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Surfing amongst Oil-Tankers: Connecting Emerging Research Fields to the Current International Landscape

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The COST Action Phycomorph (FA1406) was initiated in 2015 from a handful of academic researchers, and now joins together 19 European countries and nine international partners. Phycomorph's goal is to coordinate and develop research on developmental biology in macroalgae. This is an ambitious project, as the related scientific community is small, the concepts are complex, and there is currently limited knowledge of these organisms and there are few technologies to study them. Here we report the first step in achieving this enterprise, the creation of the Phycomorph network. We share the associated strengths, pitfalls, and prospects for setting up the network in the hope that this might guide similar efforts in other fields.

Development of Macroalgae: Why Build a Network?

Macroalgae (seaweeds) are the key primary producers in the coastal environment. 25 megatonnes are harvested annually, 99% from aquaculture, for food, feed, and valuable extracted products including hydrocolloids (for agricultural, textile and cosmetics industries), fertilisers, pharmaceuticals, and potential biofuels[i]. Beyond their economical importance, macroalgae are key players in the coastal ecosystem, as shelters and food sources for aquatic fauna. The main open question is how macroalgal sustainability can be ensured. Climate change and ocean acidification modify macroalgal populations globally [1,2]. Some algae used in industry (e.g., agar-producing *Gelidium*) are already declining and more knowledge of their growth and developmental mechanisms is required to ensure a sustainable replenishment of their currently exploited wild biomass [3].

Basic biological knowledge about macroalgal development is lacking and the following fundamental questions remain open: How do gametes fuse in moving water? How do embryos survive without a parental protective and nutritional environment? Where do instructions (signals) for development and fertility come from? What controls organ development? What is the macroalgal potential for stem cell production? Answers to these questions will have an important impact on seaweed aquaculture and sustainable management, as they will enable better control and monitoring of seaweed life cycles (including juveniles) and the development of fertility and fitness markers and of cryopreservation protocols (Figure 1).

Currently only a small scientific community addresses these subjects. Algae have no close evolutionary relationship with land plants, despite sharing some of their morphological features, so the utility of knowledge-transfer from a better-studied group is limited. Indeed, different algal lineages (red, green, and brown) are separated by over a billion years of evolution [4] despite having become adapted to similar environments.

The best way to reinforce the current knowledge base was to consolidate a small and scattered scientific community through a strong pan-European interdisciplinary collaborative network – a COST Action.

Setting up a Network: From the Initial Idea to its Realization

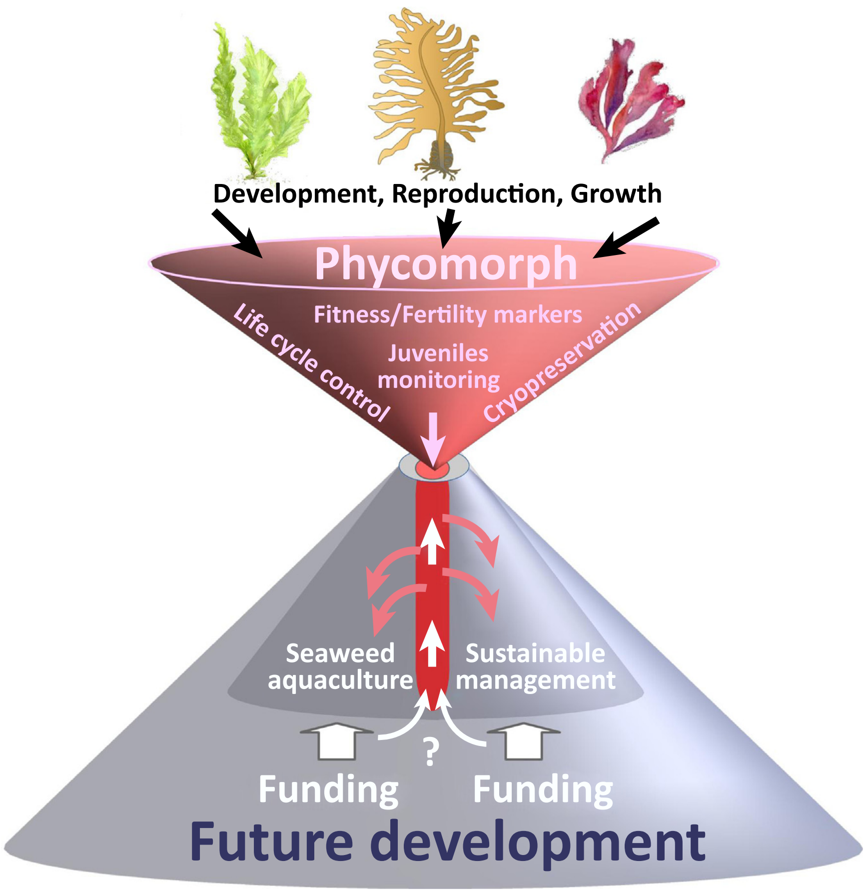
Phycomorph was originally established by three researchers working on the three separate macroalgal lineages. They had distinct scientific backgrounds: phycology, plant development, and eukaryotic evolution and development. Contacts were made first through one researcher's publication on algal morphogens, then through informal information obtained from a former post-doc who had relocated to a plant evo-devo lab. The researchers met and concluded that there was a clear requirement to structure the scientific community, which was diversifying partly because of the rise of evo-devo due to falling costs of high-throughput sequencing technology.

Did the community share common goals, and was it large enough to constitute a vibrant network? More potential collaborators were identified through bibliographic searches, word of mouth and via recently-established collaborations. Thanks to a generous financial contribution from one partner university, 18 researchers of different nationalities, ages, and disciplines gathered in late 2011. The group decided to sustain the community by seeking funding. The Phycomorph network project (FA1406) was submitted in several iterations to the COST Association, which provides financial support for 4 years. Today it includes over 40 teams from 19 European countries and nine non-European partners, with over 150 people involved in its activities.

What Are the Advantages and Pitfalls When Setting up Such Networks?

Too Small or too Big?

The first pitfall was the initial evaluation of the project by the COST Association, which defined the project as too limited to basic sciences. Based on this feedback, the project was extended to include more applied partners to give the network a higher societal relevance. There were key concerns: how would these two



Trends in Plant Science

Figure 1. COST Action Phycomorph as a Flexible Funnel Fertilizing the Seaweed Biomass Production Sector. Phycomorph, a scientific network focused on basic research, aims to provide reliable answers to specific questions that will benefit aquaculture end-users and bioresource management schemes, hence having a long-term strong socioeconomic impact (pink arrows). The aim of establishing links with large or small enterprises implies that Phycomorph will go beyond science alone. Together with the other stakeholders, it will promote innovation in this field and its future development, in line with the societal demand, provided that funding fertilises it in turn (white arrows).

communities work together, with differing short-term goals? Some were interested in 'how', the others in 'how much'. Were both goals compatible? 'Downstream' macroalgal producers (i.e., algal aquaculture and biomass exploitation), and 'fragile' SMEs were reluctant to join our call. However, publicly-funded R&D laboratories were convinced that increasing fundamental knowledge of algal growth and development is an essential step in the sustainability of macroalgal exploitation, both in hatcheries and their natural environment. The vision of these labs' managers was therefore decisive for the future reinforcement of the community: 'The societal impacts will not be seen in 10 years, but in 20'.

Maintaining the Focus

COST Actions are not closed or static; they are open at any time to anyone who applies and is qualified to join, such as industry, society, and policy stakeholders. So, how can we avoid that a small community, initially focused on specific targets, grows into a large group whose diverse overlapping interests might only have few (perhaps tangential) links with the scientific objectives? The current larger network composition provides wealth but also a certain fragility. How then to keep on course? Two safeguards, goal-tracking and funding, prevent COST networks getting lost. Working Group leaders monitor targets. A committee representing the Member States (Management Committee) evaluates the suitability of new members. Rigorous management of the Action ensures that funding is used transparently, its major goal being to achieve the objectives and deliverables of the Action through strong collaborative and networking activities. Thus, even if the network is very large 'on paper', its management, its resources, and its specific objectives act as 'filters' ensuring that only members - both long-standing and recent - directly related to the objectives actually benefit financially from its activities. It should be noted that COST Actions can be adapted as science advances.

Reliability and Efficacy of a Target-Driven Approach

Phycomorph is a bottom-up network, a researcher-originated initiative funded by COST. Bottom-up scientific initiatives encourage non-mainstream ideas and support innovation (Box 1). Although in other funding scheme frames political decision-makers, guided by societal needs, can set (usually short-term) goals, COST Action proposers, who are experts in planning and costing experiments using appropriate technologies, prepare a feasible and reliable workplan as a first stepping-stone to longer-term goals. Researcher networks provide resilience and adaptability, with combined expertise enabling cost-effective goal achievement, especially if troubleshooting is required. Thus, small networks of experts united by common research interests focused on well-defined objectives can be more efficient and more responsive than large international groups. Purely scientific networks not only share common technology or infrastructure, but most importantly they convey cutting-edge concepts, based on knowledge from decades of rigorous scientific experimentation. Their ambition is to provide reliable answers to specific questions, rather than gathering

Box 1. COST Actions Are Fully Bottom-up Networks

COST Actions[ii] are science and technology networks open to researchers and stakeholders, from COST members and beyond, having nationally funded research. They are initiated 'bottom-up' by researchers themselves, allowing them to build reliable, responsive, and focused networks in any area, but especially those considered risky or nonmainstream (Figure I). They are highly interdisciplinary, connecting both established and younger researchers; they are inclusive, increasing visibility, fostering excellence and innovation, and facilitating access to broader programmes. They are initiated by researchers from at least 5 COST countries, to achieve specific objectives within their four-year duration, centred on the creation, diffusion and application of knowledge within the framework of the COST Action. The objectives can be achieved through a wide range of networking tools supported by COST, such as workshops, conferences, training schools, short term scientific missions, and dissemination activities. Expertise of active members, inclusion of early career investigators, and good geographical and gender balance are some of the parameters that the management committee considers when deciding how to allocate the funding to participants. COST Actions are flexible and can adapt to science advancements. They often evolve into collaborative networks for Horizon2020, and in some cases into international societies and/or associations. Moreover, spinoff companies have emerged from COST Actions. In some cases, COST participants have contributed to new regulatory frameworks and standards at national and European levels. COST Actions are facilitators of both science and policy (for more details on Phycomorph see COST Action FA1406[iii]).

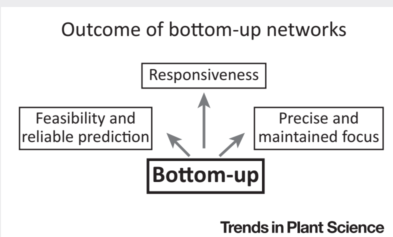


Figure I. Founding Principles and Resulting Valuable Specificities of Bottom-up Networks

vague trends on broader, less-well defined areas.

Ensuring Continuity by Training the Next Generation

Progress not only involves accumulation of data, but also needs to ensure continuity in transmitting the knowledge to the next generation. COST Actions ensures this goal by training early career scientists. In 2015, 347 COST Actions were running with 45 000 researchers involved. 266 Training Schools and 2962 Short Term Scientific Missions (STSM) took place with an annual COST budget representing less than 0.4% of H2020 budget. 95% of COST participants say their careers developed and their prospects improved due to their involvement. COST policies embrace Early Career Investigators (ECIs), who will support progress in the coming decades. About 30% of COST Actions participants are young researchers. They are encouraged to take on leadership roles, and are priority beneficiaries of Training Schools and STSMs, which are exchange visits between researchers involved in a COST Action aiming at fostering collaboration and sharing new techniques and infrastructure. The topics of the Training Schools and STSMs are defined by the needs of the Action members, always within the frame of the Action. In Phycomorph, a survey brings in line the scope of the proposed activity with the needs of members, and the trainers are selected with this goal in mind.

What's Next?

Bottom-up networks initiated by active scientists have several features (Box 1): (i) Responsiveness and flexibility to stay on track while integrating all the diversity provided by open networks, (ii) Reliable prediction of the feasibility of the project, based on understanding the necessary resources, such as time and academic knowledge, that provides a view of the past that facilitates the projection into the future. So even if network emergence often relies on random meetings and convergence of interests, tools such as COST networks allow a first launch of a small boat (planned and designed by a team of skilled people mastering the technology) equipped with a foolproof rudder, from initial guidelines provided by the COST Association. However, navigating the rough seas that are the current environments of scientific research will not succeed unless sustainable funding can consolidate the initial efforts and contribute to the improvement of Europe's research performance. This also relies heavily on training ECIs to become highly skilled researchers with a capacity to produce, transfer, and utilise knowledge in an international, interdisciplinary, and competitive research environment. Macroalgae are a source of energy and food for the future, hence the sector must undoubtedly grow (Figure 1). Phycomorph, through its inclusiveness, connects pockets of excellence across Europe and counterbalances research communities' unequal access to knowledge infrastructure, funding, and resources. It empowers European researchers to propel basic research beyond standard biological models and towards innovation.

Resources

[i] www.fao.org/fishery/species/2790/en
[ii] www.cost.eu
[iii] www.phycomorph.org/

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