Stockholms universitet

New study on powering the green plant

Researchers from Stockholm University and SciLifeLab have successfully determined the structure of chlororibosomes providing novel insights into plant protein synthesis and a new perspective on the evolution of translation. The study is published in Nature Plants.

Oxygenic photosynthesis builds a variety of organic compounds,
changing the chemistry of the air, the sea and fueling the food chain on our planet. Chemical reactions underpinning this process in plants are taking place in the chloroplast. The chloroplast has its own genome encoding at least 44 proteins, including the central components of the thylakoid membrane that carry out the essential process of oxygenic photosynthesis. These photosynthetic membrane proteins are synthesized by a dedicated chlororibosome. Because many of them also coordinate chlorophylls for the light harvesting reactions, the activity of the chlororibosome is likely to be spatiotemporally coupled to the synthesis and incorporation of pigments. This suggests chloroplast-specific regulatory mechanisms and structural adaptation of the chlororibosome.

Electron cryo-microscopy used in new Stockholm study

A study by researchers from Stockholm University and SciLifeLab was set up to investigate the molecular mechanism of protein synthesis by the chlororibosome. The chlororibosome was purified from spinach leaves and subjected to electron cryo-microscopy (cryo-EM) analysis. The density maps were calculated to 2.91 Å and 3.07 Å for the large and small chlororibosomal subunit, respectively, which allowed the model of the chlororibosome to be built. Remarkably, the quality of the density map allowed identification of errors in sequencing and mis-annotation in the UniProt database. Particularly, sequences were corrected for 8 proteins, and at least 6 others were re-annotated based on the accurate identification from the density map. In addition, two native translation factors were identified in complex with the chlororibosome: recycling factor and the long hibernation-promoting factor. Both were resolved in the cryo-EM map better than in the corresponding crystal structures of the reconstituted ribosomal complexes from E. coli and T. thermophilus.

Several molecular specialties of the large subunit

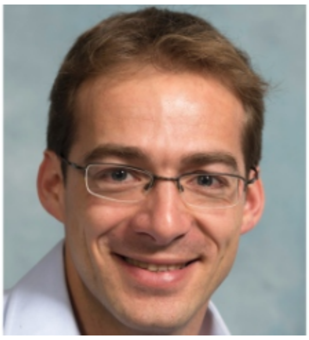
The model of the spinach chlororibosome reveals several molecular specialties of the large subunit: a prominent channel extending from the exit tunnel to the chlororibosome exterior, structural re-arrangements that led to an increased surface area for a translocon binding, and more than twofold widening of the lower tunnel that is likely to affect initial protein folding. When the authors analyzed how the large subunit is coordinated with the small subunit, they noticed that a protein-protein intersubunit bridge that in the beginning appeared to be specific to the chlororibosome turned out to be highly similar to the one found in the ribosomes from human mitochondria. This prompted to assess if there are additional means of structural adaptations of ribosomes taking a parallel evolutionary path in chloroplasts and mitochondria.

Results published in Nature Plant

The paper, which is published in Nature Plants, reports such correlations on the level of rRNA sequence variability as well as on the protein level, in particular the association of the protein bS1c with the small subunit in a way that does not allow the long hibernation-promoting factor to dimerize.

These unexpected insights into the light-driven photosynthetic protein synthesis machinery in plants are central to biology and provide a new perspective for the investigation of the evolution of translation and its regulation.

“The chloroplast translation is arguably the most active in nature, capable of producing up to 70 percent of total protein mass of an average leaf. The high levels of protein synthesis, outperforming the cytoplasmic system by two orders of magnitude, and the accessibility of chloroplastic DNA to genetic manipulations have made these translation machineries an attractive tool for the production of industrial enzymes, increased biomass and biopharmaceuticals in crop plants. The central importance of the chlororibosome to life and biotech industry requires detailed understanding of its molecular mechanisms and governing evolutionary principles”, says Dr Alexey Amunts, Stockholm University and SciLifeLab and corresponding author of the article.



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