Photocontrol of Development by *Stigmatella aurantiaca*

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Aggregation and fruiting body formation by *Stigmatella aurantiaca* were stimulated most effectively by low irradiances of blue light between 400 and 500 nm. At higher irradiances, other wavelengths of light, including those in the far-red region of the spectrum, were also effective.

Myxobacteria are gram-negative bacteria that move by gliding motility on solid surfaces. When sufficient nutrients are present, the cells grow vegetatively as flat, spreading populations called swarms. When nutrients are depleted, the cells collect into aggregation centers and construct multicellular fruiting bodies (3). We have recently described conditions under which aggregation and fruiting body formation can be induced to take place synchronously in a population of *Stigmatella aurantiaca* (6, 7). This organism is particularly useful for developmental studies because the cells progress through several easily recognizable intermediate morphological stages during the construction of a complex fruiting body. These stages include the formation of discrete raised cell aggregates that elongate into stalks bearing several sporangia. The final stage of development is the differentiation of the cells into myxospores (2, 6, 7). We were able to demonstrate that the formation of discrete aggregates and fruiting bodies is markedly stimulated by light (6, 7). As a first step in elucidating the role of light, we have investigated those wavelengths that are most effective in stimulating aggregation.

Cells were grown in liquid suspension and induced to develop on agar plates as previously described (6). For the studies reported here, the number of cells spotted on the agar plates was reduced from $2 \times 10^6$ to $5 \times 10^7$ per 5-µl drop. Such dilute populations of cells aggregate very poorly in the absence of light.

The petri dishes were then placed in cabinets (8), where they were irradiated for various periods of time with spectrally controlled regions of light. Bands of light (approximately 100 nm wide at the 5% power level) were selected with theatrical gelatin cutoff filters and liquid filters. The light was isolated from 300-W tungsten projector lamps whose filament voltage could be adjusted with powerstats. The following filter trains were used: blue ($\lambda_{\text{max}} = 450$ nm)—a 10-cm, 5% CuSO₄ aqueous filter and 5-mm-thick Rohm and Haas 2424 blue Plexiglas; green ($\lambda_{\text{max}} = 540$ nm)—10 cm of distilled water, three sheets of a Gelatine Products Co. P-43 filter mounted on single-strength window glass, and a 5-mm-thick Schott KG-1 heat-absorbing filter; red ($\lambda_{\text{max}} = 650$ nm)—a 10-cm, 41% aqueous ferrous ammonium sulfate filter, one sheet of a Gelatine Products Co. P-16 filter mounted on single-strength window glass, and a 5-mm-thick Schott KG-1 heat-absorbing filter; far red ($\lambda_{\text{max}} = 750$ nm)—10 cm of distilled water, 3-mm-thick Rohm and Haas R-2 Plexiglas, and 5-mm-thick Schott KG-1 heat-absorbing filter. Dark controls were incubated in similar boxes in the absence of light. All experiments were performed in a room maintained at a constant temperature (30°C). At various times, plates were removed from the boxes, and the number of aggregates (or fruiting bodies) were counted. We had demonstrated previously that short exposure to white light did not affect development (6).

The wavelength distribution was measured at 10-nm intervals from 380 to 800 nm with a C-3 Spectral Scanning System (Gamma Scientific, San Diego, Calif.). A 60-cm fiber optical receptor with a 50° cosine correction and an NM 7H double monochromator with a 3-mm slit width were used. The detector system was calibrated against a HL 241 tungsten standard lamp which, in turn, was calibrated from a Bureau of Standards derivative tungsten standard lamp.

Reductions in irradiance values were obtained by reducing the voltage on the projector lamps and measuring the scaled-down values with a model 550 photomultiplier photometer-radiometer (E. G. and G., Inc., Salem, Mass.), which is linear over several orders of magnitude. Irradiance values were routinely measured before cell exposures and at the end of experiments.

Several irradiance levels were tested. Representative data for two experiments are shown in Fig. 1. At the low irradiance level, blue light stimulated aggregation most effectively. As the irradiance levels were increased, other wavelengths of light became effective. The variability was large from experiment to experiment, and
no absolute irradiance values for either onset of aggregation or numbers of aggregates can be given. Of particular interest is the stimulation by far-red light at moderate irradiance levels. To our knowledge, there are no previous reports of far-red developmental effects in non-photosynthetic procaryotes. The stimulation by blue light implicates the possible involvements of a carotenoid, flavin derivative, or porphyrins and related compounds as the photoreceptor (1). The carotenoids of *Stigmatella* have been characterized as acyclic and monocyclic C_{40} carotenoids (4, 5). Such molecules would not be expected to absorb light in the far red region and are probably not the photoreceptors for far-red light.

The myxobacteria are soil organisms. It is possible that light favors the development of fruiting bodies near the surface of the soil or forest litter where dissemination of fruiting bodies or sporangia is facilitated. Aside from its possible ecological role, the influence of light on development by *Stigmatella* is of inherent interest. The behavioral responses to light strongly suggest that the light is perturbing some system, perhaps in the cell envelope, that exerts a major effect on the physiological and developmental behavior of the cells.

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**LITERATURE CITED**


