The Genetic Code

	A Ala	R Arg	N Asn	D Asp	C Cys	Q Gln	E Glu	G Gly	H His	I Ile	L Leu	K Lys	M Met	F Phe	P Pro	S Ser	T Thr	W Trp	Y Tyr	V Val	
5´	GCA C G U	CGA C G U or AGA G	AAC U	GAC U	UGC U	CAA G	GAA G	GGA C G U	CAC U	AUA C U	CUA C G U or UUA G	AAA G	AUG	UUC U	CCA C G U	UCA C G U or AGC U	ACA C G U	UGG	UAC U	GUA C G U	3´

Second Position

First Position (5´end)	U	C	A	G	Third Position (3´ end)
U	UUU Phe UUC Phe UUA Leu UUG Leu	UCU Ser UCC Ser UCA Ser UCG Ser	UAU Tyr UAC Tyr UAA Stop UAG Stop	UGU Cys UGC Cys UGA Stop UGG Trp	U C A G
C	CUU Leu CUC Leu CUA Leu CUG Leu	CCU Pro CCC Pro CCA Pro CCG Pro	CAU His CAC His CAA Gln CAG Gln	CGU Arg CGC Arg CGA Arg CGG Arg	U C A G
A	AUU Ile AUC Ile AUA Ile AUG Met	ACU Thr ACC Thr ACA Thr ACG Thr	AAU Asn AAC Asn AAA Lys AAG Lys	AGU Ser AGC Ser AGA Arg AGG Arg	U C A G
G	GUU Val GUC Val GUA Val GUG Val	GCU Ala GCC Ala GCA Ala GCG Ala	GAU Asp GAC Asp GAA Glu GAG Glu	GGU Gly GGC Gly GGA Gly GGG Gly	U C A G

Termination Signals

UAA (Ochre)
UAG (Amber)
UGA (Opal)

Single Letter Code

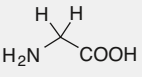
A = adenosine
C = cytidine
G = guanosine
T = thymidine
U = uridine

B = C or G or T
D = A or G or T
H = A or C or T
K = G or T
M = A or C
N = A or C or G or T
R = A or G
S = C or G
V = A or C or G
W = A or T
Y = C or T

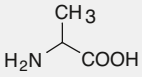
Amino Acid Structures

Each amino acid is accompanied by its three- and one-letter code, residue molecular weight (actual molecular weight minus water) and side-chain pK_a where appropriate.

SMALL

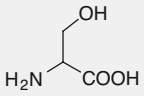


Glycine (Gly, G)
MW: 75.07

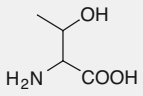


Alanine (Ala, A)
MW: 89.09

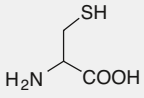
NUCLEOPHILIC



Serine (Ser, S)
MW: 105.09, pK_a ~ 16

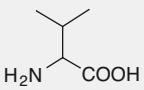


Threonine (Thr, T)
MW: 119.1, pK_a ~ 16

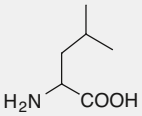


Cysteine (Cys, C)
MW: 121.2, pK_a = 8.18

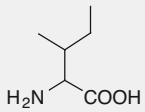
HYDROPHOBIC



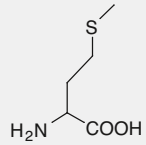
Valine (Val, V)
MW: 117.1



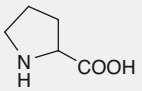
Leucine (Leu, L)
MW: 131.2



Isoleucine (Ile, I)
MW: 131.2

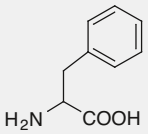


Methionine (Met, M)
MW: 149.2

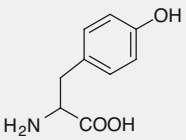


Proline (Pro, P)
MW: 115.1

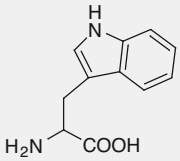
AROMATIC



Phenylalanine (Phe, F)
MW: 165.2

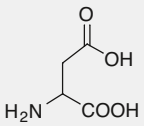


Tyrosine (Tyr, Y)
MW: 181.2, pK_a = 10.46

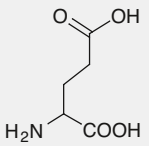


Tryptophan (Trp, W)
MW: 204.2

ACIDIC

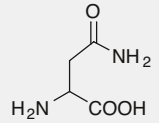


Aspartic Acid (Asp, D)
MW: 133.1, pK_a = 3.9

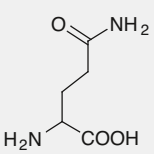


Glutamic Acid (Glu, E)
MW: 147.1, pK_a = 4.07

AMIDE

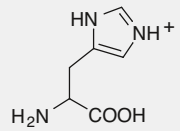


Asparagine (Asn, N)
MW: 132.1

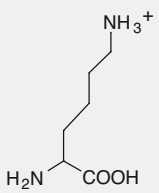


Glutamine (Gln, Q)
MW: 146.1

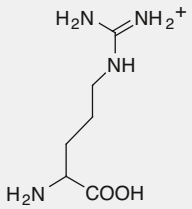
BASIC



Histidine (His, H)
MW: 155.2, pK_a = 6.04



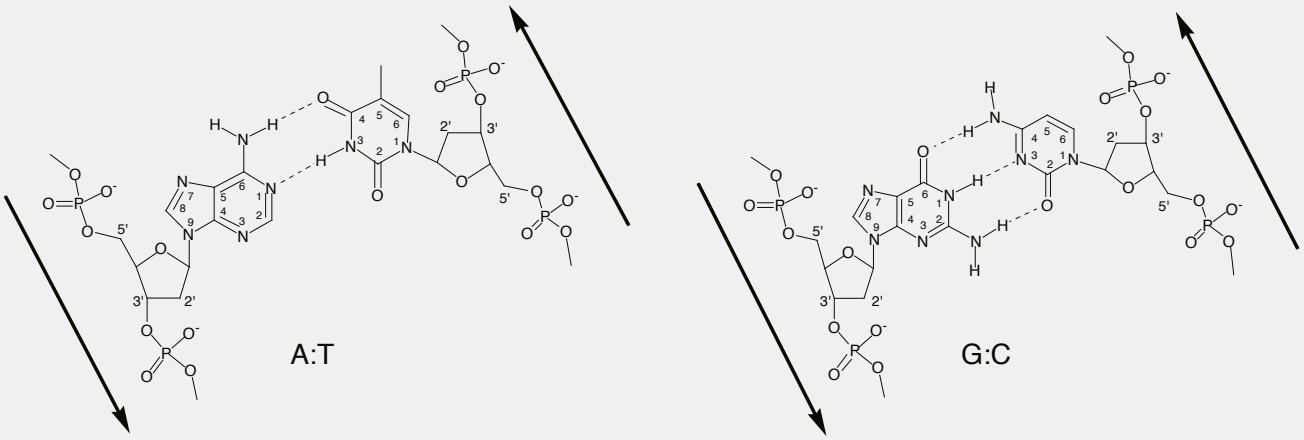
Lysine (Lys, K)
MW: 146.2, pK_a = 10.79



Arginine (Arg, R)
MW: 174.2, pK_a = 12.48

DNA Base Pairs

The structures of the adenosine:thymidine and guanosine:cytidine base pairs are shown in the context of the ribose phosphodiester backbones. The numbering schemes of the ribose and nucleotide moieties are indicated. Arrows indicate the polarity of each strand from 5´ to 3´.



Nucleic Acid Data

Average weight of a DNA basepair (sodium salt) = 650 daltons

1.0 A_{260} unit ds DNA = 50 µg/ml = 0.15 mM (in nucleotides)
1.0 A_{260} unit ss DNA = 33 µg/ml = 0.10 mM (in nucleotides)
1.0 A_{260} unit ss RNA = 40 µg/ml = 0.11 mM (in nucleotides)

MW of a double-stranded DNA molecule = (# of base pairs) x (650 daltons/base pair)
Moles of ends of a double-stranded DNA molecule = 2 x (grams of DNA) / (MW in daltons)
Moles of ends generated by restriction endonuclease cleavage:
a) circular DNA molecule: 2 x (moles of DNA) x (number of sites)
b) linear DNA molecule: 2 x (moles of DNA) x (number of sites) + 2 x (moles of DNA)

1 µg of 1000 bp DNA = 1.52 pmol = 9.1×10^{11} molecules
1 µg of pUC18/19 DNA (2686 bp) = 0.57 pmol = 3.4×10^{11} molecules
1 µg of pBR322 DNA (4361 bp) = 0.35 pmol = 2.1×10^{11} molecules
1 µg of M13mp18/19 DNA (7249 bp) = 0.21 pmol = 1.3×10^{11} molecules
1 µg of λ DNA (48502 bp) = 0.03 pmol = 1.8×10^{10} molecules

1 pmol of 1000 bp DNA = 0.66 µg
1 pmol of pUC18/19 DNA (2686 bp) = 1.77 µg
1 pmol of pBR322 DNA (4361 bp) = 2.88 µg
1 pmol of M13mp18/19 DNA (7249 bp) = 4.78 µg
1 pmol of λ DNA (48502 bp) = 32.01 µg

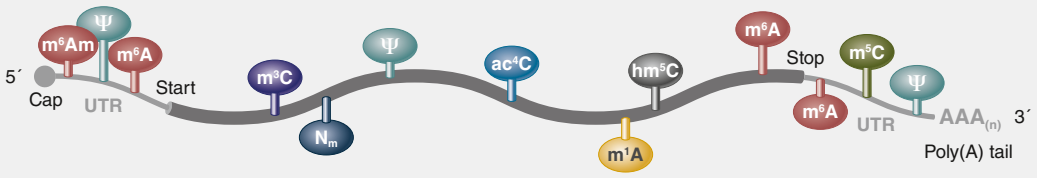
1.0 kb DNA = coding capacity for 333 amino acids ≈ 37,000 dalton protein
10,000 dalton protein ≈ 270 bp DNA
50,000 dalton protein ≈ 1.35 kb DNA

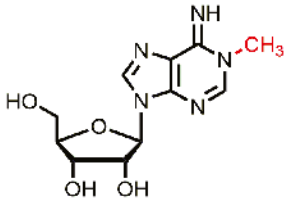
Isotope Data

Isotope	Particle Emitted	Half Life	
^{14}C	β	5,730 years	1 Ci = 1,000 mCi
^{3}H	β	12.3 years	1 mCi = 1,000 µCi
^{125}I	γ	60 days	1 µCi = 2.2×10^{6} disintegrations/minute
^{32}P	β	14.3 days	1 Becquerel = 1 disintegration/second
^{33}P	β	25 days	1 µCi = 3.7×10^{4} Becquerels
^{35}S	β	87.4 days	1 Becquerel = 2.7×10^{-5} µCi

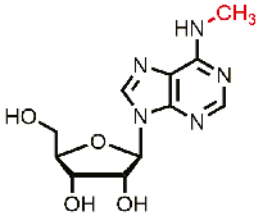
Messenger RNA Modifications

In nature, ribonucleic acid undergoes extensive chemical modification that can result in altered function or stability. The figure below shows examples of base and ribose modifications commonly found in native mRNAs

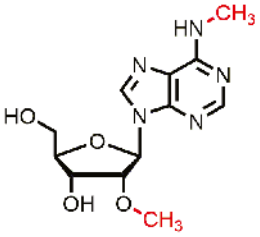




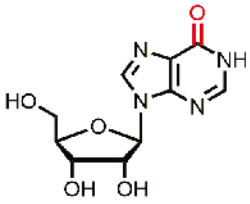
1-methyladenosine (m¹A) [1A]



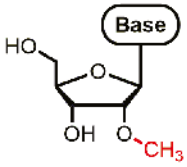
*N*⁶-methyladenosine (m⁶A) [6A]



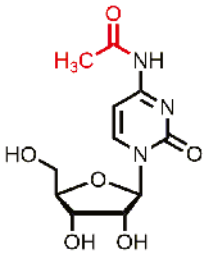
*N*⁶,2´-*O*-dimethyladenosine (m⁶Am) [06A]



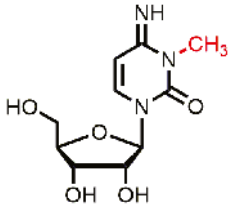
inosine (I) [9A]



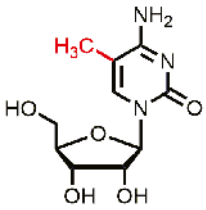
2´-*O*-methylnucleoside (Nm) [ON]



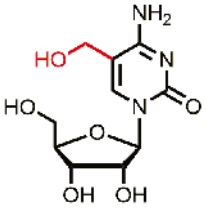
*N*⁴-acetylcytidine (ac⁴C) [42C]



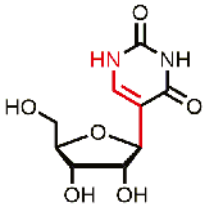
3-methylcytidine (m³C) [3C]



5-methylcytidine (m⁵C) [5C]



5-hydroxymethylcytidine (hm⁵C) [51C]



pseudouridine (Ψ) (9U)

Key:

Nucleoside Name (short name)
[new nomenclature]