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Did the quantum mechanics of early sunlight absorption influence the survival of ancient land-based plant life?

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Abstract
There is a vast array of research into the role quantum mechanics plays in the process of photosynthesis with modern day plant life. However, research is lacking into the role of quantum mechanics in ancient plant life, when the Earth's conditions and plant adaptations were very different. This paper looks into the plants of the Paleozoic era exploring how quantum mechanics aided the survival of ancient land-based plants.

Keywords: *Speculative evolution; Physics; Biology; Quantum mechanics; Metabolic processes; Photosynthesis; Paleozoic era*

Introduction

Whilst there is an extensive array of research into how modern-day organisms use quantum effects throughout photosynthesis [1, 2, 3], there is limited research into how these processes would have worked in ancient plant life. Especially, when there were vast differences to the Paleozoic plant life biology.

The Paleozoic era began around 538.8 million years ago [4] and was anticipated to be the time period when plants formed on the Earth. Therefore, to gain the most accurate answer to the question this article will reference this time period.

This article aims to discuss the likelihood that ancient plant types also used similar quantum effects throughout the Paleozoic era.

The Effects of Quantum Mechanics in Modern-Day Photosynthesis

Quantum mechanics is used in photosynthesis to transfer the energy from the light absorbed by photosynthetic molecules called chromophores to the reaction centre where photosynthesis occurs [5]. The absorbed light excites the electrons within the chromophore causing them to reach a higher energy level, making them free to move around, this leaves a free space called a hole behind. This hole and the electron act together as a boson called an exciton which then travels to the reaction centre [8].

The process, which occurring in Figure 1, transfers energy to the light dependent reactions shown in Figure 2.

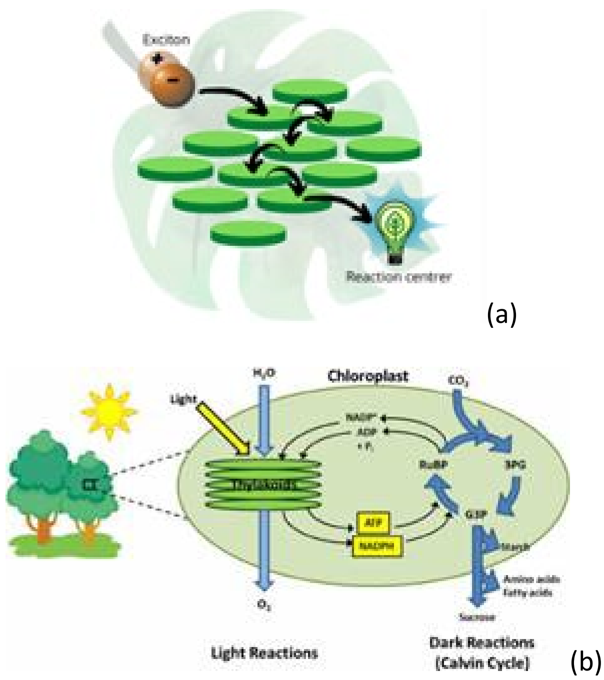

Figure 1 – Diagram showing the processes of photosynthesis in the chloroplast a) Exciton moving between chlorophyll to get to the reaction centre [6] b) The light dependent and dark reactions [7].

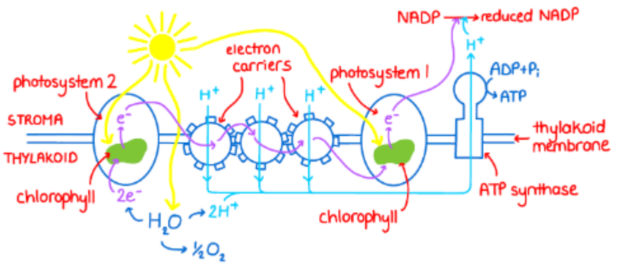

Figure 2 – The process of light dependent reactions of photosynthesis within the thylakoid membrane of the chloroplast [9].

The light-dependent reactions of photosynthesis convert this light energy to chemical energy in the form of NADPH and ATP. First, when light hits the photosystem II (PSII) water is split via photolysis into $2H^+$ and $\frac{1}{2}O_2$, two electrons and a H^+ are then transferred to NADP+ to reduce it forming NADPH. As well as this, hydrogen ions (H^+) are pumped down their electrochemical gradient through ATP synthase in the thylakoid membrane within the chloroplast to drive the production of ATP, where a phosphate group is added to ATP. This ATP and the formed NADPH are then used in the Calvin Cycle to produce sugars [10].

Differences Between Ancient Land Plant Life and Modern Plant Life

Expectedly, ancient plants were less advanced in the Paleozoic era. As a result of their smaller size, it is anticipated that they likely had poor water control [11].

Due to the lack of xylem and phloem adaptations the plants were less able to overcome the forces of gravity when trying to acquire water through the roots, and less advanced leaves [12]. Therefore, to counteract this it is anticipated that to be able to maximise the light intake of these plants there would have been photosynthetic tissues on the plants above ground to account for the lack of the advanced leaves which we can see on plants in this day and age [13].

In addition to this climate models suggest the levels of carbon dioxide were approximately around 14-16 times higher than what it is in the current day [14], implying that photosynthesis was nowhere near as efficient or effective as we see in the current day.

The Impact of the Sun During the Paleozoic Era

Throughout the Paleozoic era, there was a greater number of sun rays being reflected from the Earth's surface due to the lack of vegetation and large amounts of bare land [15]. In addition to this, the sun was also assumed to have a 30% lower luminosity [16] further providing implications for these plants to undergo photosynthesis.

Would the Effects of Quantum Mechanics be Present in the Ancient World?

With the lack of adaptations in ancient plant life that were presented earlier, the plants still had features present in modern-day plants, such as chlorophyll. Therefore, the ideas presented in Schrodinger's equation could still be applied to photosynthesis in ancient plants [17]:

$$i\hbar\frac{\partial\Psi}{\partial t} = \hat{H}\Psi(t),$$

where:

$$\Psi = \text{Excitons state across pigment sites}$$
$$\hat{H} = \text{Hamiltonian encoding site energies and coupling interactions}$$

In modern-day photosynthesis it has been discovered that it is quantum coherence that results in the transfer of energy throughout photosynthesis [18], this is a result of the particle exhibiting wave-like properties with multiple energy transfer pathways being explored simultaneously.

Therefore, with atmospheric CO_2 levels and solar luminosity being lower, and ancient plants lacking the adaptations of modern plants, there was likely a much lower quantum coherence and rate of photosynthesis. However, the underlying quantum effects governed by the Schrödinger equation would have still been present in the Paleozoic era, allowing for the transfer of energy during photosynthesis.

Conclusion

Therefore, being able to produce a definite answer to the question, "Did the quantum mechanics of early sunlight absorption influence the survival of ancient land-based plant life?" would be difficult without further research. However, it is evident that whilst there were fewer adaptations to allow for the quantum effects to aid photosynthesis, they may have still been able to occur just with less of an effect on modern-day plant forms.

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