Diatoms: Their strange evolution and remarkable properties

Kremenaste alge: Njihov nenavadni razvoj in izjemne lastnosti

Lars Olof Björn¹ and Gertrud Cronberg²

¹Lund University, Department of Biology, Sölvegatan 35, SE-22362 Lund, Sweden; E-mail address: Lars_Olof.Bjorn@cob.lu.se
²Lund University, Department of Biology, Ekologihuset, SE-22362 Lund, Sweden; E-mail address: Gertrud.Cronberg@limnol.lu.se

*Corresponding author:

Abstract: We review some new literature on diatoms, with emphasis on genomics, evolution, ecology and biomimetic nanotechnical applications. Diatoms account for a substantial part of the photosynthetic production on this planet, and their genome is a mosaic of contributions from different sources. They occupy very diverse ecological niches, and may have been the first organisms to carry out C4 photosynthesis. Their frustules (silica enclosures) with their elaborate sculpturing make it possible to follow the occurrence of different forms back in time, and the frustules is also the main reason that they are interesting for biotechnology.

Keywords: C4 photosynthesis, chloroplasts, diatoms, dynamite, endosymbiosis, nanotechnology, omega-3 fatty acid, silica

Izvleček: Prispevek je pregled novih virov o kremenastih algah s povdarkom na genomiki, evoluciji, ekologiji ter biomimetični nanotehnološki aplikaciji. Kremenaste alge prispevajo velik delež k fotosintezni produkciji našega planeta. Njihov genom je mozaik elementov različnega izvora. Zasedajo različne ekološke niše, in verjetno so bile prvi organizmi s C4 način fotosinteze. Njihove frustule (silikatni ovoji) z izdelanimi raznolikimi vzorci omogočajo sledenje različnih oblik v zgodovini in prav frustule so tiste, zaradi katerih so kremenaste alge zanimive za biotehnologe.

Ključne besede: C4 fotosinteza, kloroplasti, kremenaste alge, dinamit, endosimbioza, nanotehologija, omega-3 maščobne kisline, silicij

Introduction

Diatoms are photosynthetic, unicellular organisms. In some species several cells remain attached in colonies, but without any differentiation or division of functions between cells (see Hayakawa & al. 1994). Diatoms belong to the so-called heterokonts which, together with oomycetes and others form the stramenopiles. Brown algae are among the most well-known close relatives of diatoms, and both groups have fucoxanthin as an accessory photosynthetic pigment.

Diatoms form one of the most successful groups of organisms on our planet. They are present in most niches of the biosphere where there is, at least from time to time, some water: in seas, lakes and stream water, hot springs (up to 50°C), salty brines up to saturated concentration, dry rock and stone walls, desert surface crusts, in the surface layer of other soils, and as symbionts inside dinoflagellates and foraminifers. Some diatoms harbour cyanobacteria as endosymbionts.

The diatoms of the sea are the most important ones in a global perspective. Marine dinoflagel-
diatoms produce about 40 percent of the biomass in the sea, and for sea and continents combined they produce about 20 percent of the biomass and the oxygen. Experts do not agree on the number of diatom species. Twenty-five thousand species have been described (Alversen 2008), but some of them have been shown to be different forms of the same species. Certainly there are more than 15 thousand species; Mann & Droop 1996 say 200 thousand, and both Drum & Gordon 2003 and Sterrenburg & al. 2007 give a range of one hundred thousand to one million. The upper limit of this interval appears unrealistic. A discussion is going on about how the species concept should be defined for diatoms, since it will be impossible to carry out mating experiments except in a few cases.

The first diatoms probably appeared on land about 280 million years ago, but the oldest unquestionable fossils date from early Cretaceous, 120 million years ago. There is reason to believe in a radiation into different evolutionary lines between 160 and 150 million years ago. The first diatoms were »centric«, i.e. had radial symmetry (Figure 1), and the elongated and bisymmetric »pennate« forms (Figure 2) arose about 125 million years ago. It is thought that diatoms (as well as dinoflagellates) were favoured by the great extinction that marks the end of the Cretaceous, 65.5 million years ago, as this was a catastrophe not only for the dinosaurs, but also for coccolithophores and silicoflagellates, competitors of the marine diatoms. Diatoms and dinoflagellates could survive, probably thanks to their ability to form resistant resting cells. During their whole evolution the diatoms have also been favoured by the expanding terrestrial vegetation, which, because its roots and mycorrhiza have been expanding ever

![Fig. 1: Centric diatoms, Cyclostephanus dubius in the foreground and Aulacoseira sp. in the background (scanning electron microscope image by Gertrud Cronberg).](image)

*Slika 1: Kremenasti algi iz reda Centrales; vrsta Cyclostephanus dubius spredaj in predstavnica iz rodu Aulacoseira sp. v ozadju (foto: Gertrud Cronberg).*