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von Liebig's law of the minimum and plankton ecology (1899â€“1991)

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Abstract

The Law of the Minimum was originally formulated by Justus von Liebig, as one of the 50 interlinked laws concerned with agriculture. The original writings of J. von Liebig often were misinterpreted by his successors. Brandt (1899) took this one law out of its context and proposed that limitation by nitrogen is a dominant factor in plankton ecology, far beyond its original application to agriculture. This was opposed by Nathansohn (1908) who suggested instead a dynamic balance of growth and loss terms. Towards validating, or eventually falsifying Brandt's hypothesis, Atkins, Harvey, Cooper and others developed the chemical methods necessary for re-defining ocean nutrient cycling and growth limitation. The major exception to these modern perspectives was the Antarctic Paradox of high nutrients and low chlorophyll which inspired Gran, Atkins, Harvey and Cooper to pioneer the concept of iron limitation. An exhaustive overview is given of efforts to define Fe in seawater and its controlling effect on *in situ* plankton

growth, for the 1920â€“1984 period. Somewhat parallel work in the laboratory on single species of algae in chelation-controlled media has provided much insight, but is sketched only briefly. Martin and contemporaries developed the chemical methods necessary for defining the ocean chemistry of Fe and its role for *in situ* growth. These developments are sketched for the 1982â€“1991 period. Once again the Law of the Minimum and associated bold hypotheses served, albeit briefly, to bring a nutrient element in the forefront of research. This, and the recent awareness of CO_2 as rate limiting factor, underline the conclusion that advances in sciences often hinge on advances in technology, confirming KUHN (1962). In this case the new analytical techniques developed by Atkins, Harvey, Cooper, Martin and their associates have proven revolutionary for plankton ecology. Some observations in plankton ecology may be reminiscent of the agricultural Law of the Minimum, but this would not warrant its direct application, beyond its original context and agriculture, to plankton ecology. Rather the net rate of increase of phytoplankton is the dynamic balance of multiple growth and loss terms, together also determining the biomass at given time and space.

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