Report on the Surrey Workshop on Quantum biology

This two-day workshop at the University of Surrey held over a Friday/Saturday (21,22 July 2017) was a satellite meeting to the Biophysics Congress that took place during the preceding week in Edinburgh, and which included a session on quantum biology (QB) convened and chaired by one of the workshop organisers (JAK). The workshop was funded by PoLNet2 (£4k) with a further £2k from the University of Surrey (split equally between the Faculty of Health and Medical Science and the Department of Physics). The motivation for the workshop was that the topic of quantum biology was listed in the PoLNet2 application as one of twelve topics that would benefit from having early-stage workshops in 2017 and 2018.

Over the past few years, QB has grown from a speculative, some would even say controversial, field to one where exciting experimental and theoretical results are being explored and discovered. However, although there are a number of researchers working in the field in UK universities, the activity tends to be limited to one or two people here and there or as a side interest to other more mainstream (and better funded) research activities.

The workshop brought together a programme of speakers from a wide range of backgrounds to discuss their work and to sharpen research questions and methodologies. Typically, such specialist workshops tend to be rather focused in their remit and scope and end up being a forum for specialists to update each other on their progress. While that type of meeting plays a vital role in research, it was not the purpose of this one. Instead, the organizers deliberately brought together a wide range of speakers and delegates from different fields: molecular biologists, synthetic biologists, biochemists, physical chemists, quantum physicists as well as stake holders and potential funders from dstl and the US Air Force Research Lab. This diversity meant that the nature of the talks and the ensuing discussions tended to be far wider than normal with a good deal of constructive criticism and advise.

What emerged was two main issues surrounding the future of quantum biology as a viable and exciting new field of research:

1. The need to correctly define what ‘quantum biology’ is. The practitioners in the field would say they know – they would say it is the study of ‘non-trivial’ quantum effects and phenomena in biological systems. However, it is clear that no one working in the field would define themselves as a ‘quantum biologist’. They are quantum physicists, molecular biologists, spectroscopists, physical chemists, etc. There was considerable discussion during the Saturday afternoon about whether the name should be changed, however no consensus was reach as to an alternative title. The problem is that much of the work in biophysics and biochemistry involves quantum mechanics in some form, whether it is modelling electronic distributions with techniques such as density function theory (computational biology) or quantum mechanisms in biomolecular bonds (quantum chemistry) or looking at theoretical models of quantum phenomena in biology such as in photosynthesis (quantum information theory). Is there then a need to have an umbrella term for anyone working on non-trivial quantum effects (long-lived coherence, tunneling, entanglement) in living systems? And if so, what are the benefits of doing so?

2. The ‘So What?’ question. This is the criticism usually leveled against the field by biologists and can be encapsulated as follows: a molecular biologist or biochemist might say ‘yes, I agree that if you burrow down deep enough to the molecular and even atomic

level, then you will hit the quantum domain. But these are incidental and will not have any bearing or measureable effect on the macroworld – the world of biological processes'. Their argument is that while quantum effects are surely always there at some level, they play no active role in the mechanics of life. One skeptical speaker stated that surely below the classical, deterministic nano-machinery inside cells is just thermodynamics. Needless to say, the workshop organisers did not agree with this view. A more valid criticism is that while in certain phenomena, such as proton tunneling in enzyme catalysis or energy transfer in photosynthesis, there is now well-established work suggesting quantum effects are non-trivial, many in the life sciences community (and indeed in the physical sciences) remain unconvinced that life has *sought out* these quantum mechanisms to give it an advantage. In which case, one might argue: so what if there is quantum mechanics buried underneath?

However, the role of those working in the field of quantum biology is not to prove that quantum mechanics does indeed play a vital role in biology, but to investigate carefully whether or not it does. This is such an important and fundamental question that it needs to be addressed seriously.

In terms of the workshop, one minor point to mention was that attendance on the Saturday was much depleted, which is understandable given this was the first weekend of the school summer holidays. The organisers appreciated the need to wait until the biophysics congress had ended on the Thursday, but in future they would avoid holding meetings that ran into weekends.

As a concrete outcome, one of the organisers (JAK) has agreed to take on the task of putting together (coordinating) a white paper to address the above points, with input from interested workshop speakers and participants, and which can be presented to research councils to indicate the community's resolve and ambition in seeking funding sources. At the moment, the field suffers from not having an identifiable funding body that will take responsibility for the subject.

It was also agreed that the organisers would potentially seek further funding from PoLnet2 in the form of a sandpit and/or pump-priming funds for further discussions and collaborations to clarify real challenges and research questions that could form the basis of grant proposals.

Jim Al-Khalili

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