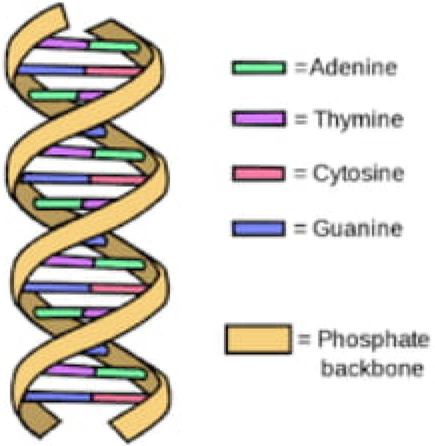
The Hereditary material : DNA

DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all other organisms. Nearly every cell in a person's body has the same DNA.

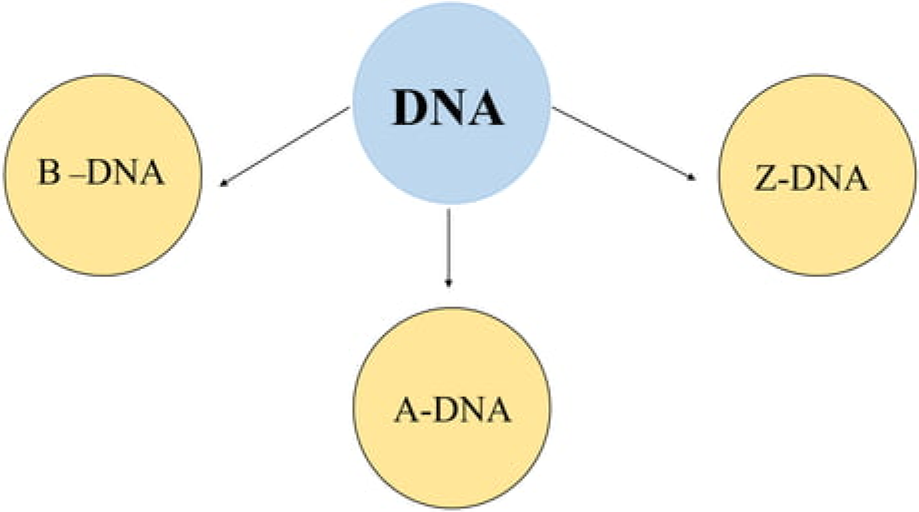
The information in DNA is stored as a code made up of four chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T).

Each base is also attached to a sugar molecule and a phosphate molecule.
Together, a base, sugar, and phosphate are called a nucleotide that gives rise to the structure of the double helix



The different forms of DNA

There are mainly 3 different forms of DNA



B-DNA

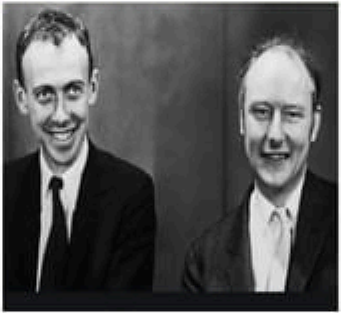


Image courtesy : The Guardian

The B-form of the DNA is the most prevalent ones.
The structure was proposed by Watson and Crick .
The binding of the purine along with the pyrimidine , is in accordance to Chargaff's rule and has 10.5 base pairs per turn
It is a right hand helix, that is wound around the same axis
The two strands are paranemic in nature (associated with base pairing : kind of interwinding)

Dimensions:

- 0.34 nm distance between base pairs and one complete turn is 3.4 nm per turn,
- 2.0 nm in diameter

- Major groove : 2.2nm
- Minor groove : 1.2nm

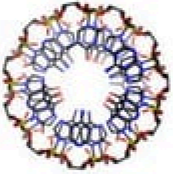


Figure 1: The top view of the double helix of B-DNA

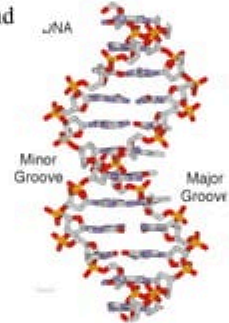


Figure 2 : The ideal B – DNA molecular structure

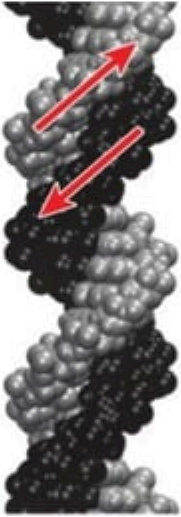


Figure 3 : The arrow marks here depict the direction of the winding :the helical turn

A-DNA

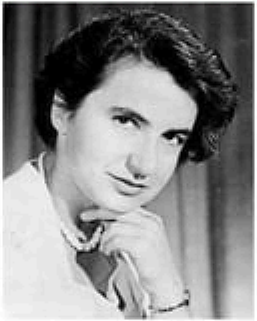


Image courtesy :Biography

This was the exact form of the DNA that was discovered by Rosalind Franklin when she was hypothesizing the structure of DNA with X-Ray crystallography.
It appears in less humidity , and has lesser water content compared to B-form .
It is a right hand helix .
It has 11 base pairs per turn
In this type of the DNA the 2'OH end projects outward , away from the atoms , that makes the helix wider .

Dimensions :
The distance between the base pairs is 0.29nm
And one complete turn is about 3.2nm
Diameter :2.3nm

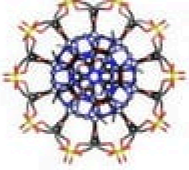


Fig 4: Top view of A-DNA

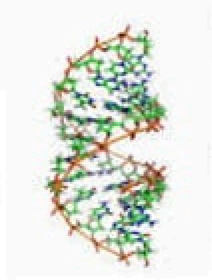


Fig 5: The molecular diagram of A-DNA

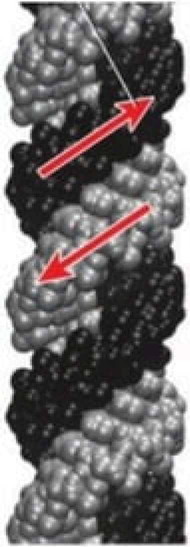


Fig 6: The width of the DNA is broader than The B-form

Z-DNA

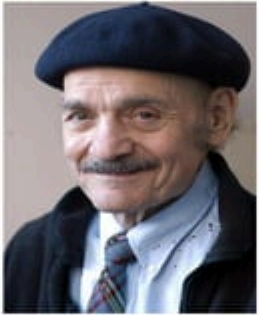


Image courtesy : news.mit.edu

This form of DNA was discovered by Alexander Rich
It is a left hand helix
The phosphate backbone are arranged in a zig-zag manner(the G and C nucleotides are in different conformations, leading to the zig-zag pattern)
It has 12 base pairs per turn.

Dimensions :

- Distance b/w each base pair is 0.37nm and one complete turn is about 4.4 per turn
- Diameter 1.8 nm

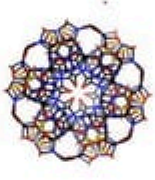


Figure 7: The top view of the Z – DNA

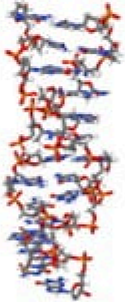


Figure 8: The molecular diagram of Z –DNA

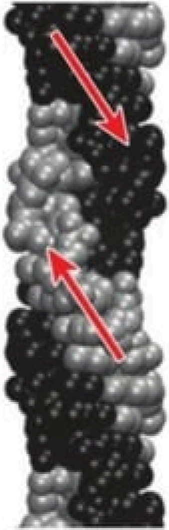


Figure 9 : The direction of the arrows shows how it forms the left hand helix

The Overall Comparison between the three forms of DNA

Feature	B-DNA	A-DNA	Z-DNA
Helix Type	Right handed	Right handed	Left handed
Helical Diameter	2.37	2.55	1.84
Distance per turn	3.4	3.2	4.5
Rise per base pair	0.34	0.29	0.37
Number of base pairs in one turn	10	11	12
Base pair tilt	+19°	-1.2°(Variable)	-9°
Helical axis rotation	Major Groove	Through the base pairs (variable)	Minor groove

The conditions that favors the transition of the DNA

Whether a DNA sequence will be in the A-, B-or Z-DNA conformation depends on at least three conditions.

The ionic or hydration environment. A-DNA is favored by low hydration, whereas Z-DNA can be favored by high salt concentration.

The presence of proteins that can bind to DNA in one helical conformation and force the DNA to adopt a different conformation. In living cells, most of the DNA is in a mixture of A-and B-DNA conformations, with a few small regions capable of forming Z-DNA.

The DNA sequence: A-DNA is favored by certain stretches of purines (or pyrimidines), whereas Z-DNA can be most readily formed by alternating purine–pyrimidine steps.

Its Prevalence in natural condition & tailor-made condition and change from one form to another

For A –Form of DNA :
A form helices are common for DNA –RNA hybrid and double stranded RNA. B-DNA can change to A-DNA during the transcription process.
The process is **sequence specific** , **cooperative** and **reversible** .

In in vitro conditions due to the addition of the solvents like ethanol or the presence of certain proteins and drugs can result in the transition in the form . The B- to A-DNA transition is driven by a force-field The process involves slide stabilizing before roll, and G-tracts undergo the transition first.

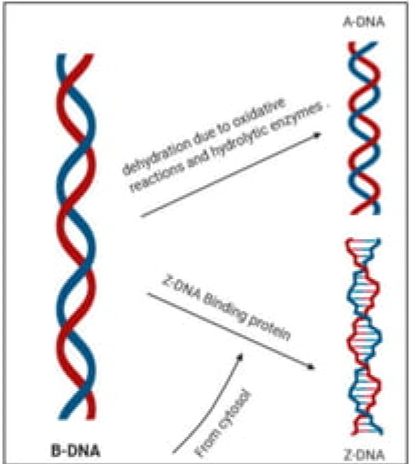


Image courtesy : created by Bio-render

For the Z-DNA helix:
The flip from the B-form to the Z-form occurs when processive enzymes such as **polymerases** and **helicases** generate under wound DNA. Also the transition can be due to Z-DNA binding protein.

In in Vitro condition : the transition could be mediated by topoisomerase (using a plasmid in experimentation) that would enable the change in electrophoretic mobility indicating change in form.

**LaCl3 +Etbr can also be used to achieve transition

So why there is a need for such transition into different forms

The transition of DNA into different forms plays a significant role in gene expression, and some other roles are :-

- A-DNA has been found to play a protective role under desiccating conditions
- A-DNA is believed to be one of the adaptations of hyper thermophilic viruses to harsh environmental conditions in which these viruses thrive.
- Z-DNA is commonly believed to provide torsion strain relief during transcription, and it is associated with negative supercoiling
- Z-DNA is unlikely to form nucleosomes, which are often located after a Z-DNA forming sequence. Because of this property, Z-DNA is hypothesized to code for nucleosome positioning.
- A biological role for Z-DNA in the regulation of type I interferon responses.

References

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Thank You