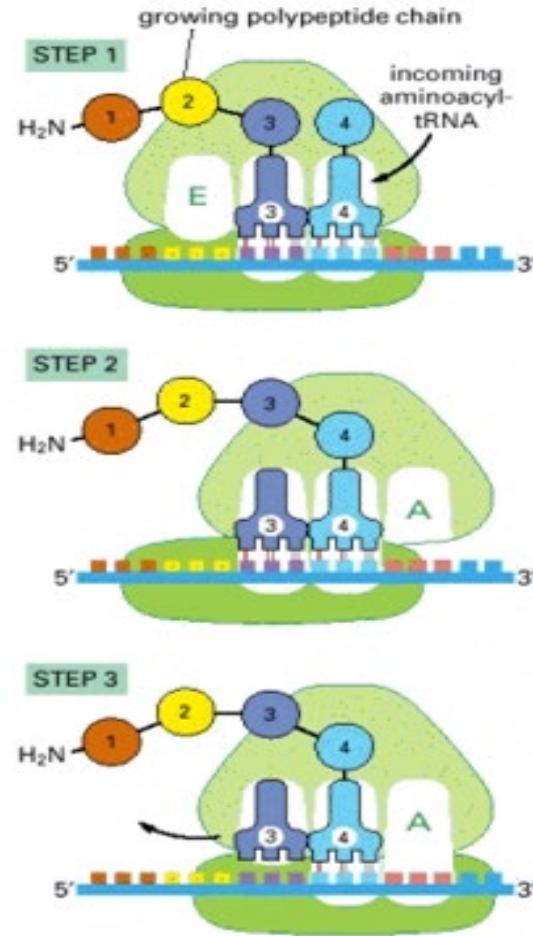
Cracking the code - Translation



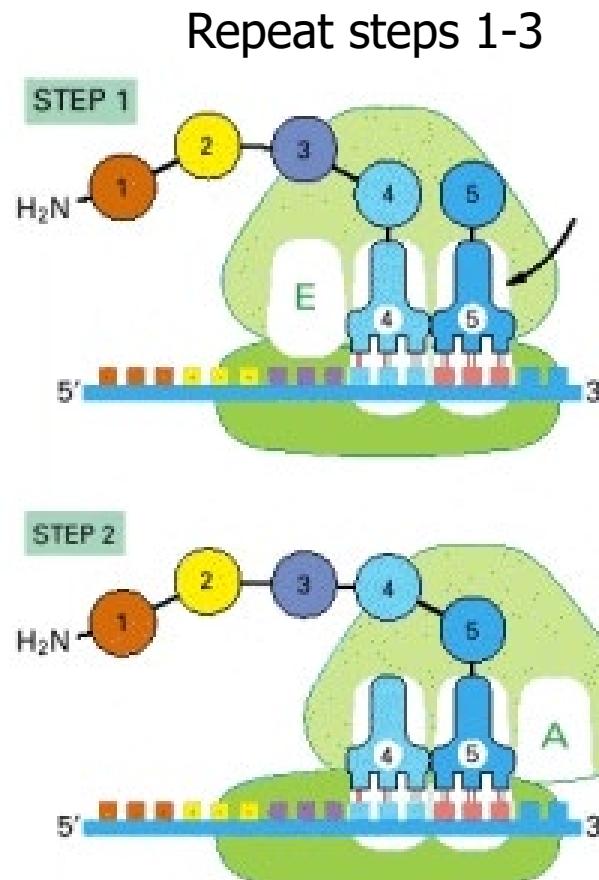
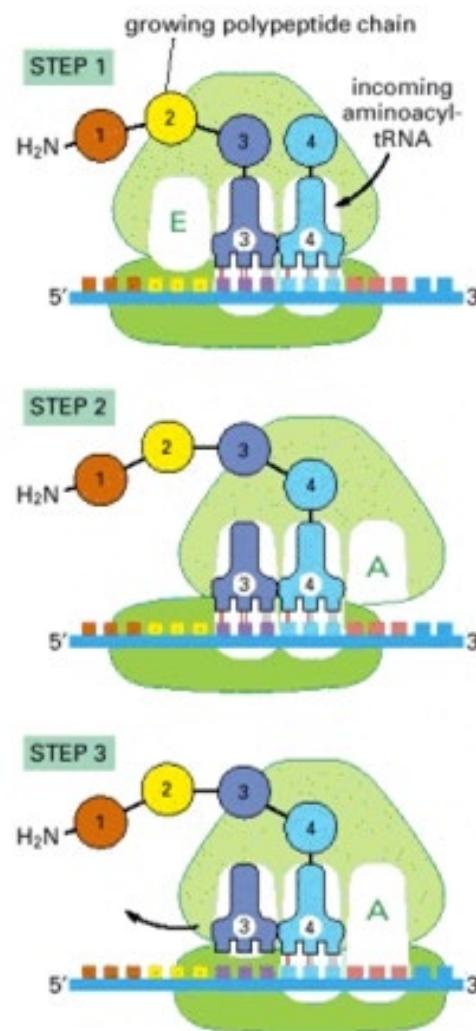
Cracking the code - Translation



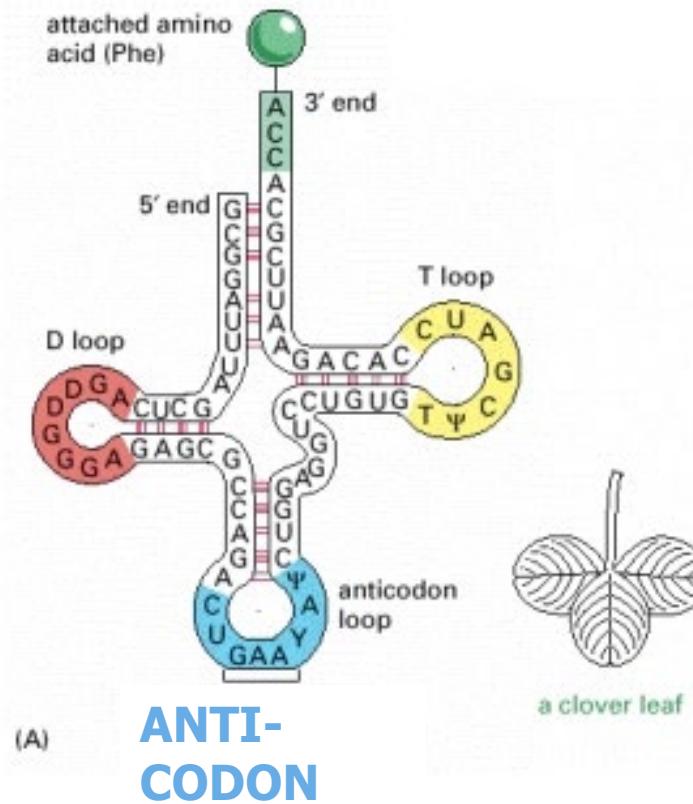
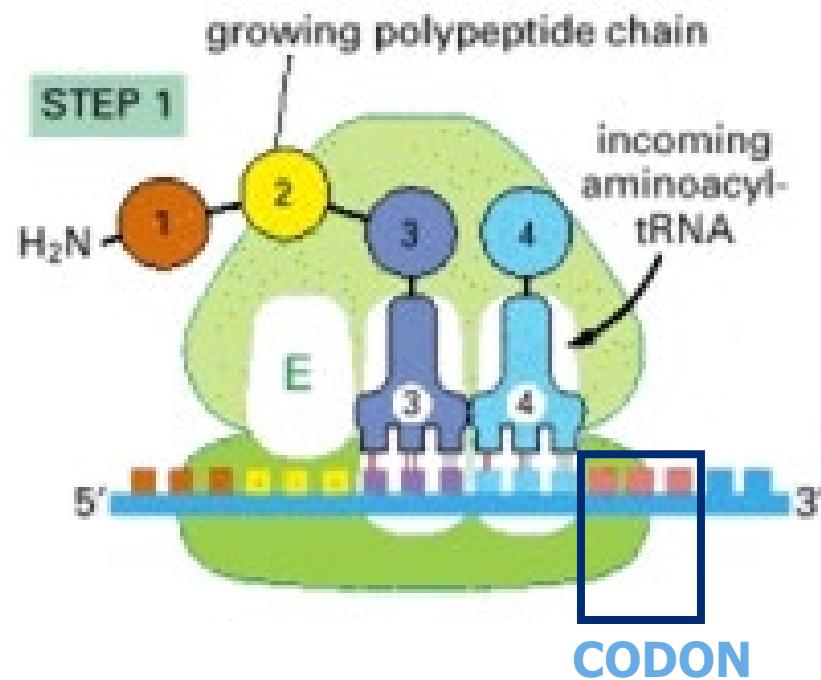
Cracking the code - Translation



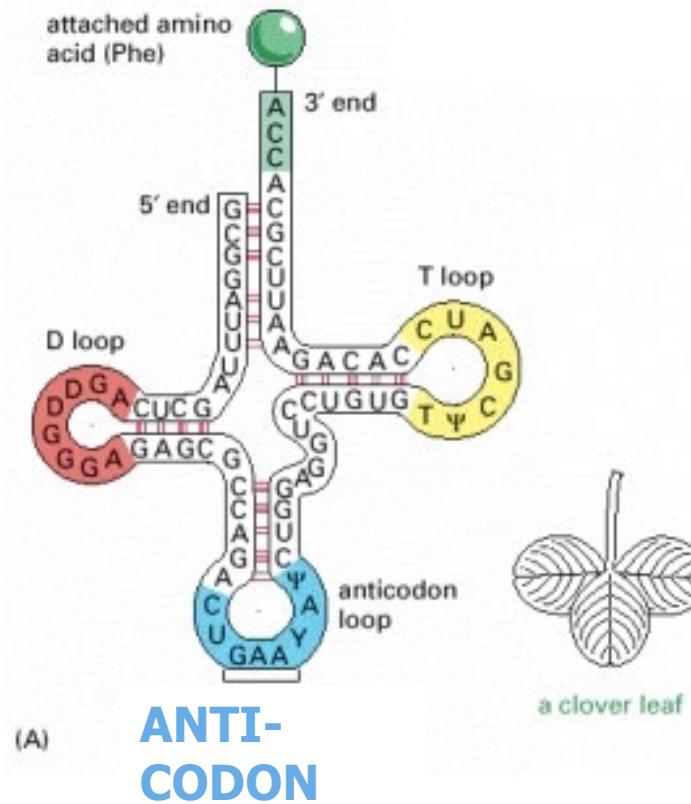
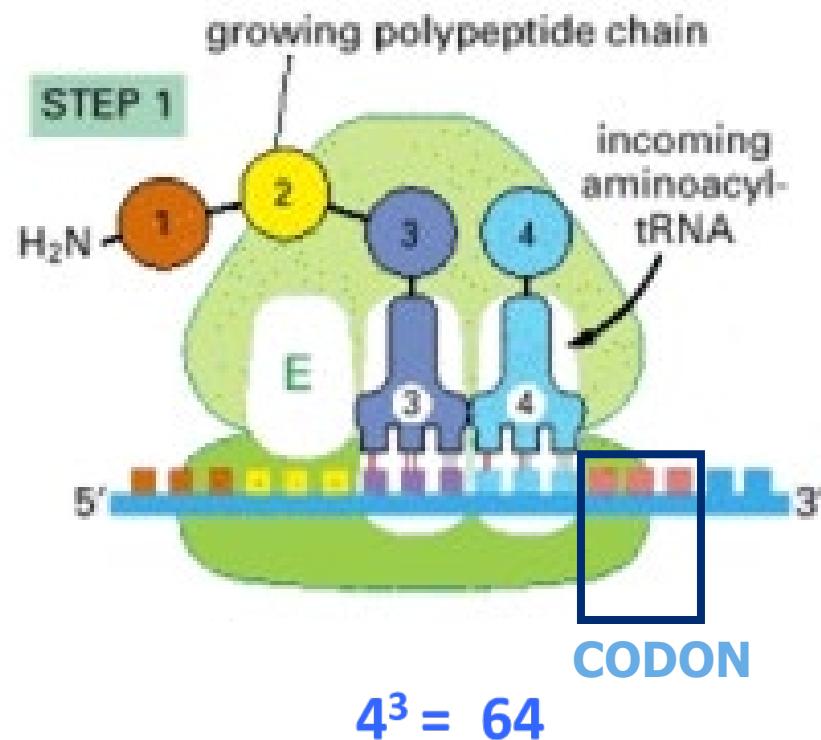
Cracking the code - Translation



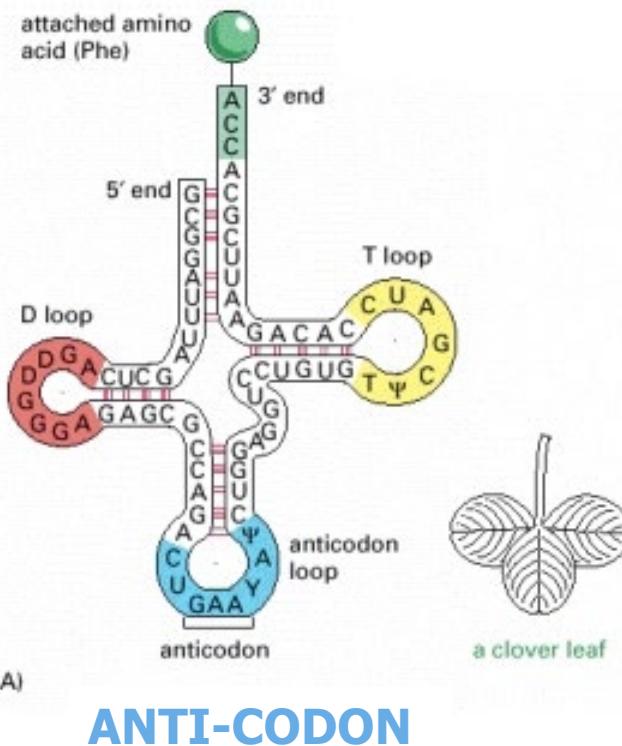
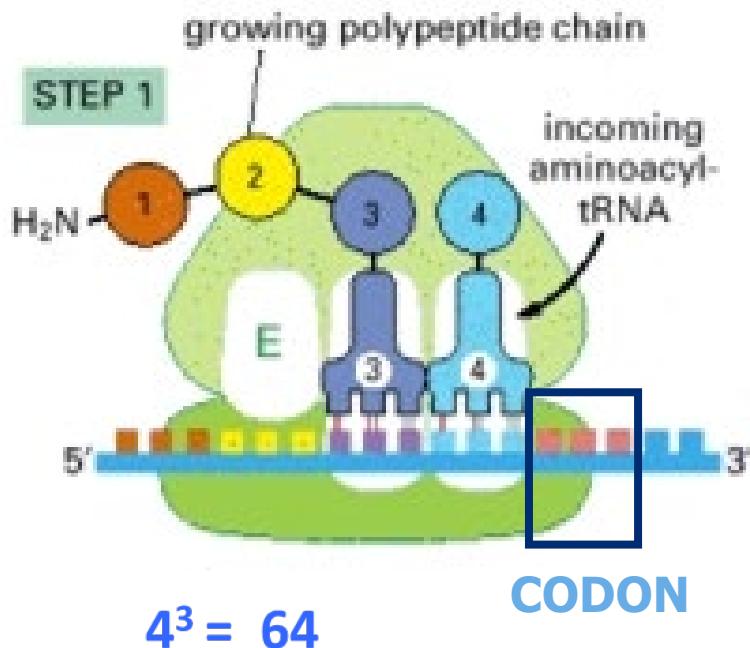
Cracking the code - Translation



Cracking the code - Translation

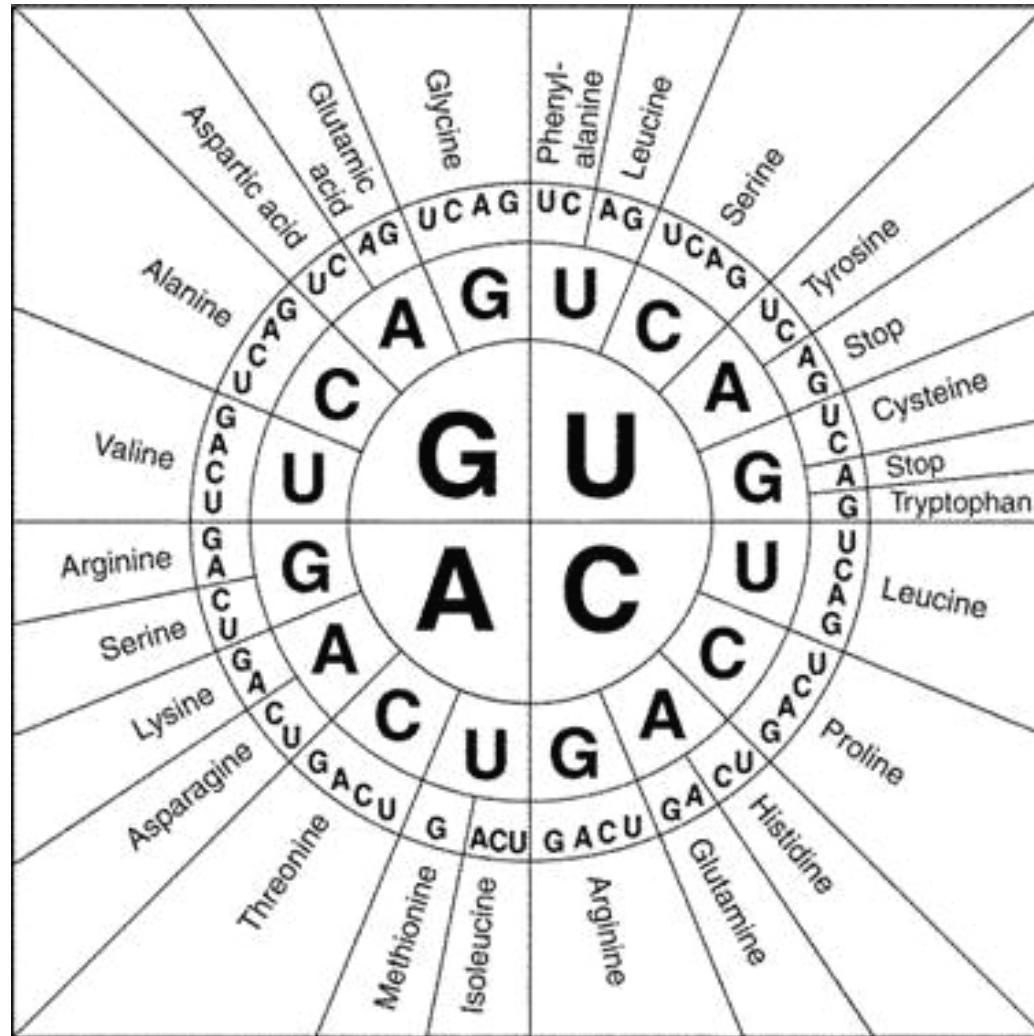


Cracking the code - Translation

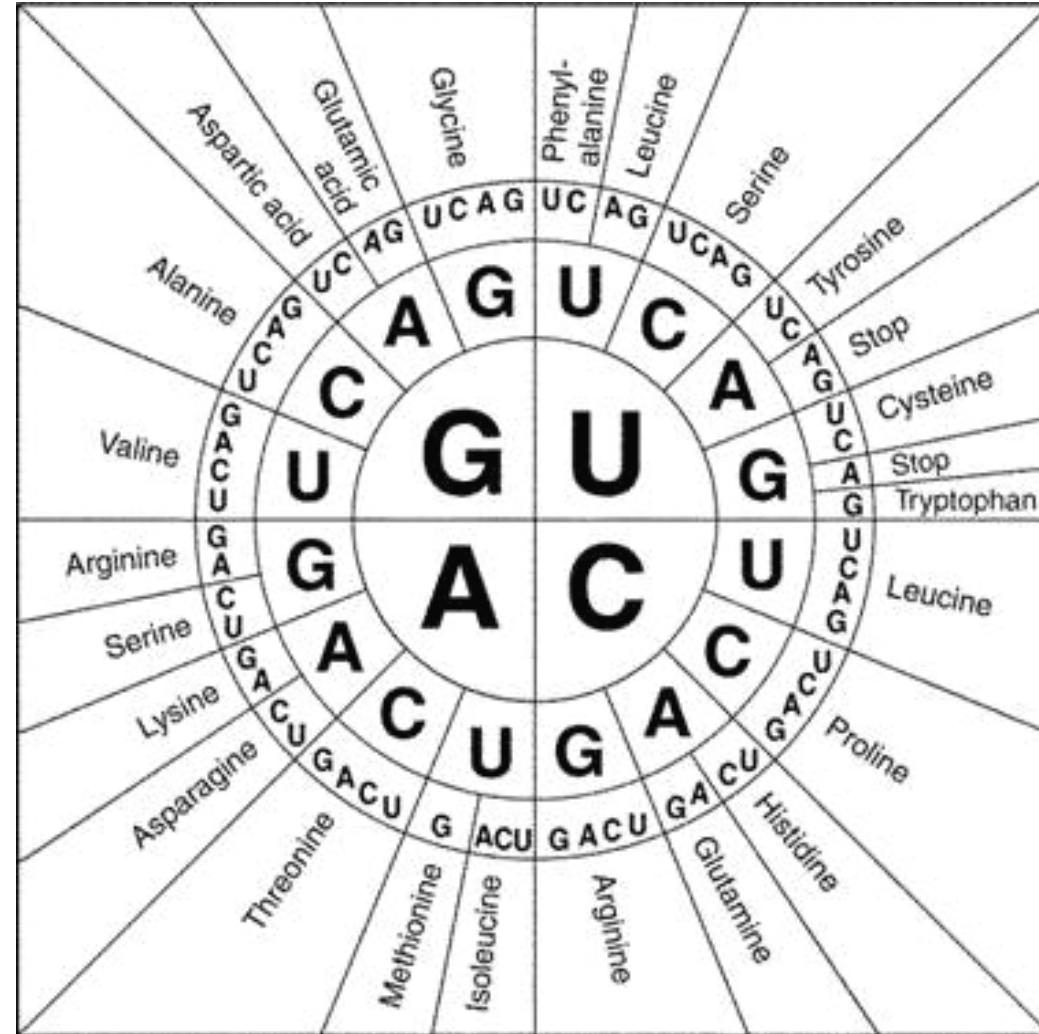


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AGG	UUG	AGU	GUC	R	N	C	O	G	H	I	L	K	M	F	P	S	T	W	Y	V		
GCA	CUA	CCA	CCU	GCA	CGA	CGC	GAA	CAA	GAC	AAC	UGC	GAA	GAG	CAC	AUC	AUU	AAA	AAG	AUG	UUU		
GCC	CUC	CCC	CCG	GCG	CGG	CGC	GGA	GGC	GAC	AAU	UGU	GGA	GAG	GGA	GGG	GGU	CAU	CAU	CUU	CUU		
GCG	CUG	CCG	CCG	GCG	CGG	CGC	GAA	GGC	GAC	AAU	UGU	GGA	GAG	GGA	GGG	GGU	CAU	CAU	CUU	CUU		
GCU	CGU	CCG	CCG	GCU	CGU	CGU	GAU	AAU	GAC	AAC	UGC	GAA	GAG	GAC	GGC	GGG	GGU	CAU	CAU	CUU	CUU	

Cracking the code

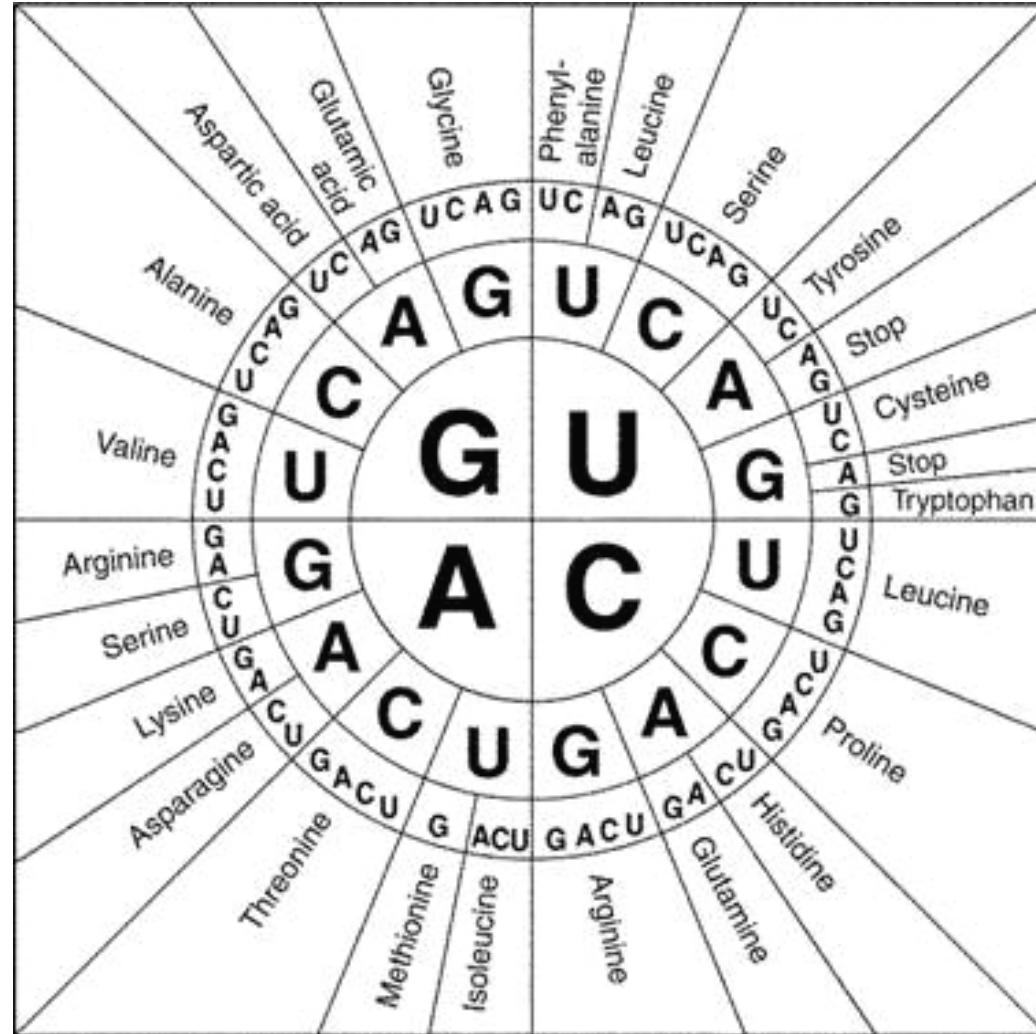


Cracking the code



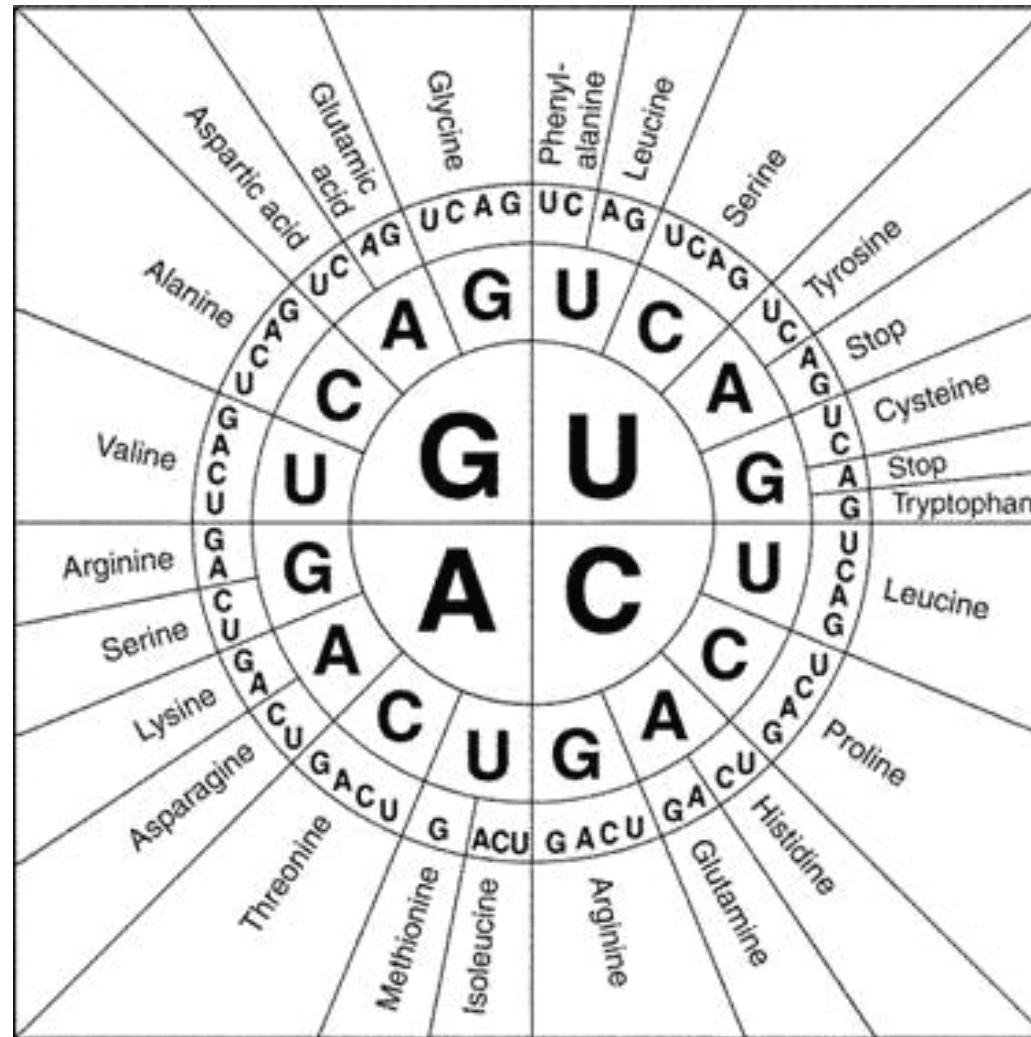
C

Cracking the code



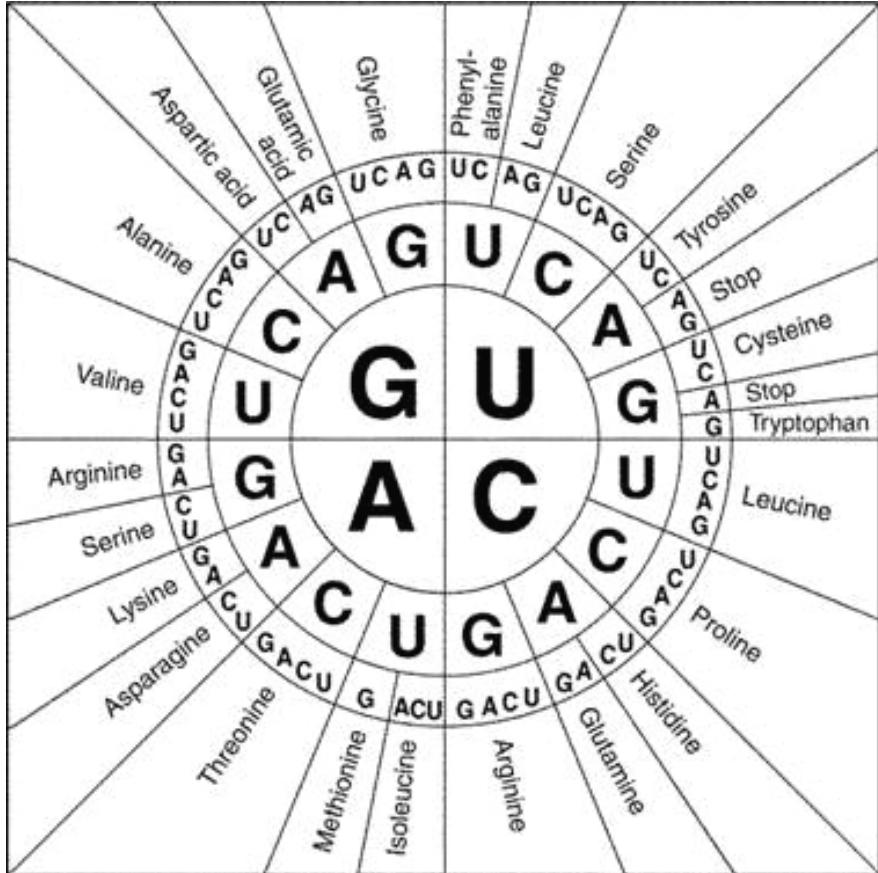
C A

Cracking the code



C | A | C

Histidine!



START always: ATG (AUG),
Methionine
STOP: TAA, TAG or TGA

5' ... A T G G C C T G G A C T T C A ... 3' **Sense strand of DNA**
3' ... T A C C G G A C C T G A A G T ... 5' **Antisense strand of DNA**

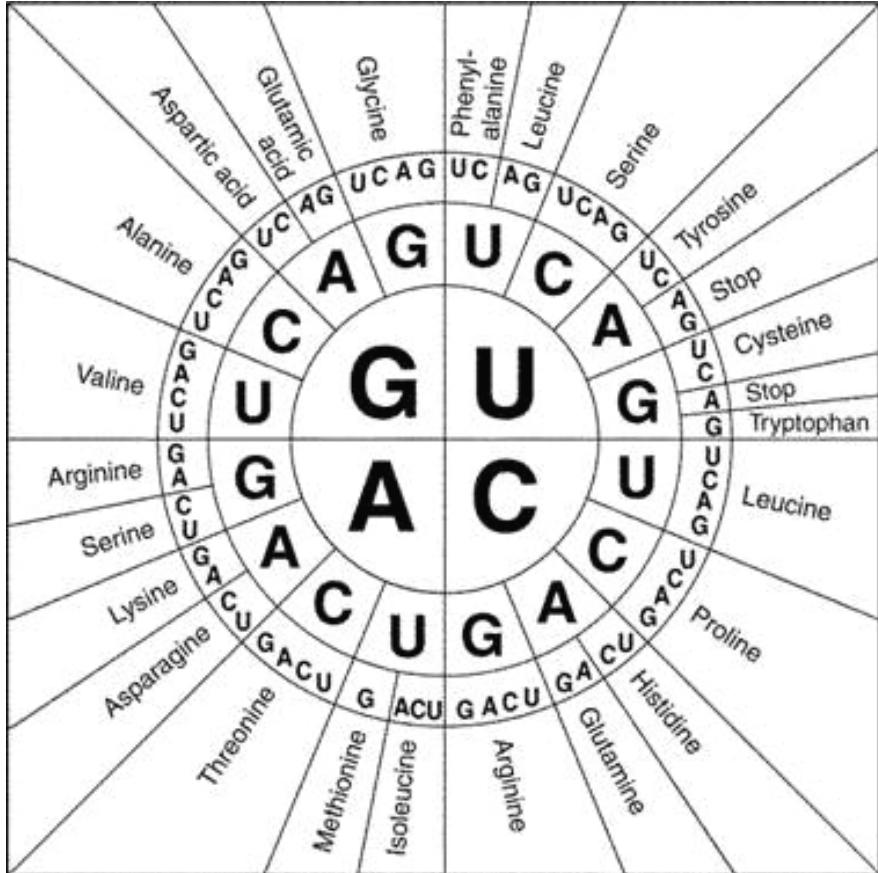
↓ **Transcription of antisense strand**

5' ... A U G G C C U G G A C U U C A ... 3' **mRNA**

↓ **Translation of mRNA**

Met—

Peptide



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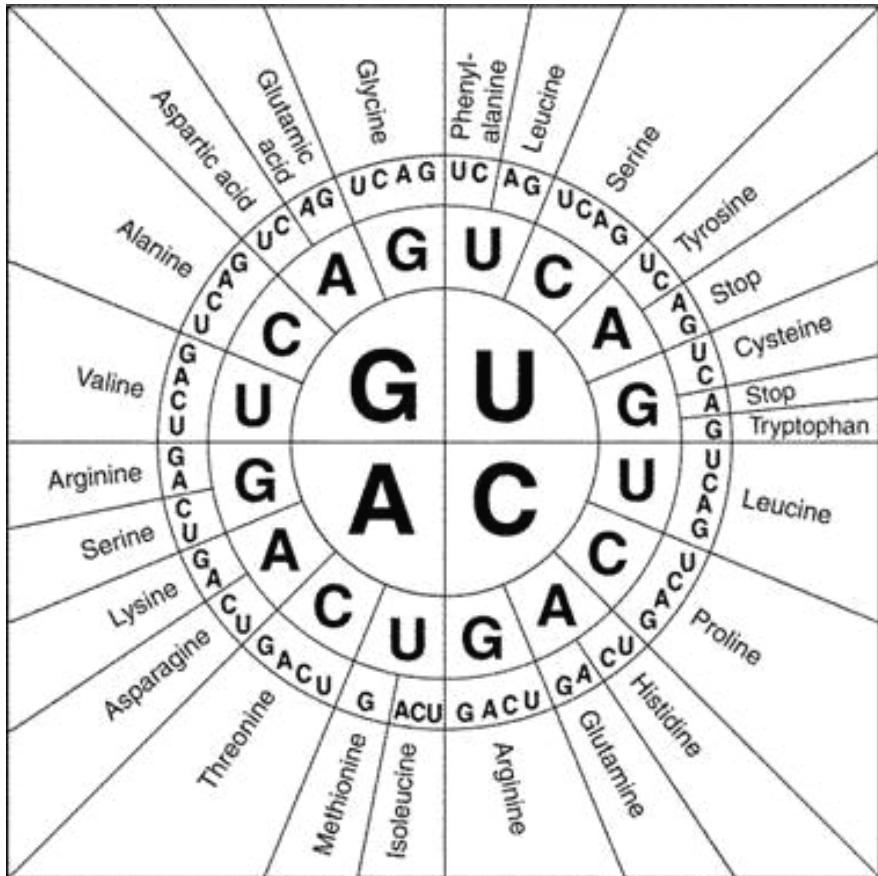
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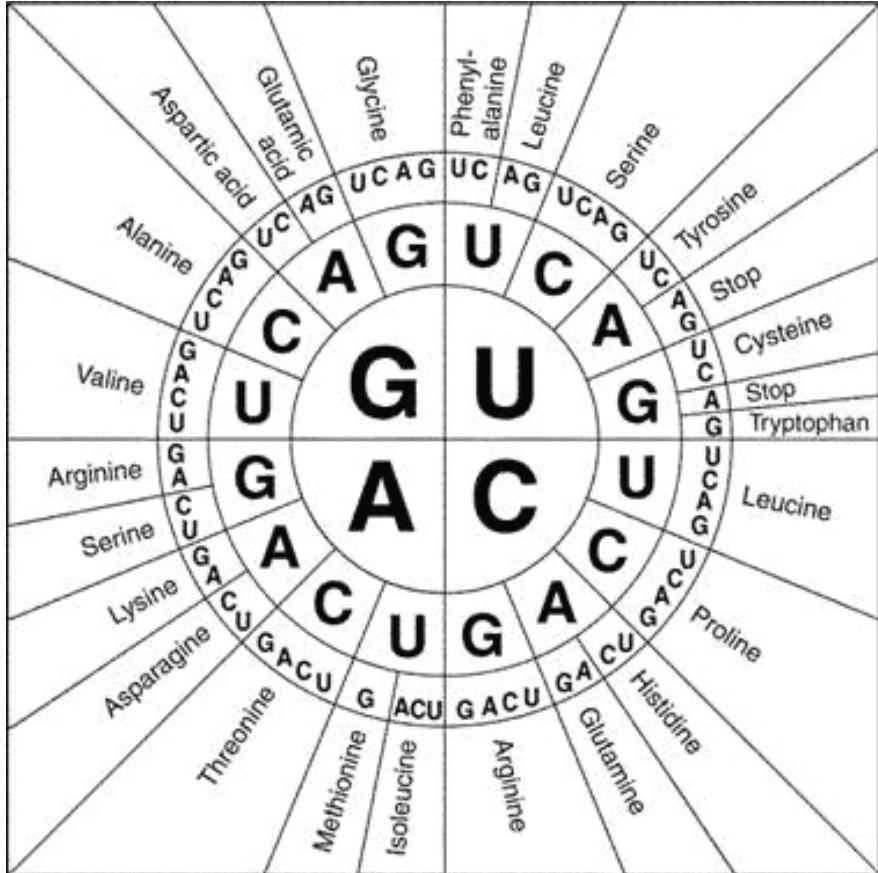
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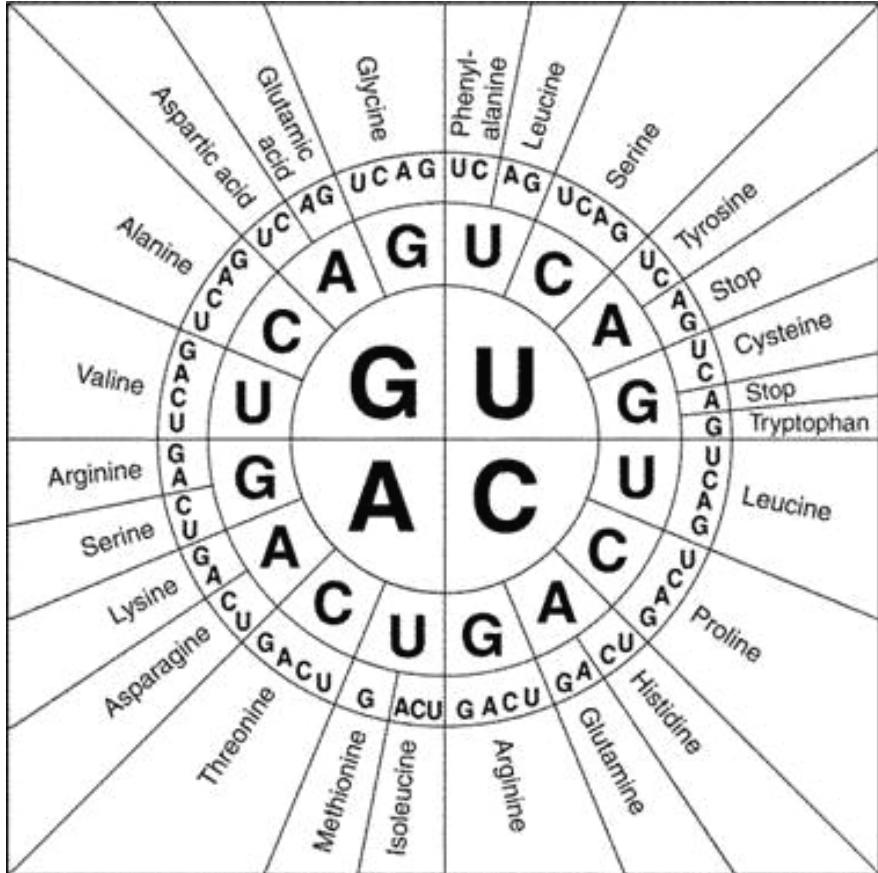
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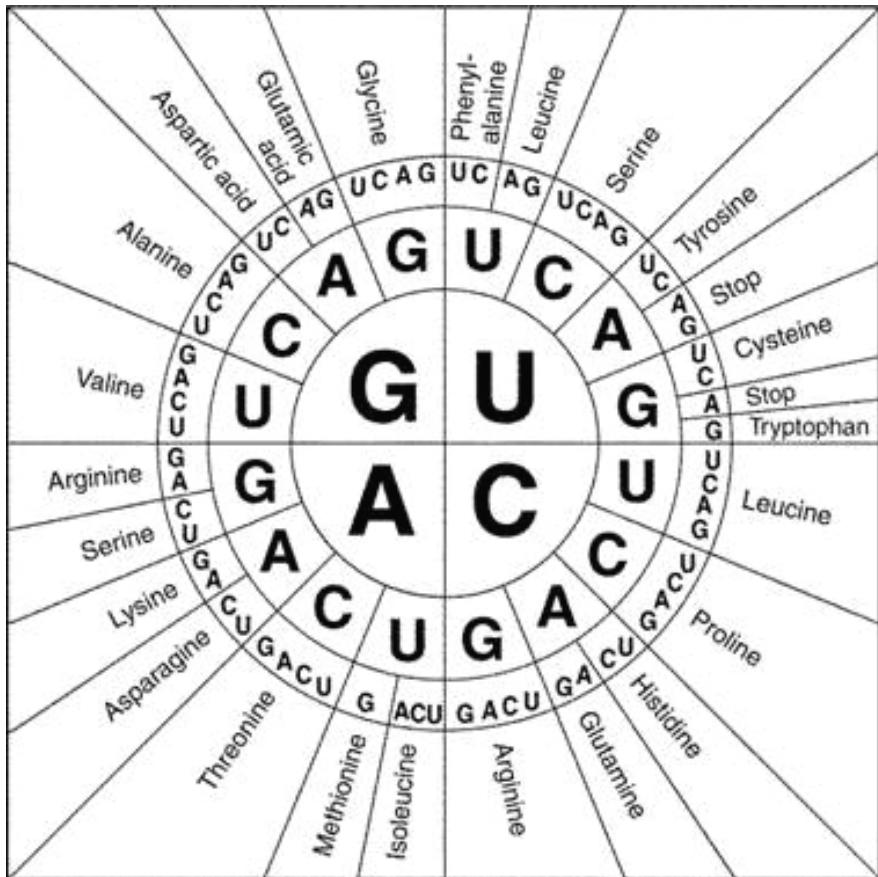
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5' ...A U G G C C U G G A C U U C A... 3' **mRNA**

↓ **Translation of mRNA**

Met—Ala—

Peptide



START always: ATG (AUG),
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5' ... A T G G C C T G G A C T T C A ... 3' **Sense strand of DNA**
3' ... T A C C G G A C C T G A A G T ... 5' **Antisense strand of DNA**

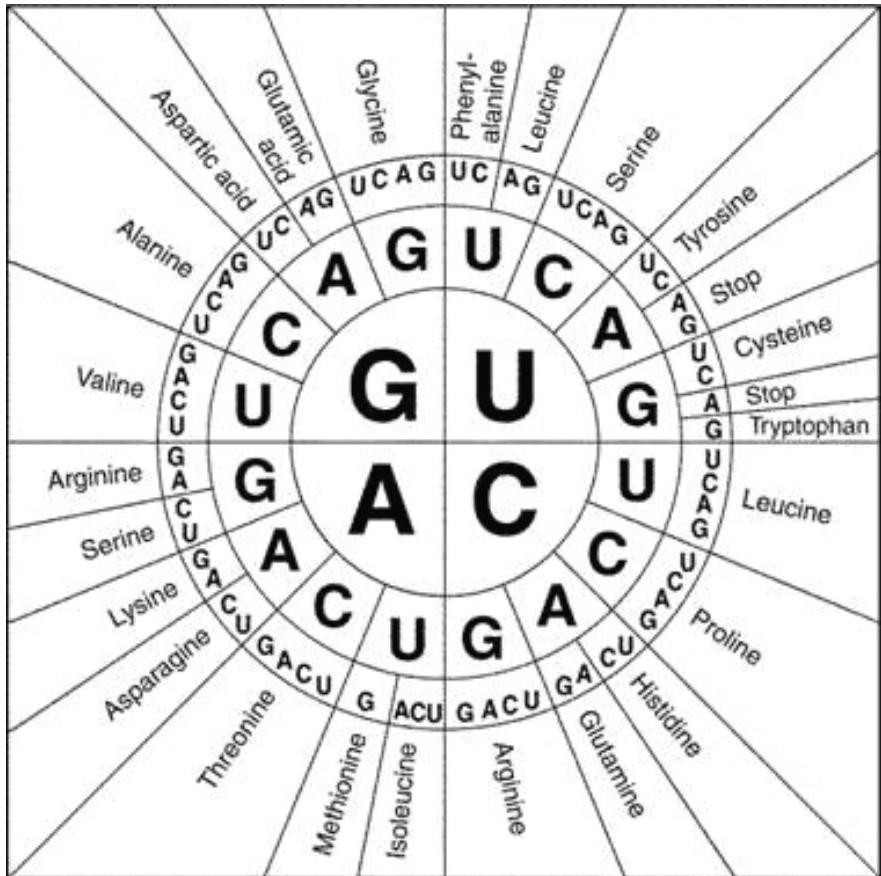
Transcription of antisense strand

5' ... A U G G C C U G G A C U U C A ... 3' **mRNA**

Translation of mRNA

Met—Ala—Trp—

Peptide



START always: ATG (AUG),
Methionine
STOP: TAA, TAG, TGA (UAA ,UAG,
UGA)

5' ... A T G G C C T G G A C T T C A... 3' **Sense strand of DNA**
 3' ... T A C C G G A C C T G A A G T... 5' **Antisense strand of DNA**

↓ **Transcription of antisense strand**

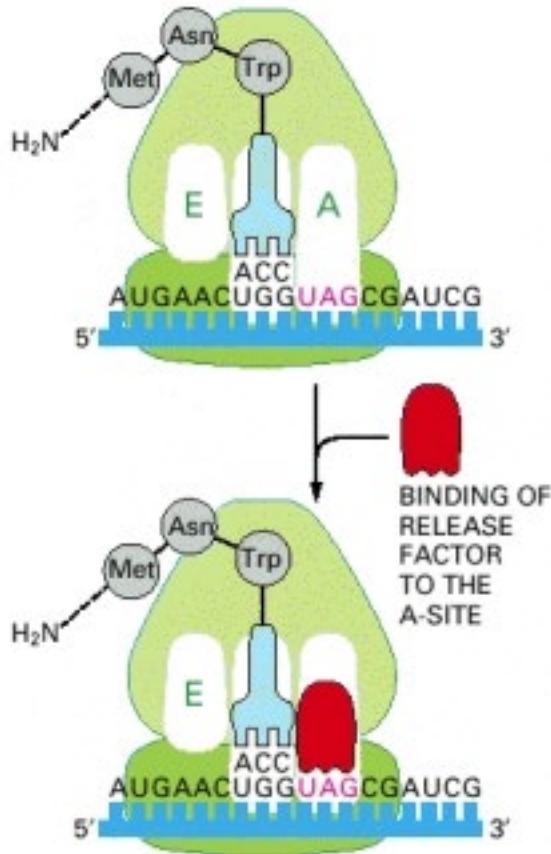
5' ... A U G G C C U G G A C U U C A... 3' **mRNA**

↓ **Translation of mRNA**

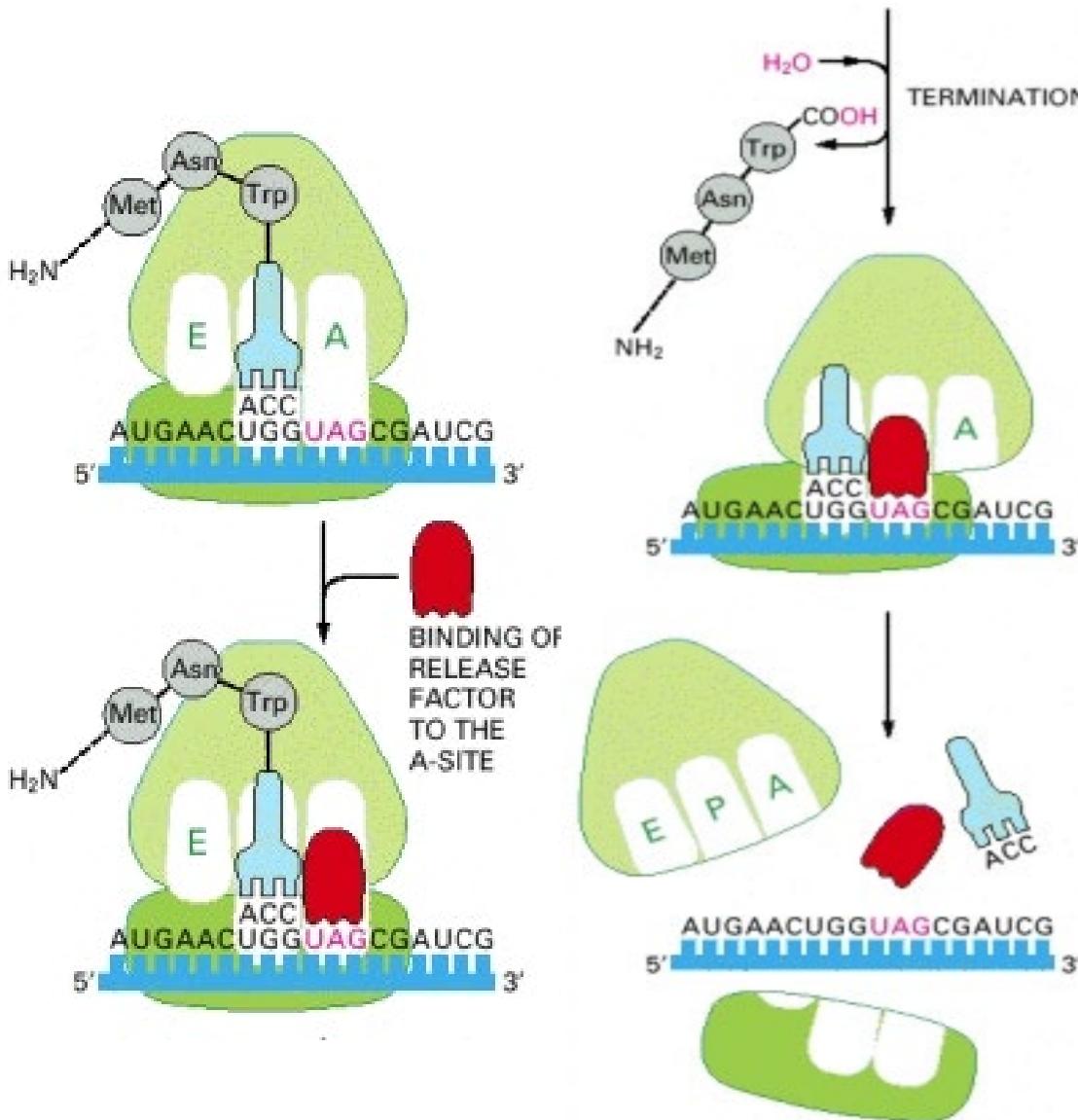
Met—Ala—Trp—Thr

Peptide

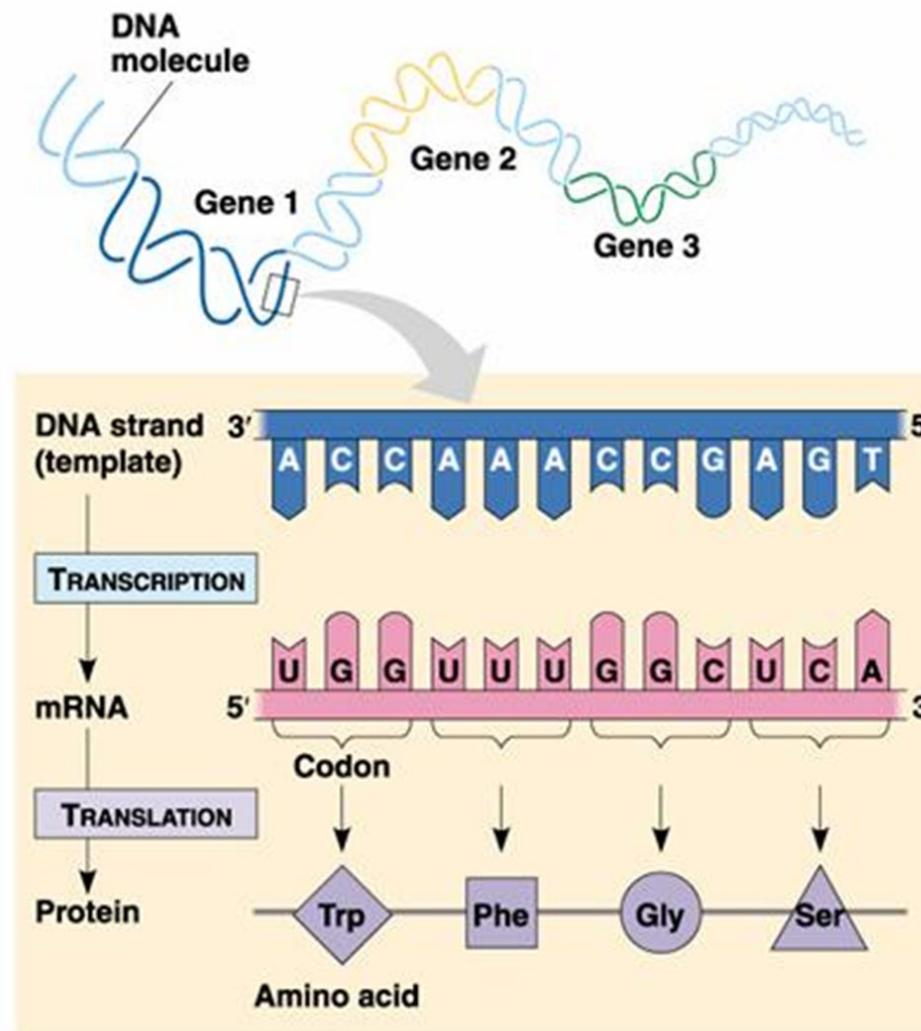
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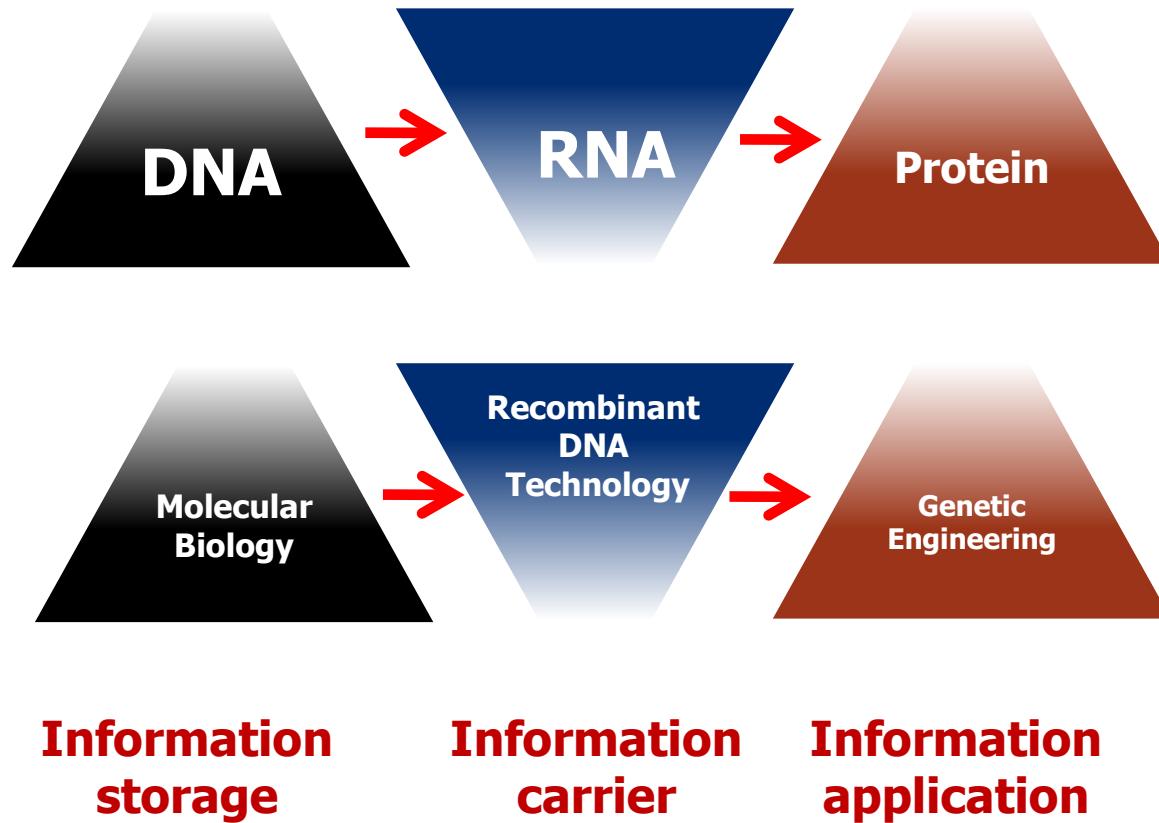
Cracking the code - Translation



The DNA – protein paradigm



Central dogma of Molecular Biology





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