On Tetraspore Formation and its Germination in *Dictyopteris divaricata* Okam., with Special Reference to the Mode of Rhizoid Formation

By

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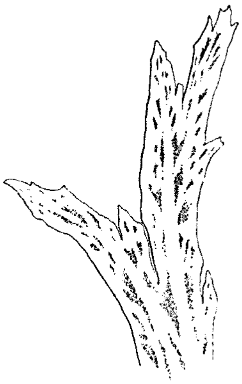
Introduction

THURET illustrated briefly the germinal development of *Dictyota dichotoma* in his classic work (1855). The cytology of the tetrasporangium and the germinating tetraspore in *Dictyota dichotoma* and *Padina pavonia* has been studied by LLOYD WILLIAMS (1904) and CARTER (1927) respectively. However, there are no cytological studies of the tetraspore in Dictyotaceous plants in Japan.

The present writer aims to describe and figure the tetraspore formation and its germination exclusively in *Dictyopteris divaricata*, with special reference to the mode of rhizoid formation, and to compare them with embryos of Fucaceous plants hitherto investigated, which are considered by taxonomists to belong to a higher class than the family *Dictyotaceae*.



Text-fig. 1.
The upper portion of a frond in *Dictyopteris divaricata* OKAM.
(life size)

Materials and Methods

Dictyopteris divaricata OKAM. is a member of the *Dictyotaceae* in Japan. Its tetrasporangial plant is found on the rocks between tide marks in the vicinity of the Muroran Institute for Algological Research. It ripens in about the beginning of August.

In this species, many tetrasporangiums form sori on the upper portion of an old frond and are arranged in oblique rows from both sides of the midrib (Text-fig. 1).

The material was collected at low tide there on the 1st, 2nd and 3rd of August.

For the observation of tetrasporangium, maturated sori on the upper portions of the thallus were cut into thin sections at the time of fixing by FLEMMING's strong solution prepared with sea water. For the study of germinating tetraspores, sori were cultured in small glass basins filled with natural sea water, partly replacing the fresh sea water several times a day. When the mature tetraspores are detached from the outer surface of a frond, they fall immediately to the bottom of the glass basins, and attach on the surface of slides which were previously prepared, and then the germination commences.

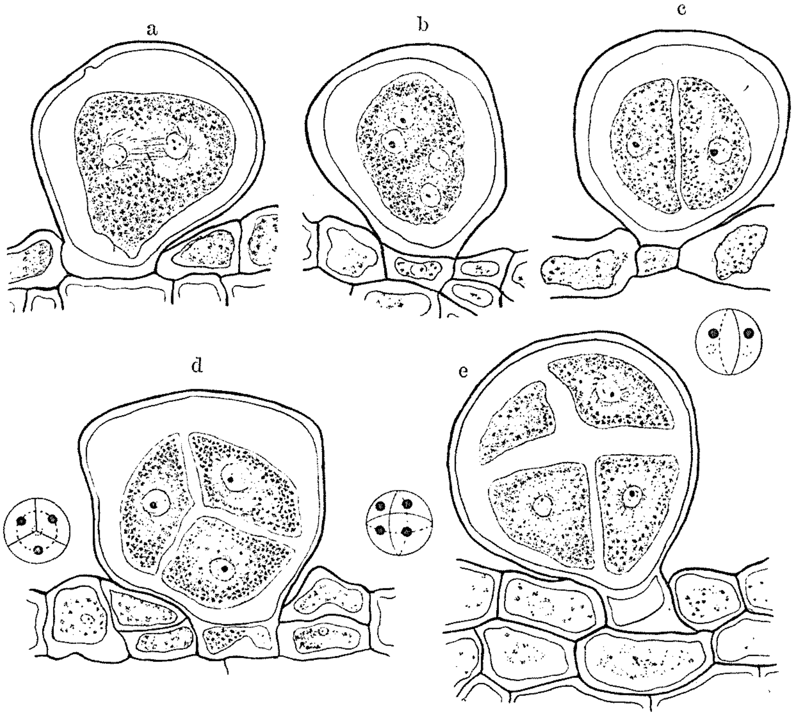
The germinating tetraspores were observed in natural sea water. For the cytological observations they were fixed exclusively by FLEMMING's weaker solution prepared with sea water. The microtome sections were cut at thicknesses varying from 5μ to 10μ and stained with HEIDENHAIN's iron alum haematoxylin.

Observations

A) Formation of Tetraspores.

In this paper no detailed observations of the stalk-cell division and the maturation division of the tetraspore mother-cell are given. These observations will be reported in a subsequent paper.

The mature tetraspore mother-cell contains a single large nucleus, surrounding which a multitude of chromatophores are seen. The nucleus divides into four small nuclei, as the result of the maturation nuclear division; namely the first and second divisions (Text-fig. 2 a, b.). After this second division, the chromatophores are scattered throughout the tetraspore mother-cell. The four small nuclei now separate from each other, and this movement of the nuclei is followed by a rearrangement of the plastids, which are disposed around each small nucleus as a centre, leaving a zone of clear cytoplasm. Then vacuoles appear in the zones of clear cytoplasm between four tetraspore rudiments, these unite to form furrows, and these furrows run tripartitely (Text-fig. 2. d.) or cruciately (Text-fig. 2. c, e.) in the wall of the tetraspore mother-cell. The tripartite division is met with more frequently than the cruciate one. In this way, four free independent tetraspores are formed packed close together within the wall of the mother-cell. From these observations, the manner of tetraspore formation in *Dictyopteris divaricala* seems, in essential points, to be very similar to those what has already been studied in *Dictyota dichotoma* and *Padina pavonia*.



Text-fig. 2. a. The tetraspore mother-cell containing two nuclei. b. The mother-cell containing four nuclei. c, d, e. The delimitation of tetraspores in the wall of the tetraspore mother-cell, c. Two quadrants in the cruciate division. d. Three quadrants in the tripartite division. e. Four quadrants in the cruciate division. (×280).

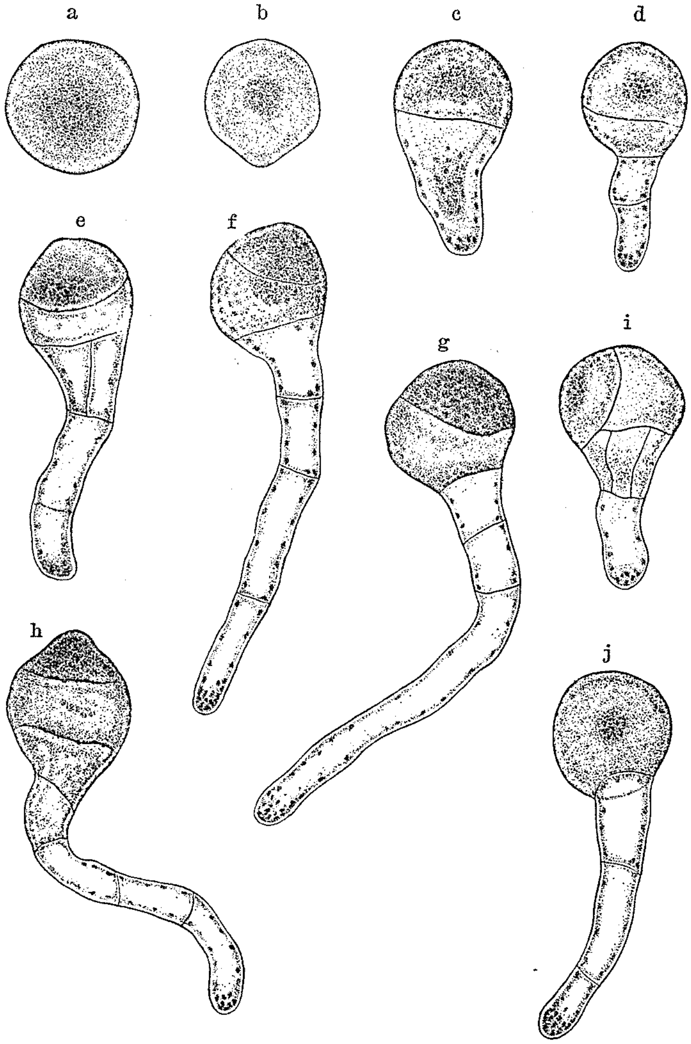
B) Germination of Tetraspores.

The liberated tetraspore is a spherical form; diameter about 90μ. In the center of its body, it has a single nucleus which is larger in size than that of quadrants of a tetraspore mother-cell and chromatophores are seen surrounding the nucleus.

The development of the tetraspore begins within ten hours after the liberation. At first a single large nucleus divides into two. (Text-fig. 3. a.) Of these two, one nucleus begins immediately to move to the periphery, and at the same time the body of the tetraspore protrudes in the same direction. (Texa-fig. 3. a. b., Text-fig. 4. b.). This direction is determined by the light.

Later the first segmentation wall runs transversely, forming two cells.

(Text-fig. 3. c., Text-fig. 4. c.). Then one nucleus of the protruded portion divides into two. Of the two nuclei, one nucleus becomes the nucleus of the rhizoid. (Text-fig. 3. d.).



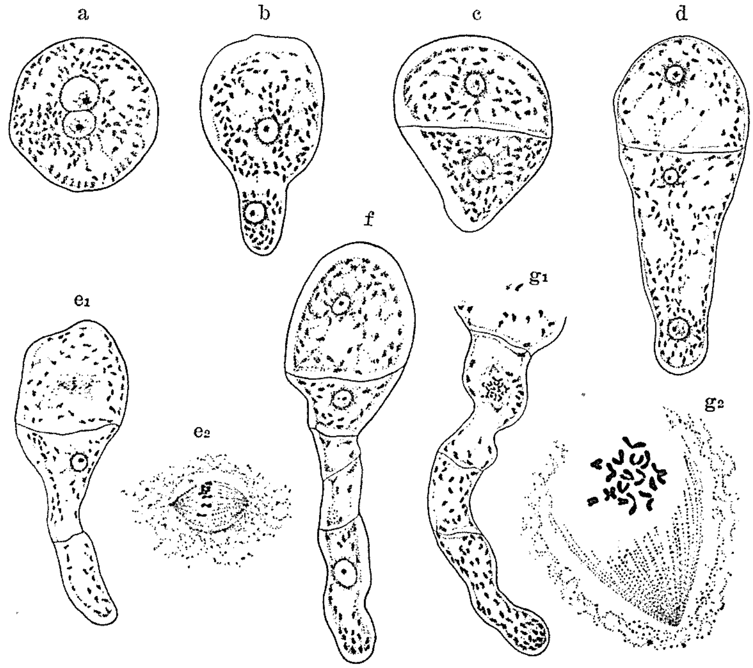
Text-fig. 3. a. The liberated tetraspore with a central nucleus and chromatophores surrounding the nucleus. b. The terminal protrusion developing from the body of tetraspore. c. First segmentation forming two cells and a rhizoid developing. d, e, f, g. A rhizoid developing further, consisting of a few cells. h. The apical protrusion developing from the germ. i. j. Abnormal germs. (from fresh materials. $\times 200$).

In the successive stage, the rhizoid elongates and comes to consist of a few cells (Text-fig. 3 d, e, f, g., Text-fig. 4. f, g.).

In the meta-anaphase of mitosis in the rhizoid cells sixteen pairs of chromosomes, the form of which are curved, are counted (Text-fig. 4. g_1, g_2) and this number, 16 is the same as in *Dictyota dichotoma* and *Padina pavonia.* The mantle fibres are very distinct, but centrosomes are not seen at both poles (Text-fig. 4. e_1, e_2, g_1, g_2.) in this species, though they have been described in *Dictyota dichotoma* and *Padina pavonia* belonging to the same family *Dictyotaceae.*

In the further development, the body protrudes toward the apical direction, elongates and becomes multicellular.

From these observations, it seems to be safe to say that in the early stage the manner of the tetraspore germination in *Dictyopteris divaricata* is the same as that in *Dictyota dichotoma* and *Padina pavonia.*

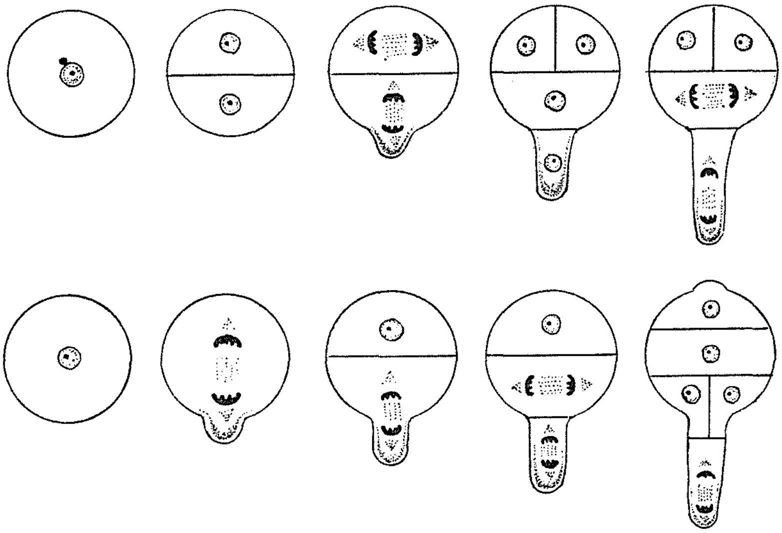


Text-fig. 4. a. Two nuclei dividing from a single large nucleus of the liberated tetraspore. b. One nucleus beginning to move towards the direction of the rhizoid. c. The first segmentation wall forming two cells. d, e_1, f. The further development of the rhizoid. e_2 Mitosis in the body of the germ. g_1. Mitosis in the rhizoid. g_2. Polar view of meta-anaphase in the mitosis of the rhizoid. (a, b, c, d, e_1, f g_1. $\times 280$., e_2. $\times 820$., g_2. $\times 1330$).

This manner, however, is different slightly in the rhizoid formation from that of the embryo in *Fucus evanescens* belonging to the lowest class of another family, *Fucaceae.* For example, a comparison of the germ development in *Dictyopteris divaricata* with the embryo development in *Fucus evanescens,* concerning the mode of rhizoid formation is made as in the following diagram (Text-fig. 5).

A

B



Text-fig. 5. Diagram of comparison of A (*Fucus*) with B (*Dictyopteris*), concerning the mode of rhizoid formation of the fertilized egg and the germinating tetraspore.

As is shown above, the formation of the rhizoid in the latter is slightly more complex than in the former. In *Dictyopteris divaricata,* the protrusion of the body of the tetraspore is formed, before the liberated tetraspore is divided into two cells. However, in *Fucus evanescens* the protrusion is formed after the embryo has been divided into two cells. At the later stage, another protrusion develops at the apical part of the germ in *Dictyopteris,* but in *Fucus* a few short hairs develop and elongate gradually.

From the above mentioned facts, it seems to be plain enough that Dictyotaceous plants are more simple in the mode of germinal development than Fucaceous ones.

Summary

i) The tetrasporangium is divided into two cells; namely a large tetraspore mother-cell and a small stalk-cell. The tetraspore mother cell

contains at first a single large nucleus which divides into four small nuclei, as the result of the maturation division. Then, the four nuclei separate from each other, and four quadrants developing to the tetraspore at the time of liberation, are formed tripartitely or cruciately within the wall of the mother-cell.

ii) The liberated tetraspore is a spherical form; diameter about 90 μ. With its development, the protrusion of the tetraspore body to develop to the rhizoid at a later stage is formed, before the germ consists of two cells, in a definite position of its body which is determined by the light. With further development, another protrusion is also formed in the apical part of its body.

iii) The haploid chromosome number of *Dictyopteris divaricata* is sixteen and centrosomes are not seen in the mitosis.

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