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A CRITICAL STUDY ON DIATOMS AND ITS BIOLOGY

CANDIDATE NAME-AKHOURI AVINASH PRAKASH
DESIGNATION- RESEARCH SCHOLAR, SRI SATYA SAI UNIVERSITY,SHEOR
GUIDE NAME- DR. NEELU JAIN
DESIGNATION – RESEARCH SUPERVISOR SRI SATYA SAI UNIVERSITY,SHEOR

ABSTRACT
Using fluorescent molecules and paramagnetic moieties to derivatize nanotextured biosilica from diatoms is an intriguing method for creating micro/nano-structured luminescent hybrid structures or multi-functional systems that have applications in everything from photonics to biology and biomedicine. Molecular properties are combined with diatom biosilica shells' extremely regular architecture in micrometre and submicrometer range, whose size and morphology are determined by the diatom species. We functionalized the biosilicas of Thalassaosilira weissflogii with the TEMPO radical, a powerful scavenger of reactive oxygen species (ROS) in biological systems, in vitro, using the cyclic 2,6,6-tetrametylpiperidine-N-oxyl radical. The bio-hybrid material has been shown to be suitable for drug delivery and bone cell growth applications. Ciprofloxacin, a commonly prescribed antibiotic for treating bacterial infections in bone implants, was successfully loaded and delivered into biosilica walls because of their high porosity. Frustules that have been functionalized with antioxidant TEMPO are more effective substrates for adhesion and proliferation of fibroblasts and osteoblast-like cells than frustules that have not been functionalized.

Keywords: - Molecules, Paramagnetic, Diatoms, Plankton.

I. INTRODUCTION

Diatoms are single-celled microalgae that have been around since the early Jurassic period and are part of phytoplankton. Diatoms, which are microscopic algae that live in water, soil, and other inhospitable environments, have been classified into more than 200 genera. Approximately 100,000 species have been identified. Heterokonts, diatoms, diatomophyceae, and Baccillariophyta are all groups of diatoms that are either autotrophs or heterotrophs. Centric diatoms or centrales, which are radially symmetrical (paraphyletic ones), and pinnate diatoms or pennales, which are bilaterally symmetrical, are traditionally divided into two orders: the centric diatoms and the pinnate diatoms (paraphyletic up). Coscinodiscophyceae, Bacillariophyceae and Fragilariophyceae, which correspond to centric diatoms, pinnate diatoms with and without raphe (a virtual nucleus from which silica wall is produced inside cells), were recently classified as three generic classes. Pinnate diatoms can be classified as either araphides or raphides depending on the presence of the raphe. The primitive starting point from which the raphe is produced is the nodule, which is always present. Since they form films at the water-sediment interfaces, some diatoms are considered plankton, while others are considered benthos. The diameter of diatoms ranges from 1 nm to 1 mm. The planktonic forms of diatoms in open water rely solely on the natural mixing of water and the influence of winds to survive.

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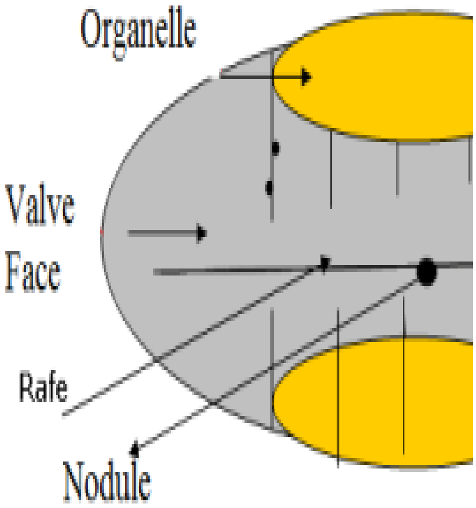
Organic and inorganic (in the form of silicates) sediment are produced by the decomposition and decay of diatoms. Corings of ocean floors or bay muds, which contain inorganic matter embedded in depositions of clays and silt sand that form a permanent geological record, can be used to analyse past marine environments. Phycologists who specialise in diatoms are known as diatomists, and the study of diatoms is a subfield of phycology.



Cells from diatoms can be isolated and connected to each other in colonies, stalks, mucilage pads, or tubes, depending on the type of diatom. Chitin is the most important molecule that connects cells together in complex geometric systems. Diatoxanthin and diadinoxanthin in particular. Carotenoids, fucoxantin, diatoxanthin, and other pigments can make chloroplasts yellowish and brown instead of green.

Binary fission is the primary method of reproduction for these organisms, with each daughter cell receiving one of the two frustules from each parent cell (theca). As an epitheca, it serves as the template for a smaller hemifrustule (or hypotheca) in each daughter cell.

In addition to sexual reproduction and auxospore formation, diatoms undergo long and repeated processes of asexual binary fission in order to restore their cell size and ensure some genetic changes. It is possible for meiosis to produce the zygote in diatom vegetative cells because they are diploid. As it grows into an auxospore, the silica theca sheds and is replaced by an organic membrane. A new generation of diatoms is born when a maximum-sized cell, known as an auxospore, is formed within the spore.

II. BIOSILICIFICATION AND DIATOMS

A model of biological and taxonomic description for diatoms that draws inspiration from animals, plants, and bacteria was first proposed by Andersen [1]. Werner [2] studied diatoms in a more systematic way about twenty years ago, focusing on their cellular composition. Biosilicification of silicalipids (silicalemma) and silaffine proteins produces the biosilica box now referred to as "frustule." Finally, these are proteins that have a strong affinity for silica-derived molecules.

Frustule production benefits diatoms in different ways due to their various properties such as protection, porousness and transparency.

Diatom cells are protected from predation by frustules because of their excellent

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mechanical qualities, which include both rigidity and flexibility. The frustule's porosity allows for precise control over the trafficking of nutrients and metabolites, as well as the flow of waste products. As natural photonic crystals, frustule transparency is thought to influence light propagation and, in turn, diatom photosynthetic activity.

The frustule structure is used to classify diatoms. [3] Silica polymerization occurs along an axis known as the raphe. Since the polysilicate layers are formed in a circular pattern within the frustule, this diatom has a circular shape.

III. FRUSTULE STAINING

Staining living diatoms with organic fluorescent probes for bioimaging of frustule biosynthesis is a powerful method for shedding light on the process. Staining agents' pH dependence and their affinity for the vesicles that promote the generation of frustules in diatom cells were the subject of the first studies. A silicon deposition vesicle (SDV), in which the silica source is deposited after it has been transported across the proximal SDV membrane, generates new valves during the cell cycle. Due to the transport of silicate which becomes silicic acid with an increase in protonic pumps over the silicalemma and the source of silica/silicic species in the silicon transport vesicles, early studies on diatoms showed that SDV has a pH range of 5 to 6. (STVs).

First, an electrostatic interface was used to test Rhodamine 123's interaction with acidic new-born silica or oldest theca . Thus, Rhodamine 123 is the first staining agent that can only be incorporated into the acidic SDV compartment by ionic interactions because of its basic functionality.

IV. BIOPHYSICS OF FRUSTULES: AN ALTERNATIVE OVERVIEW

By a physical point of view, controversial theories have approached frustules generation. Alan Turing proposed theories based on the growth of micro-periodic-systems (as silica shells in diatom cells) using the concept of “reaction-diffusion”.

Reaction–diffusion (RD) models explains how the concentration of one or more substances set in the space changes under the influence of two processes: local chemical reactions (which are basic reactions), and diffusion, which let substances be carried inside or outside a space studied.

Examples of RD models are found in biology, geology and physics and ecology. Mathematically, reaction–diffusion systems take the form of semi-linear parabolic partial differential equations. They can be represented in the general form by this RD equation:

where each component of the vector q(x, t) represents the concentration of one substance, D is a diagonal matrix of diffusion coefficients, and R is a general factor which accounts for all local reactions.

In the context of diatoms, the concept can be examined as well. The final morphology is determined by increasing the polymerization rate in the space after a primitive shape is first formed using simple oligomerizations (reaction phase) (diffusion phase). There is a "breaking phase" that occurs between the two processes. Homogeneity and symmetry become increasingly rare and anti-vital in this phase (talking about embryos, biological supramolecular systems). We can now feel the difference between leftand right-handed organisms at a specific point in time. More recent theories propose that diatom cells undergo buckling during the formation of silica shells. Temperature or mechanical processes can cause structures to buckle over time, and this buckling occurs when micro-elements, which are able to influence themselves in other processes, are built up one at a time. Several transformations occur in the buckling, where a structure is transformed into a larger, sometimes periodic, version.

V. CONCLUSION

Diatom shells have nanoscale features embedded in naturally micro/nano-fabricated periodic two-dimensional pore arrays, and their structural and morphological variety is unmatched. Biosensors and separation science could greatly benefit from the unique properties of diatom shells, which have been used in a variety of technologies over the past decade. Without the use of expensive or time-consuming chemical processes, diatoms produce silica structures that can be used in analytical science. A new class of bioactive silica nanostructures has been created thanks to recent advances in chemical modification and biofunctionalization of these materials. New approaches to photochemistry or photophysics could benefit greatly from the diatom shell's ability to collect and discriminate light, its photoluminescence properties, and its transparency.

During the course of this thesis, we went from using frustules as emitting biosilica 'pixels' to using them as silica containers and bone adhesion support. A modern challenge for the production of high-performing nanostructured and decorated biosilica is presented by the concepts of in vivo functionalization of diatoms and in vitro labelling or functionalization methodologies.

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