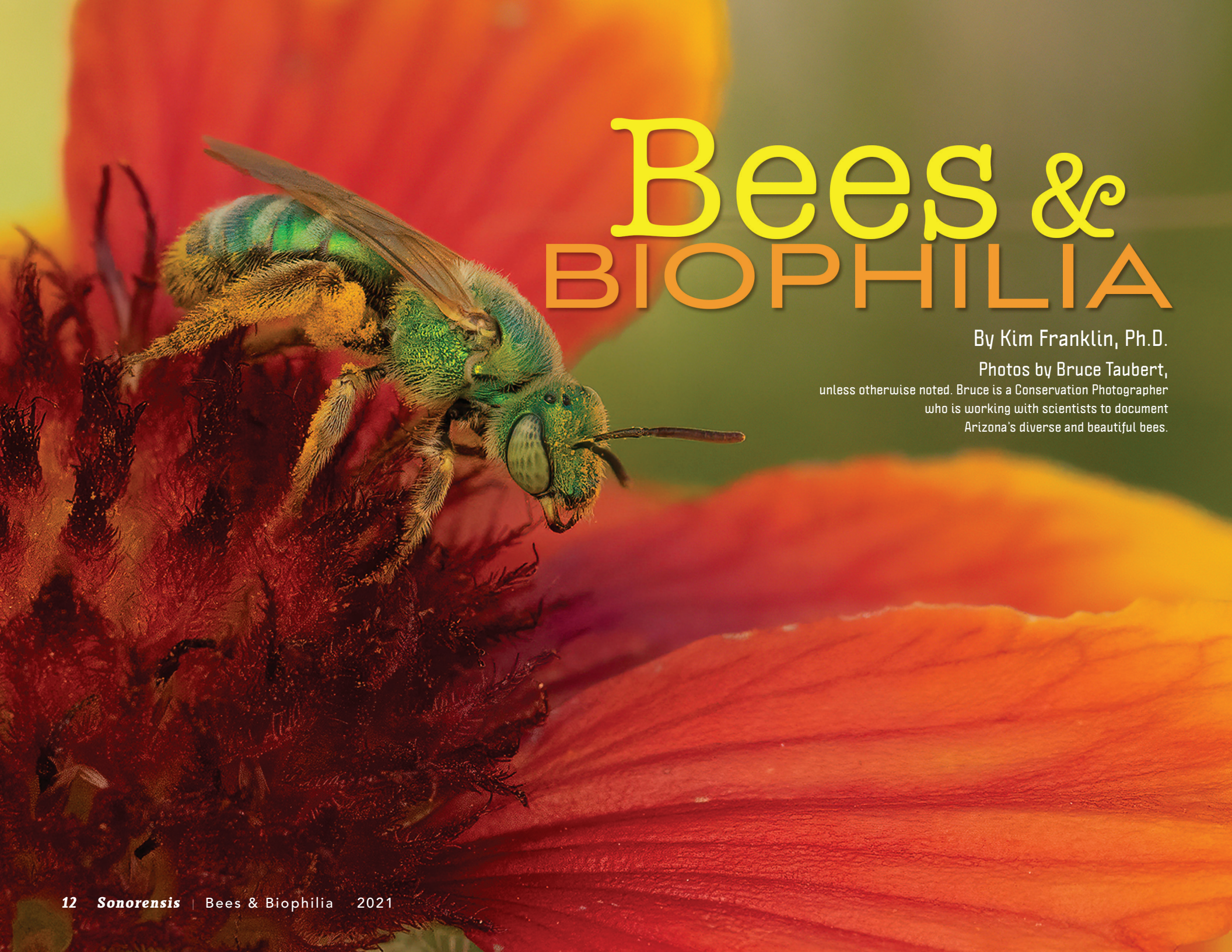
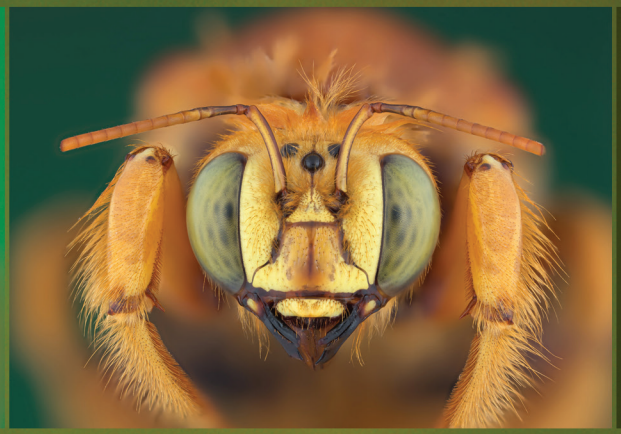
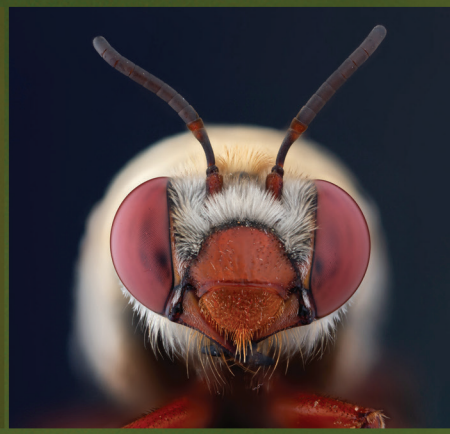


Bees & BIOPHILIA

By Kim Franklin, Ph.D.

Photos by Bruce Taubert,
unless otherwise noted. Bruce is a Conservation Photographer who is working with scientists to document Arizona's diverse and beautiful bees.



Left photo: *Agapostemon sp.; Xylocopa varipuncta; Centris pallida* male; *Centris rhodopus* female. Cut out below: The author's children.

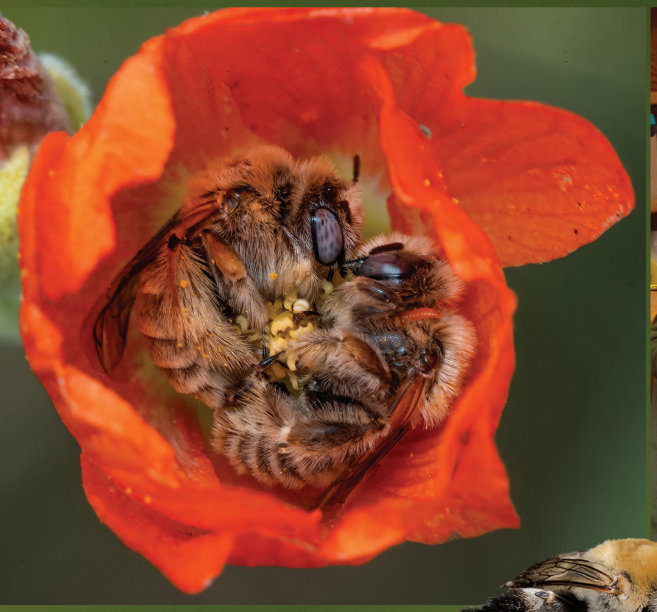
Bees

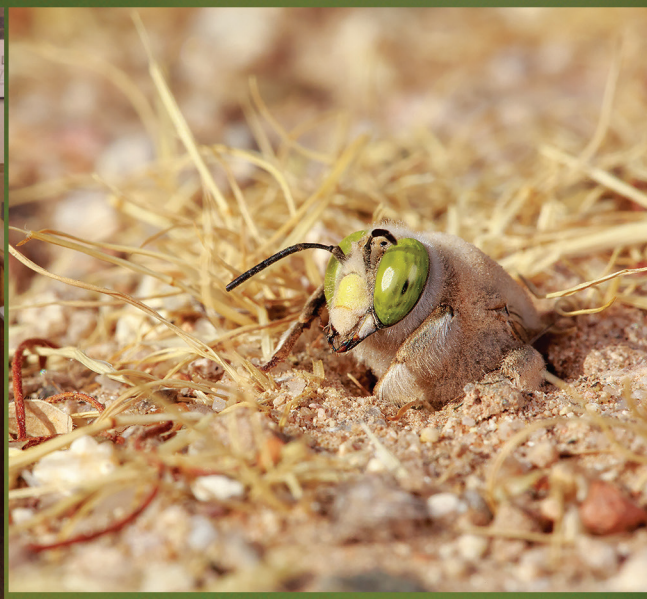
As a scientist who studies bees and the mother of two young children, I occasionally find myself in the field with two enthusiastic little helpers. Collecting bees is an activity they enjoy immensely. They are fascinated by these tiny creatures. My five year old knows more about bees than I did, even in college. She knows that they come in many different sizes, shapes and colors, and that the ubiquitous, but non-native, honey bee is just one variety. She knows they can nest in holes in the ground, or in agave stalks or even wooden beams, and that most of them won't sting. My eight year old can understand that when bees visit flowers, they are performing an essential service to plants, transferring the pollen they need to reproduce. He knows who to thank for his favorite fruits.

For me, I see a bigger picture: bees are essential workers in maintaining the biodiversity and overall health of our natural and agricultural ecosystems. Watching and learning about bees has helped all of us feel more connected to nature and less fearful of even its stingy parts. For me, I also know that this new knowledge will help us protect biodiversity into the future. This is the vision of the Tucson Bee Collaborative: connecting people to nature and to each other through bees.

At its core, the Tucson Bee Collaborative is a partnership among scientists, students, teachers, artists, and a diversity of volunteers, to better understand our regional bee diversity, and through that process, to offer opportunities to connect with nature in meaningful ways. Bees are not only an important component of our biodiversity, but a group both widely revered and feared.

Everyone has seen a honey bee, a domesticated species now found on all continents except Antarctica, but few have taken time to look for our incredible diversity of wild bees. In fact, there are more species of bees in the Sonoran Desert than just about anywhere else in the world. Most Tucsonans would be hard pressed to name even one of the hundreds of native bee species found here. They include the tiny *Perdita minima,* which is less than 0.08 inches (2 mm), to the large carpenter bees (genus *Xylocopa),* gentle giants that can have body lengths of almost 1.5 inches (40 mm). Some sport the classic black and yellow, but others are shades of grey, black, brown, or even metallic green, with textures from fuzzy to shiny.





Above, left to right: Bees sleeping in a flower; Volunteer scientists, Olga and Buzz; Bee emerging from nest. Right photo: *Agapostemon spp.*

We live in one of the richest places in the world in terms of number of bee species, yet our bees are poorly known and certainly underappreciated. This might seem to be a sorry state of affairs, but from another perspective, this lack of knowledge presents an exciting opportunity to engage the community in the process of documenting and describing the exceptional bee diversity of our city. And that is something the Tucson Bee Collaborative aims to do.

At the Desert Museum work starts with systematically collecting bees, work that is carried out by a team of indefatigable Desert Museum volunteers. We have established three long-term monitoring sites, which we sample with pan traps: small blue, white, and yellow cups attractive to bees. Our first traps were set in February 2019, and since then we've been setting traps in each site, every two weeks, never missing a sample, a testament to the dedication of these volunteers. The result is a total of nearly 12,000 bees!

But we are just getting started. We plan to monitor the bee populations in these sites for many years, perhaps even decades to come. Long-term data is critical to understanding the health of bee populations, which can fluctuate wildly among years. In many ways, native bees are like the seeds of our annual wildflowers. They can lie in a state of dormancy in the soil for many years, waiting for a signal that the flowers they depend upon for food will be in bloom. Their survival depends upon emerging from their underground nests only when conditions are just right.

For example, in just two years of sampling, we have observed dramatic differences in the abundance and diversity of bees in our three long-term monitoring sites. In 2020 Tucson experienced its hottest and second driest summer on record. As you might expect, we found fewer bees in the summer and fall of 2020 than in the same time period in 2019.

This quantitative, long-term monitoring program is critical to understanding bee populations in the Tucson Basin. But this isn't the only data we are using to document the diversity of bees in our region. We are inviting everyone to contribute by sharing their bee observations on iNaturalist (https://www.inaturalist.org/projects/tucson-bee-collaborative?tab=about), a social media platform for sharing observations of not just bees, but all species big enough to photograph. Already the public, perhaps even one of you reading this article, have contributed more than 8,000 observations of bees and

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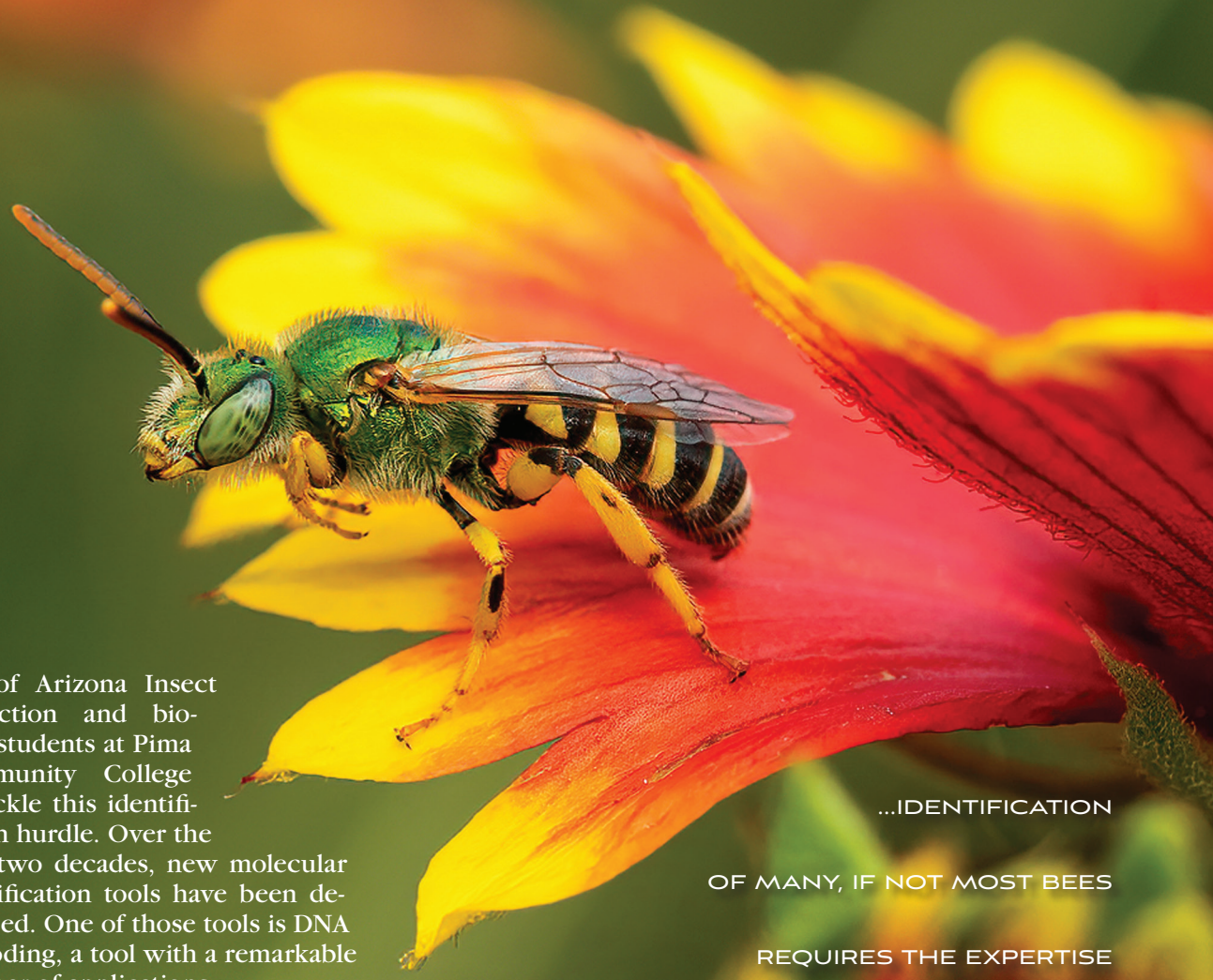

the insects associated with them. Participating not only provides people with opportunities to connect with nature, another aim of the Tucson Bee Collaborative, but helps us understand to diversity of bees throughout the region.

One of the most significant hurdles to long-term monitoring projects is accurate species identification. Collecting a single bee from a pan trap (or a flower) might take you a matter of seconds. Determining which species you collected might take days, or even weeks of careful study. That is to say, bees are not easy to identify! In fact, identification of many, if not most bees requires the expertise and experience of a scientist who has dedicated years to studying bees. Only a handful of such scientists exist.

The Tucson Bee Collaborative grew out of a collaboration between scientists at the University of Arizona Insect Collection and biotech students at Pima Community College to tackle this identification hurdle. Over the past two decades, new molecular identification tools have been developed. One of those tools is DNA barcoding, a tool with a remarkable number of applications.

DNA barcoding is a system of species identification that relies on sequencing a short stretch of DNA. For animals, that sequence is the cytochrome oxidase 1 gene (CO1). In most cases, this sequence will be identical in individuals of the same species, and differ in individuals of different species. It's like the system of product identi

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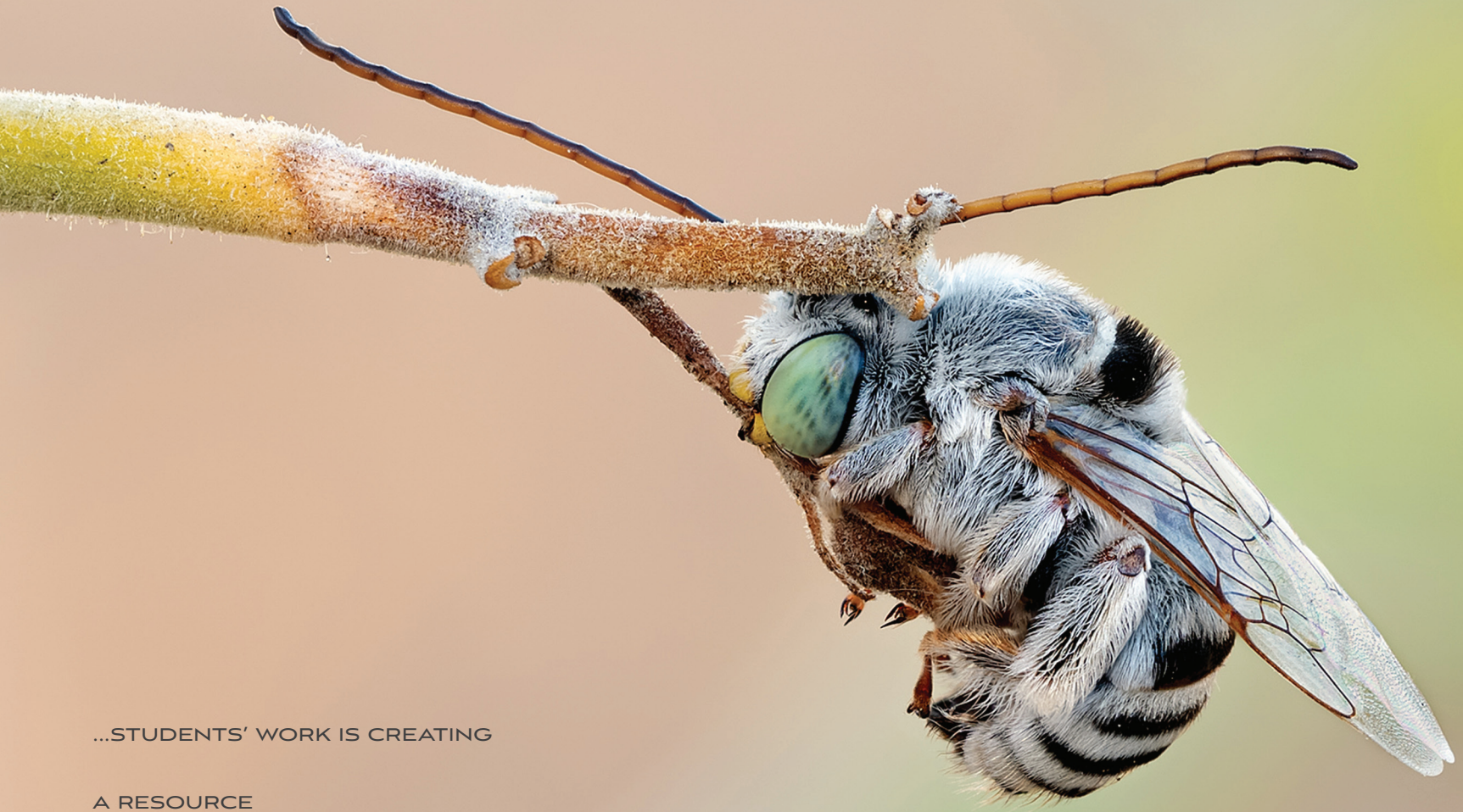

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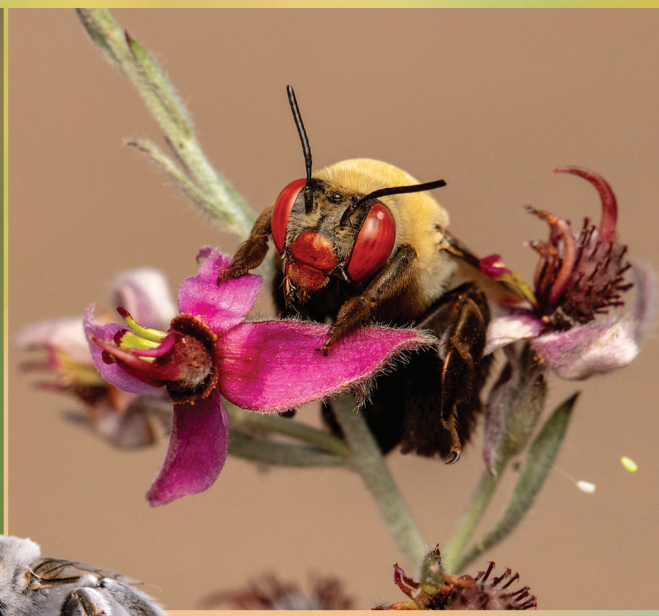


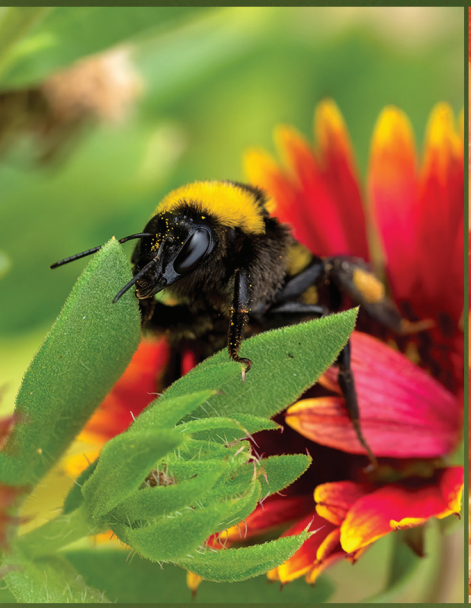
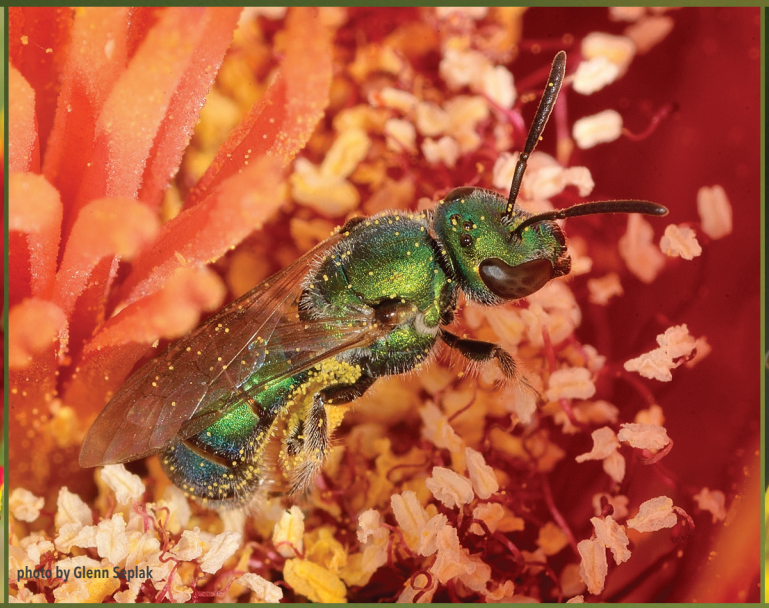
Left photo:Longhorn bee sleeping on stem; Above, left to right: Mother bee returning to nest with pollen; Bumble bee; Oil-foraging *Centris* bee on *Krameria* bush.

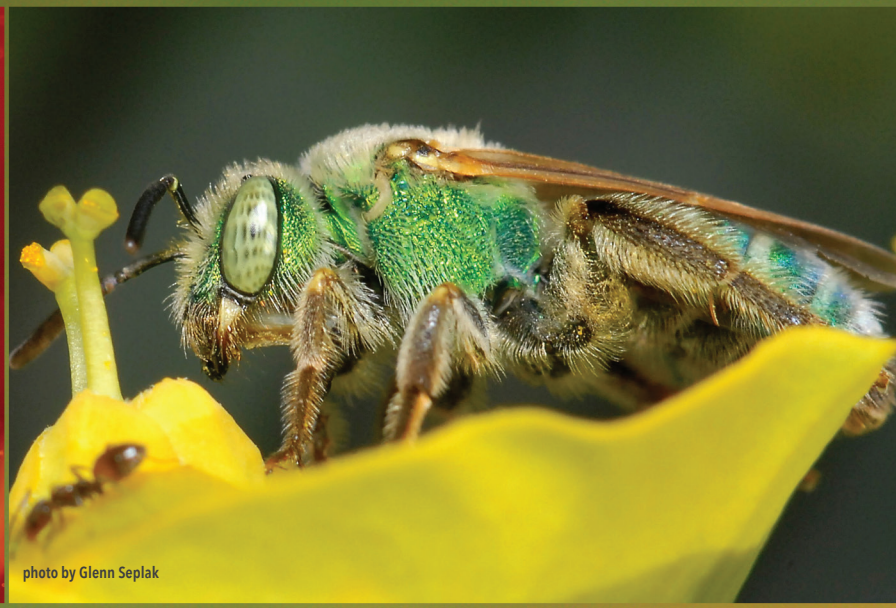
fication found in any supermarket. Just as we can scan the barcode of an item on the shelf to identify the product, we can scan the sequence of the CO1 gene from an unidentified specimen to identify the bee.

The Tucson Bee Collaborative works with students at Pima Community College, under the supervision of Jennifer Katcher, faculty member in the Division of Sciences, to prepare DNA samples for barcoding. Students obtain a bee leg and extract its DNA. Then the CO1 gene is copied many times using a technique called polymerase chain reaction. This produces a sample large enough to measure, which is then sent to a facility for DNA sequencing. Students compare their bee's DNA sequence to other sequences in the international Barcode of Life Database. Sometimes students find a match and are able to identify the bee species. Often there is no matching DNA sequence because nobody has studied the DNA of their particular bee. That means that the student is able to contribute the first sequence of that bee in the database. The students' work is creating a resource for scientists to identify and understand the diversity of bees now and into the future. With guidance from Dr. Wendy Moore, Director of the University of Arizona Insect Collection, Pima College students have published 78 bee DNA sequences, or "barcodes," including 28 DNA sequences that were new to science!

After DNA extraction, the bee specimen goes to the UArizona Insect Collection to be part of the largest known collection of Sonoran Desert bees. Natural history collections such as this one are an archive of species diversity across space and time, and can be studied to assess the impact of environmental change on biodiversity. For example, using nearly one million records of bees and other pollinators from natural history museums, researchers uncovered significant declines in bees in Britain and the Netherlands since the 1980s. Each specimen, and its associated data, also has value individually, providing a snapshot of a particular species at a particular time and location. Moreover, new technology is allowing us to unlock new information from historical specimens, for example, enabling us to sequence the DNA of specimens hundreds to even thousands of years old.

By collecting photographs and bee specimens in the field, and extracting and reading their DNA barcodes in the lab, the Tucson Bee Collaborative helps to connect people to nature and to each other through bees. Bees may be small, but they are among the easiest wild animals to observe up close. You'll find them almost anywhere you find flowers. We in



Above, left to right: Bumble bee; *Centris,* male; *Centris,* female; Right photo: *Diadasia rinconis* in a cactus flower.

vite you to participate this spring, by submitting a photograph of a bee in your neighborhood to iNaturalist. As long as you are within the Sonoran Desert Region, your observation will become part of the Tucson Bee Collaborative iNaturalist project. Your observation will help us better understand the diversity of bees.

Biophilia, The Love of Nature

Watching my kids and other young students in nature bears out what the health sciences are confirming: nature is good for us. In the 1980s famed biologist E.O. Wilson was exploring human relationships to nature and the concept of "biophilia," a term first used by the philosopher Erich Fromm to describe an attraction to living things. Wilson further developed this concept, proposing that humans have an innate desire to connect with nature as well as an innate propensity to learn about nature.

Attraction to (biophilia) and fear of (biophobia) living things are both fundamental connections to nature that likely stem from the thousands of years of evolution through which humans struggled to survive. Survival required rapid learning about both resources and threats.

At the time that Wilson was exploring the concept of biophilia, there was little research on how connection to nature impacts human health, but in recent decades the literature on this topic has exploded. Evidence that connection to nature is an essential piece of our well-being is growing rapidly. More and more studies are showing that even short bouts of nature, such as gazing up at a tree for a few minutes, benefits our physical (e.g. lowers blood pressure), emotional (e.g. relieves depression) and mental (e.g. improves cognitive function) health in many ways. (See "The Nature Spa", this issue)

As you get out to get your nature fix, I hope this peek into the world of bees has helped to increase appreciation and reduce fear of these essential buzzy bodies. They help maintain the magnificent biodiversity of our urban and wild landscapes, as well as our food supply. If you'd like to get involved or simply learn more, check out the Tucson Bee Collaborative at www.tucsonbeecollaborative.com.

Kim Franklin is the Science Program Manager at the Arizona-Sonora Desert Museum

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