Saving Our Oceans is My Planetary Duty
A MAHB Dialogue with 12-year-old Emerging Scientist Anna Du

Geoffrey Holland

Sharing our World

Anna Du has been named one of the top ten students in the US, by 3M's America's Young Scientist Challenge, as well as being selected as one of the top 30 science fair students in the nation by the Broadcom Masters Program. Her invention of an underwater ROV, used to collect plastics in the oceans, and other accolades have been featured by Discovery Education, FOX-TV 25 News, Fast Company and Smithsonian Magazine. News about her achievements have been translated to numerous languages around the world. Anna looks forward to continuing her work and aspires to attend MIT one day to become a Woods Hole oceanographer.

***Geoffrey Holland*: As a Broadcom Masters National Middle School Science Competition Finalist, you invented new technology for identifying the presence of micro-plastics in the ocean environment. Can you explain how this technology works?**

Anna Du: For the past year and a half, I have been building an ROV (remotely operated vehicle) that is designed to locate microplastics using different low-cost solutions that are easily scalable. The first system that was made, was the infrared based detection system. This is based on the concept of infrared spectroscopy, in which unique patterns of differences can be detected in absorption and reflection between plastics, and other materials. Numerous recycling facilities utilize this technology to differentiate between different types of plastics. However, my design isn't as expensive as a commercial one. The second module was the

unnatural color detection system, which can identify the colors that are within a certain wavelength on a micrograph of a sample and can mask everything else. This way, the only color on the screen is what is within the range. Using this method, the color detection system is able to isolate areas containing pre-identified color ranges representing likely synthetic dyes. The third component can classify the different shapes. Then, it will highlight that shape, and label it. These systems are all mostly created with programming, so it costs very little as the only thing you need to buy is an infrared camera, and some infrared LEDs in the lower wavelengths. This makes it substantially more scalable, and if I were to create a swarm of them, they would be inexpensive, and would be able to scan significantly more of the ocean floor.

GH: Every year, eight million tons of human plastic waste ends up in our oceans. Why is that a huge problem for our marine environment?

AD: Imagine a world where there are more plastics than fish in the ocean, and seafood would be so toxic that if a person were to eat it, he or she might die. This world is about to become a reality. According to a new research, by the year 2050, there will be more plastics than fish in the ocean. Based on the annual growth rate of the plastics industry, the number of plastic pieces will grow exponentially, beyond the point of potential recovery – if that point hasn't already been passed.

However, despite the media making a big deal out of the mass of plastics floating in the ocean, this is just the tip of the proverbial iceberg. After all, what would be more dangerous: a single, empty, polyethylene water bottle floating in the center of the Pacific Ocean or -- years later, when the bottle breaks down -- billions of smaller polyethylene chunks, barely visible and spread across thousands of miles of ocean floor, embedded into various layers of sediment? Or worse yet, imagine the possibility that half or more of these chunks were inside the guts of marine organisms, and the short life cycles of those animals - surely these will end up in an endless cycle of re-consumption by scavenging bottom feeders further transporting these increasingly smaller particles. Now, multiply this problem times billions of bottles, every single year, with that number growing rapidly. In the future, the ocean floor would be nearly ubiquitously covered in microplastic-laced mud, with the majority of these particles unable to be recovered.

The biggest problem is not the weight, but the surface area of plastics. Plastics have a high affinity for binding with other objects in the ocean, especially after these particles have broken down. UV and constant wave action cleaves plastic into smaller pieces in the ocean, leaving "freshly-cut" ends that tend to be more reactive increasing the chances that plastics would bind with other, potentially toxic objects. This would wreak havoc on the environment. Not only are

the particles more likely to spread throughout the entire water column of the ocean faster, but they would be more toxic than just synthetic polymers alone. The combination of plastic material plus biological toxins and other forms of man-made pollution substantially increases the potential toxicity of every particle.

One example of this newfound hybrid toxicity is methylmercury. In the last seventy years, though there have been few cases of methylmercury poisoning, every single one of them has been catastrophic. In the 1950s, at Minimata, Japan, there were cases of people being in extreme pain and not being able to form coherent thoughts. For generations after children from Minimata grew up with genetic mutations.

If the amount of plastics dumped into the ocean remains unchecked, then in the next few years, the amount of plastics in the ocean alone, would rise exponentially, along with the surface area. This problem is one that not many people think about but is extremely important.

GH: Why is plastic waste such a threat to marine animals from zooplankton to whales?

AD: Plastics aren't just a threat to animals in the ocean – they're a threat to everyone. They are inherently toxic, and as plastic breaks down, it releases different types of chemical toxins. One of the most prominent is Bisphenol A, which can cause heart, lung, and kidney damage, cancer, and even genetic mutations. This will affect everyone through the food chain. It doesn't matter if we don't directly eat seafood. If we eat livestock of any kind, they get fed seafood byproducts. Even if we become vegan, the plants use those livestock's manure as fertilizers. If we don't deal with this issue right now, while it's still on the small side, then it will slowly poison everyone.

In fact, just by cleaving a microplastic that's shaped like a cylinder into ten pieces, the surface area will increase by 160%. Slowly, the amount of microplastics will be able to be compared with the surface area of the sand on a beach. The number is staggering. If this were all with plastics, then that would mean there would be a lot more places where the plastics could potentially bond with other materials. If it binds with materials such as algae, then it will sink faster.

This causes animals, which use 'marine snow' as the primary source of food, to get exposed to large amounts of plastics at one time. Overtime if the exposure to toxins doesn't kill them, starvation will. They will eat so much plastic, that they can't digest, it will stay in their bodies forever.

Even if the plastics don't bind with something like algae, then it will bind to something more toxic, such as mercury or crude oils, making them more toxic than anything else.
This is the type of toxin that can completely kill all the organisms in an environment. It doesn't matter what type of animal it is, whether it's a zooplankton or a whale. As these animals are eaten up the food chain, slowly, through a process called biomagnification, the amounts of toxins in their bodies will increase, until it reaches humans, where it will be so toxic, that it would cause death. Microplastics are clearly causing an amplification of toxicity in all of our diets, that's slated to increase substantially if something isn't done now.

GH: In our oceans, there are places where plastic waste accumulates. They are called gyres. Some are larger than the entire state of Texas. Is there any practical way to remove this waste from the marine environment?

AD: This really depends of the size of the plastic that you are targeting. If you're looking at the larger pieces of plastics, then just about any method would work, as long as it won't harm the animals. This can range from using filters, to just going out in a boat yourself. This is because as long as a person, or a machine is there, then they will be able to see where the plastics are, and can simply just reach over, and pick it up.

However, if you're talking about a small piece of plastic, then it is much harder. If you use a net, or some other method like that, it could harm the environment more than help it. All of the methods which have a high accuracy for finding plastics also have deadly risk for marine life. For instance, using Nile Red Dye, one of the most accurate methods for identifying plastics, also uses a toxic chemical inside it.

GH: What are some things humans can do to prevent our plastic waste from ending up in our oceans?

AD: Recycling was introduced as a way of reusing plastics, instead of just throwing these particles away after one time has begun gaining popularity. However, despite the fact that recycling has been around for some time now, and despite the fact that people only become more and more aware of the dangers plastics possess, the rate at which the plastics are being recycled, still isn't fast enough. We're only recycling 30% of all our wastes.

In the beginning, people had to sort out all of their recycling by themselves. They had to sort out what type of material it was, and sort that from trash. However, many people felt like this was a waste of time, or just didn't want to be bothered by it. They felt it was an inconvenience. So, in order to have recycling gain popularity, single stream recycling was invented. This way, a

person can just dump everything into a trash barrel, and once it gets sent to the recycling companies, they would sort it for you . But as time goes on, the recycling companies also don't want to be inconvenienced by sorting everything out. They'd stop being in the recycling business at all.

In order to prevent something like that from happening, people need to be more conscious of when they're using single stream recycling. They should focus more on trying to sort out these plastics – after all, it can't take more than a few minutes.

GH: Since 1970, the human population on Earth has doubled, and we now have more than 7.6 billion on Earth. One of the consequences of having a larger population is that we use up our planet's resources faster. How has this impacted our oceans?

AD: The amount of plastics that are in the ocean are directly correlated to two factors – the number of objects that are made with plastic and the number of people who need to use those objects. If the population hadn't doubled since 1970, there wouldn't be as many pieces of plastics in the ocean as there are now. As the population slowly rises, so does the demand for more objects such as computers, jars, clocks etc. The companies that are producing these objects will only create more as the population rises more and we continue to make more products out of plastic than from wood, glass or metal. However, the work life of these objects is very short, especially compared to the amount of time they will spend, wreaking havoc on the environment. Even if a child has a treasured doll that they keep for many years, it's still incomparable to the centuries that it will spend in the ocean.

Once these objects have fulfilled their use, most of them get thrown away. For instance, if a chair has been worn down from years of usage, and no one wants it anymore, these materials usually get thrown away, not recycled or reused. When more people who need these objects, that means that more of these objects are also just thrown away.

GH: How has climate change directly impact our oceans? Is the situation getting worse or better?

AD: Climate change has already been a huge problem, whether it's about land, or marine life. It had been reducing food sources for animals, decreasing biodiversity and overall biomass. If those two are reduced, it will upset the entire ecosystem. This would mean that there are less top feeders, meaning that the bottom of the food chain will increase. This leads to events such as micro algal bloom happening. As these algae spread farther, they bind with microplastics, causing them to sink to the bottom of the ocean. Marine animals who rely on marine 'snow'

will be hit with these hybrids of plastics and organic debris. In case of a re-tide this would cause an instantiated ecosystem disaster, because the large amount of plastics can be extremely dangerous for all bottom feeders, potentially wiping out entire species at a time. This could cause ocean acidification, dead zones, and oxygen depletion zones. All of these, in addition to plastics and polymer chemistry, can have serious consequences on the environment.

There have been many direct links between climate change, and plastics - specifically microplastics, on how they affect life. The cumulative effect of so many broad-based changes, and different variables, are having consequences that are completely unpredictable. For instance, the physical properties of oceans changes as salinity is increasing and inland seas are drying up. Take a look at Europe and the Middle East. There are a lot of examples of significant salinity changes, physically changing the ocean. Who knows what other changes would occur that could potentially in some way interact with polymer chemistry and increased toxicity, not just to the marine environments, but to humans too.

GH: Some people believe that the future of human life on Earth depends on emerging generations (like you and other young people) to develop technologies and to create new policies that will fix the global scale problems for which humans are responsible? Do you think young people are up to the task?

AD: Children in my generation and future generations have the advantage of growing up with a wealth of scientific knowledge that has been accumulating since the dawn of human civilization. We are also inheriting the problems of generations of the past, particularly major ones such as climate change, plastic pollution, socioeconomic inequalities. As a young person, just becoming a teenager, I feel like I am in between the adult world of real problems and a world of childlike fantasies and dreams. Many of my peers at science competitions and programs across the world have very similar hopes and dreams for the future of humanity and for our roles within the world. We all dream of becoming something much bigger than ourselves and inventing the cures to all the world's ails (and maybe even win a Nobel or MacArthur prize), and I believe that based on the determination of the young people I've met in recent times, that we can indeed do it.

Now, more opportunities present themselves for students of my age and younger to learn about the major problems facing the world. Many public television networks and other organizations do a great job of communicating these concepts in a way that is understandable and interesting to young students. The ever-popular Science News, published by the organization that hosts Broadcom and ISEF, and many other publications in various media formats help make sure students are aware of the latest peer-reviewed science and engineering

related news, in a way that is more readable than complicated scientific jargon, making knowledge more accessible to younger people as it's presented in a way that is more fun and interesting, providing excellent opportunities to inspire the youth and help make them aware that global problems exist, demanding a lifelong dedication of working on just one topic to find a solution. This requires effort and above all else - inspiration. There is no shortage of smart people in any generation, including my own. The roadblock to progress in solving any major problem is really just inspiration. I, personally am inspired most through reading, as the format of books leaves more to the imagination – and I feel that this is a way to popularize science topics and reach more of my peers to help inspire them.

In such a short timeframe, I've gone from being what I would consider just an ordinary young girl with a dog and a lot of books to a place in life I could barely have imagined before, filled with interviews on the world's top broadcasting networks, trips around the country, paid invited lectures, interactions with top scientists in their fields, a meeting at the White House and numerous meetings in Congress, scholarships, a minor planet named after me, and even a book deal. These opportunities not only give me a chance to expand the prospects for my own research in the near future but also to increase awareness in the general public, and even in a small way, to have a voice that may be heard when it comes to public policy. As students, we're normally judged on the merit of our test-taking skills, however, science fairs and related competitions are a way for young people like myself to express ourselves through our ideas, and working with a hands-on project has given me the opportunity to solve a real-world problem in a way I could not do in a regular school environment, allowing me to share with the world my own perspectives on a problem that interests me. The knowledge I've gained gives me great concern for the planet that we all share. This experience has reinforced my own interest in one day becoming an engineer focused on marine life, with the goal of helping solve major world problems, and that my various science fair colleagues share my passion for their own ideas in their own respective fields, and being around them makes me want to work harder. If they are any indication of the potential for the next generation to solve major world problems, I think our planet will be in good shape. I encourage all students, parents, and mentors (of all ages) reading this to find a STEAM competition that suits you and pursue it, full STEAM ahead.

I would definitely say that my generation is "up to the task".

GH: People across the globe now have the ability to communicate and connect in many new ways that did not exist just a few years ago. Do you think we, as humans, must see ourselves as responsible citizens of the whole planet rather than just citizens of our own countries?

AD: In recent years, people have been conducting scientific research without borders. That has played a huge part in expanding and advancing human societies. Our generation feels more like global citizens rather than just citizens of one particular nation, because what's been going on recently has proven to younger people that nationalism is a thing of the past. It leads to a lack of sharing of knowledge and resources. If people around the world can't share ideas and solutions to major global problems, we will never be able to fix major global issues like cancer, water/agricultural shortages, and of course, climate change. We must choose to think and act globally.

We've learned from the Paris Accords and the Kyoto Treaty that it is difficult for individual nations to accept the blame for the problems we face. It is also hard to get multiple nations to collaborate on fixing problems that are so large. It we cannot convince the general public to understand that the blame for major global catastrophes such as wildfires, hurricanes, and earthquakes/tsunamis lies in something larger, then imagine how difficult it will be to convince people of the detrimental effects of pollution (in all forms- air, water etc) and especially the burgeoning field of microplastic pollution.

We all have a duty to fix these problems. They are not limited by political boundaries. The solutions must be implemented on a global scale. I think there's hope, because the next generation of humans are not in denial of these common problems.

GH: How do you intend to be the change you wish to see?

AD: To be a source of positive change for the world, we all need to live our ideals. Whether that means inventing new technologies for removing marine plastics efficiently, or simply reducing our daily consumption of single-use plastics, we can all participate in cleaning up our planet.

For aspiring engineers like myself, working on solving the problem of ocean microplastic pollution using math and physics in the form of a science fair project is a fun and active way for me to be part of this global change. However, not everybody wants to be an inventor or work in a lab. Fortunately, there are many other ways to volunteer on important research and active cleanup projects ranging from local to global in scale. One could simply go to the beach and count the amount of plastics that they find (and pick up for later recycling) as part of citizen science efforts. Not only does this help scientists learn more about the patterns of global pollution movement, but it also serves as a good excuse to get out and do something hands-on. Another example which relates both to marine life and climate change research is the local Audubon Society, New England Aquarium and the New England Coastal Wildlife Association.

For those people who are not interested in exercising, there are also many other ways to participate in climate change, pollution and marine animal rescue / research projects.

Water is the basis of all life on Earth, and one way or another, animals and plants that live in or near water are essential to the global food chain. The long term catastrophic potential of microplastics is something we must all be concerned about. We all need to be part of changing our future, whether it's on a small local scale, such as making a science fair project, or cleaning up a local pond/ beach, or participating in regional scientific research or global citizen science projects.

Regardless of what we choose to do with our own hands and time, it is important that we all do what we can to spread awareness to others – whether that means writing a blog, a research paper, a book, or even a Q&A for the MAHB.

Anna Du is a twelve-year-old originally from Florida, now living in Massachusetts. Through her explorations of the beaches she has developed a strong appreciation for the ocean and marine life. Throughout the past several years, her work as a young scientist has focused on the globally increasing, widespread problem of plastic pollution - specifically microplastic pollution. Recently, she has invented an underwater ROV (remotely operated vehicle) which uses infrared and other wavelengths of light, combined with artificial intelligence to identify and spatially map regions of microplastic accumulation.

Anna has been named one of the top ten students in the US, by 3M's America's Young Scientist Challenge, as well as being selected as one of the top 30 science fair students in the nation (from a pool of 80,000 students) by the Broadcom Masters Program. Her work and accolades have been featured by Discovery Education, FOX-TV 25 News, Fast Company, Smithsonian Magazine, and she is currently filming a special for WGBH's Design Squad. News about her achievements have been translated to numerous languages around the world. Anna is currently collaborating with a number of researchers in this field and is planning major additional enhancements to her patent-pending system.

Her hobbies include ice skating, gardening, violin, and reading — especially books about science. She hopes to one day attend MIT and become a Woods Hole oceanographer.

The MAHB Dialogues are a monthly Q&A blog series focused on the need to embrace our common planetary citizenship. Each of these Q&As will feature a distinguished author, scientist, or leader offering perspective on how to take care of the only planetary home we have.

Geoffrey Holland is a Portland, Oregon based writer/producer, and principal author of The Hydrogen Age, Gibbs-Smith Publishing, 2007

The MAHB Blog is a venture of the Millennium Alliance for Humanity and the Biosphere. Questions should be directed to joan@mahbonline.org