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This Week's Citation Classic

Stern A I, Schiff J A & Epstein H T. Studies of chloroplast development in *Euglena*. V. Pigment biosynthesis, photosynthetic oxygen evolution and carbon dioxide fixation during chloroplast development. *Plant Physiol.* 39:220-6, 1964. [Department of Biology, Brandeis University, Waltham, MA]

The incoming of photosynthesis in illuminated dividing and nondividing dark-grown *Euglena* was related to the formation of pigments and chloroplast structure. This work established that chloroplast development could be studied in the absence of complicating factors such as cell or plastid replication. [The *SCI*® indicates that this paper has been cited in over 140 publications since 1964.]

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"It was the late-1950s, and *Euglena gracilis* var. *bacillaris* had been isolated previously by others and had been taught to grow luxuriantly in axenic culture on a series of defined media by Seymour Hutner.[1,2] Since these media contained reduced carbon sources, the organism could be grown in darkness nonphotosynthetically or in the light as a phototroph. In darkness, the photosynthetic apparatus did not develop, but when exposed to light, the cells formed fully competent chloroplasts. There were indications that the form of the chloroplast depended on at least two processes: plastid replication and plastid development.

"At about this time, I arrived at Brandeis University as a new graduate student in a new and developing graduate program. Many of the graduate students, like myself, were Korean War veterans and were at least as old as many of the faculty. The university was young, the faculty was young, the students were eager, and there seemed to be no fixed rules about how to be a graduate student. In fact, I recall entering the science building one morning, at approximately 2 a.m., to take a point for an experiment, when I heard an eerie sound which I followed to its source, an open office in the physics department. The sound was emanating from a cello being played by a physics graduate student whose mesmerized eyes were fixed on the blackboard and who obviously was hoping to divine the solution to a complicated mathematical problem in front of him.

"Our paper was actually the first in a series of three[3,4] which related light intensity and the rate of thylakoid formation to the development of photosynthetic capacity in *Euglena*. The *Euglena* system offered a fresh new look at chloroplast development. Little was known in this organism about the onset and kinetics of various photosynthetic parameters during this process or even what the optimal light intensity was for plastid development. Also, it was not known if cell division and chloroplast development competed for resources such as organic substrates and energy. In an attempt to answer these questions, a resting medium was devised in which dark-grown cells were shown to retain their viability for long periods without division, while still retaining their capacity to form functional chloroplasts in the light.

"One reason the paper may be cited is that it describes the development of photosynthetic competence in *Euglena* under optimal light and growth conditions and relates it to the linear increase of chloroplast thylakoids. Other reasons are probably the descriptions of the resting medium and of the photosynthetic properties of five mutants.

"The chloroplast development problem in *Euglena* was just breaking, and each experiment we did seemed to yield significant results which in turn suggested additional experiments. In other words, we were following our noses and doing what seemed to be the next set of necessary experiments to learn how the system worked. At the same time, we had to devise the necessary techniques to do the job. It never occurred to us that we were writing a paper which would become highly cited. It just turned out that way. For a recent review on chloroplast development in *Euglena*, see J.A. Schiff and S.D. Schwartzbach."[5]

1. **Hutner S H & Provasoli L.** The phytoflagellates. (Lwoff A, ed.) *Biochemistry and physiology of protozoa*. New York: Academic Press, 1951. Vol. I. p. 27-128.
2. **Hutner S H, Zahalsky A C, Aaronson S, Baker H & Frank O.** Culture media for *Euglena gracilis*. (Prescott D M, ed.) *Methods in cell physiology*. New York: Academic Press, 1966. Vol. II. p. 217-28.
3. **Stern A I, Epstein H T & Schiff J A.** Studies of chloroplast development in *Euglena*. VI. Light intensity as a controlling factor in development. *Plant Physiol.* 39:226-31, 1964.
[The *SCI* indicates that this paper has been cited in over 40 publications since 1964.]
4. **Ben-Shaul Y, Schiff J A & Epstein H T.** Studies of chloroplast development in *Euglena*. VII. Fine structure of the developing plastid. *Plant Physiol.* 39:231-40, 1964.
[The *SCI* indicates that this paper has been cited in over 70 publications since 1964.]
5. **Schiff J A & Schwartzbach S D.** Photocontrol of chloroplast development in *Euglena*. (Buetow D E, ed.) *The biology of* Euglena. *Volume III. Physiology*. New York: Academic Press, 1982. p. 313-52.