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Microalgae strain catalogue

A strain selection guide for microalgae users:
cultivation and chemical characteristics for high
added-value products



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1. INTRODUCTION

Introduction to the strain catalogue

Microalgae are a broad group of diverse microorganisms that are typically single-celled, photosynthetic organisms that derive from marine, brackish, freshwater or terrestrial environments. In this catalogue we include both eukaryotic and prokaryotic (cyanobacteria) species.

There is increasing commercial interest in the usage of microalgae for a wide variety of applications including animal feed, aquaculture, biofertiliser, waste pollutant remediation, sources of nutrients and chemicals for food production, nutraceutical supplements such as omega-3 fatty acids, cosmetics, biofuels and bioenergy, pharmaceutical products, colourings, antioxidants, flavourings, and other uses. These applications all depend on the characteristics and chemical composition of different microalgae species and strains.

It is estimated that there are many thousands of microalgae species with many different properties. In addition, strains of microalgae belonging to the same species or closely related species will have different characteristics and will have differences in their chemical composition due to living in different environments and adapting to the different physical conditions of that environment. Of these many possible strains, only a relatively small number have been collected and are stored within individual labs and in culture collections. Only a small number of strains of different species have been physiologically and biochemically characterised, and an even smaller number of strains are currently commercially used.

While the majority of available microalgae strains remain largely uncharacterised, a substantial amount of research has been performed on a small number of strains with desirable characteristics. However, strain characteristic information can be challenging to identify and is typically found within many different, sometime inaccessible literature sources. Therefore this resource has been developed in order to provide collated information on the cultivation characteristics and chemical composition of selected microalgae species.

Each entry summarises the characteristics of a different species, with details taken from one or more strains of that species, which are present in a publically accessible culture collection. As much details as possible about the cultivation procedures of the strains have been described so that the chemical composition characteristics might be reproducible. However, it must be noted, that strain properties can vary based on different environmental parameters and even between different locations where conditions are considered identical. Moreover, originally identical strains (from the same original source) can adapt their characteristics over time, therefore some caution must be taken when interpreting information assigned to a particular named strain.

We hope that you find this catalogue resource useful and informative. The catalogue will be updated over time and so by registering your interest with EnhanceMicroAlgae you will be sent new versions when they are published. In addition, any feedback to this resource is welcome.

The EnhanceMicroAlgae team.



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2. STRAIN CATALOGUE

Important notes:

- Unless otherwise specified, it should be interpreted that cultivation data shown in the following pages was obtained during cultivation in batch and in phototrophic growth mode using either natural (air) or artificial supplementation of CO₂.
- A compilation of important algal growth media recipes shown throughout the catalogue is included in Appendix 1.
- Similarly, a (non-exhaustive) list of major Culture Collections is provided in Appendix 2.
- A list of common acronyms used throughout the catalogue and their corresponding description is presented here:

Acronym	Description
PBR	Photobioreactor
nd	Non-disclosed
STR	Stirred Tank Reactor
L:D	Light:Dark cycle (photoperiod)
BG11	Blue-Green medium
BBM	Bold's Basal Medium



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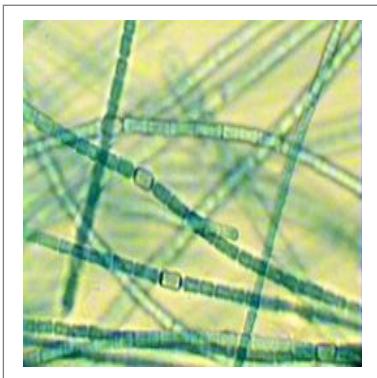
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Anabaena cylindrica



A freshwater filamentous cyanobacteria with robust growth characteristics and a source of pigments. It has nitrogen-fixation characteristics and some strains have been observed to produce hydrogen¹.

Commonly cultivated strains include:
CCAP 1403/2A, IAM M1(PCC 7122), 10 C (CSMA)

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 1403/2A ²	System: PBR Medium: BG11 Temperature: 22°C Light: 70 µmol/m ² /s, 16h L: 8h D	0.078	0.171	2.4
IAM M1 (PCC 7122) ³	System: 5 PBR's in series (0.2 dm ³ each) Medium: Detmer medium Carbon source: CO ₂ 6% Temperature: 298 K (24.85°C) Light: 1 klx, L:D cycle N/A	nd	nd	From: 0.667 (1 st PBR) to:~2.66 (5 th PBR)
10 C ⁴ (CSMA)	System: Fermentor (1 L) Medium: BG11 Carbon source: CO ₂ and acetate Temperature: 25°C Light: 32 W cool white fluorescent lamp. Continuous illumination	nd	nd	~0.3 (BG11) ~0.6 (BG11+acetate)



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Biomass characteristics

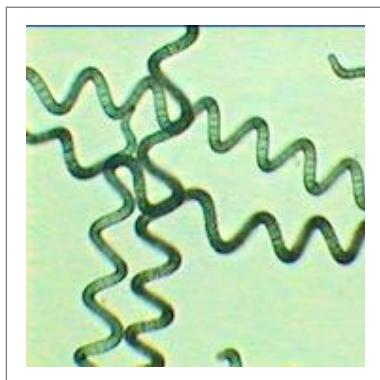
Biomass composition	Element composition	Pigments	Fatty acids
56% protein ² 7% lipid 25% carbohydrate ---	nd	nd	nd
43-56% protein ⁵ 4-7% lipid 25-30% carbohydrate			



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Arthrospira platensis



A filamentous cylindrical cyanobacteria that is commonly known commercially as spirulina. It is widely cultivated as a food source and nutritional supplement particularly because it is rich in protein and contains essential amino acids⁶. It is commonly cultivated in open ponds but can also be grown in photobioreactors. It can grow under a range of temperature conditions but has optimum growth at higher temperatures, ~35°C⁷.

Commonly cultivated strains include:
SAG 21.99, SAG 85.79, SAG 257.80, WH879

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
SAG 85.79 ²	System: PBR Medium: Zarrouk medium Temperature: 22°C Light: 70 µmol/m ² /s, 16h L: 8h D	0.06	0.21	3.1
SAG 21.99 ⁸	System: PBR (0.5 L) Medium: Zarrouk medium Temperature: 30°C Light: 120 µmol/m ² /s, Continuous light	nd	0.231	2.274
Mixed culture: <i>Arthrospira</i> sp. ⁹	System: outdoor raceway ponds, surface area 100 m ² , culture depth 30 cm Medium: SOT medium Temperature: outdoors Light: outdoors	nd	34 (g/m ² /d, accounts for irradiance surface area)	0.62
WH879 ¹⁰	System: Fed-batch PBR (1 L) Medium: Zarrouk medium Temperature: 28°C Light: 300 µmol/m ² /s, Continuous light	nd	0.594 (feeding only Nitrate)	6.78 (feeding fresh medium)



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Biomass characteristics

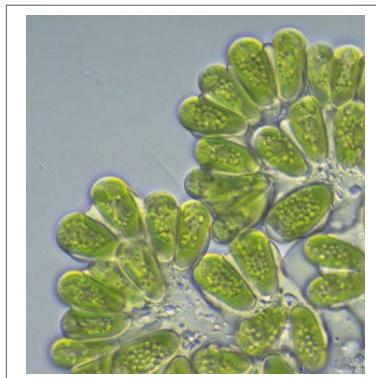
Biomass composition	Element composition	Pigments	Fatty acids
62% protein ² 9% lipid 20% carbohydrate	nd	90 mg/g phycocyanin ² 39.8 mg/g chlorophyll 3.8 mg/g carotene --- 0.28-1.5% chlorophyll ⁸ --- 5-12% phycocyanin ⁹ --- 16.1±0.2% phycocyanin ¹⁰	C16:0 40.1% ² C16:1 9.2% C18:0 1.2% C18:1 5.4% C18:2 17.9% C18:3 18.3% other 7.9%



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Botryococcus braunii



A eukaryotic planktonic Trebouxiophyceae strain, naturally found in freshwater and brackish ponds, that is typically a very slow growing microalga due to the high production of triterpene hydrocarbon oils with applications for various classes of biofuel (petroleum, kerosene, diesel) production by hydrocracking. There are a wide variety of *Botryococcus* strains (races) with very diverse oil productivities ¹¹.

Commonly cultivated strains include:

CCAP 807/2, SAG 30.81, CCALA 777, CCALA 778, CCALA 835, UTEX Bb 572, AC755, AC759, AC760, AC761, AC765 ¹²

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 807/2 ²	System: PBR Medium: 3N-BBM Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	0.027	0.098	1.94
AC755 ¹²			0.06	~1.75
AC759	System: Bubble column PBR (0.4 L)		0.09	~2.75
AC761	Medium: Chu 13 medium	nd	0.15	~3.6
CCALA 777	Temperature: 23°C		0.08	~2.2
CCALA 778	Light: 150 µmol/m ² /s, 18h L: 6h D		0.12	~3.6
CCAP 807/2			0.14	~4.6



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Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
40% protein ² 33% lipid 6% carbohydrate	nd	6% α-carotene ¹³ 6% β-carotene 22% lutein	C16:0 29.5% ² C16:1 3.3% C18:0 1.0% C18:1 44.9% C18:2 21.1% other 0.3%



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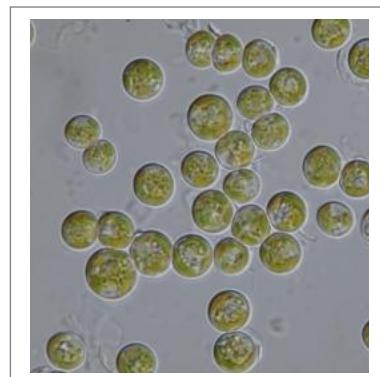
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Chlorella luteoviridis



A eukaryotic freshwater Trebouxiophyceae strain (also known as *Heterochlorella luteoviridis* or *Jaagichlorella luteoviridis*) with fast growth rate and along with other *Chlorella* sp. has applications for animal feed, nutritional supplement, and biofuel. It can be cultivated autotrophically, mixotrophically or heterotrophically.¹⁴

Commonly cultivated strains include:
CCAP 211/3, CCAP 211/4, CCAP 211/5B

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 211/3 ²	System: PBR Medium: Jaworski's medium Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	0.29	0.36	2.52
Indigenous wastewater <i>C. luteoviridis</i> strain ¹⁵	System: 250 mL conical flasks (batch; semi-continuous) Medium: Raw municipal wastewater secondary treated effluent (RMWSE) + 25 % v/v sludge liquor Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	nd	~0.8 (batch) 1.78 (semi-continuous)	0.84 (batch) 6.01-7.99 (semi-continuous)
Indigenous wastewater <i>C. luteoviridis</i> strain ¹⁵	System: Open pond (150 L, 10 cm depth) Medium: RMWSE + 25 % v/v sludge liquor Temperature: outdoors Light: outdoors	nd	~0.31 (in summer) ~0.25 (in spring)	nd



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Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
47% protein ² 22% lipid 12% carbohydrate	nd	29.8 mg/g total chlorophyll ² 3.4 mg/g total carotenoid	C14:0 2.4% ² C16:0 25.0% C16:1 9.3% C18:0 7.2% C18:1 21.3% C18:2 9.7% C18:3 24.9% other 0.2%



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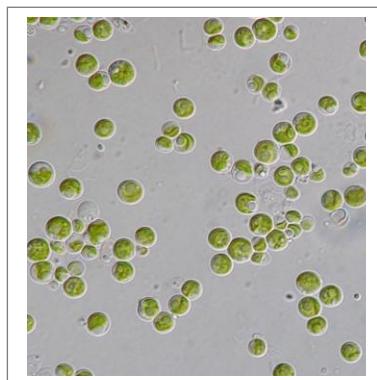
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Chlorella sorokiniana



A eukaryotic freshwater Trebouxiophyceae strain with fast growth rate with applications for animal feed, nutritional supplement, and biofuel. It can be cultivated autotrophically, mixotrophically or heterotrophically^{16, 17}. Some *C. sorokiniana* show a broad temperature range and thermotolerance up to 45°C¹⁸.

Commonly cultivated strains include:
UTEX 1230, UTEX 1602, UTEX 3016, UTEX 2805, IBVF 211-32

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
UTEX 1230 ²	System: PBR Medium: 3N-BBM Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	0.115	0.185	3.7
IBVF 211-32 ¹⁹	System: 2 L stirred tank reactor (STR) Medium: Sueoka medium Carbon source: CO ₂ , and acetate Temperature: 25°C Light: 100 µmol/m ² /s, Continuous light	nd	1.16	1.18 (on CO ₂) ~3.1 (on acetate)
UTEX 1602 ²⁰	System: 250 mL flasks Medium: Kuhl medium Carbon source: 1 % CO ₂ , glucose Temperature: 25°C Light: 100 µmol/m ² /s, Continuous light	nd	nd	0.68 (on CO ₂) 5.08 (on glucose)
UTEX 2805 ²¹	System: 250 mL flasks Medium: synthetic medium Temperature: 27°C Light: 60 µmol/m ² /s, L:D cycle nd	nd	nd	2.11±0.26 x 10 ⁶ (cell/mL)

Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
<p>56% protein ² 22% lipid 17% carbohydrate --- 6.65% lipids (<i>on CO₂</i>) ²⁰ 31.58% lipids (<i>on glucose</i>) --- 40% lipids ¹⁹</p>	<p>46% C ² 2% N C/N ratio 21</p>	<p>32.4 mg/g total chlorophyll ² 1.2 mg/g beta-carotene 7.1 mg/g lutein</p>	<p>C16:0 22.0% ² C16:1 4.3% C16:2 11.5% C16:3 5.1% C18:0 3.5% C18:1 11.3% C18:2 31.1% C18:3 9.1% other 2.1% --- C16:0 20.99% ²⁰ C16:1 5.56% C16:2 4.82% C18:0 0.33% C18:1 2.95% C18:2 13.79% C18:3 33.31%</p>

Additional biomass considerations:

Supplementation of glucose as a carbon source can increase cell density, biomass production and total lipid yield but decreases protein abundance and chlorophyll biosynthesis ¹⁷.



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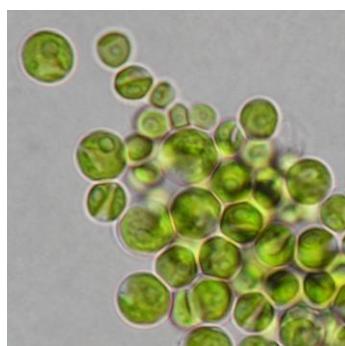
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Chlorella vulgaris



A eukaryotic marine Trebouxiophyceae strain that has large-scale commercial cultivation in Asia as a high protein-rich food and feed source, a nutritional supplement, and biofuel source. It can be cultivated autotrophically, mixotrophically or heterotrophically^{22–24}. It has quite robust growth for cultivation in open ponds as well as photobioreactors²⁵.

Commonly cultivated strains include:
CCAP 211/8K, CCAP 211/11B, CCAP 211/21A, CCAP 211/21B, CCAP 211/79, UTEX 2805, UTEX 2714

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 211/79 ²	System: PBR Medium: Jaworski's medium Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	0.18	0.428	3.0
UTEX 2805 ²¹	System: 250 mL flasks Medium: synthetic medium Temperature: 27°C Light: 60 µmol/m ² /s, L:D cycle nd	nd	nd	3.2±0.5 × 10 ⁶ (cell/mL)
UTEX 2714 ²⁶	System: 250 mL flasks Medium: modified/optimised synthetic medium Carbon source: glucose/glycerol Temperature: 26°C Light: 60 µmol/m ² /s, L:D cycle nd	nd	1.87	5.62
nd ²⁷ purchased from Connecticut Valley Biological Supply Co. Inc	System: PBR (3.8 gallon, 6 L working volume) Medium: BBM Temperature: 25°C Light: 276 µmol/m ² /s, L:D cycle nd	nd	0.35	~1.6



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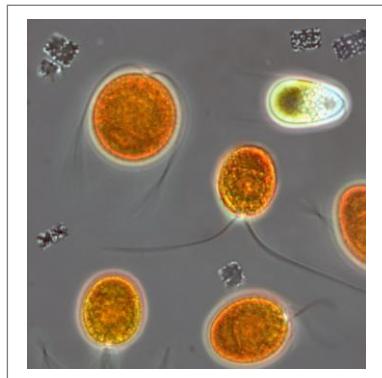


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Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
58% protein ² 12% lipid 17% carbohydrate ---			C14:0 3.1% C16:0 25.1% C16:1 5.3% C16:3 1.3% C18:0 0.6% C18:1 12.6% C18:2 7.2% C18:3 19.1% C20:3 0.8% other 24%
51-58% protein ⁵ 14-22% lipid 12-17% carbohydrate ---	52% C 3% N C/N ratio 19	22.6 mg/g total chlorophyll 2.7 mg/g total carotenoid	---
40.10% lipid ²⁶			C14:0 3.01% ²⁸ C16:0 16.99% C16:1 13.61% C16:2 5.47% C16:3 7.93% C18:0 1.51% C18:1 8.55% C18:2 14.44% C18:3 16.63% C20:4 1.24% C20:5 10.17%

Dunaliella salina



A eukaryotic marine Chlorophyceae strain that is extremely salt-tolerant and is widely cultivated as a source of beta-carotene. It has commercial interest as a source of anti-oxidant, colouring, nutritional supplement and cosmetics^{29–32}. Large scale cultivation of *D. salina* is typically in open pond or large coastal lagoons³³.

Commonly cultivated strains include:
CCAP 19/18

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 19/18 ²	System: PBR Medium: F2 (f/2) medium Temperature: 22°C Light: 70 µmol/m ² /s, 16h L: 8h D	0.135	0.224	1.28
nd ³⁴ <i>obtained from NLP corp (Busan, Korea)</i>	System: PBR (5L, 3 L working volume) Medium: f/2 medium Temperature: 20°C Light: 108.9 µmol/m ² /s, 12h L: 12h D	nd	0.0375	0.25
nd <i>obtained from Guangyu Co. (Shanghai, China)</i>	System: Bubble column (350 mL working volume) Medium: high-salinity medium Temperature: 28°C Light: 800 µmol/m ² /s, Continuous	0.66	nd	3.38 ~0.5 (in 100 µmol/m ² /s)



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Biomass characteristics

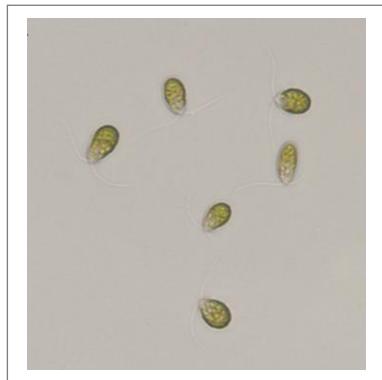
Biomass composition	Element composition	Pigments	Fatty acids
48% protein ² 24% lipid 23% carbohydrate ---			C16:0 28.1% ² C16:1 2.0% C18:0 2.9% C18:1 17.2% C18:2 9.2% C18:3 15.9% C20:1 4.8% other 19.9%
57% protein ⁵ 6% lipid 32% carbohydrate ---	41% C ² 2% N C/N ratio 21	27 mg/g beta-carotene ²	
~42% lipids in two-stage system ³⁴			



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Dunaliella tertiolecta



A eukaryotic brackish water Chlorophyceae strain that is less salt tolerant than *D. salina* and has lower productivity of beta-carotene but is of interest for its fatty acid yields with applications for nutritional supplements, and biofuel³⁵.

Commonly cultivated strains include:
CCAP 19/6B, BE 003

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 16/6B ²	System: PBR Medium: F2 (f/2) medium Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	0.048	0.128	1.6
nd ³⁴ obtained from NLP corp (Busan, Korea)	System: PBR (5L, 3 L working volume) Medium: f/2 medium Temperature: 20°C Light: 108.9 µmol/m ² /s, 12h L: 12h D	nd	0.0442	0.28
BE 003 ³⁶	System: PBR (2.2 L working volume) Medium: f/2 medium (modified with various NaNO ₃ concentrations) Temperature: 28°C Light: 17.5 klx continuous	nd	nd	0.45±0.02 (75 mg/L NaNO ₃) 1.27±0.07 (300 mg/L NaNO ₃)



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Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
<p>58% protein ² 12% lipid 8% carbohydrate --- ~40% lipids in two-stage system ³⁴</p>	<p>44% C ² 2% N C/N ratio 20</p>	<p>3.95±0.06 to 5.1±0.4 mg/g total carotenoids ³⁶</p>	<p>C16:0 17.7% ² C16:1 0.9% C16:2 3.0% C16:3 1.2% C16:4 10.6% C18:1 4.9% C18:2 12.4% C18:3 30.2% other 19.1%</p>



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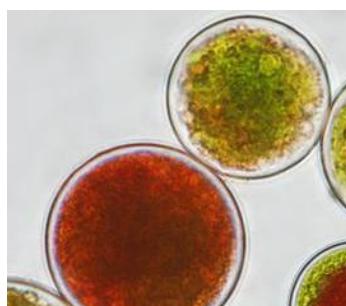
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Haematococcus pluvialis



A eukaryotic freshwater Chlorophyceae strain with the ability to produce very high concentrations of astaxanthin, with applications for aquaculture, nutritional supplement, and cosmetics, and with antioxidant characteristics. *H. pluvialis* has a green phase then a red phase of growth, which is induced by light, nitrogen or saline stress^{37–39}.

Commonly cultivated strains include:
CCAP 34/6, SCCAP K-0084, SCCAP K-0084, LUGU, CPCC 93

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 34/6 ²	System: PBR Medium: Jaworski's medium Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	0.098	0.157	3.14
SCCAP K-0084 ⁴⁰	System: 250 mL flasks Medium: BG11 medium Carbon source: ribose, sodium acetate, or gluconate Temperature: 25°C Light: 45±3 µmol/m ² /s, L:D cycle nd	nd	nd	1.03 (on ribose) 0.77 (on acetate) 1.12 (on gluconate)
SCCAP K-0084 ⁴⁰	System: 250 mL flasks Medium: BG11 medium Carbon source: gluconate Temperature: 25°C Light: 105±3 µmol/m ² /s, L:D cycle nd	nd	nd	2.09



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LUGU ⁴¹ (18S GenBankKM115647.1)	System: 1 L flask (650 mL working volume). Medium: BG11 medium + fulvic acid Carbon source: sodium acetate Temperature: 25°C Light: 50 µmol/m ² /s L:D cycle nd	nd	nd	1.57 (with 0 mg/L fulvic acid) 1.84 (with 5 mg/L fulvic acid)
CPCC 93 ⁴²	System: 2.2 L PBR Medium: M1B5 Temperature: 23±2°C Light: 15-30 klx 12 h L: 12h D	nd	nd	2.028±0.09 (on air) 4.37±0.07 (on 5% CO ₂)

Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
68% protein ² 26% lipid 9% carbohydrate	36% C ² 4% N C/N ratio 10 --- 43.57±0.61% C ⁴² 6.26±0.54% H 1.98±0.16% N 0.47±0.03% S	23.2 mg/g astaxanthin ² 2.8 mg/g beta-carotene 10.2 mg/g lutein 5.8 mg/g total chlorophyll (in red phase) --- 5.2±1.7 ug/mL chlorophyll ⁴⁰ (at 0 µmol/m ² /s) 41.3±2.9 ug/mL chlorophyll ⁴⁰ (at 105 µmol/m ² /s) --- 5.01 mg/g ⁴¹ astaxanthin content	C16:0 22.4% ² C16:1 0.6% C16:2 2.1% C16:3 3.1% C16:4 5.8% C18:0 0.9% C18:1 19.5% C18:2 28.7% C18:3 12.6% other 4.3%



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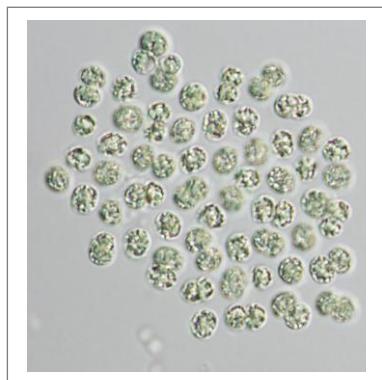
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Microcystis aeruginosa



A cyanobacteria strain known for toxic bloom formation. It can produce neurotoxins and is also a source of butylated hydroxytoluene, which has antioxidant characteristics ⁴³.

Commonly cultivated strains include:
CCAP 1450/1, FACHB-469.

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 1450/1 ²	System: PBR Medium: BG11 medium Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	0.04	0.06	0.68
FACHB-469 ⁴⁴	System: 250 mL flasks (150 mL working volume) Medium: BG11 medium with dissolved organic carbon, DOM Temperature: 25°C Light: 50 µmol/m ² /s, 12h L: 12h D	nd	nd	1.7x10 ⁷ cells/mL

Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
66% protein ² 9% lipid 8% carbohydrate --- ~4.5-8 pg cell ⁻¹ protein ⁴⁴ ~2-12 pg cell ⁻¹ polysaccharides (under various organic sources)	nd	~0.4-0.55 ug 10 ⁶ cell ⁻¹ chlorophyll content ⁴⁵	nd



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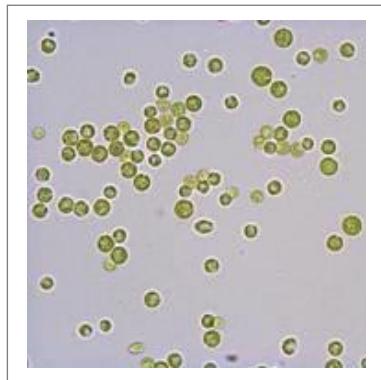
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Nannochloropsis occulata



A eukaryotic marine strain of the Eustigmatophyceae class with applications for nutritional supplement, and biofuel, particularly due to its fatty acid characteristics. It can be cultivated autotrophically in photobioreactor or open pond conditions, with a stress induction such as nitrogen starvation, typically used to induce higher fatty acid yields^{46, 47}.

Commonly cultivated strains include:
CCAP 849/1

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 849/1 ²	System: PBR Medium: F2 (f/2) medium Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	0.09	0.32	2.5
nd ³⁴ obtained from NLP corp (Busan, Korea)	System: PBR (5L, 3 L working volume) Medium: f/2 medium Temperature: 20°C Light: 108.9 µmol/m ² /s, 12h L: 12h D	nd	0.0475	0.51
nd obtained from the Fisheries Research Institute (Taiwan)	System: 3 L PBR Two stages: 1 st N replete, 2 nd N deplete Medium: Basal medium with 35 g/L salinity Temperature: 25°C Light: 300, 500 µmol/m ² /s, Continuous	nd	nd	3.36 (300 µmol/m ² /s) 3.44 (500 µmol/m ² /s)



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Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
<p>40% protein 33% lipid 10% carbohydrate --- ~30% lipids in two-stage system ³⁴</p>	<p>55% C 3% N C/N ratio 21</p>	nd	<p>C14:0 7.2% ² C16:0 23.4% C16:1 26.9% C16:3 0.5% C18:1 13.2% C18:2 1.2% C20:4 2.7% C20:5 14.3% other 10.1% --- C14:0 4.13% ²⁸ C16:0 20.70% C16:1 17.12% C16:2 3.88% C16:3 5.35% C18:0 0.98% C18:1 7.46% C18:2 8.75% C18:3 10.08% C20:4 2.88% C20:5 18.67%</p>



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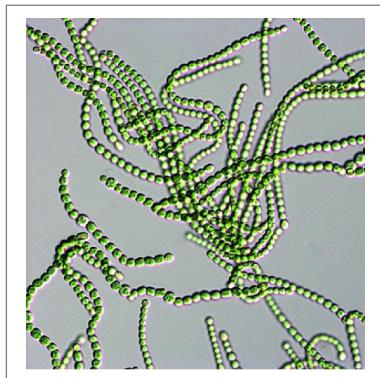
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Nostoc sp.



A cyanobacteria strain that is grown as a food and feed source, and a nutritional supplement in Asia due to its protein and vitamin constituents⁴⁸.

Commonly cultivated strains include:
CCAP 1403/17, TISTR 8872, TISTR 8873

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 1403/17 ²	System: PBR Medium: BG11 medium Temperature: 22°C Light: 70 µmol/m ² /s, 16h L: 8h D	0.122	0.197	1.38
TISTR 8872 ⁴⁹	System: Conical flasks (300 mL working volume) Medium: BG11 medium Temperature: 28±1°C Light: 60 µmol/m ² /s, 12h L: 12h D	nd	nd	0.3±0.0
TISTR 8873 ⁴⁹	System: Conical flasks (300 mL working volume) Medium: BG11 medium Temperature: 28±1°C Light: 60 µmol/m ² /s, 12h L: 12h D	nd	nd	0.2±0.04



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Biomass characteristics

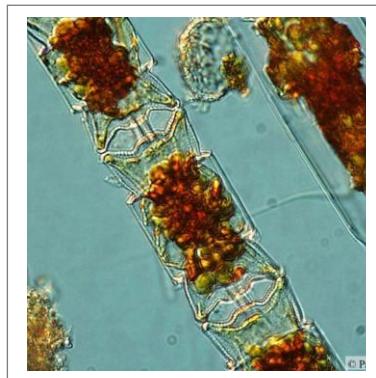
Biomass composition	Element composition	Pigments	Fatty acids
42% protein ² 8% lipid 33% carbohydrate --- From 30.66±0.58 to 32.85±1.52% starch ⁴⁹	nd	0.6 mg/g chlorophyll ² 1.7 mg/g carotenoids	nd



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Odontella aurita



A marine diatom with interest as a nutritional supplement, and pharmaceutical applications due to its fatty acid characteristics, in particular the accumulation of polyunsaturated fatty acids⁵⁰.

Commonly cultivated strains include:
CCAP 1054/1, SCCAP K 1251

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 1054/1 ²	System: PBR Medium: f/2 + Si medium Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	0.001	0.011	0.2
SCCAP K 1251 ⁵¹	System: PBR (1.2 L working volume) Medium: Modified L1 medium Temperature: 25±1°C Light: 150 µmol/m ² /s for 1 st two days, then 300 µmol/m ² /s continuous	nd	nd	3.95 (low nitrogen) 5.84 (high nitrogen)
SCCAP K1251 ⁵²	System: Glass column (300 mL working volume) Medium: Artificial seawater enriched with L1 medium Temperature: 25±1°C Light: 150 µmol/m ² /s Continuous	nd	nd	6.34 (high nitrogen) 6.58 (high phosphorous)



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Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
<p>48% protein ²</p> <p>5% lipid</p> <p>20% carbohydrate</p> <p>---</p> <p>~25% protein ⁵¹</p> <p>~10% lipids</p> <p>60.33%</p> <p>Chrysolaminarin (carbohydrate)</p> <p>---</p> <p>15.3% protein ⁵²</p> <p>15.9% lipid</p> <p>50.4% carbohydrate</p> <p>47.2 % β-1,3-glucan</p>	<p>30% C ²</p> <p>5% N</p> <p>C/N ratio 6.5</p>	<p>2.33% fucoxanthin ⁵¹ (carotenoid)</p> <p>60.33% Chrysolaminarin</p>	<p>C14:0 27.2% ²</p> <p>C16:0 7.7%</p> <p>C16:1 18.7%</p> <p>C16:2 3.1%</p> <p>C16:3 5.7%</p> <p>C16:4 3.1%</p> <p>C18:1 1.9%</p> <p>C18:2 1.2%</p> <p>C18:4 0.8%</p> <p>C20:5 22.8%</p> <p>other 7.8%</p>



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Oscillatoria lutea



A cyanobacteria strain that has interest as a source of chemicals including butylated hydroxytoluene, which has antioxidant characteristics⁵³.

Commonly cultivated strains include:
CCAP 1459/3

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 1459/3 ²	System: PBR Medium: BG11 medium Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	0.04	0.05	0.76
nd (<i>Oscillatoria lutea</i> var. <i>contorta</i>) obtained from	System: 500 mL flasks (250 mL working volume) Medium: grown on barley straw extract Temperature: 20°C Light: 65 µmol/m ² /s, 12h L: 12h D	nd	nd	~500 µg L (measured as Chlorophyll a)

Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
48% protein ² 9% lipid 18% carbohydrate	nd	9.8 mg/g chlorophyll ² 1.7 mg/g carotenoids	nd



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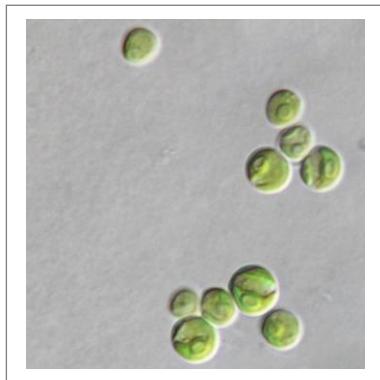
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Parachlorella kessleri



A eukaryotic freshwater Trebouxiophyceae strain with potential applications for animal feed, nutritional supplement, and biofuel. It can be cultivated autotrophically, mixotrophically or heterotrophically⁵⁴.

Commonly cultivated strains include:
CCAP 211/11G, QWY28, GB1

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 211/11G ²	System: PBR Medium: Jaworki's medium Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	0.36	0.413	2.74
QWY28 ⁵⁵ <i>collected from rivers in the district of Harbin city, China</i>	System: Conical flasks Medium: Artificial seawater Temperature: 30°C Light: 200 µmol/m ² /s, L:D cycle nd	nd	0.633±0.027	3.8
QWY28 ⁵⁵ <i>collected from rivers in the district of Harbin city, China</i>	System: 500 mL glass vessels, 2.5 % CO ₂ Medium: Raw swine wastewater Temperature: 27-30°C Light: 200 µmol/m ² /s, L:D cycle nd	nd	0.775±0.026	6.2
QWY28 ⁵⁵ <i>collected from rivers in the district of Harbin city, China</i>	System: 500 mL glass vessels, 2.5 % CO ₂ Medium: Raw swine wastewater Temperature: 27-30°C Light: 600 µmol/m ² /s, L:D cycle nd	nd	1.150±0.056	9.2



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GB1 ⁵⁶ GenBank KX151669.1	System: 500 mL flasks (200 mL working volume) Medium: BG11 Carbon source: glucose Temperature: 25±2°C Light: 28 µmol/m ² /s, Continuous	nd	0.176±0.00 (phototrophic) 1.362±0.01 (mixotrophic) 1.311±0.01 (heterotrophic)	1.043±0.02 (phototrophic) 8.176±0.06 (mixotrophic) 7.871±0.09 (heterotrophic)
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Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
51% protein ² 25% lipid 16% carbohydrate --- 54% carbohydrate ⁵⁵ (<i>of which ~35% is glucose</i>) --- 41.29±0.90% protein ⁵⁶ 20.14±0.58% lipid 34.15±0.42% carbohydrate	nd	23.6 mg/g total chlorophyll ² 4.1 mg/g total carotenoid --- 9.17±0.11 mg/g Chlorophyll a ⁵⁶ --- 3.98±0.02 mg/g Chlorophyll b 2.60±0.02 mg/g carotenoids	C14:0 1.1% ² C16:0 12.1% C16:1 7.2% C18:0 4.2% C18:1 24.2% C18:2 23.5% C18:3 26.8% C20:0 0.5% other 2.1%



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Phaeodactylum tricornutum



A marine diatom strain with ability to produce high yields of fatty acids including polyunsaturated fatty acids, therefore leading to applications for animal feed, nutritional supplement, and biofuel^{57,58}.

Commonly cultivated strains include:
CCAP 1055/1, CCMP 632, PTN0301, CCMP 632.

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 1055/1G ²	System: PBR Medium: f/2 + Si medium Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	0.084	0.16	3.2
PTN0301 ⁵⁹ <i>Isolated from water samples collected in the North Sea</i>	System: 1 L bottles Medium: modified f/2 medium, with air or CO ₂ supply Temperature: 20±1°C Light: 90-110 µmol/m ² /s, 16h L: 8h D	nd	nd	1.6 (with CO ₂) 1.0 (with air)
PTN0301 ⁵⁹ <i>Isolated from water samples collected in the North Sea</i>	System: open ponds (1000 L) Medium: digestate from anaerobic digestion Temperature: outdoors Light: outdoors	0.041	nd	Between 0.3 and 0.8
CCMP 632 ⁶⁰	System: 1 L flasks (800 mL working volume) Medium: mixture of municipal wastewater (MW) and seawater (SW) Temperature: 20±1°C Light: 120 µmol/m ² /s, 12h L: 12h D	nd	0.289±0.0001 (in MW:SW=2:1) 0.238±0.002 (in MW:SW=1:1)	1.04±0.01 (in MW:SW=2:1) 0.97±0.02 (in MW:SW=1:1)



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Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
<p>42% protein ² 12% lipid 39% carbohydrate --- <i>Growth on air</i> ⁵⁹ 41.5±0.4% protein 26.7±0.0% lipid 9.5±2.3% polysaccharides <i>Growth on CO₂</i> ⁵⁹ 33.5±1.0% protein 33.8±3.7% lipid 24.0±0.1% polysaccharides</p>	nd	nd	<p>C14:0 7.5% ² C16:0 12.6% C16:1 23.8% C16:2 4.1% C16:3 8.4% C16:4 2.9% C18:1 1.4% C18:2 2.1% C20:4 0.7% C20:5 30.2% other 6.3% --- C14:0, 6.55±0.32% ⁵⁹ C16:0, 19.24±0.19% C16:3+C16:1, 49.41±2.68% C18:0, 0.74±0.10 % C86:2+C18:1, 3.63±0.25% C20:4, 1.15±0.12% C20:5, 17.77±2.23%</p>



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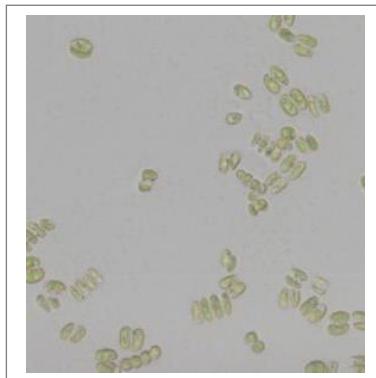
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Scenedesmus subspicatus



A eukaryotic freshwater Chlorophyceae strain with applications for animal feed, nutritional supplement, and biofuel. It can be cultivated autotrophically, mixotrophically or heterotrophically⁶¹.

Commonly cultivated strains include:
CCAP 276/20

Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity (g/L/d)	Maximum productivity (g/L/d)	Maximum production (g/L)
CCAP 276/20 ²	System: PBR Medium: Jaworski's medium Temperature: 22°C Light: 150 µmol/m ² /s, 16h L: 8h D	0.09	0.11	2.1
CCAP 276/20 ⁶²	System: 250 mL flasks (200 mL working volume) Medium: Jaworski's medium (different P levels) Temperature: 25°C Light: 144.8 µmol/m ² /s, 16h L: 8h D	nd	nd	2.4x10 ⁶ cells mL ⁻¹ (in low-P medium) 5.2x10 ⁶ cells mL ⁻¹ (in intermediate-P medium) 4.6x10 ⁶ cells mL ⁻¹ (in high-P medium)
nd ⁶³ <i>Isolated from the River Nile, Egypt</i>	System: 1 L flasks (700 mL working volume) Medium: BBM Temperature: 28±2°C Light: 2500 lux, L:D cycle nd	nd	~0.9 (stationary phase) ~0.65 (late exponential phase)	nd



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Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
58% protein ² 16% lipid 29% carbohydrate	nd	19.6 mg/g total chlorophyll ² 0.3 mg/g total carotenoid --- 0.098 ± 0.061 pg cell ⁻¹ Chlorophyll-a (<i>in Low N medium</i>) ⁶⁴ 0.617 ± 0.111 pg cell ⁻¹ Chlorophyll-a (<i>in High N medium</i>) ⁶⁴	C14:0 1.5% ² C16:0 21.8% C16:1 6.0% C16:2 4.0% C16:3 0.7% C18:1 17.9% C18:2 21.7% C18:3 3.8% other 22.6%



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APPENDIX 1. MEDIA RECIPES

A compilation of the microalgae media recipes shown in this strain catalogue is presented in this appendix. The reader should be aware that recipes shown here follow the standard protocol where culturing medium is prepared by mixing specific quantities of stock solutions so as to reach the desired components' medium concentrations.

Unless otherwise specified, all media is prepared by carrying out the following protocol:

1. Prepare all necessary stock solutions* by dissolving each component in 1 L of distilled H₂O (dH₂O);
2. Add/mix the corresponding quantity of stock solutions into dH₂O;
3. bring final volume to 1 L;
4. adjust pH if required; and
5. autoclave (sterilize at 15 psi for 15 min).

Preparation of stock solutions is very useful during media preparation as it reduces weighing errors, particularly for those components that are necessary in very small quantities (micronutrients). Whilst we have aimed to provide preparation instructions for stock solutions within all the media recipes presented here, the reader should be aware that stock solution's recipes can be modified accordingly so long as the final medium concentration of each component is met.

It is also important to note that microalgae media recipes have been subject to modifications (e.g. replacing one component for another, increasing or decreasing component concentrations, etc.) to fit the desired cultivation needs, such as optimisation of biomass or metabolite concentration, maximise nutrient uptake, etc. We would therefore encourage the reader to browse the open literature, where different variations of the recipes shown here, as well as many other, have been widely explored.

Useful sources for algal media recipes

- CCAP media recipes ⁶⁵
- Algal Culturing Techniques, by Rober A. Andersen, Elsevier Academic Press (2005) ⁶⁶



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A.1. Artificial Seawater (ASW) medium

ASW components and concentrations⁶⁵

Component ⁶⁵	Stock solution g per 1000 mL H ₂ O	Quantity used for medium
<i>Extra salts</i>		3.75 mL
NaNO ₃	30	
Na ₂ HPO ₄	1.2	
K ₂ HPO ₄	1	
<i>Vitamin solution</i>		2.5
Biotin	0.0002	
Calcium pantothenate	0.02	
Cyanocabalamin	0.004	
Folic acid	0.0004	
Inositol	1.0	
Nicotinic acid	0.02	
Thiamine HCl	<u>0.1</u>	
Thymine	<u>0.6</u>	
Soil extract (SE1)	See below	25 mL
Tricine		0.5 g

Soil extract

Soil should be air-dried. Dried soil is autoclaved together with a volume of distilled water equivalent to double the volume of soil. Once autoclaved, the supernatant is decanted, filtered (Whatman No 1 paper), and placed in appropriate vessels until used for media preparation. Soil selection is an important consideration for ASW media. Readers are referred to the recipe provided by CCAP⁶⁵.



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A.2. Blue-Green medium (BG11)

Mix stock solutions and bring to 1 L; adjust pH to 7.1 (with NaOH or HCl).

BG11 medium components and concentrations⁶⁵

Component	Stock solution g per 500 mL dH ₂ O	Quantity used for medium
NaNO ₃	75	10 mL
K ₂ HPO ₄	2	10 mL
MgSO ₄ ·7H ₂ O	3.75	10 mL
CaCl ₂ ·2 H ₂ O	1.80	10 mL
Citric acid	0.3	10 mL
Ammonium ferric citrate green	0.3	10 mL
EDTA·Na ₂	0.05	10 mL
Na ₂ CO ₃	1	10 mL
Trace metals solution	See recipe below	1 mL

Trace metals solution (also known as A5 + Co Trace metals solution)⁶⁵

Component	Stock solution qty per litre dH ₂ O
H ₃ BO ₃	2.860 g
MnCl ₂ ·4H ₂ O	1.810 g
ZnSO ₄ ·7H ₂ O	0.220 g
CuSO ₂ ·5H ₂ O	0.08 g
Na ₂ MoO ₂ ·2H ₂ O	0.39 g
Co(NO ₃) ₂ ·6H ₂ O	0.05 g



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A.3. Bold's Basal Medium (BBM) and 3N-BBM

The recipe for BBM is presented below. 3N-BBM is identical to BBM medium but requiring 3 times the nitrogen (i.e. 3N) used in BBM.

BBM medium components and concentrations⁶⁵

Component	Stock solution g per 400 mL dH ₂ O	Quantity used for medium
<i>Macronutrients</i>		
NaNO ₃	10	10 mL
MgSO ₄ ·7H ₂ O	3	10 mL
NaCl	1	10 mL
K ₂ HPO ₄	3	10 mL
KH ₂ PO ₄	7	10 mL
CaCl ₂ ·2H ₂ O	1	10 mL
<i>Trace elements solution</i>	See recipe below	1 mL
<i>Boric acid solution</i>	See recipe below	1 mL
<i>Alkaline EDTA solution</i>	See recipe below	1 mL
<i>Acidified Iron solution</i>	See recipe below	1 mL

BBM Trace elements solution⁶⁵

Component	Stock solution qty per litre dH ₂ O
ZnSO ₄ ·7H ₂ O	8.82 g
MnCl ₂ ·4H ₂ O	1.44 g
MoO ₃	0.71 g
CuSO ₄ ·5H ₂ O	1.57 g
Co(NO ₃) ₂ ·6H ₂ O	0.49 g



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BBM additional solutions⁶⁵

Component	Stock solution qty per litre dH₂O
<i>Boric acid solution</i>	
H ₃ BO ₃	11.42 g
Alkaline EDTA solution	
EDTA	50 g
KOH	31 g
<i>Acidified Iron solution</i>	
FeSO ₄ ·7H ₂ O	4.98 g
H ₂ SO ₄	1 mL



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A.4. Chu 13 medium (Modified)

Chu 13 medium components and concentrations⁶⁷

Component	Quantity used for medium
KNO ₃	400 mg
K ₂ HPO ₄	80 mg
MgSO ₄ ·7H ₂ O	200 mg
CaCl ₂ ·2H ₂ O	107 mg
Fe citrate	20 mg
Citric acid	100 mg
<i>Micronutrients</i>	
CoCl ₂	0.02 mg
H ₃ BO ₃	5.72 mg
MnCl ₂ ·4H ₂ O	3.62 mg
ZnSO ₄ ·7H ₂ O	0.44 mg
CuSO ₄ ·5H ₂ O	0.16 mg
Na ₂ MoO ₄	0.084 mg
H ₂ SO ₄ 0.072 N	1 drop



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A.5. Detmer medium (DM) modified

Detmer medium components and concentrations⁶⁸

Component	Quantity used for 1 L medium
Ca(NO ₃) ₂ ·4H ₂ O	1 g
KH ₂ PO ₄	0.26 g
MgSO ₄ ·7H ₂ O	0.55 g
KCl	0.25 g
FeSO ₄ ·7H ₂ O	0.02 g
EDTA·2Na	0.2 g
<i>Trace elements</i>	
H ₃ BO ₃	0.0029 g
ZnCl ₂	0.00011 g
MnCl ₂ ·4H ₂ O	0.00181 g
(NH ₄) ₆ MoO ₂₄ ·4H ₂ O	0.000018 g
CuSO ₄ ·5H ₂ O	0.00008 g



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A.6. f/2 medium

This is a seawater medium, prepared by bringing up the final volume to 1 L with filtered natural seawater. Adjust pH to 8 with 1 M NaOH or HCl.

f/2 medium components and concentrations⁶⁵

Component	Stock solution qty per 1 L dH ₂ O	Quantity used for medium
NaNO ₃	75 g	1 mL
NaH ₂ PO ₄ ·H ₂ O	5.65 g	1 mL
Trace metals solution	See recipe below	1 mL
Vitamins solution	See recipe below	1 mL

f/2 trace metals solution⁶⁵

Component	Stock solution qty per L dH ₂ O
Na ₂ EDTA	4.16 g
FeCl ₃ ·6H ₂ O	3.15 g
CuSO ₄ ·5H ₂ O	0.01 g
ZnSO ₄ ·7H ₂ O	0.022 g
CoCl ₂ ·6H ₂ O	0.01 g
MnCl ₂ ·4H ₂ O	0.18 g
Na ₂ MoO ₄ ·2H ₂ O	0.006 g

Vitamins solution⁶⁵ (filter-sterilise and store frozen).

Component	Stock solution Qty per L ⁻¹ dH ₂ O)
Cyanocobalamin (Vitamin B ₁₂)	0.0005 g
Thiamine HCl (Vitamin B ₁)	0.1 g
Biotin	0.0005 g



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A.7. f/2+Si (Guillard's medium for diatoms)

This is a seawater medium, prepared by bringing up the final volume to 1 L with filtered natural seawater. Adjust pH to 8 with 1 M NaOH or HCl.

f/2 + Si medium components and concentrations⁶⁵

Component	Stock solution g per 1 L dH₂O	Quantity used for medium
NaNO ₃	75	1 mL
NaH ₂ PO ₄ ·H ₂ O	5.65	1 mL
Trace metals solution	See recipe below	1 mL
Vitamins solution	See recipe below	1 mL
Sodium metasilicate solution		1 mL
Na ₂ SiO ₃ ·9H ₂ O	30 g	

F/2 + Si trace metals solution⁶⁵

Component	Stock solution Qty per L dH₂O
Na ₂ EDTA	4.16 g
FeCl ₃ ·6H ₂ O	3.15 g
CuSO ₄ ·5H ₂ O	0.01 g
ZnSO ₄ ·7H ₂ O	0.022 g
CoCl ₂ ·6H ₂ O	0.01 g
MnCl ₂ ·4H ₂ O	0.18 g
Na ₂ MoO ₄ ·2H ₂ O	0.006 g



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Vitamins solution ⁶⁵ (filter-sterilise and store frozen).

Component	Stock solution Qty per L⁻¹ dH₂O)
Cyanocobalamin (Vitamin B ₁₂)	0.0005 g
Thiamine HCl (Vitamin B ₁)	0.1 g
Biotin	0.0005 g



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A.8. Jaworski's Medium (JM)

JM medium components and concentrations⁶⁵

Component	Stock solution g per 200 mL dH ₂ O	Quantity used for medium
Ca(NO ₃) ₂ ·4H ₂ O	4 g	1 mL
KH ₂ PO ₄	2.48 g	1 mL
MgSO ₄ ·7H ₂ O	10 g	1 mL
NaHCO ₃	3.18 g	1 mL
<i>EDTA solution</i>		1 mL
EDTA·Fe·Na	0.45 g	
EDTA· Na ₂	0.45 g	
<i>Trace elements solution</i>		1 mL
H ₃ BO ₃	0.496 g	
MnCl ₂ ·4H ₂ O	0.278 g	
(NH ₄) ₆ Mo ₇ O ₂₄ ·4H ₂ O	0.2 g	
<i>Vitamins solution</i>	<i>See recipe below</i>	1 mL
NaNO ₃	16 g	1 mL
Na ₂ HPO ₄ ·12H ₂ O	7.2 g	1 mL

Vitamins solution⁶⁵ (filter-sterilise and store frozen).

Component	Stock solution qty per 200 mL dH ₂ O
Cyanocobalamin (Vitamin B ₁₂)	0.0008 g
Thiamine HCl (Vitamin B ₁)	0.0008 g
Biotin	0.0008 g



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A.9. Kuhl medium

Kuhl medium components and concentrations²⁰

Component	Quantity used for 1 L medium
KNO ₃	1 g
NaH ₂ PO ₄ ·H ₂ O	0.621 g
Na ₂ HPO ₄ ·2H ₂ O	89 mg
MgSO ₄ ·7H ₂ O	246.5 mg
EDTA	9.3 mg
H ₃ BO ₃	0.061 mg
CaCl ₂ ·2H ₂ O	14.7 mg
FeSO ₄ ·7H ₂ O	6.95 mg
ZnSO ₄ ·7H ₂ O	0.287 mg
(NH ₄) ₆ Mo ₇ O ₂₄ ·4H ₂ O	0.01235 mg
MnSO ₄ ·H ₂ O	0.169 mg
CuSO ₄ ·5H ₂ O	0.00249 mg



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A.10. SOT medium

Bring final volume to 1 L and adjust pH to 9.

SOT medium components and concentrations⁶⁹

Component	Stock solution g per L dH₂O	Quantity used for medium
NaHCO ₃		16.8 g
K ₂ HPO ₄		0.5 g
NaNO ₃		2.5 g
K ₂ SO ₄		1 g
NaCl		1 g
MgSO ₄ ·7H ₂ O		0.2 g
CaCl ₂ ·2H ₂ O		0.04 g
FeSO ₄ ·7H ₂ O		0.01 g
EDTA		0.08 g
<i>Trace metal Mix A5</i>		1 mL
H ₃ BO ₃	2.86	
MnCl ₂ ·4H ₂ O	1.81	
ZnSO ₄ ·7H ₂ O	0.222	
NaMoO ₄ ·2H ₂ O	0.39	
CuSO ₄ ·5H ₂ O	0.079	
Co(NO ₃) ₂ ·6H ₂ O	49.4 mg	
<i>Trace metal Mix B6 (modified)</i>		1 mL
NH ₄ NO ₃	0.23	
K ₂ Cr(SO ₄) ₄ ·24H ₂ O	96 mg	
NiSO ₄ ·7H ₂ O	47.8 mg	
Na ₂ WO ₄ ·2H ₂ O	17.9 mg	
Ti ₂ (SO ₄) ₃	40 mg	



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A.11. Sueoka medium

Sueoka medium components and concentrations ¹⁹

Component	Stock solution g per L dH ₂ O	Quantity used for 1 L medium
KH ₂ PO ₄		0.72 g
K ₂ HPO ₄		1.44
MgSO ₄ ·7H ₂ O		0.02
CaCl ₂ ·2H ₂ O		0.01
NH ₄ Cl		0.5
<i>Trace elements</i>		1 mL
EDTA	10	
H ₃ BO ₃	2.28	
ZnSO ₄ ·7H ₂ O	4.4	
MnCl ₂ ·4H ₂ O	1.02	
FeSO ₄ ·7H ₂ O	1	
CoCl ₂ ·6H ₂ O	0.32	
CuSO ₄ ·5H ₂ O	0.32	
Mo ₇ O ₂₄ (NH ₄) ₆ ·4H ₂ O	0.22	



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A.12. Zarrouk medium

Zarrouk medium components and concentrations ⁷⁰

Component	Stock solution (g L ⁻¹ dH ₂ O)	Quantity used for medium
NaNO ₃		2.5 g
K ₂ HPO ₄		0.5 g
K ₂ SO ₄		1 g
NaCl		1 g
MgSO ₄ ·7H ₂ O		0.2 g
CaCl ₂ ·2H ₂ O		0.04 g
FeSO ₄ ·7H ₂ O		0.01 g
EDTA		0.08 g
NaHCO ₃		16.8 g
<i>Micronutrient solution</i>		1 mL
H ₃ BO ₃	2.86	
MnCl ₂ ·4H ₂ O	1.81	
ZnSO ₄ ·4H ₂ O	0.222	
Na ₂ MoO ₄	0.0177	
CuSO ₄ ·5H ₂ O	0.079	



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APPENDIX 2. CULTURE COLLECTIONS

ACRONYM	NAME	WEBSITE
CCAP	Culture Collection of Algae and Protozoa at the Scottish Association for Marine Science UK	https://www.ccap.ac.uk/
CPCC formerly UTCC	Canadian Phycological Culture Centre Canada <i>Formerly known as the University of Toronto Culture Collection of Algae and Cyanobacteria</i>	https://uwaterloo.ca/canadian-phycological-culture-centre/
CSMA	Culture Collection of the Centro di Studio del Microrganismi Autotriti Italy	
IBVF	Biological Culture Service of the Institute of Plant Biochemistry and Photosynthesis Spain	https://www.ibvf.us-csic.es/en/biological-cultures-service
NCMA Formerly CCMP	National Center for Marine Algae and Microbiota at Bigelow Laboratory USA <i>Formerly known as the Culture Collection of Marine Phytoplankton</i>	https://ncma.bigelow.org/cms/index/index/
NIES	National Institute for Environmental Studies Japan	https://mcc.nies.go.jp/index_en.html
PCC	Pasteur Culture Collection of Cyanobacteria France	https://webext.pasteur.fr/cyanobacteria/
SAG	Sammlung von Algenkulturen der Universität Göttingen / Culture Collection of Algae at Göttingen University, Germany	http://sagdb.uni-goettingen.de/
SCCAP	Scandinavian Culture Collection of Algae & Protozoa at The University of Copenhagen, Denmark	http://www.sccap.dk/
UTEX	Culture Collection of Algae at The University of Texas at Austin USA	https://utex.org/



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