KEY CONCEPTS

BIOLOGY GLOSSARY

Extracellular polymeric substances (EPS): mixtures of polymers of high molecular weight, comprising carbohydrates, proteins, and nucleic acids, that are produced by a diversity of microorganisms. They can form a sticky matrix that holds microbial cells together in a biofilm or a mat.

Extracellular (or exogenous) organic matter (EOM): the entirety of organic matter, specifically low-molecular-weight organic compounds that collectively form an organic matrix capable of concentrating cations (e.g., Ca^{2+}, Mg^{2+}) and serving as a nucleation site for carbonate precipitation.

Sulfate-reducing bacteria (SRB): anaerobic bacteria using sulfate as a terminal electron acceptor and oxidizing organic carbon or H_2, for example.

Methanogenesis: energy metabolism producing methane by the reduction of CO_2 or organic carbon. Methanogens belong to the domain of Archaea.

Oxygenic photosynthesis: a light-driven process in which H_2O is oxidized to O_2, allowing the reduction of CO_2 to organic carbon. Oxygenic photosynthesis appeared in cyanobacteria, a phylum belonging to the Bacteria domain.

Anoxygenic photosynthesis: a light-driven process in which reduced compounds distinct from H_2O are oxidised, allowing the reduction of CO_2 to organic carbon. For example, H_2S can be oxidised to elemental sulfur (S^0), and Fe^{2+} to Fe^{3+}. In this case, no O_2 is produced. Some cyanobacteria are able to switch from oxygenic to anoxygenic photosynthesis, but this process can also be found in bacteria from several other phyla.

Autotrophs: unless otherwise specified, this term refers to carbon autotrophs. These are organisms that synthesise their organic carbon constituents using inorganic carbon sources (e.g., CO_2 or HCO_3^-). This includes oxygenic and anoxygenic photosynthesisers.

Heterotrophs: when not specified, this term usually refers to heterotrophs for carbon. These are organisms that need carbon in organic form to live. Microorganisms that respire on O_2 or sulfate (such as SRB) require organic carbon as an electron donor. They differ from autotrophs, which comprise photoautotrophs such as cyanobacteria.

Biofilm: a complex community of microorganisms that secretes an adhesive matrix (EPS) to keep together.

Eukarya (eukaryotes), Bacteria (bacteria), Archaea (archaea): the names of the three domains of life, grouping organisms that are most phylogenetically related. For example, Eukarya includes all animals, fungi, plants, as well as unicellular microorganisms including algae and protists

Carbon fixation (nitrogen fixation): a biological process by which organisms convert carbon (nitrogen) from an inorganic to an organic form. Several pathways appeared during evolution, allowing carbon fixation, including the Calvin–Benson–Bassham (CBB) cycle, which is found in cyanobacteria, for example.

STABLE ISOTOPE NOTATION

Isotopic ratios of stable isotope systems in natural samples, noted R_{spl}, are measured relative to an international standard, R_{std}, and expressed using the δ notation (EQUATION [1]):

[1] $\delta = (R_{spl}/R_{std} - 1) \times 1000$

Isotopic compositions are thus expressed in per mil (‰) as a deviation of the sample's isotopic ratio from that of a "zero" standard reference material. By convention, the heavy isotope is placed in the numerator of the isotopic ratio, and the light isotope in the denominator. For traditional stable isotope systematics, the corresponding international standard reference materials are the Vienna Pee Dee Belemnite (V-PDB) for carbon, derived from Cretaceous belemnites of the Pee Dee Formation in South Carolina, USA, AIR for nitrogen, and the Vienna Canyon Diablo Troilite (V-CDT) for sulfur, an iron meteorite collected near Meteor Crater in Arizona, USA. For novel stable isotope systems, standard reference materials are often derived from pure, homogeneous metals or salts that have been well characterised by a standardisation agency, such as the National Institute of Standards and Technology (NIST).

The absolute isotopic fractionation that occurs during a reaction ($A \rightarrow B$), noted as Δ, can be approximated by the difference in isotopic composition between A and B, in which negative values indicate lighter isotope compositions in the precipitate and positive values indicate heavier isotope compositions relative to the baseline.

For example, for carbon using the Δ notation [2]:

[2] $\Delta^{13}C_{A\text{-}B} = \delta^{13}C_A - \delta^{13}C_B$

Using the ε notation, often applied to biological reactions, for nitrogen [3]:

[3] $\varepsilon \approx \delta^{15}N_A - \delta^{15}N_B$

ENRICHMENT FACTORS

To assess the accumulation of bioessential and redox-sensitive trace elements in microbialites, enrichment factors (EFs) are frequently used. EFs are normalised to immobile, detrital-silicate-flux-derived metals such as aluminium, scandium, zirconium, titanium, or thorium. In microbialites, EFs are defined relative to weathered crustal lithologies, which can be represented globally by the Upper Continental Crust (UCC) or the Post-Archean Australian Shale (PAAS). In restricted basins, a more localised crustal average might be more appropriate for normalisation. The enrichment factor for a metal X is calculated using $EF\text{-}X_{UCC} = (X/Ti)_{sample} / (X/Ti)_{UCC}$. An $EF\text{-}X_{UCC}$ greater than 1 indicates a relative enrichment of metal X relative to the UCC baseline, suggesting potential microbial-mediated enrichment of metal cofactors. Conversely, an $EF\text{-}X_{UCC}$ less than 1 indicates a relative depletion, which could be due to redox reactions and the formation of Fe-Mn (hydr)oxides or sulfides.