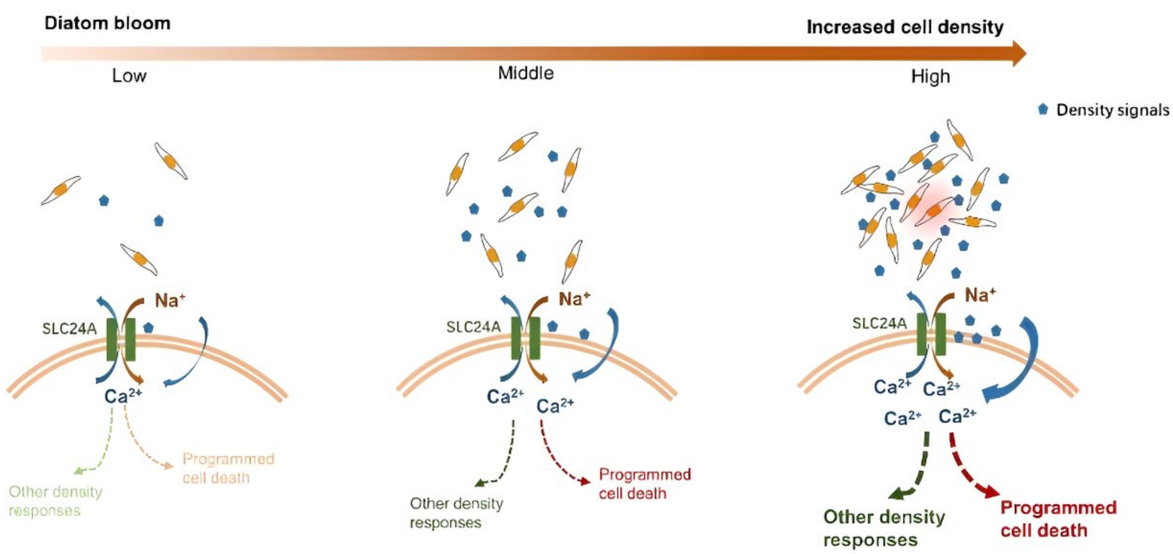
Gene editing technology reveals molecular mechanisms governing diatom population density signals

March 29 2024, by Zhang Nannan



Model of SLC24A-mediated population density perception and regulation mechanism. Credit: IOCAS

The intricate dynamics of diatom blooms, influenced by a myriad of external factors and internal signals, continue to fascinate scientists. After recognizing the potential role of density perception and intracellular signaling in dictating these phenomena, researchers have begun to elucidate the molecular basis of diatom population density regulation.

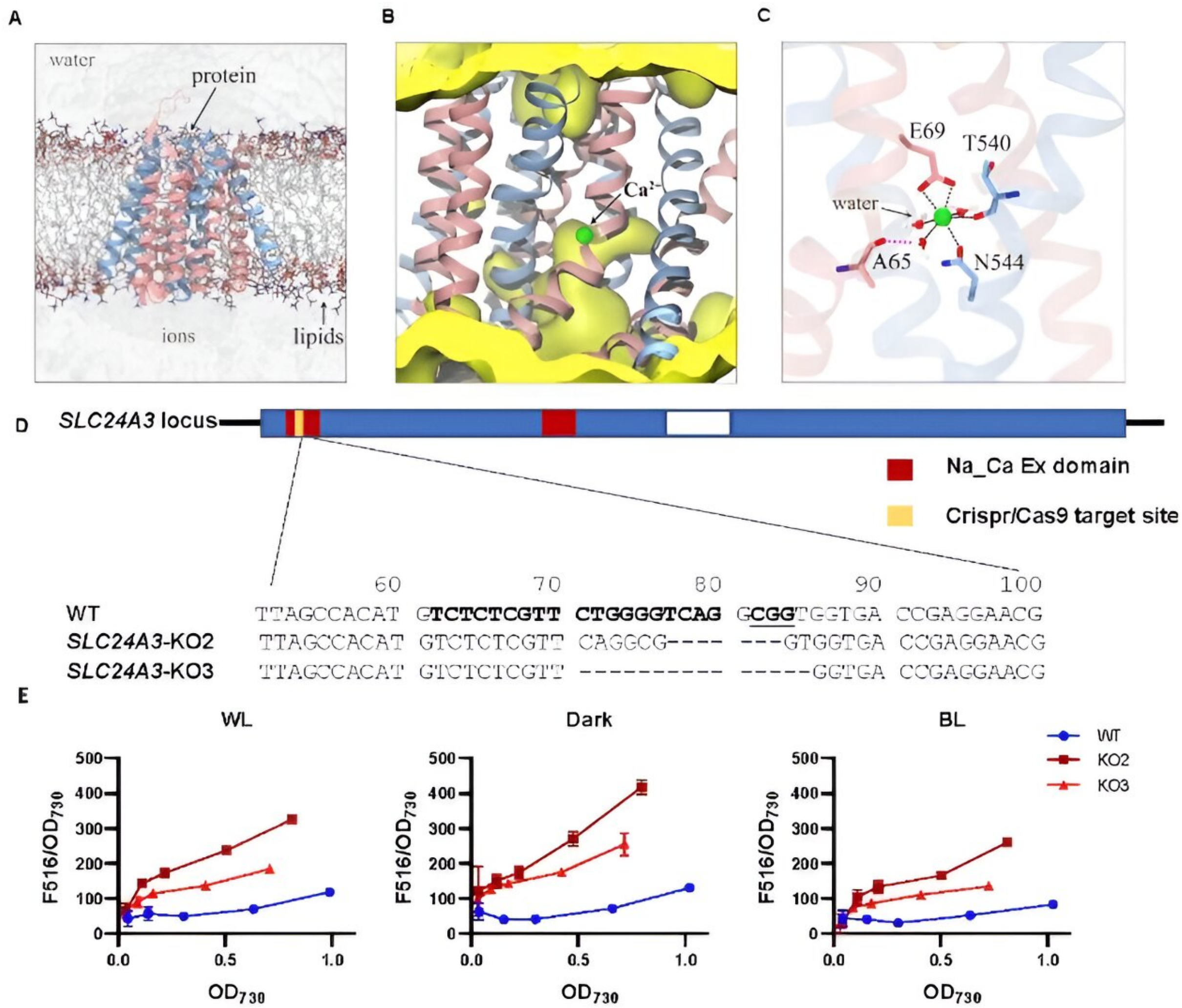
Recently, a research team led by Prof. Wang Guangce from the Institute of Oceanology of the Chinese Academy of Sciences (IOCAS) reported the significant role of the marine diatom SLC24A in population density signal perception and regulation.

The study was published in *The ISME Journal*.

The researchers meticulously identified and targeted potential genes involved in density signaling, culminating in the discovery of the central hub gene PtSLC24A. Two PtSLC24A knockout mutants of Phaeodactylum tricornutum were obtained using CRISPR/Cas9 gene editing technology.

Intracellular Ca^{2+} concentration measurements indicated that cell density could induce Ca^{2+} responses, and knockout of PtSLC24A increased intracellular Ca^{2+} concentration. Three-dimensional structural modeling and simulation calculations of the PtSLC24A protein supported its Ca^{2+} transport function.

The results showed that high density could induce cell apoptosis, and knockout of PtSLC24A exacerbated this phenomenon. PtSLC24A also affected the expression of density-dependent genes at different cell densities.



WGCNA module construction, PtSLC24A molecular dynamics simulation and its biological functions. Credit: IOCAS

Beyond the laboratory, the ecological relevance of SLC24A was underscored by its ubiquitous distribution across the Tara Oceans sites, with expression patterns positively correlating with chlorophyll content in different marine phytoplankton taxa.

"These findings underscore the pivotal role of SLC24A-mediated Ca^{2+}

signaling in mediating density-dependent responses in natural marine ecosystems and provide critical insights into the ecological implications of diatom population dynamics," said Dr. Gu Wenhui, corresponding author of the study.

Based on data from molecular genetics, cell physiology, computational structural biology, and in situ marine data, a Ca^{2+}-mediated intracellular signal transduction mechanism for marine diatom cell density signals was proposed.

According to the model, when cells receive chemical cues carrying population density signals, PtSLC24A on the cell membrane will accelerate the efflux of intracellular Ca^{2+} to maintain a specific intracellular Ca^{2+} level, and transmit density signals intracellularly, then regulate physiological processes, including cell apoptosis, and ultimately affect the fate of the population.

By delineating a Ca^{2+}-mediated intracellular signaling transduction mechanism facilitated by PtSLC24A, the study not only advances our understanding of diatom bloom dynamics, but also has profound implications for the high-density cultivation of microalgae for industrial applications.

More information: Xuehua Liu et al, SLC24A-mediated calcium exchange as an indispensable component of the diatom cell density-driven signaling pathway, *The ISME Journal* (2024). DOI: 10.1093/ismejo/wrae039

Provided by Chinese Academy of Sciences