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Characters and components:

Carboxysome contents and structure:

Visualization treatment: The main visual component of the poster will be a carboxysome cut away to show the rubisco and carbonic anhydrase inside. Elements will be labeled and there will be a description of how each structural element increases the efficiency of carbon fixation.

1. **A-carboxysome rubisco: 7ZC1**
   Available at: https://www.rcsb.org/structure/7ZC1
   Reference: Ni, T., Sun, Y., Burn, W., Al-Hazeem, M. M. J., Zhu, Y., Yu, X., Liu, L.-N., & Zhang, P. (2022, July 25). *Structure and assembly of cargo rubisco in two native α-carboxysomes*. Nature News. https://www.nature.com/articles/s41467-022-32004-w
2. **A-carboxysome rubisco: 7YYO**
   Available at: https://www.rcsb.org/structure/7YYO
   Reference: Evans, S., Al-Hazeem, M., & Mann, D. (2023, April 3). *Single-particle cryo-EM analysis of the Shell Architecture and internal organization of an intact α-carboxysome*. Structure. https://www.sciencedirect.com/science/article/pii/S0969212623000849#da0010
3. **A-carboxysome shell: EMD-14377**
   Available at: https://www.emdataresource.org/EMD-14377
   Reference: Evans, S., Al-Hazeem, M., & Mann, D. (2023, April 3). *Single-particle cryo-EM analysis of the Shell Architecture and internal organization of an intact α-carboxysome*. Structure. https://www.sciencedirect.com/science/article/pii/S0969212623000849#da0010
4. **Carboxysome shell hexamer CcmK2 (BMC-H): 2A1B**
   Available at: https://www.rcsb.org/structure/2A1B
   Reference: Faulkner, M., Szabó, I., Weetman, S. L., Sicard, F., Huber, R. G., Bond, P. J., Rosta, E., & Liu, L.-N. (2020, October 15). *Molecular simulations unravel the molecular principles that mediate selective permeability of carboxysome shell protein*. Nature News. https://www.nature.com/articles/s41598-020-74536-5#:~:text=The%20carboxysome%20shell%20serves%20as%20a%20physical%20barrier%20for%20controlling,(RuBP)%20into%20the%20carboxysome.

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5. **Carboxysome shell hexamer CsoS1A (BMC-H): 2EWH**
    - Very similar to CcmK2 in that it forms the majority of the carboxysome; however this one has better resolution

    Available at: https://www.rcsb.org/structure/2EWH
    Reference: Tsai, Y., Sawaya, M. R., Cannon, G. C., Cai, F., Williams, E. B., Heinhorst, S., Kerfeld, C. A., & Yeates, T. O. (2007, May 22). *Structural analysis of CSOS1A and the protein shell of the Halothiobacillus Neapolitanus carboxysome*. PLOS Biology. https://journals.plos.org/plosbiology/article?id=10.1371%2Fjournal.pbio.0050144

6. **Carboxysome shell pentamer CsoS4B (BMC-P): 6JY5**
    Available at: https://www.rcsb.org/structure/6jy5
    Reference: Schmid, M. F., Iancu, C. V., Otwinowski, Z., Krissinel, E., Lee, M. J., Smart, O. S., Kerfeld, C. A., Axen, S. D., Shively, J. M., Rae, B. D., Turmo, A., Heinhorst, S., Hagemann, M., Kaplan, A., Cannon, G. C., Tabita, F. R., & Badger, M. R. (2019, June 3). *Crystal structure of pentameric shell protein CsoS4B of halothiobacillus neapolitanus α-carboxysome*. Biochemical and Biophysical Research Communications. https://www.sciencedirect.com/science/article/abs/pii/S0006291X19309155?via%3Dihub
    - Found at the vertices of the carboxysome

7. **β-carbonic anhydrase, CsoSCA: 2FGY**
    Available at: https://www.rcsb.org/structure/2FGY
    Reference: Sawaya, M., Cannon, G., & Heinhorst, S. (2006, March). *The structure of β-carbonic anhydrase from the carboxysomal shell ...* Journal of Biological Chemistry. https://www.jbc.org/article/S0021-9258(19)35379-7/fulltext

8. **Carboxysome shell trimeric pseudohexamer CsoS1D (BMC-T): 3I82 or 3GFH**
    Available at: https://www.rcsb.org/structure/3I82
    https://www.rcsb.org/structure/3GFH
    Reference: Klein, M. G., Zwart, P., Bagby, S. C., Cai, F., Chisholm, S. W., Heinhorst, S., Cannon, G. C., & Kerfeld, C. A. (2009). Identification and structural analysis of a novel carboxysome shell protein with implications for metabolite transport. *Journal of Molecular Biology*, *392*(2), 319–333. https://doi.org/10.1016/j.jmb.2009.03.056

    Sagermann, M., Ohtaki, A., & Nikolakakis, K. (2009). Crystal structure of the EUTL shell protein of the ethanolamine ammonia lyase microcompartment. *Proceedings of the National Academy of Sciences*, *106*(22), 8883–8887. https://doi.org/10.1073/pnas.0902324106

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Rubisco function:

Visualization treatment: A diagrammatic representation of rubisco's place in carbon fixation will provide an overview of its function in the chloroplast. There will also be a realistic molecular visualization of its structure and a zoom-in to the active site in order to explain how it can bind to both carbon dioxide and oxygen.

1. **Ribulose-1,5-bisphosphate (RuBP):**
   Available at: https://molview.org/?cid=123658
   Reference: Meloni, M., Gurrieri, L., Fermani, S., Velie, L., Sparla, F., Crozet, P., Henri, J., & Zaffagnini, M. (2023, January 27). *Ribulose-1,5-bisphosphate regeneration in the calvin-benson-bassham cycle: Focus on the last three enzymatic steps that allow the formation of Rubisco substrate*. Frontiers. https://www.frontiersin.org/articles/10.3389/fpls.2023.1130430/full

2. **3-phosphoglycerate (3PG):**
   Available at: https://molview.org/?cid=724
   Reference: Meloni, M., Gurrieri, L., Fermani, S., Velie, L., Sparla, F., Crozet, P., Henri, J., & Zaffagnini, M. (2023, January 27). *Ribulose-1,5-bisphosphate regeneration in the calvin-benson-bassham cycle: Focus on the last three enzymatic steps that allow the formation of Rubisco substrate*. Frontiers.

Topic references:

Rubisco function and limitations:

https://www.encyclopedie-environnement.org/en/zoom/rubisco/
RubisCO. Encyclopedia of the Environment. (2020, March 4). https://www.encyclopedie-environnement.org/en/zoom/rubisco/

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7610757/#:~:text=Ribulose%2D1%2C5%2Dbisphosphate,in%20the%20global%20carbon%20cycle.
Erb, T. J., & Zarzycki, J. (2018, February). *A short history of rubisco: The rise and fall (?) of nature's predominant CO2 fixing enzyme*. Current opinion in biotechnology. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7610757/#:~:text=Ribulose%2D1%2C5%2Dbisphosphate,in%20the%20global%20carbon%20cycle.

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Carboxysome structure and function:

https://www.nature.com/articles/s41467-022-32004-w
Ni, T., Sun, Y., Burn, W., Al-Hazeem, M. M. J., Zhu, Y., Yu, X., Liu, L.-N., & Zhang, P. (2022a, July 25). *Structure and assembly of cargo rubisco in two native α-carboxysomes*. Nature News. https://www.nature.com/articles/s41467-022-32004-w

Chen, T., Fang, Y., Jiang, Q., Dykes, G. F., Lin, Y., Price, G. D., Long, B. M., & Liu, L.-N. (2021). Incorporation of functional Rubisco activases into engineered carboxysomes to enhance carbon fixation. *ACS Synthetic Biology*, *11*(1), 154–161. https://doi.org/10.1021/acssynbio.1c00311

Carboxysome engineering in crops:

https://www.nature.com/articles/s41467-023-37490-0
Chen, T., Hojka, M., Davey, P., Sun, Y., Dykes, G. F., Zhou, F., Lawson, T., Nixon, P. J., Lin, Y., & Liu, L.-N. (2023, April 25). Engineering α-carboxysomes into plant chloroplasts to support autotrophic photosynthesis. Nature News. https://www.nature.com/articles/s41467-023-37490-0

https://www.nature.com/articles/s41467-018-06044-0
Long, B. M., Hee, W. Y., Sharwood, R. E., Rae, B. D., Kaines, S., Lim, Y.-L., Nguyen, N. D., Massey, B., Bala, S., von Caemmerer, S., Badger, M. R., & Price, G. D. (2018, September 3). *Carboxysome encapsulation of the CO2-fixing enzyme rubisco in tobacco chloroplasts*. Nature News. https://www.nature.com/articles/s41467-018-06044-0

https://livrepository.liverpool.ac.uk/3025860/1/200957427_Apr2018.pdf
Fang, Y. (2018, September 4). *Repurposing bacterial CO2-fixing organelles using synthetic engineering*. The University of Liverpool Repository. https://livrepository.liverpool.ac.uk/3025860/

Appearance:

Color: monochromatic shades of green to convey the plant theme; overall a light background

Visual treatment: a combination of 2D diagrammatic components and 3D components will be integrated into the illustration

https://pubs.acs.org/doi/10.1021/acssynbio.1c00311