

**PETER DIAMANDIS**  
**EXPONENTIAL TECHNOLOGY**

**Peter Diamandis -Exponential Technology- Blogs**



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## TOP 10 TECH TRENDS TRANSFORMING HUMANITY

Despite all the negative political-related news, there were 10 tech trends this year that positively transformed humanity.

For this “2017 Kick-Off” blog, I reviewed 52 weeks of science and technology breakthroughs, and categorized them into the top 10 tech trends changing our world.

I’m blown away by how palpable the feeling of exponential change has become.

I’m also certain that 99.999% of humanity doesn’t understand or appreciate the ramifications of what is coming.

In this blog, enjoy the **top 10 tech trends of the past 12 months** and why they are important to you.

**(NOTE:** at the end of this blog, I provide a detailed reference for all of the new items below).

Let’s dive in...

### 1. We are Hyper-Connecting the World

In 2010, 1.8 billion people were connected. Today, that number is about 3 billion, and by 2022 – 2025, that number will expand to include every human on the planet, approaching 8 billion humans.

Unlike when I was connected 20 years ago at 9,600 baud via AOL, the world today is coming online at 1 megabit per second or greater, with access to the world’s information on Google, access to the world’s products on Amazon, access to massive computing power on AWS and artificial intelligence with Watson... not to mention crowdfunding for capital and crowdsourcing for expertise.

Looking back at 2016, you can feel the acceleration. Here are seven stories that highlight the major advances in our race for global connectivity:

a) **Google’s 5G Solar Drones Internet Service:** Project Skybender is Google's secretive 5G Internet drone initiative. News broke this year that they have been testing these solar-powered drones at Spaceport America in New Mexico to explore ways to

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deliver high-speed Internet from the air. Their purported millimeter wave technology could deliver data from drones up to 40 times faster than 4G.

b) **Facebook's Solar Drone Internet Service:** Even before Google, Facebook has been experimenting with a solar-powered drone, also for the express purpose of providing Internet to billions. The drone has the wingspan of an airliner and flies with roughly the power of three blowdryers.

c) **ViaSat Plans 1 Terabit Internet Service:** ViaSat, a U.S.-based satellite company, has teamed up with Boeing to launch three satellites to provide 1 terabit-per-second Internet connections to remote areas, aircraft and maritime vehicles. ViaSat is scheduled to launch its satellite ViaSat2 in early 2017.

d) **OneWeb Raises \$1.2B for 900 Satellite Constellation:** An ambitious low-Earth Orbit satellite system proposed by my friends Greg Wyler, Paul Jacobs and Richard Branson just closed \$1.2 billion in financing. This 900-satellite system will offer global Internet services as soon as 2019.

e) **Musk Announces 4,425 Internet Satellite System:** Perhaps the most ambitious plan for global Internet domination was proposed this year by SpaceX founder Elon Musk, with plans for SpaceX to deploy a 4,425 low-Earth orbit satellite system to blanket the entire planet in broadband.

## 2. Solar/Renewables Cheaper than Coal

We've just exceeded a historic inflection point. 2016 was the year solar and renewable energy became cheaper than coal.

In December, the World Economic Forum reported that solar and wind energy is now the same price or cheaper than new fossil fuel capacity in more than 30 countries.

"As prices for solar and wind power continue their precipitous fall, two-thirds of all nations will reach the point known as "grid parity" within a few years, even without subsidies," they added.

This is one of the most important developments in the history of humanity, and this year marked a number of major milestones for renewable energy.

Here's 10 data points (stories) I've hand-picked to hammer home the historic nature of this 2016 achievement.

a) **25% of the World's Power Comes From Renewables:** REN21, a global renewable energy policy network, published a report showing that a quarter of the world's power now comes from renewable energy. International investment in renewable energy

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reached \$286 billion last year (with solar accounting for over \$160b of this), and it's accelerating.

b) **In India, Solar is Now Cheaper Than Coal:** An amazing milestone indeed, and India is now on track to deploy >100 gigawatts of solar power by 2022.

c) **The UK is Generating More Energy From Solar Than Coal:** For the first time in history, this year the U.K. has produced an estimated 6,964 GWh of electricity from solar cells, 10% higher than the 6,342 GWh generated by coal.

d) **Coal Plants Being Replaced by Solar Farms:** The Nanticoke Generating Station in Ontario, once North America's largest coal plant, will be turned into a solar farm.

e) **Coal Will Never Recover:** The coal industry, once the backbone of U.S. energy, is fading fast on account of renewables like solar and wind. Official and expert reports now state that it will never recover (e.g. coal power generation in Texas is down from 39% in early 2015 to 24.8% in May 2016).

f) **Scotland Generated 106% Energy from Wind:** This year, high winds boosted renewable energy output to provide 106% of Scotland's electricity needs for a day.

g) **Costa Rica Ran on Renewables for 2+ Months:** The country ran on 100% renewable energy for 76 days.

h) **Google to Run 100% on Renewable Energy:** Google has announced its entire global business will be powered by renewable energy in 2017.

i) **Las Vegas Meets Goal of 100% Power by Renewables:** Las Vegas is now the largest city in the country to run entirely on renewable energy.

j) **Tesla's Gigafactory:** Tesla's \$5 billion structure in Nevada will produce 500,000 lithium ion batteries annually and Tesla's Model III vehicle. It is now over 30 percent complete... the 10 million square foot structure is set to be done by 2020. Musk projected that a total of 100 Gigafactories could provide enough storage capacity to run the entire planet on renewables.

### 3. *Glimpsing* the End of Cancer & Disease

Though it may seem hard to believe, the end of cancer and disease is near.

Scientists and researchers have been working diligently to find novel approaches to combating these diseases, and 2016 saw some extraordinary progress in this regard.

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Here's my top 10 picks that give me great faith about our abilities to cure cancer and most diseases:

- a) **Cancer Immunotherapy Makes Strides (Extraordinary Results):** Immunotherapy involves using a patient's own immune system (in this case, T cells) to fight cancer. Doctors remove immune cells from patients, tag them with "receptor" molecules that target the specific cancer, and then infuse the cells back in the body. During the study, 94% of patients with acute lymphoblastic leukemia (ALL) saw symptoms vanish completely. Patients with other blood cancers had response rates greater than 80%, and more than half experienced complete remission.
- b) **In China, CRISPR/Cas9 used in First Human Trial:** A team of scientists in China (Sichuan University) became the first to treat a human patient with an aggressive form of lung cancer with the groundbreaking CRISPR-Cas9 gene-editing technique.
- c) **NIH Approves Human Trials Using CRISPR:** A team of physicians at the University of Pennsylvania's School of Medicine had their project of modifying the immune cells of 18 different cancer patients with the CRISPR-Cas9 system approved by the National Institute of Health. Results are TBD.
- d) **Giant Leap in Treatment of Diabetes from Harvard:** For the first time, Harvard stem cell researchers created "insulin producing" islet cells to cure diabetes in mice. This offers a promising cure in humans as well.
- e) **HIV Genes Cut Out of Live Animals Using CRISPR:** Scientists at the Comprehensive NeuroAIDS Center at Temple University were able to successfully cut out the HIV genes from live animals, and they had over a 50% success rate.
- f) **New Treatment Causes HIV Infected Cells to Vanish:** A team of scientists in the U.K. discovered a new treatment for HIV. The patient was treated with vaccines that helped the body recognize the HIV-infected cells. Then, the drug Vorinostat was administered to activate the dormant cells so they could be spotted by the immune system.
- g) **CRISPR Cures Mice of Sickle Cell Disease:** CRISPR was used to completely cure sickle cell by editing the errant DNA sequence in mice. The treatment may soon be used to cure this disease, which affects about 100,000 Americans.
- h) **Eradicating Measles (in the U.S.):** The World Health Organization (WHO) announced that after 50 years, they have successfully eradicated measles in the U.S. This is one of the most contagious diseases around the world.
- i) **New Ebola Vaccine Proved to be 100% Effective:** None of the nearly 6,000 individuals vaccinated with rVSV-ZEBOV in Guinea, a country with more than 3,000 confirmed cases of Ebola, showed any signs of contracting the disease.

j) **Eradicating Polio:** The World Health Organization has announced that it expects to fully eradicate polio worldwide by Early 2017.

## 4. Progress on Extending Human Life

I am personally convinced that we are on the verge of significantly impacting human longevity. At a minimum, making “100 years old the new 60,” as we say at Human Longevity Inc.

This year, hundreds of millions of dollars were poured into research initiatives and companies focused on extending life.

Here are five of the top stories from 2016 in longevity research:

a) **500-Year-Old Shark Discovered:** A Greenland shark that could have been over 500 years old was discovered this year, making the species the longest-lived vertebrate in the world.

b) **Genetically Reversing Aging:** With an experiment that replicated stem cell-like conditions, Salk Institute researchers made human skin cells in a dish look and behave young again, and mice with premature aging disease were rejuvenated with a 30% increase in lifespan. The Salk Institute expects to see this work in human trials in less than 10 years.

c) **25% Life Extension Based on Removal of Senescent Cells:** Published in the medical journal Nature, cell biologists Darren Baker and Jan van Deursen have found that systematically removing a category of living, stagnant cells can extend the life of mice by 25 percent.

d) **Funding for Anti-Aging Startups:** Jeff Bezos and the Mayo Clinic-backed Anti-Aging Startup Unity Biotechnology with \$116 million. The company will focus on medicines to slow the effects of age-related diseases by removing senescent cells (as mentioned in the article above).

e) **Young Blood Experiments Show Promising Results for Longevity:** Sakura Minami and her colleagues at Alkahest, a company specializing in blood-derived therapies for neurodegenerative diseases, have found that simply injecting older mice with the plasma of young humans twice a week improved the mice’s cognitive functions as well as their physical performance. This practice has seen a 30% increase in lifespan, and increase in muscle tissue and cognitive function.

## 5. Amazing Successes with Stem Cells

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I've increasingly become confident and passionate about stem cells, the regenerative engine of the body, to help cure disease and extend the healthy human lifespan. I previously wrote about stem cells and the incredible work from Dr. Robert (Bob) Hariri [here](#).

Below are my top three stories demonstrating the incredible research and implications for stem cells in 2016:

a) **Stem Cells Able to Grow New Human Eyes:** Biologists led by Kohji Nishida at Osaka University in Japan have discovered a new way to nurture and grow the tissues that make up the human eyeball. The scientists are able to grow retinas, corneas, the eye's lens, and more using only a small sample of adult skin.

b) **Stem Cell Injections Help Stroke Victims Walk Again:** In a study out of Stanford, of 18 stroke victims who agreed to stem cells treatments, seven of them showed remarkable motor function improvements. This treatment could work for other neurodegenerative conditions such as Alzheimer's disease, Parkinson's and Lou Gehrig's disease.

c) **Stem Cells Help Paralyzed Victim Gain Use of Arms:** Doctors from the USC Neurorestoration Center and Keck Medicine of USC injected stem cells into the damaged cervical spine of a recently paralyzed 21-year-old man. Three months later, he showed dramatic improvement in sensation and movement of both arms.

## 6. The Year of Autonomous Vehicles

2016 was definitely "the year of the autonomous vehicle."

As Google, Tesla and Uber lead the charge, almost every major car company is investing heavily in autonomy.

This will be one of the defining technology developments of the decade -- soon we may well look back in shock that we ever let humans drive cars on their own...

In looking back at the last 12 months, here are the top nine developments in self-driving cars:

a) **Autonomous Uber Operational in Pittsburgh:** Uber's self-driving autonomous cars began picking up passengers in Pittsburgh this year. They also attempted a rollout in San Francisco.

b) **Uber's Self-Driving Trucks Made a Delivery of 50,000 Beers:** This year, Uber acquired autonomous truck company Otto, and the retrofitted 18-wheeler made its first delivery... 50,000 cans of Budweiser.

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- c) **Every Tesla Will Be Fully Autonomous in 2017:** Elon Musk announced that all new Tesla cars will have Level 5 autonomy. This means that by 2017, Tesla cars will be fully capable of driving themselves with zero interaction from a human driver.
- d) **Ford Targets 2021 for Autonomous Vehicle Release:** Ford announces intention to deliver high-volume, fully autonomous vehicle for ridesharing in 2021.
- e) **GM's First Fully Autonomous Car:** The company plans to bring its fully electric self-driving cars to the masses by launching its first driverless cars on Lyft.
- f) **Google Creates Waymo to Support Self-Driving Car Technology:** Google spun out its self-driving car unit as its own separate entity called Waymo.
- g) **Google Plans Ride-Sharing Service with Chrysler:** Google will deploy a semi-autonomous version of the Chrysler Pacifica minivan by as soon as the end of 2017.
- h) **Autonomy Will Kill Car Ownership:** A former Tesla and BMW exec said that self-driving cars would start to kill car ownership in just five years. John Zimmer, the cofounder and president of Lyft, said in September that car ownership would "all but end" in cities by 2025.
- i) **Self-Driving Tractors Hit Farms:** The self-driving tractors can deliver faster, more precise results than their human-controlled counterparts.

## 7. Here Come Drones & Flying Cars

Quadcopters and multicopters big and small made huge strides in 2016.

We are headed towards a world where autonomous drones will image the world at millimeter resolution, deliver products and packages, and transport humans to remote areas that were previously inaccessible by roads.

Here were the top six drone and "flying car" developments this year:

- a) **Amazon Prime Air Made Its First Delivery:** Amazon's drone delivery program "Prime Air" made its first delivery in the U.K. this year. Expect a much bigger rollout in 2017.
- b) **The 7-11 Convenience Store Leads:** Convenience store 7-11 made 77 drone deliveries this year, beating Amazon by a long shot.
- c) **Mercedes Commits \$500M to Drone Delivery:** Mercedes-Benz vans and drone tech startup Matternet have created a concept car called a Vision Van. The van's rooftop serves as a launch and landing pad for Matternet's new M2 drones.



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d) **Larry Page Funding Flying Cars:** Reports this year suggest Google cofounder Larry Page has been personally funding a pair of startups devoted to creating flying cars. He has purportedly put over \$100 million into the ventures.

e) **1,000 Organ Transplant Deliveries from Drone Ordered:** Last year we saw Chinese company eHang announce the first human-carrying drone. Recently, United Therapeutics CEO Martine Rothblatt announced a deal to fund 1,000 retrofitted eHang drones to provide organ deliveries to transplant patients, as part of Rothblatt's Manufactured Organ Transport Helicopter (MOTH) system.

f) **Uber Launched Its Elevate Program:** Global transportation giant Uber announced its plans to enter the "flying car" service arena by publishing a massive whitepaper this year detailing its plan to launch an "on demand aviation" service called Uber Elevate.

## 8. The March of Artificial Intelligence

Artificial Intelligence (AI) is the most important technology humanity will ever develop. I believe AI is a massive opportunity for humanity, not a threat.

Broadly, AI is the ability of a computer to understand your question, to search its vast memory banks, and to give you the best, most accurate answer.

AI will also help humanity fundamentally solve its grandest challenges.

You may think of early versions of AI as Siri on your iPhone, or IBM's Watson supercomputer, but what is coming is truly awesome.

Here are 10 of the most important stories for the past year:

a) **NVIDIA Revealed a Deep-Learning Computer Chipset:** The Tesla P100, Nvidia's newly announced 15-billion-transistor chip, is designed specifically for deep-learning A.I. technology. Hardware advances like this are rapidly accelerating AI developments.

b) **\$5M IBM Watson AI XPRIZE:** The XPRIZE Foundation and IBM Watson, in partnership with TED, announced a \$5M purse for the team able to develop an AI that can collaborate with humans to solve grand challenges. The top three teams will compete on the TED stage in the spring of 2020.

c) **Als Can Read your Lips:** A new AI lip reader out of Oxford called LipNet was built to process whole sentences at a time. LipNet was 1.78 times more accurate than human lip readers in translating the same sentences.

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d) **AI's Predict Election Better Than Humans:** MogIA, an AI system developed by an Indian startup, correctly predicted the outcome of this year's elections. It based its analysis on 20 million data points from platforms such as Google, Twitter and YouTube.

e) **AI System Beats 500-to-1 Odds, Predicts the Kentucky Derby Trifecta:** A startup called Unanimous AI built a swarm system in which individuals within a group influence each other's decision making. The swarm correctly predicted the top four finishers – known as a superfecta – beating 540 to 1 odds.

f) **Microsoft Speech Recognition Tech Scores Better Than Humans:** Microsoft's new speech recognition technology is able to transcribe conversational speech as well as (or even better than) humans. The technology scored a word error rate (WER) of 5.9%.

g) **AI-Written Novel Passes 1st Round of Literary Award:** Titled 'The Day A Computer Writes A Novel,' the short story was a team effort between human authors, led by Hitoshi Matsubara from the Future University Hakodate, and, well, a computer.

h) **AI Saves Woman's Life:** Reports assert that Japanese doctors have, for the first time in history, used artificial intelligence from IBM's Watson system to detect a rare type of leukemia, helping to save a patient's life.

i) **AI's Beat Human Pilot in Air Combat:** Retired United States Air Force Colonel Gene Lee recently went up against ALPHA, an artificial intelligence developed by a University of Cincinnati doctoral graduate in a high-fidelity air combat simulator. The Colonel lost to the AI.

j) **Deep Mind Beats World's GO Champion:** The Go-playing AI "AlphaGo" from Google's DeepMind beat the reigning Go world champion, winning the five-game series 4-1 overall. This is a major achievement in the field of AI and deep learning.

## 9. Physics & Exploration

This year saw a number of fundamental achievements in physics, as well as a number of notable discoveries in our quest to explore the cosmos.

Here are the top three stories for your consideration:

a) **Gravitational Waves Confirmed:** After decades of searching, scientists have succeeded in detecting gravitational waves from the violent merger of two massive black holes.

b) **Evidence Found for Planet Nine:** This year, more evidence arose suggesting there is, in fact, another giant, icy planet circling at the edges of our solar system.

c) **Earth-Size Planet Around Proxima Centauri:** A new planet that bears striking similarities to our own planet prompts remarkable inroads into the study of space. This also brings a new area to search for the possibility of extraterrestrial life.

## 10. Conquest of Commercial Space

We are living during the birth of the commercial space era, driven by passionate billionaire backers.

Companies like SpaceX, Blue Origin, Planetary Resources and various teams competing for the Google Lunar XPRIZE are building commercial rockets and spacecraft to explore the cosmos.

It is an incredibly exciting time for commercial space – here are the top four developments from the past 12 months.

a) **Bezos Announced ‘New Glenn’:** Jeff Bezos announced a massive new reusable rocket family in development for his private spaceflight company Blue Origin. The rocket, called New Glenn, will be used to launch satellites and people into space, according to Bezos.

b) **Four Companies Sign Private Contracts To Fly To Moon In 2017:** The teams are competing to win the \$20 million Google Lunar XPRIZE to become the first private team to land a spacecraft on the moon. The companies are: Moon Express, Spacell, Synergy Moon and Team-Indus.

c) **Musk Announces Mars Plans:** SpaceX founder Elon Musk said he will put a person on Mars by 2025. There are four key things we will need to get there: full reusability, refueling in orbit, propellant production on Mars, and a propellant that works.

d) **Breakthrough Starshot Project Targets Interstellar Travel:** Theoretical physicist Stephen Hawking and Russian billionaire Yuri Milner announced their collaborative venture “Breakthrough Starshot” — a \$100 million attempt to make an interstellar starship.

What a past 12 months!

## REFERENCES

### 1. WE ARE HYPER CONNECTING THE WORLD

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## **EXPONENTIAL TECHNOLOGY**

<http://money.cnn.com/2016/09/06/technology/india-reliance-jio-4g-internet/> (**Ambani offers free internet to 1B people**)

<https://futurism.com/googles-enormous-internet-balloons-finally-implemented/> (**Google Loon Finally Implemented**)

<https://futurism.com/project-skybender-googles-plan-deliver-5g-internet-drone/> (**Google plans 5G over Skybender/drones**)

<https://futurism.com/videos/facebook-just-tested-its-solar-powered-internet-beaming-drone/> (**Facebook testing Solar Power Drone Internet service**)

<https://futurism.com/new-1-terabit-internet-satellites-will-deliver-high-speed-internet-remote-areas/> (**ViaSat plans 1 Terabit Internet Service**)

<https://techcrunch.com/2016/12/19/oneweb-softbank/> (**one web raises \$1.2B from Softbank for 900 satellite constellation**)

<http://www.cnbc.com/2016/11/17/spacex-wants-to-launch-4425-satellites-into-space-to-bring-super-fast-internet-to-the-world.html> (**Musk announces 4,425 Satellite System**)

## **2. SOLAR/RENEWABLE ARE CHEAPER THAN COAL**

<https://futurism.com/a-quarter-of-the-worlds-power-now-comes-from-renewables/> (**25% of the world's power from renewables**)

<https://futurism.com/india-energy-minister-solar-now-cheaper-coal/> (**In India, Solar is now Cheaper than Coal**)

<http://qz.com/871907/2016-was-the-year-solar-panels-finally-became-cheaper-than-fossil-fuels-just-wait-for-2017/> (**2016 was year that Solar is Cheaper than Coal**)

<https://futurism.com/over-the-past-six-months-the-uk-generated-more-energy-from-solar-than-coal/> (**The UK is generating more energy from Solar > Coal**)

<https://futurism.com/the-largest-coal-plant-in-north-america-is-being-replaced-by-a-solar-farm/> (**Largest North American Coal Plant being replaced by Solar Farms**)

<https://futurism.com/energy-expert-coal-will-never-recover/> (**Coal will never recover**)

<http://www.theglobeandmail.com/globe-drive/news/trans-canada-highway/netherlands-looks-to-ban-all-gas-diesel-car-sales-by-2025/article29583676/> (**Netherlands to ban all gas & diesel cars by 2025**)

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<https://futurism.com/for-the-first-time-ever-wind-power-generated-106-of-scotlands-energy-needs/> (Scotland generating 106% from Wind Energy)

<https://futurism.com/76-days-no-fossil-fuels-costa-rica-has-been-running-on-renewables-for-over-two-months/> (Costa Circa running on Renewables for > 2 months)

<https://medium.com/world-economic-forum/google-to-run-on-100-renewable-energy-in-2017-95cad0cf1302#.q3tf1bbk9>(Google to run 100% on renewable energy)

[http://www.popularmechanics.com/science/energy/a24372/las-vegas-renewable-energy/?src=nl&mag=pop&list=nl\\_pnl\\_news&date=122016](http://www.popularmechanics.com/science/energy/a24372/las-vegas-renewable-energy/?src=nl&mag=pop&list=nl_pnl_news&date=122016) (Las Vegas meets goal of 100% powered by renewables)

<https://futurism.com/drive-on-this-france-has-opened-the-worlds-first-solar-road/> (Solar Roads being deployed in France)

<https://futurism.com/heres-what-elon-musk-revealed-at-new-tesla-product-unveiling/> (Solar Roof Tiles)

<http://www.dailymail.co.uk/sciencetech/article-4062860/Elon-Musk-s-Gigafactory-taking-shape-Drone-footage-reveals-world-s-biggest-building-added-2-4-MILLION-square-feet-just-six-months.html> (Opening of Gigafactory)

### 3. AMAZING WINS CURING CANCER & DISEASE

<https://futurism.com/t-cell-therapy-leads-to-extraordinary-results-for-cancer-patients-in-early-clinical-trials/> (T-Cell Therapy à extraordinary (50%) cure rate for Blood Cancers)

<http://gizmodo.com/the-crispr-gene-editing-tool-is-finally-being-used-on-h-1789042055> (In China, Crisper used in Human Trial to cure Lung Cancer)

<https://futurism.com/approved-first-ever-human-trials-involving-crispr-gene-editing-in-fight-against-cancer/> (In U.S., NIH Funding, Univ of Pennsylvania, Crisper used in Humans to modify T-Cells to fight melanoma, sarcoma, or myeloma in 18 patients)

<https://futurism.com/diabetes-breakthrough-engineered-mini-stomach-successfully-produce-insulin-mice/> (for first time, Harvard Stem Cell researches have created “insulin producing” islet cells to cure Diabetes in mice)

<https://futurism.com/hiv-genes-have-been-cut-out-of-live-animals-using-crispr-2/> (HIV Genes cut out of live animals using Crisper)

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## EXPONENTIAL TECHNOLOGY

<https://futurism.com/experimental-treatment-causes-hiv-cells-to-vanish-from-patients-blood/> (New treatment causes HIV infected Cells to vanish from Patient)

<https://futurism.com/crispr-gene-editing-has-been-used-to-cure-mice-of-sickle-cell-disease/> (Crisper Cures Mice of Sickle Cell Disease)

<https://futurism.com/its-official-measles-has-been-completely-eradicated-in-the-united-states/> (Measles completely eradicated from the U.S.)

<https://futurism.com/new-ebola-vaccine-proves-to-be-100-effective/> (100% effective Ebola Vaccine)

<https://futurism.com/polios-days-numbered/> (World Health Org. projects Polio to be eradicated by early 2017)

## 4. PROGRESS ON LONGEVITY

<https://www.newscientist.com/article/2100823-worlds-oldest-vertebrate-is-a-shark-that-may-live-for-500-years/> (500 year old shark discovered)

<https://futurism.com/it-was-only-a-matter-of-time-scientists-found-a-way-to-reverse-signs-of-aging/> (ALSO, Same Article here -->)

<https://www.scientificamerican.com/article/aging-is-reversible-at-least-in-human-cells-and-live-mice/> (Genetically Reversing Aging)

<http://www.telegraph.co.uk/science/2016/12/15/scientists-reverse-ageing-mammals-predict-human-trials-within/> (Genetic Reversal of Aging in Mice, soon Humans)

<https://futurism.com/scientists-genetically-engineer-mice-live-25-percent-longer/> (25% extended life based on removal of senescent cells)

<https://techcrunch.com/2016/10/27/jeff-bezos-mayo-clinic-back-anti-aging-startup-unity-biotechnology-for-116-million/> (Jeff Bezos investment in Unity Biosciences)

<https://futurism.com/young-blood-transfusions-improve-mental-and-physical-performance-in-old-mice/> (Young Blood Experiments à Longevity)

## 5. AMAZING SUCCESSES WITH STEM CELLS

<https://futurism.com/stem-cell-breakthrough-let-us-grow-new-human-eyes/> (Stem Cells able to Grow new Human Eyes)

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## EXPONENTIAL TECHNOLOGY

[https://www.youtube.com/watch?v=FuzE9TaqERs&ab\\_channel=devichechi](https://www.youtube.com/watch?v=FuzE9TaqERs&ab_channel=devichechi) --  
<http://www.telegraph.co.uk/science/2016/06/03/stroke-survivors-walk-again-after-stanford-injects-stem-cells-in/> (**Stem Cells help Stroke Victim Walk Again**)

<http://www.kurzweilai.net/paralyzed-man-regains-use-of-arms-and-hands-after-experimental-stem-cell-therapy> (**Stem Cells help Paralyzed Victim gain use of Arms again**)

## 6. THE YEAR OF AUTONOMOUS VEHICLES

<https://futurism.com/breaking-ubers-self-driving-taxis-have-hit-the-streets/> (**Autonomous Ubers hit the streets**)

<https://futurism.com/50000-beers-ubers-self-driving-truck-just-made-its-first-delivery/> (**Uber's Self Driving Trucks, make 50,000 beer delivery**)

<https://futurism.com/elon-musk-every-tesla-car-will-be-fully-autonomous-by-2017/> (**Every Tesla in 2017 to be fully autonomous**)

<https://media.ford.com/content/fordmedia/fna/us/en/news/2016/08/16/ford-targets-fully-autonomous-vehicle-for-ride-sharing-in-2021.html> (**Ford 2021 Objective for Autonomous Cars**)

<http://uk.businessinsider.com/gms-first-autonomous-car-will-be-electric-and-launch-on-lyft-2016-7?r=US&IR=T> (**GM's first fully autonomous car will be electric and launch on Lyft**)

<https://techcrunch.com/2016/12/13/googles-self-driving-car-unit-spins-out-as-waymo/> (**Google Creates Waymo to support self-driving car technology**)

<https://www.bloomberg.com/news/articles/2016-12-13/google-said-to-plan-ride-sharing-service-with-chrysler-minivans-iwnox94h> (**Google plans Ride Sharing Service with Chrysler**)

<http://uk.businessinsider.com/former-tesla-vp-georg-bauer-autonomy-will-kill-car-ownership-2016-11?r=US&IR=T#digitalhealth> (**Autonomy will kill Car Ownership**)

<http://newatlas.com/self-driving-tractor/45169/> (**Self Driving Tractors hit Farms**)

## 7. HERE COME THE DRONES & FLYING CARS

<http://uk.businessinsider.com/amazon-prime-air-drone-delivery-service-completes-first-transaction-uk-england-2016-12?r=US&IR=T> (**Amazon Prime Air makes first delivery**)

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<http://www.investopedia.com/news/711-made-77-drone-deliveries-year-beating-amazon-amzn-svndy/> (7-11 makes 77 Deliveries in 2016)

<https://techcrunch.com/2016/09/07/mercedes-benz-and-matternet-unveil-vans-that-launch-delivery-drones/> (Mercedes partners with Matternet, commits >\$500M)

<http://www.theverge.com/2016/6/9/11893032/google-co-founder-larry-page-is-secretly-building-flying-cars> (Larry Page funding Flying Cars)

<https://techcrunch.com/2016/05/04/ehang-organ-deliveries/> (Martine Rothblatt order for 1000 units)

<https://futurism.com/skype-co-founder-invests-10-million-in-a-flying-car-that-can-travel-more-than-250-kmh/> (\$10M investment in another flying car, one of many)

<http://www.theverge.com/2016/10/27/13434580/uber-flying-car-elevate-self-driving-vto!> (Uber Elevate Program created)

## 8. THE MARCH OF ARTIFICIAL INTELLIGENCE:

<https://futurism.com/future-deep-learning-nvidia-unveils-chip-15-billion-transistors/> (NVIDIA's special Deep Learning Computer)

<https://futurism.com/oxford-scientists-have-an-ai-that-can-read-your-lips/> (AI that can Read your Lips)

<https://futurism.com/a-better-journalist-ai-are-better-at-predicting-elections-than-humans/> (AI's predict election better than Humans)

<http://www.digitaltrends.com/computing/kentucky-derby-swarm-ai/> (AI System Beats 500-to-1 Odds, Predicts the Kentucky Derby Trifecta)

<https://futurism.com/microsofts-speech-recognition-tech-is-officially-as-accurate-as-humans/> (Microsoft Speech Recognition tech better than Humans)

<https://futurism.com/this-ai-wrote-a-novel-and-the-work-passed-the-first-round-of-a-national-literary-award/> (AI written novel passes 1st round of Literary Award)

<https://futurism.com/ai-saves-womans-life-by-identifying-her-disease-when-other-methods-humans-failed/> (AI Saves Woman's Life)

<https://futurism.com/an-ai-just-defeated-human-fighter-pilots-in-an-air-combat-simulator/> (AI's beat Human Pilot in Air Combat)



<https://futurism.com/googles-artificial-intelligence-beats-world-champion-wins-go-series-4-1/> (**Deep Mind beats World's GO Champion**)

## 9. PHYSICS & EXPLORATION

<https://futurism.com/new-era-physics-gravitational-waves-finally-detected/> (**Gravitational Waves Confirmed**)

<http://www.usnews.com/news/articles/2016-09-02/there-could-be-a-ninth-planet-and-we-are-not-talking-about-pluto>(**Evidence found for Planet Nine**)

<https://futurism.com/eso-confirms-earth-sized-planet-found-around-the-closest-star-to-earth-proxima-centauri/> (**Earth-size planet around Proxima Centauri**)

## 10. CONQUEST OF COMMERCIAL SPACE

<http://www.space.com/34034-blue-origin-new-glenn-rocket-for-satellites-people.html> (**Bezos announces New Glenn**)

<http://us.blastingnews.com/news/2016/11/team-indus-gets-a-launch-contract-for-a-private-moon-mission-001232733.html>(**4 companies sign private contracts to fly to moon in 2017**)

<https://futurism.com/elon-musk-mars-colony-all-his-key-points-from-todays-announcement/> (**Musk announces Mars Plans**)

<https://futurism.com/stephen-hawking-teams-billionaire-build-interstellar-spaceship/> (**Breakthrough Starshot project targets interstellar travel**)

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## **EXPONENTIAL TECHNOLOGY**

### **HUMAN INTELLIGENCE (HI)**

Are you scared of Artificial Intelligence (AI)?

Do you believe the warnings from folks like Prof. Stephen Hawking, Elon Musk and others?

Is AI the greatest tool humanity will ever create, or are we “summoning the demon”?

To quote the head of AI at Singularity University, Neil Jacobstein, “It’s not artificial intelligence I’m worried about, it’s human stupidity.”

I interviewed Bryan Johnson, the founder of a new company called Kernel which he seeded with \$100 million.

To quote Bryan, “It’s not about AI vs. humans. Rather, it’s about creating HI, or ‘Human Intelligence’: the merger of humans and AI.”

Let’s dive in.

### **Meet Bryan Johnson and His New Company Kernel**

Bryan Johnson is an amazing entrepreneur.

In 2007, he founded Braintree, an online and mobile payments provider. In 2013, PayPal acquired Braintree for \$800 million.

In 2014, Bryan launched the OS Fund with \$100 million of his personal capital to support inventors and scientists who aim to benefit humanity by rewriting the operating systems of life.

His investments include endeavors to cure age-related diseases and radically extend healthy human life to 100+ (Human Longevity Inc.), make biology a predictable programming language (Ginkgo Bioworks and Synthetic Genomics), replicate the human visual cortex using artificial intelligence (Vicarious), expand humanity’s access to resources (Planetary Resources Inc.), reinvent transportation using autonomous vehicles (Matternet), and reimagine food using biology (Hampton Creek).

Bryan is a big thinker, and now he is devoting his time, energy and resources to building “HI” through Kernel.

The company is building on 15 years of academic research at USC, funded by the NIH, DARPA and others, and they’ve begun experiments in humans.

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But what is HI? And neuroprosthetics? And how is AI related?

Keep reading.

### BCI, Neural Lace and HI

Your brain is composed of 100 billion cells called neurons, making 100 trillion synaptic connections.

These cells and their connections make you who you are and control everything you do, think and feel.

In combination with your sensory organs (i.e. eyes, ears), these systems shape how you perceive the world.

And sometimes, they can fail.

That's where *neuroprosthetics* come into the picture.

The term "neuroprosthetics" describes the use of electronic devices to replace the function of impaired nervous systems or sensory organs.

They've been around for a while -- the first cochlear implant was implanted in 1957 to help deaf individuals hear -- and since then, over 350,000 have been implanted around the world, restoring hearing and dramatically improving quality of life for those individuals.

But such a cochlear implant only hints at a very exciting field that researchers call the brain-computer interface, or BCI: the direct communication pathway between the brain (the central nervous system, or CNS) and an external computing device.

The vision for BCI involves interfacing the digital world with the CNS for the purpose of augmenting or repairing human cognition.

You might have heard people like Elon Musk and others talking about a "neural lace" (this was actually a concept coined by science fiction writer Iain M. Banks).

Banks described a "neural lace" as essentially a very fine mesh that grows inside your brain and acts as a wireless brain-computer interface, releasing certain chemicals on command.

Well... though the idea might have started as science fiction, companies like Kernel are making it **very** real.

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And once they do, we'll have robust brain-computer interfaces, and we'll be able to fix and augment ourselves. Ultimately this will also allow us to merge with AIs and become something more than just human.

### Human Intelligence (HI)

Humans have always built tools of intelligence.

We started with rocks and progressively built more intelligent tools such as thermostats, calculators, computers and now AI. These are extensions of ourselves, and so we've been increasing our intelligence through our tools.

But now, our tools have become sophisticated enough (thanks to exponential technologies riding atop Moore's Law) that we are about to incorporate them into our biology and take an exponential leap forward in intelligence.

This is so significant that it will change us as a species – we're taking evolution into our own hands.

I like to say we're going from evolution by natural selection -- Darwinism -- into evolution by intelligent direction.

We can now focus on technologies to augment human intelligence (HI).

This is what Bryan Johnson and Kernel are focused on.

The first step is to answer the basic question: can we mimic the natural function of neurons firing?

If we can mimic that natural functioning, and restore circuitry, or even if we can just maintain that circuitry, it begs the question: could we improve that circuitry?

Could we make certain memories stronger? Could we make certain memories weaker? Could we work with neural code in the same way we can work with biological code via synthetic biology or genetic code? How do we read and write to neurons? Could we merge with AIs?

In my friend Ray Kurzweil's mind, the answer is most certainly yes.

### A Refresher on Ray Kurzweil's Prediction

Ray Kurzweil is a brilliant technologist, futurist, and director of engineering at Google focused on AI and language processing.

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He has also made more correct (and documented) technology predictions about the future than anyone:

*As [reported](#), "of the 147 predictions that Kurzweil has made since the 1990's, fully 115 of them have turned out to be correct, and another 12 have turned out to be "essentially correct" (off by a year or two), giving his predictions a stunning 86% accuracy rate."*

A few months ago, I wrote a [blog](#) about his wildest prediction yet:

"In the early 2030s," said Ray, "we are going to send nanorobots into the brain (via capillaries) that will provide full immersion virtual reality from within the nervous system and will connect our neocortex to the cloud. Just like how we can wirelessly expand the power of our smartphones 10,000-fold in the cloud today, we'll be able to expand our neocortex in the cloud."

A few weeks ago, I asked Bryan about this prediction.

His response, "Oh, I think it will happen before that."

Exciting times.

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## MASSIVE DISRUPTION – QUANTUM COMPUTING

Next year, we may see the launch of the first true quantum computers.

The implications will be staggering.

This blog aims to answer three questions:

1. *What are quantum computers?*
2. *What are their implications?*
3. *Who's working on them?*

There's a lot to unpack here, so hang tight, and let's jump in!

### What is Quantum Computing?

Moore's Law (or the exponential growth of integrated circuits) is actually referring to the fifth paradigm of computation. Here's the list of the underlying technologies: (1) Electromechanical; (2) Vacuum Tube; (3) Relay; (4) Transistors; and (5) Integrated Circuits.

Quantum computers may well be the sixth paradigm, given that they work in a fashion that is entirely different from "classical" computers.

A classical computer performs operations using classical "bits" – these "bits" can be in only one of two states: "0" *OR* "1."

In contrast, a quantum computer uses 'quantum bits,' or 'qubits'. Thanks to a principle called quantum superposition, these qubits can have a value of "0", "1," or both "0 AND 1" at the same time.

This capability allows quantum computers to solve certain types of complex problems that are intractable for conventional computers. Frankly, really exciting problems for society today, as you'll see below.

For a tutorial on quantum computers, check out this short video: [LINK](#)

The power of qubits is that they scale exponentially. A 2-qubit machine allows you to do four calculations at once. A 3-qubit machine can do eight calculations. A 4-qubit machine gives you 16 calculations, all simultaneously.

By the time you get to 300 qubits, you've got a computer that can do more "calculations" than there are atoms in the universe.

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That's why the blog TechTarget described Quantum computing this way: *"Development of a quantum computer, if practical, would mark a leap forward in computing capability far greater than that from the abacus to a modern day supercomputer, with performance gains in the billion-fold realm and beyond."*

### What Are the Implications of Quantum Computing?

The implications of true quantum computing at scale are staggering, of extraordinary impact to society today (which is why I'm tracking it).

In my opinion, here are the Top 5 Applications:

1. Machine Learning: Much of machine learning is about "pattern recognition." Algorithms crunch large datasets to find signals in the noise, and the goal is to maximize the number of comparisons you make between data to find the best models to describe that data. With quantum computing, we'll be able to do this processing orders of magnitude more effectively than with classical computing. Quantum computing will allow you to compare much, much more data in parallel, simultaneously, and all permutations of that data, to discover the best patterns that describe it. This will lead to fundamentally more powerful forms of AI, much more quickly than we expect. Expect Quantum Computing to cause a positive inflection point (upward) for the speed at which the world develops AI (which, by the way, is why Google is working so hard on it).
2. Medicine: Quantum computing will also allow us to model complex molecular interactions at an atomic level. This will be particularly important for medical research and drug discovery. Soon we'll be able to model all 20,000+ proteins encoded in the human genome and start to simulate their interactions with models of existing drugs, or new drugs that haven't been invented yet. Based on the analysis of these drug interactions, we'll be able to find cures for previously incurable diseases and hopefully accelerate the time to market for new drugs. Using quantum computer simulations will be the way we design and choose our next generations of drugs and cancer cures.
3. Chemistry (and Climate Change): Worried about the climate crisis? Wondering what we can do about it? Quantum computers may be our newest tool to understand what is going on and to fight it. They will allow us to unlock "simulation-driven" solutions, perhaps design new catalysts that actually capture carbon from the atmosphere and turn it into new and valuable products at low cost and energy use.
4. Material Science & Engineering: Because we can simulate atomic interactions, we'll explore and invent entirely new, better materials. We might find better superconductors, better magnets, materials that will allow us to create much higher energy density batteries, and so on. Since 2011, the U.S. federal government has granted over \$250 million to the Materials Genome Initiative in

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an effort to “discover, manufacture, and deploy advanced materials twice as fast, at a fraction of the cost.”

5. Biomimetics, Energy Systems & Photovoltaics: Scientists believe that much of the world is built atop quantum systems. Processes like photosynthesis, for example, are likely dependent on quantum mechanical systems. Thus, as we look to the natural world for inspiration to build better energy systems or stronger materials, we'll only fully realize their potential when we can model these processes with quantum computers. This will lead to many advances and discoveries across the board.

Bottom Line: When quantum computing pans out, we'll be able to control the very building blocks of the universe.

*The question is who is going to figure it out first...*

## Who's Working on Quantum Computing?

There's a race going on – a race to prove something called "quantum supremacy."

Quantum supremacy is essentially the test that validates that the computer you have is in fact a quantum computer.

In the U.S., three major players are in the game right now:

1. Google
2. IBM
3. Rigetti Computing, a startup out of Silicon Valley

(And perhaps a fourth -- D-Wave Systems. They've developed chips with qubits, but these haven't yet been conclusively proved to operate as a quantum computer.)

Both Rigetti Computing and Google believe they will reach "quantum supremacy" in the next 12 to 18 months.

Think about that: the next one to two years...

The revolution is coming fast.

To put this into perspective, I had a chance to catch up with Chad Rigetti, the CEO of Rigetti Computing

Below is a picture of the most powerful 'classical' computer on the planet, Tianhe-2 in Guangzhou, China.



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*(Tianhe-2: The most powerful super computer on the planet)*

It costs \$400 million.

The computer burns about 20 megawatts of electricity – enough to power 20,000 households.

And it's about half the size of a football field, with 3.2 million Intel cores.

President Obama, in the attempt to drive America's return to high-performance computing supremacy, declared that the U.S. would build an exoscale computer, 30x more powerful than Tianhe-2, by 2020.

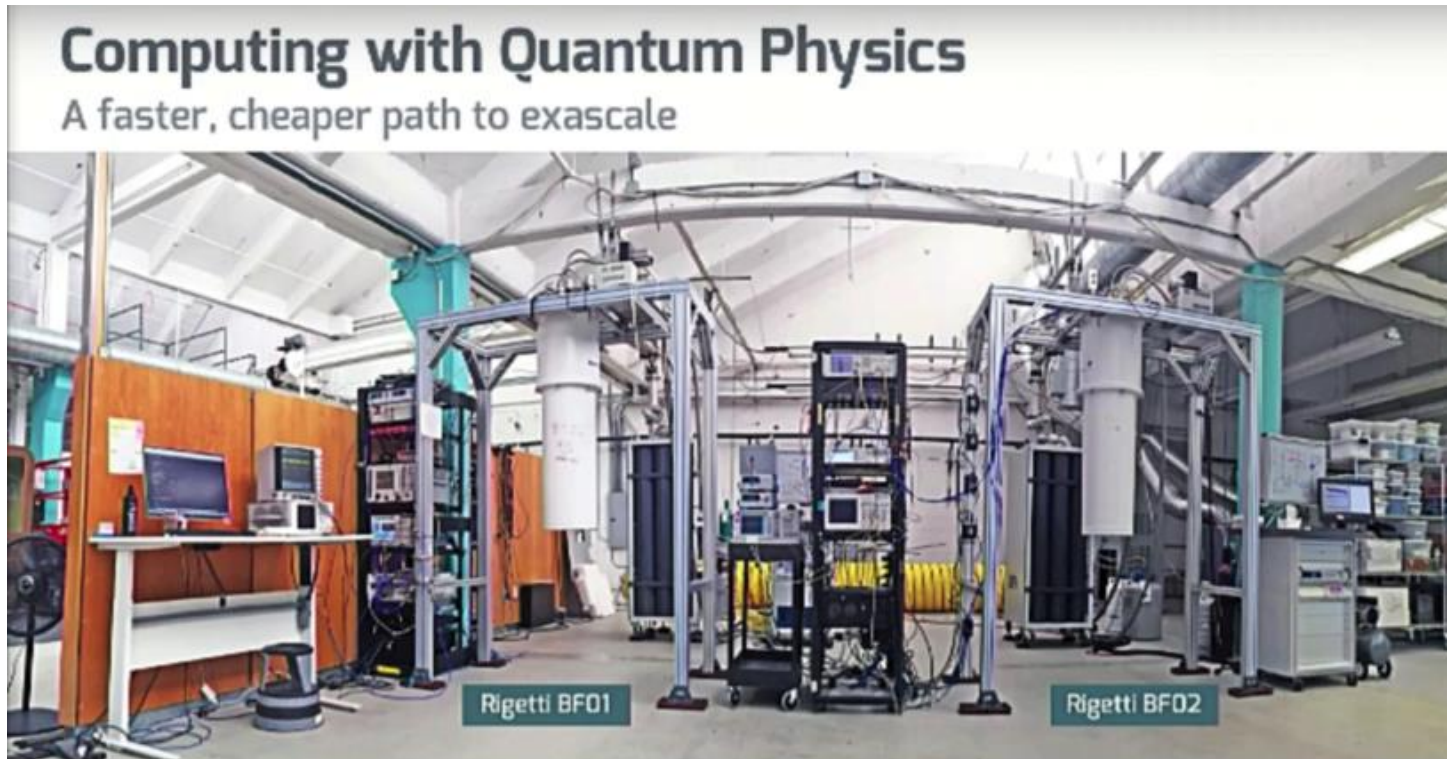
The problem is this: With current technology, it will cost a billion dollars and will require a nuclear power plant to run the supercomputer.

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"We need to do this," explains Chad Rigetti. "But there is another path. Quantum computing."

Below is a picture of two developmental systems in Rigetti's lab in Berkeley, CA.



(Developmental quantum computing systems, Rigetti Computing)

The big white cans about the size of a human are cooling systems, and inside each cooling system is a single quantum chip.

In these machines today, there is a 5-qubit processor.

The crazy part: A single chip with about 50 to 60 qubits on it would be more powerful than the entire Tianhe-2, a half-a-football-field-sized machine...

This is what quantum computing unlocks.

Rigetti is rapidly developing quantum integrated circuits and the software platform that will allow developers to build on top of them.

Along with efforts at Google, IBM, D-Wave, and many other companies and research labs around the world, we are rapidly approaching a quantum computing revolution.

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Get ready.



## DISRUPTING ENERGY

We are at the cusp of an energy revolution.

This blog is a look at how three technologies – solar, batteries and electric vehicles (EVs) – are poised to disrupt a \$6 trillion energy industry over the next two decades.

I had the chance to sit down with Ramez Naam, the Chair of Energy & Environmental Systems at Singularity University and acclaimed author of the Nexus series, to discuss these major forces and their implications.

Let's dive in.

### 1. Creating an Abundant Solar Economy

In 88 minutes, 470 exajoules of energy from the sun hits the Earth's surface, as much energy as humanity consumes in a year.

In 112 hours – less than five days – it provides 36 zettajoules of energy. That's as much energy as is contained in all proven reserves of oil, coal and natural gas on the planet.

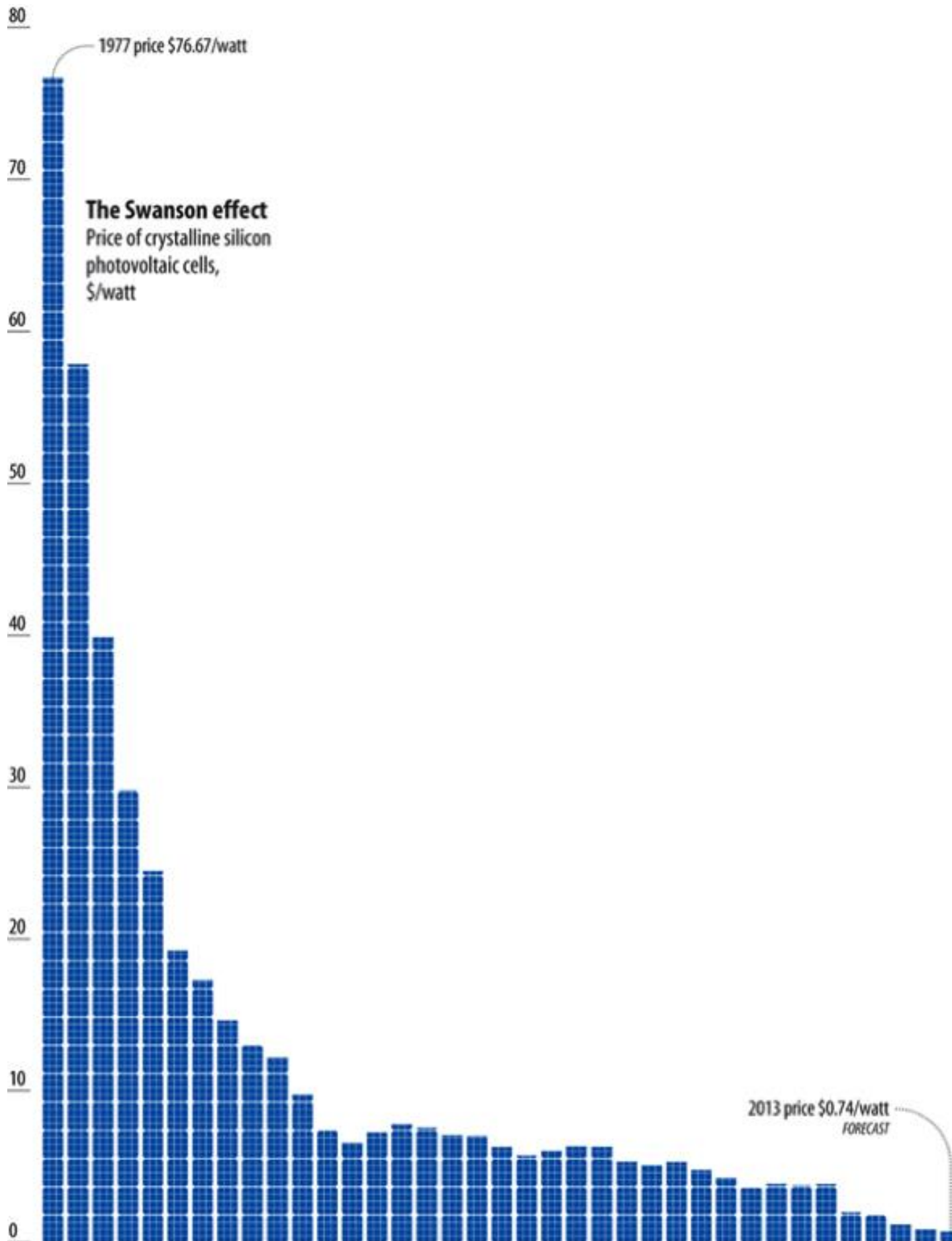
If humanity could capture 1 part in 1,000 (one-tenth of one percent) of the solar energy striking the Earth – just one part in one thousand – we could have access to six times as much energy as we consume in all forms today.

These staggering numbers, in combination with an exponential decline in photovoltaic solar energy costs (\$ per watt price of solar cells), put us on track to meet between 50 percent and 100 percent of the world's energy production from solar (and other renewables) in the next 20 years.

Solar is already undercutting coal and natural gas in sunny geographies.

Take a look at the plummeting costs...

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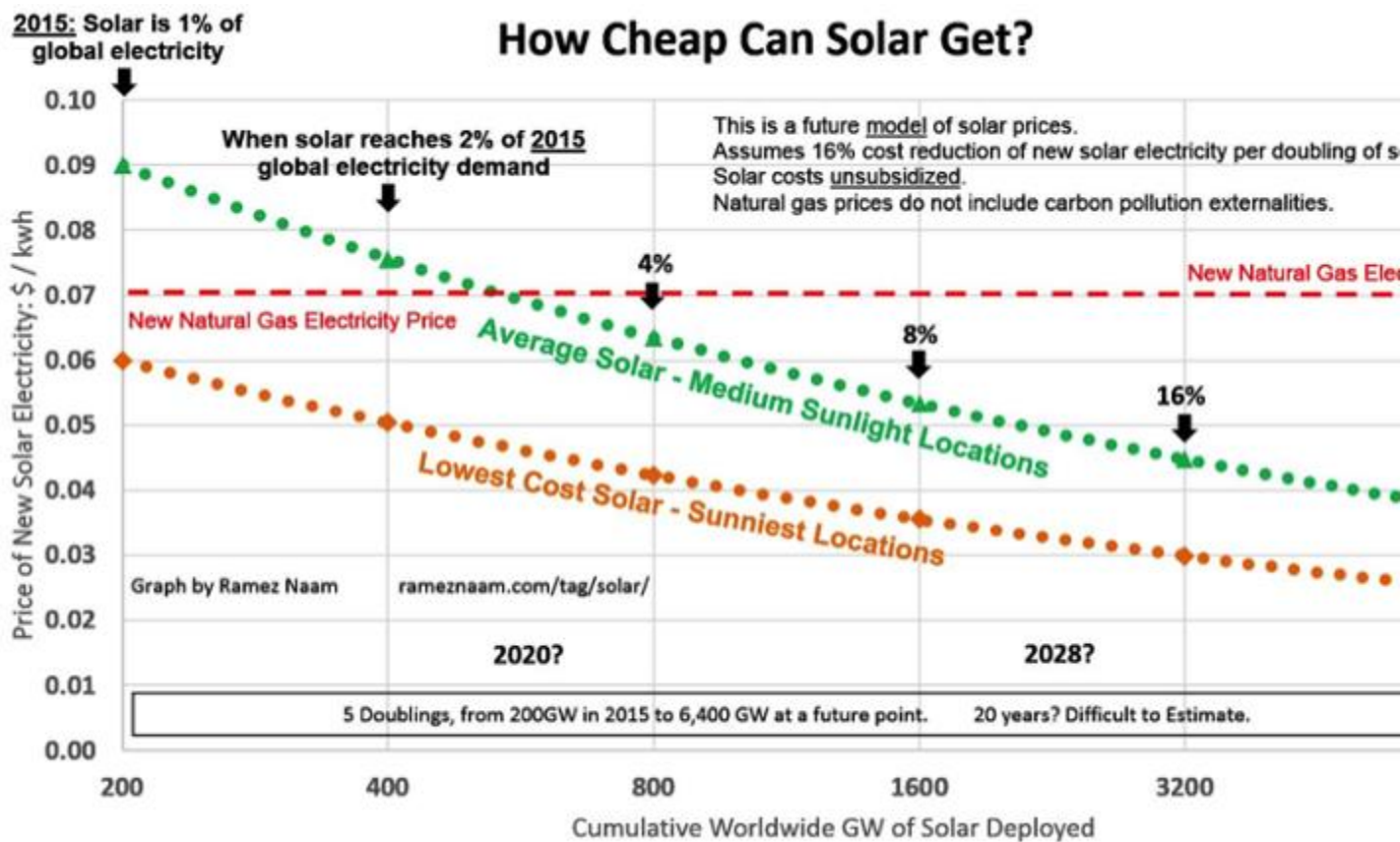
(Graph: Decreasing price per watt of photovoltaic cells)

Over the last 30 years, solar module prices have dropped by a factor of 100.

Critically -- a new solar price record was set in Chile just a few weeks ago at \$0.0291 per kWh – 58 percent less than the price of natural gas from a new plant!

And this is just the beginning. How cheap can it get?

The graph below shows that, if solar electricity continues on its current demonetization trajectory, by the time solar capacity triples to 600GW (by 2020 or 2021, as a rough estimate), we could see global unsubsidized solar prices that are roughly half the cost of coal and natural gas.



(Decreasing costs of solar electricity relative to other sources)

This is without factoring in the cost of air pollution and carbon pollution emitted by fossil fuel power plants.

## 2. Battery Technology is Reaching an Inflection Point

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Of course, one limitation of solar is that it's only available during the day. We'll need breakthroughs in battery technology to transition fully into a solar economy.

The good news is that battery technology and energy storage are also hitting an inflection point.

Here are five trends shaping the future of battery technology and energy storage:

1. **Lithium-ion Technology:** Lithium-ion batteries have been seeing rapidly declining prices for more than 20 years, dropping in price for consumer electronic uses by 90 percent between 1990 and 2005, and continuing to drop since then. This price reduction is coupled with an 11x increase in battery storage capacity per \$100 since 2000.
2. **Scaled Production:** The rollout of Tesla's Gigafactory makes \$100 per kwh lithium-ion batteries in electric vehicles possible by 2020. This price point would yield an astonishing \$0.11 per kWh electricity storage -- or, in other words, allow you to fill up the equivalent of a tank of gas for \$9.35.
3. **Flow Batteries:** Flow batteries are just starting to come to market and have been proven in the lab to operate for 5,000 charge cycles or more. This is a 10x improvement over standard consumer lithium-ion batteries.
4. **Compressed Air Storage:** Companies like LightSail Energy are creating physical components rated for 10,000+ charge cycles.
5. **Time of Use Arbitrage:** The U.S. is increasingly going to time-of-use charges for electricity. Right now that means charging consumers a low rate in the middle of the night (when demand is low) and a high rate in the afternoon and early evening (when demand is at its peak, often twice as high as the middle of the night).

These are just a few of the developments happening.

The real key here is that we are going to see a mindset shift in the near future. It will just be accepted that every home will be powered by a combination of batteries, rooftop solar and electric vehicles (i.e. Tesla's vision)... and we'll gawk disapprovingly at the idea of driving an explosive, expensive and environmentally damaging gas vehicle, and so on.

### 3. Electric Vehicles (EVs) Are Gaining Speed

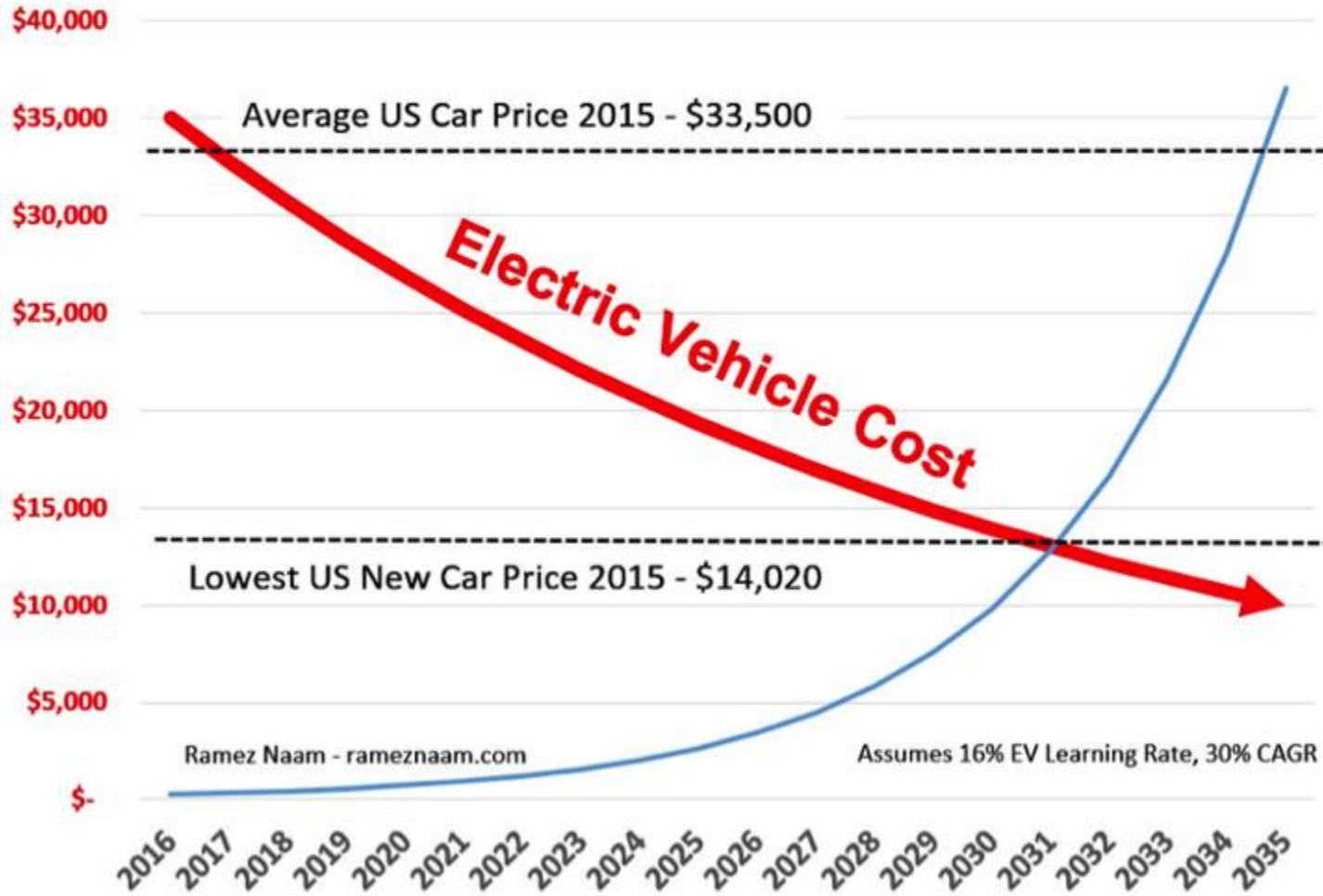
Electric vehicles (EVs) are taking the transportation industry by storm.

Within the next two decades, EVs will undoubtedly be the cheapest and most widely used vehicles on the market.

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Take a look at the chart below. By roughly 2030, EVs with a 200+ mile range are going to be cheaper than the cheapest car sold in the U.S. in 2015.

### Cost of 200 mile range EV



*(Decreasing cost of EV from 2016-2035)*

The primary factor driving this decreasing cost is that EVs are inherently simpler devices only possessing 10% of the moving parts of gasoline-powered vehicles (cheaper to build, cheaper to maintain).

Every major car manufacturer is working on electric vehicles – the number of EV models on the market has grown from 2 in 2010 to over 25 today.



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Just four months ago, Tesla Motors shattered expectations with the biggest one-week launch of any product ever by taking 400,000 preorders for its \$35,000 Model 3 (implying \$14 billion in future sales).

Ford has followed suit, investing \$4.5 billion in electric cars, and will be adding 13 electric cars and hybrids by 2020, making more than 40 percent of its lines electrified.

### **Bringing It All Together**

The convergence of solar, energy storage and electric vehicles (EVs) creates a trifecta of disruptive forces hitting the energy industry over the next two decades.

Again, in 88 minutes, the sun provides 470 exajoules of energy, as much energy as humanity consumes in a year. Just think about this...

This raw energy combined with the economic feasibility of solar, advancements in energy storage, and the resurgence of the electric car will allow abundant cheap energy for everyone on the planet.

This is an incredibly exciting time for the energy industry, and an incredibly exciting time to be alive.

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## NANOROBOTS INSIDE YOU

This blog is a status update on one of the *most powerful tools humanity will ever create*: Nanotechnology (or nanotech).

My goal here is to give you a quick overview of the work going on in labs around the world, and the potential applications this nanotech work will have in health, energy, the environment, material sciences, data storage and processing.

As artificial intelligence has been getting a lot of the attention lately, I believe we're going to start to see and hear about incredible breakthroughs in the nanotech world very soon.

### Origins of Nanotechnology

Most historians credit the concept of nanotechnology to physicist Richard Feynman and [his 1959 speech](#), "*There's Plenty of Room at the Bottom*."

In his speech, Feynman imagined a day when machines could be miniaturized and huge amounts of information could be encoded in miniscule spaces, paving the way for disruptive technological developments.

But it was K. Eric Drexler's [1986 book](#), "*Engines of Creation: The Coming Era of Nanotechnology*," which really put the idea on the map.

Drexler posited the idea of self-replicating nanomachines: machines that build other machines.

Because these machines are also programmable, they can then be directed to build not only more of themselves, but also more of whatever else you'd like.

And because this building takes place on an atomic scale, these nanobots can pull apart any kind of material (soil, water, air, you name it), atom by atom, and construct, well, just about anything.

Drexler painted the picture of a world where the entire Library of Congress could fit on a chip the size of a sugar cube and where environmental scrubbers could clear pollutants from the air.

But before we explore the possibilities of nanotechnology, let's break down the basics.

## What Does "Nanotechnology" Actually Mean?

Nanotechnology is the science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers.

Essentially, it's manipulating and controlling materials at the atomic and molecular level.

To give you perspective, here's how to visualize a nanometer:

- The ratio of the Earth to a child's marble is roughly the ratio of a meter to a nanometer.
- It is a million times smaller than the length of an ant.
- A sheet of paper is about 100,000 nanometers thick.
- A red blood cell is about 7,000-8,000 nanometers in diameter.
- A strand of DNA is 2.5 nanometers in diameter.

A nanorobot, then, is a machine that can build and manipulate things precisely at an atomic level. Imagine a robot that can pluck, pick and place atoms like a kid plays with LEGO bricks, able to build anything from basic atomic building blocks... C, N, H, O, P, Fe, Ni, and so on... While some people dismiss the future of nanorobots as science fiction, you should realize that each of us is alive today because of countless nanobots operating within each of our trillions of cells. We give them biological names like a "ribosome," but they are essentially machines programmed with a function like 'read messenger RNA to create a specific protein.'

That being said, it's important to distinguish between "wet" or "biological" nanotech, which basically uses DNA and the machinery of life to create unique structures made of proteins or DNA (as a building material) and a more Drexlerian Nanotech which involved building an "assembler," or a machine that can 3D print with atoms at a nanoscale and effectively create any structure that is thermodynamically stable.

This is an area I am fascinated by and passionate about, and given how powerful it is for our future, it's something I track closely.

Let's explore a few of the different types researchers are developing.

## Different Types of Nanorobots and Applications

There are many different types of nanorobots – here are just a few.

1. **Smallest engine ever created:** “A group of physicists from the University of Mainz in Germany recently built the smallest engine ever created from just a single atom. Like any other engine, it converts heat energy into movement — but it does so on a smaller scale than ever seen before. The atom is trapped in a cone of electromagnetic energy and lasers

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are used to heat it up and cool it down, which causes the atom to move back and forth in the cone like an engine piston.” ([Source](#))

2. **3D-motion nanomachines from DNA:** Mechanical engineers at Ohio State University have designed and constructed complex nanoscale mechanical parts using “DNA origami” — proving that the same basic design principles that apply to typical full-size machine parts can now also be applied to DNA — and can produce complex, controllable components for future nanorobots. ([Source](#))
3. **Nanoswimmers:** ETH Zurich and Technion researchers have developed an elastic “nanoswimmer” polypyrrole (Ppy) nanowire about 15 micrometers (millionths of a meter) long and 200 nanometers thick that can move through biological fluid environments at almost 15 micrometers per second. The nanoswimmers could be functionalized to deliver drugs and magnetically controlled to swim through the bloodstream to target cancer cells, for example. ([Source](#))
4. **Ant-like nanoengine with 100x force per unit weight:** University of Cambridge researchers have developed a tiny engine capable of a force per unit-weight nearly 100 times higher\* than any motor or muscle. The new nano-engines could lead to nanorobots small enough to enter living cells to fight disease, the researchers say. Professor Jeremy Baumberg from the Cavendish Laboratory, who led the research, has named the devices “actuating nanotransducers” (ANTs). “Like real ants, they produce large forces for their weight.” ([Source](#))
5. **Sperm-inspired microrobots:** A team of researchers at the University of Twente (Netherlands) and German University in Cairo (Egypt) has developed sperm-inspired microrobots, which can be controlled by oscillating weak magnetic fields. They will be used in complex micro-manipulation and targeted therapy tasks. ([Source](#))
6. **Bacteria-powered robots:** Drexel University engineers have developed a method for using electric fields to help microscopic bacteria-powered robots detect obstacles in their environment and navigate around them. Uses include delivering medication, manipulating stem cells to direct their growth, or building a microstructure, for example. ([Source](#))
7. **Nanorockets:** Several groups of researchers have recently constructed a high-speed, remote-controlled nanoscale version of a rocket by combining nanoparticles with biological molecules. The researchers hope to develop the rocket so it can be used in any environment; for example, to deliver drugs to a target area of the body. ([Source](#))

## Key Applications of Nano and Micro-Machines

The applications of these nano and micro-machines are nearly endless.

Here are some of the most exciting ones, in my eyes:

- **Cancer Treatment:** Identifying and destroying cancer cells more accurately and effectively
- **Drug Delivery Mechanisms:** Targeted drug delivery mechanisms for disease control and prevention

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- **Medical Imaging:** Creating the nanoparticles to gather in certain tissues and then scanning the body with a magnetic resonance imaging (MRI) could help highlight problems such as diabetes
- **New Sensing Devices:** With near limitless customizable sensing properties, nanorobotics would unlock new sensing capabilities we can integrate into our systems to monitor and measure the world around us
- **Information Storage Devices:** A bioengineer and geneticist at Harvard's Wyss Institute have successfully stored 5.5 petabits of data — around 700 terabytes — in a single gram of DNA, smashing the previous DNA data density record by a thousand times
- **New Energy Systems:** Nanorobotics might play a role in developing more efficient renewable energy system. Or, they could make our current machines more energy efficient such that they'd need less energy to operate at the same or high capacities.
- **Super-strong Metamaterials:** There is lots of research going into these metamaterials. A team out of Caltech developed a new type of material, made up of nanoscale struts crisscrossed like the struts of a tiny Eiffel Tower, that is one of the strongest and lightest substances ever made.
- **Smart Windows and Walls:** Electrochromic devices, which dynamically change color under applied potential, are widely studied for use in energy-efficient smart windows – these can control the internal temperature of a room, clean themselves, and more.
- **Ocean-cleaning microsponges:** A carbon nanotube sponge capable of soaking up water contaminants such as fertilizers, pesticides and pharmaceuticals more than three times more efficiently than previous efforts has been presented in a study published in IOP Publishing's journal Nanotechnology.
- **Replicators:** Also known as a "Molecular Assembler," this is a proposed device able to guide chemical reactions by positioning reactive molecules with atomic precision
- **Health Sensors:** These sensors could monitor our blood chemistry, notify us when something is out of whack, detect spoiled food or inflammation in the body, and more
- **Connecting our Brains to the Internet:** Ray Kurzweil believes nanorobots will allow us to connect our biological nervous system to the cloud by 2030

As you can see, this is really just the beginning... the opportunities are near limitless.

## Big Problem, Big Opportunity

Nanotechnology has the potential to solve some of the biggest problems that the world faces today.

A recent **National Science Foundation** report notes, "...Nanotechnology has the potential to enhance human performance, to bring sustainable development for materials, water, energy, and food, to protect against unknown bacteria and viruses, and even to diminish the reasons for breaking the peace [by creating universal abundance]."

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If this wasn't exciting enough, the markets for nanotechnology are, as you might imagine, massive.

It has been forecasted that the global nanotechnology industry will grow to reach **\$75.8 billion (USD) by 2020.**

As an entrepreneur, you need to be paying attention to these developments – there will be extraordinarily fruitful opportunities in actually building business cases around these technological developments and deploying them at scale.



## RAY'S WILDEST PREDICTION

I consider Ray Kurzweil a very close friend and a very smart person.

Ray is a brilliant technologist, futurist, and director of engineering at Google focused on AI and language processing.

He has also made more correct (and documented) technology predictions about the future than anyone:

*As [reported](#), "of the 147 predictions that Kurzweil has made since the 1990's, fully 115 of them have turned out to be correct, and another 12 have turned out to be "essentially correct" (off by a year or two), giving his predictions a stunning 86% accuracy rate."*

Two weeks ago, Ray and I spoke about predicting the future.

During our session, there was one of Ray's specific predictions that really blew my mind.

"In the 2030s," said Ray, "we are going to send nano-robots into the brain (via capillaries) that will provide full immersion virtual reality from within the nervous system and will connect our neocortex to the cloud. Just like how we can wirelessly expand the power of our smartphones 10,000-fold in the cloud today, we'll be able to expand our neocortex in the cloud."

Let's digest that for a moment.

2030 is only 15 years away...

Directly plugging your brain into the internet? Upgrading your intelligence and memory capacity by orders of magnitude?

This is a blog about the staggering (and fun) implications of that future.

### The Basics

The implications of a connected neocortex are quite literally unfathomable. As such, any list I can come up with will pale in comparison to reality... But here are a few thoughts to get the ball rolling.

*Brain-to-Brain Communication*

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This will deliver a new level of human intimacy, where you can truly know what your lover, friend or child is feeling. Intimacy far beyond what we experience today by mere human conversation. Forget email, texting, phone calls, and so on – you'll be able to send your thoughts to someone simply by thinking them.

### *Google on the Brain*

You'll have the ability to "know" anything you desire, at the moment you want to know it. You'll have access to the world's information at the tip of your neurons. You'll be able to calculate complex math equations in seconds. You'll be able to navigate the streets of any cities, intuitively. You'll be able to hop into a fighter jet and fly it perfectly. You'll be able to speak and translate any language effortlessly.

### *Scalable Intelligence*

Just imagine that you're in a bind and you need to solve a problem (quickly). In this future world, you'll be able to scale up the computational power of your brain on demand, 10x or 1,000x... in much the same way that algorithms today can spool up 1,000 processor cores on Amazon Web Servers.

### *Living in the Virtual World*

If our brains can truly connect at high bandwidth, you will be able to bypass our current sensory organs (eyes, ears, touch) to the point where brain's perception of reality can be driven completely by a gaming engine – a virtual world. Likewise, the connections would exist in the motor cortex of your brain as well. When you move your limbs, imagine a corresponding set of virtual limbs (your avatar) moving perfectly in the virtual world. This is about creation of The Matrix x 1,000.

### *Extended Immune System*

In my webinar discussion with Ray, he outlined how we already have intelligent biological devices, the size of blood cells, that kill disease. They are called T-cells. They can recognize an enemy and attack it, but they don't work on cancer, retroviruses, et cetera. In the future, nanorobots will be able to communicate wirelessly, download software when new pathogens arrives, and attack cancer, cancer stem cells, bacteria, viruses, and all the disease agents. They can also work on metabolic diseases like diabetes. They could also maintain healthy levels of everything you need in the blood, including nutrients, and basically repair and eventually replace damaged organs.

### *Downloadable Expertise*



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Remember the scene in *The Matrix* where Trinity needs to learn how to fly a helicopter, and Tank downloads a program teaching her how to do it? We'll be able to do this. Need to perform emergency surgery? Just download the ER doctor program. Need to learn a new language? Download it. Want to cook the perfect meal? Download the chef module. In fact, you probably won't even need to download it (which takes up memory), you'll probably just "stream" expertise from the cloud.

### *Expanded and Searchable Memories*

We'll be able to remember everything that ever happened to us (because we'll store our memories in the cloud), and we'll be able to search that memory database for useful information. When our memories will become searchable, we'll also be able to make them contextual by cross-referencing our calendars, GPS coordinates, health data, stock market, current news, weather conditions, and anything else that might be relevant to that particular moment in time.

### *A Higher-Order Existence*

Ray talks about how a connected neocortex will bring humanity to a higher order of existence and complexity – expanding our palate for emotion, art, humor, creativity, expression, and uniqueness. He says, "We're going to be funnier. We're going to be sexier. We're going to be better at expressing loving sentiment. We're going to add more levels to the hierarchy of brain modules and create deeper levels of expression. People will be able to very deeply explore some particular type of music in far greater degree than we can today. It'll lead to far greater individuality, not less."

## Join Me

While this future may sound fanciful to many, let's remember that exponential technologies are initially deceptive, before they become disruptive.

And today, there are many labs around the world working on molecular machinery, CRISPR/Cas9 systems that allow us to edit our own genome, and brain-computer interfaces (through cortical implants and the field of optogenetics).

So what if these fields of technological progress double every 18 months? In 15 years (2015 - 2030), we will have a 1,000-fold improvement over today. What does a future one thousand times better look like? Perhaps it's what Ray describes...

If this future becomes reality, connected humans are going to change everything...

We need to discuss the implications in order to make the right decisions now so that we are prepared for the future.

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## A GENOMICS (R)EVOLUTION

Humanity is moving from evolution by natural selection (Darwinism) to evolution by intelligent direction.

For most of human history, our average age was only about 26 years old.

We would procreate at age 13, live just long enough to help our children raise their children, and then, on average, die at age 26 (so we were no longer taking food from the mouths of our grandchildren).

It was through technological innovation -- sanitation and germ theory -- that we moved life expectancy from 26 to the mid 50's. Recently, because of modern medicine's progress in treating heart disease and cancer, we've bumped up today's global average human lifespan to 71 years.

But this is just the beginning.

Advances over the next 10 to 15 years will move life expectancy north of 100.

This blog is about advances in reading, writing, and building elements of the human body.

### Reading – Sequencing the Human Genome

Your genome is the software that runs your body.

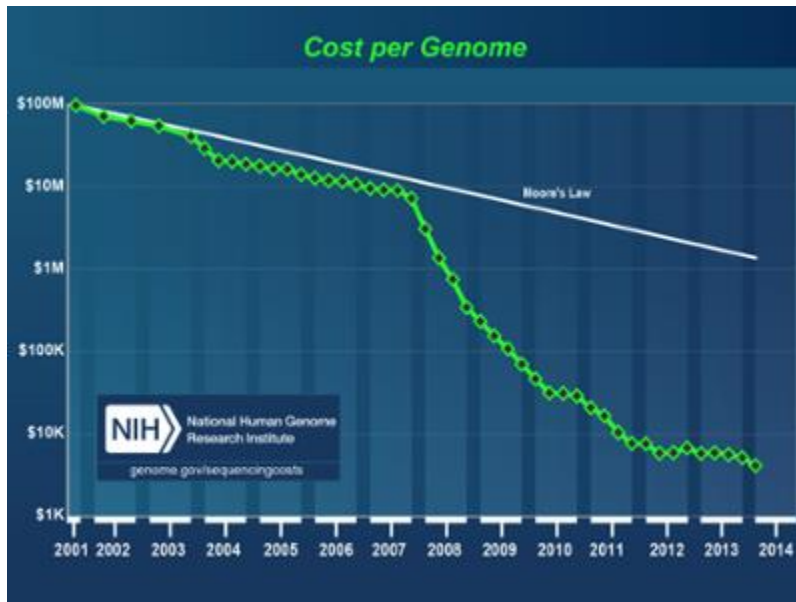
It is composed of 3.2 billion "letters," or base pairs, that code for **everything** that makes you "you" – your hair color, your height, your personality, your propensity to disease, your lifespan, and so on.

Until recently, it's been very difficult to rapidly and cheaply "read" these letters and even more difficult to understand what they do.

In 2001, my friend and Human Longevity Inc. co-founder Dr. J. Craig Venter sequenced the first complete human genome. It took about a year and cost \$100 million.

Since then, the cost to sequence a genome has been plummeting exponentially, outpacing Moore's Law by almost **3x**(take a look at the graph below).

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(Figure: The cost of genome sequencing drops 3x faster than Moore's Law)

Today, the cost to sequence a full human genome is about \$1,000.

This cost trajectory is unheard of, and it's allowing us to do some very useful and productive things.

- Data Mining + Genomics: We can now fully sequence millions of individuals' full genomes, and then mine all of that data to translate what the genome means. Each person's genome produces a text file that is about 300 gigabytes. When we compare your sequenced genome with millions of other people's genomes and other health data sets (like your microbiome, metabolome and MRI data), we can use machine learning techniques to correlate certain traits (eye color, what your face looks like) or diseases (Alzheimer's, Huntington's) to factors in the data and begin to develop diagnostics/therapies around them.
- N-of-1 Care: This is one of the most powerful and important changes coming in healthcare. When we understand your genome, we'll be able to understand how to optimize "you." We'll know the perfect foods, the perfect drugs, the perfect exercise regimen, and the perfect supplements, just for you. We'll understand what microbiome types (gut flora) are ideal for you. We'll understand which diseases and illnesses you are most likely to develop, and we'll be able to prevent them from developing (rather than trying to cure them after the fact). Right now "healthcare" is actually "sick care" – your doctor tries to find quick fixes to make you feel better. With genomics, we'll tackle the root of the problem and eventually eliminate disease all together.

Now that we can read the genome, let's talk about changing it.

## Writing – What is CRISPR/Cas9?

This past week, scientists from London's Francis Crick Institute applied for approval to edit genes in human embryos. If approved, it will be the world's first approval of such research by a national regulatory body.

Last April, a team out of Guangzhou, China reported that they'd been able to edit the genomes of human embryos.

What's powering these advances?

It's a new gene splicing technique called CRISPR/Cas9, and it's changing the game.

CRISPR stands for "Clustered Regularly Interspaced Short Palindromic Repeats." It is a strand of DNA that was found in 1987 to be part of a bacterial defense system.

The CRISPR/Cas system (Cas stands for "CRISPR associated" genes) was found in prokaryotic bacterial cells to identify and splice \*specific/targeted\* foreign genetic material that may be harmful to the bacterium.

It turns out that we can actually use this same mechanism to target and splice specific strands of our DNA – in other words, the CRISPR/Cas system is a way to **\*\*edit\*\*** our genome.

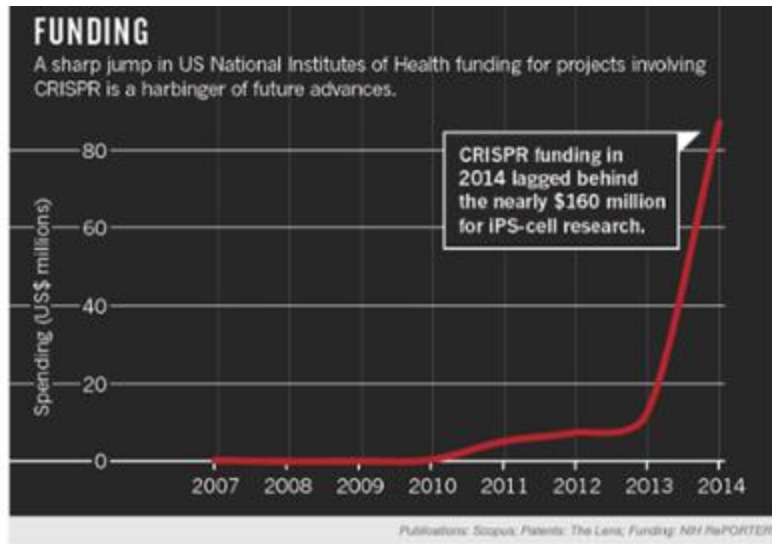
We can remove specific sequences, and we can insert specific nucleotide modifications at specific target locations.

Most importantly, unlike other gene-editing methods, it is cheap, quick, easy to use, and more accurate than previous methods, and as a result, CRISPR/Cas has swept through labs around the world as THE way to edit a genome.

With CRISPR, we will soon have the tools to eliminate diseases, create hardier plants, wipe out pathogens and much, much more.

Take a look at the funding that has poured into CRISPR over the last few years.

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(Figure: Funding for CRISPR has grown exponentially)

Hundreds of labs around the world are exploring new applications for the CRISPR/Cas system, and we expect to see more and more of these applications hitting the market in the next decade.

## Building -- Stem Cells Will Save Your Life...

You are a collection of over 10 trillion human cells.

Every one of these cells -- those in your brain, lungs, liver, skin, and everywhere else -- derives from a single pluripotent type of cell called a stem cell.

Stem cells have the remarkable ability to "differentiate" into any other type of cell in the body. After our body has developed, among our ten trillion fully differentiated human cells (skin, heart, muscle, kidney) remain a population of quiescent stem cells waiting to be called into action to help repair damaged tissue. These stem cells reside everywhere: in our bone marrow, in our fat, and in every single tissue compartment.

Today, in various locations around the world, researchers and physicians inject stem cells into areas of damage, and explore stem cell therapeutics around heart disease, brain disease, diabetes, cancer treatment, arthritis, spinal cord injuries, burns, macular degeneration, and much more.

Stem cells are being used in cancer research: "By studying adult stem cells to learn more about the genes involved in self-renewal, it may be possible to identify new molecular targets for drug and immune therapies that destroy the self-renewing cancer stem cells." (Stanford Research)

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Stem cells are being used to regenerate tissue and literally rebuild organs. Incredible work at companies like United Therapeutics and Synthetic Genomics are working on being able to regrow you a set of lungs this decade, and soon thereafter, any organ you may need.

There is a severe shortage of acceptable donor organs. With your stem cells, we can take a liver from a pig, for example, melt away the living cellular tissue, leaving only the collagen scaffolding, and then introduce your stem cells, which will then repopulate the organ, growing on the scaffolding into a perfect liver replacement, tailor-made for you.

We are living in the era of stem cell therapeutics... and the implications are staggering.

### **In Conclusion**

Healthcare today is like a repairman who is trying to constantly fix a leaky roof by putting a bucket under the leak. Healthcare tomorrow is like using a scanning device to find the weakest part of the roof and reinforce it before the leak begins.

In the next decade, advances in genome sequencing, data analytics, synthetic biology and stem cell therapeutics will allow us to tackle the roots of the problems.

We are headed to a world without chronic diseases, with longer, healthier lives, and with personalized care for everyone on the planet.