

Cultivating microalgae at high density in animal tissues: the feat of a photosynthetic marine flatworm model

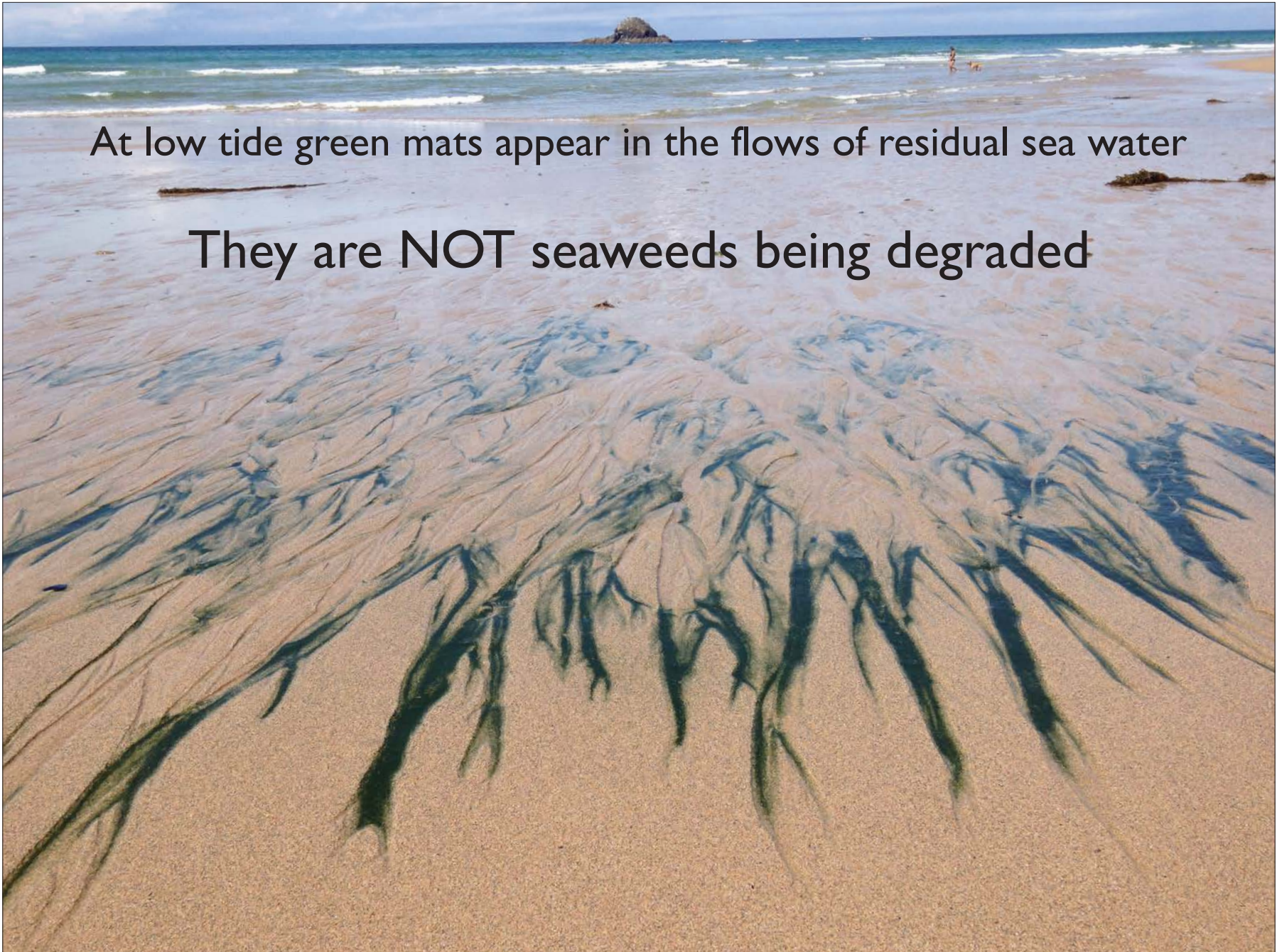
Station Biologique de Roscoff

Centre National de la Recherche Scientifique / Sorbonne Universités

**Functional Exploration in Multicellular Marine Models
and Marine Life-Cycles in Captivity**

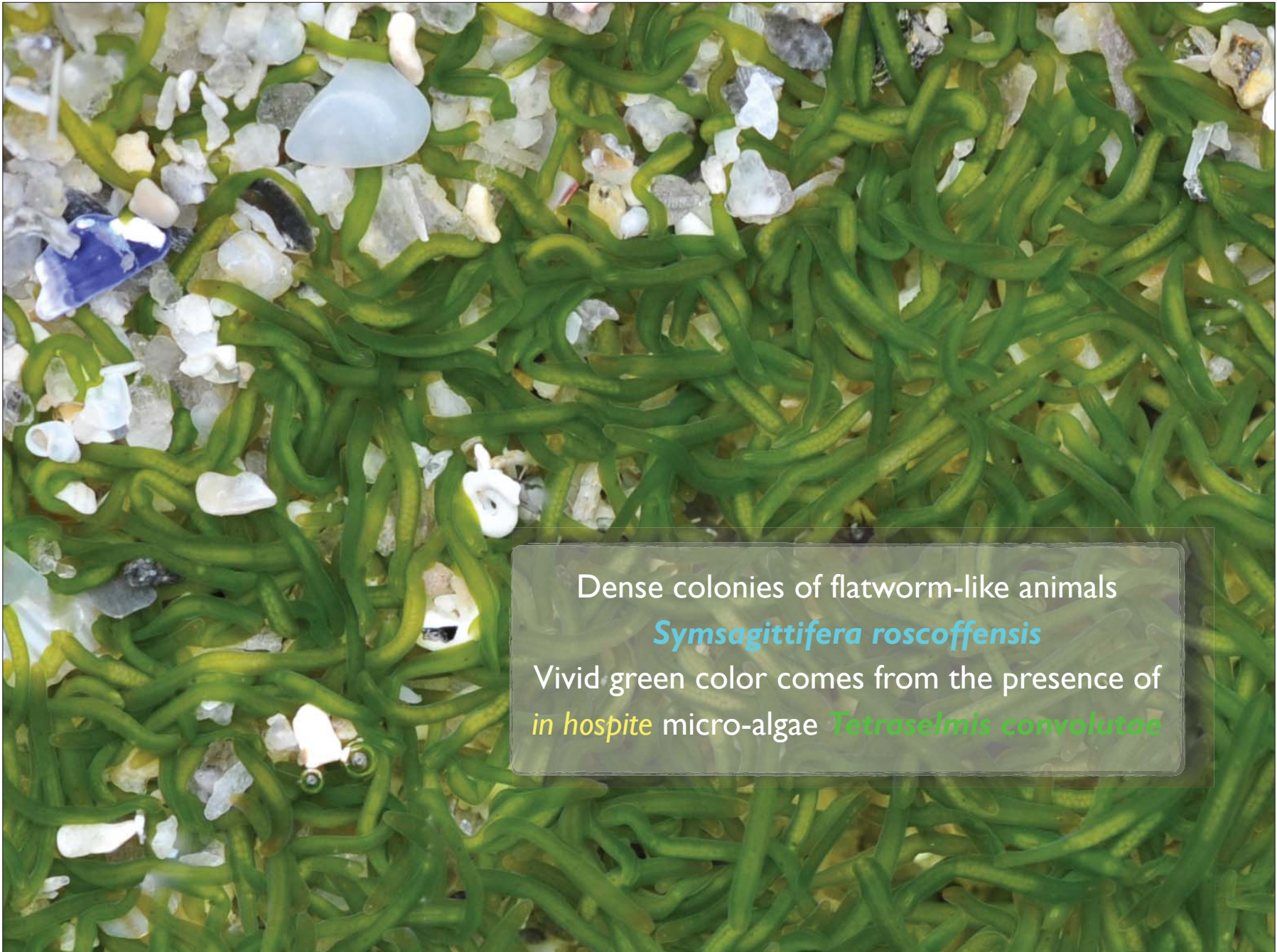
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Agrospace-MELISSA Workshop - Current and Future Ways to Closed Life Support System, Rome, May 16,18 2018



At low tide green mats appear in the flows of residual sea water

They are **NOT** seaweeds being degraded



Dense colonies of flatworm-like animals
Symsagittifera roscoffensis
Vivid green color comes from the presence of
in hospite micro-algae *Tetraselmis convolutae*

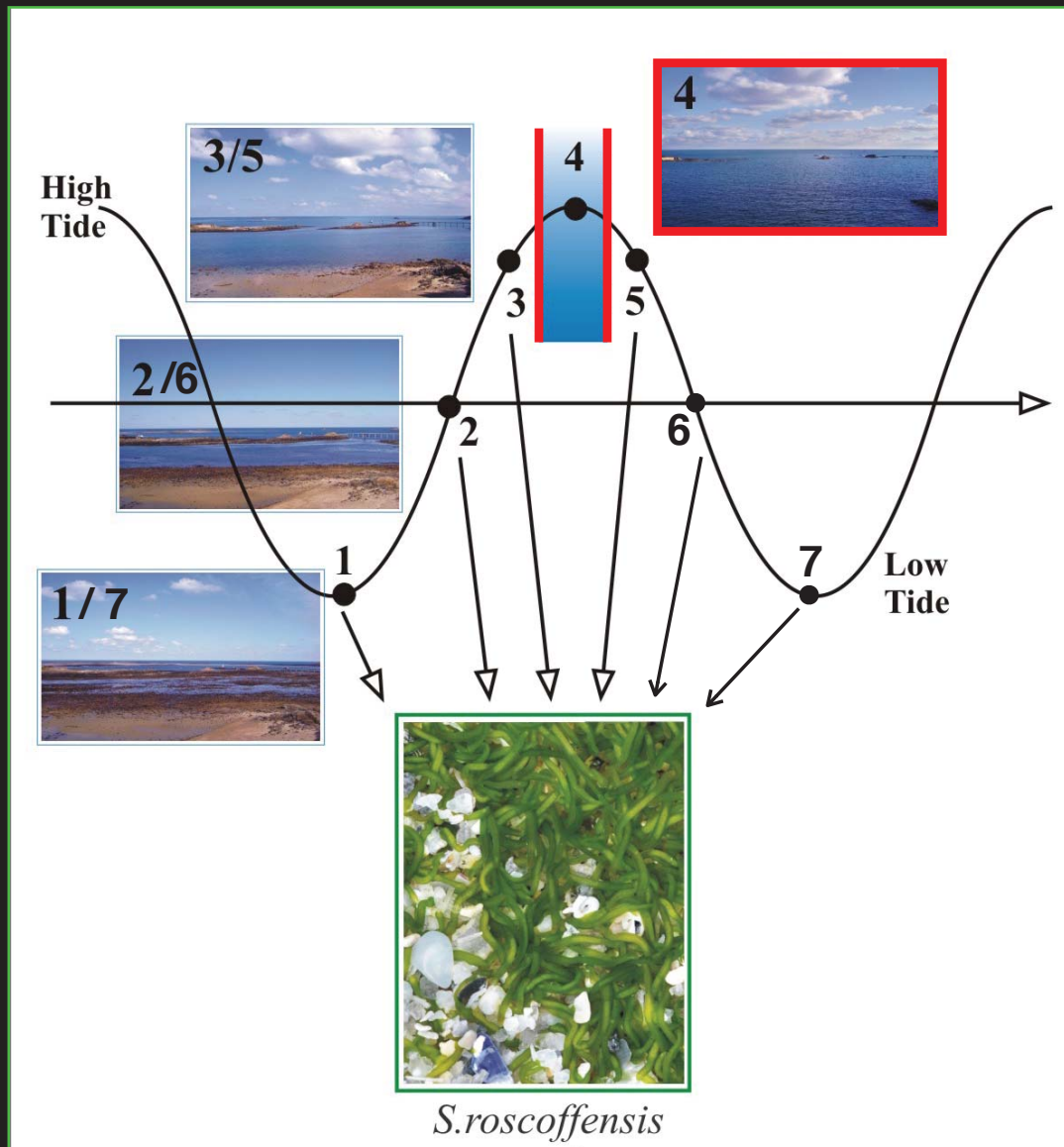
Symsagittifera roscoffensis

Adult stage

env. 3 to 4 mm

Photosynthetically functional animals

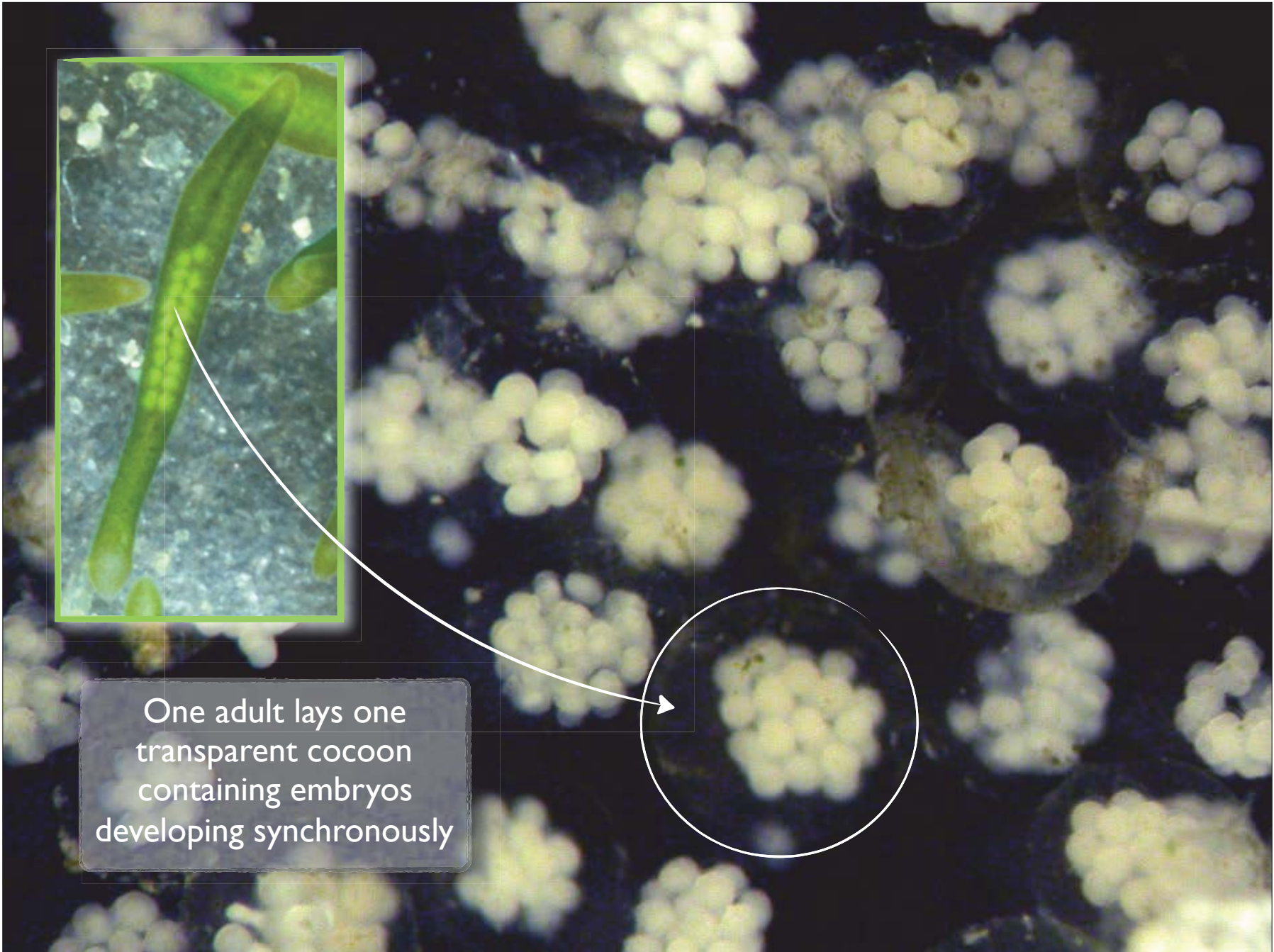
S. roscoffensis lives on the upper part of the beach and undergoes the circatidal rhythm



At high, tide animals shelter in the sand

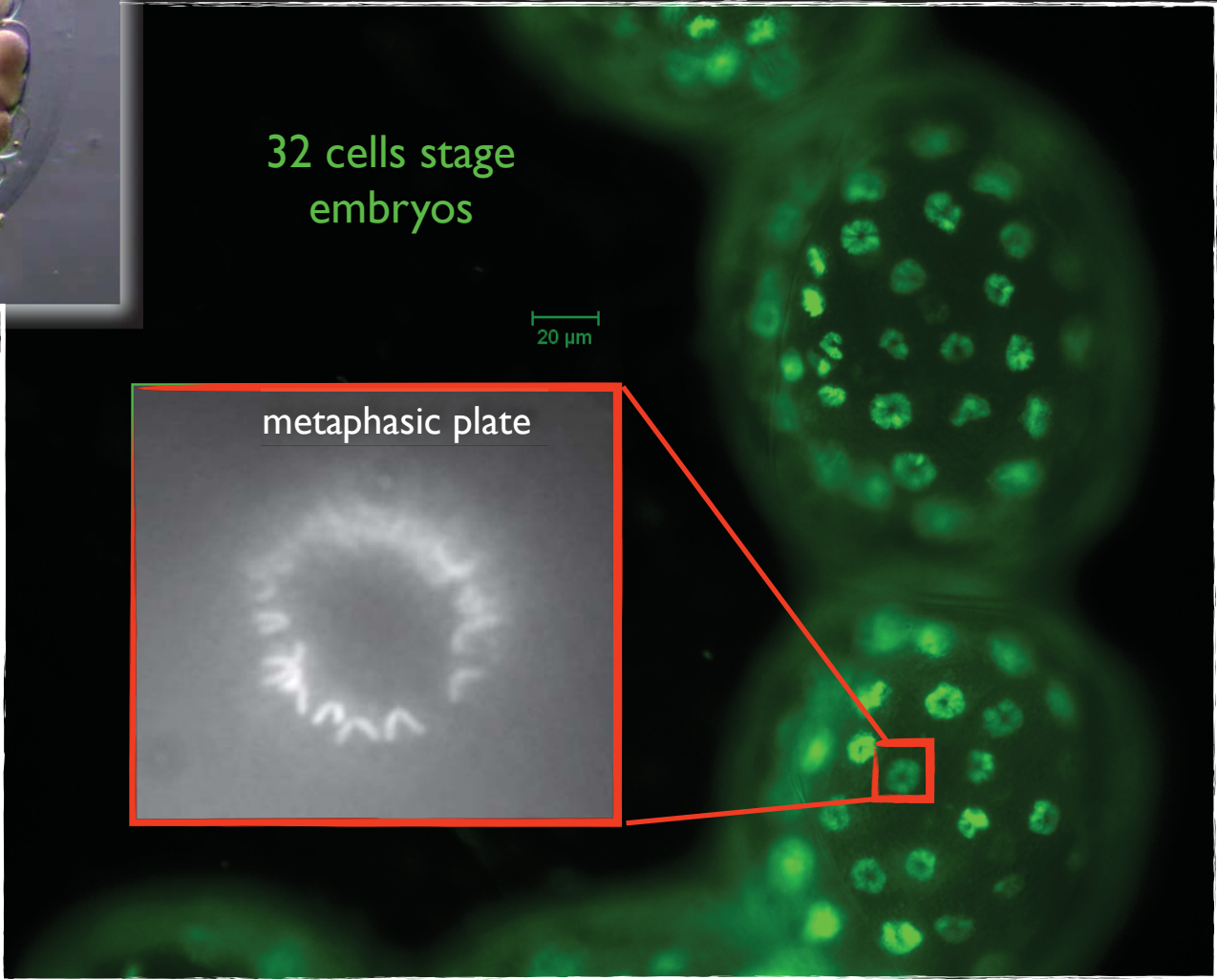
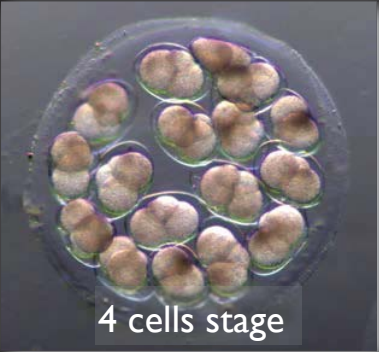
At low tide, animals lay on the sand (in residual sea water flows)

S. roscoffensis only feed on the photosynthates released by the microalgae



One adult lays one transparent cocoon containing embryos developing synchronously

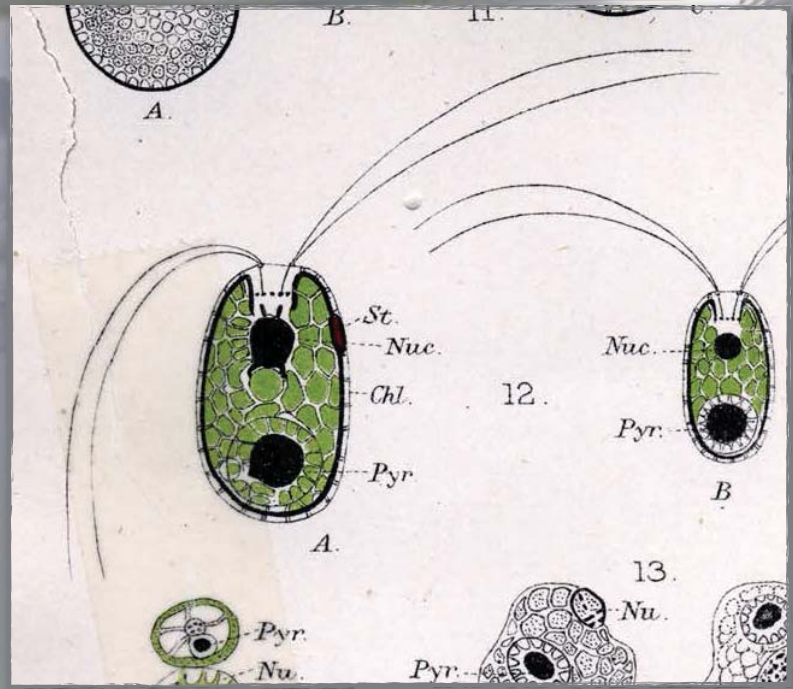
Early access to embryogenesis



A microscopic image showing several juvenile stages of the flatworm Symsagittifera roscoffensis. The organisms are translucent, elongated, and appear to be in various stages of development. They are set against a dark, almost black background, which makes their internal structures and colors (pale yellowish-green) stand out. The focus is sharp on the central organism, while others in the foreground and background are slightly blurred.

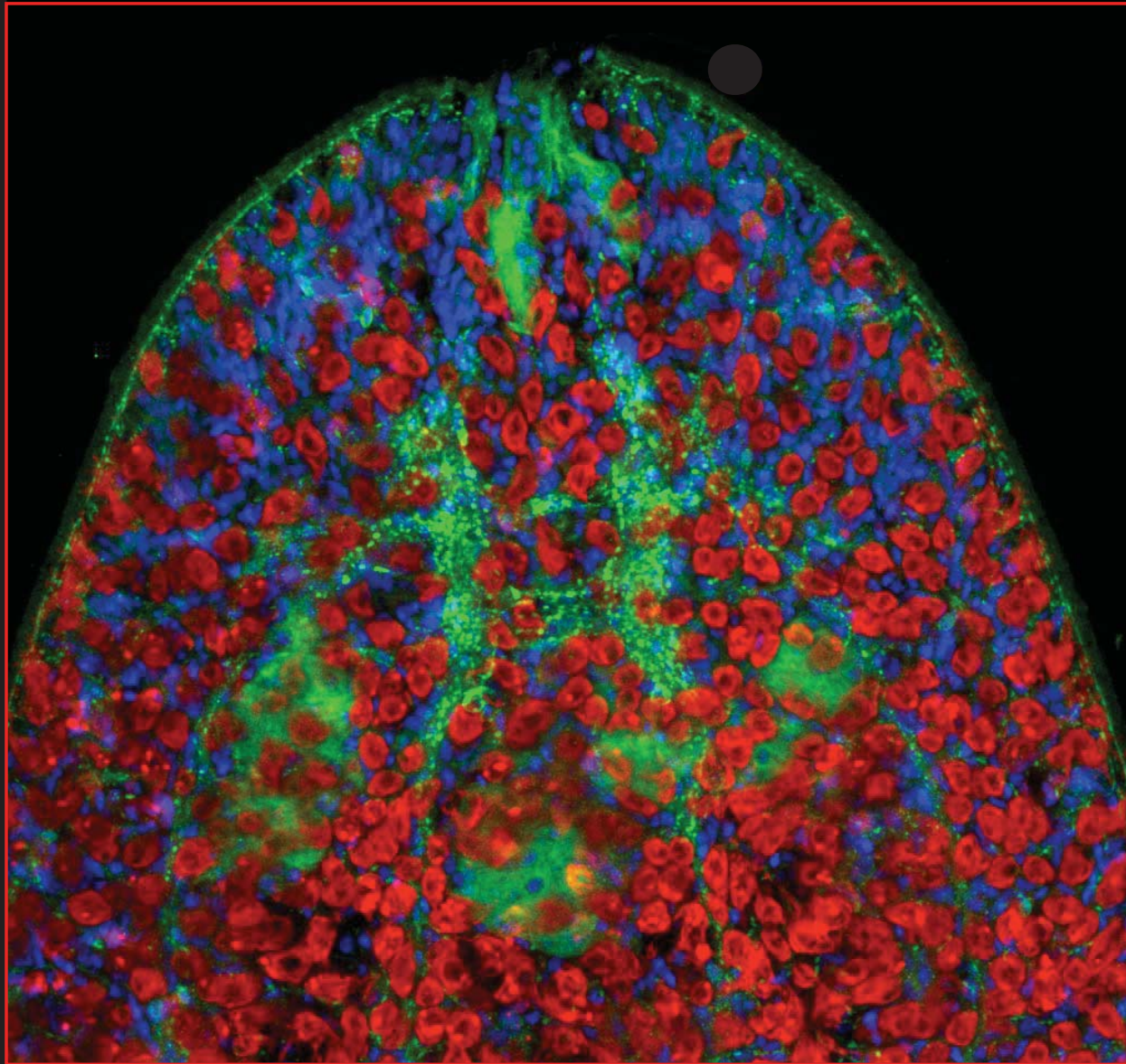
Symsagittifera roscoffensis
Juvenile stage aposymbiotic

Horizontal (environmental) transfer of the photosymbiont





Symsagittifera roscoffensis juvenile with first ingested (NOT DIGESTED) microalgae (in red - visualized with epifluorescent microscope)



40.000 to 70.000 (maybe more than 100.000) *in hospite microalgae*

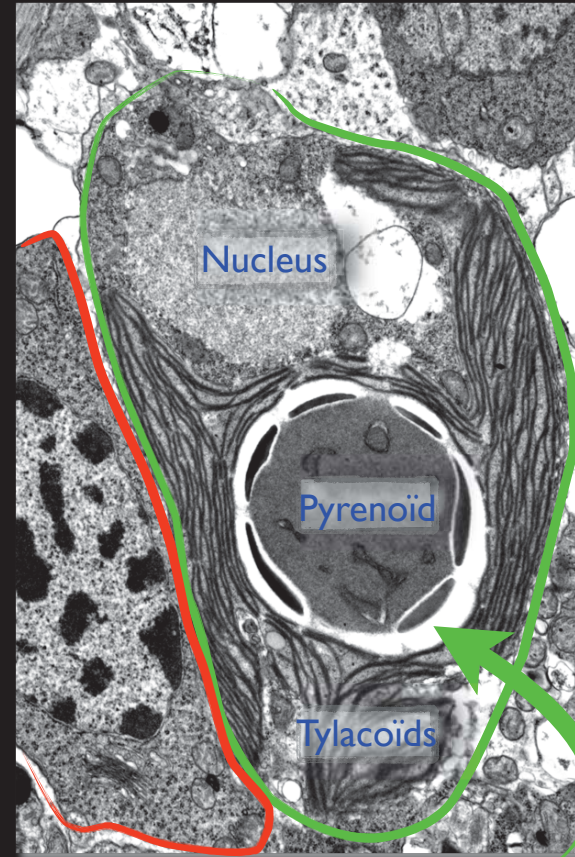
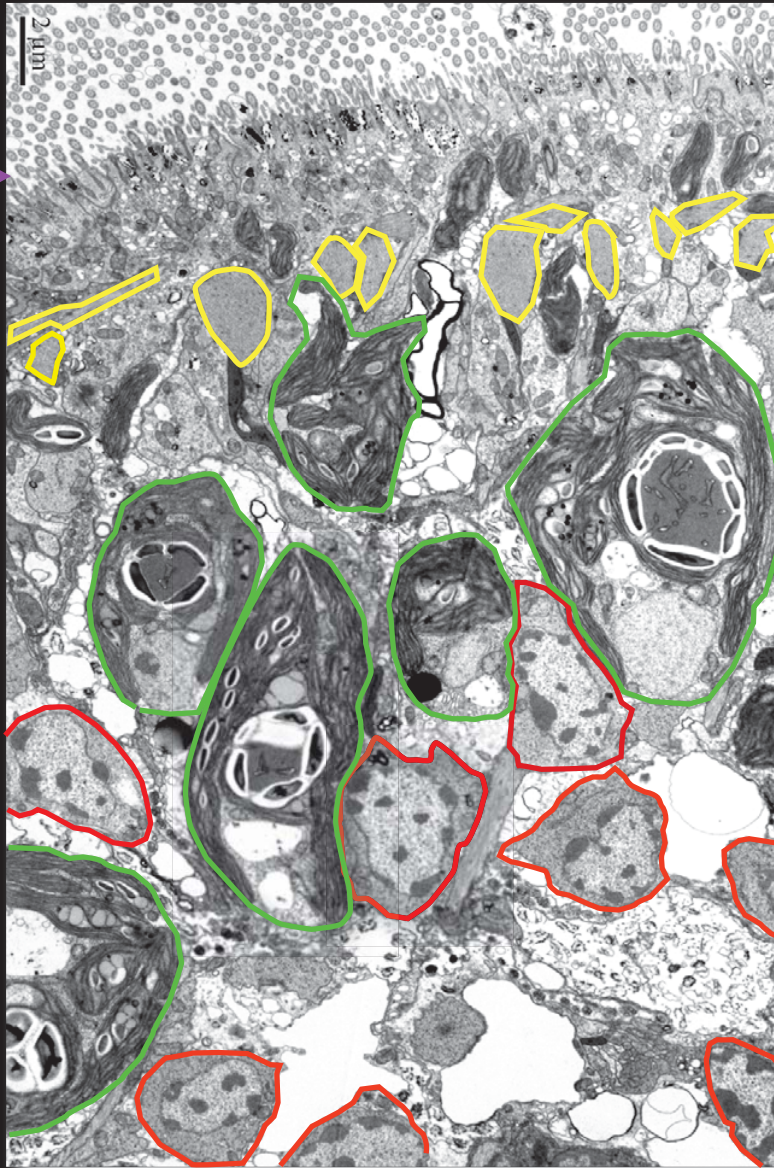
Microalgae are **NOT** internalized (= in between the animal cells)

Epidermis with cilia above

Muscular fibers

Microalgae

Animal cells



White halo = starch = energy

Transmission Electronic Microscopy (adult *S. roscoffensis*)

Trophic relationship - *S roscoffensis* is a photosynthetic animal : an animalgae

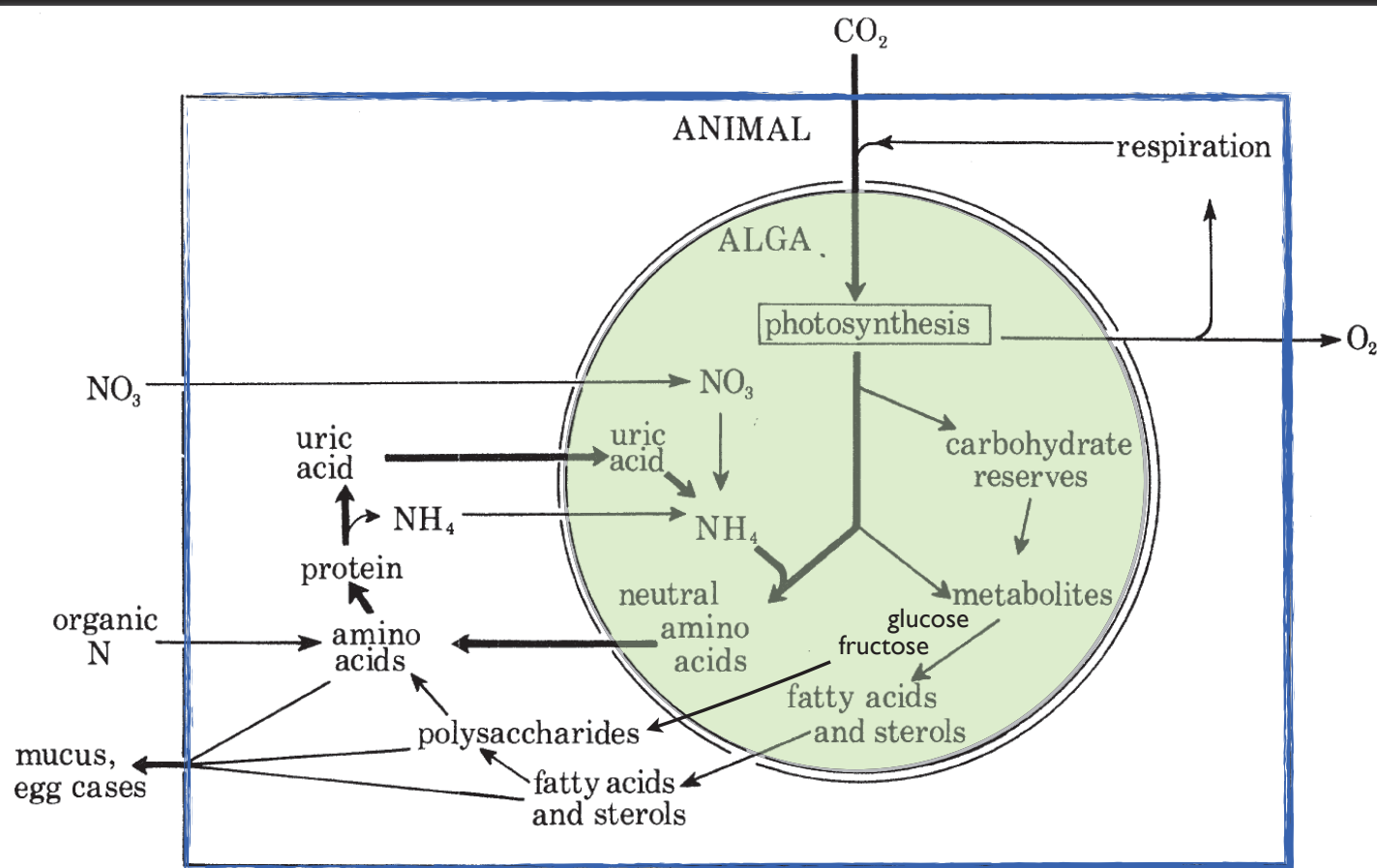
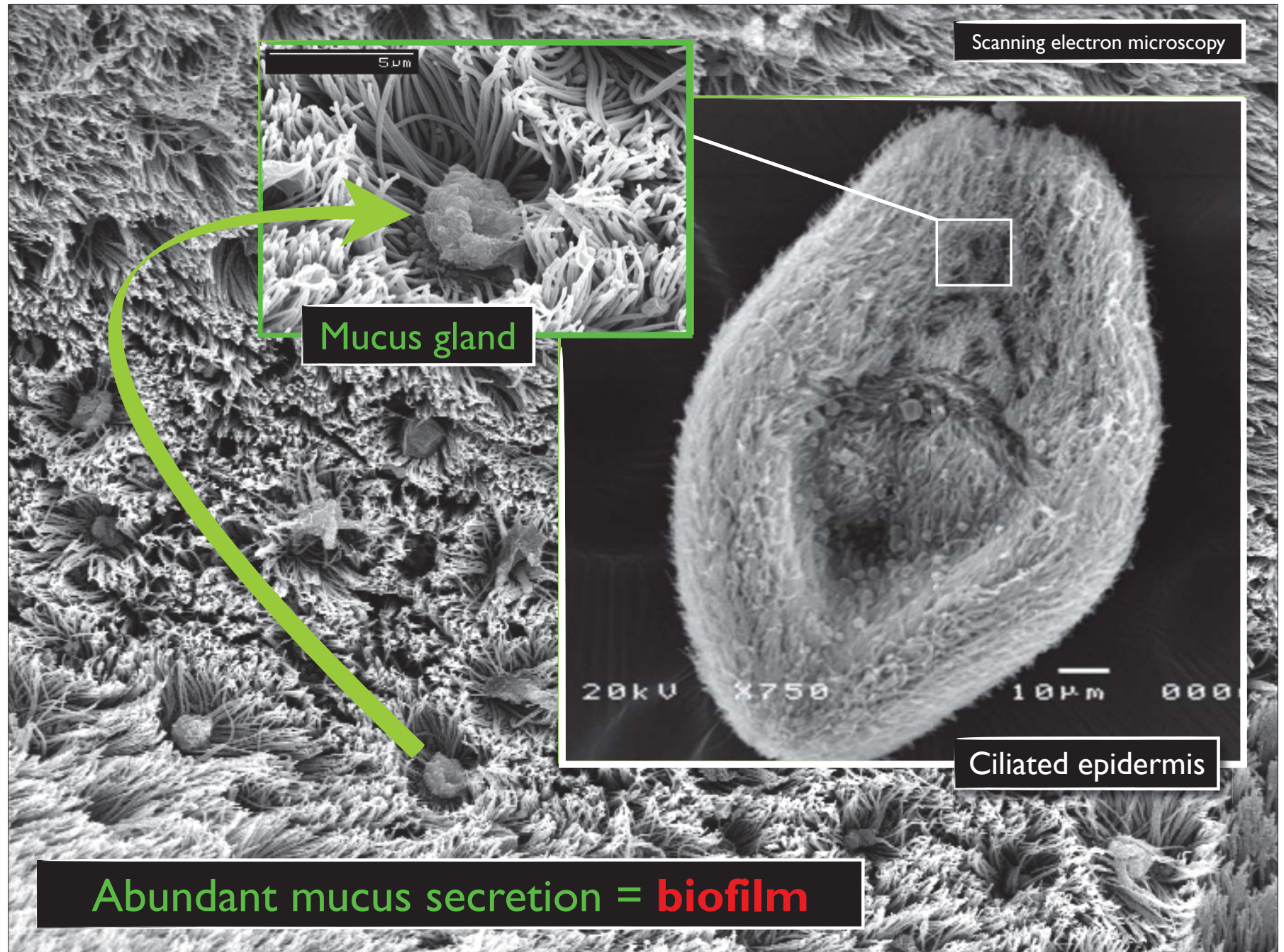
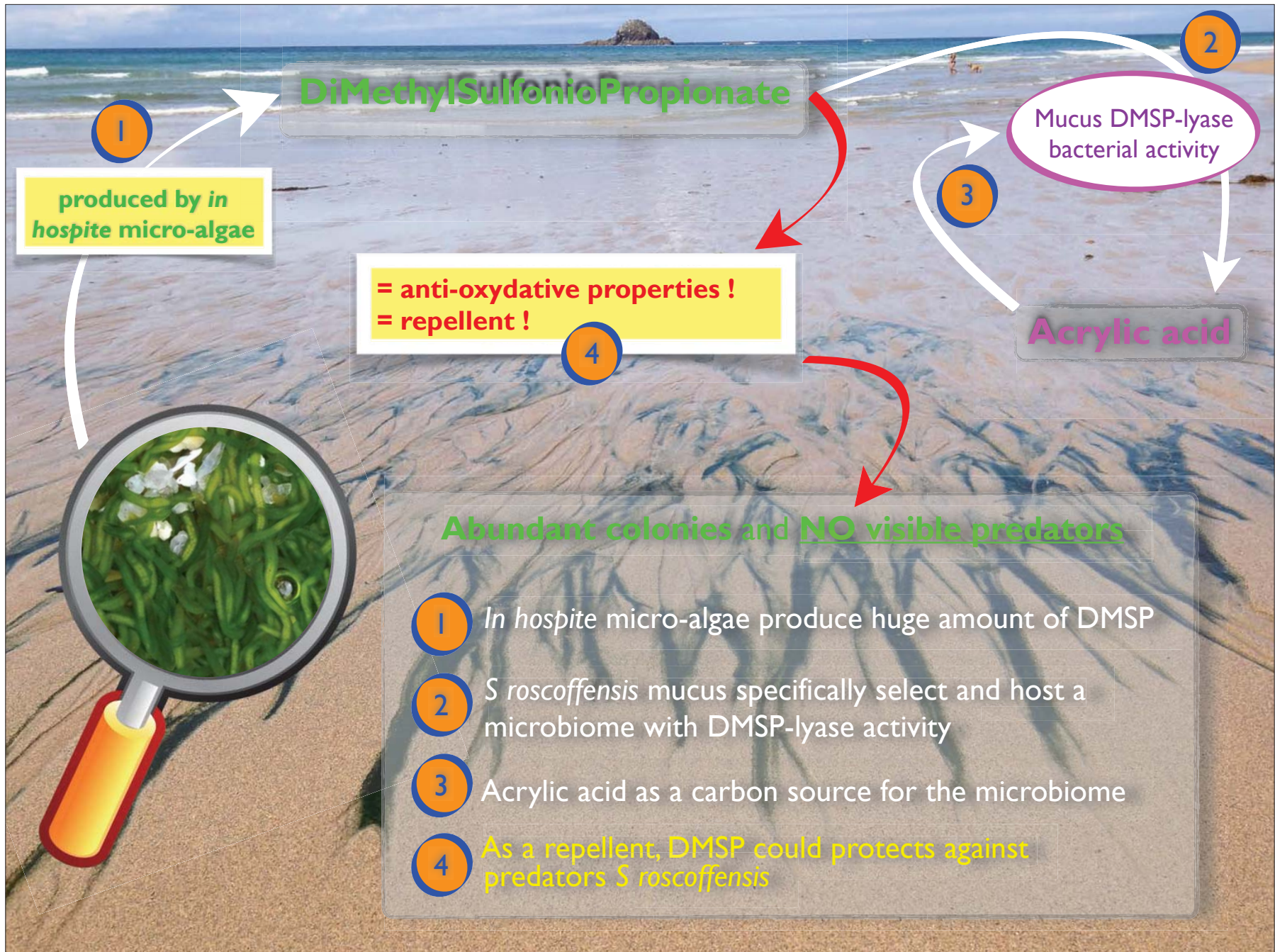
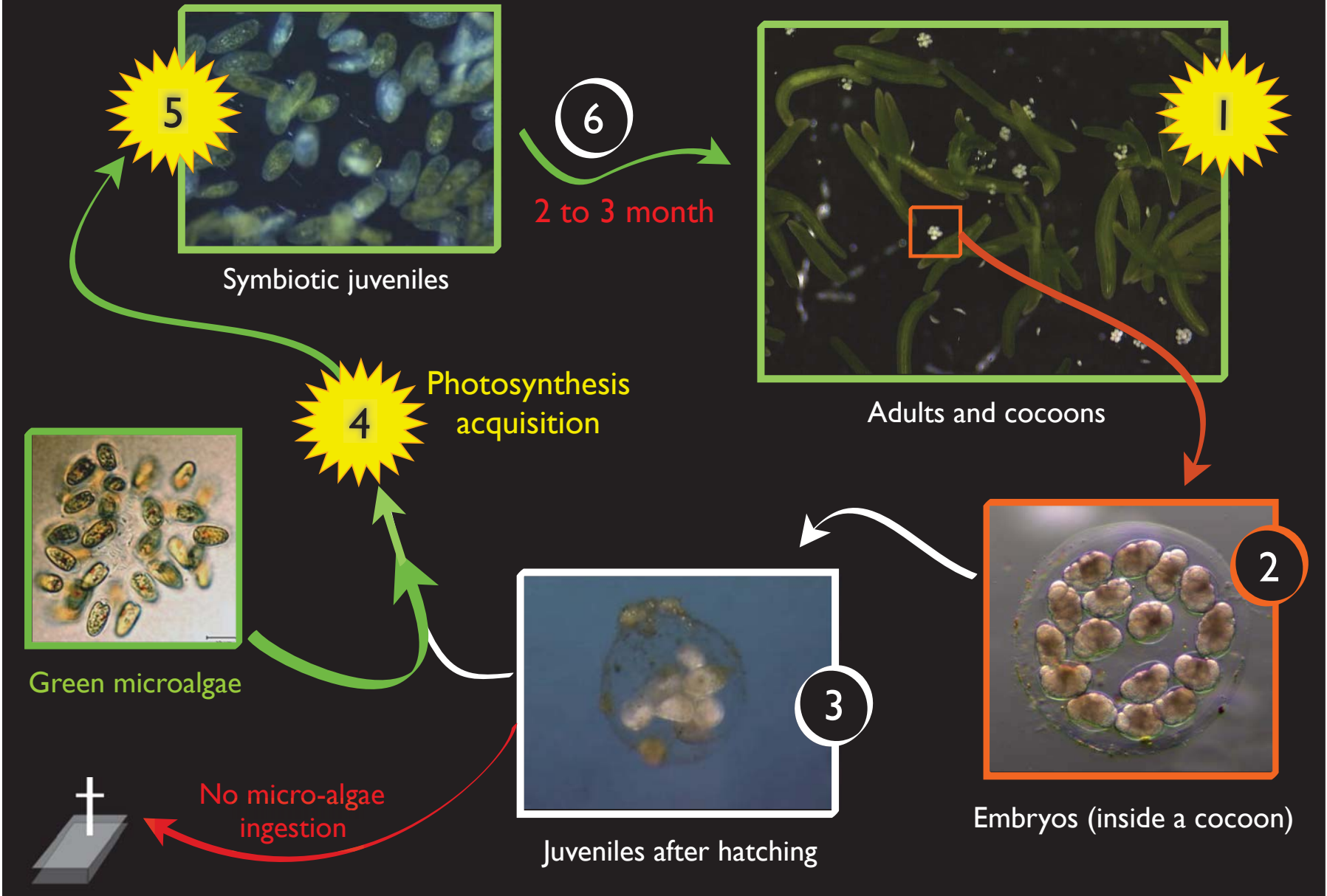


FIGURE 6. Recycling of nitrogen by the algal symbiont of *Convolvula roscoffensis*. The main pathways are indicated by the thicker arrows. The principal nitrogenous waste product of the animal is uric acid. This is taken up and broken down to ammonia by the alga (*Platymonas convoluta*), and is then used to form amino acids. Neutral amino acids (especially glutamine, but also glycine, serine and alanine) are released back to the animal. For further details, see Boyle & Smith (1975) and Holligan & Gooday (1975).

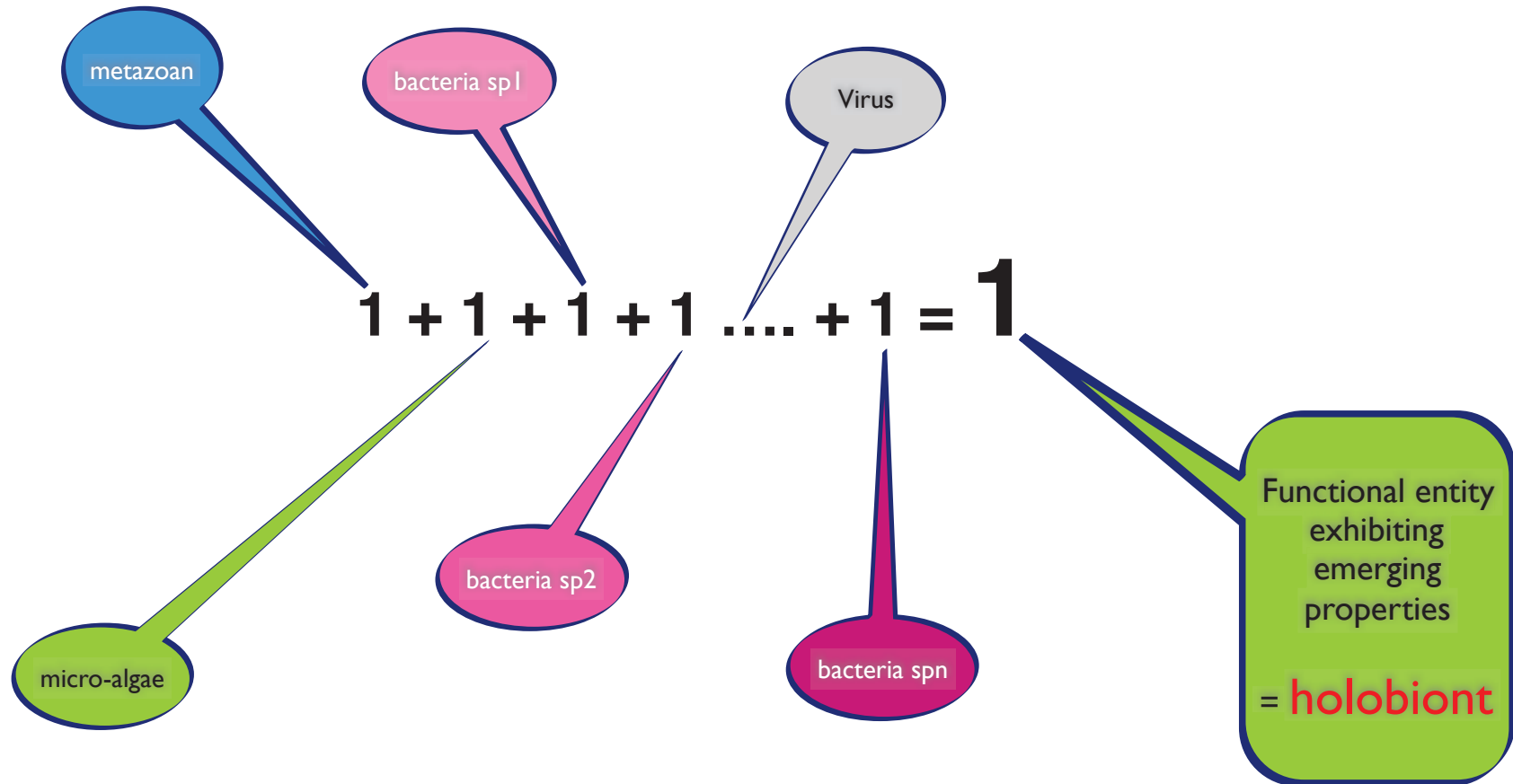


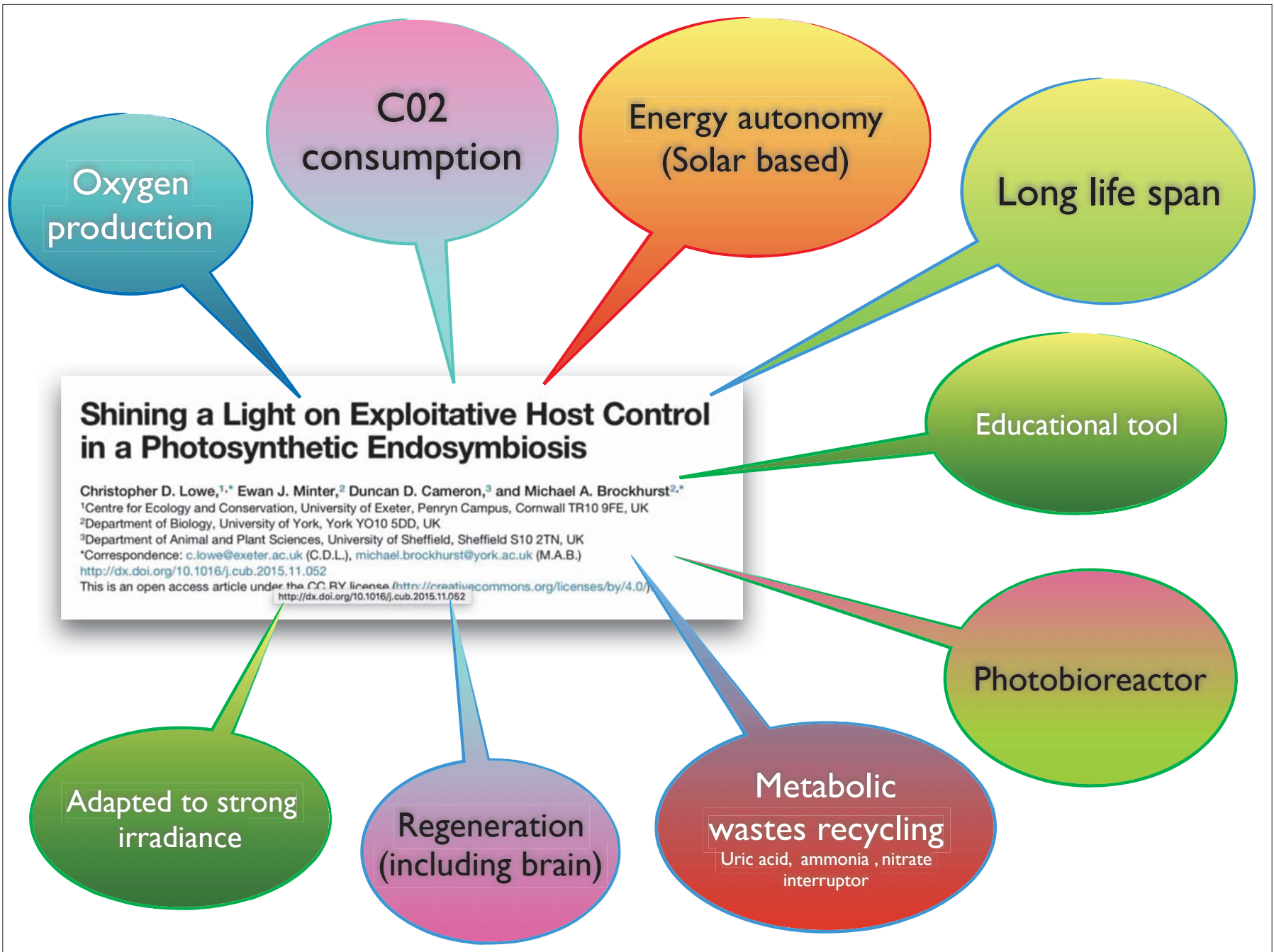


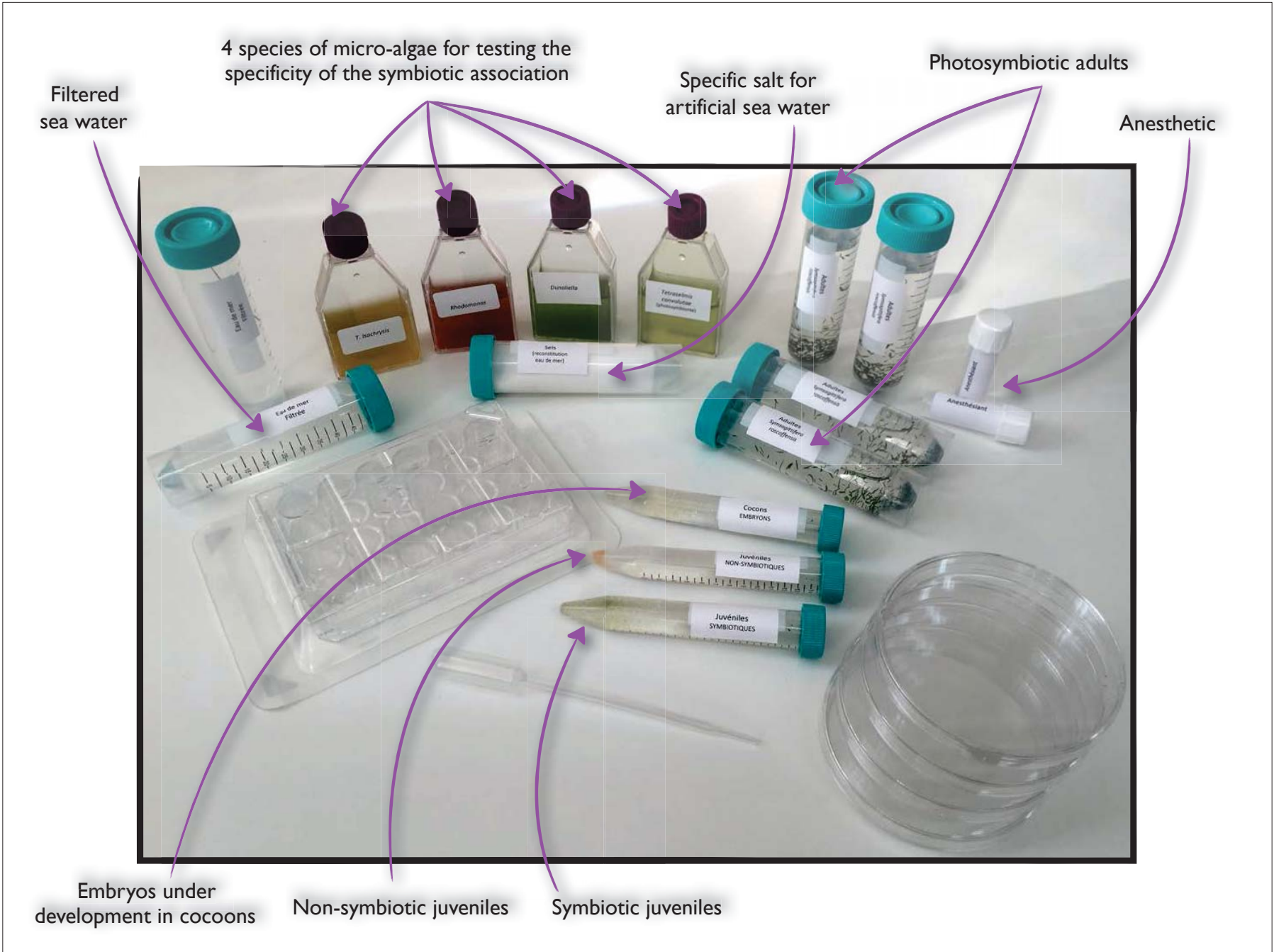
Controlling the life-cycle in captivity

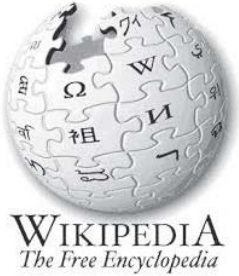


S. roscoffensis is **not the result of an addition**
but of a **complex integration of partners**









https://en.wikipedia.org/wiki/Symsagittifera_roscoffensis

The screenshot displays the Wikipedia article for *Symsagittifera roscoffensis*. The page layout includes a left sidebar with navigation options, a main content area with a table of contents and introductory text, and a right sidebar with scientific classification and a photograph of the organism. The main text discusses the biology and ecology of the species, its history, and its discovery.

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 - 1.1.1 Biotope and ethology
 - 1.2 Anatomy of the adult and reproduction of the species
- 2 The photosynthetic partner and the modus vivendi between the animal and the micro-algae
 - 2.1 Discovery and characteristics of the partner micro-algae
 - 2.2 Life cycle
 - 2.3 Modus vivendi: a highly integrated partnership - not only additive
- 3 Teaching photosymbiosis: an educational tool to introduce marine biology
- 4 Are there any egalitarian partnerships in nature?
- 5 Notes and references
- 6 See also

Biology and ecology of the species *Symsagittifera roscoffensis* [edit]

Although *roscoffensis* means "who comes from Roscoff", this flatworm is not endemic to Roscoff or North Brittany. Its geographical distribution extends over the Atlantic coast (colonies were observed from Wales to the south of Portugal).

130 years of history [edit]

In 1879, at the Station Biologique de Roscoff founded by Henri de Lacaze-Duthiers, the British biologist Patrick Geddes^[1] questioned himself on the nature and origin of the green compound of a local acœla he called *Convoluta schultzei*. He succinctly described "chlorophyll-containing cells" and the presence of associated starch "as in plant chlorophyll grains".

In 1886, French biologist Yves Delage^[2] (second director of the Station Biologique de Roscoff) published a detailed historical study describing (among other things) the nervous system and the sense organs of the same Roscoff acœla *Convoluta schultzei*. In this article Delage also wonders about "the nature of zoochlorella (i.e. micro-algae)": "are they real algae?" - "Where do they come from?" - "What are the symbiotic relationships that unite them to their commensal?"

In 1891, Ludwig von Graff, a German zoologist from the University of Graz and a specialist in acœla, undertook a taxonomic redescription of the Roscoff acœla at the Station Biologique de Roscoff.^{[3][4]} His works highlight a taxonomic confusion in the previous works of Geddes and Delage^{[1][2]} "... the researches made in Roscoff and on the Adriatic coasts showed me that the green convoluta of the Adriatic (*Convoluta schultzei*) ... is specifically different from the green *Convoluta* of Roscoff. I have preserved for the first one the old name *Convoluta schultzei*, for the second I give the name of

Scientific classification

Kingdom: Animalia
Phylum: Xenacoelomorpha
Subphylum: Acoelomorpha
Class: Acoela
Family: Sagittiferidae
Genus: *Symsagittifera*
Species: *S. roscoffensis*

Binomial name

Symsagittifera roscoffensis
(Graff, 1891)

Synonyms

Convoluta roscoffensis Graff, 1891

Original painting by Ludwig von Graff

Symsagittifera roscoffensis, the "Roscoff worm"