



## Metabolites and metals as phosphate transfer catalysts

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In modern metabolism, phosphorylated compounds play a key role<sup>[1]</sup>. The informational molecules RNA and DNA are composed of phosphorylated units (nucleotides), and phosphorylation is also used as an activation mechanism for many metabolic processes, particularly through the universal energy currency adenosine triphosphate (ATP).

The deeply conserved nature of this reaction suggests an early origin of phosphorylation to drive metabolism. However, the non-enzymatic transfer of a phosphate group is challenging in water. Additionally, the poor geochemical accessibility of phosphate constrains the plausibility of phosphorylated compounds at the origin of life that are biologically relevant and have an appropriate reactivity in aqueous conditions.

Here, I report the phosphorylation of several biologically relevant molecules by an active metabolite-metal species that uses the prebiotically plausible molecule acetyl phosphate<sup>[2-5]</sup> as phosphate donor. Occurring in aqueous solution under mild prebiotic conditions, this work furthers the notion that ATP is universally conserved across life likely due to its formation being chemically favoured in aqueous solution that has recently been suggested<sup>[6]</sup>.

### References:

- [1] Westheimer, F. Why nature chose phosphates over arsenates. *Science* (1987). 13(4793): 3601–3608.
- [2] Lipmann, F., Tuttle, L.C. Acetyl phosphate: chemistry, determination, and synthesis. *J. Biol. Chem.* (1944). 153: 571–582.
- [3] de Duve, C. Blueprint for a cell: the nature and origin of life. (1991). Neil Patterson Publishers, Burlington.
- [4] Schönheit, P., Buckel, W., Martin, W.F. On the Origin of Heterotrophy. *Trends Microbiol.* (2016). 24: 12–25.
- [5] Whicher, A., Camprubí, E., Pinna S, Herschy B, Lane N. Acetyl Phosphate as a Primordial Energy Currency at the Origin of Life. *Orig. Life. Evol. Biosph.* (2018). 48: 159–179.
- [6] Pinna, S., Kunz, C., Harrison, S.A., Jordan, S.F., Ward, J., Werner, F., Lane, N. A prebiotic basis for ATP as the universal energy currency. *bioRxiv.* (2021).

