

Building blocks

The DNA coding game



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EMBL Science Education and Public Engagement

About EMBL

The European Molecular Biology Laboratory (EMBL) is Europe's leading laboratory for the life sciences. We are an intergovernmental organisation supported by more than 27 member states and operating across six sites in Europe: Barcelona (Spain), Grenoble (France), Hamburg (Germany), Hinxton (United Kingdom), Rome (Italy) and our headquarters in Heidelberg (Germany).

At EMBL, researchers from all over the world perform fundamental research in molecular biology, studying the story of life. Our research drives the development of new technology and methods in the life sciences, and we work to transfer this knowledge for the benefit of society.

About Science Education and Public Engagement

EMBL's Science Education and Public Engagement (SEPE) office leads and coordinates the institute's science education programmes and public engagement efforts.

Formerly known as European Learning Laboratory for the Life Sciences, ELLS, the office now not only leads the institute's science education activities but also coordinates its efforts in outreach and public engagement. We are building on EMBL's long history of science education and public engagement, and support EMBL's commitment of sharing and discussing our research with young learners, teachers and diverse publics.

The Science Education team of SEPE shares the scientific discoveries of EMBL through inspiring teaching and learning experiences with school science teachers and young people of all backgrounds aged between 10 and 19 years.

Our programmes convey complex, cutting-edge topics in life science research in an exciting and insightful way, fostering the discovery of current research trends, the scientific method, and scientific career paths. Our activities are developed and run in close collaboration with EMBL scientists.

Visit our website for further information about our activities: embl.org/ells

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Access to the guide

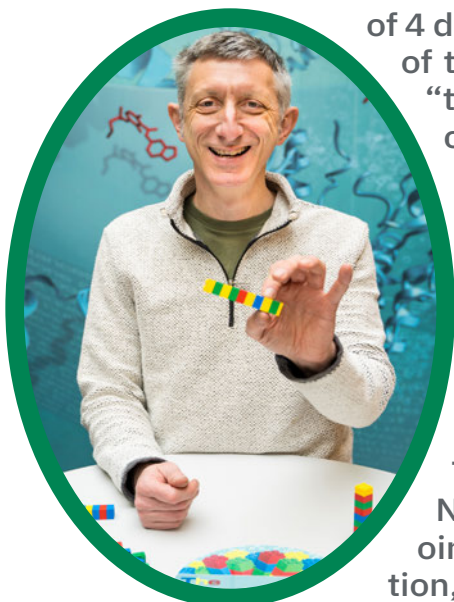
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'Building blocks': The DNA coding game

In the DNA, information is encoded by specific combinations of 4 different nucleotides, which are the “building blocks” of the DNA. This “code of life” is made up of different “triplets” or “codons”, defined combinations of 3 nucleotides that stand for a piece of information.



In this game, the DNA “building blocks” are represented by toy bricks (e.g. LEGO® bricks) of 4 different colours, which can be used to encode a word or message. Just like in the DNA, 3 colours are always combined to encode a specific letter, a number or a symbol.

The original version of this game was developed by Nick Goldman, group leader at EMBL’s European Bioinformatics Institute (EMBL-EBI). For more information, see the article: [“Building engagement. How lego can help you learn the fundamentals of DNA”](#)¹.

Participants

- **Number:** Depending on available material. Can be played alone or in small groups (2-3 people per “decoding station”).
- **Age:** 7-12, but can be adapted to higher ages.
- **Background knowledge:** This game works with only the most basic concept of the DNA structure, so it can be used to introduce the topic to young children or people with no knowledge of biology. The questions asked can be adapted depending on the participants’ background. You can encode anything you want.
- **Reading skills:** Indispensable, since the whole game mechanic revolves around reading and writing “codes” made up of letters and numbers. However, if young children who are not able to read individual letters still wish to participate, they can team up with a family member or friend for help. Or they could just find other uses for the blocks...



Materials

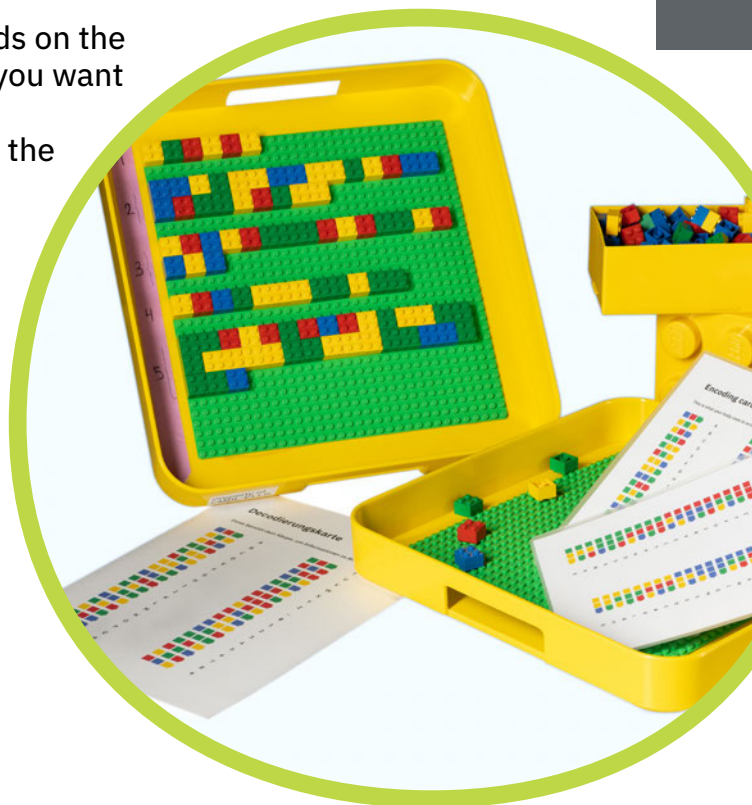
- **Building blocks:** The most important thing you need are toy building blocks or interlocking bricks (e.g. from LEGO®) in 4 different colours. Ideally, you will use the same colours as in the coding and decoding keys: **red**, **green**, **blue** and **yellow**.

The number of blocks you need depends on the number of participants and the words you want to encode.

For example, to encode the answers to the 5 example questions in this guide, you would need 93 blocks (3 per letter).

The proportion of colours depends on the language you play in and on how often certain letters appear in it. (As “E” is the most common letter in many languages, for example, you might need more yellow blocks.)

- **Encoding and decoding cards:** You will find printable versions of these at the end of the guide.
- **Base plate:** Although not indispensable, a base plate to attach the blocks and a tray to transport the plate make things easier.



Game instructions

The basic mechanics of the game are simple:

Version A: Decoding

1. **Encode** answers to questions (e.g. the sample questions) or a message for the participants to decode. Use the encoding card to encrypt your message: find the right colour combination for each letter, and place the appropriate blocks on the plate.
2. Participants **decode** the message with help of the decoding card.
3. In the end, reveal the right answers.

Here are some different ways to play this version of the game. You can also come up with your own!

a. Decode at your own speed.

- b. Race for it:** Participants compete against each other, either in pairs or in a big group, to see who can find the right answers more quickly. You can create a leaderboard and see who comes out on top!

Version B: Secret messages

The participants work in teams. One participant encodes a short message of their liking (using the encoding card) and their partner translates it (using the decoding card).

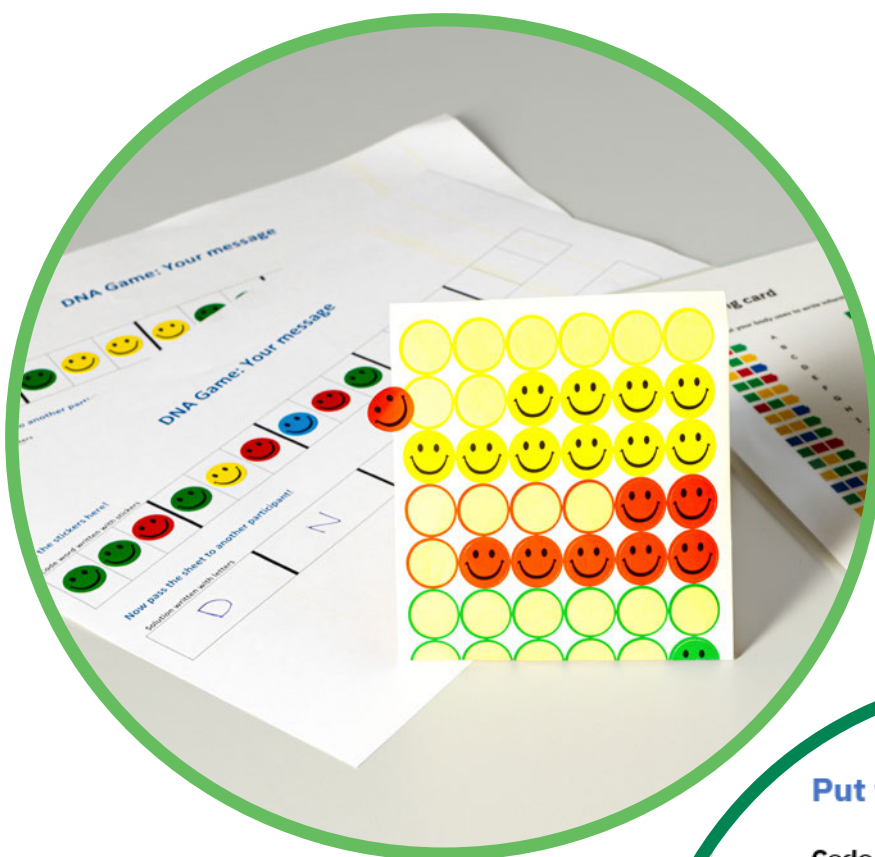
Game variation: Stickers

If you are playing the game under conditions where not every participant should touch the same equipment or you do not have access to LEGO® blocks, you can use **stickers** instead.

You will need stickers in **4 different colours** (and something to stick them on). To make it easier, use the same colours as in the coding and decoding keys: **red, green, blue** and **yellow**.

The game mechanics are the same as in the toy brick version.

Of course, you can use any other materials instead!



Put the stickers here!

Code word written with stickers

--	--	--	--	--	--

Now pass the sheet to another participant!

Solution written with letters

--	--	--	--	--	--

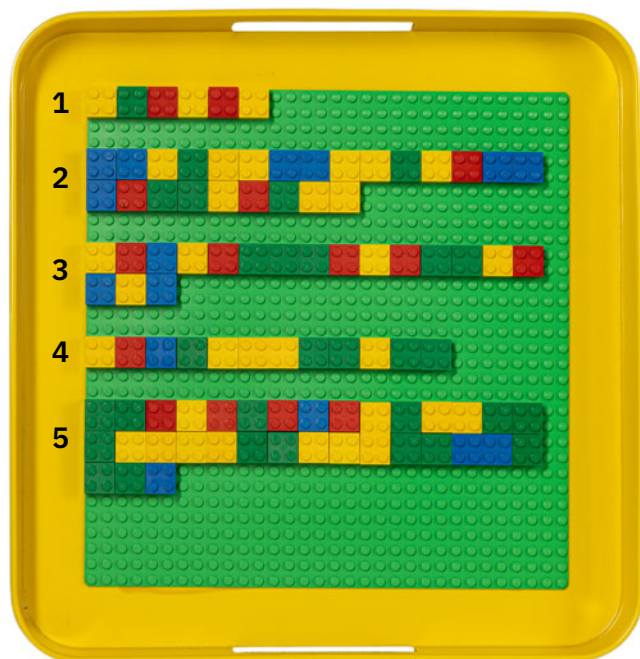
Example questions

Here are some examples of questions you can use in the game. You can encode the answers beforehand and let the participants decode them using the decoding key. You will find a printable version of these questions later in the guide.

1. Humans are made up of around ... trillion cells.
2. The outer “skin” of a cell is called ...
3. The genetic DNA code consists of ...
4. What is the fundamental unit of life?
5. The long spiral of DNA is called ...

Answers to the example questions

1. 80
2. Membrane
3. Codons
4. Cell
5. Double helix



This is what the encoded answers look like.

NOTE: You can encode anything you want!

NOTES



A large grid of small grey dots arranged in 15 columns and 25 rows, intended for taking notes.



Printable materials







Building blocks

The DNA coding game












Encoding card

This is what your body uses to *write* information.

	A		T
	B		U
	C		V
	D		W
	E		X
	F		Y
	G		Z
	H		-
	I		0
	J		1
	K		2
	L		3
	M		4
	N		5
	O		6
	P		7
	Q		8
	R		9
	S		

Decoding card

This is what your body uses to *read* information.

	-		V
	Z		A
	7		Y
	F		4
	U		W
	1		I
	R		Q
	9		M
	2		S
	J		3
	T		O
	P		C
	6		0
	D		8
	5		L
	X		B
	N		H
	K		G
	E		



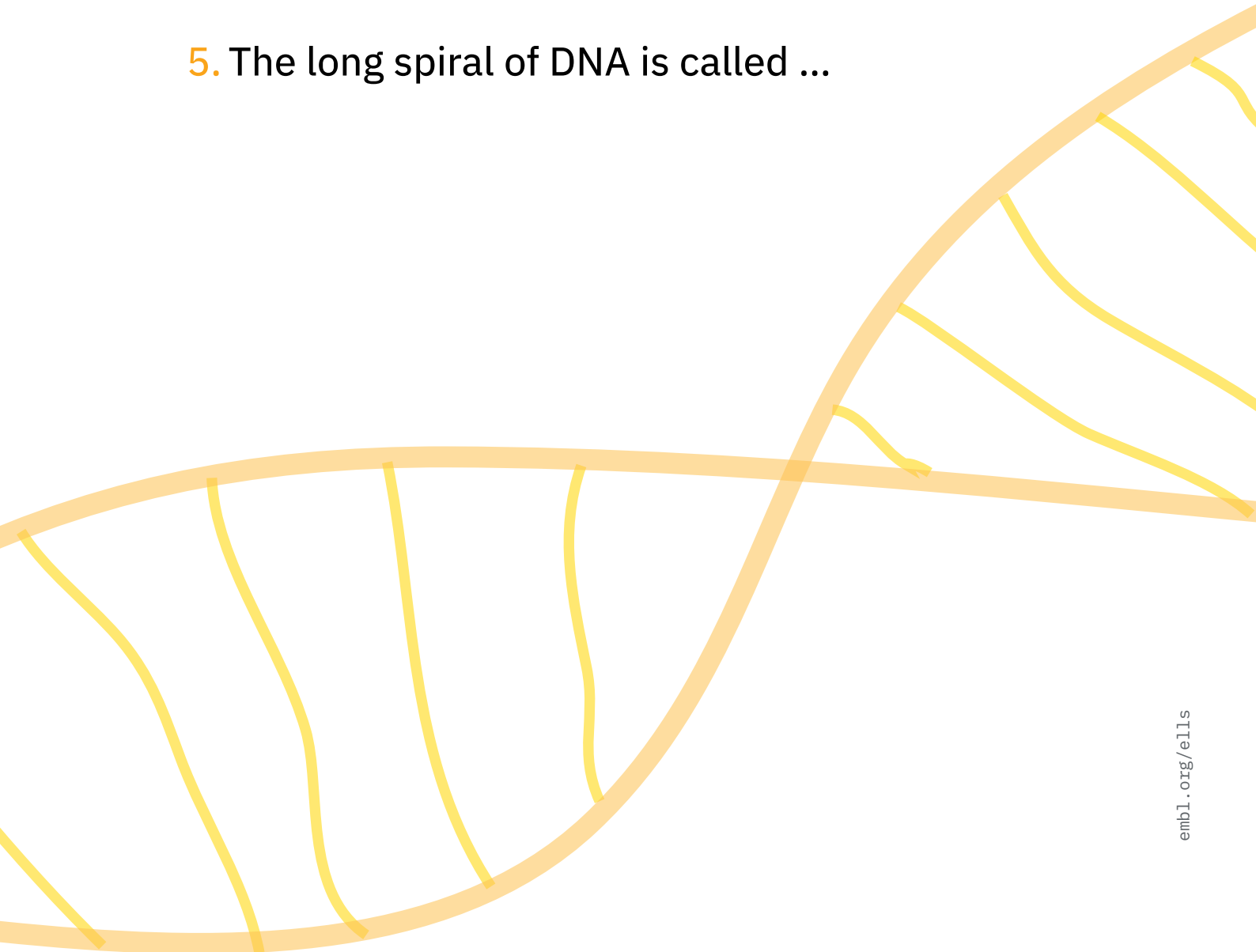
Game instructions

- A. Encode a message.* Use the **encoding card** to encrypt your message. Find the right combination of 3 colours to represent each letter, number, or sign and place the appropriate blocks on the plate.
- B. Decode a message:* Use the **decoding card** to help you. Look at the first 3 bricks, find out which letter, number, or sign is represented by that colour combination and write it down. Do the same for the rest of the code until you can read the secret message!



Questions

1. Humans are made up of around ... trillion cells.
2. The outer “skin” of a cell is called ...
3. The genetic DNA code consists of ...
4. What is the fundamental unit of life?
5. The long spiral of DNA is called ...



Science background

Every human being consists of 80 trillion cells and in almost every cell, more precisely in every cell nucleus, the **DNA** is contained. DNA (deoxyribonucleic acid) is the genetic material that makes up each person's "blueprint". It's a kind of coded cipher, and the task of the human body is to decode it so it knows how it should look and function.

You can imagine the DNA in the cell nucleus as long threads. In every tiny human cell nucleus, there are 2 metres of DNA! In order to fit in the nucleus, they are condensed and form a structure called a "double helix", which looks like a long spiral.

But in its most basic form, DNA can be broken down into simple components: organic molecules called **nucleotides**. Each nucleotide contains 1 of 4 different so-called bases, which are denoted by 4 letters: A, T, C, and G.

The DNA code is made up of many different "**triplets**" or "**codons**", combinations of 3 bases that stand for a piece of information. The DNA code can therefore be seen as a kind of secret language of your body.

Game expansion: Mutation

Changes in the sequence of bases in DNA are called **mutations** or, more precisely, gene mutations. Gene mutations are divided into substitution (the replacement of a nucleotide), deletion (the absence of one or more nucleotides) and insertion (the insertion of one or more nucleotides). If only one nucleotide is affected by a substitution, insertion, or deletion, it is a **point mutation**.

Mutations can have a range of effects, from harmful to beneficial to the organism. Sometimes, they have no effect at all. But these changes in a DNA sequence are the basis of **evolution**. Every genetic feature in every organism started out as the result of a mutation, which spread through reproduction. The history of many animal and plant species can be seen as a gradual accumulation of point mutations.

Incorporating mutations into the game

You can incorporate point mutations into the game by changing one letter (block) in a sequence and letting the participants figure out the mistake. It is best to do this with a word that is well known and in a context in which the mistake is obvious to everyone.

For example, you could ask the question “*What do lions eat?*” and code the answer “**HEAT**” instead of “**MEAT**”.

An example in German: If you code “*Ich schmiere Mutter auf meinen Toast*”, it should be obvious to everyone that the non-mutated answer would be “**Butter**”!

Find out more

Get in touch

We invite you to get in touch, to learn more about our activities and about ways you can collaborate with us.

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Version 2: June 2023

