

“Vanilla-flavoured Synthetic Biology” Game

Objectives

This practical activity aims to illustrate to the general public some basic concepts of synthetic biology by simulating genetic manipulation on the yeast genome *Saccharomyces cerevisiae* to produce vanillin, using the strategy developed and patented by the EVOLVA company. This manipulation involves transferring 4 genes into the yeast genome from *Homo sapiens*, *Podospora pauciseta*, *Nocardia iowensis* and *Corynebacterium glutamicum*, respectively.

The game is based on puzzles made up of pieces designed to represent the genomes of these organisms and the respective genes involved in the production of vanillin, as well as the resulting vanillin molecule.

The participants will be invited to identify the 4 pieces representing the 4 “genes of interest” in the puzzles simulating the genomes and to transfer them into a fifth puzzle, which illustrates the *Saccharomyces cerevisiae* genome.

The format designed for this game, based on puzzles made up of specifically designed pieces, is a graphic simplification which means to clarify the genetic engineering procedure involved in the production of vanillin.

Players

The game can be played individually or in groups, we would suggest two players per group.

Game parts and description

Puzzles

1-“*Homo sapiens*” puzzle made up of 8 pink-coloured pieces divided into: 1 “*Homo sapiens*” piece, 2 “continue” pieces, 4 “sequences” pieces, 1 “gene of interest” piece.

2-“*Podospora pauciseta*” puzzle made up of 8 orange-coloured pieces divided into: 1 “*Podospora pauciseta*” piece, 2 “continue” pieces, 4 “sequences” pieces, 1 “gene of interest” piece.

3-“*Nocardia iowensis*” puzzle made up of 8 blue-coloured pieces divided into: 1 “*Nocardia iowensis*” piece, 2 “continue” pieces, 4 “sequences” pieces, 1 “gene of interest” piece.

4-“*Corynebacterium glutamicum*” puzzle made up of 8 light-blue coloured pieces divided into: 1 “*Corynebacterium glutamicum*” piece, 2 “continue” pieces, 4 “sequences” pieces, 1 “gene of interest” piece.

5-“*Saccharomyces cerevisiae*” puzzle made up of 8 green-coloured pieces divided into: 1 “*Saccharomyces cerevisiae*” piece, 2 “continue” pieces, 5 “sequences” pieces. The fourth and fifth piece show two “START” and “STOP” symbols to indicate the insertion point of the genes which will be transferred from the other 4 organisms.



6-**“Vanillin” puzzle** made up of 4 pieces illustrating the vanillin molecule and wording: 1 “VA” piece, 1 “NIL” piece, 1 “LI” piece, 1 “N” piece. The colour used for these pieces is made up of the 5 colours of the organisms.

Puzzle pieces

The pieces which make up the 6 puzzles are intended as follows:

“Organism name” piece

Quantity: 1 piece per puzzle.

Description: This piece shows the scientific and the common name and a graphic representation of the organism.

Position in the puzzle: At the start (that is, the top left end of the puzzle).

“Continue” piece

Quantity: 2 pieces per puzzle.

Description: These pieces show a DNA chain between dashes to indicate that the sequence continues at both ends.

Position in the puzzle: One piece is in the second place (that is, after the “*organism name*” piece) and the other at the end of the puzzle (that is, bottom right end).

“Sequence” pieces

Quantity: 4 pieces per puzzle.

Description: They represent a part of the genome of the organism, illustrated by a sequence of DNA.

Position in the puzzle: Between two “*continue*” pieces.

“Gene of interest” pieces

Quantity: 1 piece per puzzle of the 4 donor organisms of the genes of interest.

Description: This piece shows, for each organism, the gene of interest to be transferred into the yeast genome. It is identical to the “*sequence*” piece but shows a magnifying lens which enlarges the sequence of interest.

Position in the puzzle: Between two “*sequence*” pieces.

“Vanillin” piece

Quantity: 4 pieces per puzzle

Description: These 4 pieces, once assembled in the right sequence, will simulate the vanillin molecule, each one showing a part of the word “vanillin”: “VA”, “NIL”, “LI”, “N”. They are intended to show the protein synthesised by the engineered yeast, that is vanillin.



In short, the sequence of pieces which make up the 5 organism puzzles (thus excluding the “vanillin” puzzle) is the following:

- 1- “Organism name” piece
- 2- “Continue” piece
- 3- “Sequence” piece
- 4- “Sequence” piece
- 5- “Gene of interest” piece
- 6- “Sequence” piece
- 7- “Sequence” piece
- 8- “Continue” piece

How to play the game

Before starting the game, the operator will assemble all the puzzles , with the only exception for the “vanillin” one, which will be put together by the players during the game. Thus, the players will find the 5 puzzles representing the 5 organisms (*Homo sapiens*, *Podospora pauciseta*, *Nocardia iowensis*, *Corynebacterium glutamicum* and *Saccharomyces cerevisiae*), already put together on their desk, and the “vanillin” puzzles , broken up into 4 pieces.

The players will be asked to examine the genomes of the 4 donor organisms (*Homo sapiens*, *Podospora pauciseta*, *Nocardia iowensis*, *Corynebacterium glutamicum*) and to identify the 4 “genes of interest” pieces. They will isolate, from the respective puzzles, these pieces and transfer them into the “*Saccharomyces cerevisiae*” puzzle. These must be inserted between the two “sequence” pieces which are worded ”START” and “STOP”. As a result of the insertion of the 4 “genes of interest” pieces, the simulation of yeast genome engineering will be accomplished.

Finally, the players will be able to simulate the codification of the vanillin molecule from the engineered yeast: they will relate the coding genes with the 4 pieces representing the "vanillin" puzzle and put them into the right sequence to complete this puzzle.

The objective is to understand: the function of the transferred genes, the relation between these genes and the vanillin sequence, as well as the strategy applied in producing vanillin with synthetic biology.

Game-activity table

Game Phase	Objectives	How to play	Player’s Actions
Preparation	Setting up the stations and the game.	The operator assembles the puzzles on the desks which represent the genomes of the 5 organisms. One station is provided for each player group (2 participants per group is recommended).	None.
Introduction to	To be aware of how to	The players stand in front of	To listen and interact



the game.	use the game.	the stations which have already been set up so they can understand the operator's explanations on how to play the game and how to use the puzzles and the various pieces.	with the operator and examine the puzzles to understand how to play the game.
Playing the game: 1-Yeast engineering.	Becoming familiar with basic concepts such as: the presence of genes in the genomes; their function; the possibility of isolating them to be transferred into other organisms.	The players: identify the 4 " <i>genes of interest</i> " pieces; isolate them from the respective puzzles; transfer them into the " <i>Saccharomyces cerevisiae</i> " puzzle.	Recognizing and isolating the " <i>genes of interest</i> " in order to insert them into the " <i>Saccharomyces cerevisiae</i> " puzzle.
Playing the game: 2-Vanillin synthesis.	Understanding: the roles of genes in vanillin production; the possibility of genes from phylogenetically distant organisms being expressed in genetically modified organisms; the genetic engineering mechanisms involved in synthetic.	By putting together the "vanillin" puzzle, finally the players will be able to produce the vanillin molecule from the genetically engineered yeast obtained in the previous activity	-Assembling the " <i>Vanillin</i> " puzzle; -understanding the relation between transferred genes and the vanillin molecule, also by observing the colours of the pieces involved in this part of the game.