Modeling Photorespiration Pathway through E-Cell

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1 Introduction

Photorespiration is a process wherein a plant takes up air and water in order to conduct photosynthesis. In order to understand and manipulate photorespiration, it is important not only to translate photorespiration into mathematical equations but also pipe these equations into a reliable simulation environment. E-Cell is a modeling and simulation environment for biochemical and genetic processes [3]. It allows a user to define functions of proteins, protein-protein interactions, protein-DNA interactions, regulation of gene expression and other features of cellular metabolism, as a set of reaction rules. E-Cell simulates cell behavior by numerically integrating the differential equations described implicitly in these reaction rules. The user can observe, through a computer display, dynamic changes in concentrations of proteins, protein complexes and other chemical compounds in the cell. Our objective is to integrate enzyme rate equations and stoichometry of photorespiration pathway that leading to a reliable simulation environment using E-Cell system.

2 Method and Results

The present model combines the stoichometry of C3 plant photorespiration and the mathematical rate equations from the published literature [1, 2]. Using substance-reactor logic of E-Cell , a total of 14 enzymes mediated reactions form the bulk of this modeling mass. These reactions are spread out in three cellular compartments comprising of chloroplast, peroxisome and mitochondria as shown in the Figure 1.

3 Discussion

This model has 33 state variables representing the concentration of substrates in chloroplast, peroxisome and mitochondria. Each of this variable is linked to a specific differential equation. The law of mass action is used to formulate differential equations from stoichometric equations. Since photorespiration takes place without really affecting photosynthesis, the present modeling effort revolves around a proven stable system. It also appears that mechanism of photosynthesis and photorespiration can be explained largely in terms of stoichometry. Our future homework would be to compete photorespiration and photosynthesis models with each other in order to fine tune for anomalies, if any.

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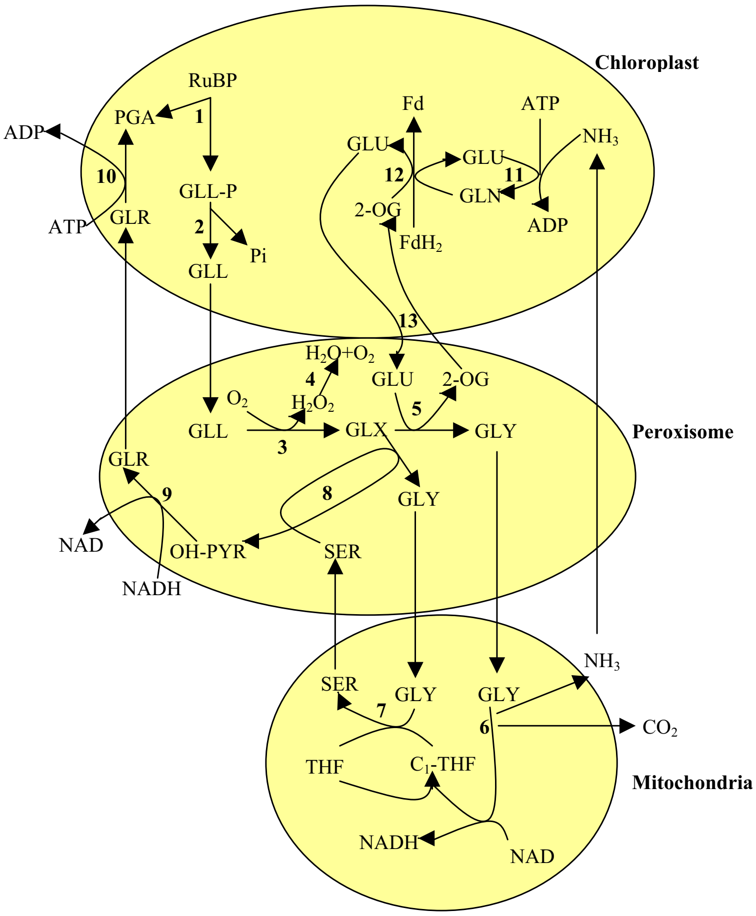

Abbreviations:
RUBP:Ribulose-1,5 biphosphate, **GLL-P**:2-phosphoglycolate, **GLL**:Glycolate, **GLX**:Glyoxalate, **GLY**:Glycine, **THF**:H4 Folate, **C1-THF**:Methylene hydrofolate, **SER**:Serine, **OH-PYR**:Hydroxypyruvate, **GLR**:Glycerate, **GLU**:Glutamate, **2-OG**:Alpha-ketoglutarate, **PGA**:3-phosphoglycerate, **GLN**:Glutamine, **ATP**:Adenosine Triphosphate, **ADP**:Adenosine Diphosphate.
1:Ribulose biphosphate carboyxlase / oxygenase, **2**:Phosphoglycolate phosphatase, **3**:Glycolate oxidase, **4**:Catalase, **5**:Glutamate :glyoxylate aminotransferase, **6**:Glycine decarboxylase, **7**:Serine transhydroxymethylase, **8**:Serine-glyoxalate aminotransferase, **9**:Hydroxypyruvate reductase, **10**:Glycerate kinase, **11**:Glutamate synthase, **12**:Glutamine synthetase, **13**:Chloroplast dicarboxylic acid transporter.

Figure 1: Photorespiration pathway in C3 plants.

References

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