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This Week's Citation Classic®

Droop M R. Vitamin B_{12} and marine ecology. IV. The kinetics of uptake, growth and inhibition in *Monochrysis lutheri*. *J. Mar. Biol. Assn. UK* **48**:689-733, 1968.
[Marine Station, Millport, Scotland]

This paper examines, *inter alia*, the relationship between supply of vitamin B_{12} and growth rate (of a marine microalga), relating the latter most succinctly to the internal vitamin concentration (cell quota), and proposes a general model of nutrient-related algal growth. [The *SCI*® indicates that this paper has been cited in over 170 publications since 1968.]

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The popularity of this paper has little to do with the achievement or otherwise of the original aim of the research, which was to settle an ecological question, but to the fact that it was one of two papers independently originating the so-called cell quota model of algal growth. The other (of the same date) was the work of John Caperon.[1]

The vitamin requirements of marine microalgae had occupied my attention at the Marine Station, Millport, Scotland, for over a decade. I had become involved in a controversy over the likely ecological importance of vitamin B_{12} to phytoplankton. Arguments on both sides were speculative to say the least, since little was known either of the levels of vitamin found in the sea or of the magnitude of the requirement on the part of algae. Continuous culture was the obvious way to answer the latter question, with the aid of course of the well-known Monod expression[2] relating microbial growth rate to ambient substrate concentration. Unfortunately (or fortunately, as it turned out), Monod just would not fit my results (due, it proved, to interference by an excreted protein), but there was a very clear and simple relation between growth rate and internal vitamin concentration ("cell quota" as I termed it). At that time, microbiologists had considered the effect of microbial growth rate on cell composition but not that of cell composition on growth rate. Yet when one comes to think of it, the processes of growth are more directly related to internal than to external concentrations. My equation forms the heart of what has become known as the cell quota model of algal growth. I went on to study uptake and the interfering protein and was thus finally able to relate my results to Monod. The cell quota model is in effect a dissection of Monod, from a one-compartment (external substrate) to a two-compartment (external substrate, internal substrate) model.

Little of the circumstance of the paper remains with me now, but I do remember plaguing my colleagues for an explanation of my U-shaped curves, and later the thrill at the first results of simulating growth on an early desktop calculator (for some reason, it was only able to "grow the cultures" backwards).

I think there are two main reasons why the cell quota model has "caught on." First, my equation has since been found to be applicable to many algae and other nutrients. Second, algal cell quotas are easily measured, whereas significant external substrate concentrations are often below the limits of the available methods. But to my mind, the main advantages of the cell quota model over Monod lie in the freedom (and enhanced relevance to field situations) introduced with the second compartment, especially the ability to handle transients and to handle both limiting and excess nutrients simultaneously. Much of the model's potential came to light subsequently.[3-6]

Perhaps the moral of the story is that it is no bad thing to be forced to look at things in a new way and if necessary to "stick one's neck out" by questioning the limitations of accepted dogma.

1. **Caperon J.** Population growth response to *Isochrysis galbana* to variable nitrate environment. *Ecology* **49**:866-72. 1968. (Cited 70 times.)
2. **Monod J.** *Recherches sur la croissance des cultures bactériennes.* Paris: Hermann, 1942. 210 p. (Cited 645 times since 1955.)
3. **Droop M R.** 25 years of algal growth kinetics. A personal view. *Bot. Mar.* **26**:99-112. 1983.
4. ----------. The nutrient status of algal cells in continuous culture. *J. Mar. Biol. Assn. UK* **54**:825-55. 1974. (Cited 125 times.)
5. ----------. The nutrient status of algal cells in batch culture. *J. Mar. Biol. Assn. UK* **55**:541-55. 1975.
6. **Droop M R, Mickelson M J, Scott J M & Turner M F.** Light and nutrient status of algal cells. *J. Mar. Biol. Assn. UK* **62**:403-34. 1982.

