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Induction of Polarity in Fucus Furcatus by a Localized Concentration of Hydrogen Ions.*

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The *Fucus* egg is spherical (diam. = 65-90μ). About 17 hours after fertilization (15°C.) a protuberance develops at one side of the egg (involving softening and extension of the cellulose wall, and ordinarily protruding in a plane parallel to the substrate). This protuberance extends (Fig. 1), and the plane of the first cell division passes across just back of the base of the protuberance, perpendicular to the direction of protrusion. This results in 2 cells of different shape and very different developmental fate or potentiality. The protuberance cell gives rise to the rhizoid of the new organism, the other cell to the thallus. When the point of development of the rhizoid protuberance is determined, the polarity and the developmental pattern of the whole embryo is determined.

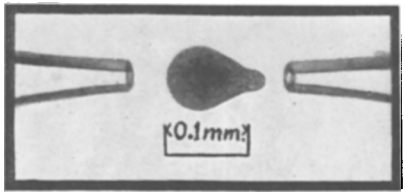

FIG. 1.
Egg developing in pH gradient. Medium is sea water at pH 7.8. Left pipette contains sea water agar (pH 7.8). Right pipette contains buffered acidified sea water agar (pH 6.4). Rhizoid protuberance develops at region of low pH.

Among conditions which affect the point of origin of the rhizoid is the presence of neighboring eggs which lie within a few egg diameters (sea water between). The rhizoid is induced to form on the side toward a neighbor, or in the resultant direction of neighbors.[1,2,3] One of the conditions which may be expected to obtain during this action at a distance is a gradient of hydrogen ion concentration, due to diffusion of CO_2 or other acid metabolites from each cell, with highest concentration toward the neighbor.

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1 Kniep, Hans, *Jahrb. f. wiss. Bot.*, 1907, **44**, 635.

2 Hurd, A. M., *Bot. Gaz.*, 1920, **70**, 25.

3 Whitaker, D. M., *Biol. Bull.*, 1931, **61**, 294.

The experiments reported here are part of an investigation of the factors involved in the mutual influences and will be published elsewhere at greater length with additional data.

Gradients of hydrogen ion concentration were established across 50 individual eggs by means of micro-diffusion pipettes. Pipettes were drawn from 10 mm. pyrex tubing tapering to internal diameters of about 10-20 microns in a length of 1-2 cm. Tips were cut off squarely with diamond points, and pipettes were matched in pairs.

One pipette was filled from the tip with 1% agar sea water (pH range 7.4-8.3), the other with 1% agar and sea water buffered variously at pH 5.8 to 6.4. The pH was measured with a glass electrode. Buffer strengths were adjusted so that pH held constant within 0.1 unit for 24 hours with eggs developing in the mixture but there was little more than enough capacity to attain this effect. Thus upon being diluted in diffusing from the tip of the pipette the buffered mixture rapidly lost its buffer capacity and was therefore unable seriously to drop the higher pH on the other side of the egg.

Eggs were obtained and reared in a dark constant temperature room (15°C.), being exposed briefly only to red light. Soon after fertilization an egg was placed alone in a dish of sea water on the stage of a microscope on a Taylor micromanipulator. The 2 pipettes were mounted in the manipulator and the tips approached the egg on opposite sides, as in Fig. 1. The level of the contents of the pipettes was several millimeters above the level of the sea water in the dish to augment diffusion with a slight pressure flow and to increase the reserve of solutions. Results were recorded photographically.

Of 50 eggs, 46 (92%) developed rhizoids on the side of the egg toward the acid pipette. Of these, 24, or more than half, developed the rhizoid within 10° of a line toward the source of hydrogen ions. A typical good case is shown in Fig. 1. The same results were obtained using McIlvaines, or HCl-bicarbonate buffer.

Summary. Hydrogen ions in suitable concentration, when applied to a localized region of the *Fucus* egg in sea water, induce formation of the rhizoid protuberance. The polarity and the developmental pattern of the whole embryo are determined.