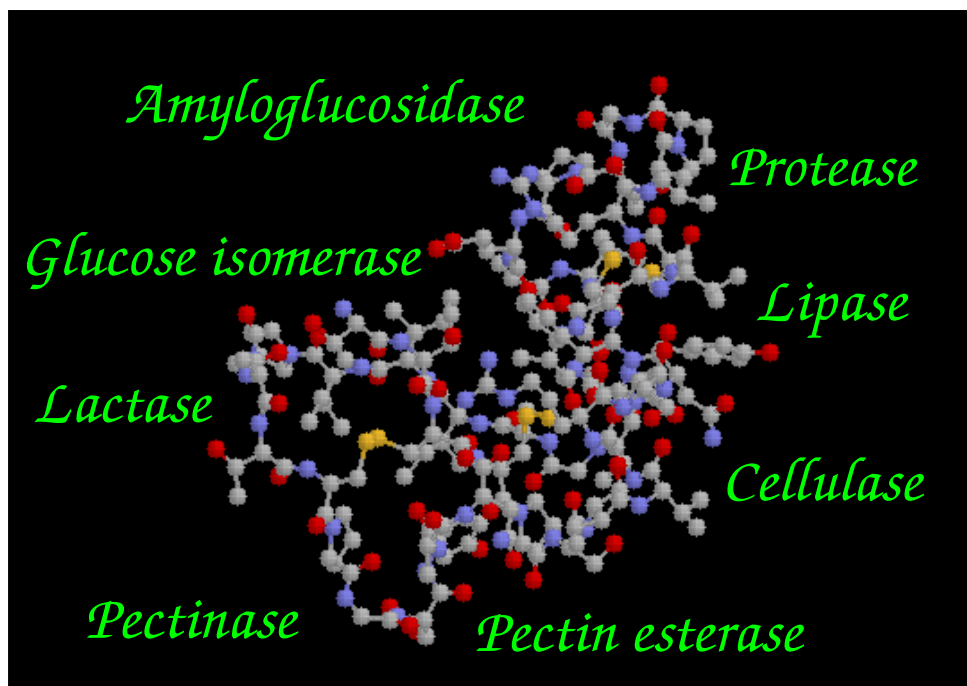


The Enzyme Game

How to play the Enzyme Game

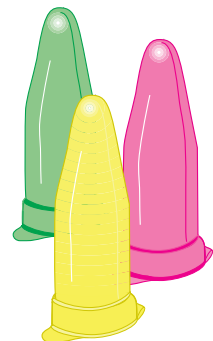
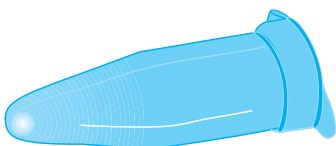


The information for this image was obtained from the Protein Data Base. The image represents the molecular structure of the enzyme cellulase and is shown in stick and ball format.
(<http://www.rcsb.org/databases.html>) Protein code PDB 1KUL

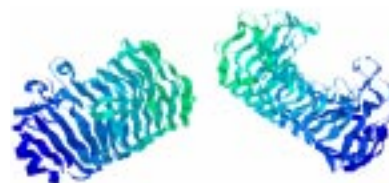
**A game that explores the production
and use of commercial enzymes**

Materials required to play the game

- 1 A Game board for 4 players : two A4 sheets of card.
- 2 An enzyme booklet containing information data sheets on the enzymes and the names of the organisms that produce the enzymes.
- 3 A set of spinners:
 - 4 pink for enzyme production:
 - 1, enzyme choice spinner,
 - 2, culture hurdle,
 - 3, fermentation fence,
 - 4, processing ditch.
 - 4 blue spinners for enzyme utilisation
 - 1, enzyme substrate fence,
 - 2, pH hurdle,
 - 3, temperature ditch and
 - 4, application fence.
- 4 A normal six sided die, used to move the enzyme markers round the track.
- 5 Money:
EIBE bank notes (€500, €1,000, €2,000, €5,000, €10,000).
- 6 Coloured microcentrifuge tubes (0.5ml) are used as counters to move round the board.
- 7 A set of pink 'Production Chance Cards' - cards that influence enzyme production.
- 8 A set of blue 'Utilisation Chance Cards' - cards that influence enzyme utilisation .
- 9 A set of rules and instructions on how to play the game.
- 10 Laboratory journal pages



Rules and Instructions



- 1 Each game requires 3 or 4 players.
- 2 Each player must obtain an enzyme by spinning the 'enzyme choice spinner' (pink spinner 1) which contains the names of enzymes and microorganisms that produce the enzyme. Information on the enzyme that the player has selected can be found in the enzyme data sheet e.g. *Aspergillus niger* overproduces the enzyme AMG - Amyloglucosidase. Any other player that spins and selects an enzyme that is taken by another player must spin again until each player has a different enzyme.
- 3 Once all the players have spun the enzyme choice spinner and identified their enzyme they should collect from the bank the amount of money stated in the enzyme data sheets.
- 4 Play can now begin. Each player throws the die in turn and moves his or her enzyme counter (coloured tube) the set number of spaces scored.
- 5 Play continues until the first obstacle is reached. The enzyme counter has to stay on the obstacle until the next turn. Players cannot pass the obstacle until the spinner for the obstacle is used and the result obtained acted upon.
- 6 After a player has used the special spinner for the obstacle he or she must decide either to pay to continue (by forfeiting the amount specified on the information data sheet to the bank) or wait for another go and spin again. If the required value is obtained then the enzyme counter can move off the obstacle on to the next space. Then a normal die is used and players continue in the normal way until the next obstacle is reached.
- 7 The game is divided into two parts the production of the enzyme then the use of the enzyme in an industrial process. There are three obstacles in the production of the enzyme and there are four obstacles in the use of the enzyme.
- 8 The first player to pass the sales gate receives €5000, the second, €4000 the third €3000 and the last person €2000.
- 9 All the information needed to pass each obstacle is given on the enzyme data sheets. At different obstacles players will have to make decisions whether to proceed or not.
- 10 If after 3 attempts a player cannot proceed over an obstacle then the play can proceed by giving each player €500
- 11 All players should record the different condition and factors that other players accept so that a full record of play is obtained, since it might affect who wins the game.
- 12 Any player that lands with their enzyme counter on a pink or blue square has to take a chance card. One or all players may then be affected by the information given on the card, the game continues once all the players have acted on the information given on the card.
- 13 The game is finished when all players have passed the finish line. The player with most money is the winner - it might not be the first to finish!
- 14 The first player to finish should double their money, the second to finish should receive half the money they hold, while the third should receive a quarter of the money they hold. The last nothing!

Laboratory Journal

Enzymes are for Life! 

Enzyme production and enzyme utilisation cards can effect decisions that have been taken at different hurdle and fences so it is important that players keep a full record of all players decisions.

Enzyme Production

	Player 1	Player 2	Player 3	Player 4
Name of player:
Colour of counter:
Enzyme choice spinner: (selection of enzyme & microbe)				
Microbe selected by spinner:
Enzyme produced by the microbe:
Culture hurdle: (bacteria, fungus, microbe)				
Culture selected by players:
Fermentation fence: (permission, condition, both)				
Value obtained by player:
Processing ditch: (liquid, granulated, immobilised food grade, purified, sterile filtered)				
Value obtained by player:

Enzyme Utilisation

	Player 1	Player 2	Player 3	Player 4
Name of player:
Colour of counter:
Enzyme substrate fence (lactose,glucose,pectin,protein, starch,cellulose,fat & oil, joker)				
Substrate used by player:
pH fence (pH 1,2,3,4,5,6,7,8,9,10,11,12,13,14)				
pH selected by player:
Temperature ditch (10,20,30,40,50,60,70,80,90,100 °C)				
Temperature selected by player :
Application fence				
Application obtained by player :
Money left at end of game:
Bonus added for finish position:
Total money obtained:

Help with Enzymes

What you should know after playing the game:

- # Commercial enzymes are made in microbial cells in fermenter systems
- # Enzymes are specific in their action and work on specific substrates
- # Enzymes are affected by factors like temperature and pH
- # Enzymes play a major role in industrial processes
- # An appreciation that enzymes play an important role in many industrial processes - biological solution to industrial problems.

It is anticipated that by playing the game many questions will be raised relating to enzyme use and their commercial production. Space has been provided below for players to record notes and questions that arise while playing the game.

Questions:

.....

.....

.....

.....

Notes:

.....

.....

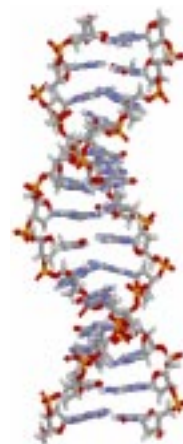
The following references, resources and web sites are provided as a start to help players find out more about enzymes.

Web sites:

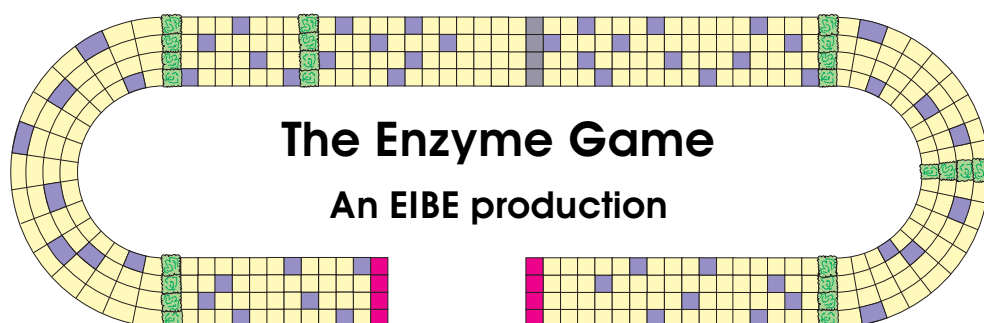
web site addresses: **Novozymes A/S.** (enzymes) (<http://www.novozyme.com>)

web site addresses: **Grist Brocades.** (<http://www.gist-brocades.nl>)

web site addresses: **RSCB Protein Data Base.** (<http://www.rcsb.org/pdb>)



What is the relationship between DNA and enzymes?

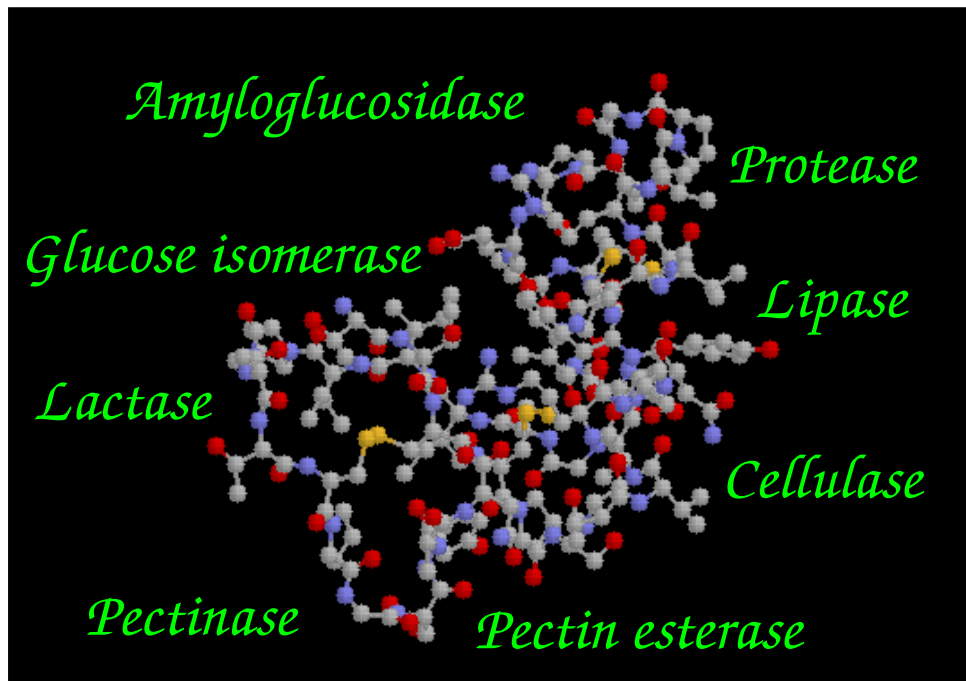


A game originally conceived and designed by John Schollar
unit co-ordinator but refined and improved by EIBE unit members:
Dorte Hammelev and John Watson.

The members of the group would like to thank Novoezymes A/S for their
help and support in the production of this game.

The Enzyme Game

Information data sheets on the enzymes
used in the Enzyme Game



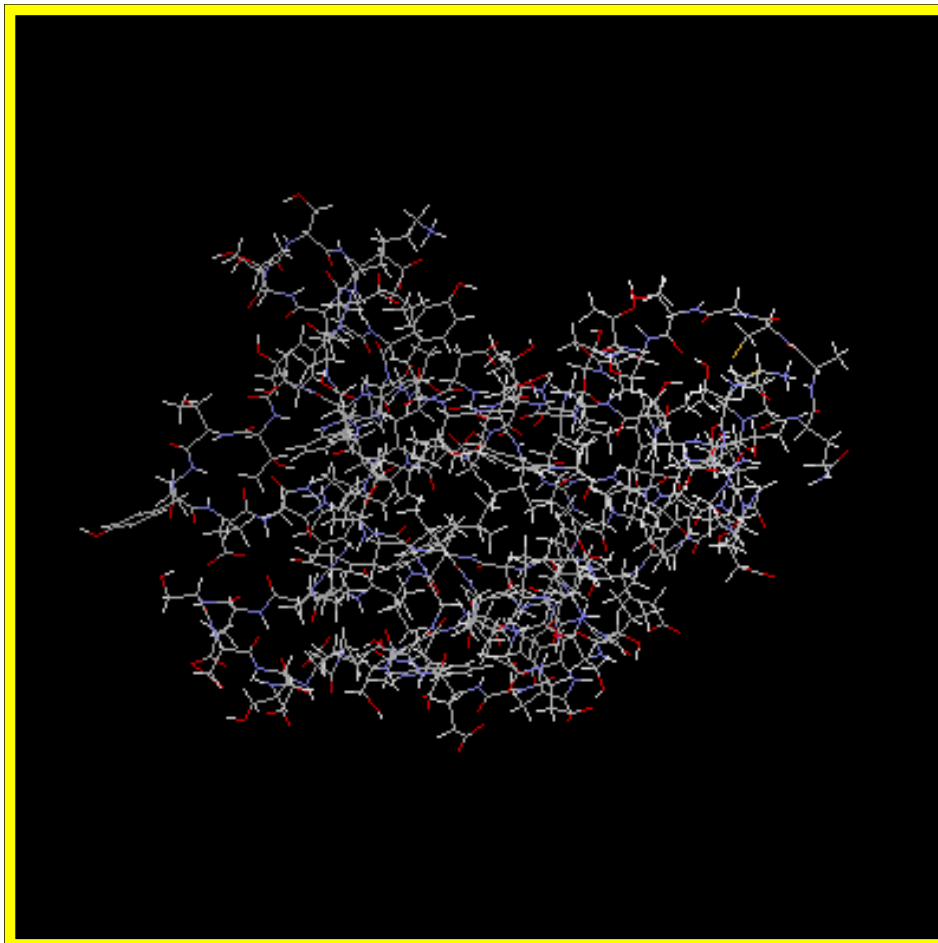
The information for this image was obtained from the Protein Data Base. The image represents the molecular structure of the enzyme cellulase and is shown in stick and ball format.
(<http://www.rcsb.org/databases.html>) Protein code PDB 1KUL

**A game that explores the production
and use of commercial enzymes**

Microorganism: *Aspergillus nigr*a

Enzyme produced : Amyloglucosidase

The information for this illustration was obtained from the Protein Data Base (<http://www.rcsb.org/databases.html>)
Protein code PDB 1KUL



Wire frame structure of AMG - Amyloglucosidase.
The enzyme hydrolyses starch molecules to glucose units.

AMG is the enzyme amyloglucosidase. It hydrolyses starch to glucose by removing glucose units in a stepwise way from the non-reducing end of the starch molecule. The enzyme will hydrolyse both 1,4 and 1,6 glucose molecule linkages. The microorganism that produces the enzyme is a selected stain of a fungus called *Aspergillus niger*.

Information on Production and Utilisation of AMG an amyglucosidase

Production Information

Collect 10000 € from the bank

The following information is necessary for the successful production of the enzyme and will be needed to play the game. It relates to the microbial culture that is required to produce the enzyme, permission to grow the microorganism and the correct conditions for the successful production of the enzyme. Finally processing so that the enzyme can be sold as a marketable product.

Culture hurdle

Only the following cultures will allow you to pass over the hurdle and progress on to the next fence.

'fungal' pay 1000 € to the bank for culture

'microbe' pay 2000 € to the bank for culture

Fermentation fence

Only the following will allow you to surmount the fence and progress on to the next ditch.

'permission and conditions' pay 1000 € to the bank

'permission' pay 2000 € to the bank

'conditions' pay 2000 € to the bank

Processing ditch

Only the following process will allow you to surmount the hurdle and progress on to the next stage of the game .

'liquid' pay 1000 € to the bank for processing costs
or

'granulated' pay 1000 € to the bank for processing costs

Utilization Information.

The following information is necessary for the second part of the enzyme game, if the enzyme is to be used efficiently. A suitable substrate will need to be obtained and optimum operating conditions (temperature and pH) selected.

Enzyme substrate fence

At the fence you must buy a suitable substrate for the enzyme you have selected.

'starch' pay 1000 € to the bank for substrate
or

'substrate joker' pay 2000 € to the bank for substrate.

pH hurdle

At the hurdle you can only surmount it and progress if you obtain the recommended operating pH value for the enzyme. Alternatively you can progress on to the next fence with a close pH value, but you have to pay to the bank money for using the enzyme inefficiently and thus uneconomically. Rather than pay money to the bank you can decide to wait at the hurdle in the hope of obtaining a more beneficial value the next time and thus no payments to the bank.

pH 4.0 recommended operating pH of the enzyme progress on.

pH 5.0 and 6.0 rather inefficient, pay 1500 € to the bank.

pH 3.0 inefficient, pay 1000 € to the bank.

Temperature ditch

At the ditch the value you obtain determines the temperature that you operate the enzyme at. If the value falls between the recommended operating temperature then you can progress on to the next hurdle. If the value you obtain is outside the recommended you can either wait and try again or pay the premium set out below:

60°C recommended operating temperature, progress on.

70°C enzyme is not as stable as recommended operating temperature. Pay 1000 € to the bank

40°C and 50°C enzyme is stable at these temperatures but not as efficient. The substrate temperature is lower so more energy efficient. Pay 500 € to the bank.

Product production hurdle

The last hurdle considers how the enzyme might be use by industry. Some enzymes are very specific to a particular industry, they perform a very specific task while other enzymes are used by very many different industries.

'baking industry' used in chilled and frozen doughs
Collect 500 € from the bank.

'sugar industry' starch saccharification - 'breakdown'
Collect 500 € from the bank.

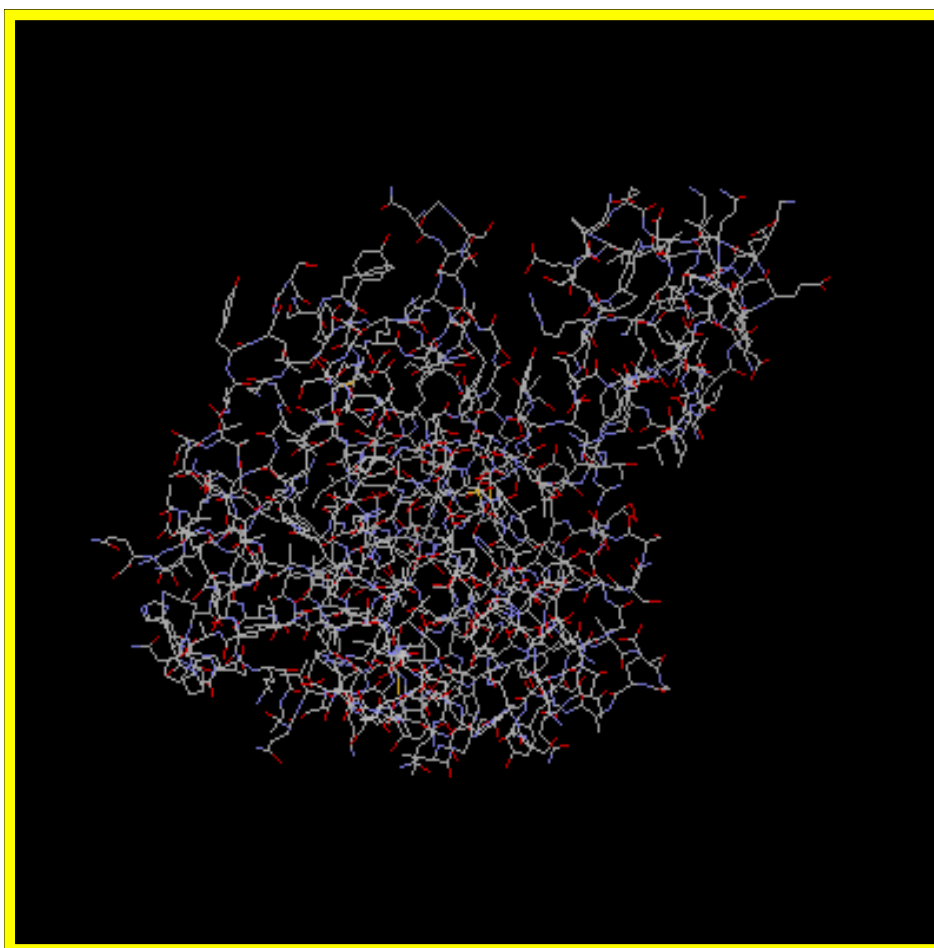
'brewing industry' used in production of low - calorie beers
Collect 500 € from the bank.

'joker' progress on.

Microorganism: **Bacillus sp.**

Enzyme produced : **Savinase® (protease)**

The information for this illustration was obtained from the Protein Data Base (<http://www.rcsb.org/databases.html>)
Protein code PDB 1A10



**Wire frame image of enzyme Subtilisin A protease.
Proteases are used by the detergent industry in the
production of biological washing powders**

Savinase® is a protease that is used by the detergent industry. It is used in washing powders and dishwasher powders and removes stains that are protein based like blood, grass, egg and gravy. These stains are often difficult to remove for they are insoluble in water and stick strongly to clothes and crockery. The enzyme Savinase® hydrolyses the proteins to peptides which are soluble in water and dissolve into the washing water. Savinase® is produced by a submerged fermentation of a genetically modified bacterium called Bacillus.

Information on Production and Utilisation of Savinase® a protease used in laundry and automatic dishwashers.

Production Information

Collect 13,000 € from the bank

The following information is necessary for the successful production of the enzyme and will be needed to play the game. It relates to the microbial culture that is required to produce the enzyme, permission to grow the microorganism and the correct conditions for the successful production of the enzyme. Finally processing so that the enzyme can be sold as a marketable product.

Culture hurdle

Only the following cultures will allow you to pass over the hurdle and progress on to the next fence.

'bacterium' pay 1000 € to the bank for culture

'microbe' pay 2000 € to the bank for culture

Fermentation fence

Only the following will allow you to surmount the fence and progress on to the next ditch.

'permission and conditions' pay 2000 € to the bank

'permission' pay 3000 € to the bank

'conditions' pay 2000 € to the bank

Processing ditch

Only the following process will allow you to surmount the hurdle and progress on to the next stage of the game.

'liquid' pay 1000 € to the bank for processing costs
or

'granulated' pay 2000 € to the bank for processing costs

Utilization Information.

The following information is necessary for the second part of the enzyme game, if the enzyme is to be used efficiently. A suitable substrate will need to be obtained and optimum operating conditions (temperature and pH) selected.

Enzyme substrate fence

At the fence you must buy a suitable substrate for the enzyme you have selected.

'protein' pay 2000 € to the bank for substrate

or

'substrate joker' pay 2000 € to the bank for substrate.

pH hurdle

At the hurdle you can only surmount it and progress if you obtain the recommended operating pH value for the enzyme. Alternatively you can progress on to the next fence with a close pH value, but you have to pay to the bank money for using the enzyme inefficiently and thus uneconomically. Rather than pay money to the bank you can decide to wait at the hurdle in the hope of obtaining a more beneficial value the next time and thus no payments to the bank.

pH 8.0, 9.0 or 10.0 recommended operating pH of the enzyme progress on

pH 7.0 and 11.0 inefficient, pay 1500 € to the bank.

pH 12.0 more inefficient, pay 1000 € to the bank

Temperature ditch

At the ditch the value you obtain determines the temperature that you operate the enzyme at. If the value falls between the recommended operating temperature then you can progress on to the next hurdle. If the value you obtain is outside the recommended you can either wait and try again or pay the premium set out below:

50°C recommended operating temperature, progress on.

40°C or 60°C uneconomic operating temperature. Pay 1000 € to the bank.

30°C or 70°C uneconomic operating temperature. Pay 2000 € to the bank.

Product production hurdle

The last hurdle considers how the enzyme might be used by industry. Some enzymes are very specific to a particular industry, they perform a very specific task while other enzymes are used by very many different industries.

'detergent industry' used in the production of washing and dish washing powders.

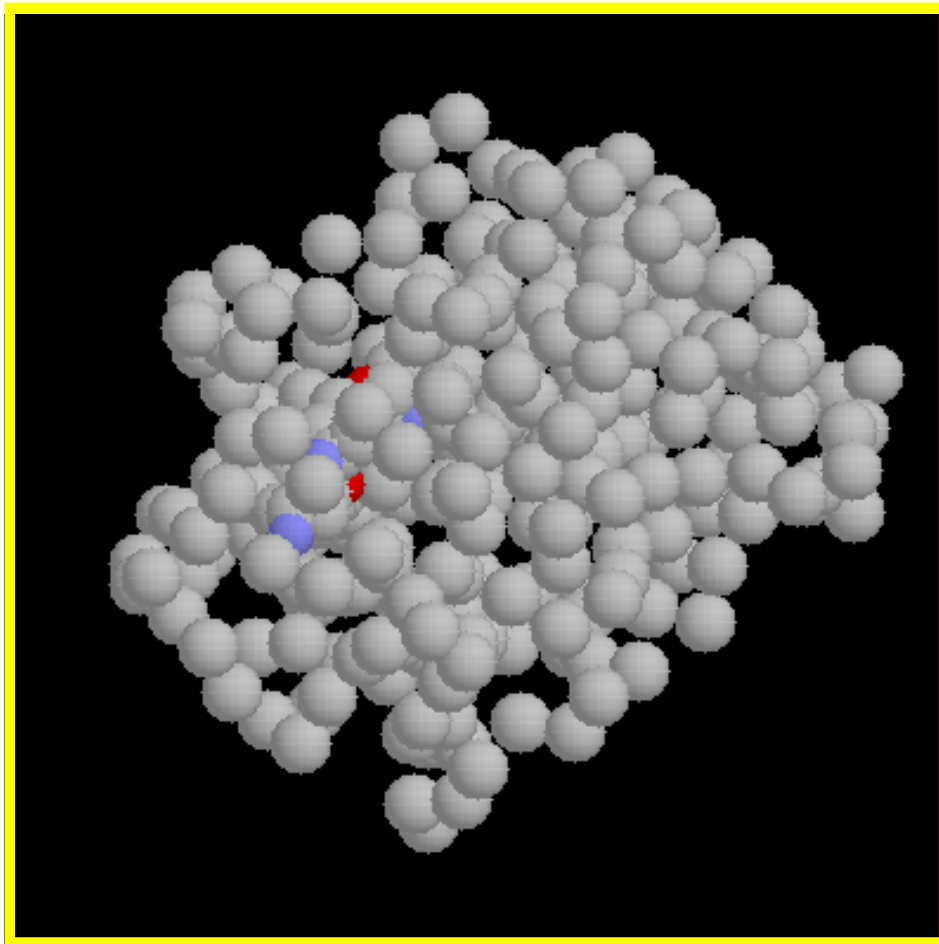
Collect 1000 € from the bank.

'joker' progress on.

Microorganism: **Aspergillus oryzae**

Enzyme produced : **Lipolase™ (lipase)**

The information for this illustration was obtained from the Protein Data Base (<http://www.rcsb.org/databases.html>)
Protein code PDB 1TGL



Space filled model of a lipase.
Lipolase is an enzyme used by the detergent industry.

Lipolase™ is a lipase that is used in the detergent industry to remove fat and oil based clothing stains. It will hydrolyse triglycerides into diglycerides and monoglycerides, glycerol and fatty acids which are all more soluble in water than the original fat and oil. It works efficiently on fats and oils derived from animal and plant. It thus removes stains resulting from frying fats, salad oils, butter, soups, human sebum and cosmetics like lipstick efficiently. Lipolase™ is produced using DNA technology. Genetic information for the production of the enzyme was transferred from the donor fungus (*Mucor*) to a laboratory strain of the fungus *Aspergillus oryzae*.

Information on Production and Utilisation of Lipolase™ a detergent enzyme for fat rich stains

Production Information

Collect 12,500 € from the bank

The following information is necessary for the successful production of the enzyme and will be needed to play the game. It relates to the microbial culture that is required to produce the enzyme, permission to grow the microorganism and the correct conditions for the successful production of the enzyme. Finally processing so that the enzyme can be sold as a marketable product.

Culture hurdle

Only the following cultures will allow you to pass over the hurdle and progress on to the next fence.

'fungus' pay 1000 € to the bank for culture

'microbe' pay 2000 € to the bank for culture

Fermentation fence

Only the following will allow you to surmount the fence and progress on to the next ditch.

'permission and conditions' pay 2000 € to the bank

'permission' pay 3000 € to the bank

'conditions' pay 2000 € to the bank

Processing ditch

Only the following process will allow you to surmount the hurdle and progress on to the next stage of the game.

'liquid' pay 1000 € to the bank for processing costs or

'granulated' pay 2000 € to the bank for processing costs.

Utilization Information.

The following information is necessary for the second part of the enzyme game, if the enzyme is to be used efficiently. A suitable substrate will need to be obtained and optimum operating conditions (temperature and pH) selected.

Enzyme substrate fence

At the fence you must buy a suitable substrate for the enzyme you have selected.

'fats / oils' pay 2000 € to the bank for substrate or

'substrate joker' pay 2000 € to the bank for substrate.

pH hurdle

At the hurdle you can only surmount it and progress if you obtain the recommended operating pH value for the enzyme. Alternatively you can progress on to the next fence with a close pH value, but you have to pay to the bank money for using the enzyme inefficiently and thus uneconomically. Rather than pay money to the bank you can decide to wait at the hurdle in the hope of obtaining a more beneficial value the next time and thus no payments to the bank.

pH 10.0 and 11.0 works well in alkaline conditions found in detergents washing powder. Progress on.

pH 7.0, 8.0 and 9.0 the enzyme still works but not as efficiently. Pay 1500 € to the bank.

Temperature ditch

At the ditch the value you obtain determines the temperature that you operate the enzyme at. If the value falls between the recommended operating temperature then you can progress on to the next hurdle. If the value you obtain is outside the recommended you can either wait and try again or pay the premium set out below:

30°C or 40°C recommended operating temperature, progress on.

50°C and 60°C the enzyme is stable but high temperatures - waste of energy. Pay 1500 € to the bank.

10°C or 20°C the enzyme still works well and is stable. Pay 1000 € to the bank.

Product production hurdle

The last hurdle considers how the enzyme might be used by industry. Some enzymes are very specific to a particular industry, they perform a very specific task while other enzymes are used by very many different industries.

'detergent industry' used in the production of washing powders.

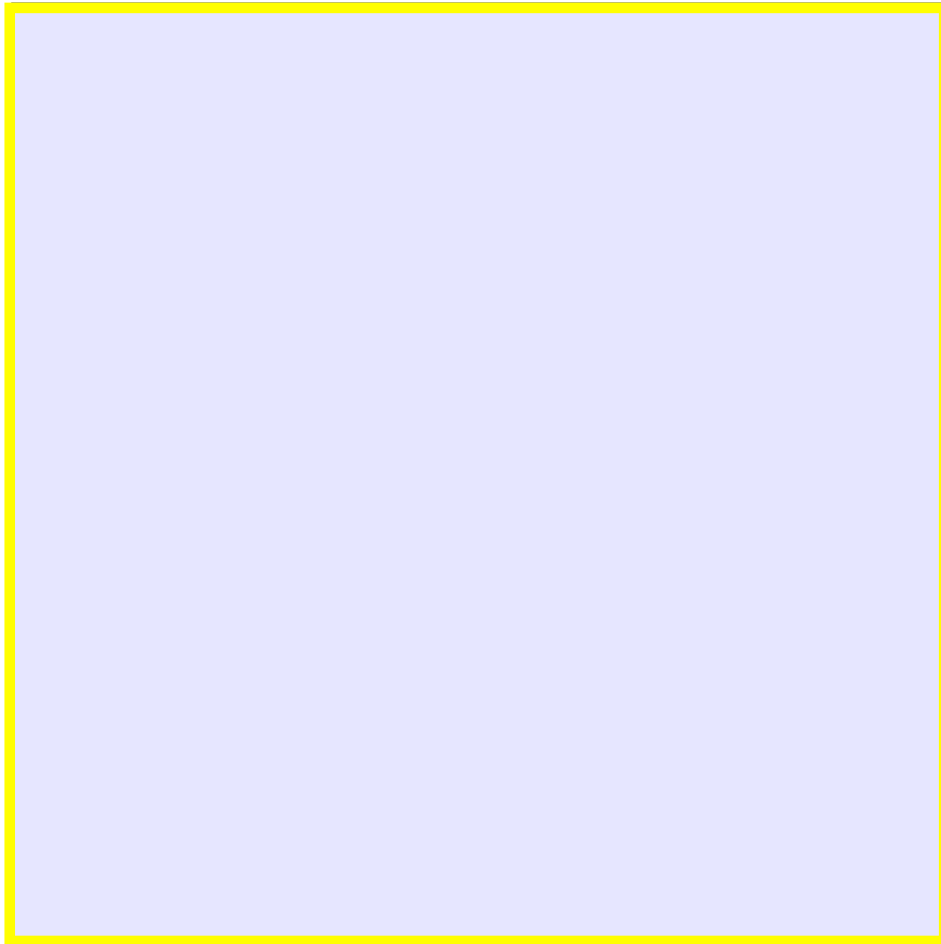
Collect 1000 € from the bank.

'joker' progress on.

Microorganism: **Aspergillus oryzae**

Enzyme produced : **NovoShape™ (pectinesterase)**

The information for this illustration was obtained from the Protein Data Base (<http://www.rcsb.org/databases.html>)
Protein code PDB



**Pectinesterase is an enzyme that hydrolyses methylated pectin.
It is used to help maintain fruit shape and structure
in food preparations.**

NovoShape™ is a pure pectinesterase enzyme found in a fungus *Aspergillus aculeatus*. DNA technology has been used to transfer the genetic information for the production of the enzyme from a donor *Aspergillus* fungus to another a laboratory strain of the fungus *Aspergillus oryzae*.

Information on Production and Utilisation of NovoShape™ a pure pectinesterase

Production Information

Collect 12000 € from the bank

The following information is necessary for the successful production of the enzyme and will be needed to play the game. It relates to the microbial culture that is required to produce the enzyme, permission to grow the microorganism and the correct conditions for the successful production of the enzyme. Finally processing so that the enzyme can be sold as a marketable product.

Culture hurdle

Only the following cultures will allow you to pass over the hurdle and progress on to the next fence.

'fungal' pay 1000 € to the bank for culture

'microbe' pay 2000 € to the bank for culture

Fermentation fence

Only the following will allow you to surmount the fence and progress on to the next ditch.

'permission and conditions' pay 2000 € to the bank

'permission' pay 3000 € to the bank

'conditions' pay 2000 € to the bank

Processing ditch

Only the following process will allow you to surmount the hurdle and progress on to the next stage of the game .

'liquid' pay 1000 € to the bank for processing costs
or

'purified' pay 2000 € to the bank for processing
or

'food grade' pay 2000 € to the bank for processing costs.
.

Utilization Information.

The following information is necessary for the second part of the enzyme game, if the enzyme is to be used efficiently. A suitable substrate will need to be obtained and optimum operating conditions (temperature and pH) selected.

Enzyme substrate fence

At the fence you must buy a suitable substrate for the enzyme you have selected.

'pectin' pay 2000 € to the bank for substrate
or

'substrate joker' pay 2000 € to the bank for substrate.

pH hurdle

At the hurdle you can only surmount it and progress if you obtain the recommended operating pH value for the enzyme. Alternatively you can progress on to the next fence with a close pH value, but you have to pay to the bank money for using the enzyme inefficiently and thus uneconomically. Rather than pay money to the bank you can decide to wait at the hurdle in the hope of obtaining a more beneficial value the next time and thus no payments to the bank.

pH 5.0 recommended operating pH of the enzyme progress on.

pH 4.0 and 6.0 the enzyme is less efficient. Pay 1000 € to the bank.

Temperature ditch

At the ditch the value you obtain determines the temperature that you operate the enzyme at. If the value falls between the recommended operating temperature then you can progress on to the next hurdle. If the value you obtain is outside the recommended you can either wait and try again or pay the premium set out below:

40°C recommended operating temperature, progress on.

50°C and 30°C less efficient operating temperature. Pay 1000 € to the bank

20°C reduced enzyme active at this temperature. Pay 1500 € to the bank.

Product production hurdle

The last hurdle considers how the enzyme might be use by industry. Some enzymes are very specific to a particular industry, they perform a very specific task while other enzymes are used by very many different industries.

'dairy industry' used to solidify fruit in milk products.
Collect 1500 € from the bank

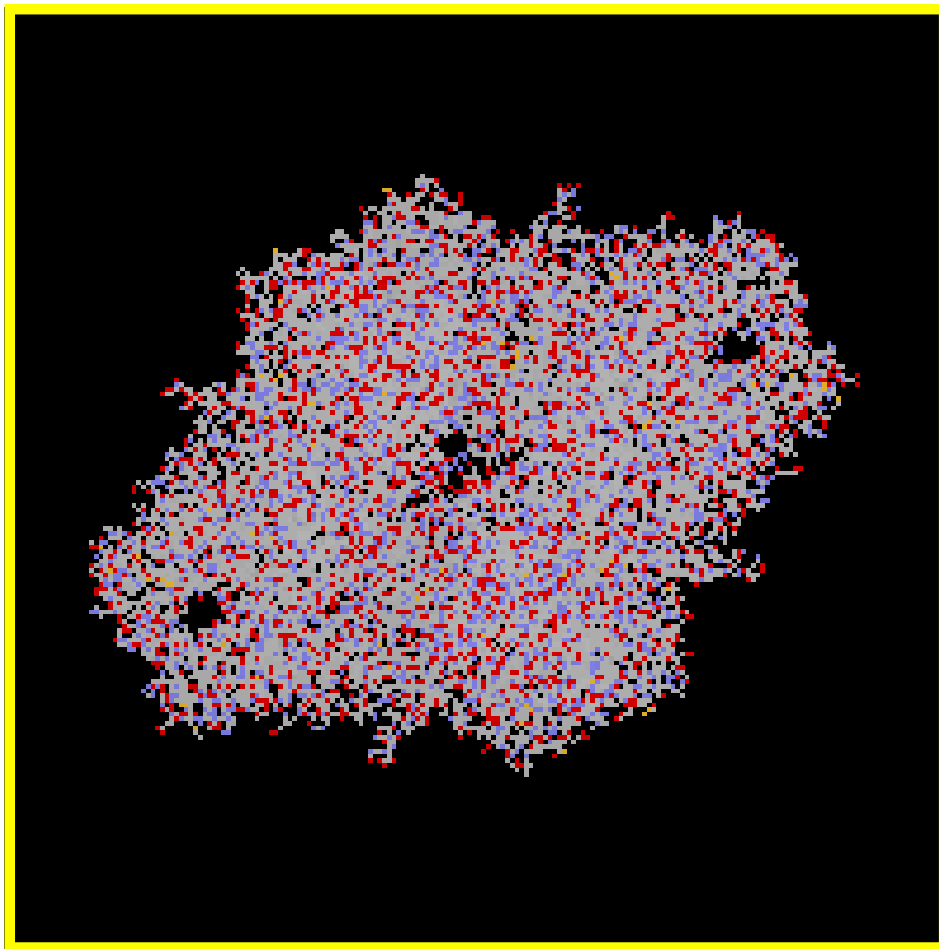
'jam industry' used to solidify fruit jams and jellies. Collect 1500 € from the bank

'joker' progress on.

Microorganism: Kluveromyces sp.

Enzyme produced : Lactozym® (lactase)

The information for this illustration was obtained from the Protein Data Base (<http://www.rcsb.org/databases.html>)
Protein code PDB 1BGL



**Image of enzyme lactase also called β -galactosidase.
The enzyme splits lactose sugar to glucose and galactose.**

Lactozym® is a β -galactosidase which is also known commonly as lactase and it is produced by a fermentation of a selected strain of a yeast Kluveromyces. The enzyme is used by the dairy industry to hydrolyse the milk sugar lactose to glucose and galactose. These sugars are sweeter than lactose and so can produce sweeter products without having to add extra sweetener. Many people are lactose intolerant and cannot drink milk, but milk treated with the enzyme lactase produces a more palatable milk product.

Information on Production and Utilisation of Lactozyme® an enzyme that hydrolyses lactose

Production Information

Collect 9000 € from the bank

The following information is necessary for the successful production of the enzyme and will be needed to play the game. It relates to the microbial culture that is required to produce the enzyme, permission to grow the microorganism and the correct conditions for the successful production of the enzyme. Finally processing so that the enzyme can be sold as a marketable product.

Culture hurdle

Only the following cultures will allow you to pass over the hurdle and progress on to the next fence.

'fungal' pay 1000 € to the bank for culture

'microbe' pay 2000 € to the bank for culture

Fermentation fence

Only the following will allow you to surmount the fence and progress on to the next ditch.

'permission and conditions' pay 1000 € to the bank

'permission' pay 2000 € to the bank

'conditions' pay 2000 € to the bank

Processing ditch

Only the following process will allow you to surmount the hurdle and progress on to the next stage of the game.

'liquid' pay 1000 € to the bank for processing costs
or

'food grade' pay 1000 € to the bank for processing
or

'sterile filtered' pay 1000 € to the bank for processing costs.

Utilization Information.

The following information is necessary for the second part of the enzyme game, if the enzyme is to be used efficiently. A suitable substrate will need to be obtained and optimum operating conditions (temperature and pH) selected.

Enzyme substrate fence

At the fence you must buy a suitable substrate for the enzyme you have selected.

'lactose' pay 1000 € to the bank for substrate
or

'substrate joker' pay 2000 € to the bank for substrate.

pH hurdle

At the hurdle you can only surmount it and progress if you obtain the recommended operating pH value for the enzyme. Alternatively you can progress on to the next fence with a close pH value, but you have to pay to the bank money for using the enzyme inefficiently and thus uneconomically. Rather than pay money to the bank you can decide to wait at the hurdle in the hope of obtaining a more beneficial value the next time and thus no payments to the bank.

pH 6.0 and 7.0 suggested operating pH for the enzyme process on.

pH 8.0 less efficient, pay 500 € to the bank.

Temperature ditch

At the ditch the value you obtain determines the temperature that you operate the enzyme at. If the value falls between the recommended operating temperature then you can progress on to the next hurdle. If the value you obtain is outside the recommended you can either wait and try again or pay the premium set out below:

40°C recommended operating temperature, progress on.

50°C not as economic as 40°C since the enzyme is not as stable at this temperature. Pay 1000 € to the bank

20°C and 30°C are more economic operating temperature for the enzyme it is stable, but is it not as active. Pay 500 € to the bank.

Product production hurdle

The last hurdle considers how the enzyme might be used by industry. Some enzymes are very specific to a particular industry, they perform a very specific task, while other enzymes are used by very many different industries.

'dairy industry' used to sweeten dairy products and make milk more palatable for lactose intolerant people.

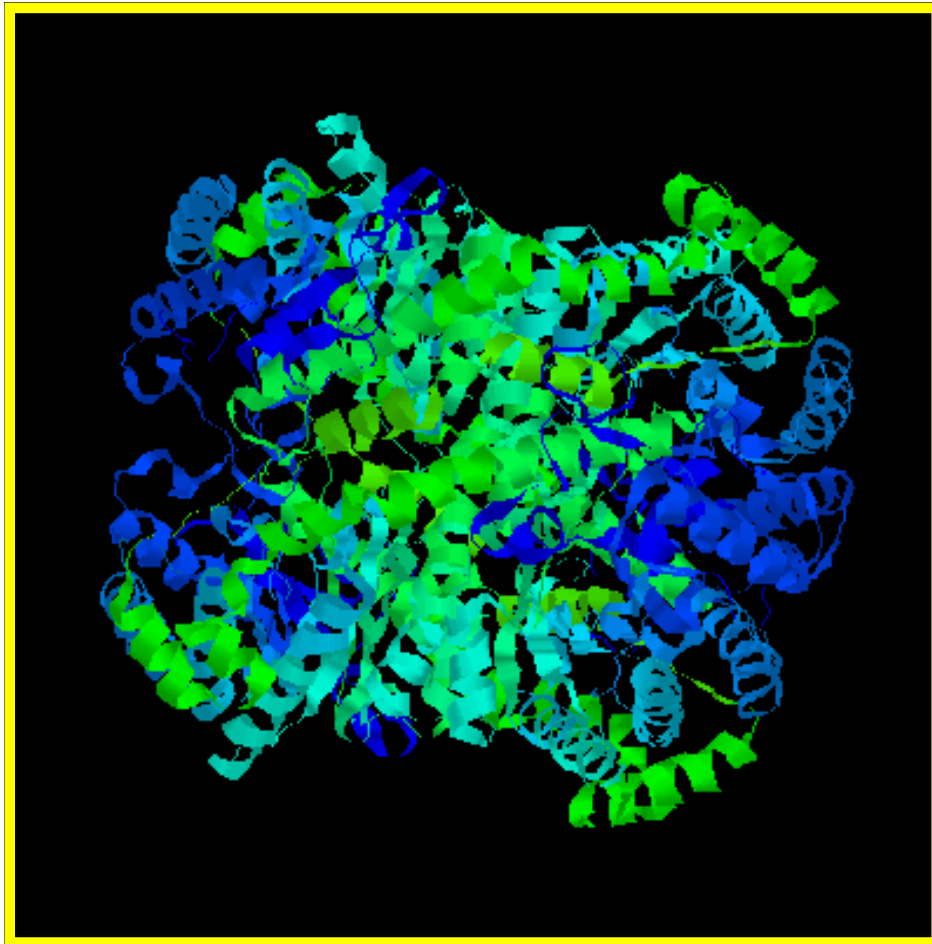
Collect 1000 € from the bank.

'joker' progress on.

Microorganism: **Streptomyces murinus**

Enzyme produced : **Sweetzyme®**
(glucose isomerase)

The information for this illustration was obtained from the Protein Data Base (<http://www.rcsb.org/databases.html>)
Protein code PDB 1IAOC



Ribbon image of the enzyme Sweetzyme®
The enzyme changes glucose into fructose a sweeter sugar

Sweetzyme® is an isomerase it converts the sugar glucose into fructose. The enzyme is immobilised on to a matrix so that it can be used in a continuous column process. The product has been developed to convert glucose syrups, obtained by enzyme hydrolyse of starch, to fructose syrups that can be used in the food industry. Fructose is a sweeter sugar than glucose and thus fructose syrups have benefits over glucose alone as a sweetening product.

Information on Production and Utilisation of Sweetzyme® T an immobilised glucose isomerase

Production Information

Collect 9500 € from the bank

The following information is necessary for the successful production of the enzyme and will be needed to play the game. It relates to the microbial culture that is required to produce the enzyme, permission to grow the microorganism and the correct conditions for the successful production of the enzyme. Finally processing so that the enzyme can be sold as a marketable product.

Culture hurdle

Only the following cultures will allow you to pass over the hurdle and progress on to the next fence.

'bacterium' pay 1000 € to the bank for culture

'microbe' pay 2000 € to the bank for culture

Fermentation fence

Only the following will allow you to surmount the fence and progress on to the next ditch.

'permission and conditions' pay 1000 € to the bank

'permission' pay 2000 € to the bank

'conditions' pay 2000 € to the bank

Processing ditch

Only the following process will allow you to surmount the hurdle and progress on to the next stage of the game.

'food grade' pay 1000 € to the bank for processing
or

'immobilised' pay 1000 € to the bank for processing costs

Utilization Information.

The following information is necessary for the second part of the enzyme game, if the enzyme is to be used efficiently. A suitable substrate will need to be obtained and optimum operating conditions (temperature and pH) selected.

Enzyme substrate fence

At the fence you must buy a suitable substrate for the enzyme you have selected.

'glucose' pay 1000 € to the bank for substrate
or

'substrate joker' pay 2000 € to the bank for substrate.

pH hurdle

At the hurdle you can only surmount it and progress if you obtain the recommended operating pH value for the enzyme. Alternatively you can progress on to the next fence with a close pH value, but you have to pay to the bank money for using the enzyme inefficiently and thus uneconomically. Rather than pay money to the bank you can decide to wait at the hurdle in the hope of obtaining a more beneficial value the next time and thus no payments to the bank.

pH 7.0 - 8.0 recommended operating pH of the enzyme progress on.

pH 9.0 enzyme works but not very stable. Pay 1000 € to the bank.

Temperature ditch

At the ditch the value you obtain determines the temperature that you operate the enzyme at. If the value falls between the recommended operating temperature then you can progress on to the next hurdle. If the value you obtain is outside the recommended you can either wait and try again or pay the premium set out below:

60°C recommended operating temperature, progress on.

70°C enzyme is more active but the temperature adversely affects enzyme stability. Pay 500 € to the bank.

80°C and 90°C enzyme is very active but the enzyme is not very stable at these temperatures so the enzyme does not last as long. A higher substrate temperature is also less energy efficient. Pay 1000 € to the bank.

Product production hurdle

The last hurdle considers how the enzyme might be used by industry. Some enzymes are very specific to a particular industry, they perform a very specific task while other enzymes are used by very many different industries.

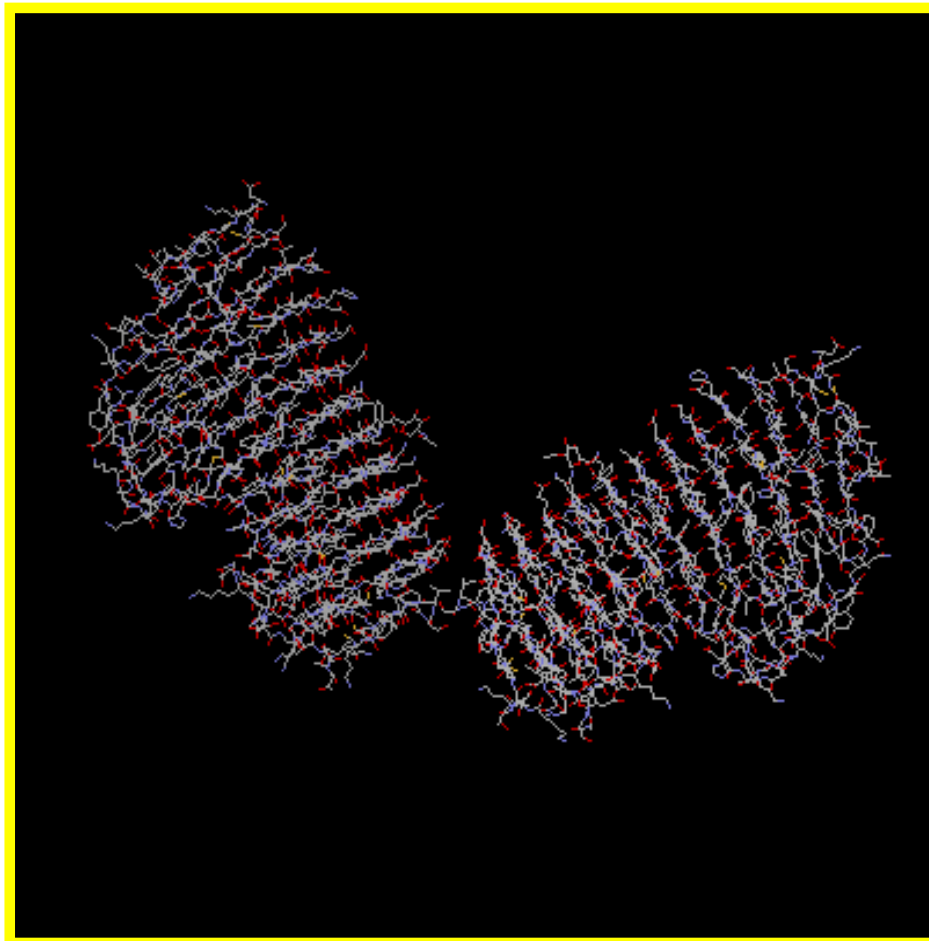
'sugar industry' starch saccharification - 'breakdown'
Collect 2000 € from the bank.

'joker' progress on.

Microorganism: **Aspergillus aculeatus**

Enzyme produced : **Pectinex® (pectinase)**

The information for this illustration was obtained from the Protein Data Base (<http://www.rcsb.org/databases.html>)
Protein code PDB 1TCZF



Wire frame image of enzyme pectinase.
Pectinases are used by the fruit juice industry to
clear and extract juice from fruit pulp.

Pectinex® is an enzyme preparation produced from a selected strain of the fungus *Aspergillus aculeatus*. The preparation contains a pectolytic enzyme (breaks down pectin) and a range of hemicellulase enzymes that disintegrate plant cell walls. It is used commercially for the treatment of fruit and vegetable mashes where it increases the yield of juice obtained from the plant material. It also helps clear polysaccharide hazes from the fruit juice extracted.

Information on Production and Utilisation of Pectinex® Ultra SP-L a pectolytic enzyme

Production Information

Collect 10000 € from the bank

The following information is necessary for the successful production of the enzyme and will be needed to play the game. It relates to the microbial culture that is required to produce the enzyme, permission to grow the microorganism and the correct conditions for the successful production of the enzyme. Finally processing so that the enzyme can be sold as a marketable product.

Culture hurdle

Only the following culture/s will allow you to pass over the hurdle and progress on to the next fence.

'fungal' pay 1000 € to the bank for culture

'microbe' pay 2000 € to the bank for culture

Fermentation fence

Only the following will allow you to surmount the fence and progress on to the next ditch.

'permission and conditions' pay 1000 € to the bank

'permission' pay 2000 € to the bank

'conditions' pay 2000 € to the bank

Processing ditch

Only the following process will allow you to surmount the hurdle and progress on to the next stage of the game.

'liquid' pay 1000 € to the bank for processing costs
or

'food grade' pay 2000 € to the bank for processing
or

'lpurified' pay 2000 € to the bank for processing costs

Utilization Information.

The following information is necessary for the second part of the enzyme game, if the enzyme is to be used efficiently. A suitable substrate will need to be obtained and optimum operating conditions (temperature and pH) selected.

Enzyme substrate fence

At the fence you must buy a suitable substrate for the enzyme you have selected.

'pectin' pay 1000 € to the bank for substrate
or

'substrate joker' pay 2000 € to the bank for substrate.

pH hurdle

At the hurdle you can only surmount it and progress if you obtain the recommended operating pH value for the enzyme. Alternatively you can progress on to the next fence with a close pH value, but you have to pay to the bank money for using the enzyme inefficiently and thus uneconomically. Rather than pay money to the bank you can decide to wait at the hurdle in the hope of obtaining a more beneficial value the next time and thus no payments to the bank.

pH 4.0 and 5.0 recommended operating pH of the enzyme progress on.

pH 3.0 inefficient pH, pay 500 € to the bank.

Temperature ditch

At the ditch the value you obtain determines the temperature that you operate the enzyme at. If the value falls between the recommended operating temperature then you can progress on to the next hurdle. If the value you obtain is outside the recommended you can either wait and try again or pay the premium set out below:

30°C or 40°C recommended operating temperature, progress on.

20°C uneconomic operating temperature. Pay 500 € to the bank.

50°C the enzyme is less stable, the process is less energy efficient, pay 1000 € to the bank.

Product production hurdle

The last hurdle considers how the enzyme might be used by industry. Some enzymes are very specific to a particular industry, they perform a very specific task while other enzymes are used by very many different industries.

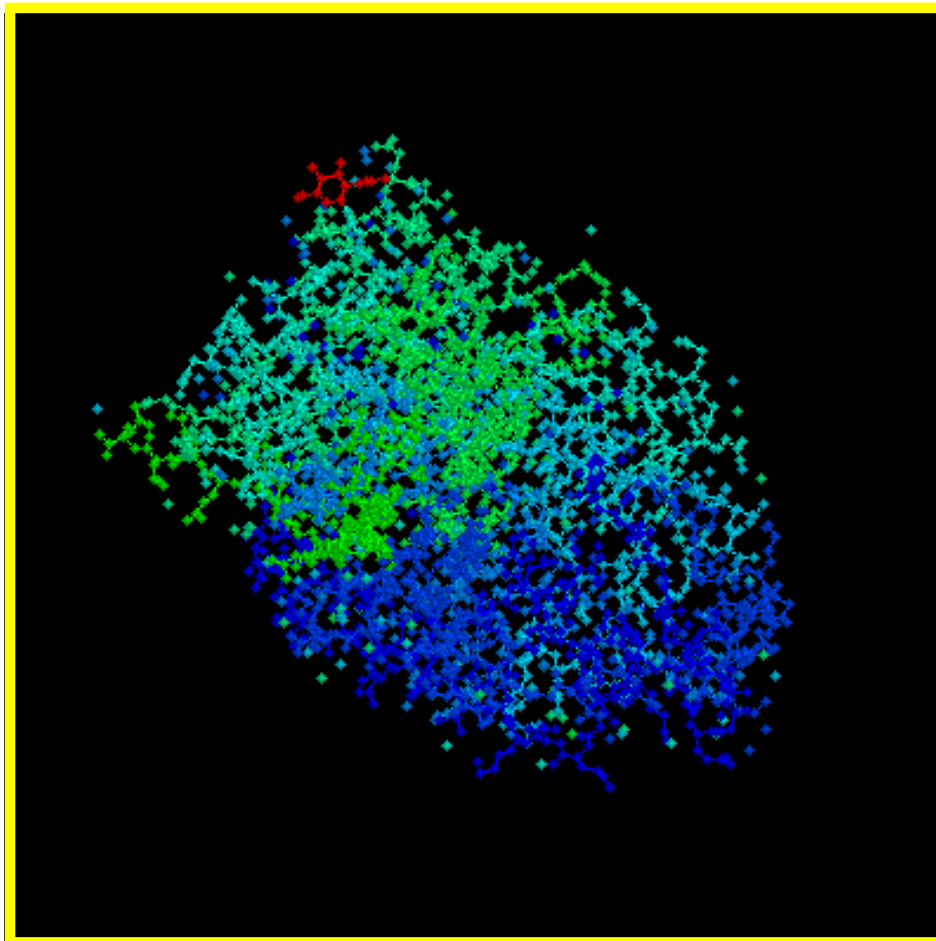
'fruit processing' used in fruit juice production.
Collect 1500 € from the bank.

'joker' progress on.

Microorganism: Trichoderma reesi

Enzyme produced : Celluclast® (cellulase)

The information for this illustration was obtained from the Protein Data Base (<http://www.rcsb.org/databases.html>)
Protein code PDB 1TCZF



Ball and stick image of the enzyme cellulase.
Industry use the enzyme to reduce viscosity of plant extracts
and where cellulose has to be broken down.

Celluclast® is a cellulase preparation that is produced from the fermentation of the fungus Trichoderma reesi. The enzyme breaks down cellulose into glucose, cellobiose and glucose polymers. The enzyme has an effect on cellulosic substrates by reducing its viscosity. It is used in industry where cellulosic material has to be broken down to fermentable sugars. Where a reduction in viscosity is required and where increase in extraction yields of products from plant material are required. It is often used in combinations with other enzymes where there is a synergistic effect.

Information on Production and Utilisation of Celluclast® Ultra SP-L a pectolytic enzyme

Production Information

Collect 8500 € from the bank

The following information is necessary for the successful production of the enzyme and will be needed to play the game. It relates to the microbial culture that is required to produce the enzyme, permission to grow the microorganism and the correct conditions for the successful production of the enzyme. Finally processing so that the enzyme can be sold as a marketable product.

Culture hurdle

Only the following culture/s will allow you to pass over the hurdle and progress on to the next fence.

'fungal' pay 1000 € to the bank for culture

'microbe' pay 2000 € to the bank for culture

Fermentation fence

Only the following will allow you to surmount the fence and progress on to the next ditch.

'permission and conditions' pay 1000 € to the bank

'permission' pay 2000 € to the bank

'conditions' pay 2000 € to the bank

Processing ditch

Only the following process will allow you to surmount the hurdle and progress on to the next stage of the game.

'liquid' pay 1000 € to the bank for processing costs

Utilization Information.

The following information is necessary for the second part of the enzyme game, if the enzyme is to be used efficiently. A suitable substrate will need to be obtained and optimum operating conditions (temperature and pH) selected.

Enzyme substrate fence

At the fence you must buy a suitable substrate for the enzyme you have selected.

'cellulose' pay 500 € to the bank for substrate
or

'substrate joker' pay 2000 € to the bank for substrate.

pH hurdle

At the hurdle you can only surmount it and progress if you obtain the recommended operating pH value for the enzyme. Alternatively you can progress on to the next fence with a close pH value, but you have to pay to the bank money for using the enzyme inefficiently and thus uneconomical. Rather than pay money to the bank you can decide to wait at the hurdle in the hope of obtaining a more beneficial value the next time and thus no payments to the bank.

pH **5.0** recommended operating pH of the enzyme progress on.

pH **4.0** and **6.0** inefficient pH, pay 500 € to the bank.

Temperature ditch

At the ditch the value you obtain determines the temperature that you operate the enzyme at. If the value falls between the recommended operating temperature then you can progress on to the next hurdle. If the value you obtain is outside the recommended you can either wait and try again or pay the premium set out below:

40°C recommended operating temperature, progress on.

30°C uneconomic operating temperature. Enzyme is stable but does not work that efficiently. Pay 500 € to the bank

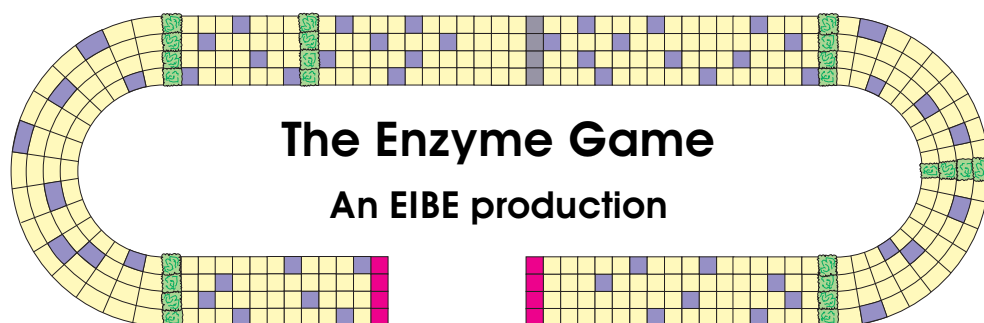
50°C the enzyme is less stable at this temperatures. Less energy efficient temperature. Pay 500 € to the bank.

Product production hurdle

The last hurdle considers how the enzyme might be used by industry. Some enzymes are very specific to a particular industry, they perform a very specific task while other enzymes are used by very many different industries.

'brewing industry' used in reducing viscosity of plant extracts
Collect 1000 € from the bank.

'joker' progress on.



A game originally conceived and designed by John Schollar
unit co-ordinator but refined and improved by EIBE unit members:
Dorte Hammelev and John Watson.

The members of the group would like to thank Novozymes A/S for their
help and support in the production of this game.

SALES GATE

enzyme

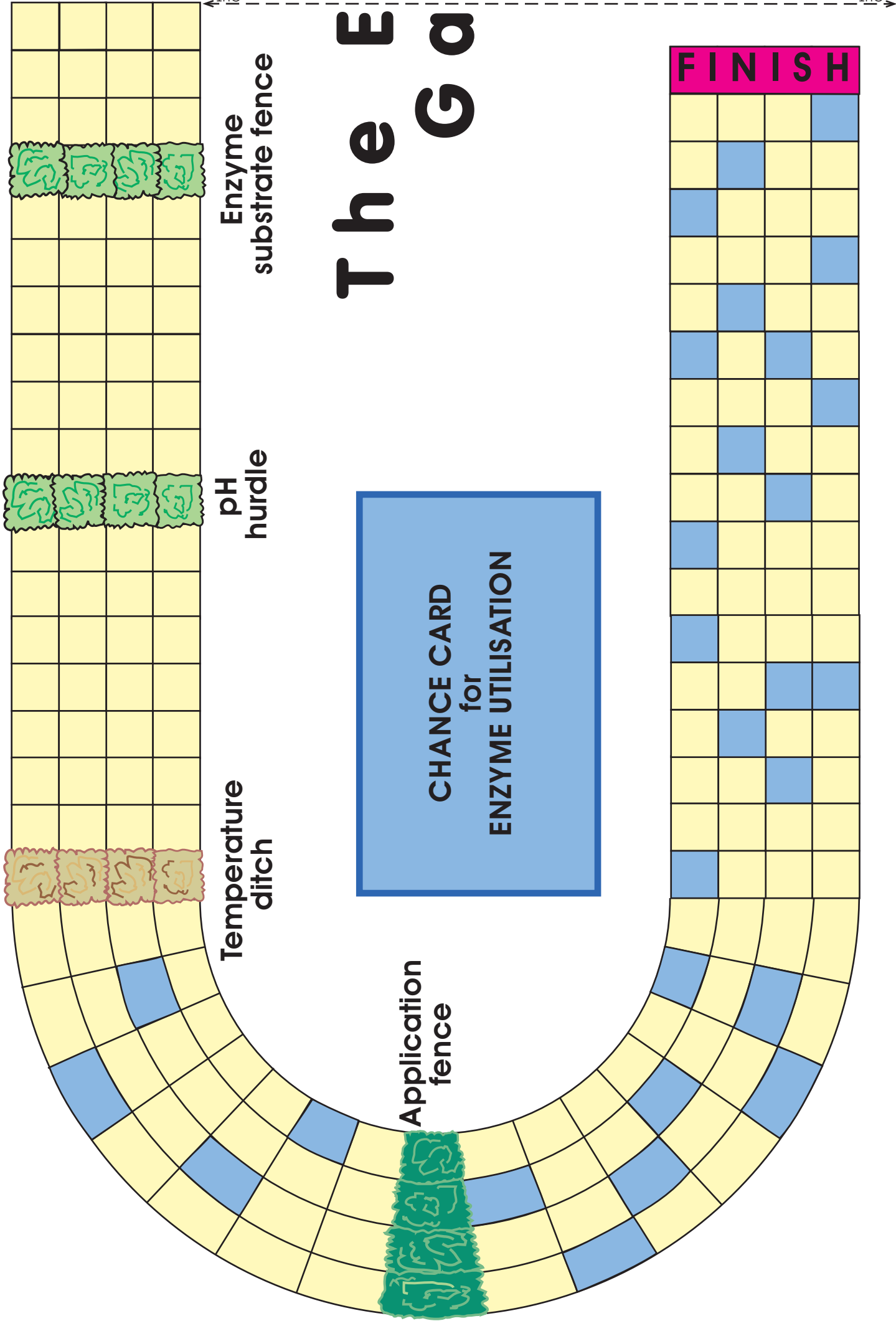
CHANCE CARD
for
ENZYME PRODUCTION

Processing
ditch

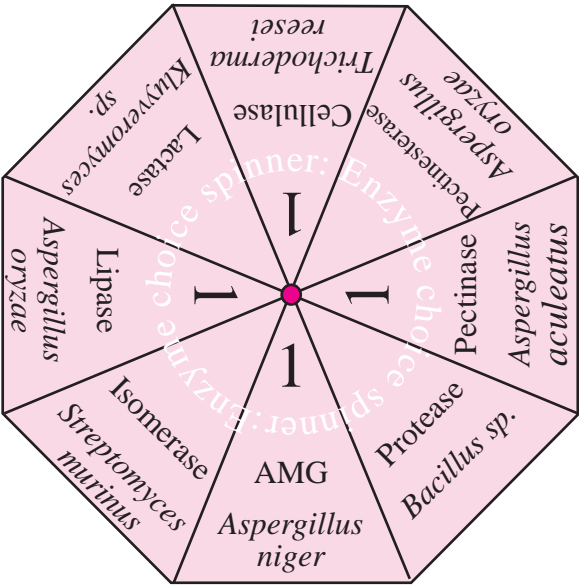
Fermentation
fence

Culture
hurdle

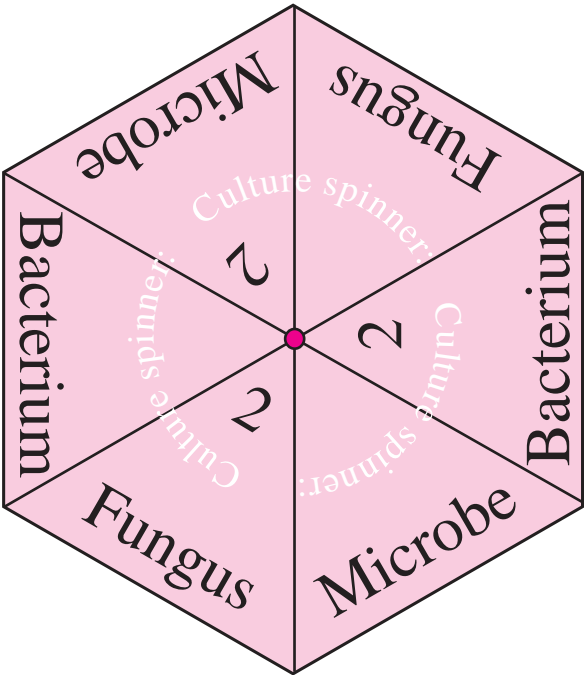
START



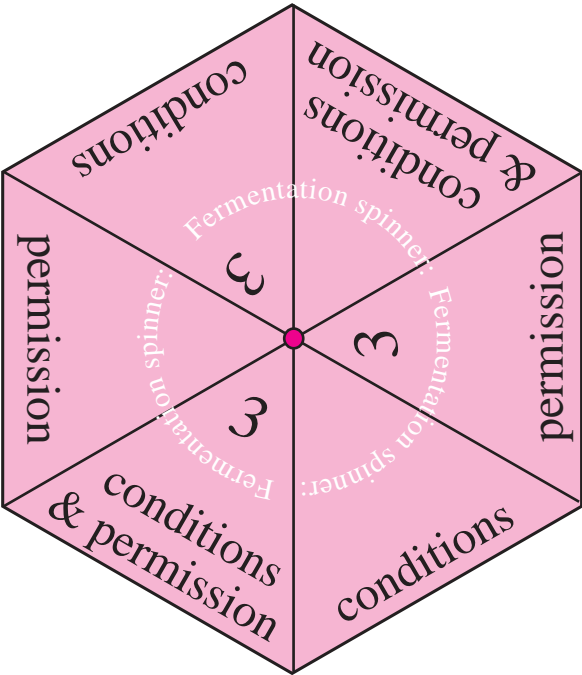
Production spinners



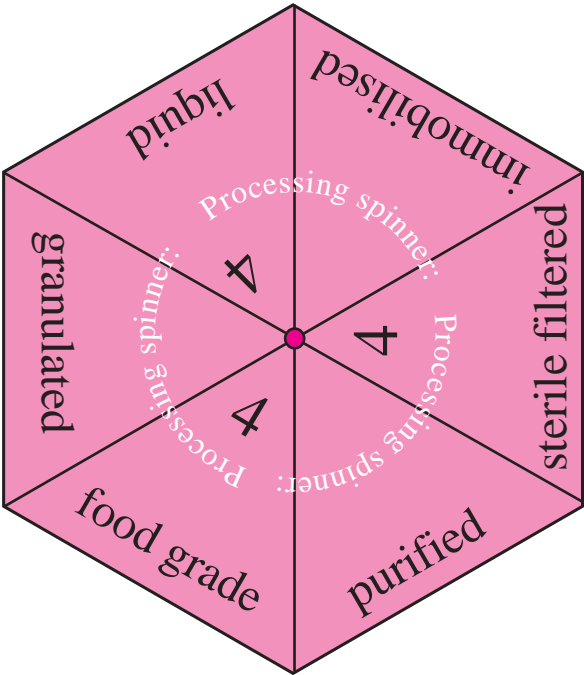
Enzyme choice



Culture hurdle

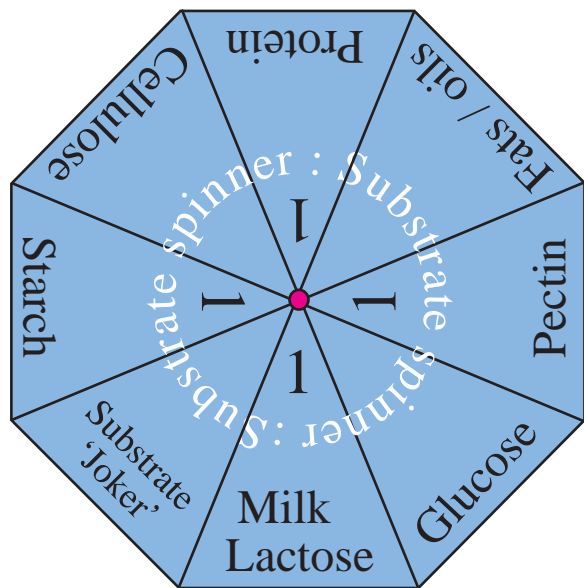


Fermentation fence

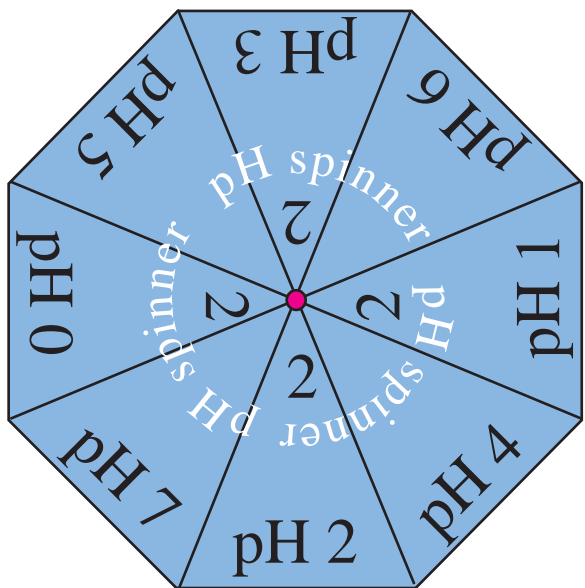


Processing ditch

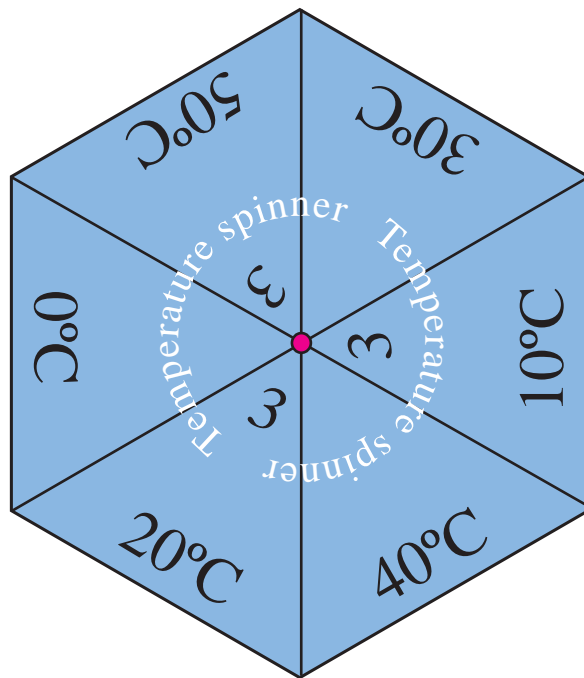
Utilisation spinners



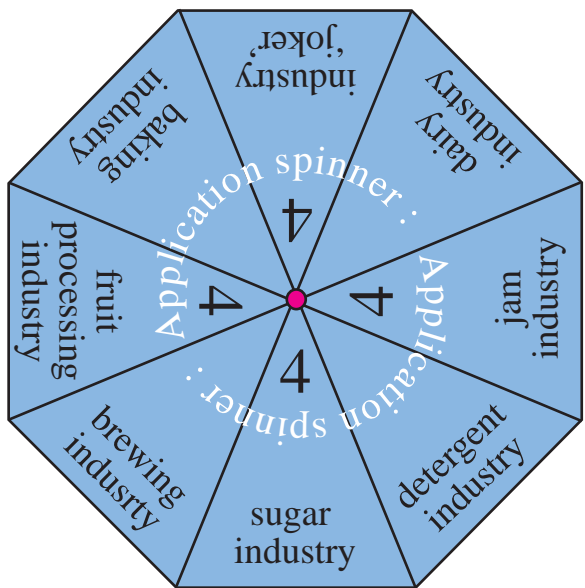
Substrate
fence



pH fence

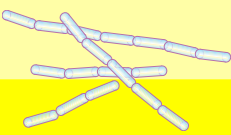


Temperature
ditch



Application
fence

€500

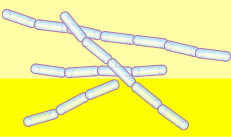


EIBE Bank

Ognian Serafimov

€500

€500

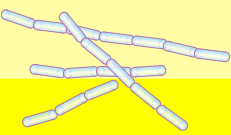


EIBE Bank

Ognian Serafimov

€500

€500

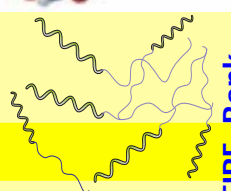


EIBE Bank

Ognian Serafimov

€500

€1000

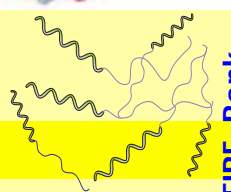


EIBE Bank

Kirsten Schlüter

€1000

€1000

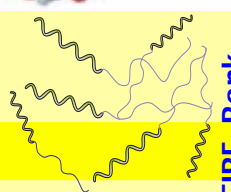


EIBE Bank

Kirsten Schlüter

€1000

€1000

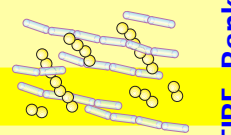


EIBE Bank

Kirsten Schlüter

€1000

€10000

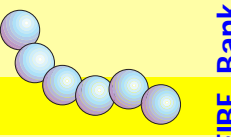


EIBE Bank

John Schollar

€10000

€5000




EIBE Bank

Dore Hammelev

€5000

€2000

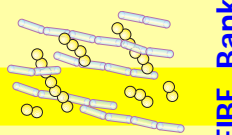


EIBE Bank

John Watson

€2000

€10000

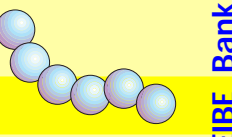


EIBE Bank

John Schollar

€10000

€5000

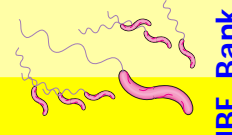


EIBE Bank

Dore Hammelev

€5000

€2000



EIBE Bank

John Watson

€2000

CHANCE CARD

Production costs have risen. You have to pay to the bank 1000 €.

Enzyme Game: Production Chance Card 1

CHANCE CARD

A scientist in the research department develops a more efficient downstream process. Collect 1000 € from the bank.

Enzyme Game: Production Chance Card 2

CHANCE CARD

Your microbial culture becomes contaminated. Go back to the Processing ditch.

Enzyme Game: Production Chance Card 3

CHANCE CARD

Rival companies put up the prices of their enzymes and you gain business. Collect 500 € from each player.

Enzyme Game: Production Chance Card 4

CHANCE CARD

A young sales person becomes sales person of the year. The publicity increases sales of your enzyme. Have an extra turn.

Enzyme Game: Production Chance Card 5

CHANCE CARD

A large order from an important customer is lost. Pay 5000 € to the bank.

Enzyme Game: Production Chance Card 6

CHANCE CARD

A new secretary misplaces an order to an important customer. Miss a turn while the order is found.

Enzyme Game: Production Chance Card 7

CHANCE CARD

A competitor comes into the market and undercuts your price. Pay 1000 € to the bank for loss in trade.

Enzyme Game: Production Chance Card 8

CHANCE CARD

A rival company launches a new enzyme and as a result some trade is lost. Miss a turn.

Enzyme Game: Production Chance Card 9

CHANCE CARD

A temperature probe fails in a fermentation vessel and the contents are spoilt. Pay 1000 € to the bank.

Enzyme Game: Production Chance Card 10

CHANCE CARD

A journal features your enzyme and as a result increased orders are received. Collect 2000 € from the bank.

Enzyme Game: Production Chance Card 11

CHANCE CARD

The Health and Safety Executive visit your factory and are pleased with your working practices. Collect 2000 € from the bank.

Enzyme Game: Production Chance Card 12

CHANCE CARD

A sales campaign pays dividends and sales improve. Collect 1000 € from the bank.

Enzyme Game: Production Chance Card 13

CHANCE CARD

A new genetically engineered strain of microbe results in increased enzyme production. Collect 1000 € from the bank.

Enzyme Game: Production Chance Card 14

CHANCE CARD

Some of your raw materials increase in price. You only pass on some of the cost to your customers. Pay 1000 € to the bank

Enzyme Game: Production Chance Card 15

CHANCE CARD.

A new firm starts up and places a large order with you to supply all its enzyme needs. Collect 2000 € from the bank.

Enzyme Game: Production Chance Card 16

CHANCE CARD

You have to work extra hard this month to meet sales targets. Miss a turn.

Enzyme Game: Production Chance Card 17

CHANCE CARD

Modified fermenter design results in improved enzyme yield. Collect 1000 € from the bank.

Enzyme Game: Production Chance Card 18

CHANCE CARD

Bank interest rates go up and your bank loan for factory improvements is costing more. Pay 1000 € to the bank.

Enzyme Game: Production Chance Card 19

CHANCE CARD

A European grant results in improved research facilities. This benefits the company and profits increase. Collect 1000 € from the bank.

Enzyme Game: Production Chance Card 20

CHANCE CARD

Quality control reject a batch of enzyme as substandard. Pay 1000 € to the bank.

Enzyme Game: Production Chance Card 21

CHANCE CARD

A modified broth proves more efficient. The broth costs less and yields of enzyme are satisfactory. Collect 1000 € from the bank.

Enzyme Game: Production Chance Card 22

CHANCE CARD

Work men outside the factory cause a power failure. This results in loss of productivity. Miss a turn until the power is restored.

Enzyme Game: Production Chance Card 23

CHANCE CARD

An overseas exhibition leads to the signing of a trade agreement. Your company features prominently so collect 2000 € from the bank.

Enzyme Game: Production Chance Card 24

CHANCE CARD

Unacceptable levels of your production organism are found in the waste water. Clean up costs are high, pay 2000 € to the bank.

Enzyme Game: Production Chance Card 25

CHANCE CARD

An environmental group's 'Green Audit' gives your factory high marks. Have an extra turn.

Enzyme Game: Production Chance Card 26

CHANCE CARD

Leaks from your production plant causes an ecological problem damaging the green images of the industry. Pay the other players 500 € each.

Enzyme Game: Production Chance Card 27

CHANCE CARD

The labelling of your enzyme does not conform to EU regulations. Pay 2000 € fine to the bank.

Enzyme Game: Production Chance Card 28

CHANCE CARD

You have become company of the year due to your green image. Collect 1000 € from the bank.

Enzyme Game: Production Chance Card 29

CHANCE CARD

A new risk assessment is required if you are using a GMO. All players using GMOs pay 1000 € to the bank.

Enzyme Game: Production Chance Card 30

Make your own!

CHANCE CARD

Enzyme Game: Production Chance Card

CHANCE CARD

Enzyme Game: Production Chance Card

CHANCE CARD

Enzyme Game: Production Chance Card

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Enzyme Game: Production Chance Card

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Enzyme Game: Production Chance Card

**CHANCE CARD
for
ENZYME PRODUCTION**

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ENZYME PRODUCTION**

CHANCE CARD

A trainee factory operator adds too much acid to the enzyme system. Pay 500 € to the bank.

Enzyme Game: Utilisation Chance Card 1

CHANCE CARD

A new company enters the market and you lose some sales to this new competitor. Miss a turn.

Enzyme Game: Utilisation Chance Card 2

CHANCE CARD

A surplus of substrate comes on to the market and you buy it at a very advantageous price. Collect 2000 € from the bank.

Enzyme Game: Utilisation Chance Card 3

CHANCE CARD

The cost of fuel rises all players pay 1000 € to the bank. Players that ran their system above optimum temperature pay 2000 € to the bank.

Enzyme Game: Utilisation Chance Card 4

CHANCE CARD.

A television company features your product and it results in increased sales. Take an extra turn.

Enzyme Game: Utilisation Chance Card 5

CHANCE CARD

A strong advertising campaign increases sales and profits. Collect 1000 € from the bank.

Enzyme Game: Utilisation Chance Card 6

CHANCE CARD

The cost of fuel falls and profits go up. Collect 1000 € from the bank. Other players collect 500 € if they ran their system at optimum temperature.

Enzyme Game: Utilisation Chance Card 7

CHANCE CARD

A research program comes to fruition and results in improved substrate conversion. Collect 1000 € from the bank.

Enzyme Game: Utilisation Chance Card 8

CHANCE CARD.

Quality control question the purity of a substrate. Pay 1000 € to the bank.

Enzyme Game: Utilisation Chance Card 9

CHANCE CARD

Adverse publicity results in loss of sales and increased sales to your competitors. You pay 500 € to the bank, other players collect 500 €.

Enzyme Game: Utilisation Chance Card 10

CHANCE CARD

Workers industrial action results in delayed deliveries of product. Miss a turn for disruption of supplies to your customers.

Enzyme Game: Utilisation Chance Card 11

CHANCE CARD

An industry award increases moral in the company. Collect 2000 € from the bank.

Enzyme Game: Utilisation Chance Card 12

CHANCE CARD

Repayment of a loan for plant improvements is due. Pay the bank 500 €.

Enzyme Game: Utilisation Chance Card 13

CHANCE CARD

Factory improvements start to pay dividends with an increase in company profits for the financial year. Collect 1000 € from the bank.

Enzyme Game: Utilisation Chance Card 14

CHANCE CARD

A recession in trade results in all players having to stock pile materials. All players pay 1000 € to the bank.

Enzyme Game: Utilisation Chance Card 15

CHANCE CARD

Food products are selling well world wide. Any player producing food products collects 2000 € from the bank.

Enzyme Game: Utilisation Chance Card 16

CHANCE CARD

A new Company Director cuts out waste practices. Any player that did not use optimum pH or temperature pays 1000 € (for each) to the bank.

Enzyme Game: Utilisation Chance Card 17

CHANCE CARD

Preparation for a trade exhibition takes a lot of your time. Miss a turn while you prepare for the weeks exhibition.

Enzyme Game: Utilisation Chance Card 18

CHANCE CARD

Your supplier of acids and alkalis increase their costs. If any player used their enzyme outside the optimum pH pay 1000 € to the bank.

Enzyme Game: Utilisation Chance Card 19

CHANCE CARD

Company taxes rise. All players pay 1000 € to the bank.

Enzyme Game: Utilisation Chance Card 20

CHANCE CARD

Improved plant design results in more efficient substrate conversion. Collect 1500 € from the bank.

Enzyme Game: Utilisation Chance Card 21

CHANCE CARD.

The cost of chemicals remain stable - you had projected increases. Collect 500 € from the bank.

Enzyme Game: Utilisation Chance Card 22

CHANCE CARD

Improved preliminary waste treatment results in lower waste water charges. Collect 1000 € from the bank.

Enzyme Game: Utilisation Chance Card 23

CHANCE CARD

The cost of petrol and diesel goes up. Pay 1000 € to the bank for increased transport costs.

Enzyme Game: Utilisation Chance Card 24

CHANCE CARD

There is an increased demand for apple juice. If your enzyme is involved in apple juice production collect 2000 € from the bank.

Enzyme Game: Utilisation Chance Card 25

CHANCE CARD

A major supermarket chain produces a new enzyme detergent. If your enzyme is involved in detergent production collect 2000 € from the bank.

Enzyme Game: Utilisation Chance Card 26

CHANCE CARD

Excess carbohydrate produces increased demand for enzymes for making sweeteners. If your enzyme is involved collect 2000 € from the bank.

Enzyme Game: Utilisation Chance Card 27

CHANCE CARD

Is it summer and very hot... ice cream sales soar. If your enzyme is involved in ice cream production collect 3000 € from the bank.

Enzyme Game: Utilisation Chance Card 28

CHANCE CARD

New low-calorie, whole-fruit yoghurts have become very popular. If your enzyme is involved, collect 2000 € from the bank.

Enzyme Game: Utilisation Chance Card 29

CHANCE CARD

A new research project, 'alcohol for fuel' requires enzymes for producing fermentable sugars. If your enzyme is involved, collect 2000 € from the bank.

Enzyme Game: Utilisation Chance Card 30

Make your own!

CHANCE CARD

Enzyme Game: Utilisation Chance Card

CHANCE CARD.

Enzyme Game: Utilisation Chance Card

CHANCE CARD

Enzyme Game: Utilisation Chance Card

CHANCE CARD

Enzyme Game: Utilisation Chance Card

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CHANCE CARD

Enzyme Game: Utilisation Chance Card

**CHANCE CARD
for
ENZYME UTILISATION**

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