The Problem With Phosphorus. . .

The following short, whimsical note makes some significant points in an unorthodox way. I hope it adds a bit of spice to your day.

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Phosphorus is King of the aquatic plant kingdom.[1] Without it there would be no growth, no reproduction, and thus no life.[2] This simple principle has been concealed from a generation of aquatic scientists seduced by the powers of the Queen Consort, Nitrogen.[3]

If Phosphorus is King and Nitrogen is Queen, then a naive observer[4] of the Chess Game of Life might prematurely conclude, after watching the moves unfolding on the board, that the Queen is all powerful and controls the game. She can move both diagonally and laterally across the board[5] and travels long distances in one jump.[6] Clones can be created from thin air on the back row.[7] She literally dances over the board and controls the tempo of the game.[8] A game without a dominant Queen is rare.[9]

The King, on the other hand, is indeed a subtle prince, spending his life sequestered on the back row.[10] He exerts little if any influence on the flow of the game, scarcely moving except perhaps to exchange places with his cornerstone vassal in the event of a threatened weak-side attack,[11] and sallying forth at a single-step pace only near the end in a reckless attempt to avoid capture.[12] He is the least dynamic member of the aristocracy, dividing his time between hiding and running away.[13] Our observer might not discover the significance of this King until near the end of the Game.[14]

Phosphorus is a weak King.[15]

Notes

[1]If the ultimate purpose of life on our planet is the evolution of an optimum energy (information) transfer system based on harnessed sunlight, then Phosphorus availability is the single most likely chemical control on the ability of the global aquatic ecosystem to transform the Sun's energy into useful chemical bonds. P limits the biomass and production rate of the global oceanic ecosystem of this planet's surface. This self-evident truth is unprovable on time scales of human endeavor and space scales less than global but has been forcefully argued from observational, experimental, and theoretical evidence [*Hutchinson*, 1951; *Redfield*, 1958; *Broecker*, 1974; *Schindler*, 1977; and a few others].

[2]All forms of life on Earth require Phosphorus for their energy transmission systems (ATP), for information storage and retrieval across generations (DNA), and for secluding the delicate biochemistry of life from the cruel outer environment (phospholipids in cell membranes).

[3]*Ryther and Dunstan*, 1971; and thousands of others.

[4]Scientists are by definition ignorant of the rules of the Game: Indeed, our purpose is to discover them. God did not leave us a Game plan.

[5]Nitrogen comes in three phases, at least five oxidation states, and as many readily identifiable chemical species as one might want.

[6]Transformations in the Nitrogen cycle are dynamic and amendable to invasive investigation and experimentation because of the analytical tractability of chemical speciation. Thus what might appear as a morass of transfigurations is, in fact, a chemically well identifiable system.

[7]N_2-fixation: the creation of "useful" Nitrogen out of biologically "inert" N_2 gas in the atmosphere.

[8]Nitrogen is literally everywhere, and the biological transformations of Nitrogen species in aquatic systems are indeed dazzling to behold.

[9]. . .but not impossible. One can lose a Queen and still win the Game, but it is an uphill battle (N-fixation costs lots of energy). But without a King. . . "Ohne Phosphor, Kein Gedanke" (anonymous German proverb).

[10]Most of the Phosphorus eroded from continental rocks (the only utimate source of dissolved P) remains unavailable for biological interaction, locked in the inorganic particulate phases transported by rivers and streams to the sea. The life history of a P atom is bleak compared to its flashy consort, Nitrogen. There are no gas phase transformations, and there is only one redox state both in solution (phosphate) and in solid phases (phosphate). The myriad forms in solid phase (phosphatic minerals and surface phases) are not chemically identifiable in natural systems, much less separable, so Phosphorus dynamics are singularly monotonic and commonly characterized by squalid operationally defined entities (for example, *Froelich* [1988].

[11]Phosphorus is chemically leached from rocks into solution very slowly, probably via a mechanism that is not biologically intermediated. An ecosystem can not produce P out of thin air at any cost.

[12]P limitation is usually observable only under carefully contrived conditions.

[13]Phosphorus is a trace element which is particle reactive. It reversibly sorbs off of and onto particle surfaces, playing hide-and-seek with both scientist and plankton.

[14]An endgame consisting of a solitary King and an opponent's King and a few pawns can result in "creation" of a Queen. A system without fixed Nitrogen but with its King and a pawn will use every last resource to produce fixed Nitrogen and the game goes on. Without dissolved Phosphorus, the game is ended.

[15]The real problem with Phosphorus is weak chemistry.

References

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