BEE –AN ENDANGERED SPECIES
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ABSTRACT
Bees are not ordinary wildlife. They have a special relationship with human society for they are vital to our current and future food supply.

Einstein once said: "If the bee disappeared off the surface of the globe then man would only have four years of life left. No more bees, no more pollination, no more plants, no more animals, no more man"[1]

For millions of years bees have evolved to perform an essential role in pollinating flowers and food crops on which animals and humans depend. For 90% of 100 major crops of world's food supply, 71% are bee pollinated. The bee pollination in the U.S. is estimated at $16 billion[2].

Tragically, bees today are dying at an unprecedented rate. This does not augur well for the present and future supply of food for our planet— a problem that deserves to be much better known and discussed among the most serious facing the world—an impending crisis that demands urgent mitigation. In the winter of 2012, 30% bees died in US; in Canada 29% ; and in Europe, 20%[2]. In China, farmers have resorted to human pollination[3,4].

Our intensive agriculture, driven by inextricable global overpopulation explosion, with wide use of toxic insecticides like neonicotinoids[5] is main reason for bees' decline. We list threats bees face and how citizens at all levels, particularly futurists— can directly help preserve bees and save humanity.

We look at our future with diminishing bee population and propose viable solutions.

INTRODUCTION

How much of bees' action is all instinctive?
The evolution of the bees has a long history. The discovery of a bee fossil embedded in amber in Myanmar[6] showed bees appeared 100 million years ago. From the study of the bees' DNA, there is some link between the bee and the wasp. Much interest has been focused on the relationship between bees and flowering plants - a most diverse organism - 'an abominable mystery' - according to Charles Darwin[7]!

Back in 330 BC, the Greek philosopher Aristotle noticed some sort of organization exists with the bees:
"*Each bee on her return is followed by three or four companions... how they do it has not yet been observed"*
Aristotle, *Historia Animalium*, IX[8,9].

On the discovery of the dance language of bees. Karl von Frisch said[10]: “In the summer of 1944 a few very simple experiments led to a result that was just as unexpected as it was thrilling[10]. He was awarded a Nobel prize in 1973 for his work on bee communication

SOCIAL ORGANIZATION OF BEES

The bees have a fascinating social organization that is unmatched in the animal kingdom. Forager bees collect nectar while pollen is dusted on their back. They then return to communicate to the others the direction and distance where to find their trove by a set of dances[3].

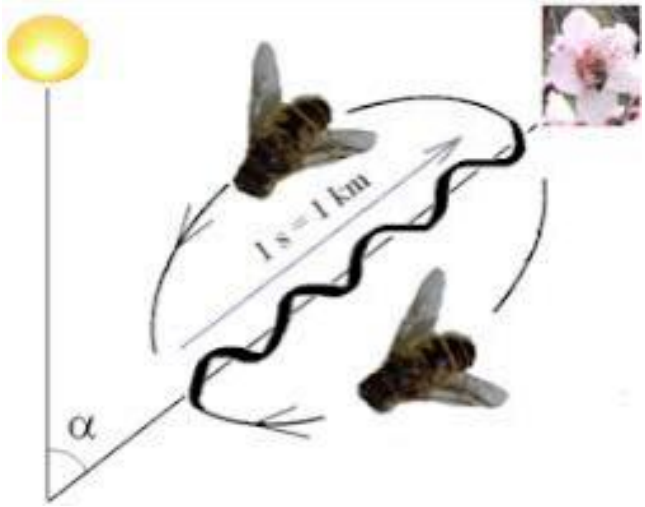


Figure 1 Diagram showing the direction of the waggle dance. in relation to the sun and the flower. The straight portion of the waggle dance points to the source of nectar.

WHY ARE BEES DISAPPEARING?

The importance of bees in our food cycle cannot not be over-emphasized. More than 2/3 of the worlds crop species rely on bee pollinators. Honeybees and wild bees are the most important pollinators of many of the fruits and vegetables we eat. Examples include not only familiar fruits and vegetables, but also many of the herbs we use to season our foods, as well as nuts, berries, cotton for clothing, and even clover and alfalfa which provide the main feed for cattle.

Yet despite their economic importance, for over a decade now bees have been dying at an unprecedented rate. In the United States alone, nearly 44% of bee colonies had collapsed by 2016[11,12]. Since 2007, an average of 30% of all colonies have died every winter in the United States. This loss is about twice as high as what U.S. beekeepers consider economically tolerable[2].

The main reasons for their disappearance are[13]:

1) **Overuse of insecticides:**
Worldwide, the intensive agriculture used to provide food for Earth's ever growing population has led to the more intensive use of insecticides. One of the deadliest, and most widely used of these, the neonicotinoids[5], are sprayed directly on the leaves or coated on the seeds of

major crops including corn, from where they infiltrate flowers and their nectars. This can have a devastatingly toxic effect on the bees' immune systems and make them vulnerable to pests, also damage the bees' ability to navigate back to the hive. Although another extremely toxic new insecticide, chlorpyrifos[14], has been found to effect human brains, it has not yet been banned and is still being used as a pesticide.

Ironically, the side effect of harming the bees is counter productive to the purpose of increasing food production with our intensive agriculture.

2) **Loss of habitat:**
Here too global overpopulation is posing a threat to bees**.** As rural areas become urban, the patches of green space that remain are often stripped of all weeds and their flowers, which bees rely on for food. Lack of fresh water in urban areas can cause bee distress.

3) **Climate change:**
Drought, storms and inclement weather can destroy the habitat for flowers. Unusually warm winters have caused plants to shift their schedules. When bees come out of hibernation, the flowers they need to feed on have already bloomed and died. Largely as a result of global warming, bees have lost nearly 300 km off the southern end of their

historic wild range in both the US and in Europe, a trend that is continuing at a rate of about 8 km every year.

4) Disease:
Increasing transport from different countries brings pathogens like mites which weaken bees and make them more susceptible to pesticide poisoning. The most destructive is the varroa destructor mite which can hitch a ride on a bee into the hive. Then they lay eggs which will feed on the young bees, especially the drones, and ultimately wipe out the entire hive. To control mite infestation early detection is important. A product called Apistan is a strip which can be hung in the brood nest area of the colony for 4 weeks to kill the mites.

5) **Radiation:**
Although not yet definitively proven, scientists suspect that growing radiation used by communication towers for mobile phones can interfere with the bees' ability to navigate through their antennae. More research is required in this area.

WHAT CAN WE DO TO HELP?

Like most animals, bees are not naturally aggressive but will defend themselves if they feel threatened. Sadly, the greatest threats bees face today come from forces against

which they have no natural defense. Instead, humans must act for them; and here are some of the things we can do:

* Take political action by urging our governments to regulate or ban toxic insecticides and replace them wherever possible with effective organic substitutes.
* Help diversify our farms and urban landscapes by planting native flowers along crop borders, in land unprofitable for crop production, along roadsides, power line corridors, in city lawns and on urban roof top gardens. It is important to plant flowers of the same kind together in blocks, as bees, when they find a trove, always report its exact size, location and scent to others in their hive.
* Homeowners, plan a garden, watch the bees pollinate it and get the pleasure of seeing them while you reward yourself and the world with healthy food and beautiful flowers.
* Provide a water source like a shallow bird bath with rocks.
* Consider being proactive and start our own hive! I am glad to say that my son in Philadelphia has just done that on his own balcony.
* Start a project like the very laudable 'The Navajo Bee Project'[15] initiated by a group of concerned environmentalists near Santa Fe. It aims to reverse the damage wrought by the leaking radioactivity of nearby

uranium mines by providing 100 beehives on 25 acres of land to detoxify the soil.

Even though, as individuals, we may only contribute a little, the aggregate of our efforts can lead to a decisive change for the better in the bee environment. It is time for all of us to act.

FUTURE OUTLOOK

Faced with a vast reduction in the bee population, what will our future society look like? Human society is infinitely adaptable and we need not cry over the diminishing of the existing bee population as. there exist several options open to us which are likely to happen in our fast developing technological world.

1) Self-pollination.
Although plants have mostly evolved along the lines of cross-pollination with the help of bees, wasps, birds and other animals. The main justification for that is the fact that bi-sexual reproduction is better for reasons of genetic virility - the possibility of mutations may make the plant more resistant to disease. But there do exist self-pollinating plants. These have evolved over the centuries under adverse conditions where there were no reliable agents for pollen transport - mostly this occurs for annuals but also for trees. One example of self-pollination is

Cleistogamy which occurs before the flower opens. The pollen is released from the anther within the flower or the pollen on the anther grows a tube down the style to the ovules.

Fortunately, today with the use of genetic tools such as CRISPR, which allow us to target a specified segment of the DNA in a fast and relatively effortless way, it is conceivable that we can alter the genetic makeup of plants, trees through the seeds in such a way that they can all be self-pollinating.

2) Creation of new insecticide bacteria harmless to bees.

It is well known that dioxyribonucleic acid - DNA is the basis of the living cell. Its structure is a deceptively simple, yet beautiful double helix. Two strands of helix are tied together by pairs of molecular amino acids - bases. They are Adeniine(A), Guanine(G), Cytosine(C) and Thymine(T), which pair up as chemical bases: A with T and G with C. The sequence of these bases gives us the genetic hereditary information - the code which is passed on through reproduction[16].

The Human Genome Sequencing Consortium successfully decoded the human genome in 2003. It found that there are about 20,000 genes - functional units of DNA and altogether about 3 billion base pairs. To have mapped the size and locations of such a large and important system must rank as comparable in achievement as sending a man to the moon!

Since then, the scientists, given the knowledge and the technology gained, have diverged in two directions. A large group joined the NIH- National Institute of Health, to study the pathology of human disease. To diagnose and invent new drugs as well as in preventive medicine. Another group, led by J. Craig Venter, initiated a pioneering effort in a new venture - Synthetic Biology.

Synthetic Biology - Creation of new cells

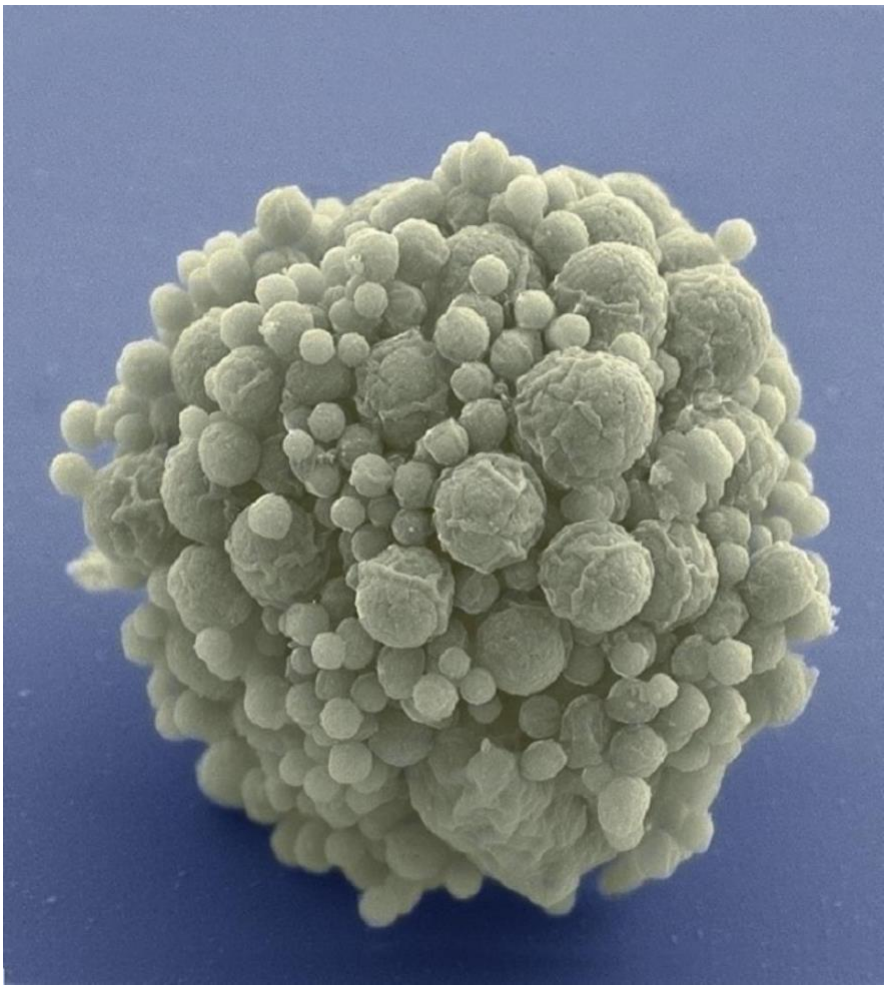
In his recent book: "Life at the speed of life, from the double helix to the dawn of digital life"[16,17], Venter describes how to synthesize a new functional genome. The starting point is a most simple goat bacterium that is one million bases long. Using the 4 base chemicals A,T,G,C from the laboratory, they synthesized and mimicked the complete genome of this bacterium. This is stored in the computer. They then made minimal changes to the sequence, basically creating a new organism. This chemical was then injected into an empty host cell and the new bacterium proved to be an accurate enough version of the original goat bacterium that it was able to manufacture a specified sequence of proteins simply by following the instructions implicit in the structure of the synthesized DNA.

After a 20-year quest, scientists led by Craig Venter in 2016 have finally synthesized a bacterium with a genetic code smaller than any known to exist in nature. It is a new organism with a minimum code necessary for life[18].

The new microbe, named JCVI-syn3.0 has 473 genes, of these 149 genes have completely unknown functions. Now we have a living organism which does not do

anything magical other than live, eat and self-replicate. But it is the first designer organism in history.

Figure 2 Image of JCVI-syn3.0
by Tom Deerinck and Mark Ellisman of the National Center for Imaging and Microscopy Research at the University of California at San Diego



Given the recent advances in the tools for gene splicing such as CRISPR, the cost and time necessary for the creation of a programmable new organism have much reduced, paving the way for a host of applications. A good example of the useful application of the technology is in the flu vaccine. During the outbreak of the h7n9 flu epidemic in China, Chinese scientists sequenced the virus and posted it on the Internet. Given just the digital signal, the US was able to synthesize the virus within 10 hours and developed a vaccine towards it.

The whole field of synthetic biology opens up enormous and exciting possibilities. But as a responsible futurist we need to be aware of the bioethical implications. This brave new world we have ventured into can lead us to an utopia or a dystopia. The first question to ask is: ‘Can the bacteria we synthesize become a rogue species and run wild out of our control or can it be harnessed for society’s benefit?’ Who is to provide the regulations, to decide what needs to be developed and what should be forbidden? Already society is grappling on the market with Genetically Modified Organisms - GMO - while we do not fully understand all their functions and ramification?

It is conceivable we can synthesize, after may be some trial and error, insecticide bacteria without the side effect of harming the bees.

3) Pollination by humans

With the fast advance of Artificial Intelligence- AI - our society will soon be faced with the problem what to do with the potentially unemployed masses of people. Here is one solution: Do like the Chinese and use humans for cross pollination by means of brushes.

4) Robot Bees

For a decade Harvard Microrobotics Lab has been making robot bees. So far this robobee has a 3 cm wingspan and only 80 milligrams. It can perch on a surface and take off again using electrostatic adhesion and it is fitted with some vision, optical flow and motion sensors. However, this robobee is tied to a power source. Furthermore, in order for it to have a bee like resilience to sense the wind and adjust to the complex environment it would need a lot of computer AI software. Scientists at Cornell[19] are developing a ‘neuromorphic’ chip processor which would mimic the large number of neurons in our neural network in the brain. It will also be fitted with new micro devices such as a camera, expanded antennae for tactile feedback, contact sensors on the robot's feet and airflow sensors that look like tiny hairs.

So we can expect mini-robots equipped with AI to scan all plants for cross-pollination: trees, flowers, agricultural crops....

There is just one snag. There are 60,000 bees in a hive. Though only a fraction of them are foragers, the bee population is huge. How can we produce enough robot bees?

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