KISHINCHAND CHELLARAM COLLEGE

Wonders of Pale Blue Dot

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CYANOBACTERIA
Tiny green cyanobacteria played an outsize role in Earth's history by creating the planet's oxygen-rich atmosphere through photosynthesis. Ancestral forms also evolved into chloroplasts, the cell

We are made of Star Stuff , We are a way for the Cosmos to know itself. ~ Carl Sagan

Inside this issue:

A New Antibiotic Kills Pathogens Without Detectable Resistance.

"Teixobactin is the first new class of antibiotic announced in decades."

Widespread introduction of antibiotics in the 1940s, beginning with penicillin and streptomycin, transformed medicine, providing effective cures for the most prevalent diseases of the time. Resistance development limits the useful lifespan of antibiotics and results in the requirement for a constant introduction of new compounds. However, antimicrobial drug discovery is uniquely difficult, primarily due to poor penetration of compounds into bacterial cells. Natural products evolved to breach the penetration barriers of target bacteria, and most antibiotics introduced into the clinic were discovered by screening cultivable soil microorganisms. Overmining of this limited resource by the 1960s brought an end to the initial era of antibiotic discovery. Synthetic approaches were unable to replace natural products. About 99% of bacteria can't be grown under our current lab techniques, according to Drs. Kim Lewis and Slava Epstein, of Northeastern University in Boston. Working with the National Institutes of Health and the German government, they have developed a remarkably clever new technique, which they call iChip. Soil is greatly diluted. Using a lattice of tiny wells holding individual bacteria within agar, the iChip is covered with a permeable membrane, and replaced into the original soil. Using this technique, Lewis's team has been able to screen 10,000 bacteria, previously unculturable, discovering a new bacteria, Eleftheria terrae, which showed good activity against S. aureus, and 25 new compounds. The mechanism of action of teixobactin was found was intriguing as well. This compound is promising as an antibiotic for several reasons. First, it is a new cell wall inhibitor type of antibiotic, meaning it blocks bacteria from being able to reproduce. It binds to lipid II, and is different in its action than other glycopeptide drugs, like vancomycin or dalbavancin. Teixobactin shows great activity against some of the problem Gram positive superbugs I deal with regularly—MRSA, enterococci, and C. diff—and has activity against tuberculosis and B. anthraces. Importantly, the drug is bactericidal vs VISA (Vancomycin Intermediate S. aureus)—meaning it will kill this resistant bacteria, a scourge of hospitals.

We have a genetic kinship with all life on earth, an atomic kinship to all matter in the cosmos. So when I look at the Universe, I feel large, because I remind myself that not only are we living in this Universe, the Universe is living within us.
~ Neil DeGrasse Tyson

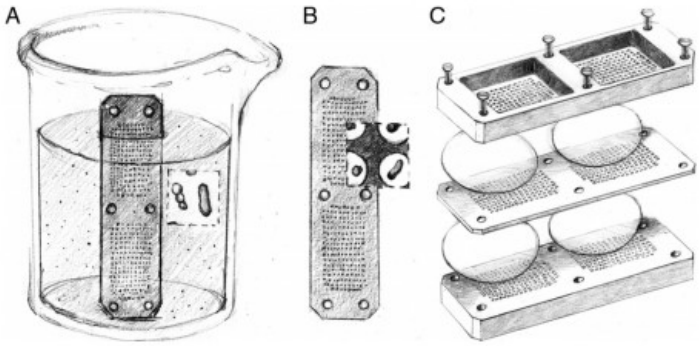
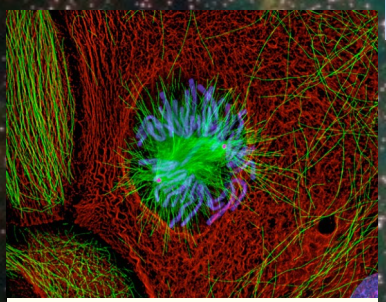


FIG. 1. Isolation chip, or ichip, for high-throughput microbial cultivation *in situ*. (A) Dipping a plate with multiple through-holes into a suspension of mixed environmental cells leads to capturing (on average) a single cell (B). (C) Ichip assembly: membranes cover arrays of through-holes from each side; upper and bottom plates with matching holes press the membranes against the central (loaded) plate. Screws provide sufficient pressure to seal the content of individual through-holes, each becoming a miniature diffusion chamber containing (on average) a single cell. (Artwork by Stacie Bumgarner, Whitehead Institute for Biomedical Sciences, Cambridge, MA.)

Microscopes That See The Impossible.

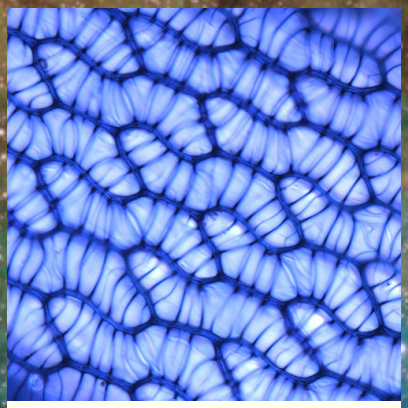


A fluorescent micrograph showing the nuclear envelope of an amphibian cell breaking up in preparation for cell division.

Watching individual memories form in brain cells, DNA in action and plaques form in Alzheimer's disease are all now possible thanks to advances by Eric Betzig of the Howard Hughes Medical institute in Ashburn, Virginia, William "W. E." Moerner of Stanford University in California – and Stefan Hell of the Max Planck Institute for Biophysical Chemistry in Göttingen, Germany. Their ingenuity has given biologists an otherwise impossible window into the nanoscale world of living things, turning the microscope into a "nanoscope". To succeed, they had to overcame a natural barrier called Abbe's diffraction limit, discovered a century ago, which makes all objects smaller than 0.2 millionths of a metre blurred when viewed through a conventional microscope. Their efforts culminated in the development of super-resolved fluorescence microscopy, a method of routinely viewing living objects tinier

than the Abbe limit, including viruses, proteins, small organic molecules and tiny chambers within cells."The work of the laureates has made it possible to observe living processes in real time," said Måns Ehrenberg of Uppsala University in Sweden. "It means we can watch DNA as it's read and turned into proteins, how proteins related to disease aggregate in brain diseases including Alzheimer's, and seen changes in neurons in the brain during learning processes," said Ehrenberg.

Hell said that the method has made it possible in theory to view all objects, however small. "It shows the cell at a molecular scale, which is very important to understanding how the cell works and what goes wrong if the cell is diseased," he said, calling in to the announcement. "So it's very important for understanding physiology and disease."



Sphagnum moss :An ultra close-up view of this moss leaf shows what look like a bunch of worms clumped together. The "tiles" in the pattern are hyaline cells: dead cells capable of holding large amounts of water.

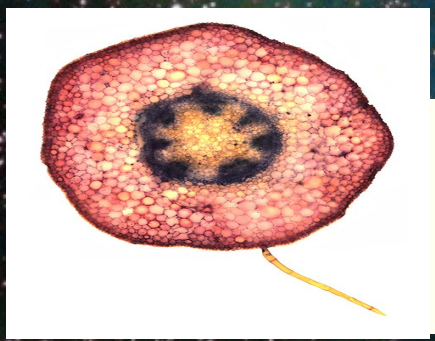
"Fall in love with some activity, and do it! Nobody ever figures out what life is all about, and it doesn't matter. Explore the world. Nearly everything is really interesting if you go into it deeply enough. Work as hard and as much as you want to on the things you like to do the best. Don't think about what you want to be, but what you want to do. Keep up some kind of a minimum with other things so that society doesn't stop you from doing anything at all." ~ Richard Feynman

Bacteria Can Use Magnetic Particles To Create a 'natural battery'

According to study leader Dr James Byrne (Tübingen): "The geochemistry is interesting in itself, but there are also potentially useful implications which may derive form this work. The flow of electrons is critical to the existence of all life and the fact that magnetite can be considered to be redox active opens up the possibility of bacteria being able to exist or survive in environments where other redox active compounds are in short supply in comparison to magnetite. In our study we only looked at iron metabolizing bacteria, but we speculate that it might be possible for other non-iron metabolizing organisms to use magnetite as a battery as well -- or if they can be made to use it, through genetic engineering. But this is something that we do not know yet."

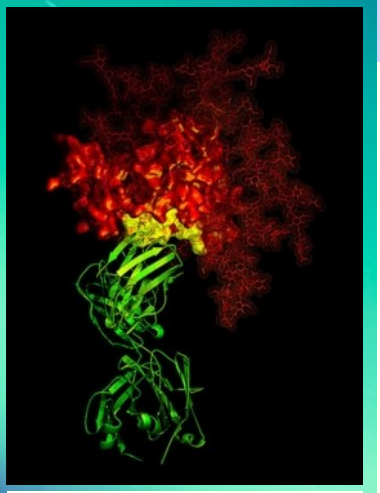
Researchers from the University of Tübingen, the University of Manchester, and Pacific Northwest National Laboratory, USA, incubated the soil and water dwelling purple bacteria *Rhodopseudomonas palustris* with magnetite and controlled the amount of light the cultures were exposed to. Using magnetic, chemical and mineralogical analytical methods, the team showed that in light conditions which replicated the day-time, phototrophic iron-oxidizing bacteria removed electrons from the magnetite, thereby discharging it. During the night-time conditions, the iron-reducing bacteria took over and were able to dump electrons back onto the magnetite and recharge it for the following cycle.

This oxidation/reduction mechanism was repeated over several cycles, meaning that the battery was used over repeated day-night cycles. Whilst this work has been on iron-metabolizing bacteria, it is thought that in the environment the potential for magnetite to act as a battery could extend to many other types of bacteria which do normally not require iron to grow, e.g. fermenters.



Primrose :The stem of this flowering plant conceals a star-like shape in its centre, its outline formed by a black ring of seven tightly-packed vascular cells. This common primrose is distinguished from other species by its pale yellow flowers that grow on long, hairy stalks

A Pill That Mimics the Immune System



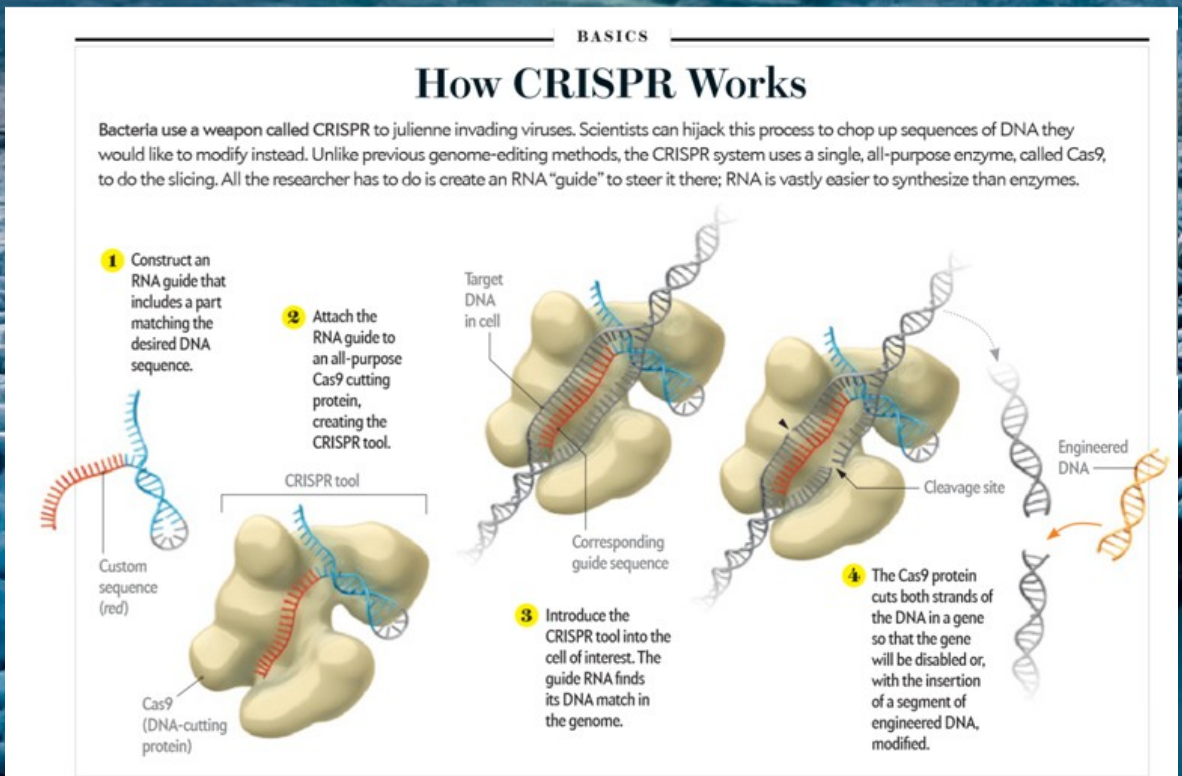
The therapeutic potential of synthetic antibody like compounds is vast.

The human body doesn't like outsiders. When a foreign pathogen or substance, say an unwanted virus, finds its way into our blood streams we produce antibodies that the neutralize the threat. These "Y"-shaped proteins are made by a class of white blood cells called plasma cells and bind to molecules on the invaders called antigens, triggering another set of white blood cells to literally ingest the interloper. For years now doctors have used antibodies and other protein-based therapies (aka biologics) to treat a range of illnesses, cancers, infections and autoimmune diseases among them.

In work recently published in the *Journal of the American Chemical Society* Spiegel and his team have successfully developed the first synthetic molecules that behave like antibodies. Like the real thing, these so-called "synthetic antibody mimics"—or "SyAMs"—bind to both diseased cells and disease-fighting immune cells. Specifically the compounds were found to zero in on and bind to a specific antigen on prostate cancer cells. The SyAMs also bind to and activate certain immune cells that then devour the malignancy. Spiegel's SyAMs are produced in a way that is similar to conventional drugs, by using chemical reactions to piece together various structural features often not found in nature. As he explains, the therapeutic potential of synthetic antibodylike compounds is vast: "Because antibodies are proteins they're difficult and expensive to produce on a large scale, can cause unwanted immune reactions and tend to aggregate and denature with long-term storage."

Spiegel speculates that SyAMs will be easier and cheaper to produce and less likely to incite aberrant immune activity. SyAMs are also one twentieth the size of antibodies—more akin to the size of most medications—and can therefore perhaps be administered orally. This could be a major boon to patients with cancers and autoimmune diseases like multiple sclerosis who who have to regularly get themselves to infusion centers for monoclonal antibody therapy.

And although SyAM research remains in the petri dish, a mouse model is in the works and human studies are no far off. A number of other labs are also researching ways to fight disease by manipulating antibodies and synthesizing molecules that act on the immune system.



CRISPR, after clustered, regularly interspaced, short palindromic repeats—the genetic mug shots that bacteria use to remember viruses that have attacked them.

Engineers develop new yeast strain to enhance biofuel and biochemical production.

Researchers in the Cockrell School of Engineering at The University of Texas at Austin have used a combination of metabolic engineering and directed evolution to develop a new, mutant yeast strain that could lead to a more efficient biofuel production process that would make biofuels more economically competitive with conventional fuels. Their findings were published online in the journal Metabolic Engineering in March.

Beyond biofuels, the new yeast strain could be used in biochemical production to produce oleochemicals, chemicals traditionally derived from plant and animal fats and petroleum, which are used to make a variety of household products.

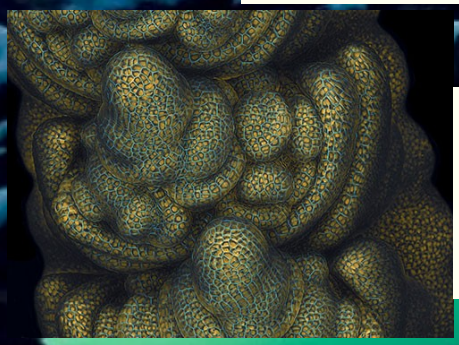
Hal Alper, associate professor in the McKetta Department of Chemical Engineering, and his team have engineered a special type of yeast cell, Yarrowia lipolytica, and significantly enhanced its ability to convert simple sugars into oils and fats, known as lipids, that can then be used in place of petroleum-derived products. Alper's discovery aligns with the U.S. Department of Energy's efforts to develop renewable and cost-competitive biofuels from non-food biomass materials.

"Our re-engineered strain serves as a stepping stone toward sustainable and renewable production of fuels such as biodiesel," Alper said. "Moreover, this work contributes to the overall goal of reaching energy independence."

Special microbes make anti-obesity molecule in the gut.

Researchers have programmed bacteria to generate a molecule that, through normal metabolism, becomes a hunger-suppressing lipid. Mice that drank water laced with the programmed bacteria ate less, had lower body fat and staved off diabetes -- even when fed a high-fat diet -- offering a potential weight-loss strategy for humans.
One advantage to microbial medicine would be that it's low maintenance.
For a therapeutic molecule, Davies and colleagues at Vanderbilt University selected N-acyl-phosphatidylethanolamines (NAPEs), which are produced in the small intestine after a meal and are quickly converted into N-acyl-ethanolamines (NAEs), potent appetite-suppressing lipids. The researchers altered the genes of a strain of probiotic bacteria so it would make NAPEs. Then they added the bacteria to the drinking water of a strain of mice that, fed a high-fat diet, develop obesity, signs of diabetes and fatty livers. Compared to mice who received plain water or water containing control, non-programmed bacteria, the mice drinking the NAPE-making bacteria gained 15 percent less weight over the eight weeks of treatment. In addition, their livers and glucose metabolism were better than in the control mice. The mice that received the therapeutic bacteria remained lighter and leaner than control mice for up to 12 weeks after treatment ended.

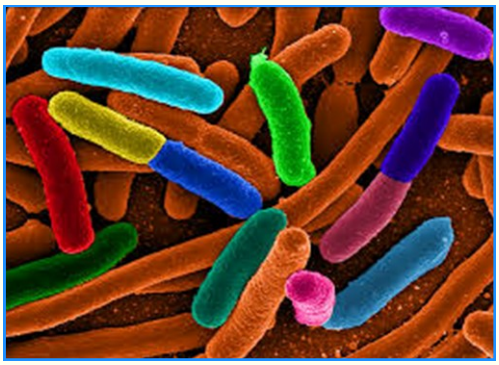
In further experiments, Davies' team found that mice that lacked the enzyme to make NAEs from NAPEs were not helped by the NAPE-making bacteria; but this could be overcome by giving the mice NAE-making bacteria instead. "This suggests that it might be best to use NAE-making bacteria in eventual clinical trials," says Davies, especially if the researchers find that some people don't make very much of the enzyme that converts NAPEs to NAEs. "



Wheat Through the Looking Glass
This image of the young flower buds of wheat was taken using a scanning electron microscope. The photo was created by superimposing two SEM images, then artificially coloured to highlight the cell outlines in blue and the nuclei in orange.

GMO "Kill Switches"

One of the biggest concerns about genetically modified organisms (GMOs) is that they can infiltrate wild populations and spread their altered genes among naturally occurring species. Two groups present a new method of containing GMOs: by making some of their essential proteins reliant upon synthetic amino acids not found outside of the laboratory.



"What really makes this a valuable step change is that kill switches beforehand were very susceptible to mutation or other conditions, such as metabolic cross feeding, from basically inactivating them," said Tom Ellis, a synthetic biologist at Imperial College London who was not involved in the studies. The new approach circumvents some of those problems by making it extremely unlikely for the genetically modified bacteria to be able to survive outside of the conditions dictated by their custom-designed genomes.

Both research teams—one led by George Church at Harvard Medical School and the other by Farren Isaacs at Yale University—based their work on so-called genetically recoded organisms (GROs), bacterial genomes that have had all instances of a particular codon replaced by another. Church and Isaacs, along with their colleagues, had previously developed this concept in collaboration. Since then, their respective groups designed the replacement codons to incorporate a synthetic amino acid, and engineered proteins essential to the organism to rely upon the artificial amino acid for proper function.

"Here, for the first time, we're showing that we're able to engineer a dependency on synthetic biochemical building blocks for these proteins," Isaacs told reporters during a conference call.

Both teams found that the cells perished in environments lacking the synthetic amino acid. Although the technology is not ready for industrial-scale deployment, the scientists suggested that such an approach could be applied as a safeguard against the escape of GMOs.

Genes and Microbes Influence One Another.

The ecology of the gut microbiome may trigger or contribute to a variety of diseases, including autoimmune disorders and obesity, research suggests. Factors such as early environment, diet and antibiotic exposure have a lot to do with why people differ from one another in the composition of their microbiomes. But specific gene variants are also linked to greater risks of developing many of these diseases. Do your genes act on your microbiome, which in turn promotes disease?

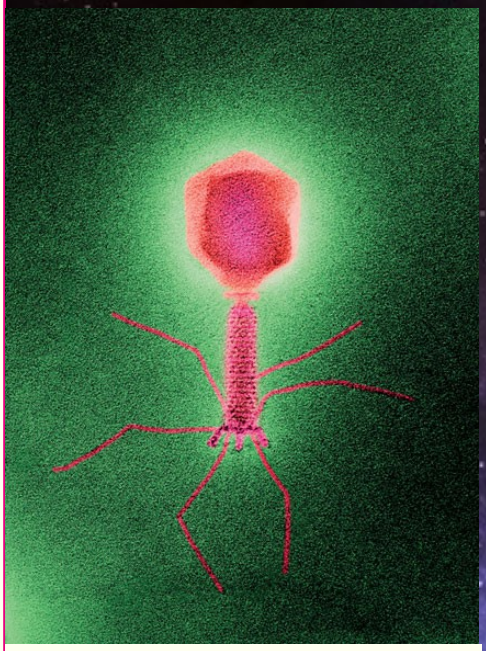
One way researchers have addressed this question is to pick specific genes that are good candidates—for instance, those with a strong link to a disease that also has a microbiome link—and examine whether people who carry mutations that are known to increase the risk of a certain disease also have microbiomes that differ from those who do not have the mutations. A team led by Dan Frank at the University of Colorado Denver took this approach and revealed that specific variants of the NOD2 gene that confer a high risk of developing inflammatory bowel disease to their carriers are also associated with an altered intestinal microbiome.

Experiments in germ-free mice showed that one gut bacterium in particular, Christensenella minuta, can influence the phenotype—the composite of observable characteristics or traits—of the host. Germ-free mice live in sterile bubbles—and they are very skinny. When they are given a microbiome in the form of a fecal transplant from a human donor, however, they plump up within a day or two because the bacteria help them digest their food and develop a proper metabolism. We found that if C. minuta was added to the feces of an obese human donor, the recipient mice were thinner than when C. minuta was not added. Results showing C. minuta has an effect of controlling fat gain in the mouse match data that reveal lean people have a greater abundance of C. minuta in their gut than obese people.

This is evidence that a person's genes can influence the gut microbiome's composition and in turn can shape the individual's phenotype.

Facts:

1. The bacteria-infecting viruses, bacteriophages, are the most abundant life-form on the planet, their number far exceeding that of stars in the universe. Trillions inhabit each of us!
2. Microbes generate at least half the oxygen we breathe.
3. Microbes have been around longer than anything else on Earth, longer even than dinosaurs.
   If you imagine Earth began as a single day: Microbes appeared at 5am Dinosaurs appeared at 10pm ... and humans appeared seconds before midnight.
4. There are more microbes living on our hand than there are people on the planet.
5. Researchers have revived a 250 million year old bacterium, *Bacillus permians*, that was discovered in salt crystals.
6. Deinococcus radiodurans: withstand blasts of radiation 1,000 times greater than would kill a human being.
7. If a single bacterium (10 to power minus 12 gram with a generation time of 20 min would, if it continued to grow exponentially for 48 hour, produce a population that weighed about 4000 times the weight of the earth.
8. Tardigrades can withstand temperatures from just above absolute zero to well above the boiling point of water (100° C), pressures about six times greater than those found in the deepest ocean trenches, ionizing radiation at doses hundreds of times higher than the lethal dose for a human, and the vacuum of outer space. They can go without food or water for more than 10 years, drying out to the point where they are 3% or less water, only to rehydrate, forage, and reproduce.
9. Researchers have discovered that bacteria live and thrive in clouds.



Bacteriophage feeds on bacteria.

INTESTINAL BACTERIA
The human gut teems with bacteria, many of their species still unknown. They help us digest food and absorb nutrients, and they play a part in protecting our intestinal walls. Gut bacteria may also help regulate weight and ward off autoimmune diseases.

PAENIBACILLUS
A lab-grown colony of *Paenibacillus vortex* organizes into a fanlike pattern, with arms reaching out to scout for food. Bacteria can act collectively, communicating with chemical signals.

Look up at the stars and not down at your feet. Try to make sense of what you see, and wonder about what makes the universe exist. Be curious.~ Stephen hawking

An unusually high concentration of Noctiluca scintillans, a bioluminescent microorganism, turned the water a bright, glowing, ethereal blue.

Contributors:

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We are all *connected;* To each other, biologically. To the earth, chemically. To the rest of the *universe atomically*. ~ Neil Tyson