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Possibilities of enhanced algal biofuel production using optimality, pathway modification and waste

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In response to their environment, algae in the wild may use an approximation to optimality of resource allocation in cellular structures, photosynthetic pigments, enzymes, transporters in membranes and RNAs, and in their genetic material. However, under controlled conditions, when algae are grown for biofuel (lipid) production for example, some of these processes can be altered to increase the efficiency of photosynthesis and therefore, lipid yield. This suggests that there is scope for selecting mutations and for genetic engineering at various levels in the photosynthetic apparatus with the aim of increasing efficiency of photon use and the rate of transformation of resources per unit biomass to improve biofuel yields. More specifically, the wavelength range covered by photosynthetic pigments and photochemical reaction centres could be increased, the number of protons transported from the thylakoid lumen to the stroma per unit ATP synthesised by the ATP synthetase could be decreased, the flickering light effect could be utilised, and photosynthetic pathways changed e.g. replacing part or all of the current machinery for autotrophic fixation of inorganic carbon. There are also possibilities for decreasing carbon loss by ‘wasteful’ aspects of dark respiration and of dissolved organic carbon loss. Provided that the environmental fluctuations to which algal growth conditions are constrained, there are possibilities for decreasing the resource cost (less ROS protection) and the lost capacity due to the changes in apparatus or regulation (e.g. by having fewer xanthophyll pigments) and acclimation related to environmental variations. For example, in a less variable light environment, there is the possibility of down-regulating photoprotective mechanisms, as well as limiting the capacity to repair processes related to photoinhibition. Decreased protein turnover is also a potential energetic saving. These interventions apply to individual processes; however, this may not be immediately incorporated into the optimal allocation of resources by the alga, and further intervention using a system biology approach may be required.

Keywords: ATP synthesis stoichiometry; inorganic carbon assimilation pathways; photochemistry; photoinhibition; protein turnover; biofuel

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利用优化，途径改造和垃圾来增强藻类生物燃料生产的可能性

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野外藻类可以使用一个近似的细胞结构，达到光合色素，酶，质膜转运体和 RNA，以及在他们遗传物质中的资源最优配置，来回应它们所处的环境。然而，在受控条件下，当藻类生长被用于生物燃料（脂质）的生产，例如，一些过程可被改变用以增加光合作用的效率，即脂质产率。这表明，可通过选择突变和对各级光合器官进行基因工程来实现生物燃料产量的提高， 目标是提高光子利用效率和每单位生物质资源转化率。更具体地，光合色素和光化学反应中心所涉及的波长范围可以被增加；ATP 合成 酶合成单位 ATP 时，从类囊体腔运送到基质的质子数可以减少；采用闪烁的灯光效果来改变光合途径，比如取代部分或全部的无机碳自养固定电流机械。也有通过溶解有机碳和暗呼吸的“浪费”，来减少碳损失的可能性。只要限制藻类生长的波动环境条件，也有可能降低资源成本（更少的活性氧保护）和由于机构或调控（例如，通过具有更少的叶黄素色素）的变化以及环境适应的变化而引起的行为能力丧失。例如，在一个不太变化的光环境下，存在着下调光保护机制，以及限制有关光抑制过程能力修复的可能性。减少蛋白质周转也是一个潜在节能方式。这些措施适用于单个进程；然而，这可能无法立即并入藻类的资源优化配置，并且可能需要使用系统生物学方法来进一步干预。

关键词：ATP 合成化学计量；无机碳同化途径；光化学；光抑制；蛋白质转换；生物燃料