

The Miraculous Honey Bee

Slide 1: title of talk

I Introduction

So that we are all on the same wave-length, and to set the stage for our discussion, I am going to start by talking a little about the miraculous honeybee.

I want to present some facts about honey bees in a way that allows us to be in awe of what they do, and amazed at how well they are equipped to do it -setting the stage for wanting to ask and answer the question: How did the honey bee happen?

I hope to illustrate how they are unusual in that worker bees don't reproduce, and to make the argument that it takes some pretty creative adaptations to use the theory of evolution to explain every aspect of the development of honey bees.

I will use excerpts from a talk I gave at Luther Oaks last fall about honey bees, and the idea of "My Top Ten Amazing Things About Worker Honey Bees" to do this.

And my caveat is that I bring this topic to the group as a student, not an expert- having a lot more questions than answers.

One more Thing: Slide 2: The DaVinci Code, by Dan Brown

Amazing Thing 1- Their Love Life

Back in the day, some popular songs, like this one by Dean Martin and Jerry Lewis, made out that the love life of bees was pretty special, and humans could learn some lessons from them. I hate to disappoint any of you who believe this, but I'm about to throw a pretty soggy wet blanket on that idea.

Slide 3: Video, Martin and Lewis"- Birds and Bees

Slide 4: Types of Bees and Their Love Life, with captions

So let me tell you the straight dope about the "bees and the bees". In the "love life" of honey bees, there is only one woman who ever mates. This specially anointed woman- Queen, and mother of all the other women, flies out on a single little trip, mates with around 10 males—while flying in the air no less-- and spends the rest of her life using their sperm to fertilize 2000 eggs a day. She never mates again. And every male, after mating the first time, is viciously rendered not capable of mating again, and dies. Pretty bleak. So don't expect any good love life advice from bees.

And here is where we come upon a glitch in explaining the development of bees in terms of evolution. The theory is that *the DNA of an organism sometimes mutates and “through reproduction, the beneficial mutation spreads.”* Suppose a mutation changes the DNA of a worker bee. *How can that mutation spread if worker bees don’t reproduce?*

Amazing Thing 2 - Their Limitations & Accomplishments in Spite of Them

The story of the worker honey bee may be the most interesting success story ever told. But first, let’s look at what might be considered their limitations.

Slide 5: Limitations and Accomplishments, in Spite of Them

This creature is ½ inch long, weighs about as much as an ordinary toothpick, has a brain the size of a mustard seed, and only lives about 42 days.

Slide 6: How Big is a Worker Bees Brain?

So, you say, “pretty much nothing here, so what are you getting excited about?”

But let’s not judge the present by its package. Let’s also look at what worker bees do – their accomplishments.

Slide 7: A worker honey bee’s life and accomplishments

Talk about being “busy as a bee!” The worker bees, aptly named, do all the work.

Since worker bees spend ¼ of their life foraging for nectar, let’s take a quick look at making honey- their special accomplishment. Remember, honey is the only food made by an insect that people eat, and which, throughout history, has been considered very valuable, healthwise, to humans.

Slide 8: Overview of Honeybee’s Main Task- Making Honey

To put it in perspective, it is reported that during the last 10 days of her life a worker bee spends foraging for nectar, she produces only 1/12 of a teaspoon of honey! So it takes 12 worker bees to produce a single teaspoon of honey! Taking that further, to produce 0.5lb (227g) of DrBeekeeper honey it takes about 30,000 bees travelling 27,500 miles and visiting more than a million flowers to gather the nectar required.

Amazing Thing 3- How Worker Bees are Equipped to Help Them Do What They Do

Slide 9: How does the way worker bees are made help them do what they do?

Slide 10: Diagram of Honey Bee's Anatomy

The worker honey bee is unbelievably well equipped to do what she does. I leave it to you to explain she got to be so well equipped, but she did.

I want to go through some of the things the worker bee needs to do... and the equipment she has to help her do it.

Slides 11, 12, and 13 In Order to Do ----, She Has -----

The honey bee needs to... in order to do it, (she has...)

1. Feed larvae Royal Jelly to grow a Queen Bee. (She has a Royal Jelly Gland)
2. Smell, hear, taste, feel, navigate to get nectar, care for hive. (She has Antennae)
3. See flowers, navigate with sun, use ultraviolet light. (She has 5 special eyes)
4. Suck nectar from flowers, taste, and transfer food. (She has a Proboscis)
5. Fly a ways to get nectar and fly back with heavy load. (She has special wings)
6. Carry nectar she's collected back to the hive. (She has a honey stomach)
7. Carry pollen she's collected back to the hive. (She has pollen baskets)
8. Have wax to make honey combs. (She has 8 wax glands)
9. Protect the hive from intruders. (She has a stinger and venom sac)
10. Collect pollen from flowers. (She has 3 million electrostatic hairs on her body)
11. Make honey from nectar(She has enzyme glands that help produce honey)
12. Communicate (She has 15 pheromone glands that help her communicate)

Everything the worker bee needs, she has! She seems perfectly equipped to do what she does. How did this all happen?

How does a little ½ inch, mustard seed brain, 1/10 gram honey bee have on and in her body all these things specifically tailored to help her run a bee hive, and make honey? Totally Unbelievable!

- Time out for bee stuff and jokes :

Slide 14: The Bee Shouldn't Be Able to Fly

Slide 15 Bee Jokes

Amazing Thing 4 – How Smart They Are

Not only is the honey bee equipped with a body that totally helps her do what she does, but she is equipped with a brain, albeit small, that makes her pretty smart, and contributes to her ability to do what she does extremely well.

Slide 16: How Smart is a Worker Honey Bee?

Amazing Thing 5 - The Way They Build Honeycombs

Slide 17: The Way They Build Their Honeycombs

Make Wax When they are between 10 and 20 days old, the worker honey bees prepare to make honeycombs by first becoming *wax-making machines*.

They just start eating honey, which is digested and converted to wax by eight wax glands in their abdomen.

The wax then oozes through the bee's pores, and appears as flakes on their outer abdomen.

The bees then chew the wax flakes off of each other, continue chewing until the wax is moldable like clay, and then use it to build the honeycomb.

Efficient Plan Somehow, probably centuries ago, bees discovered that *a hexagonal honey comb can have the same capacity as a triangular or square honey comb, and it takes less wax to build it.*

Build the Honeycomb We will probably never know why or how, but the bees begin building the hexagonal honeycomb by making stacked cylinders, and allowing the spaces created when they didn't quite fit together to be filled with wax. See "At the Start" photo (a) below.

Slide 18: Analyzing a Honeycomb

At The Start

After 2 Days[/caption]

Shaping the Honeycomb Using the heat from their bodies, and their bodies as tools and measuring instruments, they melt and expand the wax between the cylinders to form the sides of the larger hexagon shaped honeycombs in the "After two days" (photo b).

My Amazement So the fact that these short-lived little worker honeybees do build a perfect hexagonal honeycomb with wax *they make themselves* is, without a doubt, an "amazing thing." I still don't see how they learned to do it.

Slide 19: Bee cartoon. "So, where are we exactly?"

Amazing Thing 6- How They Make Honey Honey

Nectar. which the worker bees collect from flowers, is not honey.

Bees not only collect the nectar, but they change it chemically to make the honey.

Slide 20, 21: The Way Honey Bees Make Honey Honey

After she collects nectar (80% water) in her honey stomach, the worker bee heads back to the hive, and on the way she adds an enzyme invertase (produced in her saliva gland), into the nectar. Invertase changes sucrose into equal parts glucose and fructose.

In the hive, the nectar, on its way to being honey, is transferred to house worker bees, who pass it around from honey stomach to honey stomach. Note that honey at this stage, partly because it contains hydrogen peroxide and is acidic, has an inhibiting effect on 60 species of bacteria- so no need to worry about germs.

In the passing process, enzymes amylase and glucose oxidase, are also added, to make it easier to digest and stabilize it's PH (acid balance). Catalase is also added, to finally change hydrogen peroxide into water and oxygen, and make the honey taste better.

Then the bees store the honey in the comb, fan it with their wings until it is about 18% water, and seal it in with a wax cap.

Slide 22: The Honey Bee is an Exquisite Chemist

The fact that these little worker bees can do all this, and do it just right does indeed fit the “amazing” category.

Amazing Thing 7- Their Eyes and the Way They Use Them

Another aspect of bees that really amazes me is their eyes.

Slide 23: Their Eyes and the Way They Use Them

I can hear some of you thinking, “Are you kidding me?! A ½ inch mustard seed brained honeybee needs FIVE EYES????”

Well, they do have 5 eyes: two large compound eyes, one on each side of their head, and three smaller eyes at the top of their heads. And they make good use of them-

Slide 24: Bee’s compound and small eyes

Compound Eyes-

- Each of the compound eyes have around 6000 little photosensitive lenses, called facets, each acting as a single eye. (You might say the bee has thousands of “eyes”). At the intersection of these facets a hair grows.
- Each group of 150 facets has a specialized skill- seeing motion, ultraviolet light, patterns, or color- and is connected to the optic nerve. (40+ optic nerve connections)
- These compound eyes enable bees to do things humans can’t do- see 300 pictures per sec, see ultraviolet light, see in almost all directions, navigate using the sun, and use the hair in their eyes to stay on course in windy conditions.

Small Eyes-

- Help the bee maintain stability, stay oriented, detect movement, and judge light

intensity, aid in navigation(triangulate the bees position relative to the sun} , and to find the way back home.

Honeybees can discriminate among similar human faces and remember a face they've seen before.

Slide 25: Exchanging Glances

Scientists believe if we want to design automatic facial recognition systems, we could learn a lot by using the bees' approach to face recognition.

Wow! What a bee does with her eyes really is amazing!

Joke: Why Do Honey Bees never get mad? ((Because they cant see red)

Another bee skill hard to comprehend, is how bees communicate so precisely with each other.

Amazing Thing 8- How They Communicate

Most people have no idea that honey bees can “talk” to each other. But they do! How do you think they would do it?

Slide 26: The Way They Communicate..With a Waggle Dance (With Pheromones)

Let's first focus on the Waggle Dance. Karl Von Frisch discovered, in 1973, that bees use a waggle dance to communicate with each other. He received a Nobel Prize for this discovery. This video will help us learn more about the Waggle Dance.

Slide 27: Video, Bees Waggle Dance.

So, let's review. A honey bee discovers a new food source more than 150 meters(1 ½ football fields) away, returns to the hive, and does a Waggle Dance to tell other honey bees exactly how to find it.

Slide 28: Interpretation of the Waggle Dance

The duration of the dance tells how far away the source is, and the angle the bee dances to the sun's vertical shows the direction to the flowers. And the bee compensates for the movement of the sun.

The honey bee dance is an amazing example of honey bee communication, but their communication using their sense of smell is even more extensive.

As mentioned earlier, honey bees use pheromones (chemical substances secreted by the bees exocrine glands and smelled by other bees) in all aspects of their life. It is the most important way in which bees communicate.

It is beyond the scope of this talk to go into this deeply, but here are some pheromones that bees use

Slide 29: Some of the Pheromones that Bees Use

The queen bee emits a pheromone(odor) that tells the hive all is well with her, and discourages workers from laying unfertilized eggs. A drone emits an odor to tell fellow drones its time to congregate at the mating sight. The worker bees emit an odor that signals that she has stung an intruder, and another worker's pheromone signals which eggs are the Queens.

And so it goes- the most complex pheromonal communication systems found in nature- using 15 known glands that produce odorous compounds used for communication.

Wow! Something Else Amazing!

Amazing Thing 9- The Scientific Value of Their Sense of Smell

Slide 30 The Way They Outdo Science- As Bomb Detectors

In the picture on the left, the bees antennae look like a couple of little twigs sticking out of its head. If we stop there, we miss an awful lot.

I'd love to spend a fascinating day talking about all their antennae can do(among them measuring speed, temperature, and humidity, etc.), but it's the value of the antennae in providing a honey bee's acute sense of smell that I want to highlight.

"How acute is their sense of smell, you might ask?" Well, first, they have 170 odor receptors in their antennae, and their "nose" is 100 times more sensitive than humans, and 50 times more than a dog.

This makes their ability to smell so sensitive that they can detect a trace of scent in flight. And bees are able to recognize odors that are as faint as only two parts per trillion in an air sample.(the equivalent of finding a grain of sand in a swimming pool)

So we shouldn't be surprised that Scientists have harnessed the insect's phenomenal sense of smell to detect and track down explosives hidden by terrorists!

But how do they do it? Prepare to be amazed!

In the picture to the right on the slide, you see the bee's proboscis, which the bee uses to suck nectar from a flower, and which also plays a key role in the bee's detection of explosives. It works like this.

If you hold up sugar water [to bees], they automatically stick out their proboscis. Proboscis Extension Reflex (PER) I call this the Bee's "Per-ing"

By mixing a bomb chemical with sugar water and then presenting the mixture to the bee, the researchers can train the bees (in no more than 2 hrs) to also stick out their proboscis when they smell only the chemical.

Scientists say the bees proved to be more sensitive in explosive detection than their sophisticated man-made devices, detecting odors their devices cannot. (Such as detecting TNT in motor oil)

All this, for sure, is beyond amazing!

And finally, as a brief addendum, a couple more examples of bees outdoing science.

Slide 31: The Way They Outdo Science-Computer Science and Medicine

1) Computer scientists found the procedures honey bees use to search for nectar are the most efficient procedures to use to allocate computer servers to internet traffic. They call these procedures The Honey Bee Algorithm, and it has saved the computer industry millions of dollars!

In computing, a *server* is a computer program or a device that provides functionality for other programs or devices, called "clients". ... Typical *servers* are database *servers*, file *servers*, mail *servers*, print *servers*, web *servers*, game *servers*, and application *servers*.

2) Medical researchers found that bees can be trained in 10 minutes to detect the odor of early stage cancer. Bees are placed in a glass chamber, and a patient blows into the chamber. If the bees detect the cancer smell, they start per-ing. This works with several other diseases too.

Amazing Thing 10- How Valuable They Are To Humans

Just take look at Einstein's quote.

Slide 32: Just How Valuable are Honey Bees?

How could this be?

First, Honey bee's help us by pollinating flowers. Cross Pollination is a process by which plant pollen is transferred from the male reproductive organ [stamen (anther)] of a flower to the female reproductive organ [pistil(stigma)] of another flower, so seeds can be formed. This little animated photo shows the process.

Slide 33: What Do Honey Bees Do For Us

Amazingly, One out of every 3 mouthfuls of food in our diet is a product of honey bee pollination.

And Honey Bee's yearly contribute \$20 billion to U.S. Crop production.

Finally, Honey bees provide the world with honey, and provide models that help scientists accomplish important tasks more efficiently.

And three bee products are very helpful to us.

Benefits of **Bee Pollen** to the human body.

- relieve inflammation.
- work as an antioxidant.
- boost liver health.
- strengthen the immune system.
- work as a dietary supplement.
- ease symptoms of menopause.
- reduce stress.
- speed up healing.

Benefits of **Propolis** to the human body.

- Propolis and its extracts have numerous applications in treating various diseases due to its antiseptic, anti-inflammatory, antioxidant, antibacterial, antimycotic, antifungal, antiulcer, anticancer, and immunomodulatory properties.

Benefits of **Royal Jelly** to the human body.

- Royal jelly is widely marketed as a [dietary supplement](#). It is an [alternative medicine](#) that falls under the category of [apitherapy](#)

\What's the Bottom Line on the Bees and Our Future?

Slide 34: What's the Bottom Line on the Bees, and Our, Future?

My question is, Do bees do most of the amazing things they do through instinct, or can(do) they really learn a lot of new stuff with that compact little brain of theirs.

I think the latter is true, but scientists still argue both sides of the issue. And were they created suddenly in all their glory, or did they evolve over millions of years?

Let's talk about it.