**THE DARK CYCLE GUIDE FOR INSTRUCTORS & PLAYERS**

BEFORE PLAYING:

1. Print player’s piece and board.
2. Cut out player’s pieces (each piece = 3 CO2 atom).
3. **Advanced players only:** print and cut out stress factor cards. You can add your own stress factor cards by dividing a letter-sized (8.5 x 11in) paper into 8th. Shuffle the cards.
4. Assign one player to be the record keeper to keep track of the number of cycles (turns around the board) and (**advanced players only**) any long-term debuff from the stress factor cards.
5. Either find a die or have players download one of the many free virtual dice apps onto their smart phone. 6-sided die is preferred.

RULES

1. This game can be played up to 4 players at a time.
2. Start with the player’s piece (the CO2 atom) at the start position. Roll die to determine the number of steps to take forward.
3. **Advanced players only:** start with player’s piece at the start position pull a stress factor to start at the carboxylation (carbon fixing, i.e. the green colored) step.
4. **Advanced players only:** draw a stress factor card each time you land on a square with the lighting bolt symbol, then follow the directions on the stress factor card.
5. **Advanced players only:** each time you land on a square where there is a double-sided arrow (⭤ ), if you rolled the number of the carbons in the carbon molecule (e.g. 5 for ribulose, RuBP, or 3 for GAP), you must move to backwards to the space of the molecule indicated by the double-sided arrow, because the double-sided arrow means the reaction can proceed in either direction. E.g. if you rolled “3” when you’re on the position for BPG, you must move backward to PGA. If you rolled “5” when you’re at Ru5P you must move backward to Xy5P.
6. The first player to complete de-novo synthesis of 1 molecule of glucose (2 cycles along the squares on the game board in a dark cycle containing 3 molecules of ribulose bisphosphate) wins.

CLASS MATERIAL COVERED IN THIS GAME

* How many turns of the cycle does it take to generate one glucose (assuming a cycle starting with 3 ribulose sugar)
* What are the three phases of the cycle, and which phase has the most steps
* How many ATP and NADPH it takes per cycle, and how many it takes to generate one glucose.
* How the carbons are shuffled during each cycle
* How many water molecules are used per cycle, and how many it takes to generate one glucose.
* Basic concept of how stress factors can affect photosynthesis.
* Chemical structure of key molecules in the cycle
* Which enzymatic reactions are reversible
* **NOTE:** for simplicity (and board layout), the ribose-5-phosphate steps and some of the GAP conversions with trans-ketolase, aldolase etc are excluded

SUGGESTIONS FOR INSTRUCTORS

* Either have students play the game once after the module on photosynthesis, or run a gaming “championship” as a review session (i.e. assemble everyone into groups of 4, and then have the winners play each other).
* Have students add their own stress factor cards.
* Provide “resilience cards” featuring questions from exam question banks. If answered correctly, it can cancel out a “debuff” (negative effect from the stress factor card or a roll of 3 or 5 on the ⭤ locations).

SUGGESTIONS & COMMENTS

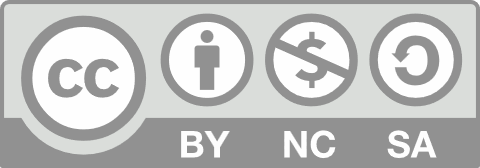
Email: [shxzhang@ucdavis.edu](mailto:shxzhang@ucdavis.edu)

Feedback form: <https://forms.gle/Z9guQHyPseKtTCYu7>

CITATION & SHARING

Version 1 of THE DARK CYCLE boardgame is last updated Nov. 18, 2022 by Shuxiao Zhang

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