# CULTIVATION OF MARINE ALGAE

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## Contents





## Summary

This review summarises the diversity and commercial use of algae and provides the basic methods of mass culturing of microalgae and macroalgae (seaweeds). For microalgae, the review briefly describes the methods for indoor mass culture, large production ponds, and deep channelled systems and provides some discussions on the media-species relationships and the limits to microalgal growth. For macroalgae, the review briefly describes the culturing techniques using vegetative growth, and non-motile and motile spores. Some discussions of site selection and future work are included.

## 1. Introduction

Marine algae are a diverse group of photosynthetic organisms. They, like other algae, have a photosynthetic system based on chlorophyll *a*. However, they generally lack structural complexity; their reproductive structures lack sterile cells; and they do not form embryos.

Algae are divided into eight major groups or divisions (Table 1). Algal divisions differ in their photosynthetic pigments, carbohydrate reserves, and cell structures. As can be seen, the term algae used in this review includes the blue-green algae (cyanophyta, cyanobacteria).

Division Cyanophyta (cyanobacteria or blue green algae)

Class Cyanophyceae

Division Prochlorophyta

Class Prochlorophyceae

Division Chlorophyta (green algae)

Class Prasinophyceae

Class Chlorophyceae

Class Charophyceae

Division Chrysophyta

Class Chrysophyceae (golden brown algae)

Class Prymnesiophyceae (=Haptophyceae)

Class Tribophyceae (=Xanthophyceae (yellow-green algae)

Class Eustigmatophyceae

Class Bacillariophyceae (=Chloromonadophyceae)

Class Bacillariophyceae (=Diatomophyceae) (diatoms)

Class Phaeophyceae (=Fucophyceae) (brown algae)

Division Rhodophyta (red algae)

Class Rhodophyceae

Subclass Florideophycidae

Subclass Bangiophycidae

Division Pyrrophyta (=Pyrrhophyta = Dinophyta (dinoflagellates))

Class Dinophyceae

Division Cryptophyta (cryptomonads)

Division Euglenophyta (euglenoids)

Class Euglenophyceae



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Table 1. Divisions and classes of algae
(adapted from Sze, 1993)

These algal groups contain unicellular members (collectively called microalgae) and multicellular members (macroalgae or seaweeds).

The economic utilization of both marine macroalgae and microalgae has been explored for some time. Marine macroalgae have been exploited over hundreds of years, as

human food and animal fodder, as a source of phycocolloids and bioactive products, and recently in biofiltration. In the 1940s and 1950s there was interest in microalgae as a source of liquid fuels and single-cell protein. Then in the 1960s, with the discovery that the extremely halophilic green algae *Dunaliella salina* was the best natural source of beta-carotene, the commercial utilization of microalgae gained impetus. At present, microalgae provide a wide range of fine chemicals, oils, and polysaccharides, as well as being used as soil conditioners and in waste treatment and aquaculture. As a result of their usable products, the natural resources of algae cannot meet the demand and they are overexploited in their natural habitats. The cultivation of macroalgae is presently one of the most productive and environmentally friendly forms of livelihood among the coastal populations. This paper will review the past and present techniques of cultivation of microalgae and macroalgae and make suggestions for future use and cultivation.

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Boney A. D. (1975). *Phytoplankton*, 113 pp. The Institute of Biology's Studies in Biology No. 52. London: Edward Arnold Publishers. [This book contains detailed information on the phytoplankton (the fraction of microalgae which floats in the water column). It examines the diversity of phytoplankton, factors affecting phytoplankton growth, buoyancy of phytoplankton, successions and associations, interactions with other organisms, measuring phytoplankton populations and primary productivity, and man-made effects on phytoplankton. It also contains useful culture media for phytoplankton.]

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Borowitzka M. A. and Borowitzka L. J. (1990). Algal biotechnology. In M. N. Clayton and R. J. King, eds. *Biology of Marine Plants.* Melbourne: Longman Cheshire. pp. 386–398. [This chapter describes the uses of microalgae and macroalgae. Macroalgae topics include cultivation and utilisation, alternate culture systems and genetic improvement. Microalgae topics include microalgae products, mass culture techniques and the *Dunaliella salina* - case study.]

Chapman V. J. (1950). *Seaweeds and Their Uses*, 304 pp. London and Southampton: The Camelot Press. [This book has been written not only for those with technical knowledge but also for the general reader. It covers topics such as the occurrence and distribution of seaweeds, the early kelp industry and iodine production, the American potash industry, algae as food for man, laver (nori) and carrageen, agar-agar,

algin and alginates, and looking for seaweeds.]

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Doty M. S. (1973). Farming the red seaweed, *Eucheuma*, for carrageenans. *Micronesica* **9**, 59-73. [This paper provides all aspects of the farming of *Eucheuma*, including taxonomy and identification, production, farming system, site selection, farm operation, and economic return.]

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Oswald W. J. (1988). Large-scale algal culture systems. In M. A. Borowitzka and L. J. Borowitzka, eds. *Micro-algal Biotechnology*. Cambridge: Cambridge University Press. pp. 357–394. [This chapter examines the engineering design of algal cultivation systems of a size sufficient to produce tonnes of algae or algal products daily.]

Price I. R. (1990). Marine plant life. In M. N. Clayton and R. J. King, eds. *Biology of Marine Plants* Melbourne: Longman Cheshire. pp. 5–24. [This chapter describes in detail the characteristics (morphological, biochemical, ultrastructural) which allow marine plants to be classified and identified.]

Raven J. A. (1988). Limits to growth. In M. A. Borowitzka and L. J. Borowitzka, eds. *Micro-algal Biotechnology*. Cambridge: Cambridge University Press. pp. 331–356. [This chapter describes and discusses the factors limiting the growth of microalgae (including cyanobacteria) under conditions in which endogenous factors are determining growth rates. Among the limitations on growth in culture are culture temperature, the supply of chemical resources, the supply of photons for photosynthesis.]

Renaud S. M. Thinh Luong-Van, and Parry D. L. (1999). The gross chemical composition and fatty acid composition of 18 species of tropical Australian microalgae for possible use in mariculture. *Aquaculture* **170**, 147–159. [This work investigates the nutritional value of the 18 recently isolated tropical Australian microalgal species.]

Santelices B. (1996). Seaweed research and utilisation in Chile: moving into a new phase. *Hydrobiologia* **326/327**, 1–14. [This article describes the three phases in the history of Latin American phycological research - the explorer phase characterised by the taxonomic work, the diversification phase marked by the establishment of resident scientists, and the third phase characterised by a significant increase in scientific and economic activity centred around seaweeds.]

Santelices B. (1999). A conceptual framework for marine agronomy. *Hydrobiologia* **398/399**, 15–23. [This study reviews the main approach and concepts in marine agronomy. Integrating these contributions with others, a basic conceptual framework for marine agronomy is presented.]

Stein J., ed. (1973). *Handbook of Phycological Methods*, 448 pp. Cambridge: Cambridge University Press. [This handbook presents a compendium of techniques for culturing and measuring growth of microalgae, for experienced researchers as well as non-phycologists. Topics include isolation and purification, general equipment and methods, special culture methods, growth measurements and bioassay.]

Sze P. (1993). *A Biology of the Algae*, 118 pp. Dubuque: Wm C Brown Publishers. [This book introduces the readers to the algal characteristics and diversity. It considers the algae from a morphologic, evolutionary and ecologic perspective at a level appropriate for undergraduate students.]

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microalgae for the enrichment of the dietary value of brine shrimp, *Artemia* nauplii. *Aquaculture* **170**, 161–173. [This work investigates the use of thirteen species of tropical Australian microalgae in the rearing of *Artemia*. In terms of survival, growth and nutritional characteristics of *Artemia*, it was found that one Australian species could replace the commercially used northern hemisphere species.]

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**Biographical Sketch**

**Jim Luong-Van** is a senior lecturer in botany and has been teaching microbiology, microalgae and macroalgae for aquaculture, and aquatic ecology at the Northern Territory University in Darwin, Northern Territory, Australia since 1986. He obtained his Ph.D. in microalgal physiology and ultrastructure at La Trobe University in 1972. Before coming to the Northern Territory University, he was a staff member of the James Cook University in Townsville, Queensland, where he taught marine botany. He is a member of the Australian Marine Science Association, Australian Institute of Biology, Australian Society for Plant Physiologists, and International Phycological Society.