Influence of Environmental Factors on the Development of the Valve in Diatoms

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Received November 25, 1978
Accepted November 30, 1978

Summary

The species-specific form and structure of the diatom shell is variable within a given genetical reaction-norm, depending on the dynamic interrelation between cell and environment. The appearing modifications—based on quantitative disarrangement of construction-units as well as on a change in size and outline—can be understood as the morphological expression of a changed metabolism which has become necessary for adaption to adverse conditions. The diatoms react very sensitively, especially to the salinity factor, whereby actually two alternatives of adaption occur: a vegetative, in building resting spores (i.e., Navicula cuspidata) and a generative (i.e., Anomoeoneis sphaerophora, Surirella peisonis).

Teratologies have been found in totally unbalanced surroundings (especially under conditions of ion unbalance), where the usually symmetrical forms have lost the coordination of the construction-units to each other (i.e., Surirella peisonis). They supply good criteria in clarifying the problems concerning pattern development.

Keywords: Adaptation; Diatoms; Environment; Resting-spores; Sexual reproduction; Valve formation.

1. Introduction

The taxonomy of diatoms is based on the presumed invariability of the structure of the valves. The valves however, are merely the inorganic deposition products of living cells, which are—as autotrophic organisms—in their reactions closely dependent on their environment. HUSTEDT (1930–1966) always mentioned that “the continuous influence of altering concentrations—as happens in nature—must show in the diatoms a more or less conspicuous physiological reaction, the consequences of which have to be detectable in morphology as well”. Already in 1909 and 1911, RICHTER demonstrated in an experiment that diatoms—Nitzschia putrida—change their form if the salin—
ity of the incubation medium is changed. Very elegant methods to manipulate the cell size of diatoms have been worked out by Stosch (1942, 1965) but the crucial point of these investigations was the elucidation of development rather than the detection of ecological influences. From the ecological standpoint Geissler (1968, 1970 a, b) has done pioneer work: the influence of environmental factors on the shape and structure of valves was confirmed in several species. Her statistical measurements indicated a ± variability of all characteristic valve structures.

A synthesis of developmental and ecological investigations should make possible the induction of structural alterations in the valve to different developmental stages of a single species induced by changes in the environment. For that purpose some benthic diatoms were exposed to different stress situations, which by all means could occur at their natural habitat. At first this concerned the factor of salinity, which as far as possible, was separated to its osmotical and ionic components (Schmid 1973).

A vegetative possibility for resisting adverse conditions is to survive them in an inactive stage. Many planktonic diatoms are known to make resting spores, but with one exception (Anderson 1975, 1976) they are all centric diatoms. Comparing the sequential phases of resting spore formation (Stosch and Drebes 1964, Drebes 1969 a, b) with the formation of internal valves in the group of pennates, one could presume a similar function. Internal valves can be developed in consequence of an

a) inaequal cell division,

b) acytokinetic mitosis, or an

c) inaequal cell division, where both the nuclei are in the big cell and in the small one is only protoplasm (Geitler 1927, 1932, 1953, 1963, 1970, Stosch and Kowallik 1969). Due to the inhibited cell division Geitler (1953) calls it a "Depressionerscheinung", which is opposed to pathological inhibitions modified so, that something viable and useful occurs".

The opinions about the function of the internal valves are somewhat diverging: Pfizter (1871) thought they were resting cells, Grunow (zit. bei Hustedt 1930–1966) considered them as a protection against desiccation. Müller (1899) and Hustedt (1930–1966) enlarged the protection-theory, thinking also of chemical influences—Hustedt above all on alkalinity. Küster-Winkelmann (1938, 1949) and Cholnoky (1968) however trace the internal valves back only to changes in osmotical pressure, as the expression of an imperfect osmoregulation. They supposed the curving of the valves to be caused by the surface of the plasmolyzed protoplast, whereas Geitler (1953) attributed it to the turgor of the surviving cell.

Diatoms with internal valves were found only in habitats which were exposed to high evaporation, resulting in concentration changes and alterations of ionbalance (Müller 1899, Liebisch 1929, Simonsen 1965, Schmid 1973, 1975). Cholnoky (1968) found that an evaporation-loss of 10% is sufficient