Codons Found In Messenger RNA

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

An explanation of the Genetic Code: DNA is a two-stranded molecule. Each strand is a polynucleotide composed of **A** (adenosine), **T** (thymidine), **C** (cytidine), and **G** (guanosine) residues polymerized by "dehydration" synthesis in linear chains with specific sequences. Each strand has polarity, such that the 5'-hydroxyl (or 5'-phospho) group of the first nucleotide begins the strand and the 3'-hydroxyl group of the final nucleotide ends the strand; accordingly, we say that this strand runs 5' to 3' ("*Five prime to three prime*") . It is also essential to know that the two strands of DNA run *antiparallel* such that one strand runs 5' -> 3' while the other one runs 3' -> 5'. At each nucleotide residue along the double-stranded DNA molecule, the nucleotides are complementary. That is, **A** forms two hydrogen-bonds with **T**; **C** forms three hydrogen bonds with **G**. In most cases the two-stranded, antiparallel, complementary DNA molecule folds to form a helical structure which resembles a spiral staircase. This is the reason why DNA has been referred to as the "Double Helix".

One strand of DNA holds the information that codes for various genes; this strand is often called the template strand or antisense strand (containing anticodons). The other, and complementary, strand is called the coding strand or sense strand (containing codons). Since mRNA is made from the template strand, it has the same information as the coding strand. The table above refers to triplet nucleotide codons along the sequence of the coding or sense strand of DNA as it runs 5' -> 3'; the code for the mRNA would be identical but for the fact that RNA contains **U** (uridine) rather than **T**.

An example of two complementary strands of DNA would be:

(5' -> 3') **ATGGAATTCTCGCTC** (Coding, sense strand)
(3' <- 5') **TACCTTAAGAGCGAG** (Template, antisense strand)

(5' -> 3') **AUGGAAUUCUCGCUC** (mRNA made from Template strand)

Since amino acid residues of proteins are specified as triplet codons, the protein sequence made from the above example would be Met-Glu-Phe-Ser-Leu... (MEFSL...).

Practically, codons are "decoded" by transfer RNAs (tRNA) which interact with a ribosome-bound messenger RNA (mRNA) containing the coding sequence. There are 64 different tRNAs, each of which has an anticodon loop (used to recognize codons in the mRNA). 61 of these have a bound amino acyl residue; the appropriate "charged" tRNA binds to the respective next codon in the mRNA and the ribosome catalyzes the transfer of the amino acid from the tRNA to the growing (nascent) protein/polypeptide chain. The remaining 3 codons are used for "punctuation"; that is, they signal the termination (the end) of the growing polypeptide chain.

Lastly, the Genetic Code in the table above has also been called "The Universal Genetic Code". It is known as "universal", because it is used by all known organisms as a code for DNA, mRNA, and tRNA. The universality of the genetic code encompases animals (including humans), plants, fungi, archaea, bacteria, and viruses. However, all rules have their exceptions, and such is the case with the Genetic Code; small variations in the code exist in mitochondria and certain microbes. Nonetheless, it should be emphasized that these variances represent only a small fraction of known cases, and that the Genetic Code applies quite broadly, certainly to all known nuclear genes.

Codon Tables

Third Position

First Position	Second Position	A	C	G	U
	AA	Lys	Asn	Lys	Asn
F	AC	Thr	Thr	Thr	Thr
i	AG	Arg	Ser	Arg	Ser
r	AU	Ile	Ile	MET	Ile
s	CA	Gln	His	Gln	His
t	CC	Pro	Pro	Pro	Pro
	CG	Arg	Arg	Arg	Arg
&	CU	Leu	Leu	Leu	Leu
	GA	Glu	Asp	Glu	Asp
S	GC	Ala	Ala	Ala	Ala
e	GG	Gly	Gly	Gly	Gly
c	GU	Val	Val	Val	Val

o	UA	|	.	Tyr	.	Tyr
n	UC	|	Ser	Ser	Ser	Ser
d	UG	|	.	Cys	Trp	Cys
	UU	|	Leu	Phe	Leu	Phe

Another way to look at this is:

NAME	3 Letter Abbreviation	1 Letter Abbreviation		DNA codons for each Amino Acids
Alanine	Ala	1.	A	GCA,GCC,GCG,GCU
Cysteine	Cys	3.	C	UGC,UGU
Aspartic Acid	Asp	4.	D	GAC,GAU
Glutamic Acid	Glu	5.	E	GAA,GAG
Phenylalanine	Phe	6.	F	UUC,UUU
Glycine	Gly	7.	G	GGA,GGC,GGG,GGU
Histidine	His	8.	H	CAC,CAU
Isoleucine	Ile	9.	I	AUA,AUC,AUU
Lysine	Lys	11.	K	AAA,AAG
Leucine	Leu	12.	L	UUA,UUG,CUA,CUC,CUG,CUU
Methionine	Met	13.	M	AUG
Asparagine	Asn	14.	N	AAC,AAU
Proline	Pro	16.	P	CCA,CCC,CCG,CCU
Glutamine	Gln	17.	Q	CAA,CAG
Arginine	Arg	18.	R	CGA,CGC,CGG,CGU
Serine	Ser	19.	S	UCA,UCC,UCG,UCU,AGC,AGU
Threonine	Thr	20.	T	ACA,ACC,ACG,ACU
Valine	Val	22.	V	GUA,GUC,GUG,GUU
Tryptophan	Trp	23.	W	UGG
Tyrosine	Tyr	25.	Y	UAC,UAU
Stop Codons		.		UAA,UAG,UGA – B(2)J(10)O(15)U(21) Z(26)

An example of the multiple combinations of DNA possible for a single peptide is an example of spelling my first name (without a termination codon):

So to code for 'MARK' there would be 16 combinations, other sequences of 4 letters would vary in the number of possibilities based on the number of codons that could code for a single amino acid. Some amino acids have up to 6 codons that will be translated into a single Amino Acid.

M	A	R	K	M	A	R	K	M	A	R	K	M	A	R	K
MET	Ala	Arg	Lys	MET	Ala	Arg	Lys	MET	Ala	Arg	Lys	MET	Ala	Arg	Lys
AUG	GCU	AGA	AAG	AUG	GCU	AGG	AAG	AUG	GCU	AGA	AAA	AUG	GCU	AGG	AAA
AUG	GCG	AGA	AAG	AUG	GCG	AGG	AAG	AUG	GCG	AGA	AAA	AUG	GCG	AGG	AAA
AUG	GCC	AGA	AAG	AUG	GCC	AGG	AAG	AUG	GCC	AGA	AAA	AUG	GCC	AGG	AAA
AUG	GCA	AGA	AAG	AUG	GCA	AGG	AAG	AUG	GCA	AGA	AAA	AUG	GCA	AGG	AAA