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Adapted from a model of unknown origin from 1959*

Modelling the helix

A cut-out 3-D model of DNA

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Aim

This stunning cut-out 3-D model of DNA can be used to learn about the structure of B-DNA.

Equipment and materials

Needed by each person or group

- Nucleotide templates, copied onto card from the following pages
- Scissors
- Bodkin or strong needle, for punching holes through card
- Paper glue
- Drinking straws
- Fine string
- Crayons (if coloured prints of the following pages are not used)
- OPTIONAL: Sharp craft knife and cutting board

Procedure

1. Make several copies of the nucleotide templates on card. *Ten nucleotide pairs are required for a complete turn of the double helix. To see the major and minor grooves in the double helix clearly, the model needs to have at least 16 nucleotide pairs.*
2. If colour copies have not been used, colour in the card appropriately. *The colours that are often used in sequencing markers for DNA bases are: Cytosine=Blue; Guanine=Yellow; Adenine=Green; Thymine=Red.*
3. Cut out the nucleotide pairs around the thicker, outer lines. Make two small cuts into the card by the phosphate groups where indicated. *OPTIONAL: Use a sharp craft knife to make cuts above the deoxyribose molecules where shown.*
4. Carefully punch a small hole in each cut-out where shown. *This will be the axis of the DNA model through which the string will be threaded. Don't make these holes too big!*
5. Fold the sugar-phosphate 'backbones' where indicated by dotted lines. *These folds must be made in the directions shown on the accompanying pages. Take care not to make left-handed DNA!*

** The model upon which this one is based was brought to the author's attention by Dr Cheong Kam Khow of the Singapore Science Centre. We have no idea of its origins other than a cryptic copyright note '© V.R.P. 1959'. If you are V.R.P., please contact us as we'd like to give you credit for this magnificent model, which evidently pre-dated most peoples' interest in DNA.*

6 Cut 25 mm lengths of drinking straw. *You will need one less piece of straw than you have nucleotide pairs.*

7 Glue the phosphate group on one cut-out onto the deoxyribose on the next. Do the same with the opposite sugar–phosphate strand. *Remember that the sugar-phosphate chains run in opposite (anti-parallel) directions. The orientation of the letters on the card should help you to assemble the model correctly.*

8 Hold a piece of drinking straw between the holes in the cut-outs, and thread the string through them.

9 Repeat steps 5–8 for as many nucleotide pairs as desired.

10 Cut out the genetic code, and glue the two side together onto the string at the bottom of the model.

Timing

It will take the average person about 90 minutes to assemble a model of 16 nucleotide units.

Further activities

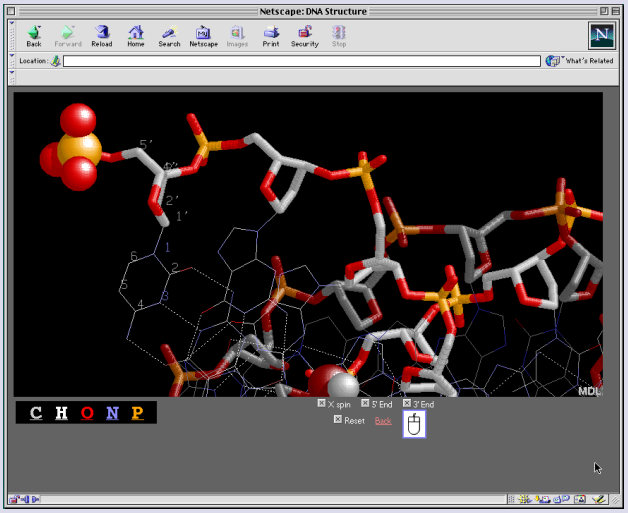
Photocopy or print the nucleotide pairs into overhead transparency sheets instead of card. These can be assembled to make a particularly attractive model.

Computer modelling

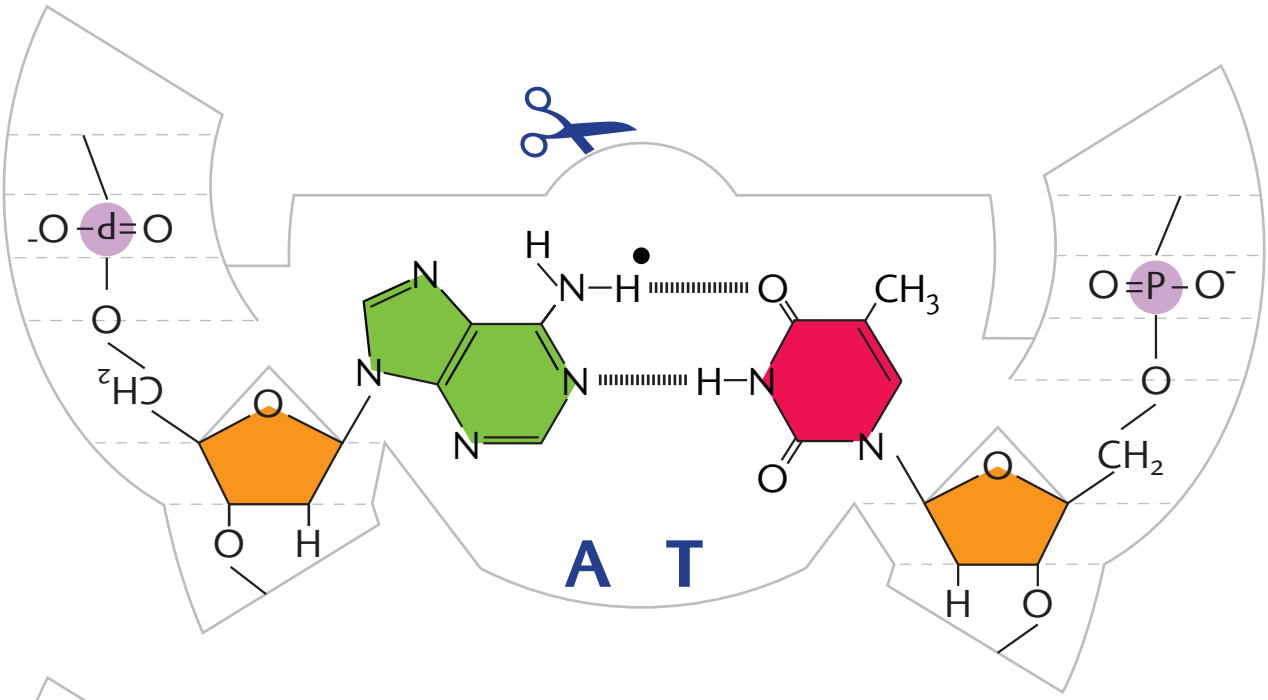
RASMOL is a 3-D molecular modelling programme for *Macintosh*, *Windows*, *UNIX* and *VMS* operating systems. It was written by Roger Sayle and can be downloaded free-of-charge from the *RASMOL* Web site (http://www.umass.edu/microbio/rasmol).

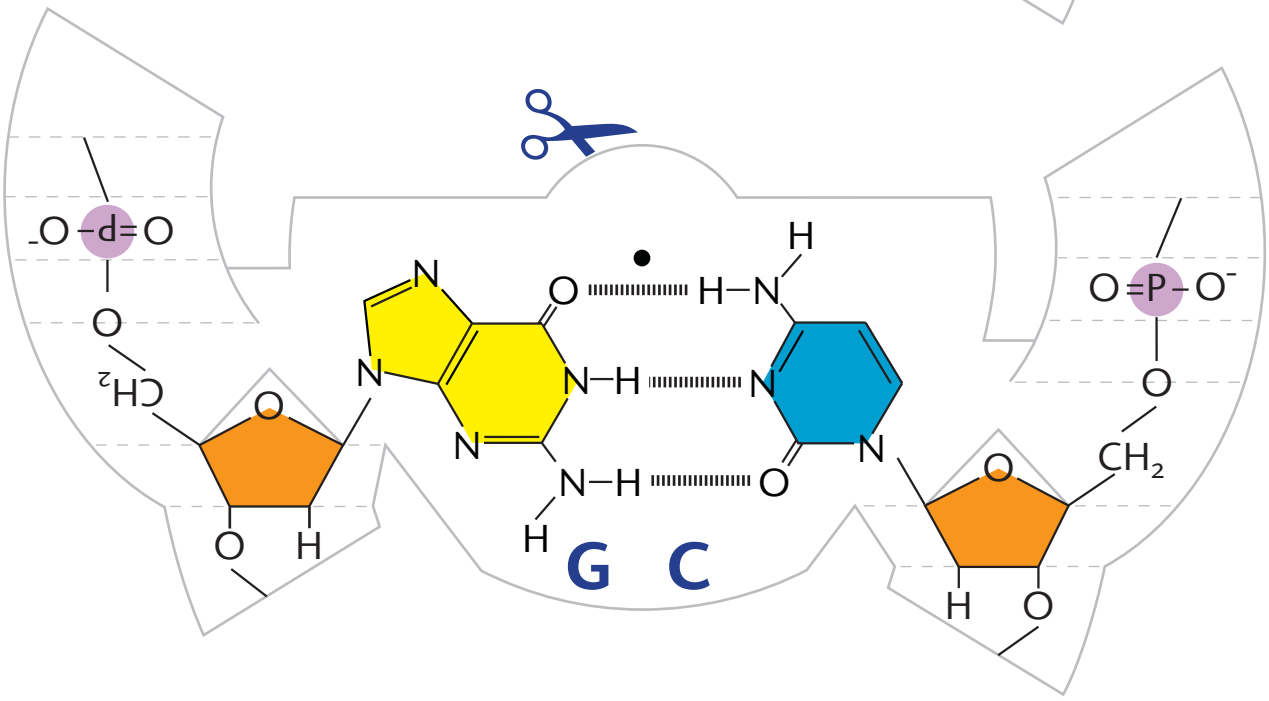
It is a good idea to print out *RASMOL's* 40-page manual (which comes with the programme), as although *RASMOL* is easy-to-use, to make the most of it you will need to use the commands described in the manual.

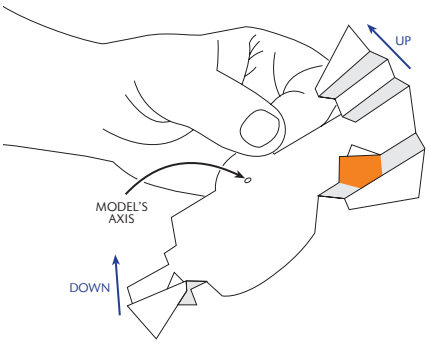
Molecules can be depicted in several different forms and coloured, highlighted and labelled in many ways (for example, to show the general motifs that comprise a protein). It is easy to rotate molecules and zoom in on parts to examine their structures in detail.



The CHIME plug-in (details of which can be found at the RASMOL Web site) can be used to view molecular structures within the Netscape Web browser. The image on the left comes from a complete suite of animated, interactive CHIME pages designed to help students learn about the structure of DNA. It can be viewed or downloaded entirely (for viewing off-line) from: http://www.umass.edu/microbio/chime/dna/.

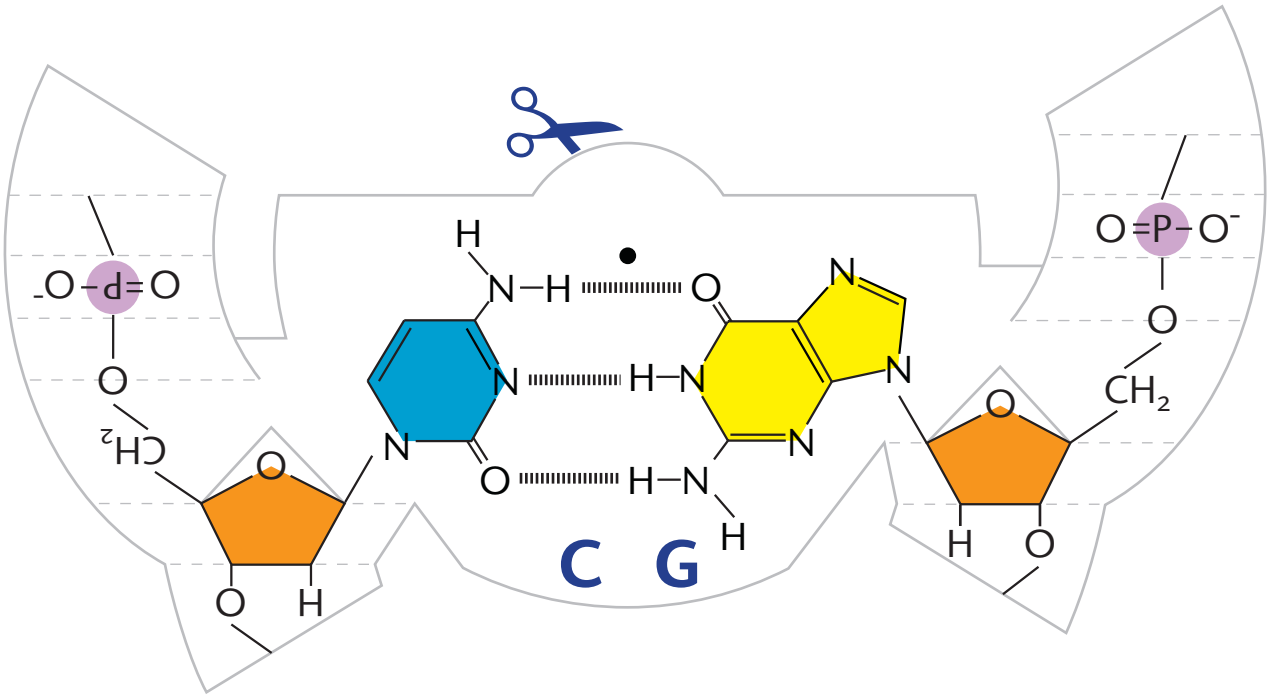


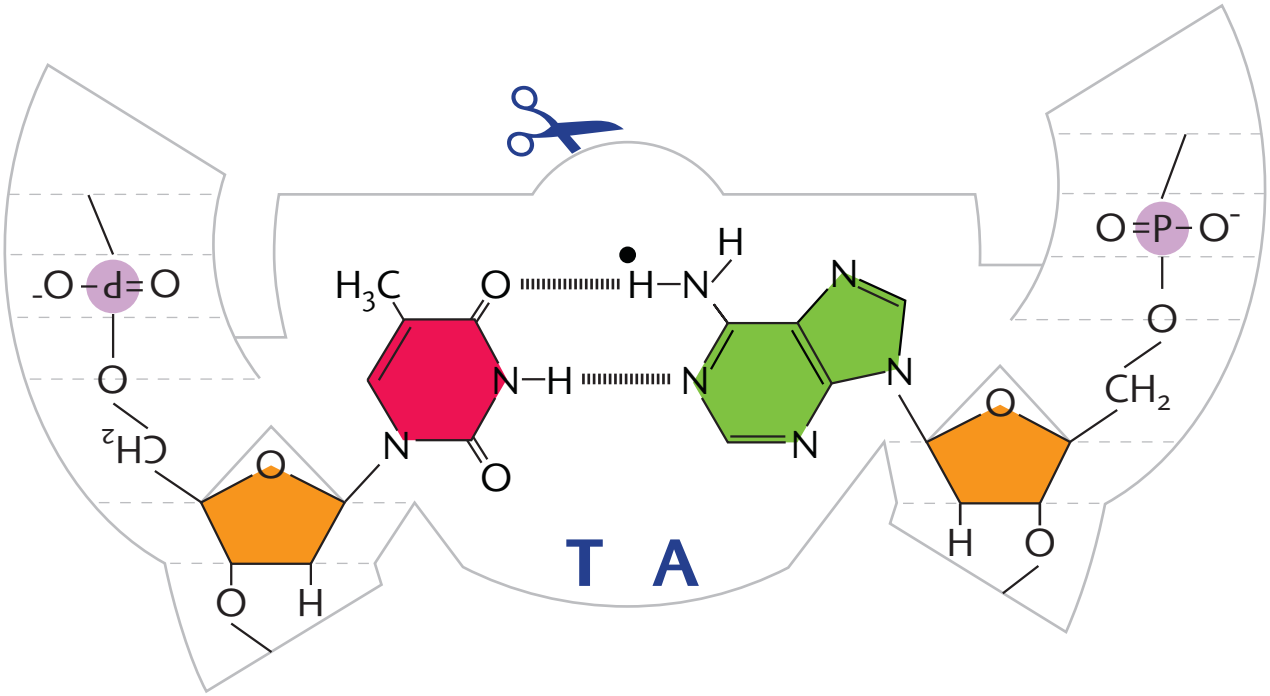




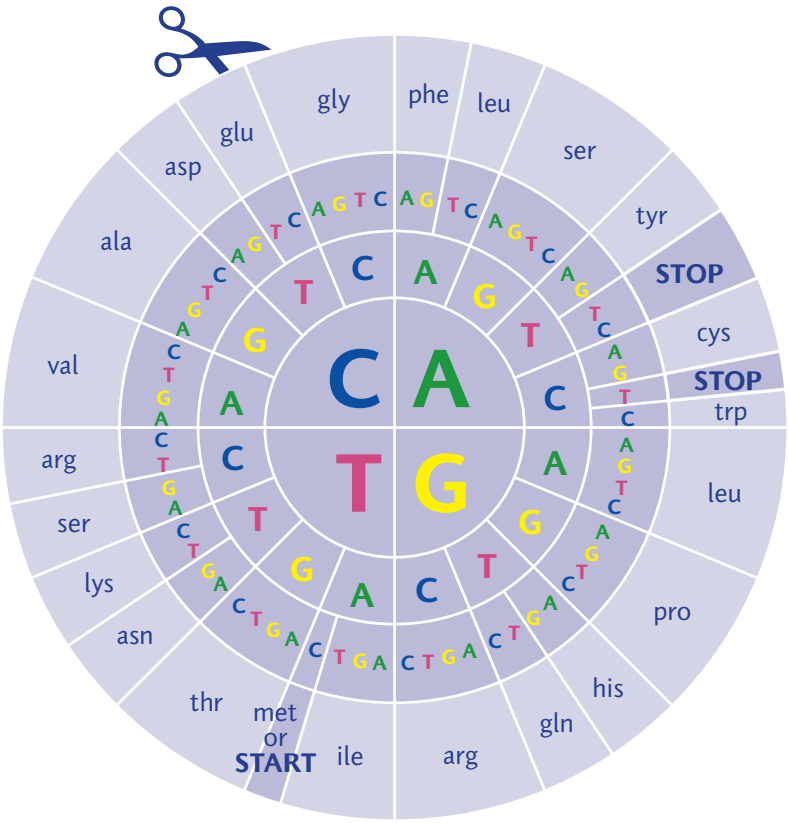
IMPORTANT!
Take care not to make left-handed DNA.

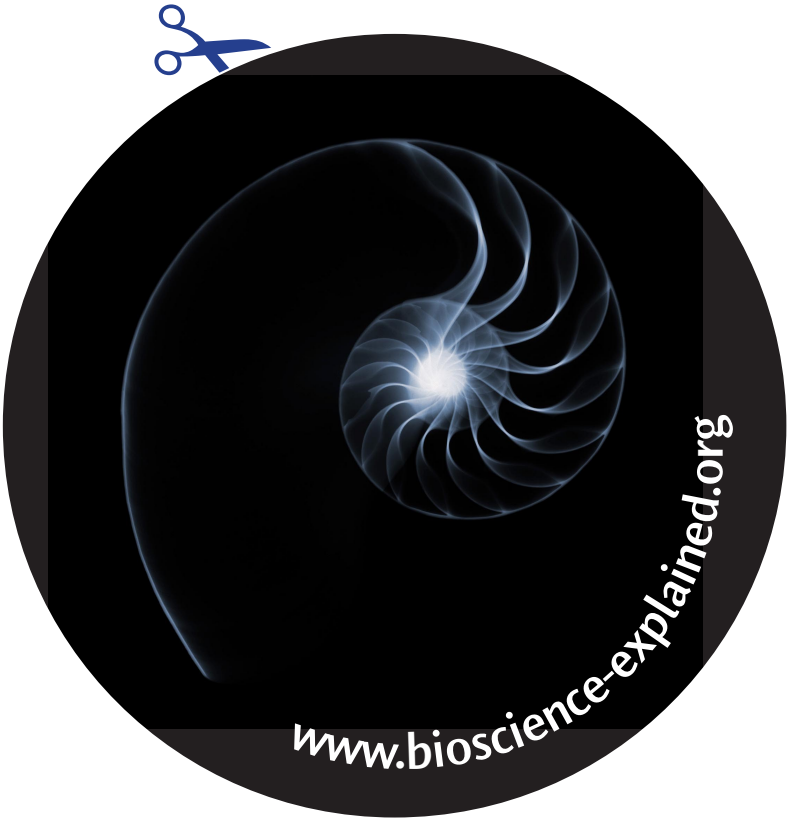
Phosphate groups on the left side fold DOWN, phosphates on the right fold UP.





Cut these pieces out and glue them together back-to-back on the string below the model.





Further reading

Rosalind Franklin and DNA by Anne Sayre (1978) London: W. W. Norton and Company. ISBN: 0 393 00868 1.

The double helix. A personal account of the discovery of the structure of DNA by James D. Watson [Gunther Stent, Ed.] (1980) New York: W. W. Norton and Company. ISBN: 0 393 95075 1.

What mad pursuit by Francis Crick (1990) London: Penguin Books. ISBN: 0 14 011973 6.

A passion for DNA by James D. Watson [Walter Gratzer, Ed.] (2000) Oxford: Oxford University Press. ISBN: 0 19 850697 X.

Illuminating DNA by Dean Madden (2000) Reading: National Centre for Biotechnology Education. ISBN: 0 7049 1370 4.

This comprehensive practical guide for schools can be downloaded from: http://www.ncbe.reading.ac.uk

Web sites

The left-handed DNA hall of fame
http://www.lecb.ncifcrf.gov/~toms/LeftHanded.DNA.html

DNA from A to Z
http://dna2z.com

DNA graphics created with POVCHEM
http://www.chemicalgraphics.com/paul/DNA.html

Institute of Molecular Biotechnology, Jena: Image Library
http://www.imb-jena.de/IMAGE.html

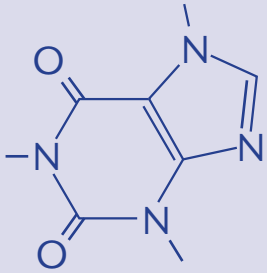
Nucleic Acid Database
http://ndbserver.rutgers.edu/NDB/ndb.html

A structure for DNA (Watson and Crick's original letter to *Nature*)
http://www.nature.com/genomics/human/watson-crick/watson_crick.pdf

Why is DNA like a cola drink?

- Both contain sugar
- Both contain phosphate (phosphoric acid)
- The chemical structure of caffeine is similar to that of adenine

Caffeine



Adenine