Nucleic acid:

Nucleic acids are macromolecules ranged in molecular weight from 30,000 to several millions. The repeating units of nucleic acids are nucleotides. Each nucleotide is made up of three units, a sugar, phosphoric acid and nitrogenous base. The sugar is the pentose sugar which β –D-Ribose in case of the DNA. The nitrogenous base may be the derivatives of purine and pyrimidine.

Definition:

The nucleic acids are biopolymers of high molecular weight mononucleotide as their repeating units.

Classification of Nucleic acids:

1. Deoxy ribonucleic acid (DNA)
2. Ribonucleic acid (RNA)

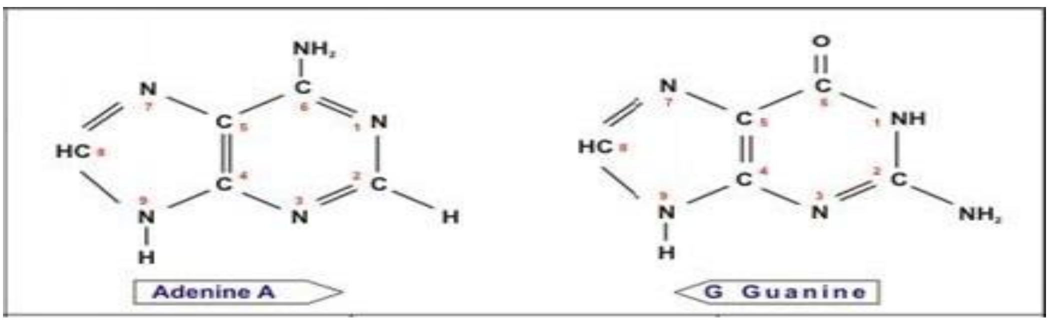
Structure of Nucleic acids:

The nucleic acids are the polymers of nucleotides (polynucleotide). The repeating units in RNA are ribonucleotides, while the repeating units in DNA are deoxy ribonucleotides and nucleosides can be regarded as phosphoester of a nucleoside. A nucleoside is interning an N-glucosides consisting of pentose sugar which may be either ribose or deoxy ribose and a nitrogenous base. This may be derivative of purine and pyrimidine.

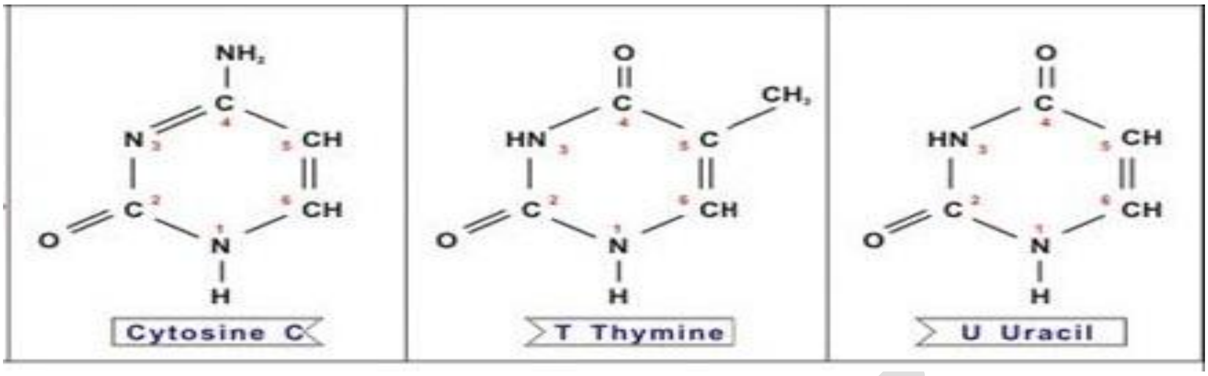
The variable portion of the nucleotide in the nucleic acid is the nitrogenous base which is either purine or pyrimidine. The two major purines are adenine and guanine and the three major pyrimidines are thymine, cytosine and uracil.

Structure of Nitrogenous Base:

Purine:



Pyrimidine:



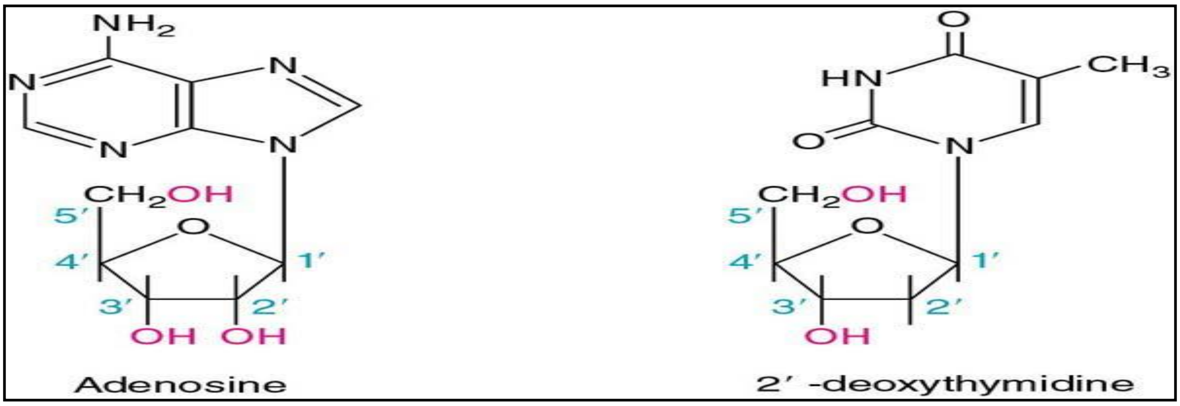
Structural components of nucleic acids:

Sl No.	Component	RNA	DNA
1.	Acid	Phosphoric acid	Phosphoric acid
2.	Pentose sugar	Ribose	Deoxy-ribose
3.	Nitrogenous bases		
	Purine	Adenine	Adenine
		Guanine	Guanine
	Pyrimidine	Cytosine	Cytosine
		Uracil	Thymine

Nucleoside:

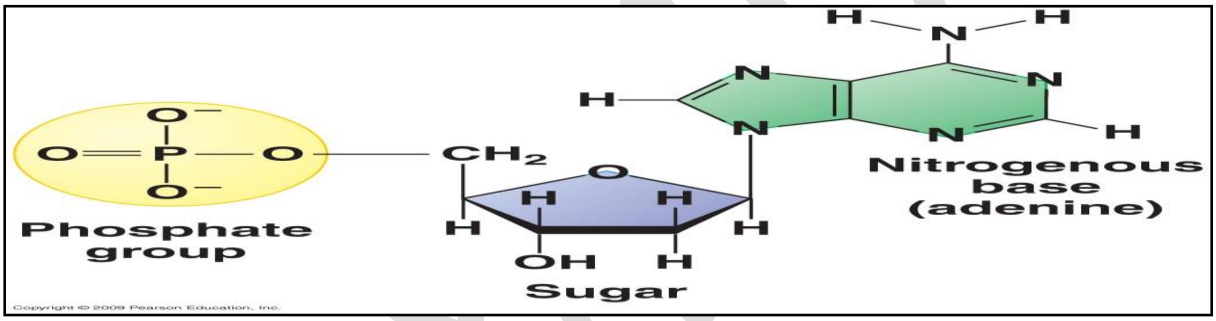
The nucleoside consists of a purine or pyrimidine base linked to a pentose sugar either D-ribose or Deoxy ribose. In the nucleoside the glycosidic C_1-carbon atom is linked or bonded to the N_1 of the pyrimidine or N_9 of the purine. The configuration of the glycosidic linkage is β in all naturally occurring nucleosides.

General structure of Nucleoside:



Nucleotide:

Nucleotide is a phosphate ester of a nucleoside. One of the OH group in this sugar structure is esterified. The most common site of esterification is the OH group attached to the C_5 of the sugar. Such a compound is called nucleoside $5^{/}$ Phosphate of $5^{/}$ Nucleoside.



Function of Nucleotides:

1. They are building blocks or monomeric units in the nucleic acid (DNA & RNA) structure.
2. Nucleotides are the structural components of several co-enzymes of B-complex vitamins.
   e.g. FAD, NAD^+, $NADP^+$, co-enzyme A.
3. They serve as carriers of high energy intermediates in the bio-synthesis of carbohydrates, lipids and proteins.
4. Nucleotides are intimately involved energy reactions of the cell. e.g. ATP is the energy currency of the cell. The hydrolysis of ATP and other nucleotide triphosphate is an exergonic reaction. The bond between the ribose and α-phosphate is an ester linkage. The α-β and β-γ linkages are phosphoric acid anhydrides. Hydrolysis of the ester linkage yields about 14 KJ/mol, where as

hydrolysis of each the anhydride bond yields about 30KJ/mol. In biosynthesis ATP hydrolysis often drives less favourable metabolic reactions.

5. Nucleotides control several metabolic reactions by their action as allosteric regulations.
6. Cyclic AMP and cyclic GMP are the second messengers in hormonal function.
7. **As chemical messengers:**

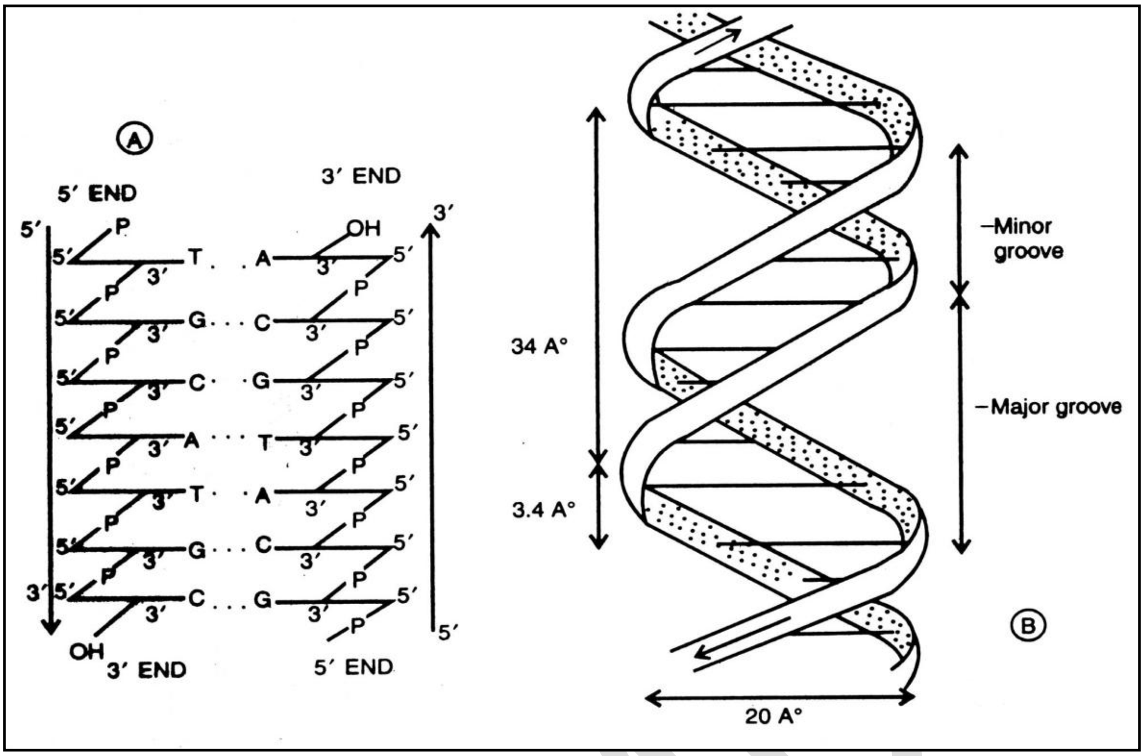
   The cells respond to their environments by taking clues from hormones or other chemical signals in the surrounding medium. The interaction of these chemical signals to the formation of second messengers inside the cell, which in turn lead to adaptive changes inside the cell, often the second messenger is a nucleotide.

   One of the most common second messenger is the nucleotide adenosine $3^{/}$ -$5^{/}$ cyclic mono phosphate (cyclic AMP or c AMP).
8. Nucleotides may have one, two or three phosphate groups covalently linked $5^{/}$ -OH of ribose. These are referred to as nucleotide mono, di and tri phosphates and abbreviated as NMP's, NDP's and NTP's respectively. The $3^{/}$ phosphate groups are generally labelled as α, β and γ starting from the ribose.

DNA Structure (Watson and Crick Model):

In 1953 Watson and Crick postulated a three dimensional model of structure that explain the X-ray diffraction pattern and also accounted for chargaff's findings. They postulated a double helical structure for DNA. The features of Watson and Crick model are as follows-

1. The DNA molecule has a α - helical structure and it is double stranded, here the relatively hydrophobic bases are present inside and protected from water. While the polar sugar and phosphoric acid molecules are present towards the outside. The two polynucleotide strands are tightly coiled around each other and can be separated from each other, only by unwinding or uncoiling of the two strands. Such type of coiling of the helix is called **"plectoneomic coiling".**



2. **Stability:** The double helix is stabilized by hydrogen bonding between complementary purine and pyrimidine bases. There are two hydrogen bonds between adenine and thymine and there are three hydrogen bonds between guanine and cytosine. Pairing between two purines or two pyrimidines doesn't occur since the diameter of the strands is 2nm (20 A^0) in thick.
3. **Co-planarity of Bases:** The bases lie in the same plane and sacked one above the other perpendicular to the central axis.
4. **Anti parallel polarity:** The two strands run at opposite direction and thus are anti-parallel to each other. They are $3^{/}$ - $5^{/}$ inter nucleotide phosphor diester bridges, which run in anti-parallel direction.
5. **Complementarities:** The two strands are exactly complementarities to each other. Hence if the sequence of bases on one strand is known that on the other strand may be easily written.
6. **Periodicity:** Ten mono nucleotides are present in one turn of the helix giving rise to a periodicity of 3.4 nm (34 A^0) along. The distance between two adjacent nucleotide is 0.34 nm (3.4 A^0).
7. The special relationship between two of DNA creates a major or deep groove and minor or shallow groove.

Function of DNA:

1. DNA plays an important role in all synthetic and hereditary functions of all living organisms.
2. DNA acts as the carrier of genetic information from generation to generation.
3. DNA is very stable macromolecule in all living organisms and it is immortal.
4. DNA contains all developmental process of an organism and all life activities.
5. DNA synthesis RNA.

RNA (Ribonucleic acid):

RNA is like DNA, a long un-branched macromolecule consisting of nucleotides joined by $3^{/}$-$5^{/}$ phosphor diester bonds.

Difference with DNA:

Although sharing many features with DNA, the RNA molecule possess several specific differences –

1. As apparent from its name, the sugar moiety in RNA, to which the phosphate and the nitrogen bases are attached, is ribose rather than $2^{/}$ - deoxyribose of DNA. Ribose contains a $2^{/}$ - hydroxyl group not present in deoxyribose.
2. RNA contains the pyrimidine uracil in place of thymine which is characteristic of DNA molecule. Uracil like thymine can form a base pair with adenine by 2 hydrogen bonds. However, it lacks the methyl group present in thymine.

Types of RNA:

In all prokaryotic and eukaryotic organisms 3 general types of RNA's are found. Several of RNA present in living cells are as follows –

Type	**Relative amount**	**Sedimentation coefficient**	**Molecular Weight**
1. Ribosomal RNA (r RNA)	80%	23s 16s 5s	1.2×10^6 0.55×10^6 3.6×10^4
2. Transfer RNA (t RNA)	15%	4s	2.5×10^4
3. Messenger RNA (m RNA)	5%	-	Heterogeneous

Messenger RNA:

Messenger RNA is a nucleic acid which carries genetic information for protein synthesis from the DNA to the cytoplasm. The term m-RNA was coined by Jacob and Monad in 1961. If forms about 3 to 5 % of the total cellular portion. The m-RNA is synthesized as a complementary stand upon the chromosomal DNA. The genetic message from DNA is transcribed to this m-RNA. The m-RNA carries the message in a form of **triplet codons**.

The life span of m RNA is too less. In eukaryotes it lives for few hours to a day. In animal eggs and plant seeds m RNA is stabilised for months or years. Protein synthesis must be carried out within this life span.

Types of m RNA:

Based on the number of genes from which an m RNA is formed is on the size of protein molecule synthesized two types of m RNA are known. They are –

a) **Monocistonic m RNA:**

It is formed from a single cistron (functional gene) and it codes for a single polypeptide chain. The eukaryotic m RNA is monocistonic. A ciston is a DNA segment corresponding to one polypeptide chain.

b) **Polycistonic m RNA:**

A polycistonic m RNA is formed from many cistons and encodes several different polypeptide chains. The prokaryotic m RNA is polycistonic.

Structure of m RNA:

1. The m RNA is a single stranded polynucleotide chain containing 500 to 1500 nucleotides.
2. The molecular weight of an average sized m RNA is about 5, 00,000.
3. The m RNA contains phosphoric acid, ribose sugar, purines namely adenine and guanine; pyrimidines namely cytosine and uracil.
4. The m RNA carries genetic information from DNA. The genetic information carries by the m RNA is the sequence of nitrogenous bases in m RNA. The genetic code is formed of several codons. Each codons is a specific sequence of 3 nitrogenous bases which code for one amino acid. As each codon is formed of three nitrogenous bases, it is called a triplet code.

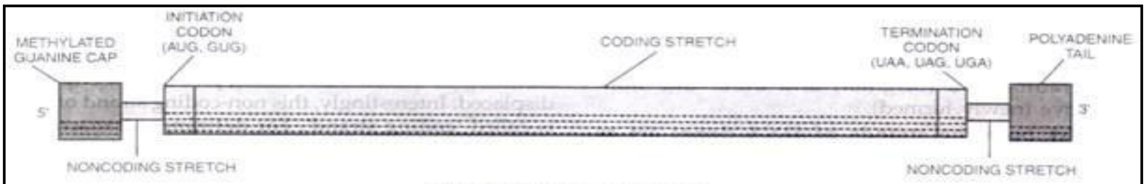


Fig. 6.26. Structure of mRNA.

5. Among RNA's m RNA is the longest one of the m RNA contain 900 to 1500 nucleotides.
6. Each m RNA contains the codon for one peptide chain. If the m RNA contains 900 nucleotides the polypeptide chain synthesis this, m RNA will contain 300 amino acids.
7. One end of m RNA is called $5^{/}$ end the other end is called $3^{/}$ end.
8. At one $5^{/}$ end cap is found in eukaryotes and animal viruses. The cap formed by the condensation of guanyl residues. The cap helps the m RNA to be with ribosome.
9. The cap is followed by a non-coding region. It does not contain code (message) for protein and hence it cannot translate protein. It is formed of 10 to 100 nucleotides and is rich in "A" and "U" residues.
10. The non-coding region is followed by the initiation codon. It is made up of AUG.
11. The initiation codon is followed by the coding region which contains the code for proteins. It has an average of 1500 nucleotides.
12. The coding region is followed by termination codon. It completes the translation. It is made up of UAA, UGA or UAG in eukaryotes.
13. The termination codon is followed by a non-coding region 2. It has a nucleotide sequence of AAAAAA.
14. At the 3/ end of m RNA, there is an adenylated sequence (poly A). It consists of 200 to 250 adenine nucleotide (AAAA....). But as the age increase, the poly A shortness.

Transfer RNA (t RNA):

The basic sequence of t RNA molecule was first elucidated by Robert Holley. All t RNA molecules have common structure features.

1. There are many modified base in t RNA. A few of these dihydrouridine, methylinosine, methylguanosine, pseudouridine an inocine occur frequently and in particular region other are found in a verity of positions. In some case the substituent the purine and pyrimidine rings are so numerous and complex that the base is called hyper modified. In only a few cases is the significance of these unusual bases known.

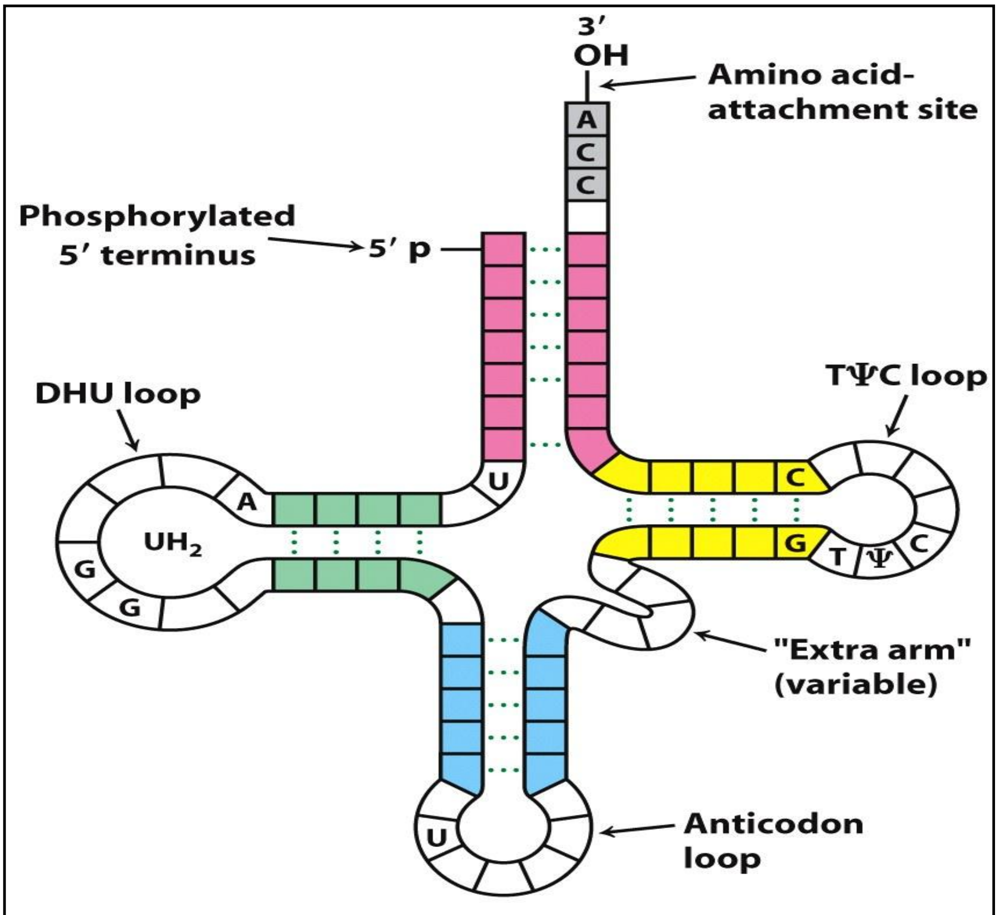


Figure 30.3
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2. The rate of unusual bases i.e. t RNA are uncertain base pair so that some of the bases are available for the interaction. These are four double stranded regions called stems or arms. The stems have no invariant bases.
3. The $5^{/}$ end of the t RNA are phosphorylated and the residue is usually phosphorylated guanine. The $5^{/}$ phosphorylated terminus is always base paired. It is thought that this contributes to the stability of t RNA.
4. The $3^{/}$ OH terminus is always 4 base single stranded regions having the base sequence XCCA $3^{/}$ OH, in which X can be any base. This is called the CCA or acceptor end. This is also called as aminoacyl end.
5. About half of the nucleotides in are base paired doubled helix. However 5 groups of bases are not base pair.
6. There are three large single stranded loops. The lower most or anticodon loop contains bases. The anticodon occupies position 34 to 36. This arm is recognises specific codons of the m RNA strands and binds to them during the process of protein synthesis.

7. The dihyrouracil arm is made up of a sequence of 5-7 nucleotide of dihydrouracil is predominant. No hydrogen bonding takes place with the loop. Hydrogen bonding however takes place in TψC arm.
8. In addition to the above features, many t RNA process as the extra arm. This is called as variable are or variable loop and it is present in between the TψC arm and anticodon arm. It is usually made up of 5 or 6 nucleotides.

Ribosomal RNA (r RNA):

Ribosomal RNA is present in ribosome in both prokaryotes and eukaryotes. It constitutes about 80% of the total cellular RNA.

Structure of r RNA:

The ribosomal RNA is single stranded. Each strand is formed of many nucleotides. Each nucleotides is formed of three different molecules namely a phosphate, a ribose sugar and nitrogenous bases. The nitrogenous bases are two types namely purines and pyrimidines. The purines present in the r RNA are adenine and guanine. The pyrimidines present in r RNA is cytosine and uracil.

In some regions, the single stranded twisted upon itself to form a double helix. The helical regions are connected by inter single stranded regions. In the helical region most of the base pairs are complementary, so in r RNA the purine and pyrimidine bases have not equal.

Types of r RNA: It is changed into 7 types according to their sedimentation co-efficient. They are –

In eukaryotes	In prokaryotes
28s r RNA	23s r RNA
18s r RNA	16s r RNA
5.5 s r RNA	5s r RNA
5s r RNA	