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Grove keynote Cruise 2016

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W: Weird Life/SynBio

Synthetic biology is both the design and construction of new biological entities, and the redesign of existing biological organisms. Basically, SynBio is a growing effort to make biology easier to manufacture, manipulate and reprogram through advances in biology, engineering, chemistry, robotics and computer science. We might think of it as “hacking nature.” SynBio is evolving at a breakneck pace.

IndieBio is one of the new biotech accelerators. Two of its many startups are:

- *Pembient*, which will produce bioengineered rhino horn and elephant ivory using rhino DNA and 3D printed keratin, selling these at prices that make the \$20B illegal business of poaching unprofitable, and
- *Bioloop*, which is bioengineering textiles as an alternative to growing cotton or using petrochemicals.

Synbio startups in *food* include:

- *Counter Culture Labs*: One of its groups of bio-hackers is trying to make cow’s milk cheese without the cow. Using mail-order DNA, they’re tricking yeast cells into producing a substance that’s molecularly identical to milk. And if successful, they’ll turn this milk into cheese.

- Another startup called *Muufri* (“moo-free”) is developing its own cow-less cow milk
- In Switzerland, *Evolva* is using synbio to make flavors traditionally derived from hard-to-find plants, such as vanilla and saffron.
- *Solazyme* is engineering microalgae to produce algal “butter,” protein-rich flour, and a vegan protein.
- And *Clara Foods* is working on producing egg whites ex-vivo – no chicken required.

The divide between “natural” and “artificial” in food is becoming blurred – amateurs in their kitchens can tinker with life to make edible substances that are both highly artisanal and highly processed at the same time. There is a potentially large ecological impact. For instance, engineered fermented yeast does not require any arable land to grow. This, along with decreased water and energy usage, could portend a significant game-changer in feeding the world.

With regard to *clean energy*, Audi, for instance, recently announced plans for a new petroleum-free, synthetic, plant-based fuel. Others are looking to reengineer the DNA of various types of algae (a.k.a. “green crude”) as a way to produce clean biofuel.

Considering *animal life*, while many hail this century as the ‘biotech century,’ it is also a century of mass extinctions. It is projected that half of the 9 million known species on earth will disappear by the end of the century. Designer Kathryn Fleming has presented prototypes for new organisms that could be created using synthetic biology, and that conserve characteristics found in endangered species. These include a beaked porcupine that lays eggs, and a six-legged carnivore with retro-reflective skin. Fleming says that, “Rather than preserving animals as artefacts of a wilderness that no longer exists, we need to evolve them to live in the world we are creating.”

Alexandra Ginsberg is also at the forefront of artists and designers who focus on emerging bioengineering and the social implications of it. In her vision of our biotech future, coupled with increasing attention to the microbiome, we might drink probiotic shakes of microbes bioengineered to measure our intestinal health. The microbes would turn different colors as they passed through our intestines. Another of her concepts is a slug that goes along the forest floor, using its slime trail to restore the pH balance of soil high in acids from pollution. And her ‘Autonomous Seed Disperser’ includes a porcupine who wanders the forest catching seeds in its fur and spreading them. Her aim is to preserve biodiversity by asking what could be *invented*, rather than conserved or protected. She sees a future where bioengineers will actually save nature, at a time when forests will be nearly devoid of native animals.

Ginkgo BioWorks is culturing microbes to produce scents that are not only cheaper than using naturally sourced ingredients, but to replace synthetic scents largely made from petrochemicals. The company is also sampling Ice Age wildflowers preserved in permafrost. If the surviving DNA fragments contain genes present in modern-day plants, researchers may be able to develop a yeast strain that mimics the extinct plants’ long-lost fragrances.

And Beyond Earth:

Ultimately, synthetic biology could allow space travelers to produce their own fuel, food, medicines and building materials from readily-available raw materials at the destination (e.g., on the moon), rather than bringing all necessary supplies aboard. This could help herald a new, far more efficient, era of space exploration. Scientists believe that in order to colonize other planets, we’ll need to encode the human genome into bacteria, send those bacteria into space, and reassemble the genomic data once they land on another planet. And Elon Musk wants to partner with Craig Venter to 3-D print life on Mars. The ink would be a universal recipient cell that can have any sort of DNA spliced into it and brought to life.

Implications:

Many predict new SynBio solutions will feed, fuel, heal, recreate and even rectify the world. The possibilities are endless. Right now, SynBio is aiming to do everything from helping ‘heal’ outdated infrastructure (e.g., self-healing concrete), to replacing traditional packaging with biodegradable materials (e.g., mushroom packaging), to using bioluminescence to power household items (e.g., glow-in-the-dark bacteria). But the possibilities and dangers of a future predicated on SynBio have yet to be fully imagined.

Economic realities have resulted in a surplus of un- and underemployed scientific experts who are increasingly drawn into community labs which offer many benefits ranging from retaining IP rights to cheap lab space. Rather than being bogged down by institutions, this new crop of experienced biohackers is leading the next wave of startups. The company *Arcturus Biocloud*, for instance, wants to provide cloud-controlled roboticized lab space to biohackers of all kinds. The purpose is to share genetic creations or co-create with other users. The hope is to broaden the base of people who can start doing genetic engineering experiments and come up with things researchers may never have thought up on their own. What we are witnessing is a transition from research once stuck in and limited to academia to something that anyone with a laptop and an idea can pursue

Now that people are able to tinker with lifeforms the same way children tinker with Lego sets, is this ultimately leading to the democratization of creation? Just like anyone can now be a hotel critic on TripAdvisor or a food reviewer on Yelp, will we reach a time when anyone can become a *biological designer*? What are the legal, philosophical, moral, ethical and spiritual ramifications of this? For instance, DIY biologists are working, using genetically engineered yeast, to make morphine from sugar, raising questions of how to regulate home-brewed opiates and other drugs. Another potential concern regards intellectual property rights. Ginsberg, for instance, presents her bioengineered species as patent applications. These creatures are imagined as the IP of biotech

companies. As research labs and private industry begin to converge, open-source altruism may likely give way to private profit motives, thereby opening up the potential for serious litigation.

Ultimately these questions on morality and regulation may be moot as the technology will always likely outpace regulation and legislation.

According to biophysicist and synthetic biologist Christopher Voigt, in the coming years, people will be able to think about the organism they want, and build that organism from scratch to solve whatever problem they want to address.

A: Alternate Currencies

Points, Virtual, Cryptocurrencies (Bitcoin) – Blockchain (Distributed Ledger technology) (ZCash), Tweets, Local (Berkshares), Barter/Countertrade

Microcurrencies for Microjobbing/the gig economy (wearing a t-shirt, doing a concierge service, spreading the word)

Fintech startups: loans, investments, banking, insurance

T: Terrestrial vs. Non-Terrestrial Security

Outer Space: Exploration Exploitation Tourism

Non-Terrestrial activities are increasing privatized, run by companies and entrepreneurs all over the world.

Drones: Drones are multiplying and are being developed and/or deployed for an increasing number of purposes, including delivery of things and weapons, observation, Internet connectivity, search and rescue, and medical emergency response. The Consumer Electronics Association predicts that commercial sales of private unmanned aerial vehicles will have reached \$130 million in revenue in 2015, up 55 percent from 2014, putting 400,000 units in the sky.

Aside from the many privacy issues, there is now serious concern regarding safety and security, with the need for geofencing and drone capture technology.

Much of modern life is now entirely dependent on *satellite* technology with maps, banks, road systems, airlines, agriculture, mining, entertainment, criminal justice, medical and disease tracking, weather forecasting, power grids and mobile phones all reliant on the global network of ‘eyes-in-the sky’.

Defense experts are now predicting that future conflicts will be fought in space as rival nations compete to plunge each other into a ‘technological Dark Ages’ by destroying communications satellites. Many superpowers now have the capability to blast satellites out of the sky, as China demonstrated in 2013 when it used a missile to destroy a satellite in geostationary orbit. Non-state players will develop the same capability.

So the next major world conflict may be signaled by the destruction of satellites. Such an attack would trigger an all-out ‘space war’ with powers retaliating quickly to disable the technology of enemies and prevent them from pressing their communications advantages.

This could take the battles back on Earth to a pre-digital world, where if we lose navigating satellites, spy satellites and communication satellites, we’re thrown back to fighting like it’s WW1 or WW2.

Jeremy Greaves, of the Airbus Group, which makes military satellites said: “We are dealing with a reality that you just cannot ignore: space as a sovereign nation. Space is the fourth frontier. You have got surface warfare, air warfare and under-sea warfare. And now space warfare.” The U.S. has recently invested \$10 billion in space security after recognizing the Earth’s orbit is now a ‘contested operational domain.’

E: The E-Sports Revolution: Video Games as the Next Great Spectator Sport

In an era of decreasing attention spans and increased distraction, some traditional sports are struggling to maintain their audiences. In the U.S., people are actually debating whether baseball (America's pastime) or football (the U.S.'s most popular sport) will survive in the long-term. One of the things actually helping to sustain these sports (if not allow them to *gain* audience) is the explosion of fantasy sports. More than 40 million people played fantasy sports in North America last year. This year the daily fantasy-sports industry will collect more in entry fees than all the sports books at Vegas casinos combined. But, while fantasy sports have been a short-term boost for real sports, do they represent a sustainable solution? Enter the new competitive threat: e-sports.

Global revenue in the video game industry is now \$20 billion higher than the music industry's and is chasing that of the movie business. Video game companies are spending millions of dollars to build faster networks for online games.

But video gaming has now turned toward the lucrative world of *professional video game competition*, known as "e-sports." Pro gaming has been big in countries like South Korea for over a decade. Now, e-sports are literally exploding on a global scale. Tournaments sell out arenas and some attract at-home audiences larger than those of top traditional sporting events. Prizes for some events are now in the millions of dollars. Thousands of gamers called *e-thletes* competed in *Evo* 2014, an annual tournament for fighting games. A week later, a team at an event in Seattle earned \$5 million for winning a tournament. In January, in West Los Angeles, the North American branch of the League of Legends Championship Series was a 4-week tournament seen by 330 million viewers. Staged in Berlin last October, 36 million viewers watched a \$1 million championship match. In competitive gaming, the top players are superstars, and pro gamers – e-thletes -- are no less dedicated than mainstream athletes.

E-sports have taken off at colleges across the U.S. More than 10,000 students now play in the biggest college league. Winning a big tournament can sometimes earn e-athletes several years' worth of tuition money. And in a possible sign of the future, the athletic department of Robert Morris University created an official video game team, offering the same scholarships given to other athletes.

Last year, the State Department even began granting visas to professional gamers. And streaming video of yourself playing at home is now an essential part of being a pro gamer. Live-streaming is a big source of income. No longer on the fringes of entertainment, e-sports is fast becoming a major cultural and commercial movement.

Amazon recently bought Twitch for \$970 million. Twitch is a website that lets users live-stream video game play over the Internet, creating celebrity players in the process. Launched in 2011, Twitch has had 55 million visitors and more than a million new videos a month. Twitch now beats Facebook, Amazon and Tumblr in terms of peak U.S. Internet traffic. Millions of viewers want to watch other people playing games. In many cases, the popularity of game-watching comes down to the personality of the player. And, viewer participation is becoming a larger part of the experience. Twitch has also become a lucrative source of revenue for e-athletes, who can make money through a mix of advertisements, subscription fees and donations from viewers.

Most gamers prefer playing against their friends, but intelligent bots could become the ultimate opponents in video games of the near future. Start-up *GiantOtter* wants to take artificially intelligent (AI) game characters to another level of realism, using data from crowdsourced human interactions. They are developing bots in games that behave in ways that are both unpredictable and more natural. If we get to a point where AI can match or exceed human capabilities in gaming, the entire paradigm of e-sports will change yet again.

Some of tech's biggest companies have been working on rolling out virtual-reality (VR) headsets in an effort to create a new market for games and other software. This has been made possible by decades of advances in 3D graphics and improvements in sensor speed. Examples include: *Samsung's Gear VR, Google's I/O Cardboard, Sony's Project Morpheus, Microsoft's Fove and Facebook's Oculus Rift* (Facebook acquired Oculus VR for \$2 billion). And, Microsoft has created a prototype *Holodeck*, called *RoomAlive*, which transforms an entire room into a virtual gaming environment. As the sophistication of VR evolves, the realism of e-sports – and the entire multi-sensory experience itself, from both a player's and spectator's perspective – will also evolve.

Contrary to stereotypes about gamers, nearly 50 percent of people now playing games are female. Even more surprising, there are more adult women playing than there are boys under 18. The demographics of game creation, however, lag considerably. Developers are still overwhelmingly male, and most mainstream games cater to the interests and expectations of young middle-class men. More broadly, serious debates over gender equality and discrimination within gaming culture have undermined industry growth in recent years. Steps toward greater inclusion are beginning to emerge. Twine is a popular program that allows people to instantly publish games so that anyone with a browser can access them. While roughly 75 percent of traditional game developers are male, many prominent Twine developers are women.

Implications:

E-sports will unquestionably grow to a large enough scale that it will create a wholly new economic ecosystem. Entire series and films will be made to chronicle the e-sports phenomenon. Video game music is already a wildly popular sub-genre, and that will only increase. Social Internet platforms designed around the evolving e-sports experience (including, eventually, VR) will explode to attract more traffic and consume more bandwidth than anything else. And, e-sports events/tournaments will surely become highly attended mega-festivals of

the future; Think a combination of SXSW and the Super Bowl. They will showcase game developers, musicians, artists, filmmakers, entrepreneurs and, of course, the piece de resistance – the celebrity gamers themselves. And, just as is the case with major sporting events or huge festivals, different cities and countries will compete to attract the biggest e-sports events. Not only would these events be tremendous revenue sources for local economies, but they would also showcase host markets as having a sophisticated future vision. Markets looking to attract tourism in the future will likely bid on banner e-sports events the same way that they currently bid on the Super Bowl, the World Cup and the Olympics.

It is very conceivable that e-sports will overtake real sports in global popularity, market size and revenue within the next decade – and almost guaranteed within the next 20-30 years.

R: Robotics and Sensors : Socialbots

Driverless, autonomous vehicles are developing rapidly. Consumer electronics robotics, like The Roomba, are well known. And there are also nanobots: microscopic robots that can be injected into the human body, treat water, clean up the environment, or disguised as cockroaches, spy on others.

Jeremy Howard, CEO of Enlitic, says: “*Taking the machine-learning algorithm and using it in software attached to some kind of actuators is what we call a robot.*” Deep learning, the software term for machines that continuously learn higher orders of functions, has in the last five years become about 10,000 times faster and about 10 times more accurate at understanding the content of images, and soon, human language. AI programs like Watson are seen as the new law associates of the future, and even perhaps as future board members. And there are over 3,000 daVinci surgical robots in hospitals worldwide that have the precision and extrasensory capacity to make surgeries less invasive and more accurate.

Researchers are attempting to build a RoboBrain – a knowledge engine that is iterative via ongoing learning. As more researchers contribute knowledge to RoboBrain, their robots perform better, advancing the robotics community at large.

And more robots are taking on human-like features:

- Robots that look like human hands can send handwritten notes in the owners' own handwriting.
- Multi-lingual humanoid robotic shopping assistants can greet customers, ask if they need help and guide them through a store. The International Federation of Robots estimates sales of more than 400 humanoid robots worldwide by 2017 that serve as guides or information providers in places such as supermarkets, exhibitions and museums.
- Labs are making robots that use pressurized skins and no metal.
- Sophisticated humanoid robots are learning how to overcome obstacles and move across more varied terrain. Computation has become so cheap and powerful that it's easy to bring cognitive capacities to bear on advances in sensing, mapping, mechanical articulation and behavior.

Enter the “Socialbot:” Social robots are ***any robots that collaborate with, look after, or help humans.*** They are physically embodied, autonomous agents that communicate and interact with humans on an emotional level.

- Early social robot pets included Furbies and Tamagotchi, which alerted their owners when they needed food or bathing. Sony also sold 150,000 Aibos, robot dogs, from 1999-2006. Owners' attachment to these robodogs, costing from \$600 to over \$2,000, became serious. They were considered members of the family, and would accompany their owners everywhere. Sony no longer supports the maintenance of Aibos, and their devastated owners have formed a community to help each other with ongoing repairs of these aging “family members.”

- Nao, a 2-foot-tall humanoid made by a French company, will work on a trial basis in branches of a Japanese bank. Nao has a camera on his forehead, and speaks 19 languages. He analyzes customers' emotions from their facial expressions and tone of voice, enabling him to greet customers and ask which services they need. Nestle Japan has announced plans to employ Pepper, another "emotional" robot, to sell its coffee machines at up to 1,000 outlets. Pepper, a 4-foot-tall android, already works as a shop assistant at SoftBank mobile phone outlets in Tokyo.
- In Nagasaki, the two-story Henn-na Hotel will be run almost entirely by robots, from its porters to room cleaners and front desk staff. About 10 human employees will work alongside their robotic colleagues. Many of these "Actroid" robots will resemble young Japanese women. They will speak Japanese, Chinese, Korean and English, make hand gestures and mimic eye movements.
- The National Museum of Emerging Science and Innovation in Tokyo debuted a girl and woman android, Kodomoroid and Otonaroid. The robots greet and read news to visitors, and hold press conferences announcing new robots.
- Martine Rothblatt, the transgendered founder and CEO of United Technologies, is now working on mind clones, or artificial operating systems like the one featured in the movie "Her." Rothblatt downloaded her wife's personality based on her wife's memories, thoughts and feelings, into a robot that looks, expresses herself and dresses like her wife. She believes mind clones are only about a decade away from becoming mass market products.
- In 2012, Jan De Coster designed a robot called Yummy. Yummy looked at Jan, and an emotional link was made between them. When Jan showed the robot to other people, he discovered it had other qualities, like imperfection, beauty, and a form of empathy. So he made more robots. Herb the robot is mainly an exploration in style and attitude. Rachel was his attempt to explore what it could mean for a robot to be perceived as "real." Steve weighs 220

pounds and is over 6 feet tall, and will be employed by Brightfish to host events and marketing campaigns. De Costa believes that more robots should be given human personas and appearances. He says that the Mars rover Curiosity is doing difficult work, so it should look more like a human space hero. With more emotional appeal, more people would tune in to follow its work. He believes NASA thought something about an emotional link, because they gave Curiosity a Twitter account, so people could talk to him. Based on movies like Wall-E and Blade Runner, humans probably do want to emotionally connect with robots.

- The era of realistic, affordable and emotionally intelligent robots will include sex robots. There are over a dozen high-end manufacturers globally who are making “love dolls” or “sex dolls,” and many more are making cheaper models. One proponent believes these dolls will evolve into robots whose fabrication will ultimately be driven by hobbyists, being made by makers (the term for the do-it-yourselfers in everything from 3-D printing to brewing beer). Someone named Davecat41 is part of a group known as the iDollators, who say they prefer the intimacy of sex robots to “Organiks,” aka human beings. Davecat lives with 3 dolls, and has made up personalities and gotten Twitter accounts for each of them. He is one of the subcultures calling themselves “robosexual,” and says he’d rather have a Gynoid than a doll (Gynoids being a technical term for female humanoid robot).

The Socio-Emotional Connection: People have become psychologically and emotionally attached to cars, mobiles, GPS systems, shop tools, battlefield machinery and anything that they interact with, especially if it talks to them. Interacting with these things triggers genuine emotions and reactions.

And we humans have a deep tendency toward anthropomorphism – the imputation of human-like qualities onto animals and nonliving things. Anthropomorphizing pets, for example, doesn't require the belief that the pet is human, only that the personality and behavior inspires humans to treat it like a person with complex desires, motivations or memories. It is a near certainty that we will do the same with social robots as they become increasingly commonplace. Social robots are purposefully designed to elicit anthropomorphic reactions. The goal of many roboticists is to get to a point where robots can successfully manipulate our emotions.