COCCOLITHOPHORES FOR EXHIBITION: A NOTE

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Introduction

When we work with coccolithophores, we sometimes overlook their beauty, strangeness and visual impact. However, recently their visual qualities were amply confirmed, after one of us (MG) spent an afternoon false-colouring an SEM image for a science photography competition: the resultant image won First Prize in the 'Science Close Up' category of the Novartis/Daily Telegraph Visions of Science competition. Further information about the competition, and this winning image, can be viewed at www.visions-of-science.co.uk. Through this medium, non-scientists got their first vision of the beauty of these minute works of art.

By a happy coincidence, The Natural History Museum has recently devoted space to temporary exhibitions of artwork related to natural history. Consequently, we were asked to prepare a temporary exhibition of coccolithophore images for it. In collaboration with an editor and exhibition designer, we selected 14 images of coccospheres. Selection was partly based on image quality and attractiveness but, also, an attempt to show a wide range of morphologies and some of the more interesting structures was made. A TEM section was included to provide a graphic illustration of the relationship between the coccosphere and the cell, and also a coccolithophore bloom image (courtesy of S. Groom, PML) to highlight the potential ecological impact of coccolithophores.

The images were false-coloured both to increase the visual impact and to highlight specific features for text-reference. The images have been enlarged to 1m across for the exhibition and make a very attractive display, which the visitors seem to like. The plate captions presented here are essentially the same as those in the exhibition and reflect how we have tried to encourage public understanding of our science, although there are limits to what you can do in the number of words allowed. The exhibition will be displayed in the public galleries until March/April and after that will probably move to our common room. If any other INA members would like an opportunity to use the exhibition for public display we would be pleased to hear from you.

Plate 1

Fig.1: *Calcidiscus leptoporus*
Coccolithophores mostly reproduce asexually by simple binary cell-division. But sexual reproduction does occasionally occur and is marked by production of haploid daughter-cells covered by holococcoliths. Following fusion of two daughter-cells, a diploid cell is produced and the coccolith type reverts to heterococcolith. This award-winning image provides rare documentation of this process, as the diploid cell with its cover of heterococcoliths (in pink) emerges from within the cover of the fused daughter-cells (in green). For a detailed figure explaining the life-cycle refer to Plate 2, Figure 7. This specimen is from the Alboran Sea, western Mediterranean (R/V *Hesperides* cruise Mater II, station 69).

Fig.2: *Syracosphaera pulchra*
Coccolithophores can produce different scales to cover their surface. This cell has an inner, endothecal layer (in pink), with coccoliths bearing spine-like protrusions around the flagellar pole (top right), and an outer, exothecal cover (in green). This specimen is from the Canary Islands, North Atlantic (R/V *Poseidon* cruise P233b, station 3). Image courtesy of Claudia Sprengel, Alfred Wegener Institute, Bremerhaven, Germany.

Fig.3: *Syracosphaera nodosa*
In this specimen, the wheel-like exothecal coccoliths (in green) have fallen off and are lying on the filter. Again, the inner coccoliths (in pink) show spine-like protrusions around the flagellar pole. This specimen is from the Alboran Sea, western Mediterranean (R/V *Hesperides* cruise Mater II, station 61).

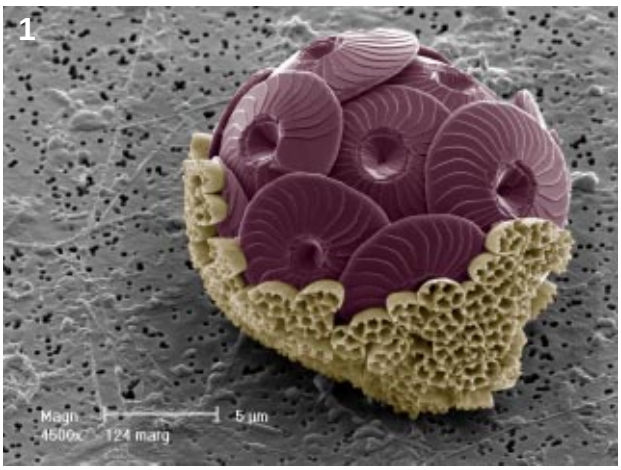
Fig.4: *Syracosphaera anthos*
This is a rare example of *Syracosphaera anthos* with the exothecal cover of coccoliths (in green) almost completely in place. Species with exothecal coccoliths are very fragile and often disintegrate during the filtration process. This specimen is from the North Atlantic (station FB16).

Fig.5: *Algirosphaera robusta*
This species is of interest since it lives in the deep photic zone, more than 50m below the surface, and is therefore poorly known. A single cell was recently isolated from Mediterranean sea-water and successfully maintained in culture, which has allowed detailed study of its morphology and behaviour. This specimen is from the Alboran Sea, western Mediterranean (R/V *Hesperides* cruise Mater II, station 69).

Fig.6: *Algirosphaera robusta*
This very different image was taken with a TEM, and shows the internal structure of a coccolithophore. Two types of heterococcolith cover the cell – some are hood-like (in pink) and others elongated (in green) around the flagellar pole. The interior is dominated by a large chloroplast (in dark green), the light-collecting motor of the cell. Above this sits the nucleus (in pink), which contains the organism's genetic material. In addition, a coccolith in production can be seen inside the cell. This specimen is from the Alboran Sea, western Mediterranean (R/V *Hesperides* cruise Mater II, station 69). Image courtesy of Ian Probert, Université de Caen Basse-Normandie, Caen, France.

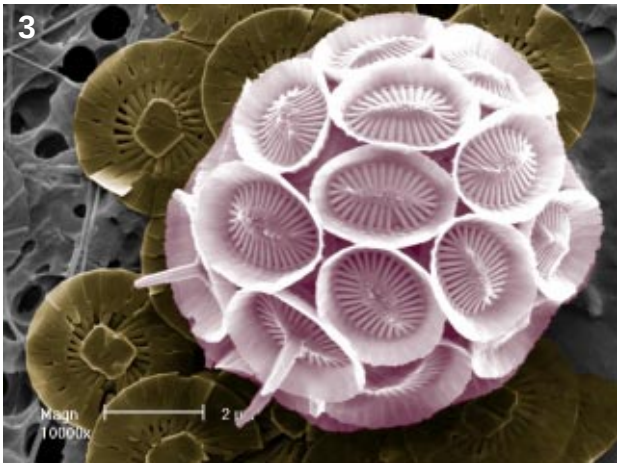
Fig.7: *Emiliania huxleyi*
This is perhaps the best known and most intensively researched coccolithophore. With the exception of the Southern Ocean around Antarctica, this species can be found in all oceans. This single species can form massive blooms (see Plate 2, Figure 6), the lateral extent of which can be very broad and, with the ability to calcify and fix biomass, this species, and coccolithophores in general, contributes significantly to the carbon cycle. This specimen is from the Canary Islands, North Atlantic (R/V *Poseidon* cruise P233b, station 2).

Fig.8: *Reticulofenestra sessilis*
This species (in green) forms unique symbiotic associations with the diatom *Thalassiosira* (in pink). This specimen is from the Gulf of Mexico (R/V *Gyre* cruise 90-G-15, station 9).

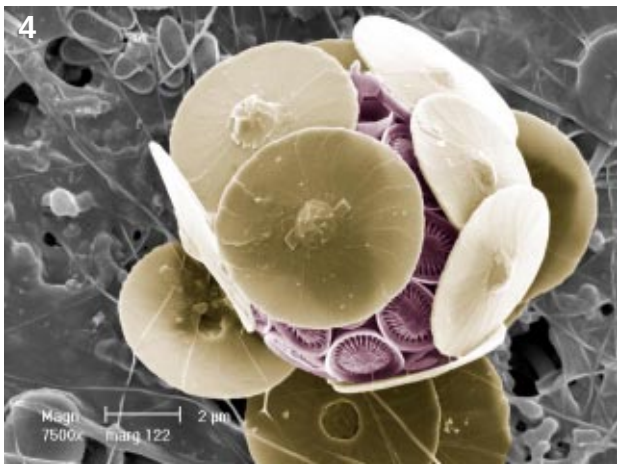


Calcidiscus leptoporus

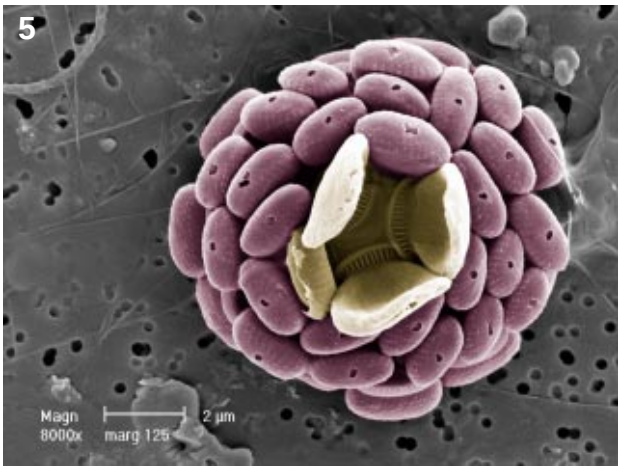
Syracosphaera pulchra



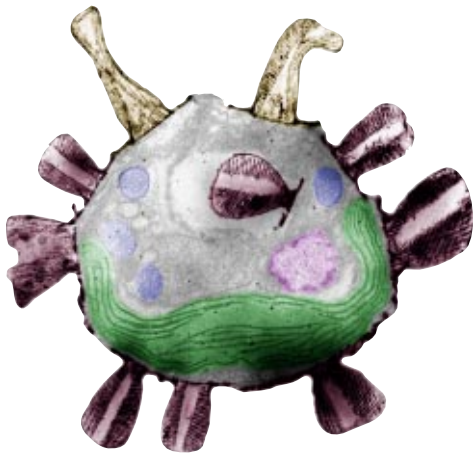
Syracosphaera nodosa



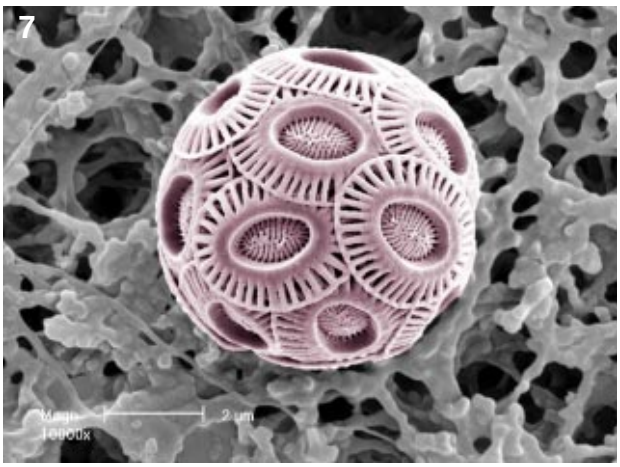
Syracosphaera anthos



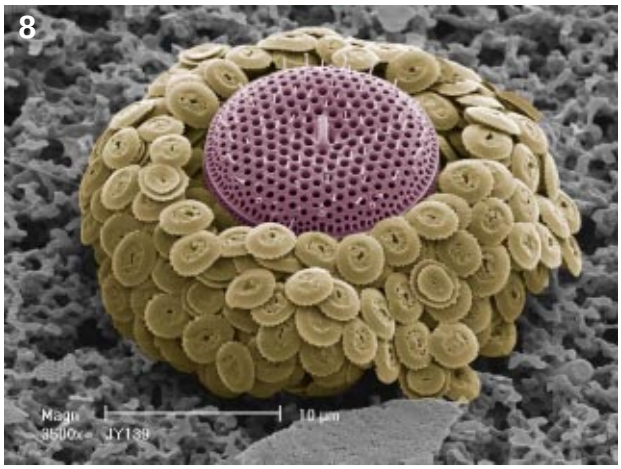
Algirosphaera robusta



Algirosphaera robusta



Emiliania huxleyi



Reticulofenestra sessilis

reproduced from Journal of Nannoplankton Research, 24, 1, 2002

Plate 2

Fig.1: *Discosphaera tubifera*
The coccoliths produced here are trumpet-shaped. The actual cell is very small in comparison to the coccoliths. The cell diameter is less than the length of the coccolith, thus the coccolith is produced inside the cell with its base folded, which causes considerable stretching for the cell. This specimen is from the Alboran Sea, western Mediterranean (R/V *Hesperides* cruise Mater II, station 69).

Fig.2: *Rhabdosphaera clavigera*
Rhabdosphaera (in green) forms long protrusions from the centre of the coccolith, and the precise architecture of these spines can be seen. A coccosphere of *Emiliania huxleyi* (in pink) can be seen in the background. These specimens are from the Alboran Sea, western Mediterranean (R/V *Hesperides* cruise Mater II, station 69).

Fig.3: *Gephyrocapsa ornata*
This species reflects the ornamentation, with an elevated bridge spanning the central area (in pink). Whilst a number of *Gephyrocapsa* species have been described, and *Gephyrocapsa oceanica* is distributed globally, *Gephyrocapsa ornata* is very rare. This specimen is from the Alboran Sea, western Mediterranean (R/V *Hesperides* cruise Mater II, station 44).

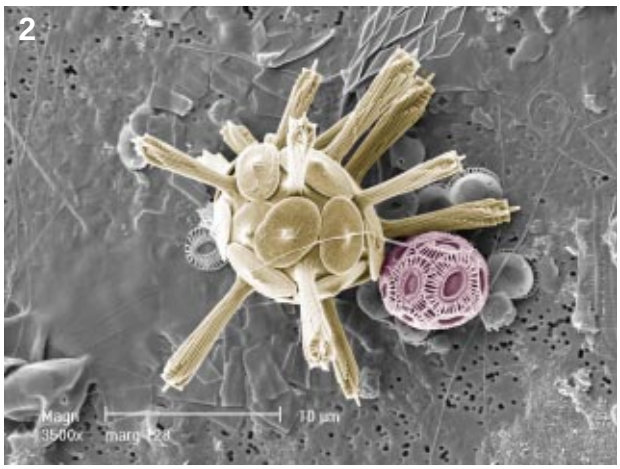
Fig.4: *Michaelsarsia elegans*
Michaelsarsia belongs to a group of coccolithophores the most striking feature of which is the presence of long appendages (in pink) around the flagellar pole. These are highly modified coccoliths, the function of which, however, is unknown. This specimen is from the Alboran Sea, western Mediterranean (R/V *Hesperides* cruise Mater II, station 69).

Fig.5: *Periphyllophora mirabilis*
This species represents another example of a holococcolith. The hole surrounded by the coccoliths (in green) is the flagellar opening. Creating a good micrograph of holococcoliths is difficult, as they are rare in the plankton and tend to disintegrate rapidly. This specimen is from the Alboran Sea, western Mediterranean (R/V *Hesperides* cruise Mater II, station 15).

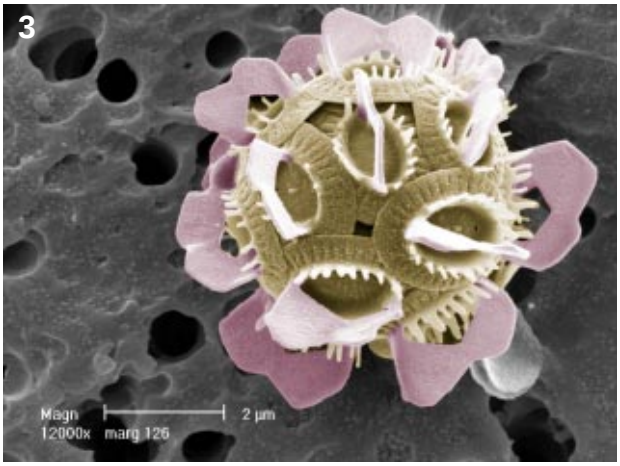
Fig.6: *Emiliania huxleyi* bloom off Cornwall
Under certain conditions, *Emiliany huxleyi* can form massive blooms which can be detected by satellite remote sensing. What looks like white clouds in the water, is in fact the reflected light from billions of coccoliths floating in the water-column. Image courtesy of Steve Groom, Plymouth Marine Laboratories.

Fig.7: Coccolithophorid life-cycles
Schematic representation of coccolithophorid life-cycles. The diploid stage of *Calcidiscus leptoporus* is covered with heterococcoliths (left, in pink) which are produced inside the cell, whereas the motile stage is covered with holococcoliths (right, in green) which are produced outside of the cell membrane.

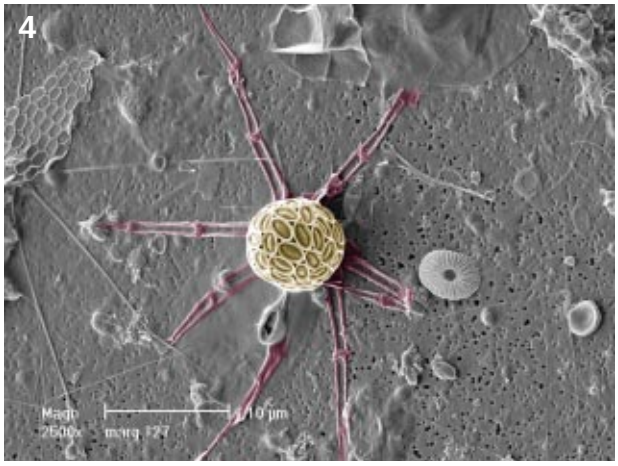
Discosphaera tubifera



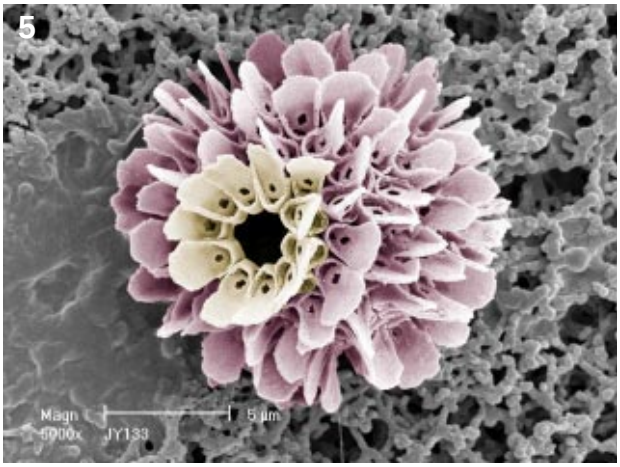
Rhabdosphaera clavigera



Gephyrocapsa ornata

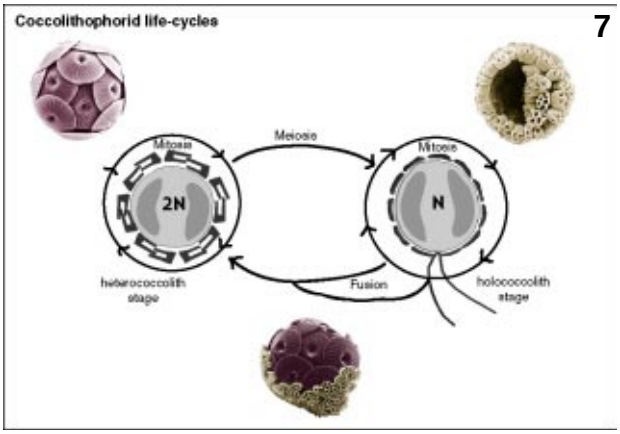


Michaelsarsia elegans



Periphyllophora mirabilis

Emiliania huxleyi bloom



Coccolithophorid life-cycles