

E! Canasta

energizing ATP's synthesis



Thalles Henrique Faria de Souza
Eduardo de Figueiredo Peloso
Gabriel Gerber Hornink



LABORATÓRIO DE MÍDIAS
EDUCACIONAIS

The card game E! Canasta is a fun way of dealing with biochemical pathways related to the synthesis of ATP inside a cell, bringing key concepts such as allosteric modulation of enzymes, enzymatic regulation, demand and simultaneity of the pathways in the metabolism. This is a work of the Laboratório de Mídias Educacionais, dept. of Biochemistry, Universidade Federal de Alfenas.

1 Educational Objectives

The identification of intermediaries in reactions involved in the synthesis of ATP, seeking to understand not only the sequences of the reactions, but the interactions between the pathways(suits) and the ways in which the aerobic synthesis of ATP can be regulated inside the cell.

2 Subjects Involved

- Reactions/intermediaries: Glycolysis pathway; Acetyl-CoA synthesis; Krebs Cycle (Citric Acid Cycle); Electron Transport Chain (ETC) and oxidative phosphorylation;
- Strategies of regulation, with emphasis in the allosteric modulation and inhibitors.

3 Contexts of use

The game E! Canasta may be used in a multitude of ways, depending on the pedagogic approach of your subject, however, we endorse that students should have a previous understanding of the pathways. Regardless, it may be used before classes in such a way that, through the game, students are instigated to recognize and comprehend the pathways, their regulations and interactions. We recommend that "Player's material" *.pdf file be sent beforehand and that the .ppt presentation be used in class for the explanation of the rules. Moreover, we also suggest between 70 to 90 minutes of actual play, often in the presence of moderators (professors or monitors), who will help students in the comprehension of the game, pathways and their regulations.



4 Number of Players

E! Canasta can be played with at least 2 and up to 6 players, which in this last case, there will be 3 duos. With four people the game may be played individually or in duos. Moreover, when played in pairs, the game may stimulate collaborative learning between players, further increasing the teaching-education process.

5 Cards

The game is made up of 4 suits (Glycolysis, Krebs, Acetyl-CoA, ETC), special effects cards and the joker (81 cards) - File ready for printing, front and back.

Glycolysis Suit (20 cards) Glucose - GLU (1 card) Glucose-6-phosphate - G6P (1 card) Fructose-6-phosphate - F6P (2 cards) Fructose-1,6-bisphosphate - F16P (2 cards) Dihydroxyacetone-phosphate-DHAP(2 cards) Glyceraldehyde-3-phosphate - G3P (2 cards) 1,3-Bisphosphoglycerate - 13BPG (2 cards) 3-Phosphoglycerate - 3PG (2 cards) 2-Phosphoglycerate - 2PG (2 cards) Phosphoenolpyruvate - PEP (2 cards) Pyruvate - PYR (2 cards) Acetyl-CoA Suit (8 cards) Pyruvate - PYR (2 cards) Hydroxyethyl - HET (2 cards) Acetyl - AC (2 cards) Acetyl-CoA - ACOA (2 cards) Special Effect Cards(16 cards) ATP (3 cards) ADP (3 cards) NAD ⁺ NADH (3 cards) 2,4-DNP Barbiturate - BARB Rotenone - ROT Malonate - MALO Antimycin A - AMA Cyanide - CN	Krebs Suit (18 cards) Acetyl-CoA - ACOA (2 cards) Citrate - CITR (2 cards) Isocitrate - IC (2 cards) α -ketoglutarate - AKG (2 cards) Succinyl-CoA - SCOA (2 cards) Succinate - SUC (2 cards) Fumarate - FUM (2 cards) Malate - MAL (2 cards) Oxaloacetate - OAA (2 cards) ETC Suit (14 cards) NADH Dehydrogenase - CI (2 cards) Succinate dehydrogenase - CII (2 cards) Ubiquinone - UBI (2 cards) Cytochrome bc ₁ - CIII (2 cards) Cytochrome - CITO (2 cards) Cytochrome C oxidase - CIV (2 cards) ATP Synthase - CV (2 cards) Joker (5 cards) Cards with a lightning - Energizing (5 cards)
---	---

6 Rules

- 1** – Set teams and organize yourselves between 4 to 6 players, with each duo sitting on opposing sides;
- 2** – Shuffle cards;
- 3** – Allow the player to the right to cut the deck (No more than 2 times);
- 4** – Distribute 10 cards face down for each player in a clockwise fashion;
- 5** – Wait for a few minutes until all players get their own cards arranged;
- 6** – Start the game from whoever first received the cards and carry on clockwise;
- 7** – The player will have up to one minute to perform his turn, if time passes, the player will lose 10 points;
- 8** – A player may meld organized sequences of, at least, 3 cards (cards of special effect do not apply to meld the first set). The canasta may be natural(with a single suit), mixed or dirty (with a card from another suit that may be used as part of the set or using a joker, respectively);
- 9** – A player may use cards of special effect or any other that has an effect over their own sequences. Such cards may only start getting used if at least one of the duo has put down a meld of no less than three cards;
- 10** – If a player uses a special effect card incorrectly, the card is discarded and the player loses 50 points;
- 11** – If a player makes a meld of an incorrect sequence, they lose 10 points per card laid out wrong, in which they must return to his hand;
- 12** – If a player does not have a meld to put down or does not wish to do so, they must take a card from the stock or take the first card from the discard pile e discard themselves one card, finishing their turn. (Whenever a card is taken, one must be discarded);
- 13** – When played in duos, both players may add to their shared sets or play special effect cards that may apply both to their own game or their opponents, although following the turns sequence;
- 14** – A player may join or split sets of cards however they wish. For example, they may split the canasta in two sets to separate a card of negative effect, as long as each set has at least 3 cards;
- 15** – If the stock is depleted, the cards from the discard pile must be reshuffled to make up a new stock;
- 16** – The game may end in two ways:
 - i – When either of the players play all of their cards, leaving none in their hands (Going Out, bonus of 100 point to whoever goes out);
 - ii – When there are no more cards to be taken from the stock and none of the players can make any moves (in such case, no points are awarded).
- 17** – As the game ends, players must compute their points, paying attention to special effect cards (negative or positive), which can be checked on the sheet of card interactions, sequences and scoring.

7 Card Interactions Chart

Card	Biochemical Context	Effects in-game - upon the indicated card			
		Positives		Negatives	
2,4-DNP	Decoupler	--	--	Any card from the ETC	-50
Acetyl-CoA	Pyruvate dehydrogenase complex	---	---	Pyruvate (Acetyl-CoA suit)	-20
ADP	Used by enzymes that synthesize ATP, which can work as a modulator of isocitrate dehydrogenase	1-3-Bisphosphoglycerate Phosphoenolpyruvate Isocitrate ATP-synthase	+20	---	---
Antimycin A	Acts upon complex III	---	---	Complex III	zeroes
ATP	Participates in phosphorylation reactions and may work as a negative modulator.	---	---	Fructose 6-phosphate α -Ketoglutarate Complex IV	-50
Barbiturate	Acts upon complex I	---	---	Complex I	-50
Cyanide (CN ⁻)	Acts upon complex IV	---	---	Complex IV	zeroes
Citrate	Phosphofructokinase 1	---	---	Fructose 6-phosphate	-20
Fructose-1,6-bisphosphate	Phosphofructokinase 1 Pyruvate kinase	Phosphoenolpyruvate	+10	---	---
Malonate	Acts upon complex II	---	---	Complex II	-100
NAD ⁺	Oxidized coenzyme, which may be used in oxyreduction reactions	Glyceraldehyde 3-phosphate Isocitrate α -Ketoglutarate Malate	+20	---	---
NADH	Reduced coenzyme, which may be used upon complex I, while it may also inhibit some pathways	Complex I	+20	Pyruvate (Acetyl-CoA suit) Isocitrate α -Ketoglutarate	-50
Oxaloacetate	Succinate dehydrogenase	---	---	Succinate	-20
Pyruvate	Pyruvate dehydrogenase kinase / complex pyruvate dehydrogenase	Pyruvate (Acetyl-CoA suit)	+10	---	---
Rotenone	Acts upon complex I	---	---	Complex I	-50
Succinyl-CoA	Regulation of the α -ketoglutarate dehydrogenase complex	---	---	α -Ketoglutarate Citrate	-20

8 Canasta / Score

- **Natural Canasta** (full set of the suit): Glycolysis: 400 points; Krebs Cycle: 300; Acetyl-CoA synthesis: 100 points; ETC: 200
- **Royal Canasta** (natural canasta + substance that precedes or succeeds the pathway): Score of a natural canasta + 50 points per card chained.
- **Dirty Canasta** (full pathway with a joker or card from another suit): Glycolysis: 200 points; Krebs Cycle: 150; Acetyl-CoA synthesis: 75 points; ETC: 100
- **Mixed Canasta/Unfinished** (only part of a pathway, with at least 3 cards, which may be part of the same suit or be a sequence between suits: 3 cards: 50 points; 4 cards 75 points; 5 cards or more 100
- **Going Out** (the first player going out): 100 points

9 Licence



This game is licensed under the terms of Creative Commons Attribution-NonCommercial 4.0 International (<http://creativecommons.org/licenses/by-nc/4.0>), in other words, you are

allowed to use, share and adapt (as long as the original authors are kept, adding the new ones) under the same license, being prohibited its commercial use.

10 Final Thoughts

From E! Canasta we expect that students identify and comprehend the reactions involved in ATP's synthesis, in aerobic pathways, recognizing connections between substrates, and the ways in which regulation (allosteric modulation, negative feedback) can happen. All of that through the dynamics of the game, using cards of special effect and of modulation while also finding entertainment through the education process. We believe that the game in duos enhances collaborative learning, as well as giving greater dynamic to the game, turning it into a pleasant experience.

References

NELSON, D., COX, M.M. **Princípios da Bioquímica de Lehninger**. 6.ed. Porto Alegre: Artmed, 2014.

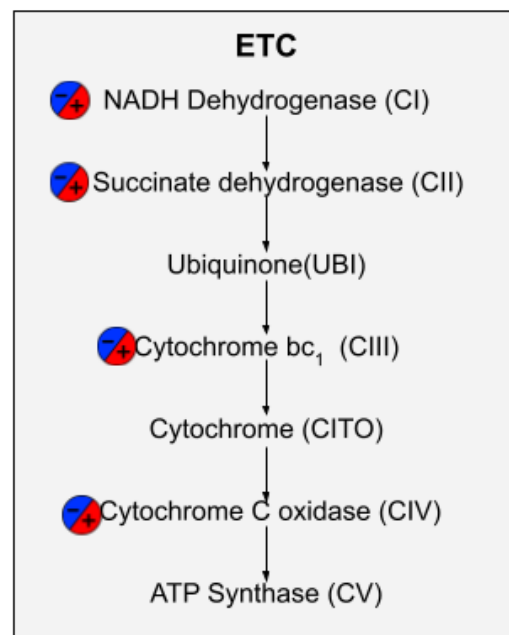
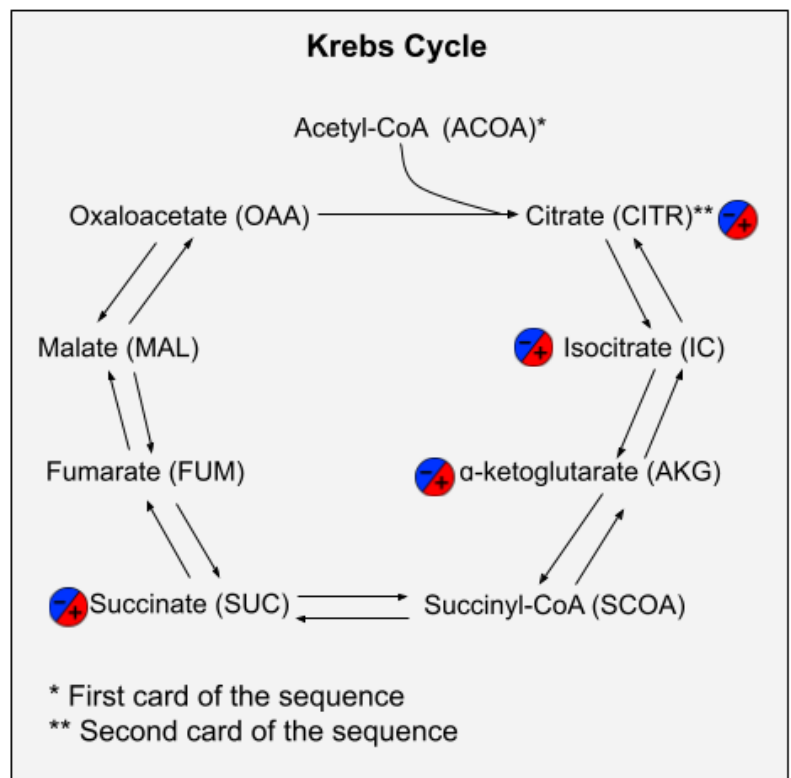
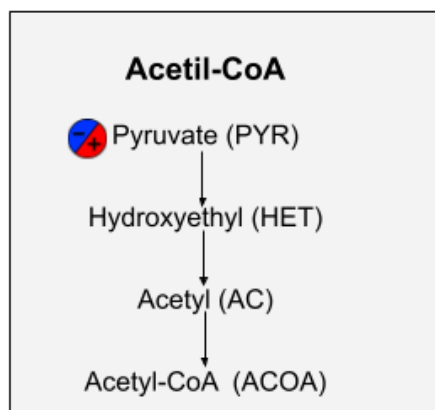
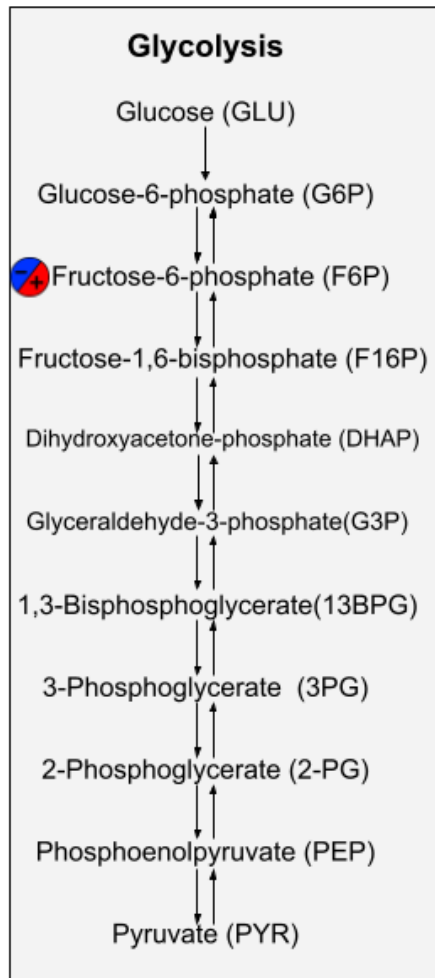
MARZZOCO, A. TORRES, B.B. **Bioquímica Básica**. 4a. Edição. São Paulo: Guanabara Koogan, 2015.

MODENA, D., ROCHA, A.F., RIBEIRO, L., GONÇALVES, G., FARIA, G., HORNINK, G.G. **Buraco Energético: um jogo de carta sobre a formação do ATP** (trabalho apresentado como parte da avaliação da disciplina de Bioquímica, curso de Biomedicina. Alfenas: UNIFAL-MG, 2014.

SOUZA, T. H. F., PELOSO, E. F., HORNINK, G.G. **E! Canastra: Energizando a formação de ATP**. Alfenas: UNIFAL-MG, 2020. <http://educapes.capes.gov.br/handle/capes/563908>



Appendix A. Biochemical pathways / suit sequences for ATP's synthesis.



 Point of regulation/inhibition: look up chart of interactions for which cards may be used and the effects (+ or -).