

## Collated feedback from Workshop 2

### **What is accepted as known about the interactions between plasma generated species (including photons and fields) and living cells (including bacteria and crop seeds, and associated biomolecules) in terms of individual species and their combinations?**

*How does the plasma interact with cell membranes: is it simple protein etching, or electrostatic charging? Can plasma constituents directly influence the charge-exchange or dielectric properties of living cells? How does enhanced early growth of seeds arise from plasma treatment?*

- There is a wealth of review papers and studies in initial plasma medicine/agriculture research that we can access to fill in our knowledge
- some things known for different systems, different cell types etc. but not known how that knowledge translates and extends.
- do we miss the link between different people's systems that work.
- big efforts to translate existing biomedical communities into review papers. we can do more though.
- infection control is possible - both direct and indirect plasmas

### **What are the major gaps in our understanding, and how do we prioritise progress?**

*Where are the tantalising but unexplored edges of the field? What do we need (equipment, models, insight) to venture there?*

- Lack of in-vivo experiment and in vivo proof. Why? Can perform in-vitro experiment but situation is very different in in-vivo. In-vivo is more expensive and more complicated (ethical approval etc). Need lots of samples for in-vivo – a lot more than in-vitro.
- In-vivo systems are more complicated, understanding in-vitro is already very hard.
- Need more in-vivo experiment.
- Plasma exposure brings so many extra processes to consider (reactive species, electric field, UV, etc). Need to have control experiments to determine their individual effects.
- Need a two-pronged approach to research: studies that push ahead into the unknown, adding more complexity without necessarily understanding the detail, simultaneously with studies that consolidate understanding of the specific details.
- Lack of statistical understanding and methods in terms of appreciating medical/biological trials.
- In bioplasma field are start-up companies profitable/viable? No, small companies struggle, they have no capacity to compete with bigger companies.
- Is it worth having a reference source/cell that experiments can be characterised against?
- make your results easily categorised so that we can easily see important details of experiments.

- community database searchable.
- we need reproducible plasmas so that the less reproducible biology doesn't exponentially increase variability.
- we need control and feedback
- does the unknowable shot-to-shot behaviour of the plasmas prohibit FDA approval.
- big motivator for indirect treatment is ease of approval.
- Soil treatment - if we treat water with a plasma are we killing off good bacteria? Are we promoting growth at the cost of nutrition?
- Connecting the biochemistry to the plasma characteristics will be essential to managing progress.
- Developing consistency in producing plasma jets for treatment and also developing a database of successes and failures will be necessary for characterising medical and agricultural applications.
- Which conditions will induce which cellular response (e.g. cell death mechanisms, proliferation). There is no standardized "plasma" approach (multitude of kinds of plasmas and different conditions - no uniform approach). We should approach medical community to forge collaborations to understand what can be achieved. We should be pro-active, initiate and recruit multi-disciplinary team of other specialists.
- need clarity on the role of charging with respect to cell membranes
- does plasma kill bacteria, or just render them temporarily non-viable? We should engage with bio community
- We need to be clear about terminology: sterilisation vs decontamination
- Can bacteria become resistant to plasma treatment?

## **What other relevant points should be made?**

*Are there important issues in this topic that are not covered in the answers above?*

- Are the resources there to expand plasma medicine as a discipline?
- Is plasma and medicine coming together (is it better?): it is very separate. The medical field isn't as aware of plasma discipline and what they can do.
- are there studies about change in crop yield rather than just germination time re:seed growth.
- treat water that used to water or directly polluting with plasma is important for environmental issues
- very important to answer these question before industrial use.
- are we ruining soil faster with the plasma treatment leading to higher fertiliser use?
- Funding for such research varies very much between countries. We should have a community-response from this conference to some of the major global problems (e.g. hunger). We need a uniform road-map showing what do we need and organize it well, so we maximize the use of available resources. Public awareness of plasma is poor. If it increased there would be a better chance of funding such research. We could use TED video as an outreach tool to address this problem. Editing Wikipedia could help as well. The community should be pro-active about it. We should tap into cancer research funding in collaboration with the current cancer research community. We should lobby for NERC, EPSRC and BBSRC to jointly fund the Centre for Doctoral Training focused around plasma, medicine and food industry.

- we need to be clear about plasma and other synergistic effects - eg temperature, photons