Teacher Prompt Sheet

When doing this workshop in person I wander around and ask the students about their thought-processes with regards to how to solve their world issues. If they're stuck or getting side-tracked, I'll ask leading questions and facilitate them finding the "correct" answer, although the aim here isn't necessarily to show them exactly what scientists are pursuing/have pursued with trying to solve these issues - there are a few different combinations for all of these things that they can try to address their problems, and it's good to show them that experimental biology can be quite a creative subject.

Medicine and disease:

This is a tough one as the students have two different diseases to sort out.

For diabetes, it's important to mention, if it comes up, that you can't take insulin orally as it will be denatured in the stomach, so it has to be injected. This means they need a way of producing a lot of insulin, and a way to easily extract it in large quantities so that it can be injected. This is most easily done with the E. coli – they grow really fast and you can extract loads of protein from them, so putting the human insulin gene into these is the best shout. This has been done by scientists already – see Humulin in this article https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3714061/

For keratomalacia, there are a couple of different ways you could approach this. Tomatoes are already a source of beta-carotene, so boosting their beta-carotene levels with the genes to help synthesise beta-carotene is one way of approaching this. Keratomalacia is a disease which usually affects people in less-economically developed countries, however, and the climates of these countries are wide-ranging and sometimes harsh, which may discourage tomatoes from growing very well. Considering that, perhaps the best organism to modify with the beta-carotene genes is rice, as it grows everywhere, even in harsh climates. This has also been done been done before by scientists, see this Wikipedia article: https://en.wikipedia.org/wiki/Golden_rice

World food shortages:

Loads of different ways to address this one – probably the most creative. Putting the photosynthesis boost genes into any edible plant could feasibly increase its growth – bigger plants = more food etc. Scientists in the past have tried splicing the anti-freeze gene from a winter flounder into tomatoes, in an attempt to get them to grow through the winter (see Environmental Stress Tolerance in here https://en.wikipedia.org/wiki/Genetically_modified_tomato) although this didn't work and the company has since gone out of business, but this is a great train of thought for the students. Of course, you can put more than one gene into a single organism – anti-freeze plus photosynthesis boost could give massive tomatoes which could grow through the winter. Has come up before where students have suggested putting Bt toxin in the tomatoes/rice to make them pest resistant – great train of thought – perhaps also a good opportunity to discuss how the public may perceive this, whether it would be safe to put an insecticidal toxin inside edible foods etc.

Renewable energies:

The key organisms here are really the algae and the cotton plant. The cotton plant is a great source of cellulose which can be converted into biofuels – the algae is rich in oils which can be converted into biofuels. Adding photosynthesis-boost for either of these could feasibly yield larger plants with

more cellulose/oils for biofuels. Adding cellulose synthase genes could give the plants for cellulose which could be converted into biofuels, but also as cellulose is a major constituent of plant cell walls, it may also support the growth of larger plants (?). Algae does have the advantage of growing under water – this is nice to discuss with the students because it means that they have to weigh up multiple world issues at the same time. Growing GM cotton plants on land could take up agricultural land which could have been used to grow food, whereas growing more algae under the sea which is not, to my knowledge, utilised so much for agriculture could allow you to address both of these issues more effectively.