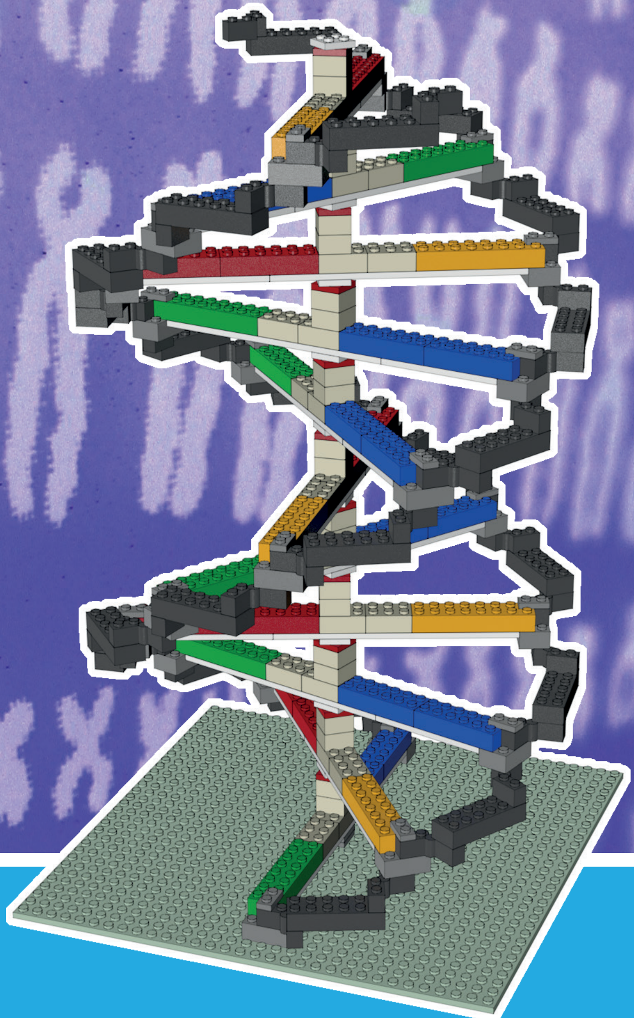
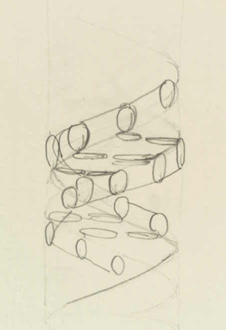
MRC | Laboratory of Molecular Biology

1953





Francis Crick sketch 1953.

What is DNA?

DNA stands for Deoxy-ribo Nucleic* Acid, a molecule made of carbon, phosphorous, oxygen, nitrogen and hydrogen atoms. Nucleic acids, along with lipids (fat), proteins and carbohydrates (sugars), are the fundamental building blocks of life. If one were to look at it very closely, DNA looks like a spiral staircase or double helix made of two banisters (the backbone) with steps (the bases) linking the two. There are four bases (guanine, cytosine, adenine and thymine) - using different combinations they are used to store and transmit genetic information.

Why is DNA important?

DNA is present in all forms of life: from plants and fungi to large mammals, through to bacteria and viruses. DNA contains all the information required to make up a living organism**. For example, DNA has instructions to determine your number of fingers, eye and hair colour. That is why DNA is often referred to as the “carrier” of the genetic information or life’s 'instruction manual'.

What is Genetics?

Genetics is a branch of biology that studies heredity. Geneticists measure differences in the visible characteristics (traits) of live organisms and try to understand how they are transmitted to the next generation. This way, they learn about the function of different genes (the units of information in DNA), and how the traits relate to the genetic make-up of individuals.

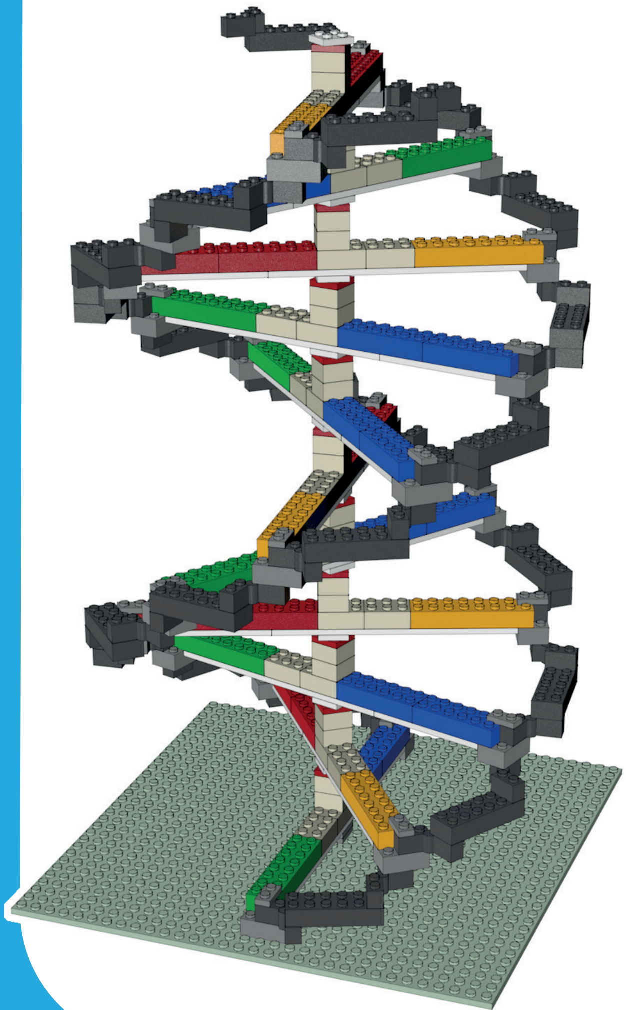
What can we learn by studying DNA?

Chemists first identified DNA in the late 19th century. In the early 20th century, scientists showed that it is essential for the transmission of hereditary traits from one generation to the next. LMB scientists in Cambridge built a model of DNA based on X-ray data collected by Rosalind Franklin and Raymond Gosling in London. This model showed that DNA forms a double-helix. The exciting part was that the model explained how the genetic information could be duplicated and transmitted to the next generation. The discovery of the structure of DNA marked the beginning of the era of molecular biology.

In 1962, James Watson, Francis Crick and Maurice Wilkins were awarded the Nobel Prize for physiology and medicine for their elucidation of the structure of DNA. This Lego model simplifies the key features of Watson and Crick's Model. It was designed by John Schollar at the National Centre for Biotechnology Education, whose support we gratefully acknowledge.

James Watson and Francis Crick

** the term nucleic refers to the fact that DNA is found in the nucleus of cells.*
*** in some viruses the genetic information is contained in a slightly different nucleic acid called RNA.*



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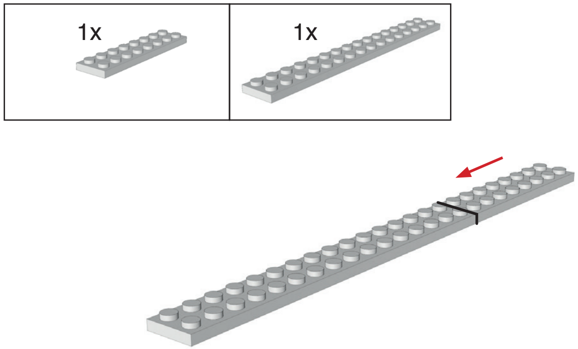

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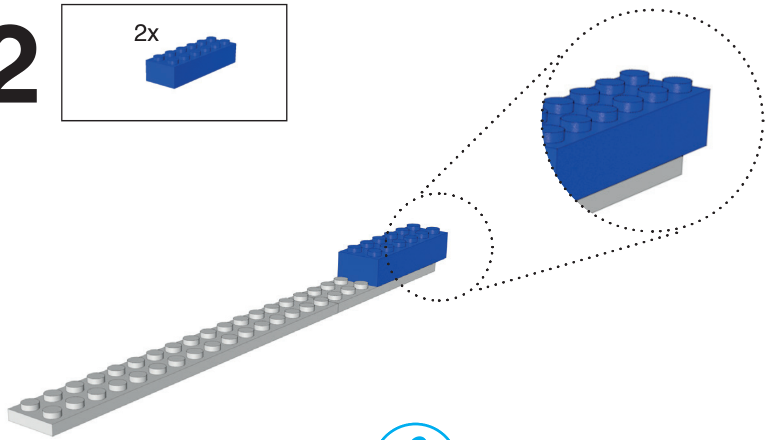
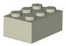
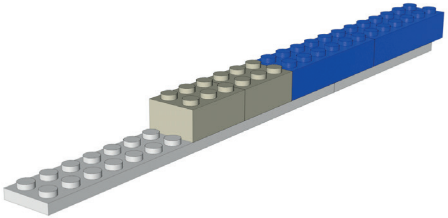


Blue blocks represent adenine base.

3

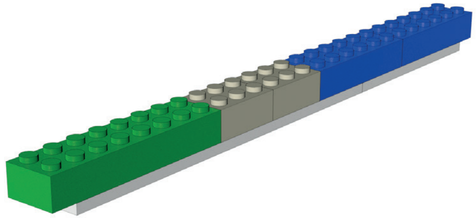
2x 



Clear Blocks represent Hydrogen Bonds between the bases. These "weak" bonds hold our DNA strands together.

4

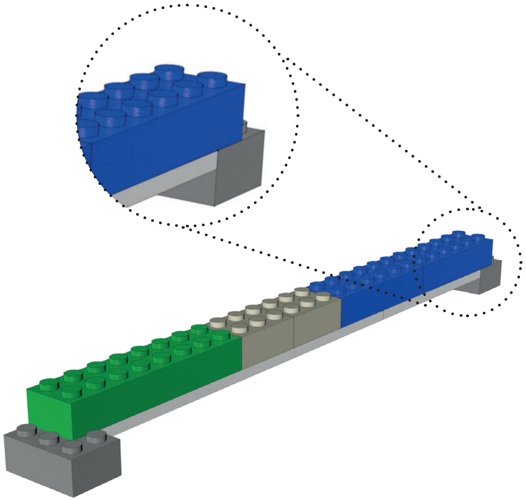
1x 



Green (thymine) pairs with blue (adenine). When DNA is copied, these base pairs are 'melted'. Note that adenine is a larger base than thymine.

5

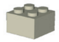
2x

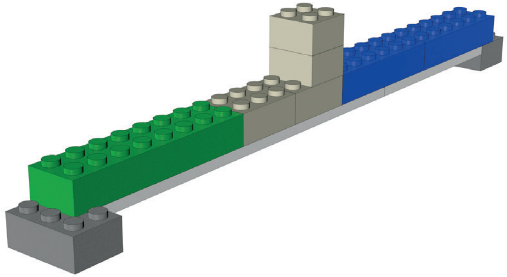


Grey Blocks represent the sugar (deoxyribose): one unit of sugar and the nucleobase combined is called a nucleoside.

6

2x





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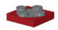
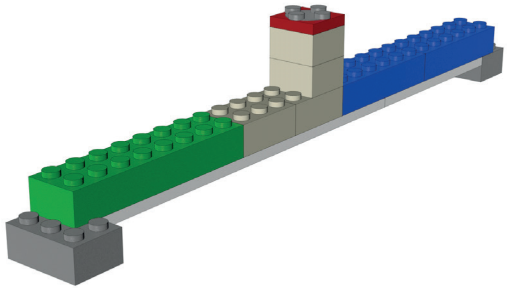
1x





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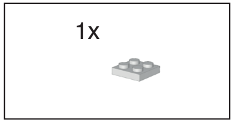

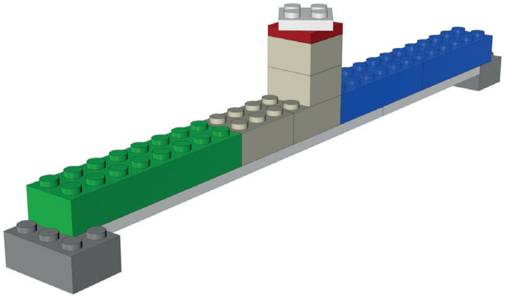

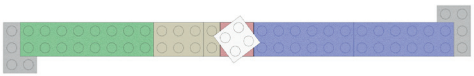

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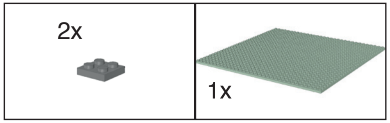

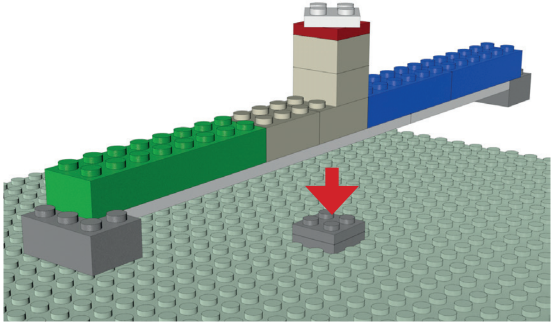

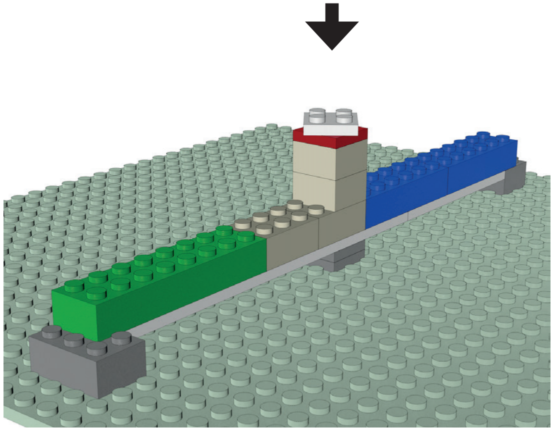

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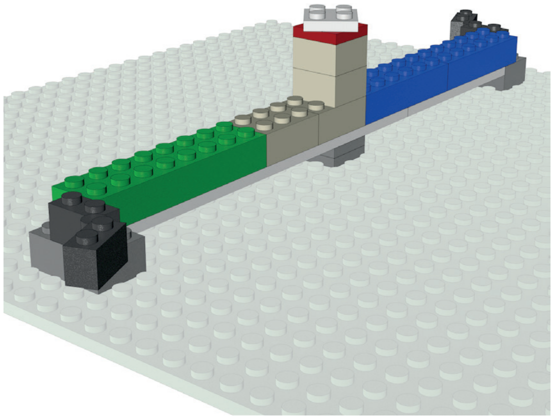

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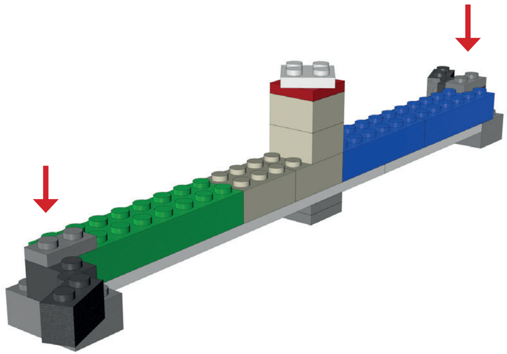

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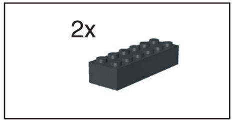
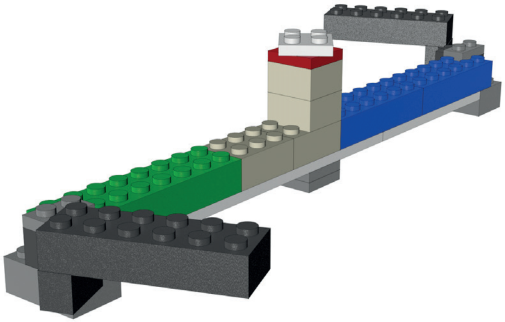
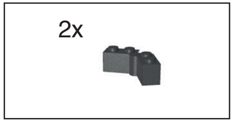
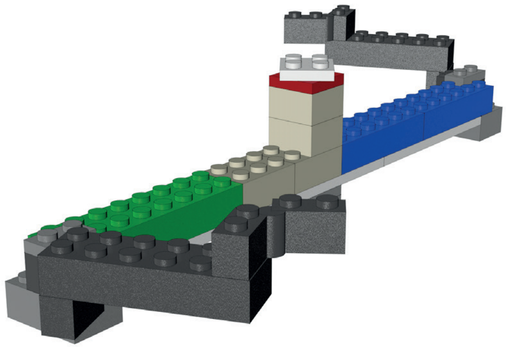




The black blocks represent the phosphate groups of the backbone.

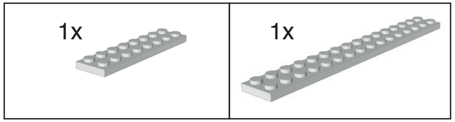
13

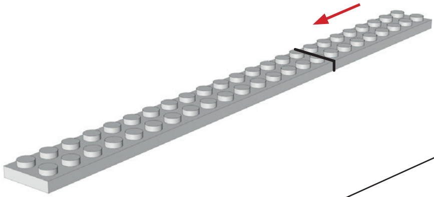




You've completed a full nucleotide base pair - now start building the next tier.

14





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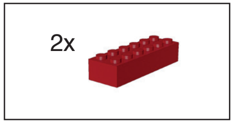
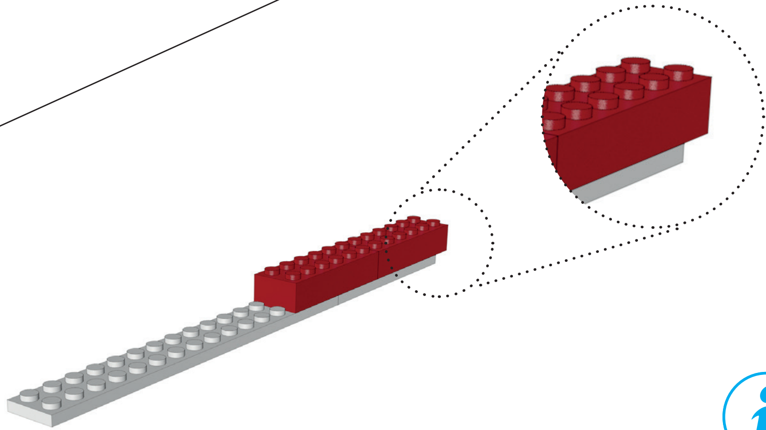
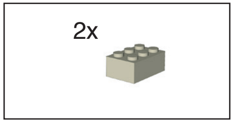
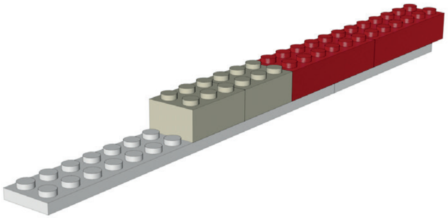




Red blocks represent the base guanine.

16





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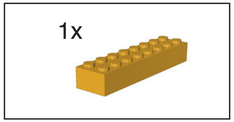
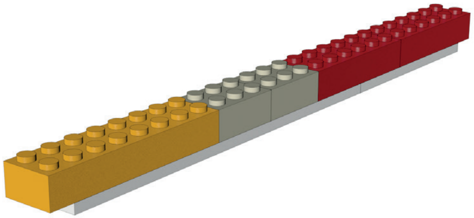
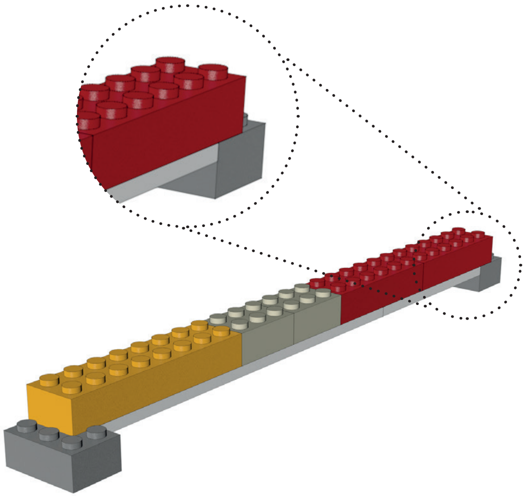




Yellow bricks show cytosine, which pairs with guanine - notice the difference between the sizes.

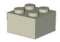
18

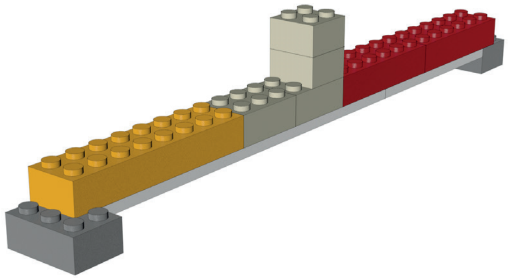
2x



19

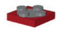
2x

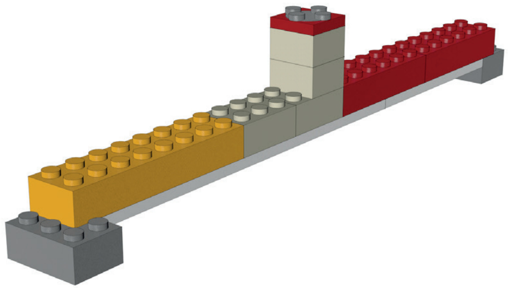




20

1x





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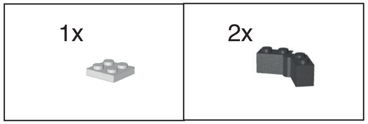

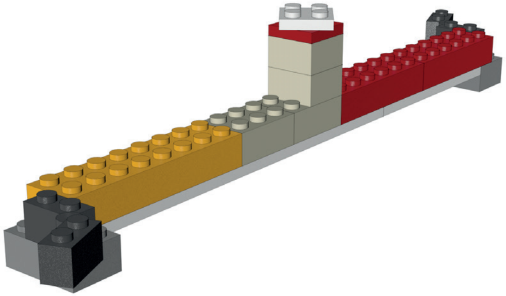

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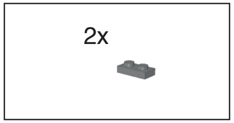

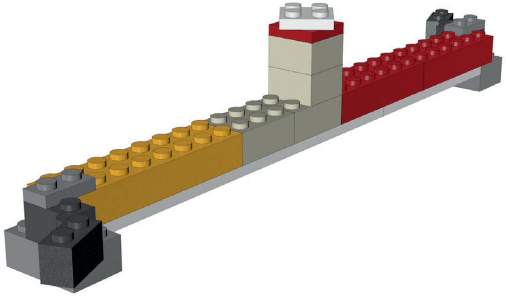

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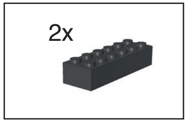

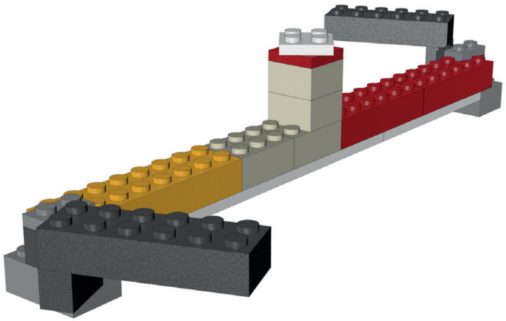

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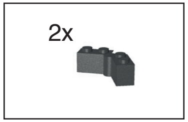

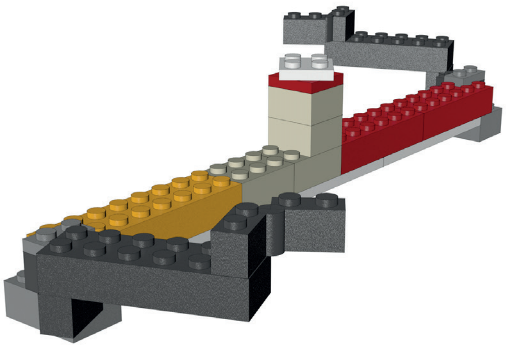

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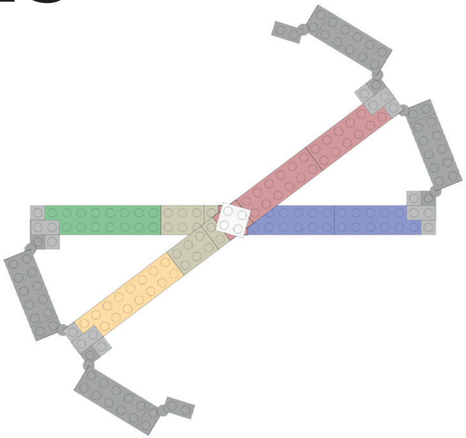
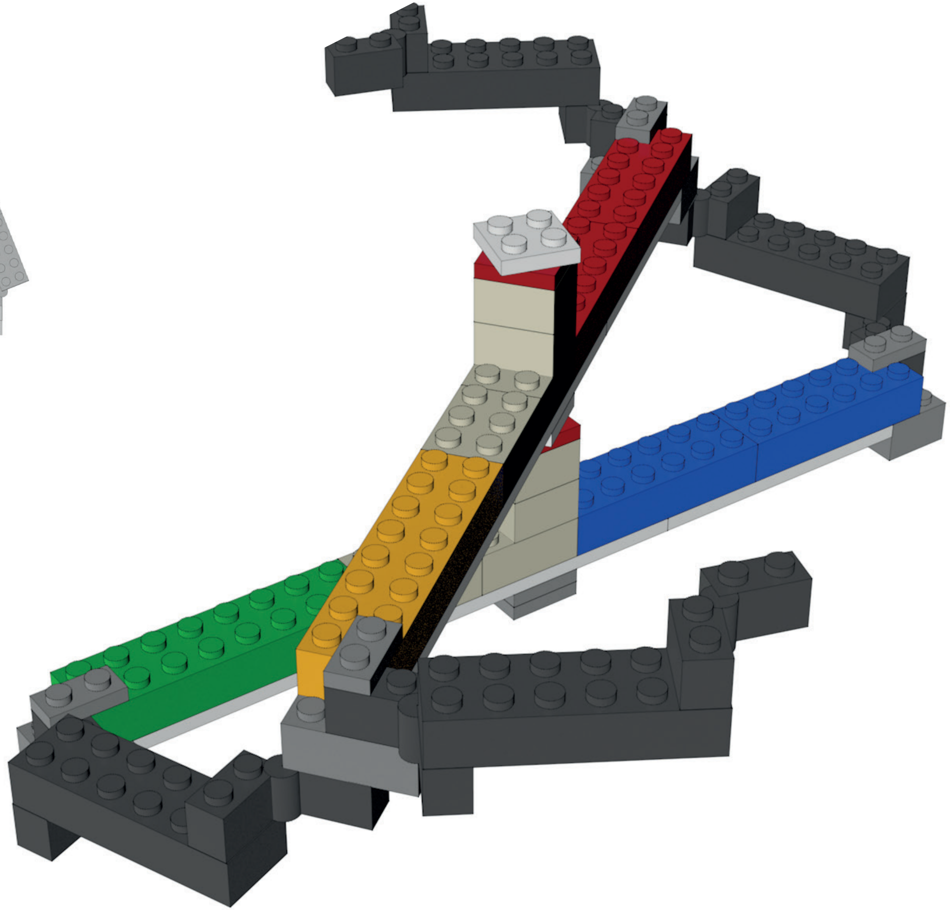
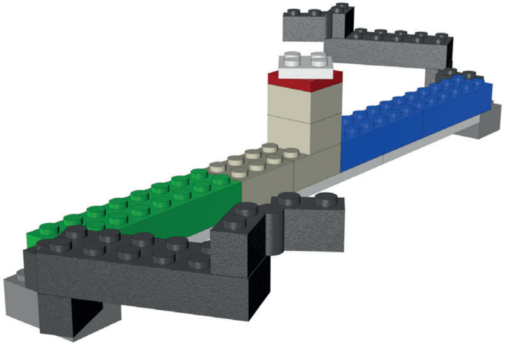




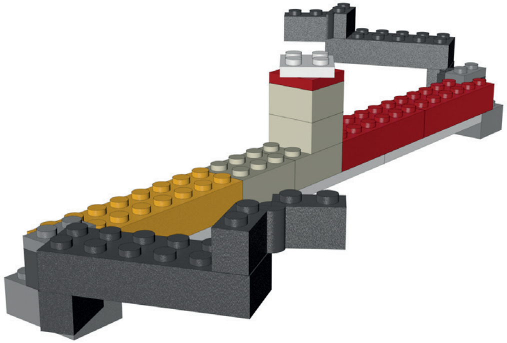
Add this base pair (red/yellow) to the base (blue/green) to make the first turn of your double helix.

26



Repeat steps 1-8, 10-13.

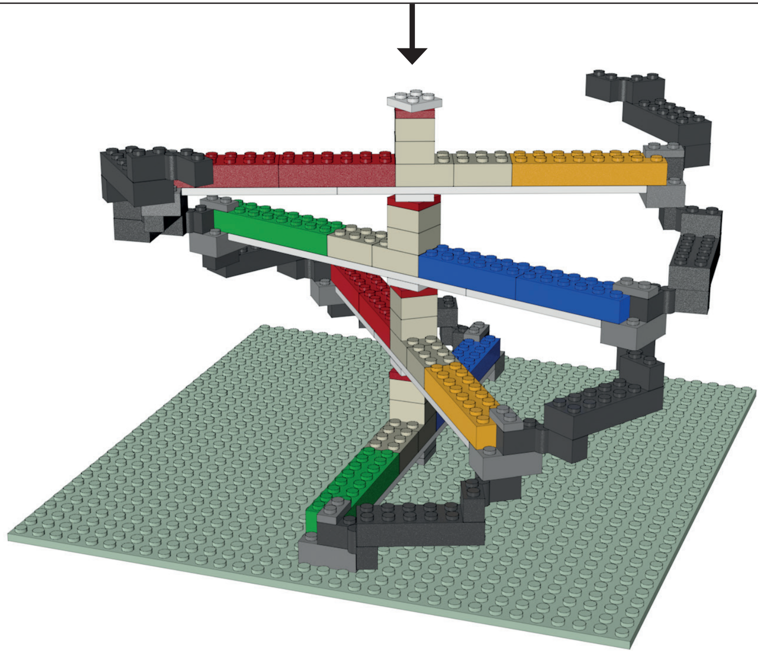
27



Repeat steps 14-24.

28

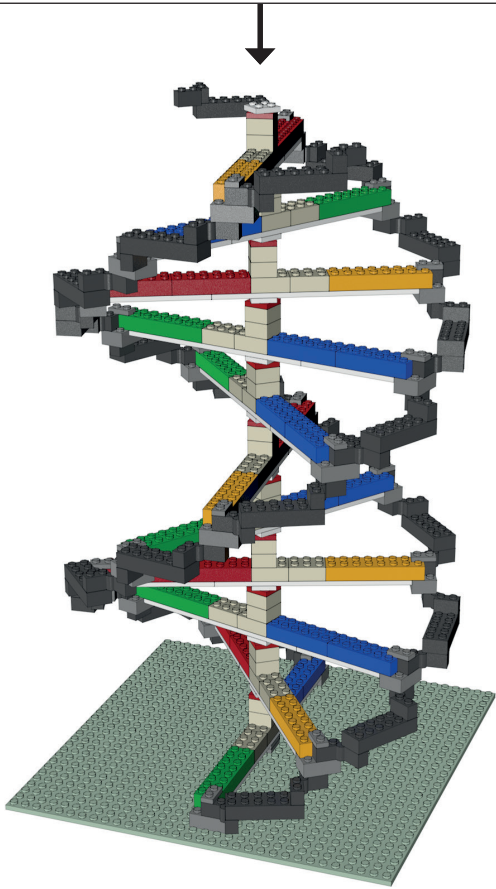
1x 26 1x 27



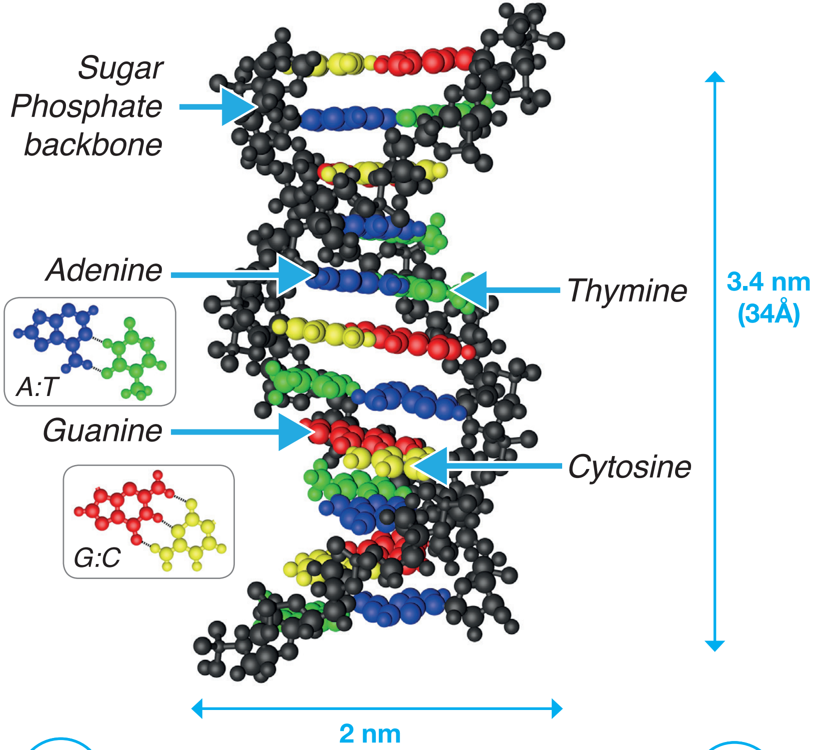
Add nucleotide 'base pairs' to start forming the helix.

29

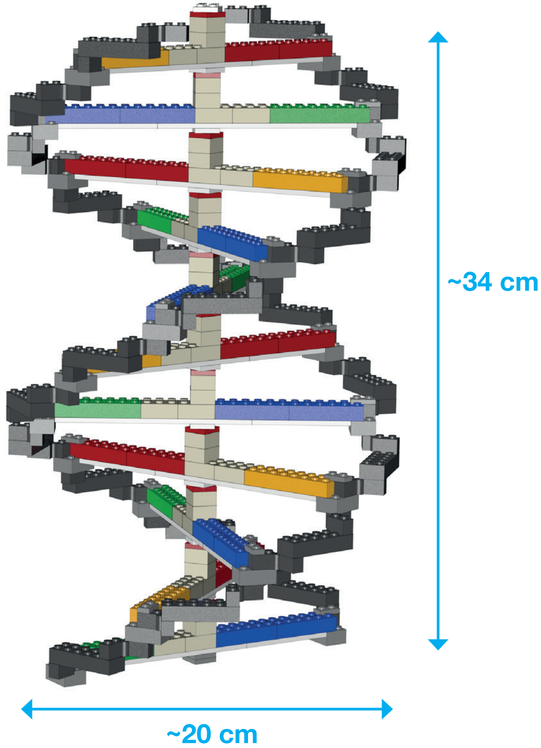
4x **26** 3x **27**



1:1



100,000,000:1

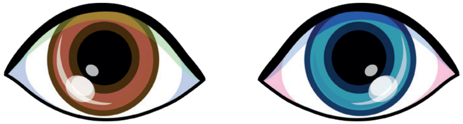


One strand of DNA measures about 2 nanometers in diameter. It would take about 12,500 strands of DNA to equal the diameter of a human hair!

Compare your lego model to the Watson-Crick model - what are the similarities and the differences? Where is the information stored and how could you access it?

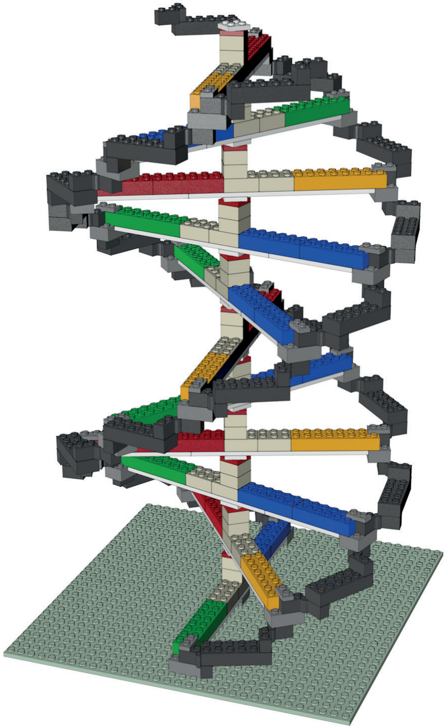
LEGO SCALE MODEL

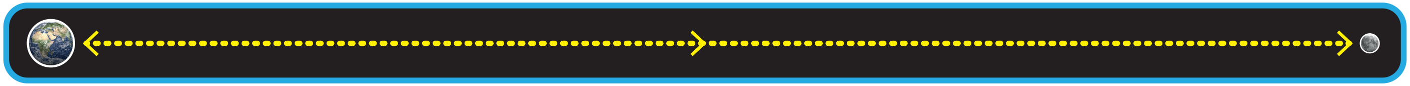
The scale of this Lego model is 1:100,000,000.



At this scale just one gene that determines eye colour (called OLA2, 340,457 base pairs) would reach over 10 km.

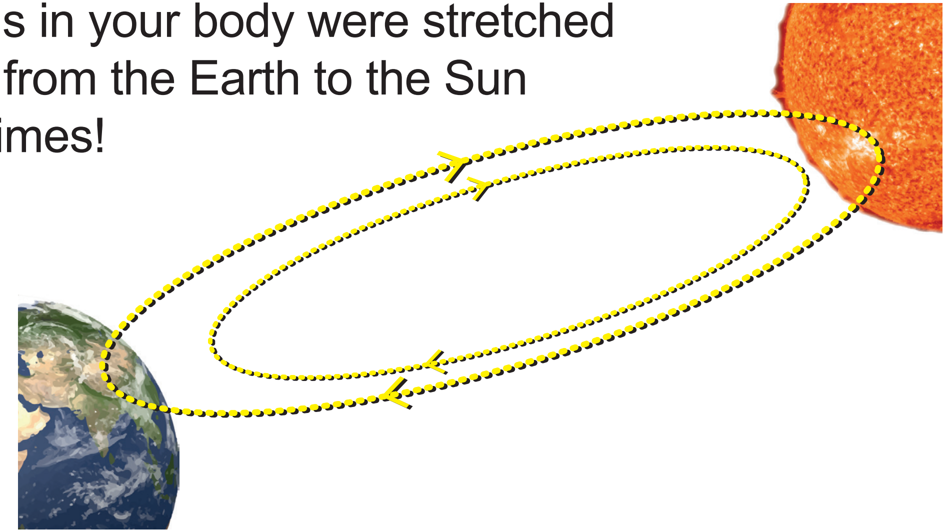
The model contains 11 base pairs, in a human cell there are 6 billion base pairs. If you unravelled all the DNA from one human cell it would measure 2 metres. At the scale of the Lego model that would reach more than half way to the moon!

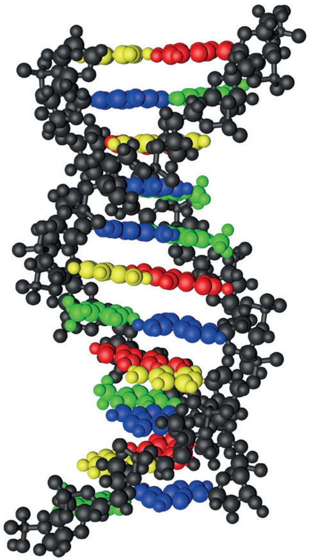




DNA SCALE MODEL

If the DNA from all the cells in your body were stretched end-to-end it would reach from the Earth to the Sun and back more than 250 times!
How can all this DNA fit?
DNA has to be packaged.





A chromosome is a single piece of coiled DNA which is packaged up with proteins. Humans have 46 chromosomes, receiving 23 from each parent. Humans are 99.8% genetically identical, so just a 0.2% difference provides all the diversity and variation seen in the human population.

Lego kits were designed by John Schollar at the National Centre for Biotechnology Education.

Images were supplied by:

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