User's Manual

This is a very fun game that can be played by children, teenagers and adults. It helps us visualize and understand how the decoding of a secret message works. The message is hidden in the form of a code, and only those who have access to the rules of that code, which one day had to be deciphered by someone very clever, will be able to translate the hidden message, thus finding out what it means. Once you begin to understand and master the rules of the game, you will be able to create your own “secret messages”, which can be deciphered by other people, as long as they too know the rules of the code. You can play alone, in pairs or in groups, with friends, family, or even in your classroom, under the orientation of a teacher.

At first glance, you make think this is a very simple game, because anyone can learn and apply its rules to assemble toys and the most diverse objects. But did you know that many biological processes which we learn at school or see in fiction movies follow this same logic? This is the case of our genetic code, created by nature over 3 billion years ago, which is based on the DNA that we inherited from our parents and grandparents, and is later translated into “products” or “substances”. These substances will control, inside and outside of our cells, all the mechanisms that make life possible and that explain a lot of what we are. Are you ready to begin?

The game contains 311 components in total, 307 of which are attachable pieces of wood, and also four laminated tables. You can visualize all the components on chart 1. The idea is that you're able to notice the relation between the isolated pieces and their meaning when they're together, ordered in a specific sequence. This sequence, composed of simple and repetitive units of four distinct colors, can be translated into something completely different and more complex, like a wooden object or toy. In this game, where the possibilities of secret messages and resulting products are almost infinite, you will have to learn how to "read" the "codified products" of certain toys, so that later you can translate them, transforming information contained in simple colored sequences into tridimensional objects, which can be useful and even fun.

It is as though you were a translator who masters two languages and thus is capable of translating information from a language to the other, where everything is correlated and analogizes with our own biology. Be it looking at the game as a mere toy factory, or relating each step with what you've learned (or will learn) in school, about heredity and molecular genetics (DNA, RNA and proteins), you'll notice that some codes can be redundant, in other words, two different sequences can have the same translation. Finally, you can also notice how a subtle change in the information is able to completely alter its final product.

Chart 1. Description of the game components and their quantities.

Piece/items	Quantity
Table in A3 format	4
Rod/Stem (mRNA axis)	8
Round blue piece	50
Round red piece	50
Round yellow piece	50
Round green piece	50
Unpainted and numbered piece: nº 1, 3, 5, 6, 8, 11 to 18 and 20	4*
Unpainted and numbered piece: nº 2 and 9	10*
Unpainted and numbered piece: nº 4	8*
Unpainted and numbered piece: nº 7, 10 and 19	5*

* quantity of each piece

Well, let's go! First, you need to understand how to assemble the secret message, later to be decodified. This wooden rod in figure 1 will be the base of our information.

Did you know that in our cells there are molecules that look a bit like these rods? Their name is messenger RNA (or mRNA). They carry the information present in the genes, located in the DNA, so that it can be translated into everything that the cell needs!

Figure 1. Base of the information, wooden rod.

To compose the secret message, you will need to fit the colored pieces in figure 2, which are the fundamental units of the information, into the wooden rod, detaching the round tip to expose the far end of the rod, since the other tip is glued onto it.

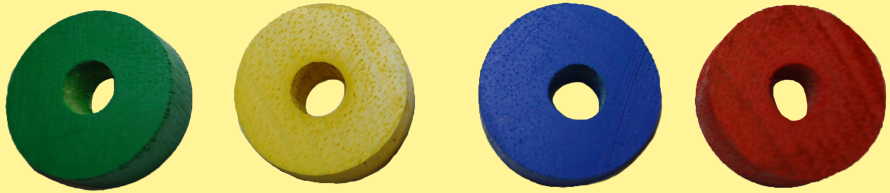


Figure 2. Units of the code.

Next, are the unpainted pieces of wood, shown below. There are 20 different types and their numbers are carved into the wood. Each one has a hole and a pin, that fit together with other similar pieces.

1

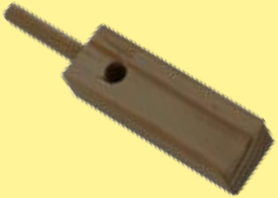
2

3

4

5

6

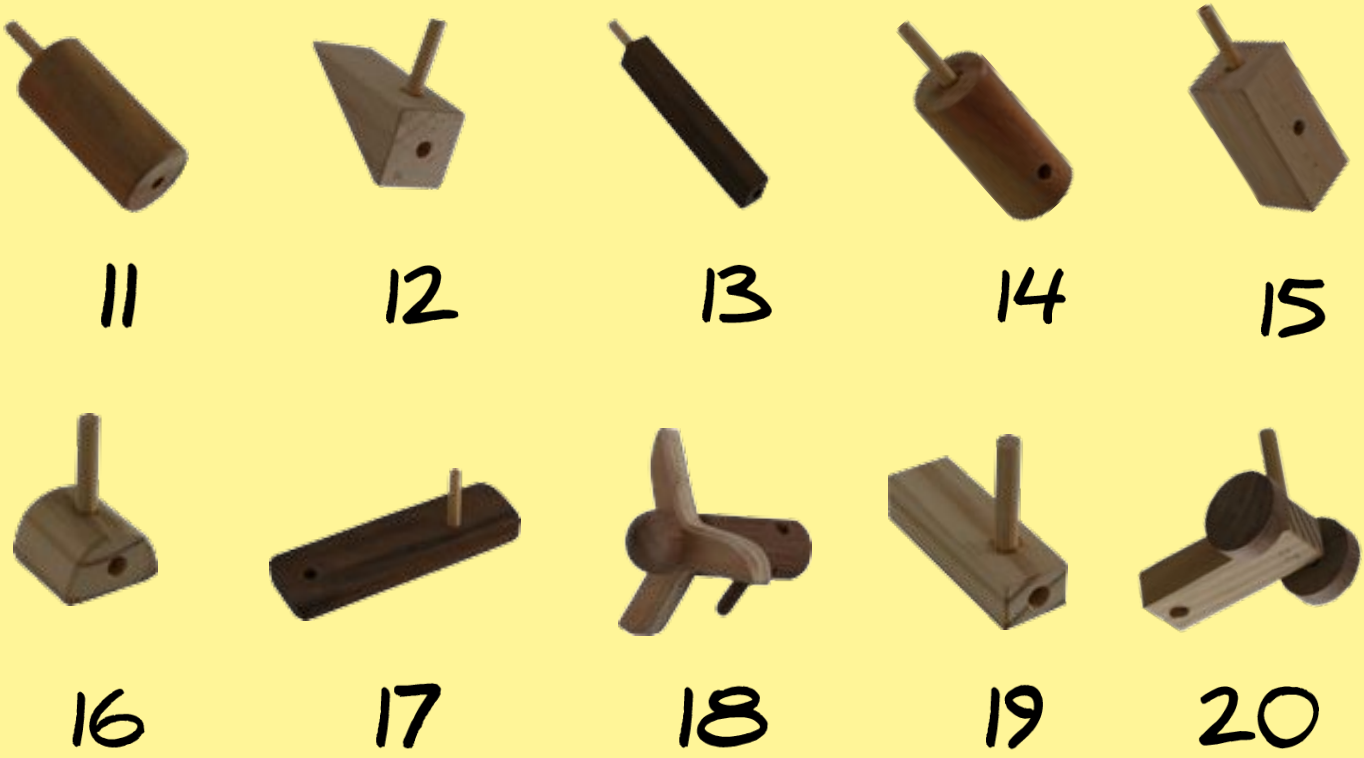


7

8

9

10



In our cells, these numbered and unpainted pieces can represent the 20 amino acids that compose all the existent cellular proteins.

Now that you already know all the pieces of the game, what can our colored message mean? Each message will be a secret recipe to form a specific object or toy as its final product. To decode and translate each secret message into something that makes sense (or doesn't), you will need to learn the rules of a code that remained hidden inside the cells of all living beings on Earth for 3 billion years, but was later to be deciphered by scientists. Pay close attention now: each triplet of colored fundamental units, read from the round tip to the other end of the rod, will work as a command to insert a specific unpainted piece of wood into the assembly of the new object (see Table 1).

Notice that each part of the object contains a pin and a hole, because the individual pieces need to fit in the order that the code determines. But always, the hole of the new piece (for example, the second) must fit in the pin of the piece that was already there (for example, the first). This way, each newly assembled piece must leave its pin available, which will fit into the hole of the next piece.

DECIPHERING THE CODE

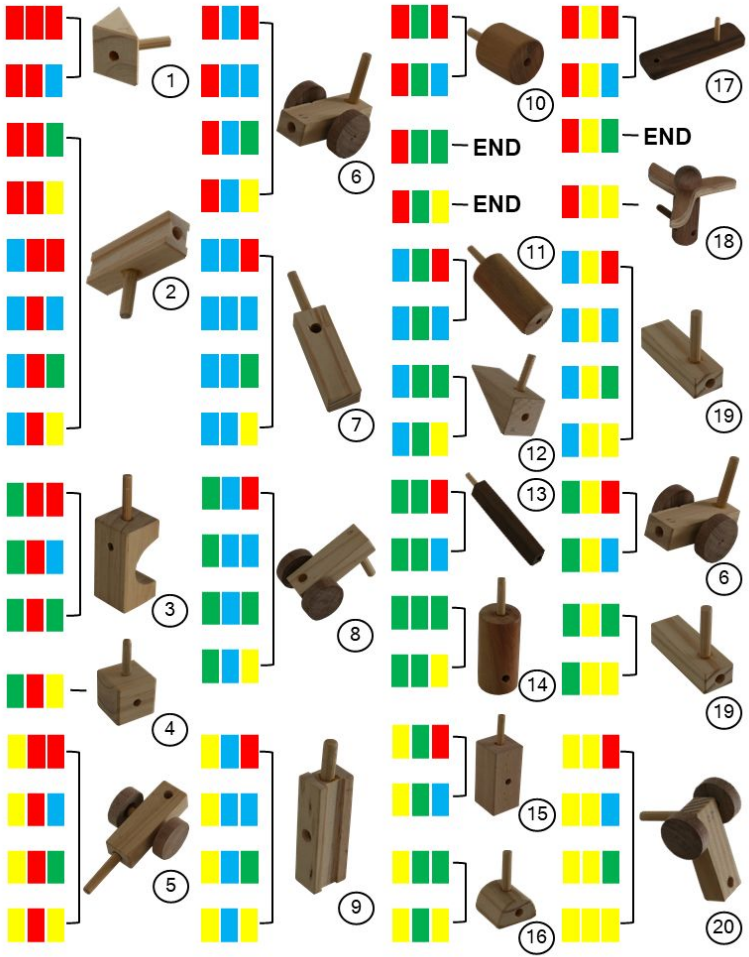


Table 1. Relation between all the possible triplets of colors and the 20 unpainted pieces of wood provided with holes and pins.

And when a triplet of pieces indicates the end? That is when the translation sequence ends. This way, we know that the object is finished.

Do you know what these objects represent in our cells? The proteins! They compose the cells and execute the most variable functions required to keep the cell alive! Did you know that living beings are made of cells? That's why proteins are very important for all kinds of life!

Now that you already know all the elements of the game and understand some rules and basic concepts, let's learn how to play?

Step 1: Organize the groups (if you're not playing alone), distribute a laminated table (Table 1) and a rod to each group and spread the remaining wooden pieces onto a large table. When playing in groups, which is always more fun, it's recommended that they don't exceed five people, with a minimum of two. Four groups is a good number to make the most of the options that the game offers.

Step 2: Assemble, with your group, a colored sequence using the pieces in figure 2, attaching them to the rod in figure 1. Remember that to make the rod accessible to the pieces, you must remove the round piece on the tip. In the end, it's gonna look something like figure 3.

Figure 3. Example of a randomly assembled colored sequence.

The color sequence can be random and of the size of your choice, made up to a maximum of 30 pieces. Remember that each triplet of colored pieces will code for an unpainted piece of the final object or toy, so we suggest that you insert on the rod a number of colored pieces that is a multiple of 3 (9, 12, 15, etc.). The colored sequence will begin to be translated from the extremity that has a half sphere on the tip, to the opposite extremity that ends with a rectangular block.

Tip: the game becomes more fun when the last triplet to be read is one of those three that indicate the end of the object, as in figure 4!

Step 3: After the sequences are assembled, you can exchange them among the groups reciprocally, handing out your sequence to a certain group and receiving back the sequence which that group assembled. If you're playing alone, you can keep your own sequence.

Step 4: Now you and your group will translate the secret colored message, using the code provided in table 1! With it, find out what are the pieces with holes and pins that will form your final object. Notice that they must be put together following the colored sequence, starting by the round tip! The pin on piece 1 fits in the hole on piece 2, the pin on piece 2 fits in the hole on piece 3 and so on, until the colored sequence ends or you reach a triplet that indicates the end of translation.

Step 5: After the object is assembled, take a close look at it. If possible, compare it with the other groups' objects. You can even take pictures of them. Do they look the same or are they different? If they are different, are there any similarities between them? Can you imagine a possible use for these objects?

Knowing that these objects could represent proteins, which have their size, composition and shape defined by the sequence of nucleotides in our genetic material (DNA), can you imagine how many different types of proteins a living being can have?

Now that you've learned how the game works, we will give you a few suggestions to make it even more interesting!

Variation 1: In this variation, instead of assembling a random sequence on step 2, assemble one of the sequences in figure 4 (if you're playing in four groups, each group can choose one of the following sequences to assemble):

Sequence 1:

Sequence 2:

Sequence 3:

Sequence 4:

Figure 4. Examples of sequences to assemble.

Once gain, follow steps 4 and 5. After you finish assembling the four objects, how do they look like? Do these objects remind the groups of something? Can you imagine and suggest to your friends what could be the use for each one of them? At the end of this manual, we put the answers, but don't go looking for them, otherwise, it's not fun, eh?

Variation 2: Did you notice that some of the triplets of colored pieces mean the same thing, in other words, they correspond to the same part of the resulting object? If not, go back to the code table and take a closer look. Now, can you try assembling new colored sequences for the final objects, different from those that determined them on variation 1?

Can different colored sequences be translated into the same final object? How many different sequences can you assemble to make the same objects in variation 1?

Did you know that this can also happen in our DNA and in our RNA? Sometimes, because of this fact, a nucleotide is replaced with another in our genes, but this exchange doesn't imply an altering in the resulting protein. They are called silent or synonymous mutations!

In cells, proteins can have diverse shapes, or conformations. Their shapes usually are related to the functions that they execute. There are proteins that help with transport, energy generation, breaking down other proteins and many other functions! Can you propose analogies between the newly assembled toys and real proteins that exist in our cells?

Variation 3: And now, what about changing some triplets for others, in order to alter parts of the final object? What you are simulating now, in the case of our cells, would be called a mutation. Change one part, two, or how many you'd like! Notice the change that happens in the final object. Do you think these changes could compromise or improve the function of the object?

This type of change can also happen in our DNA sequence and consequently in our RNA. A change that causes an alteration in the protein is called a substitution mutation, and can compromise the function of the protein! This type of mutation can be very dangerous, depending on the protein and where it was affected. Imagine if a protein that carries oxygen lost this capability, for example! This exists in real life and is called sickle cell anemia.

Variation 4: Is the reverse way possible? Starting from an object or toy, can you define the colored sequence that coded it? Assemble with your group a new object, different from the ones that were already built. Do it any way you want, and in the end, you and your group, or the other group you're playing with, will have to assemble the colored sequence according to the code table. Remember that the limit of fundamental units that can fit on the rod is 30, and that three colored pieces are necessary to code one piece with a hole and pin, and that the last triplet will code for the end. So, we suggest that you assemble original objects with a maximum of nine pieces with a hole and pin.

So, were you and your friends able to decipher all the secret messages? And starting from an object, were you able to find a single sequence to assemble it? Would that be possible? If you'd like to see more tips about the game Ima-gene, access Imagine Project's website (https://projetoimagine.ufsc.br/). There, the game is available for free as an Open Educational Resource. But if you'd like to purchase an original set of the game from its own manufacturer, that took part in its conception, get in touch with Oficina do Aprendiz (https://oficinadoaprendiz.com.br/).

If you can imagine different ways of playing the game, or even create competitions with groups of friends, far away or close, we would like to know! Maybe you can venture to create a new object and send us its secret message so we can try and build it ourselves? You can send your ideas to our project's email address (projetoimagineufsc@gmail.com).

Answers to the sequences described in variation 1: Sequence 1 = track; Sequence 2 = hammer; Sequence 3 = train; Sequence 4 = wind turbine.

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