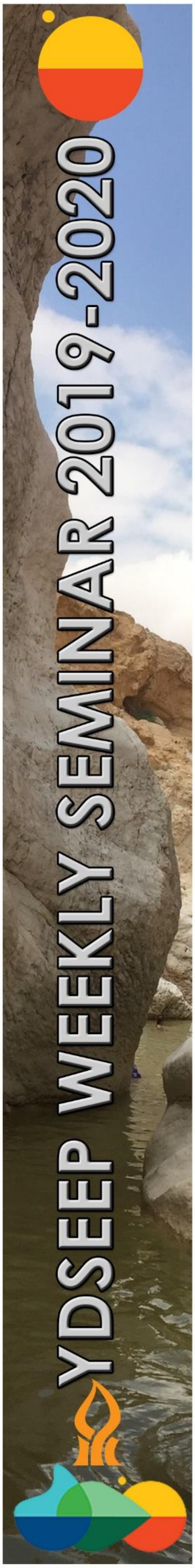

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SOME ASPECTS of PHOTOSYNTHESIS: A physicist view

(Pulsed Light:
A way to significantly increase photosynthetic efficiency in algae)

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Abstract:

Unicellular algae can be immense sources of proteins, chemicals for various industrial processes, as well as for biofuels. However, at present, they are not a viable resource owing to the low production rates achieved.

The inability of the photosynthetic apparatus to process large photon fluxes under continuous illumination is one major source of inefficiency. At low fluxes, the biomass production rate grows linearly with photon flux. However, already at fluxes of the order of a 1/10 -1/6 of a full sun, the production rate grows less than linearly and reaches saturation. As a result, at a photon flux corresponding to a full sun, about 80% of the impinging photons are wasted.

Very few experiments have been performed, which clearly indicate the ability to increase the efficiency of exploitation of photons by the photosynthetic apparatus by factors as high as 3-10 through the use of a pulsed-light regime with judiciously chosen pulse and dark times. The experimental results will be reviewed and a simple model, which explains them and has predictive capabilities, will be presented. The model counts photon pairs that have the capacity to split water molecules, and accounts for three key main factors:

1) Both photosynthesis and the full biomass production process are affected by one and the same bottleneck time scale of the order of 10 ms;

2) Each PS II (first stage in the photosynthetic system) can store the energy extracted through splitting of (on the average, about 7) water molecules;

3) Photon arrival times at the chlorophyll antenna vary randomly.

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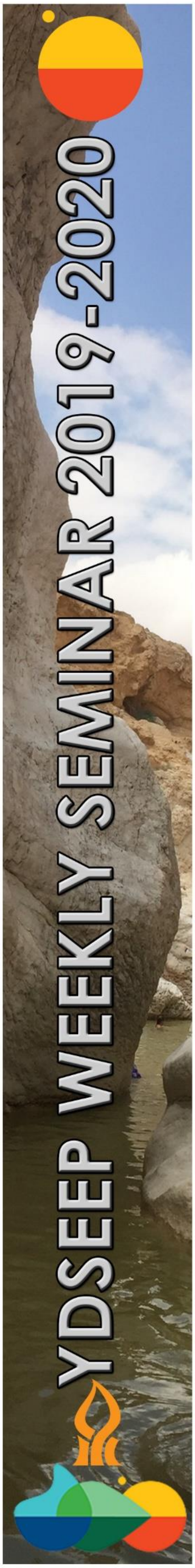
Date & Location:

Tuesday, November 5, 2019, 11:00
Lecture room, Physics Building (ground floor)



The duration of a light pulse ought to be no longer than the time it takes to fill up the energy storage of PS II. If light is not shut off when storage is filled up, then additional photons that hit the chlorophyll antenna are wasted. If light is shut off when, or before, storage is filled up to its full capacity, to be followed by a sufficiently long dark time, then all the stored photon energy is exploited. To a good approximation, no photons are then wasted.

It will be argued that, depending on chlorophyll antenna absorption cross-section and the energy storage capacity of PS II, the efficiency of photon exploitation relative to continuous light exposure can be increased by factors of order 10 and more.

Some open questions of a fundamental nature regarding the characteristics of biomass production will be reviewed.

The engineering design that exploits these ideas in order to come up with highly efficient bioreactors does not exist yet.

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