FQXi Essay Contest: How Should Humanity Steer the Future?

Steering the Happy Path to Humanity's Future

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Abstract: Humanity should steer the future with the goals of technological progress, comfortable living, protecting the biosphere, and long-term survival of intelligent life. How far humanity can go depends on laws of physics, how well and soon we can understand those laws and engineer solutions. The feasibility of breakthroughs in energy and interstellar travel determine what is possible. Advances in computing and genetic engineering shape the future along with many other technologies.

1. Introduction

Predicting and steering the future is extensively explored in futures studies and science fiction. Many new technologies could dramatically shape the future, but they all need energy. Some of the ideas in this essay are new to me but surely have already been written about by experts before, though maybe not in this combination.

Humanity continuously steers the future using its evolving institutions: economic, financial, governmental, political, legal, military, educational, corporate, professional, organizational, cultural, activist, religious, and the United Nations. Individuals can have a big impact by scientific discovery, inventions, leadership and philanthropy. Humanity as a whole makes choices (not always intentional) through many individual actions.

Nature steers the future as much as humanity, determining what physics is possible, what the biosphere can support, and when natural disasters occur.

2. My Influences

People with different backgrounds can make very different predictions about the future. My background is as a software engineer and longtime fan of physics and science fiction. Here are some of my influences.

1996 Star Trek: First Contact got me really fired up. Warp drive was the key breakthrough needed to go from a grim situation to a bright future. And 2063 was not that far off, so the physics had to be discovered soon. (On the crackpot index, this is 20 points for use of science fiction works or myths as if they were fact.)

1995 The Physics of Star Trek explained that most technology in Star Trek is impossible or extremely unlikely with known physics or conceivable future physics advances [1].

2000 PBS Nova/Frontline: Global Warming What's Up With The Weather warned that burning fossil fuels is causing global warming. Carbon dioxide in the atmosphere traps heat and climbed from 300 parts per million before the industrial age to 370 ppm in 2000. It was projected to go to 560 ppm in 2050. (It was measured at 397 ppm in 2014 [2]). The world is running out of oil, but has enough coal for at least 100 years. But if all the coal is burned, the carbon dioxide level would go much higher, possibly causing oceans to raise enough to displace millions of people. The world will use three to four times more energy in 2100 than 2000 because of increasing population and increasing use per person [3].

2004 The Coming Generational Storm said the United States and other countries may have a financial crisis by 2030. This is because of deficit spending and the aging population raising the cost of Social Security and health care. The book recommended how to revamp those systems [4]. (The 2009 Affordable Care Act addresses some of the book's health care concerns.)

2007 The 12-part documentary Mars Rising explained how incredibly difficult it would be getting to Mars and living there. Problems include the cost of transporting so much material, the energy source, shielding from radiation, growing food, and dealing with emergencies [5]. We really need many new technologies.

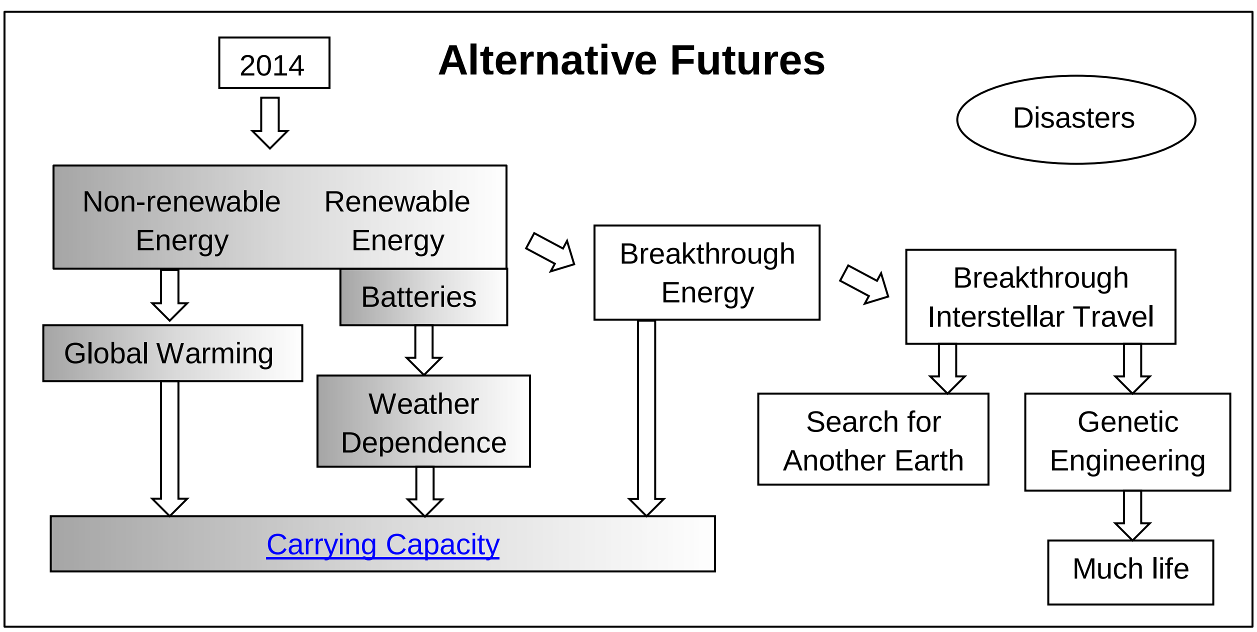
2010 A Scientific American article said using fusion as an energy source may never work [6]. (Here is one development in fusion energy that gives some hope [7].)

2010 Bill Gates talked about pursuing multiple energy solutions and reducing carbon emissions to zero by 2050 to avoid global warming. We need a breakthrough on a schedule [8].

So my thinking about the future is influenced by the combination of financial problems: deficit spending, rising costs for energy, social security, health care, and dealing with global warming.

3. Alternative Futures

Below is a diagram of alternative futures that depend on what breakthroughs are possible and whether humanity can achieve them in time.



The shading in this diagram represents a continuum of possibilities, aggregated from the state of all life and resources. Breakthroughs in energy and interstellar travel would allow civilization off Earth, allowing them to steer their own path. The “Happy Path” in this essay title alludes to paths through computer code with no error conditions, here meaning no global disasters.

4. Energy

Modern civilization was made possible by energy from burning fossil fuels. But Earth is running out of oil, global warming is increasing, and energy demand is increasing. Civilization is transitioning to other energy sources to survive. Renewable energy alone will not meet demand, but it helps. New batteries and high temperature superconductors would help make wind and solar power less dependent on weather and region. Oil is still needed to make many products like fertilizers, detergents, solvents, adhesives, and most plastics.

Soon a breakthrough energy source will be needed, which is cleaner/safer fission, fusion or something requiring new physics. Unfortunately that will bring new dangers, and will allow for increased population which will further stress the biosphere.

Petroleum engineers are having success extending reserves, but it is costly and environmentally damaging. Everyone should support renewable energy, conserve energy and increase efficiency as much as possible to buy more time to make an energy breakthrough.

5. Natural Disasters

Natural disasters come in a continuum of severity. Regional disasters happen every few years and are tragic and costly enough. A global disaster like below would challenge modern civilization:

Year	Event	If It Happened Today
535-536	Volcano or impact four hours of sunlight a day.	Crop failures, less air travel, less solar power, drought?
1816	Volcano	
1859	Solar storm	Damaged transformers, satellites
1918	Flu pandemic infected 30%, killed 3-5%	Service disruption

If civilization is stretched to the limit growing food for too many people, it does not have excess capacity to absorb a global disaster. Also if civilization collapses, it may not be possible to rebuild to modern level due of lack of remaining accessible non-renewable energy.

An extreme global disaster is rare but threatens all of humanity. The options are for some people or robots to go underground for 10-1000 years, repopulate Earth from a Mars colony, or go to another star system. There may be years of warning or no warning. It would be safer to spread out to other star systems before being forced by an extreme disaster.

6. New Physics

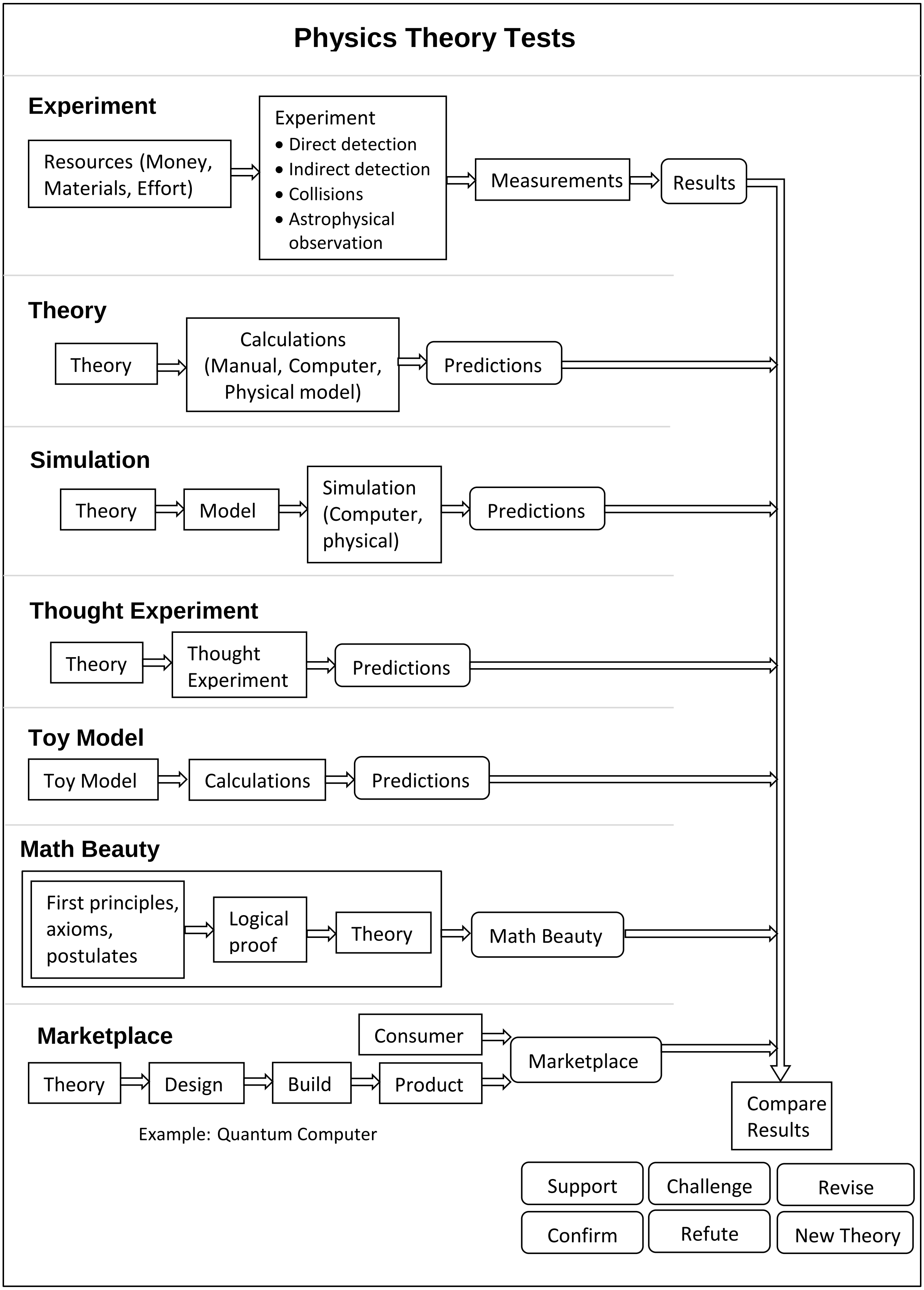
New physics is needed possibly for energy, probably for stopping natural disasters, and certainly for interstellar travel. New physics might be quantum gravity or new understanding of existing theory. The standard model and general relativity seem to explain physics very well except in extreme situations like the big bang and black holes. What hope is there to find new physics that will be of practical help? There are at least 139 unsolved problems in physics and surely other questions that have not even been thought of yet. So a huge breakthrough may still be possible.

I follow physics as a hobby like many people follow sports. The following is like a fan calling into sports radio to talk about the team. Some of this is wrong but something may be helpful.

6.1. Testing Physics Theories

There are several ways to test physics theories. A diagram is on the next page. Unfortunately, there are problems with each type of test, listed in this table:

Physics Theory Test	Problems and Notes
Experiment	• Cannot reach Planck energy scale. • Technology may not exist. • May be too expensive. ○ Need repeatable results using different experiments.
Theory	• Underdetermined - theories differ but predictions that can be tested in both theories match experimental results. • May take computer too long to calculate predictions. • Difficulties finding useful equations or algorithms. ○ Dualities – theories make same predictions but some calculations are easier in one theory. ○ Not all predictions must be testable for a theory to be correct. ○ Some theories can be modified to match results, but may become too ad hoc to be tenable.
Simulation	• Some computer simulations may take too long. • Simulation may not accurately model reality.
Thought Experiment	• May not find flawed reasoning.
Toy Model	○ Simplified theory makes calculations feasible. • Predictions are hard to compare with other tests of real theory.
Math Beauty	• Beauty is subjective. For example, proof must be less than three pages. • "If other sets of laws of physics are possible, even just mathematically, this implies that our laws of physics cannot be derived from first principles." [9] arXiv:1306.5083 [hep-ph] page 2.
Marketplace	• Failure in marketplace does not necessarily disprove theory. ○ Success in marketplace can be more convincing than formal evidence.


Physics Theory Tests
Experiment
Resources (Money, Materials, Effort)
Experiment
• Direct detection
• Indirect detection
• Collisions
• Astrophysical observation
Measurements
Results
Theory
Theory
Calculations (Manual, Computer, Physical model)
Predictions
Simulation
Theory
Model
Simulation (Computer, physical)
Predictions
Thought Experiment
Theory
Thought Experiment
Predictions
Toy Model
Toy Model
Calculations
Predictions
Math Beauty
First principles, axioms, postulates
Logical proof
Theory
Math Beauty
Marketplace
Consumer
Theory
Design
Build
Product
Marketplace
Example: Quantum Computer
Compare Results
Support
Challenge
Revise
Confirm
Refute
New Theory

Some of the above tests have permanent problems. But there is hope for new experiment technology and discovering new predictions, a better equation, or related theories.

Now consider situations where a computer would take too long to calculate predictions or run simulations. A computational problem with Nondeterministic Polynomial complexity cannot be solved by a computer in a feasible amount of time in the worst case. Not even in the future with faster computers, usually not even with quantum computers [10].

An example of an NP algorithm is predicting particle interactions with QCD using Feynman diagrams, which depend exponentially on the number of particles [11]. Very encouragingly, the new unitarity method [12] is not NP (Lance Dixon talk [13]).

Maybe the unitarity method could be adapted to speed up calculations in other theories? Also a quantum computer could efficiently simulate local quantum systems. If more calculations and simulations could use real theories instead of toy models, it would be a big advance.

6.2. Multiverse Problem

Our universe has several physical constants that seem highly fine-tuned that allow life to exist. The main scientific explanation is there are many universes with different physical constants, and we have to live in a universe that allows life. String theory may describe $10^{\wedge \text{hundreds}}$ of possible universes with different physical constants with the string theory landscape. However finding the landscape configuration matching our universe is an NP problem [14] arXiv:hep-th/0602072. So string theory cannot make specific predictions about our universe. The most that might be achievable is proving that the Standard Model is in the string theory landscape [9] arXiv:1306.5083 [hep-ph]. Other quantum gravity theories have similar problems making predictions [15].

There are other mysteries about string theory [16]. What is string theory? What is space-time? What are the underlying symmetries of string theory? What is the useful non-perturbative description of Quantum Gravity? Even if these mysteries are solved, string theory still may not be able to make specific predictions about our universe. String theory and other quantum gravity theories are still worth investigating because they give insight about other theories, and they may hold surprises allowing predictions.

6.3. New Techniques Needed

The leading extension to the Standard Model is Supersymmetry. It adds many parameters that make searches extremely challenging and makes the theory difficult to exclude. This is a bad situation with so many unsolved problems in physics, and extensions to proven theories having such trouble making definite predictions.

One hope is the amplituhedron, a geometric mathematical object used to calculate probabilities for particle interactions in a simplified supersymmetric theory. Locality and unitarity arise as emergent phenomena, and space and time may be emergent or derived too [17]. Arkani-Hamed explains how the theory can be developed, guided by experimental results in addition to math [18].

6.4. Could Intelligent Computers Find New Physics?

Some futurists predict computers will become more intelligent than humans in the 21st century. Will an intelligent computer be able to find new physics, with or without human help? First physicists would need to prepare consistent training documents for the computer to learn. (Unfiltered arxiv.org contains many contradictory theories disagreeing on basics like how many dimensions there are.) A computer would encounter the same problems as humans, like experiment energy limits and NP computational problems. A computer currently cannot find an equation for a general set of measurements because it is an NP problem [19]. But a program like Eureqa using a genetic algorithm can find candidate equations with human help. Maybe a computer could develop human-like skills to approximately solve some NP problems using heuristics and intuition. This would be needed to handle NP problems like making proofs and writing computer programs.

What might a computer do better than people? A computer might be more methodical in keeping track of what it knows. I cannot find a centralized list of facts that might help guide the search for new physics. Also a computer would not be biased or limited in memory when evaluating many theories. And a computer could consider many seemingly crackpot ideas, and unlike a crackpot, discard those ideas that do not work out. However intelligent computers may not arrive in time, if at all. People can already use computers for massive calculations and it is not clear computers would be better at higher level thinking.

6.5. Other Ideas:

- Look at the list of unsolved problems in physics and look for connections between problems. Could multiple problems be fixed by changing one assumption?
- Use crowdsourcing [20] where applicable to speed up physics discovery like polymathprojects.org for math. (This FQXi essay contest is a form of crowdsourcing.)
- Computer science majors starting on a Masters or PhD should consider asking physicists for research topics. Many areas of programming help physics, like numerical algorithms, pattern recognition for astronomy, systems programming for handling big data, and the web.
- Recommend discussing religion in a physics blog or presentation like in a modern scientific paper, rarely and respectfully. Remember there are multiple religions and denominations with different interpretations, so no fact proves or disproves a matter of faith universally. Physics benefits everyone and needs everyone's support.
- Consider how many people it took to find the Higgs boson--six people to propose it and 10,000 to find it. But those people used cars, grocery stores, the internet and the rest of the infrastructure of civilization supported by billions of people. This is a great time to make a breakthrough.
- Find new physics, get a T-shirt!

Ordinary citizens can help:

- Participate in a citizen science project.
- Donate spare computer time for physics research (tradeoff electricity cost).
- Support a cause, like Save the James Webb Space Telescope.
- Support science and math education.

7. Space Colonization

Earth is currently paradise, but space colonization is necessary for humanity's long term survival. Yet the rest of the solar system is horrible for life. Terraforming Mars is not possible because of cost, we can't wait 100-10,000 years to form a new atmosphere, and Mars has no magnetic field so the atmosphere would be lost again and would not protect against radiation. Space is extremely costly so it cannot solve humanity's population problem nor allow for mass evacuation in case of disaster. Space is for only a few to start anew.

7.1 Interstellar Travel

Interstellar travel with known physics is essentially impossible, either with people or robots. It would take too much energy, cost too much, take too long, there would be too much heat transfer from exhaust to vehicle, and too much damage from micrometeoroids and radiation.

Miguel Alcubierre heroically proposed faster than light propulsion using aspects of general relativity, inspired by warp drive from Star Trek and previous science fiction. But this method of propulsion has been shown to be impossible for faster than light travel [21]. However it might still be used for relativistic sub-light speed travel [22].

A wormhole seems to be always accompanied by quantum entanglement [23]. Entanglement does not allow transmitting information faster than light, so a wormhole is no help.

I read special relativity is wrong; it does not take an infinite amount of energy to accelerate an object to the speed of light. Instead when a particle gains Planck energy, it loses all mass and goes the speed of light. But that would take an enormous amount of energy. It would allow travelling any distance instantly, like with the fictional Battlestar Galactica jump drive.

Let's assume it is impossible to go faster than light because that would allow time travel. Let's assume interstellar travel is possible using yet-to-be-discovered physics, using extra dimensions, something about the quantum vacuum or emergent space/time, or who knows what. Somehow it would shield against radiation and interstellar debris. Inertia and g-forces during acceleration would not be a problem. Very little or no time would pass for the travelers but centuries could pass on Earth.

7.2. Finding Habitable Planets

Methods of detecting exoplanets keep improving. But detecting an Earth-size planet in an Earth-type orbit is still very difficult. A planet's atmosphere usually can only be studied if the planet passes in front of or behind its star when viewed from Earth. Sampling techniques can estimate the number of planets in the galaxy but cannot find every habitable planet or moon or find the best, closest one.

Oxygen could be detected in the atmosphere of a planet and the approximate gravity and temperature could be determined. But unless aliens on the planet are transmitting detectable radio signals, the only way to know if a planet is habitable is to actually go there. How much of the planet is land and water, what is the temperature variation, how much harmful radiation reaches the surface, is there fresh water, eatable plants and animals?

With a given number of starships, determining the shortest routes to visit all the star systems is an NP problem like the traveling salesman problem. The best pattern may be to just pick the next nearest or most promising unvisited star. Communication between ships would take too long so each ship would need to plot its own course.

7.3. Populating Planets

After arriving at a habitable planet, who will live there? If the planet has intelligent life, we may just exchange information and move on. If there is no life, just deposit microbes to start changing the atmosphere. If there are plants and animals, what intelligent life should be put there? Suppose it gets up to 140 degrees Fahrenheit, the gravity is twice that of Earth, the atmosphere is barely breathable, it is hard to see in the different sunlight, and the plants are uneatable. It would be unethical to send humans to live there.

John D. Barrow defined a scale for measuring a civilization's level of technological advancement, based on their ability to manipulate their environment over increasingly smaller dimensions. This includes reading and engineering genetic code and creating complex forms of artificial life [24, p. 133]. Would it really be possible to genetically engineer an intelligent life form to live on that planet?

There are theoretically $2^{\wedge 12,000,000,000}$ possible arrangements of base pairs in the human genome [25]. And humans also need many non-human cells to live. There is no way a computer could run an evolutionary computation long enough to produce something living, well adapted for its environment, intelligent, with a good body image. Even the problem of finding the folded ground state of a protein is NP-hard arXiv:hep-th/0602072 p27. Nature accomplishes this using evolution, a massively parallel computation running for billions of years that seeks out best case solutions rather than NP worst case [14].

In the future, DNA might be decoded well enough that building blocks could be spliced together to genetically engineer life forms rather than building up DNA from individual base pairs. But probably it would be better to let life evolve naturally.

8. Conclusion

Humanity's problems of energy, interstellar travel and finding habitable worlds would also apply to aliens and robots. Fermi's paradox questions why there is no evidence of alien civilizations, and the answer has to do with those problems. Depending on my mood, I think humanity has won the cosmic lottery so many times to get to this point; this is as far as we can go. Other times I think a few heroes will make another breakthrough. And if all of humanity can steer the future by many individual actions to save the Earth, the future looks bright with lots of lens flare.

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