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The Culture Collection of Algae and Protozoa (CCAP): A biological resource for protistan genomics

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Abstract

CCAP, the largest European protistan culture collection, is based at the Scottish Association for Marine Science near Oban, Scotland (http://www.ccap.ac.uk). The Collection comprises more than 2700 strains in the public domain, of which 1050 are marine algae, 1300 freshwater algae, and 350 protozoa. The primary mission of CCAP is to maintain and distribute defined cultures and their associated information to its customers. It also has a support and advisory function on all aspects of protistan science. In addition, it is involved in the training of students and researchers in algal identification and culture techniques.

In light of the increasing number of fully sequenced protists, the CCAP is striving to provide targeted services and support to workers involved in all aspects of genomic research. At present, the Collection holds several hundred strains of genomic model taxa including: *Acanthamoeba*, *Cafeteria*, *Cercomonas*, *Chlamydomonas*, *Chlorella*, *Cyanophora*, *Dictyostelium*, *Dunaliella*, *Ectocarpus*, *Emiliania*, *Euglena*, *Micromonas*, *Naegleria*, *Nephroselmis*, *Paramecium*, *Pavlova*, *Phaeodactylum*, *Porphyra*, *Pseudendoclonium, Pylaiella*, *Rhodomonas*, *Scenedesmus*, *Staurastrum*, *Tetrahymena*, *Thalassiosira*, *Volvox* and *Zygnema.* These strains provide a defined representation of natural variation within model organisms, an increasingly useful resource for post-genomics approaches. Our aim over the next 2–5 years is to add value to the Collection by increasing the number of genome model species, and by offering an integrated, up-to-date, easy-to-use resource that would provide curated information on our strain holdings. In collaboration with other major Biological Resource Centres worldwide, we intend to build a hub providing access to both protistan cultures and their associated bioinformatics data.

Keywords: Biodiversity; Biological resource centre; Cyanobacterium; Integrated database; Model organism; Natural variation

1. Introduction

CCAP traces its origins to the pioneering development of algal culture methods by Prof. E.G. Pringsheim and his co-workers in Prague during the 1920s. Formally established as the UK's protistan service collection in Cambridge in 1947, the collection was split in 1986 and relocated to Windermere (freshwater/terrestrial algae and protozoa), with the marine algal strains transferred to Oban (Day et al., 2004b). Subsequently, the freshwater/terrestrial and protozoan holdings of the Collection were remerged with the marine section and relocated to a custom-built, state-of-the-art facility at the Dunstaffnage Marine Laboratory in 2004.

From a phylogenetic perspective, it is debatably the most diverse protistan collection, holding eukaryotic algae, a unique collection of free-living, non-pathogenic protozoa, as well as prokaryotic cyanobacteria. Over 300 authentic strains, i.e. cultures derived from the original type material are maintained. They constitute a taxonomic/biodiversity resource of international importance. The strains originate from a wide range of environments (freshwater, marine, brackish, hypersaline, and terrestrial) and include isolates from all climate zones, polar to tropical. Currently (beginning of 2007), CCAP holds 1300 freshwater and 1050 marine algae (among which 250 are cyanobacteria), and 350 protozoa in its publicly accessible collection (see http://www.ccap.ac.uk and Table 1). A further ca. 1000 strains are held in

Abbreviations: BRC: Biological Resource Centre.

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Table 1
Overview of the strains held in CCAP

	No. of strains held by CCAP	No. of strains with EBI-Genbank-DDBJ accession no. in the CCAP database
Green algae	1211	26
Red algae	93	12
Brown algae	304	1
Amoeboid organisms	160	13
Obligate heterotrophic flagellates	23	1
Dinoflagellates	38	1
Cyanobacteria	256	21
Glaucocystophytes	1	0
Haptophytes	33	1
Slime moulds	3	0
Diatoms	139	6
Nuclearids	2	0
Cryptophytes	53	6
Chrysophytes/xanthophytes/ eustigmatophytes/synurophytes	117	0
Euglenophytes	116	10
Ciliates	60	1
Rotifera	1	0

associated research collections, some of which will soon be accessed into the public collection. CCAP has close ties with other researchers in the Scottish Association for Marine Science (SAMS, http://www.sams.ac.uk/) and the European Centre for Marine Biotechnology (ECMB, http://www.ecmb.org/), as well as the worldwide scientific community.

CCAP performs all the roles of a Biological Resource Centre (BRC) and its core service and research activities are funded by the UK Natural Environment Research Council (NERC), of which it is a National Facility. More generally, it is recognized as an important resource for UK and European science, both academic and commercial. CCAP is a key constituent of the UK National Culture Collection (UKNCC), established as a consequence of the governmental review of BRCs (Anon, 1994) and collaborates with all the major protistan collections world-wide. It is also an International Depository Authority (IDA) for patented strains under the terms of the Budapest Treaty (1977).

CCAP provides its customers with defined strains for a fee. Users of the cultures have very diverse profiles and backgrounds, ranging from researchers/academics to ecotoxicologists, biotechnology companies and aquaculturists. Although many customers work in "traditional" research fields, e.g. taxonomy, physiology, ecology, cell biology, increasingly researchers are using them in areas as diverse as geochemistry and bioremediation. Whenever possible, CCAP fulfils non-standard orders (e.g. large volumes, or material cultured under specific growth conditions, DNA extracts, PCR products and taxonomic identifications). CCAP also routinely offers informal support and advice on virtually every aspect of algal/protistan biology and on occasions provides commercial consultancy services for biotechnological customers.

CCAP activities are linked to a number of "in-house" scientific programs, including the development of cryopreservation techniques, e.g. within the EU funded COBRA project (The COnservation of a vital European scientific and Biotechnological Resource: microAlgae and cyanobacteria). It underpins other SAMS research projects such as the NERC SOLAS programme (http://badc.nerc.ac.uk/data/solas/) and harmful algal bloom research. Under the auspices of the Consortium for the Barcoding of Life (CBoL, http://barcoding.si.edu/) and in collaboration with partners from the Canadian Barcode of Life Network, CCAP has initiated a programme to obtain barcode sequences of its entire strain holdings (Williamson et al., 2007). Like other major BRCs involved in this effort, the objective is to link barcode sequences in the major nucleotide databases to "biological standards" (ideally type cultures/ authentic strains), but also to enhance the quality control of the collection itself by obtaining barcode sequences (Cox 1, rbcL, SSU and ITS rDNA, if suitable, for the organism) as unambiguous identifiers of individual strains (or species). In addition, CCAP has coordinated the development of the AlgiNet portal (http://217.114.171.142/alginet/), a WWW tool to browse simultaneously the catalogues of most European algal collections, both public and private (Day et al., 2004a). The above recent projects and long-standing curatorial effort have positioned the CCAP at a point where it can realistically develop into a "one-stop shop" for biological resources and information for the marine and freshwater protistan/cyanobacterial scientific communities.

2. A resource for nuclear and organelle genomics in protists

As a result of the development of genomics, a major new body of protistan knowledge has emerged with large-scale sequencing projects. These include organelle and/or nuclear genome sequences, which increasingly represent a reasonable cross-section of microbial/ protistan biodiversity (Table 2). Furthermore, "bulk" sequencing of environmental samples provides a wealth of un-annotated sequence data, which ultimately needs to be linked with identified strains.

Along with pursuing its traditional activities, CCAP strives to keep up-to-date with genomic developments and to provide its users with high quality biological materials and data (see http://www.ukncc.co.uk/html/Information/quality.htm for details of Quality Assurance standards). In this context, CCAP maintains a number of fully sequenced strains and their close "relatives" (Table 2). We believe that the scientific potential of model organisms increases with the availability of additional related strains that offer the best possible representation of the biologic diversity within (and around) model taxa. For example, we hold ca. 300 strains of the filamentous brown alga *Ectocarpus*, which provide a world-wide cross-section of its biogeographic and genetic diversity. These strains have been used to generate much of the literature available on *Ectocarpus* and as a result a large and diverse dataset is available on their phenotype, interbreeding capability, lipid content, viral infection, etc. (e.g. Müller, 1964; Stache-Crain et al., 1997; Müller et al., 1999). Also, the unicellular green alga *Chlamydomonas* is used as model organism in more than 100 laboratories around the world. Its nuclear, plastidial and mitochondrial genomes are