Letter to the Editor

# A Young Algaeneers' perspective: communication and networking are key to successful multidisciplinary research

Anna Matuszyńska[1], Martina Angeleri[2], Anthony Riseley[3], Erick Miguel Ramos-Martinez[4], Tiago Guerra[5] and Fiona Wanjiku Moejes[1,6]

[1]Heinrich-Heine University Düsseldorf, Germany; [2]University of Turku, Finland; [3]University of Cambridge, United Kingdom; [4]Copenhagen Plant Science Center, Department of Plant and Environmental Sciences, University of Copenhagen, Frederiksberg, Denmark; [5]A4F, Portugal; [6]Daithi O'Murchu Marine Research Station, Ireland

Corresponding author: anna.matuszynska@hhu.de

## Introduction

Attracting Masters and PhD students as well as fresh-faced Post-Doctoral researchers, the Young Algaeneers Symposium (YAS) is a biennial algal research event organised by students for students. It is the brainchild of a group of PhD students from Wageningen University, The Netherlands, who in 2011 realised that they were unsatisfied with the experiences they had at the large well-established algal conferences. The obvious absence of experienced researchers, including heads of institutes and principal investigators, provides a platform for free and open discussion and allows for the unbiased critique of current problems faced in the field. The inaugural YAS event took place in Wageningen in 2012, while the second edition was held in Montpellier and Narbonne in 2014. The third edition [1] was organised by us, a group of PhD fellows from six different European institutions, on the island of Malta. 100 early stage researchers from over 20 countries, representing six continents, gave a glimpse into their scientific work and discussed the future of algal research and how we could optimise the manner in which we exchange scientific information.

In this Letter to the Editor we would like to share the concluding remarks of the third edition of YAS (YAS2016 hereafter) with the wider algal research community and provide a voice for the young generation of researchers with regards to the burning issues across the varying disciplines of algal research that they face. The symposium not only allowed for the discussion of novel, exciting ideas and the optimisation of the various technical aspects in areas such as algal cultivation and application, but highlighted a common issue: the lack of clear and open discussion in this field. This Letter is reviewing the importance of interdisciplinary communication and benefits of discussion panels. By communicating our experience of hosting YAS2016, we would like to encourage and instil scientific exchange amongst the new generation of scientists and suggest solutions to various problems arising from a lack of mutual understanding.

## YAS2016

Since its first edition four years ago, YAS is growing into a well-established platform amongst the young Algaeneers in Europe, allowing them to share their knowledge and expertise in the field of algal biotechnology. One essential part of the meeting is to meet old and new colleagues and to expand their professional networks. Organised by young researchers for young researchers, YAS allows Masters, PhD and Post-Doctoral researchers from all disciplines of algal research to communicate their results and interact with other fellows in a laidback environment. Led by Fiona Moejes, YAS2016 was organised by fellows from two European Commission Marie Curie Initial Training Networks (ITNs): AccliPhot [2] and PHOTO.COMM [3]. Being part of such multidisciplinary, international collaborations, we had a great appreciation of 'scientific blending' and we were more than eager to organise this event. The number of research groups focusing on algae biotechnology has grown considerably across Europe in recent years, thus a forum like YAS is vital to creating scientific social networks and encourage communication and collaboration.


**Figure 1:** YAS2016 group photograph (photographer: Kailash Adhikari)

YAS2016 attracted over 100 Algaeneers from more than 20 countries and 50 institutions from both the academic and industrial sectors to the idyllic island of Malta from. This brought a wide variety of cultural backgrounds, scientific expertise and experience to the YAS2016 forum. Different trending topics within the algae biotechnology field were covered by the participants in this edition of YAS (Figure 2). Between posters sessions and oral presentations, this diversity allowed the participants to engage in scientific discussion, networking and establishing new collaborations across all disciplines of algal research.

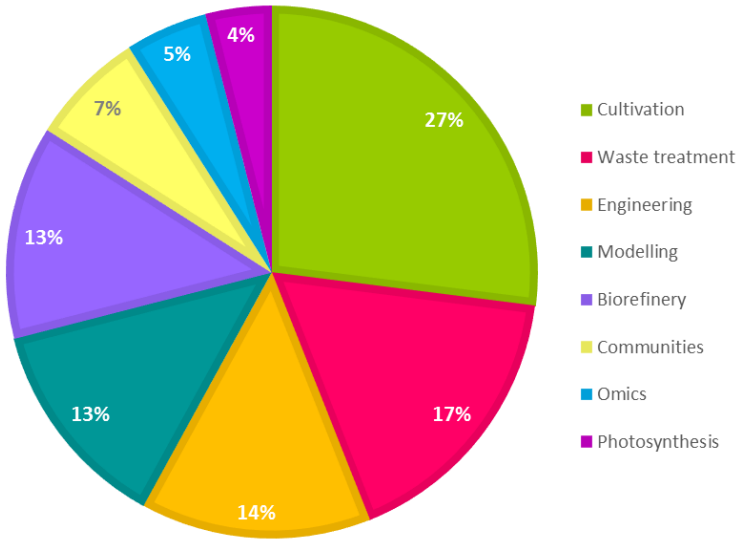


**Figure 2:** Pie chart of the main themes of abstracts submitted to YAS2016

**Social and Scientific Networking.** To optimise knowledge and idea exchange, the YAS2016 organising team included collaborative activities and a number of novel ways of presenting the science. One of the fundamental concepts was to ensure that the scientific content and quality was guaranteed and decided by the participants. This was achieved allowing participants to suggest topics of interest for discussion which did not have to necessarily be based on their scientific fields of expertise. The sessions were also shaping solely on the abstracts submitted by participants. This would ensure that the participants would be guaranteed a topic for discussion creating an atmosphere in which they would feel comfortable to engage in dialogue with other participants with the aim of sparking lifelong collaborations.

To break the ice and shake off any nervousness that comes with attending an international conference, as well as provide a care-free platform for participants to get to know one another, a GPS Challenge of Valletta was arranged. The two-hour activity spread across the city of Valletta was a successful team building experience that was followed by a “scientific speed dating” session in which participants briefly introduced themselves to each other. With only 5 minutes to spare, each participant explained their research interests, approaches and long-term goals to as many fellow Algaeneers as the speed dating session allowed.

The official scientific program was based on the subject matter of the submitted abstracts, which we separated in to three distinct sessions, creatively titled as: ‘Cooltivation, bro’ where all aspects of algal cultivation were addressed, ‘Algaeneering: from bench to bank’ which included talks and discussions on fundamental research approaches and industrially-relevant applications, and ‘Midas Touch: turning waste into green gold’ where we covered the use of algae in bioremediation and wastewater treatment.

The program included twelve 20-minute spotlight presentations as well as over 40 short pitches coined ‘Flash Talks’. The fundamental idea behind the Flash Talks came with the realisation that the current system of financing scientific research, to some degree, a scientist needs to be a salesman. Therefore, with only 5 minutes allocated to each pitch, more than 40 participants had the opportunity to present their research in a clear and attractive way. The concise and focused Flash Talks allowed for the stimulation of curiosity and discussion, and providing the opportunity for more science to be presented in a shorter amount of time. Posters session were also part of the program, with the majority of the posters containing further details that complement a Flash Talk, allowing for continued in-depth discussions between participants.

Last, but certainly not least, YAS2016 introduced a session purely dedicated to discussion, coined ‘Algal Gaps’. It was the outcome of this session that motivated us to write this Letter. Though we organised four parallel group discussions that focused on separate issues, the reoccurring theme that transcended from all the individual group discussions was a lack of communication between disciplines and even between scientific groups working within the same field. Most often problems arise while communicating science to a public [4], but also between the academic and industrial sector and even between scientists working in different disciplines [5]. Table 1 contains the titles and descriptions of the four discussion panels formed during the Algal Gap session.

**Table 1:** Topics of discussion during the Algal Gaps

| | |
|---|---|
| **Topic 1: Multidisciplinary approach to algal research** | *monitored by Dr Antonella Succurro (Heinrich-Heine University Düsseldorf)* |
| Are theoretical models reflective of reality? What is the current state of bioinformatics approaches in algal research? How well are we utilising and analysing big data? | |
| **Topic 2: Future of cultivation** | *monitored by Gergana Kostova (University of Freiburg)* |
| What is the potential of anaerobic digestion of algae? What causes biogas production inhibition when using algae as the substrate? Can we design cell wall-less mutants? How far can be push the modification of active ingredients? Any improvements in DIY cultivation-harvesting methods? | |
| **Topic 3: Novel applications of algal biotechnology** | *monitored by Witold Januszewski (University of Freiburg)* |
| To what extent could algal biotechnology aid in international development approaches? Is there any advancement in the use of algae as a biofilter? Are we aware of any novel valuable products from algae? Is the use of algae as bioindicators being utilised to its full potential? | |
| **Topic 4: The business of algae** | *monitored by Dr Tiago Guerra (A4F)* |
| What is the current state of biofuel production from microalgae? Can promises meet industrial expectations? How much can we, as algaeneers, promise potential investors? How can expertise from academia and laboratory-scale be more effectively translated into efficient algal companies and upscaling projects? Does legislation hinder the full potential of algal products? | |

**Figure 3**: Discussion during the Algal Gap session on modelling, monitored by Dr Antonella Succurro (Heinrich-Heine University Düsseldorf)

**Social Media in Science.** One of the main keywords of YAS2016 was “networking”. In this digital age, social media tools play a key role to improving connectivity, providing a means of exchanging ideas, establish new collaborations and increase visibility of scientific work. Furthermore, social media helps to build and maintain newly established scientific social networks especially after a scientific meeting. Early stage researchers in the field of algae biotechnology can benefit from a scientific network of people with a similar level of experience and interests. Younger scientists are more exposed to virtual communities where we share our scientific opinions, post updates from upcoming scientific meetings, courses, seminars and job opportunities. Most researchers that are active on social media choose mainstream channels like Twitter [6], which are great platforms to enhance professional networks and keep up with new research developments. To some extent, Twitter is also used to promote and advertise scientific meetings around the world due to its power to create visibility by simply posting updates before, during and after the event. For the third edition of YAS, we had a great response on Twitter using the hashtag #YAS2016Malta that was used to communicate the multidisciplinary research presented during the symposium. Indeed, social media can be intimidating for some; therefore other channels such as LinkedIn or ResearchGate should also be implemented to maintain and advance scientific networks.

## The Future Direction of Algal Research

**Research Focus on Ecosystem and Natural Habitat.** When studying natural environments algae do not exist as an isolated sovereign entity but rather exist as part of a complex community which is poorly understood. Increased understanding of the interactions could allow for the exploration of ‘synthetic ecology’ as a novel scaling up technique [7]. To progress towards the goal of creating a synthetic community, an in-depth understanding of the naturally occurring interactions between members of the community, which are predominantly based on a ‘biological barter trade system’ between diatoms and bacteria – where substances such as trace metals, vitamins, and nutrients (nitrate, phosphate, silicate, carbon) are traded – is necessary.

Looking at what nature has already perfected over millennia, such as the use of native strains instead of model organisms for industrial applications seems to be a winning formula. For instance, when screening for algal candidates for biodiesel production the screening of local strains proved to be more successful. A study carried out in Finland, and presented during the meeting by Anita Santana Sanchez from the University of Turku (Finland), found that local strains produced more biodiesel than model strains under relatively cool conditions [8].

**Novel Approaches in Genetic Engineering for Algal Research.** Finally, genetic engineering of algal species is an important approach [9–12], and the use of genetically-modified organisms (GMOs) especially in Europe, still needs further discussion and regulation [13,14]. Use of antibiotics as selective markers is a regulatory issue related to GMOs [15–18]; to avoid this problem, techniques to engineer marker-less GM

strains in cyanobacteria have been developed and encouraged [19]. To provide further options, Yuen Tin Lui from University college London (UK) presented her research on creating markerless mutants in *Synechocystis* sp PCC 6803 using *codA* (a gene encoding cytosine deaminase) which converts 5-fluorocytosine to the toxic product 5-fluoroacil.

Furthermore, alternative approaches such as ‘continuous pressure selection’, which uses a wild-type subjected to an accelerated ‘natural’ selection procedure, have been established. An example of this was presented by Dr Hubert Bonnefond from INRIA (France) whose work modified the optimal growth temperature and thus the metabolome of the studied algae by applying continuous pressure selection.

The multiple techniques of marker-less engineering in algae further encourages the creation of strains ‘safe’ for the environment and for human consumption. Both approaches allow the use of strains with improved characteristics in large-scale industry.

## Advancing the Quality of Research for Young Algaeneers

During the meeting we noticed several common approaches and trends, from intensifying interdisciplinary approaches in research to engaging industrial partners. This section includes possible solutions to advancing algal research based on the discussions that took place during YAS2016.

**Interdisciplinary Research.** Algal research is incredibly broad, encompassing fundamental research on photosynthesis and its application as a chassis in synthetic biology, to the production of high-valued compounds and biofuel applications, as well as its use in bioremediation efforts. Each scientific question can be approached by selecting different methods, but the power lies in combining more than one. We encountered this during the YAS2016 program. For instance, the lipid production in diatom *Phaeodactylum tricornutum* was studied both *in silico* via a mathematical model presented by Dr Elahe Radmaneshafar from the University of Aberdeen (UK) and *in vivo* through experiments optimising mixotrophic conditions for cultivation presented by Valeria Villanova from Fermentalg (France). Moreover, interactions between diatoms and the bacterial communities that establish themselves within these cultures was extensively studied by several groups in Europe, combining large scale studies with bioinformatical tools such as those presented by Fiona Moejes, Daithi O´Murchu Marine Research Station (Ireland). The results from the varied research projects were compared and discussed, and the young Algaeneers showed interest in sharing their data and learning in an interdisciplinary way. However, effective multidisciplinary collaboration may face some significant difficulties. We will focus on collaborations in more detail in the next sections below.

**Engagement of the Industrial Sector.** Due to the many potential industrial applications of algae, one would assume that the link between fundamental algal research and industrial applications was clear-cut. However, despite the tremendous advancement in the industrialisation of algal cultivation over the last few

decades, the sector is still relatively immature and lacks the support and input from the scientific and technological advancements of fundamental research efforts. This link needs to be fortified and optimised in order for the industrial applications of algal-derived products to expand and categorically impact industrial sectors such as nutraceuticals, pharmaceuticals and cosmetics industries. This fact justifies the increased involvement of a significant number of industrial organisations in YAS, with YAS2016 attracting over 10 industry representatives.

The increasing interaction between academic research and industrial application was attested by the presence of a number of industry representatives that openly presented their respective research approaches during YAS2016. Amongst the attendants of YAS2016 there were over 10 representatives from algal-based companies from Portugal, UK, Belgium, Ireland, France and the USA. The decision to allow young industrial representatives into YAS2016 was intentional by the organising committee in order to promote, the exchange of ideas, in this case between the industrial and the academic sectors. This fact also suggests that algal-based industries are becoming increasingly willing to communicate openly with academic institutions.

Even though it seems that the era of secrecy in the algal-based industry is slowly coming to an end, it is important for academics to understand the needs and difficulties faced by the industrial sector for e.g. gearing scientific research and technology development in the most impactful directions to the society-at-large, and promoting realistic expectations of what is achievable in industry with state-of-the-art research to prevent overselling and over-promising by the academic sector. Actions such as under-delivering of promises can seriously damage the reputation of fundamental algal research and dissuade investments in future years. Conversely, industry representatives can learn how new fundamental cutting-edge technologies and concepts can be applied to solving industrial problems. Notably an example of a new scientific trend that can be extremely useful for industry is synthetic ecology and the application of meta-omics techniques to industrial cultures.

Finally, as the academic world is incapable of absorbing a large proportion of the Master, PhD and Post-Doctoral (hereafter Post-Doc) researchers, industry representatives at YAS2016 were able to provide early stage researchers ideas of possible career paths after their studies are completed. A vibrant industrial algae sector will require talented, knowledgeable and skilled researchers to run the algae companies of the future.

**More Post-Doctoral Positions, for longer.** It is widely understood that the number of PhDs offered are on the increase and many arguments have been made for and against this movement [20,21]. What is concerning, is the minimal number of well-funded, long term Post-Doc positions available for these newly-capped doctors to move into. It is generally accepted that Post-Docs are by far the most productive members of an academic research group (excluding the PI). This observation is backed by a study demonstrating that Post-Docs produce 3.5 publications on average over 5 years whereas PhDs produced only 1 paper during this period [22]. Indeed, another study found that while Post-Docs produce more

publications, PhDs produce higher impact papers on average [23]. Perhaps this is due to PhD candidates' enthusiasm or naivety in pursuing high risk/high reward research and/or the potential that Post-Docs understand the need to publish more to be considered for tenure track positions. It also begs the question; would those PhDs produce the high impact papers as often without the support of Post-Docs? And who came up with the idea of those risky yet rewarding research projects in the first place?

We think it is widely accepted that variation in your workplace is needed to experience different techniques and methodologies, and in general, to encourage curiosity and open-mindedness. Science is incredibly time-consuming and so is the time it takes to build the necessary experience and knowledge-base to come up with novel ideas and solutions. If governments and/or independent funding bodies want increased productivity and scientific impact of their grants, we call for longer Post-Doc positions. There are a number of benefits in doing this: firstly, you will attract a larger and more talented pool of Post-Docs to choose from; secondly, the Post-Docs will have more productive years of work in their laboratory as they increase their expertise in the techniques and in the field but also, they will be able to plan for longer, high risk/high reward experiments; thirdly, you will be contributing to a more sustainable lifestyle for Post-Docs which could have profound implications for attracting and keeping women in academic science [24] and; finally, there will be far more enthusiasm in encouraging the next generation to pursue a career in science that has more stability and security.

## A Critique of the Current State of Algal Research

The scientific approaches in algal research have been proven successful; with funding for algal-based projects remaining on the increase. However, the supporting structures around the core practices are becoming outdated and sluggish, holding back the scientific progress from its true potential. In this section, we discuss our concerns with the increasingly antiquated system of publishing, the lack of communication between research groups working on similar topics as well as between disciplines such as mathematics and molecular biologists. In addition to these communication issues, we discuss the subtler aspects of academia including how we evaluate the skillset of a scientist and rebalancing the ratio of PhDs and Post-Doc positions and its potential impact on attracting and maintaining talent in academic science.

**Collaboration and Understanding in Algal Research.** During the Algal Gap panel on Multidisciplinary Approach we unfortunately identified a number of problems in the cross talk between classical bench-top experimentalists and dry laboratory Algaeneers. The fact that the research community is aware of these problems, and that these issue are not specific to a single algal field, is alarming. In our understanding, the long-standing attitude of mutual disrespect and lack of understanding, originates from the misconception of what interdisciplinary collaboration actually means. The Young Algaeneers attending YAS2016 showed a keenness towards legitimate interdisciplinary collaboration based on fact that they were willing to discuss and tackle this issue.

With the advancement in technology we now, more than ever, have the magnificent opportunity to study biological phenomena by combining various experimental approaches, ranging from molecular genetics to proteomics. But, when it comes to including experiments *in silico*, researchers become sceptical at the usability of findings provided by mathematical models and therefore undermine the importance of this approach. We believe that this unfortunate artificial separation between experimentalists and theoreticians lies at the heart of the mistrust of each other's work. From the point of view of an experimentalist, the modelling approach is unfamiliar, complex and far from 'reality'; thus it is difficult to even begin to identify the advantages a model can bring to their research. Though it seems tempting to ignore the main principles behind the tools used by fellows from other discipline (e.g. big data analysis or gene sequencing), considering them as a 'black box' carries a risk of significantly underestimating the skills and scientific knowledge of mathematicians, statisticians or informaticians.

Lack of mutual understanding leads to misconception and mistrust that, in the long run, results in disappointment and minimal collaboration. Interdisciplinary collaboration should, therefore, focus their efforts on the elemental aim of the research topic by ensuring each partner gains basic know-how of each research approach implemented, thus establishing a level of trust and mutual; understanding between all parties involved. In reality, when it comes to applied science, a mathematician testing regulatory mechanisms *in silico* performs no less of an experiment than the researcher working on an algae strain in the laboratory. A mathematical model is a simplification of reality in the same way as a model organism is a simple representation of a whole genus or family. Once communication channels have been opened between fields, it appears clear that the wet and the dry laboratory approaches are mutually dependent on each other, and once the model is complemented with experimental data, it can be used to verify if our current understanding is sufficient. If it can reproduce the currently available data, it can predict results of otherwise hard to perform *in vivo* experiments, or provide insight into the optimal experimental approach one should implement.

We agreed that we need to intensify the interdisciplinary experience by providing early stage researchers with opportunities to gain experience using various research approaches that they would otherwise never have the opportunity to. For instance, AccliPhot provided workshops where all fellows were taught about the possibilities and limitations of mathematical modelling and the reality of classical laboratory bench work. Becoming more aware of other working environments allows researchers to carry out better communication, remain appreciative of other research approaches, as well as acquire the basic capabilities to implement an interdisciplinary approach to their research. This will give rise to multifaceted and increasingly robust research results in the future.

**Standardising Scientific Publishing.** Discussion about the vast inefficiencies and frustrations of scientific publishing are becoming increasingly common. Major concerns lie with limited public access of scientific articles, faster turn-around times from submission to publication of an article, lack of publication of negative results (discussed in our next section), reproducibility of research studies and limited word/figure count

[25,26]. Indeed, we are seeing examples from both new and old journals tackling these issues [27,28]. However, one major issue that should be seriously discussed is the standardisation of formatting and guidelines amongst journals.

The rejection of your original research article from a journal can be a disheartening experience. What makes the whole process worse is the fact that you will have to reformat your writing, figures and tables to suit the next journal you plan to submit to. Indeed, some journals offer initial submission in any format, but once accepted, the author will have to reformat the article. This is extremely time consuming when calculated over the entire career of a scientist as well as the scientific community as a whole. The opportunity cost for scientists (and, thus, usually the taxpayers' money) is time away from the laboratory investigating the next big scientific question.

Solving this issue is perceived as non-trivial as there is a lack of incentive for journals to conduct such a complex task of aligning themselves. However, we believe this isn't so daunting if we start with something we are all familiar with: research. There is plenty of research and discussion on how scientists can effectively communicate science to the public or how to write in a 'journalistic style', but how about the format of written communication from scientist to scientist through the medium of publication? We argue for a thorough and rigorous research program to be conducted on identifying the most effective format of scientific publishing to communicate original research data most efficiently, including the use of all technological tools available for use today. In addition, the idea of having limitations for words or figures should be challenged and instead, be considered with more flexibility as this custom dates back to the time of physical/economic limitations of the printing press.

When the most efficient set of guidelines have been identified, top journals should lead the community by aligning themselves to this standard if they wish to remain as a top communicator of scientific research. Once this happens, second tier journals should also follow suit. Incentives for second tier journals should also steer these journals to be effective communicators by adopting this 'optimal format'. This is not just for the benefit of the public and scientific community but also for the journals bottom line (i.e. making a profit) – the easier and more informative their publication, the more reads and citations. Secondly, as second tier journals are competing for the rejected articles from the first tier, the easier you can make the transition for authors into your journal, the more likely you are to receive submissions, therefore boosting the quality and impact of your journal. It may be naïve to assume this could actually work, however at the very least we hope to raise and encourage discussion on this issue within the scientific community.

**Publishing Negative Results.** The lack of publication of negative results in scientific literature is a serious quagmire in research [29–31]. The vast amounts of inefficient and unnecessary repetition of potentially costly experiments across various laboratories, although difficult to quantify, no doubt exists. Scientific publications are geared to only include 'significant' or 'positive' results and are, therefore, an incomplete and often inaccurate representation of the scientific body of work. This is especially impactful in medicine and psychology. It is also incredibly difficult to publish work that contradicts or fails to replicate experiments

published by previous researchers, thus hindering the opportunity to question previous work, which prevents the advancement of science in general. Furthermore, the monetary cost of the repetition of experiments that were shown to be unsuccessful when conducted by another research group, but was not communicated to the wider scientific community, should be a more pressing issue for funding bodies.

Fortunately, there are a number of new journals tackling this issue such as the Journal of Negative Results in Biomedicine and New Negatives in Plant Science. Let's hope that we continue this trend of publishing positive and negative data in parallel to maximize balance and clarity in the literature.

**Definition of a 'Good Scientist'.** We see growing demand from academic employers for an increasingly narrow set of standards that determine how successful your scientific career is. It almost seems as though minimal creativity and diversification is expected from us. A successful scientist is currently equated to an average novel writer i.e. to produce many publications, not necessarily of high impact, but with no exception, as the first author. Furthermore, there is minimal appreciation of the specialist in a specific technique, which tend to complement the published research and, hence, land third place in authorship. And leaving writing aside, how is public engagement factored into scientific evaluation? With a significant amount of research funds coming from the taxpayers, a surprisingly small number of researchers get involved in outreach projects, which help to encourage children, students and citizens to understand the results and importance of their work. From our personal experience, engaging pupils with hands on experiments can bring a dual benefit for both participants and us, the organisers. With the help of our ITNs, we created numerous outreach activities such as photosynthetic workshops for primary school children under British Science Week or Algae Biotech Experience (ABE) for year 12 high school students. By learning how to communicate our science to people outside of the field we get to ask fundamental questions on 'why'. Why what we do is of any relevance to society-at-large? Why are we doing it in this way? Is there any alternatives? Finally, organising scientific conferences for our peers, like YAS2016, for some evaluators is considered an inadequate task that a 'real' scientist 'should not' find time for. Do we really want to sustain a view of scientists as self-occupied, chaotic and disconnected from reality, or rather should we reinforce attitudes to be creative, impactful and effective at communication?

## Summary

It is clear, from our personal experiences, and even more so, from the feedback from the participants of YAS2016, that the new approaches to science dissemination we used in Malta provided altogether a powerful tool of communication and enabled new collaborations. An interdisciplinary approach to algal research will not only give rise to a new generation of algal researchers with a wider skillset, but will ensure communication between algal researchers in different fields. Our concerns with the current politics of publishing scientific results are those not only faced by Algaeneers, but by science in general. We could not stress enough the importance of dissemination to the wider public; after all, many projects are funded by

the taxpayer and therefore we must consider it our duty to familiarise them with our research. We hope that we have shed some light on these unpleasant, yet unequivocally important, issues usually not discussed, openly, allowing for the optimisation and improvement of future algal research efforts.

## Acknowledgements

Anna Matuszyńska and Fiona Wanjiku Moejes are both funded by the Marie Curie Initial Training Network project ‘AccliPhot’ (grant agreement number PITN-GA-2012-316427). Martina Angeleri, Anthony Riseley, Erick Miguel Ramos-Martinez and Tiago Guerra are all funded by the Marie Curie Initial Training Network project ‘PHOTO.COMM’ (REA grant agreement number 317184).

We confirm that we have mentioned all organisations that funded the research in the Acknowledgements section of this Letter, including grant numbers where appropriate.

## References

[1] YAS2016, http://www.yas2016.eu/.

[2] AccliPhot, http://accliphot.eu/.

[3] PHOTO.COMM, http://photocomm.ku.dk/.

[4] L. Savadori, S. Savio, E. Nicotra, R. Rumiati, M. Finucane, P. Slovic, Expert and public perception of risk from biotechnology, Risk Anal. 24 (2004) 1289–1299.

[5] S. Talbot, The role of the engineer in bio-medical science, Bio-Medical Electron. IRE Trans. 8 (1961) 212–216.

[6] R. Van Noorden, Online collaboration: Scientists and the social network., Nature. 512 (2014) 126–129.

[7] E. Kazamia, D.C. Aldridge, A.G. Smith, Synthetic ecology – A way forward for sustainable algal biofuel production?, J. Biotechnol. 162 (2012) 163–169. doi:10.1016/j.jbiotec.2012.03.022.

[8] F. Lynch, A. Santana-Sanchez, M. Jämsä, K. Sivonen, Screening native isolates of cyanobacteria and a green alga for integrated wastewater treatment, biomass accumulation and neutral lipid production, Algal Res. 11 (2015) 411–420.

[9] R. Braun, People’s concerns about biotechnology: some problems and some solutions, J. Biotechnol. 98 (2002) 3–8.

[10] G. Traxler, The GMO experience in North and South America, J. Technol. Glob. 2 (2006) 46–64.

[11] H. Mahaffey, F. Taheripour, E. Wallace, Evaluating the Economic and Environmental Impacts of a Global GMO Ban, 2016 Annual Meeting. *July 31-August 2, 2016, Boston, Massachusetts* (No. 235591). Agricultural and Applied Economics Association.

[12] A. Kumar, Z. Perrine, C. Stroff, B. Postier, D. Coury, R. Sayre, F. Allnutt, Molecular tools for bioengineering eukaryotic microalgae, Curr. Biotechnol. 5 (2016) 93–108.

[13] R. Binimelis, A. Myhr, Inclusion and Implementation of Socio-Economic Considerations in GMO Regulations: Needs and Recommendations, Sustainability. 8 (2016) 62.

[14] P. Rzymski, A. Królczyk, Attitudes toward genetically modified organisms in Poland: to GMO or not to GMO?, Food Secur. (2016) 1–9.

[15] B. Miki, S. McHugh, Selectable marker genes in transgenic plants: applications, alternatives and biosafety, J. Biotechnol. 107 (2004) 193–232.

[16] P. Gay, S. Gillespie, Antibiotic resistance markers in genetically modified plants: a risk to human health?, Lancet Infect. Dis. 5 (2005) 637–646.

[17] D. Goldstein, B. Tinland, L. Gilbertson, Human safety and genetically modified plants: a review of antibiotic resistance markers and future transformation selection technologies, J. Appl. Microbiol. 99 (2005) 7–23.

[18] M. Woegerbauer, J. Zeinzinger, R. Gottsberger, Antibiotic resistance marker genes as environmental pollutants in GMO-pristine agricultural soils in Austria, Environmental. 206 (2015) 342–351.

[19] D.J. Lea-Smith, R. Vasudevan, C.J. Howe, Generation of Marked and Markerless Mutants in Model Cyanobacterial Species., J. Vis. Exp. 111 (2016). doi:10.3791/54001.

[20] J. Gould, How to build a better PhD, Nature. 528 (2015) 22–25. doi:10.1038/528022a.

[21] D. Cyranoski, N. Gilbert, H. Ledford, A. Nayar, M. Yahia, Education: the PhD factory, Nat. News. (2011).

[22] C. Woolston, Bigger is not better when it comes to lab size, Nature. 518 (2015) 141–141. doi:10.1038/518141f.

[23] E. Pain, Staffing labs for optimal productivity, Science (80-. ). (2015). doi:10.1126/science.caredit.a1500057.

[24] J. Lober Newsome, The Chemistry PhD: the impact on women's retention, Adv. Chem. Sci. (2008).

[25] K. Powell, Does it take too long to publish research?, Nature. 530 (2016) 148–151. doi:10.1038/530148a.

[26] Challenges in Irreproducible research, Nat. Editor. (2016). http://www.nature.com/news/reproducibility-1.17552#/Editorial.

[27] Nature Publishing Group, Nature Publishing Group, (2016). http://www.nature.com/openresearch/?shunter=1458577077494.

[28] eLife Journal, eLife Journal, (2016). https://elifesciences.org/about.

[29] E. Granqvist, Why science needs to publish negative results, Elsevier Connect. (2015). https://www.elsevier.com/authors-update/story/innovation-in-publishing/why-science-needs-to-publish-negative-results.

[30] L. Goodchild van Hilten, Why it's time to publish research "failures," (2015). https://www.elsevier.com/connect/scientists-we-want-your-negative-results-too.

[31] N. Matosin, E. Frank, M. Engel, J.S. Lum, K.A. Newell, *et al.*, Negativity towards negative results: a discussion of the disconnect between scientific worth and scientific culture., Dis. Model. Mech. 7 (2014) 171–173. doi:10.1242/dmm.015123.