History

1859 Evolution Theory by Natural Selection. Charles Darwin & Alfred R. Wallace.

1865 Heredity Transmitted in Units. Gregor Mendel.

1869 DNA Isolated. Frederick Miescher.

1879 Mitosis Described. Walter Flemming.

1900 Rediscovery of Mendel's work. Botanists DeVries, Correns, and von Tschermak independently rediscover Mendel's work while doing their own work on the laws of inheritance.

1902 Chromosome Theory of Inheritance (Meiosis). Walter Sutton.

1902 Orderly Inheritance of Disease. A British physician, Archibald Garrod, observes that the disease alkaptonuria is inherited according to Mendelian rules.

1909 The Word Gene. Wilhelm Johannsen coins the word "gene".

1911 Chromosomes Carry Genes. Thomas Hunt Morgan and his students study fruit fly chromosomes.

1941 One Gene, One Enzyme Hypothesis. George Beadle and Edward Tatum's experiments.

1943 DNA Has a Regular Periodic Structure. William Astbury, a British scientist, obtains the first X-ray diffraction pattern of DNA, which reveals that DNA must have a regular periodic structure.

1944 DNA Transforms Cells. Oswald Avery, Colin MacLeod, and Maclyn McCarty show that DNA (not proteins) can transform the properties of cells --thus clarifying the chemical nature of genes.

1944 Jumping Genes. Barbara McClintock.

1952 Genes Are Made of DNA. Alfred Hershey & Martha Chase show that only the DNA of a virus needs to enter a bacterium to infect it, providing strong support for the idea that genes are made of DNA.

1953 DNA Double Helix. Francis H. Crick and James D. Watson described the double helix structure of DNA.

1955 DNA copying enzyme. Arthur Kornberg and colleagues isolated DNA polymerase.

1958 Semiconservative Replication of DNA. Matthew Meselson and Franklin Stahl demonstrate that DNA replicates semiconservatively.

1961 mRNA Ferries Information. Sydney Brenner, François Jacob and Matthew Meselson discover that mRNA takes information from DNA in the nucleus to the protein-making machinery in the cytoplasm.

1966 Genetic Code Cracked. Marshall Nirenberg and others figure out the genetic code that allows nucleic acids with their 4 letter alphabet to determine the order of 20 kinds of amino acids in proteins.

1968 First Restriction Enzyme Described.

1972 First recombinant DNA.

1973 First animal gene cloned. Researchers fuse a segment of DNA containing a gene from the African clawed frog *Xenopus* with DNA from the bacterium *E. coli* and placed the resulting DNA back into an *E. coli* cell.

1975 DNA Sequencing. Two groups, Frederick Sanger and colleagues, and Alan Maxam and Walter Gilbert, both develop rapid DNA sequencing methods. The Sanger method is most commonly employed in the lab today.

1976 First Genetic Engineering Company. Herbert Boyer founds Genentech. The company produces the first human protein in a bacterium, and by 1982 markets the first recombinant DNA drug, human insulin.

1977 Introns Discovered. Richard Roberts' and Phil Sharp's labs show that eukaryotic genes contain many interruptions called introns.

1981 First Transgenic Mice and Fruit Flies.

1982 GenBank Database Formed.

1983 PCR Invented.

1987 Yeast Artificial Chromosomes.

1989 Microsatellites Are New Genetic Markers.

1991 ESTs, Fragments of Genes.

1993 miRNA.

1994 FLAVR SAVR Tomato. The Food And Drug Administration.

1996 Dolly Sheep.

1997 *E. coli* Genome Sequenced.

1998 *M. tuberculosis* Bacterium and Roundworm *C. elegans* Sequenced.

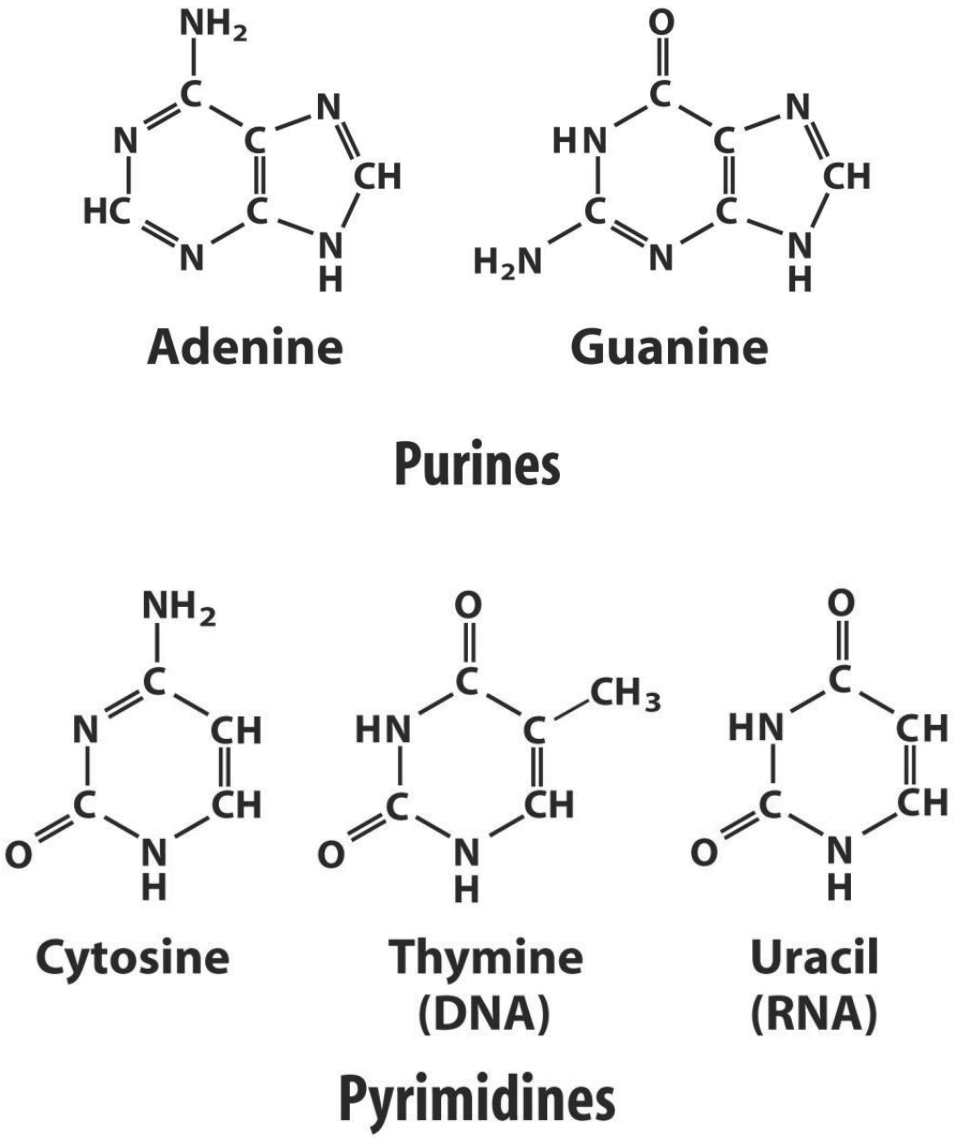
2000 Human Genome Working Draft Completed.

2003 Completion of the Human Genome Sequencing.

2005 Next Generation Sequencing.

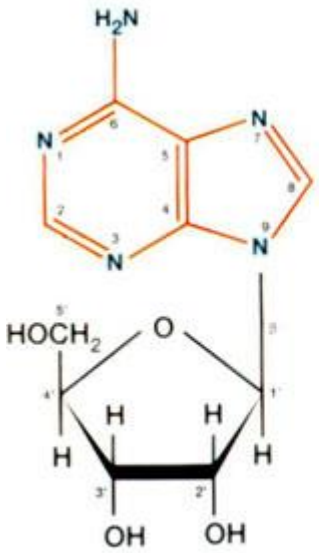
2013 CRISPR

Nucleósidos y Nucleótidos

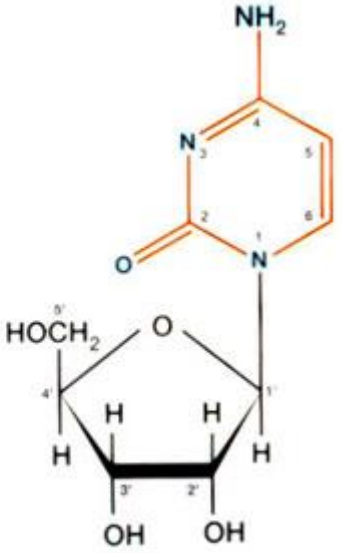


IUPAC nucleotide code	Base
A	Adenine
C	Cytosine
G	Guanine
T (or U)	Thymine (or Uracil)
R (Purine)	A or G
Y (Pyrimidine)	C or T
S	G or C
W	A or T
K	G or T
M	A or C
B	C or G or T
D	A or G or T
H	A or C or T
V	A or C or G
N	any base
-	gap

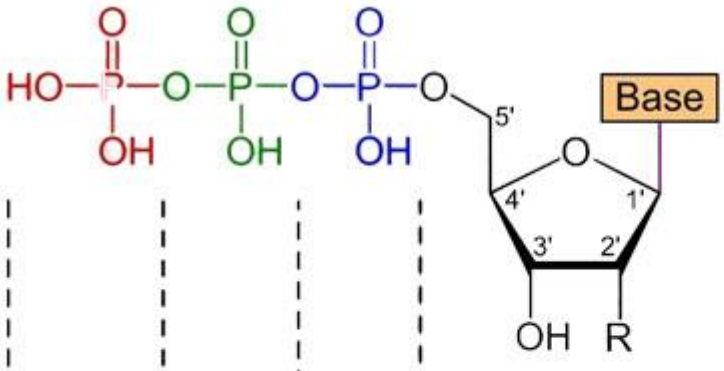
Nucleósidos y Nucleótidos



Adenosina



Citidina



Pentosa
R=OH: Ribosa
R=H: Desoxirribosa

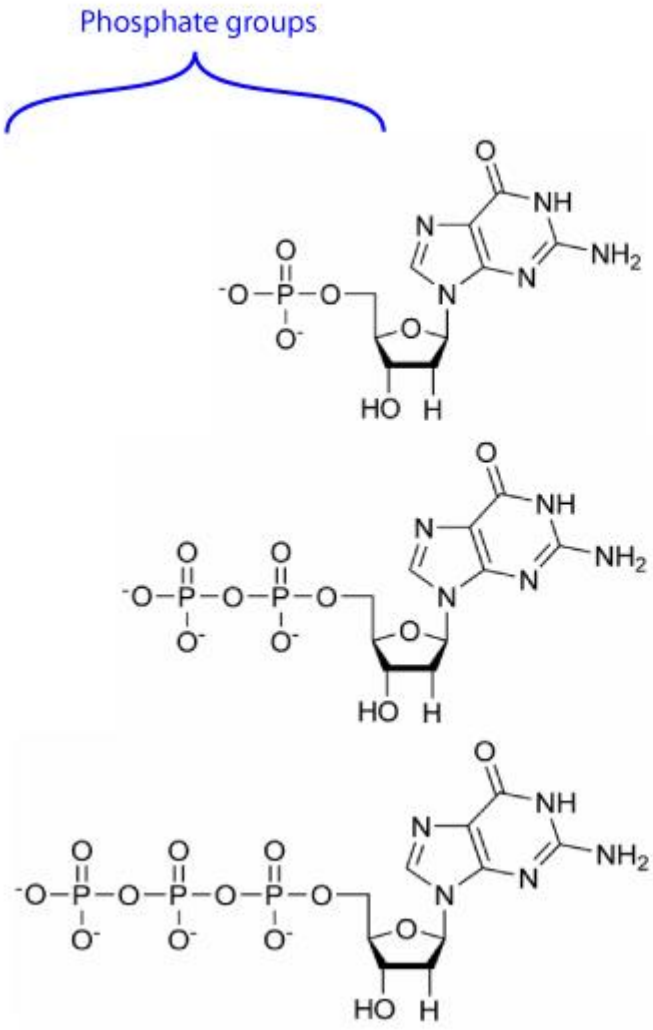
Nucleósido

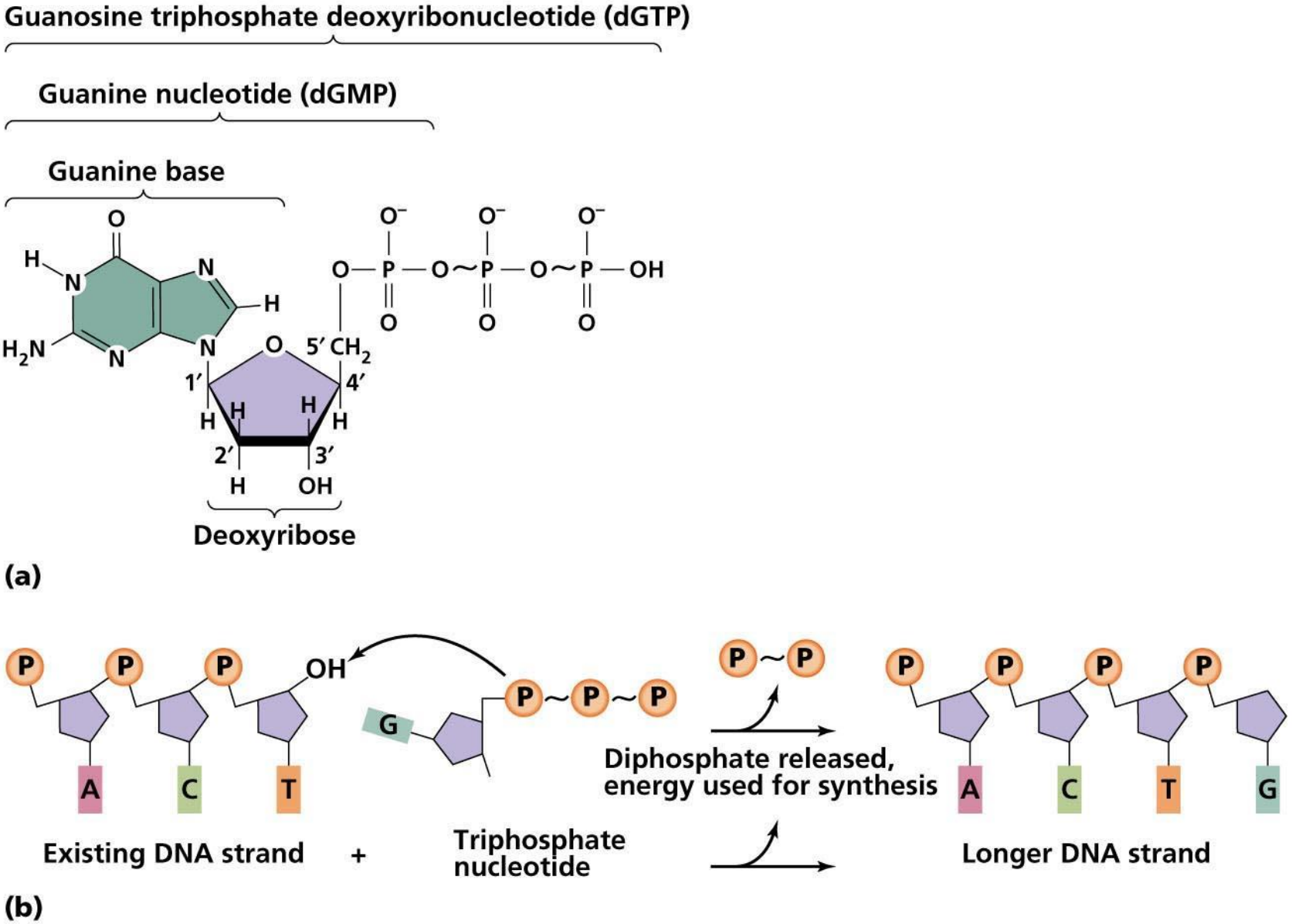
Nucleótido monofosfato

Nucleótido difosfato

Nucleótido trifosfato

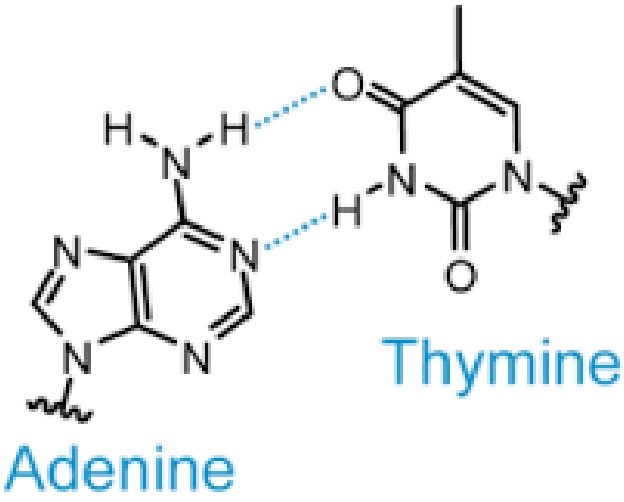
} Nucleótido

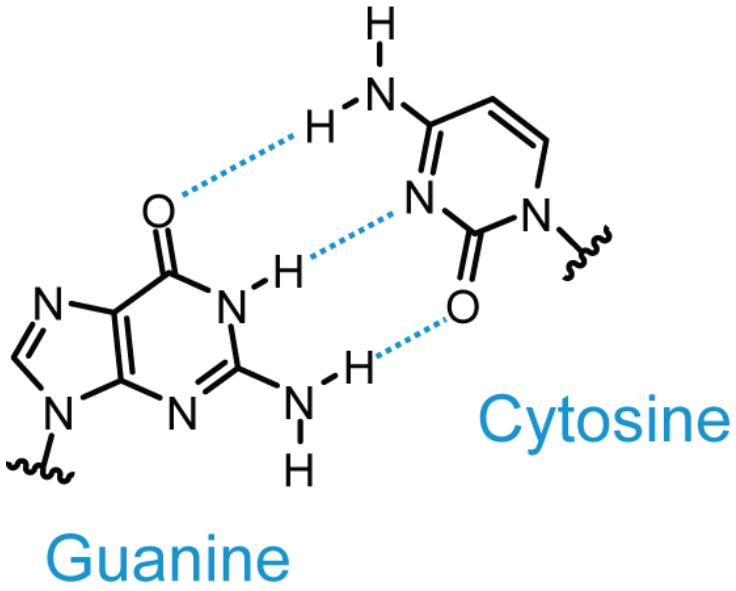

Phosphate groups
Monophosphate Nucleotide
Diphosphate Nucleotide
Triphosphate Nucleotide
Only nucleotides that are "triphosphate" can be used for DNA synthesis.



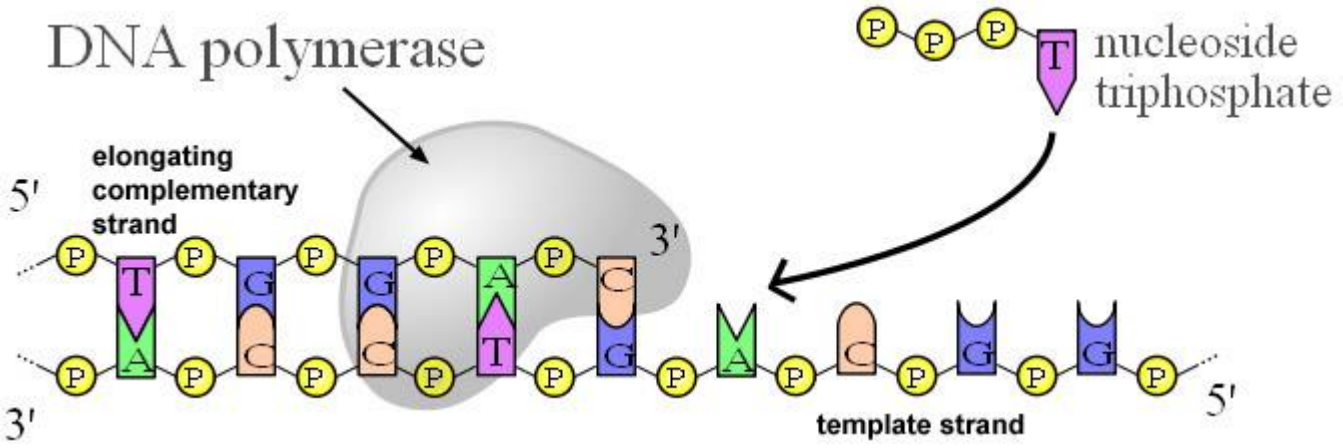
Relative Proportions (%) of Bases in DNA

Organism	A	T	G	C
Human	30.9	29.4	19.9	19.8
Chicken	28.8	29.2	20.5	21.5
Yeast	31.3	32.9	18.7	17.1
E. coli	24.7	23.6	26.0	25.7

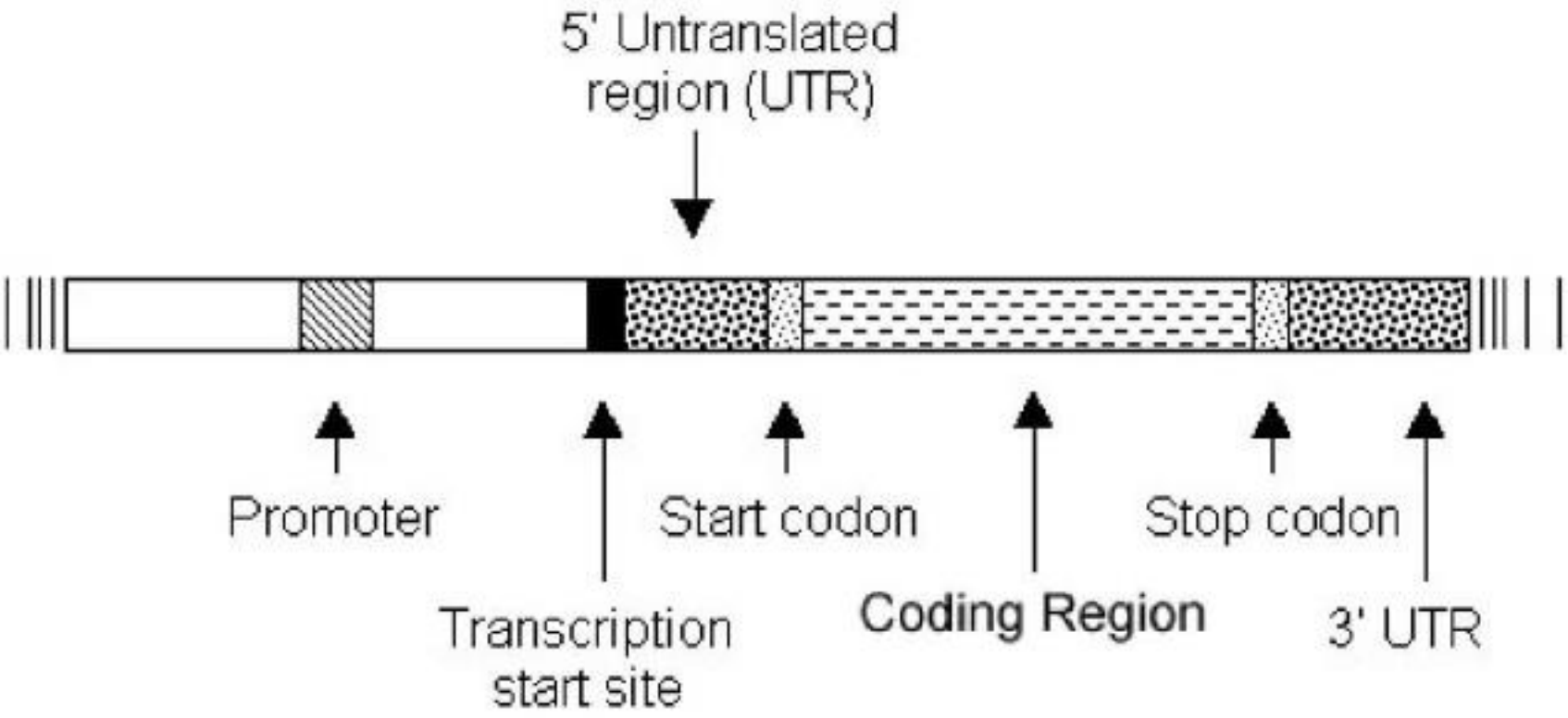




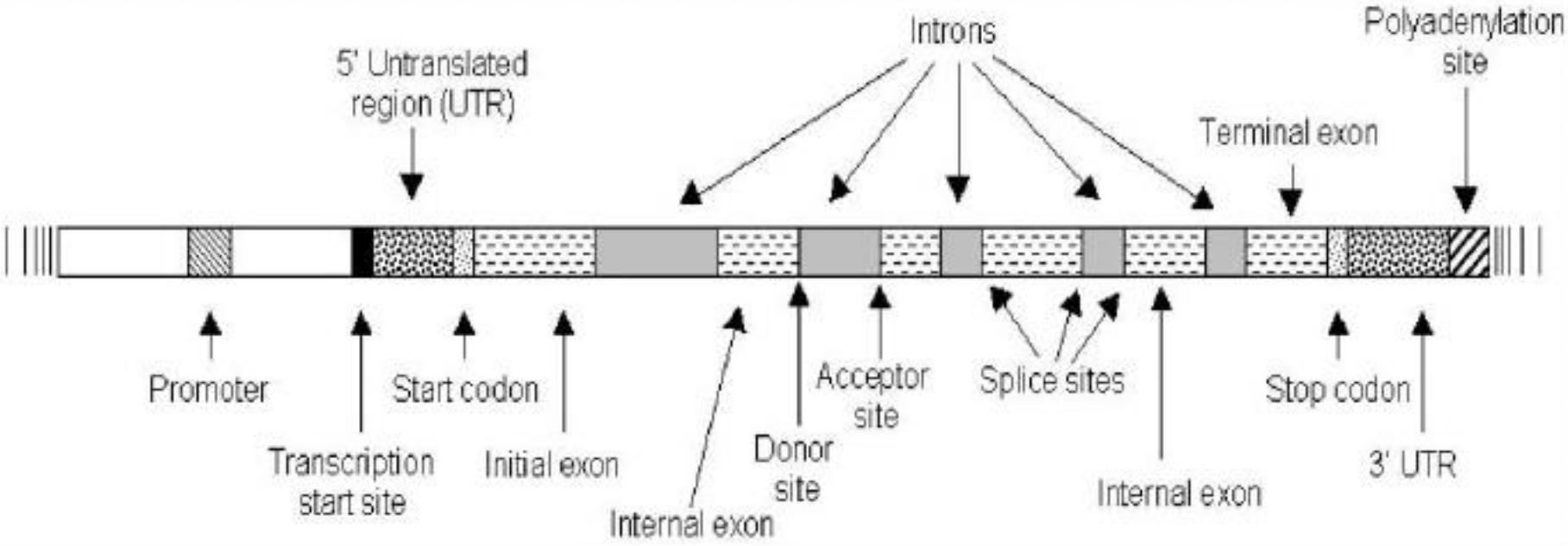
DNA synthesis



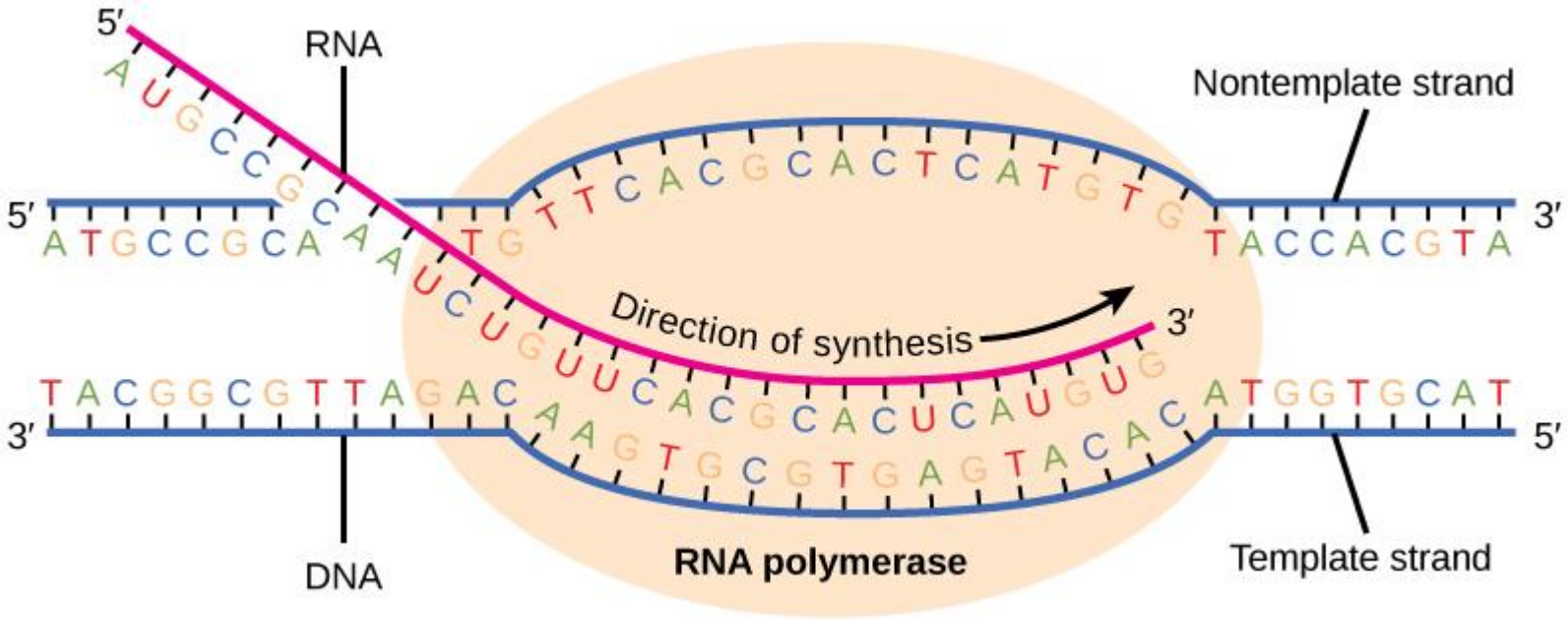
Prokaryotes gene structure



Eukaryotes gene structure



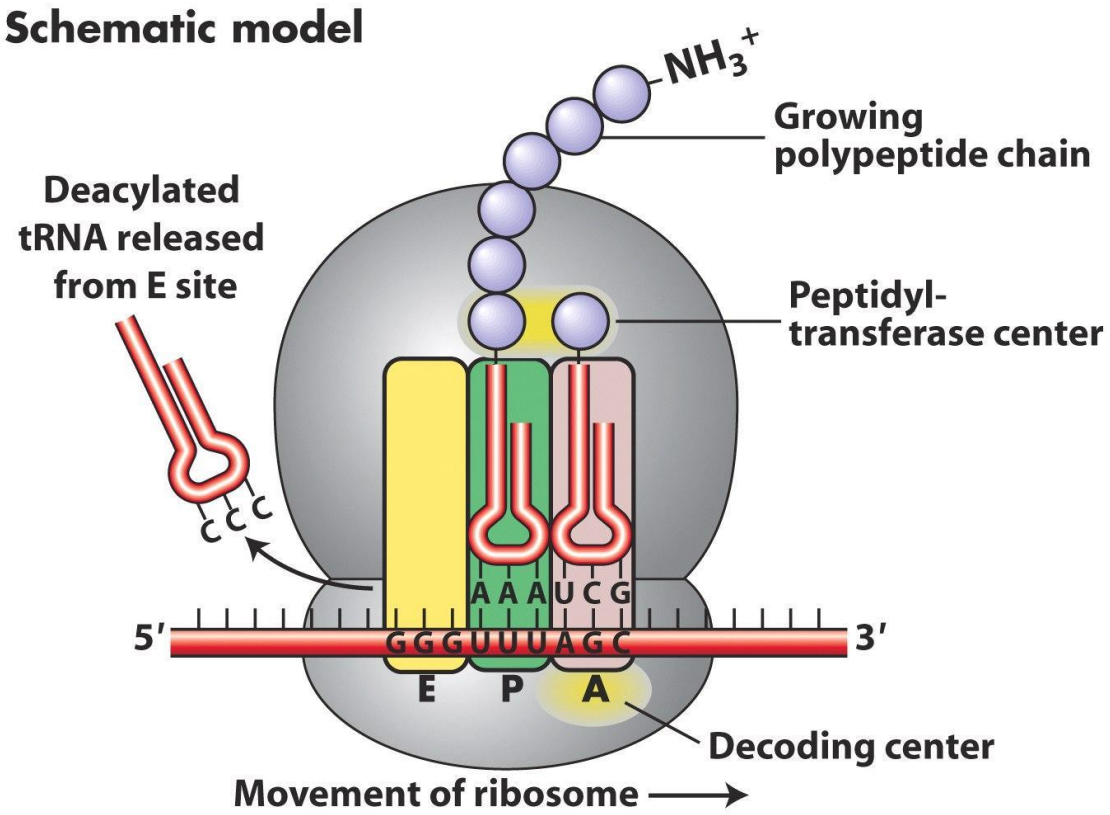
RNA transcription



Protein synthesis

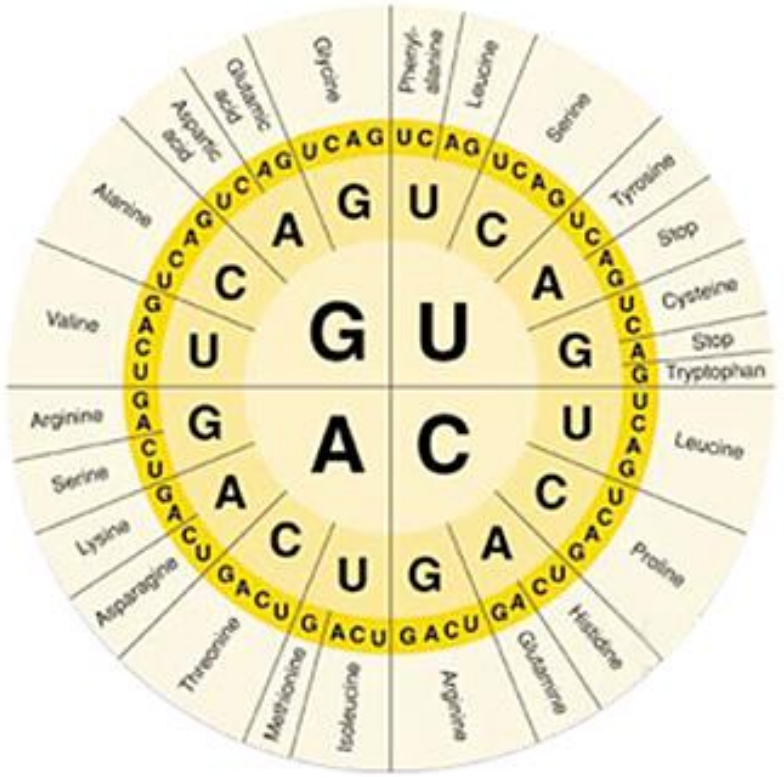
Eukaryote: cap dependent

Prokaryote: RBS



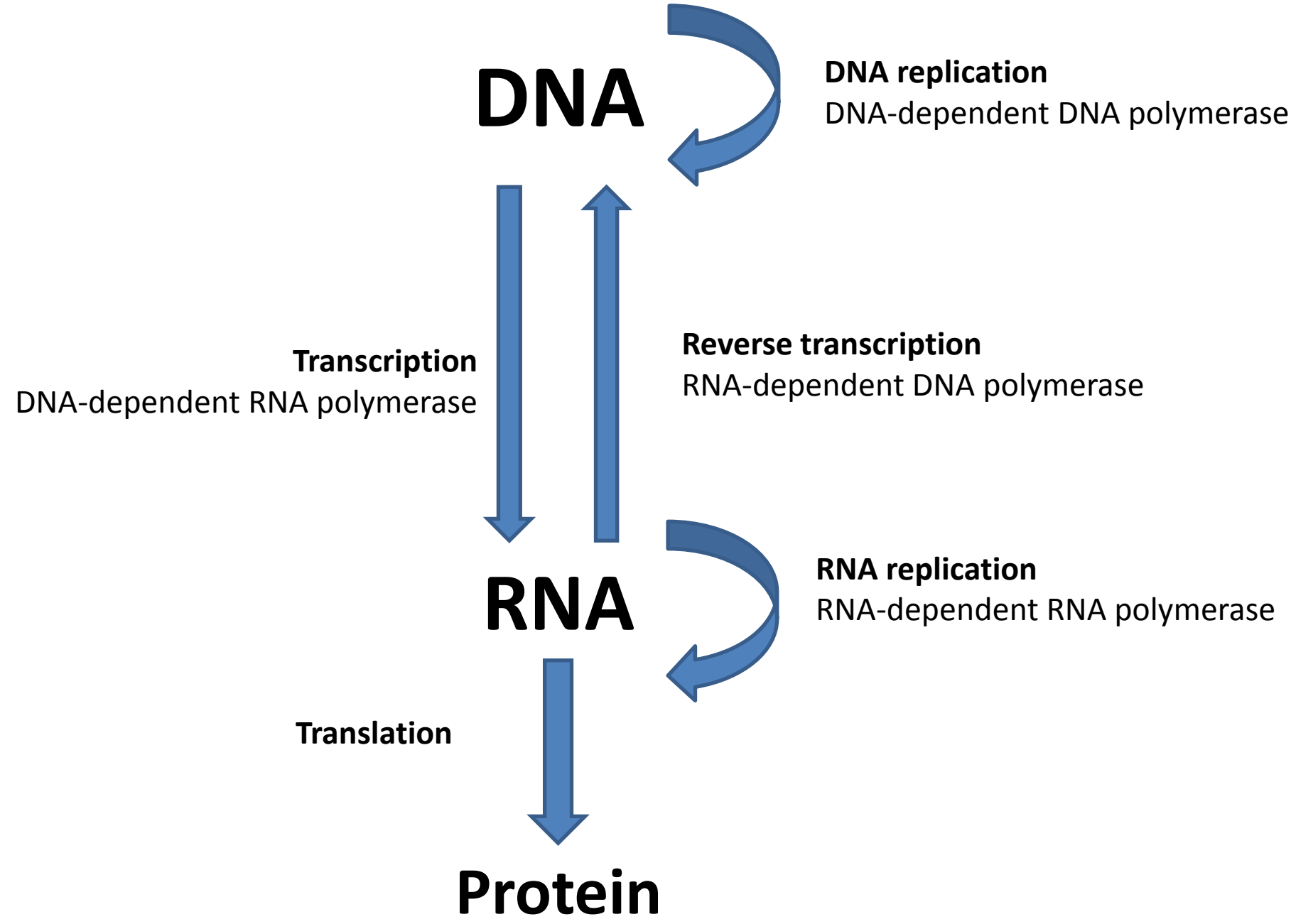
Genetic code

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



CODON USAGE IN *E. COLI* GENES[1]

	Codon	Amino acid[2]	%[3]	Ratio[4]	Codon	Amino acid	%	Ratio	Codon	Amino acid	%	Ratio	Codon	Amino acid	%	Ratio	
U	UUU	Phe (F)	1.9	0.51	UCU	Ser (S)	1.1	0.19	UAU	Tyr (Y)	1.6	0.53	UGU	Cys (C)	0.4	0.43	**U**
	UUC	Phe (F)	1.8	0.49	UCC	Ser (S)	1.0	0.17	UAC	Tyr (Y)	1.4	0.47	UGC	Cys (C)	0.6	0.57	**C**
	UUA	Leu (L)	1.0	0.11	UCA	Ser (S)	0.7	0.12	UAA	STOP	0.2	0.62	UGA	STOP	0.1	0.30	**A**
	UUG	Leu (L)	1.1	0.11	UCG	Ser (S)	0.8	0.13	UAG	STOP	0.03	0.09	UGG	Trp (W)	1.4	1.00	**G**
C	CUU	Leu (L)	1.0	0.10	CCU	Pro (P)	0.7	0.16	CAU	His (H)	1.2	0.52	CGU	Arg (R)	2.4	0.42	**U**
	CUC	Leu (L)	0.9	0.10	CCC	Pro (P)	0.4	0.10	CAC	His (H)	1.1	0.48	CGC	Arg (R)	2.2	0.37	**C**
	CUA	Leu (L)	0.3	0.03	CCA	Pro (P)	0.8	0.20	CAA	Gln (Q)	1.3	0.31	CGA	Arg (R)	0.3	0.05	**A**
	CUG	Leu (L)	5.2	0.55	CCG	Pro (P)	2.4	0.55	CAG	Gln (Q)	2.9	0.69	CGG	Arg (R)	0.5	0.08	**G**
A	AUU	Ile (I)	2.7	0.47	ACU	Thr (T)	1.2	0.21	AAU	Asn (N)	1.6	0.39	AGU	Ser (S)	0.7	0.13	**U**
	AUC	Ile (I)	2.7	0.46	ACC	Thr (T)	2.4	0.43	AAC	Asn (N)	2.6	0.61	AGC	Ser (S)	1.5	0.27	**C**
	AUA	Ile (I)	0.4	0.07	ACA	Thr (T)	0.1	0.30	AAA	Lys (K)	3.8	0.76	AGA	Arg (R)	0.2	0.04	**A**
	AUG	Met (M)	2.6	1.00	ACG	Thr (T)	1.3	0.23	AAG	Lys (K)	1.2	0.24	AGG	Arg (R)	0.2	0.03	**G**
G	GUU	Val (V)	2.0	0.29	GCU	Ala (A)	1.8	0.19	GAU	Asp (D)	3.3	0.59	GGU	Gly (G)	2.8	0.38	**U**
	GUC	Val (V)	1.4	0.20	GCC	Ala (A)	2.3	0.25	GAC	Asp (D)	2.3	0.41	GGC	Gly (G)	3.0	0.40	**C**
	GUA	Val (V)	1.2	0.17	GCA	Ala (A)	2.1	0.22	GAA	Glu (E)	4.4	0.70	GGA	Gly (G)	0.7	0.09	**A**
	GUG	Val (V)	2.4	0.34	GCG	Ala (A)	3.2	0.34	GAG	Glu (E)	1.9	0.30	GGG	Gly (G)	0.9	0.13	**G**
		U				**C**				**A**				**G**			


DNA
DNA replication
DNA-dependent DNA polymerase
Transcription
DNA-dependent RNA polymerase
Reverse transcription
RNA-dependent DNA polymerase
RNA
RNA replication
RNA-dependent RNA polymerase
Translation
Protein