The questions that kids ask about science aren’t always easy to answer. Sometimes, their little brains can lead to big places that adults forget to explore. That is what inspired our series Science Question From A Toddler, which uses kids’ curiosity as a jumping-off point to investigate the scientific wonders that adults don’t even think to ask about. The answers are for adults, but they wouldn’t be possible without the wonder that only a child can bring.

Q: What weighs more: all of the people or all of the bugs? — Carson S., age 4

This answer is maybe best illustrated by two unrelated studies whose authors probably never guessed they’d be used together. In 2012, scientists estimated the global human biomass (i.e., how much we all weigh) at 287 million metric tons.2 Five years later, a different group of scientists set out to estimate how much the world’s spiders were eating. They came up with a horrifying (if somewhat inexact) estimate of 400 million to 800 million metric tons’ worth of prey each year. In other words, just the subset of bugs eaten by spiders last year probably outweighs all the humans on Earth. Even if the humans are, generally speaking, a touch better off in the end.

So all of the bugs definitely weigh more than all of the humans. But as you hug your knees and gently rock, trying not to touch any of the filthy, bug-covered surfaces that surround you at all times, you should know that this apparent win for bugkind masks some serious problems for the bugs and, as a result, for us. Turns out, there are fewer bugs than there used to be — both in total weight and in terms of species diversity. And we humans are to blame.

But first, let’s back up a minute and talk a bit about why it’s possible for bugs to outweigh humans. The sheer number of bugs in the world is a little difficult to fathom. “There’s an estimated 10 quintillion insects on the globe,” said Julie Peterson, professor of entomology at the University of Nebraska-Lincoln. “That’s 10 with 18 zeros after it, and that’s not counting other arthropods like spiders and mites.” Insects — along with ticks, centipedes, spiders and all the other land-dwelling creepy-crawlies that we colloquially call “bugs” — probably represent as much as 80 percent of the species on this planet. In contrast, humans are a single species, made up of (as of this writing) 7,386,922,190 individuals.

To make those enormous numbers easier to grasp, let’s turn to an anecdote: Elizabeth Borer, a biology professor at the University of Minnesota, told me about a 1982 study in which an entomologist named Terry Erwin went to Panama and started taking samples of the beetles he found in one type of local tree. To do this, researchers fog a tree with pesticide the way an exterminator might fog a house, and then they count and categorize the unfortunate bugs that fall out. Erwin found more than 955 species of beetles in just 19 trees. Not 955 individual beetles. Species. Based on what he knew about the prevalence of this type of tree in the Panamanian forest and the prevalence of beetles compared to other kinds of insects, Erwin came up with a back-of-the-envelope calculation that every hectare of Panamanian forest could be home to as many as 41,000 species of insects — millions, maybe hundreds of millions, of individuals living in an area not much larger than a couple of soccer fields.3

And this is why bugs, as a whole, beat humans in a pound-for-pound weigh-off. Individual bugs may be small — the largest species, such as New Zealand’s grasshopper-like giant weta, top out around 70 grams, Peterson said — that’s about the size of a jumbo chicken egg. But even if you take what Peterson thinks is likely an underestimate of the average bug size — 0.05 milligrams, say — it still adds up by the time you multiply it by 10,000,000,000,000,000,000. This is a numbers game, and the bugs are very much ahead.

Granted, all of these numbers come from extrapolation and estimation. Scientists frequently do studies like Erwin’s, going to a region and taking samples that tell them how many bugs live in a tree, or on one square meter of

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Newly Developed Insecticide And Fungus Combination Could More Effectively Control, Eliminate Termites

A new Purdue University-developed technology concept could provide pest control companies with a more effective way to control termites and prevent associated damage. The technology works by targeting the termite’s resistance genes that help the insect fight off a known fungus that can effectively eliminate termites.

“Termites damage approximately 600,000 homes in the U.S. each year,” said Michael Scharf, an associate professor and the O.W. Rollins/Orkin Chair in Purdue’s Department of Entomology, who developed the technology. “Understanding the small, wood-destroying insect’s biology and behavior can lead to more effective methods that are specifically targeted at termites to control infestation, prevent damage and potentially decrease the insects’ spread.”

Scharf said non-specific chemical insecticides are sometimes ineffective, or not preferred by some homeowners, and a method to target the termite’s genes to dismantle their defense mechanisms against fungus is needed.

“Termites have all these microbes living in their gut, like humans do. These microbes are able to help fight off a known pathogenic fungus that can infect termites and eliminate them,” Scharf said. “Some insecticides and drugs can kill some of the microbes that provide termites with resistance to pathogenic fungus, making termites more vulnerable to fungal pathogens. However, a more effective method is needed to target the termites.”

Scharf said the core of the technology is being able to target the termite’s resistance genes and make the termites susceptible to the fungus.

“If you try insecticide or fungus by itself, in really low doses, nothing happens,” he said. “Although the insecticide has been in use for a long time, it has never been used in combination with the fungus. Through testing we found that once you combine the two together, all the termites were eliminated.”

Scharf said the technology is ready for a company to further test and develop the approach.

“We hope to determine other methods to silence the termite’s genes that give resistance to the fungus; this could be with RNA interference, drugs or antibiotics,” he said. “Doing this will make the fungus more effective without using the insecticide.”

– Source: Phys.Org
Continued from Page 1 – Bugs Could Squish Us All

ground. Take enough samples like that, and you start to get an idea of what’s normal for a particular kind of ecosystem. Then it’s just a matter of figuring out how much of that ecosystem covers the Earth and doing the math, Peterson said.

The estimates also assume that there are a lot of insect species we don’t yet know about. One million species of insects have been named and documented, their type specimens sealed in jars or illustrated in books. There may be more than 4 million species yet to be catalogued.

And if all of that isn’t blowing your mind, consider what those quintillion bugs mean to the world. For starters, they’re an important part of the food chain — bird health, in particular, depends on bug health. Bugs are also pollinators, and that’s not just bees. Wasps, ants, flies and beetles all get in on that hot plant reproductive system action. And while not all the food we eat relies on pollinators, some of the really good stuff — almonds, avocados, many fruits and nuts, and the alfalfa that feeds our meat animals — does. Then there’s the role bugs play in decomposition. Dung beetles save the U.S. cattle industry $380 million every year by breaking cow poop down into dirt, a service that also helps to put nitrogen — an important source of plant food — back into the soil.

Bugs matter, and if scientists know how many bugs are in a square meter or what those bugs weigh, they can get an idea of how capable the existing bug population is of doing all the jobs bugs do. This is what scientists mean when they talk about “biomass.” If you know how much material a single dung beetle is responsible for decomposing, then knowing how many dung beetles there are helps you understand how much can be decomposed. If you know how many pounds of bugs a single bird eats, then you know how many birds can live off the bugs in a Panamanian tree. And the answers to those questions are pretty important, because they tell you practical facts — like whether birds can survive in a given habitat, or whether the poop is going to start piling up on your farm.

That means biomass is both a measure of the health of an insect community and of nature as a whole. And this is where the wacky science of weighing bugs starts to overlap with the existentially stressful science of watching helplessly as ecosystems collapse. Invertebrates, a group that includes insects, are poorly studied by conservation biologists, at least in comparison to their numbers, and the health of their communities can vary a lot by location and species. But the research that does exist suggests that insects aren’t doing well. For instance, the International Union for the Conservation of Nature (the group whose research plays a big role in determining which species we consider endangered) tracks only 3,623 species of terrestrial invertebrates — bugs, basically, plus worms and some mollusks. But of those, 42 percent are threatened with extinction. “We’re probably losing species faster than we can give them names,” Peterson said.

And you can see this in specific groups of species, as well. A 2015 study took advantage of a long history of records documenting populations of moths and butterflies in a protected grassland in Germany. It found declines in the number of species recorded, from a high of 123 in the 1870s to 71 by the early 2010s. What’s more, habitat-specific species were more likely to have been lost. In the 1870s, 50 percent of the moth and butterfly species were generalists: animals that can happily live in many places. By the 2010s, 68 percent were generalists. The species that were particular to those German grasslands faded faster. Peterson said that this pattern is reflected in many other places. Resilient generalists survive, while the species that can’t adapt as easily flounder. And that’s bad for people, because the most resilient generalists are the species we consider pests — cockroaches, say, or mosquitoes. “As we lose insect diversity, we’re seeing an increase in pest species,” she said.

We’re losing pollinators. We’re losing the food other animals eat. We’re losing the bugs that bury poop and dead things and help return waste to the soil.

And the culprit, inconveniently, is us. The biggest threat to insect species is habitat loss caused by agriculture, logging and infrastructure development. And that makes stopping the loss of insects difficult, Peterson told me. Often the people who need the bugs the most — for example, the Nebraska farmers who rely on burying beetles to serve as undertakers for the dead frogs and mice that help make their farmland fertile — are also the people whose livelihoods depend on destroying those bugs’ habitat. This beetle was native to the prairie, Peterson said. There’s not much prairie left and, consequently, not many beetles. But the beetles helped make the rich prairie soil, which made their habitat a great place to convert into the farmland that wrecked the beetles’ own homes. If they die off, that’s not good for farmers. But farmers also can’t just stop farming, because a prairie can’t feed humans.

There are no easy answers. In Nebraska, Peterson said, the Environmental Protection Agency now requires farmers who want to use insecticides to first make sure that there aren’t burying beetles on their land. If they find these helpful bugs, farmers have to use a more expensive insecticide that can kill pests while protecting the beetles. Peterson sees this as a trade-off: Spend a little more money now on insecticide so you don’t have to spend as much on fertilizer later. But the world is full of millions of conflicts like this — as many as there are species of insects, probably. There’s almost no way to make everybody, insects and humans, happy. The bugs might weigh more than us — for now — but we might not really feel that weight until it’s gone.

Maggie Koerth-Baker is a senior science writer for FiveThirtyEight.
Driving Personal Vehicles for Business Purposes

There are many situations in which a technician or office employee may drive their personal vehicle to perform a business related task or activity: a technician may use their own vehicle to service clients, an employee might use their own auto to pick up the mail, visit the bank or run errands for the office, or you may rent a car while on a business trip. It is important to consider the risk you assume in these everyday occurrences.

Driving a personal auto in lieu of a company owned vehicle may seem to minimize an employer’s liability, but companies can be held liable for damages in the event of an accident. If it is found that the individual was driving for business, action can be taken against the employer.

Your business can be held accountable and sued based on an employee’s use of a personal vehicle. Generally, the basic automobile policy only covers employees while operating a company owned vehicle for business. When an employee drives their own car for work, there are several actions you can take as an employer to mitigate the risk.

**Purchase Hired and Non-Owned Coverage**

Any pest control company that allows or requires its technicians to use their personal vehicles for business should either purchase non-owned and hired insurance coverage or add it to an existing automobile policy.

Hired coverage protects the company against liability from bodily injury and property damage caused by a vehicle you hire, including rented or borrowed vehicles, whereas non-owned coverage protects the company against liability caused by non-owned vehicles, including those owned by technicians and used for work-related travel.

In the event of an accident, this coverage supplements the technician’s personal auto policy, which is typically triggered first. This coverage provides vital protection to the company if your business is found legally liable as a result of an accident and mitigates your exposure if the employee’s personal policy has lapsed.

**Use a Company Policy to Reduce Risk**

In addition to purchasing hired and non-owned coverage, instituting a company policy that proactively manages this risk is paramount. The policy should clearly state when the use of a personal vehicle is allowed, and identify all job descriptions where the use of a personal vehicle could be used. As a condition to employment, and at least on an annual basis, employees driving personal vehicles should be required to provide:

- Proof of a driver’s license
- Motor vehicle safety inspection certificates
- Copy of insurance certificates proving personal automobile liability coverage at or above an established company limit, including personal injury and medical limits

**Enforce the Policy**

After establishing the policy for the hired and non-owned exposure, it should be communicated and actively enforced. Pest control managers should be directed to monitor the safety and maintenance of any personal vehicles that are being utilized for business. If an employee is found out of compliance with the company policy, immediate action should be taken to correct the infraction, including the reassignment of duties until the situation is corrected. Mitigating risk is important to your business, hired and non owned auto exposure is often overlooked and could pose a significant financial exposure to your business if not managed correctly.

Contact your insurance broker for help assessing your company’s risk regarding the use of personal vehicles, or to learn more about hired and non-owned coverage.

By Gary Shapiro, Senior Vice President, Weisburger Insurance Brokerage
Will Climate Change Help Ticks And Mosquitoes Spread Disease?

by Michaeleen Doucleff

Most creepy, crawly bugs are pretty much harmless when it comes to infectious diseases.

But there are two classes of little critters that cause big — and we’re talking big — problems: ticks and mosquitoes.

To learn how climate change could alter the course of tick- and mosquito-borne diseases, we talked to two scientists who have devoted a major chunk of their careers to answering that question.

Let’s start with the bloodsuckers that can stay on your skin for days.

Ticks

Cocktail party chatter: These little guys aren’t insects. They’re arachnids. That’s the same class of animals as spiders.

What they cause: Ticks are best known for transmitting Lyme disease. But these arachnids carry more than a dozen diseases in the U.S., including spotted fevers, a malaria-like disease and several rare but deadly viruses, such as Heartland virus and Powassan.

How climate change will affect the spread of these diseases:

Lyme disease is rapidly expanding in the U.S. In the past 30 years, the number of cases has more than tripled. The disease — and the ticks that transmit it — have spread northward all the way to Maine in New England and Minnesota in the Midwest.

Part of the reason? A warming climate, says Rick Ostfeld, an ecologist at the Cary Institute of Ecosystem Studies in Millbrook, N.Y. “We know that climate change has contributed to Lyme disease spreading northward and to higher elevations.”

Here’s why.

Ticks need to feed on the blood of three animals over the course of two years to complete their life cycle, Ostfeld says. That meal could be a mouse, a chipmunk, a human — just something with nice, warm blood.

Ticks can look for this yummy meal only when the weather is warmer — the cold-blooded insects can’t move when temperatures drop near freezing.

“If they don’t have a long enough season to find a host, they’ll use up their reserves and drop dead,” Ostfeld says.

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A few decades ago, many places in the U.S. just didn't have a long enough summer to keep the ticks healthy. And tick-borne diseases weren't a problem in northern states.

But with spring coming earlier in many places, ticks end up having more time to look for their food. So they're surviving in more places.

States in the northern U.S., such as Maine and Vermont, used to be inhospitable to ticks. Now they have huge outbreaks of Lyme disease each summer.

And these earlier springs mean ticks are out on the prowl earlier. Ticks typically become a big problem in mid-May. But Ostfeld and his colleagues have found warmer springs have bumped up the peak feeding time a few weeks, to early May or even late April.

**Bottom line:** Climate change is likely to make Lyme disease more common in the U.S. The ticks are creeping northward and starting to bite people earlier in the year.

Now there is one big caveat to this. Ticks don't like dry weather, Ostfeld says. So if climate change brings drier springs, we might actually see a decline in tick activity in some places.

**Mosquitoes**

**Cocktail party chatter:** Known as Mosquitoes in Australia and New Zealand, mosquitoes don't actually “bite” people. Instead they “saw” into our skin with a set of six needles.

**What they transmit:** The list of mosquito-borne diseases is long, including chikungunya, dengue, malaria, West Nile Virus, yellow fever and Zika.

**How climate change will likely affect the spread of these diseases:** It's no secret that mosquitoes like warm weather. Just like ticks, these critters become inactive at low temperatures and stop growing because they're cold-blooded. And winters that drop below freezing can actually wipe out particular mosquito species, including the one that spreads dengue, yellow fever and Zika.

But warmer weather doesn't necessarily mean a greater chance of mosquitoes spreading more dengue, more yellow fever and more Zika, says Erin Mordecai, who studies the ecology of infectious diseases at Stanford University.

In fact, hotter weather could mean fewer cases of mosquito-borne diseases in some places.

Here's why.

When a mosquito bites a person with a virus or parasite, the insect swallows the pathogen. Eventually, the mosquito can pass that pathogen onto another person. But not right away.

"That pathogen has to basically go through an incubation period within the mosquito — anywhere from a couple of days to over a week," Mordecai says.

The amount of time depends on the temperature outside. The warmer weather, the faster the pathogen will be ready to infect another person.

But there's a major obstacle for pathogen: Mosquitoes don't live very long, only about a few weeks to a month.

The mosquito's lifespan also depends on the outside temperature — but in the opposite direction. The warmer the weather, the shorter the mosquito's life.

So in a way, it's a race between maturation of the pathogen and the mosquito's lifespan.

At cooler temperatures, the pathogen will take too long to mature. The mosquito will be dead before it has a chance to infect another person. At high temperatures, the pathogen will mature quickly but the mosquito will also die quickly.

But in places where the temperature is currently just slightly too cool for transmission of mosquito-borne diseases, warmer summers could spell trouble for mosquito-borne diseases.

"That's why we're worried about climate change in temperate zones," Mordecai says. "Warmer temperatures will speed up the parasite's development rate and just make the region more suitable for transmission of diseases."

So in the southern U.S., for example, the transmission season might expand from just summer into spring and fall. "Or in a place like Miami, that already has warm temperatures, transmission could occur year-round," she says.

**Bottom line:** The jury is still out on how climate change will alter mosquito-borne diseases. The final outcome will likely depend on the place, the disease and the specific mosquito that carries them. But here in the U.S., warmer springs and summers are likely to make transmission worse in the south and possibly cause diseases to creep northward.

— Reprinted from NPR’s Goats and Sodas

**Why We Can't Seem To Get Rid Of Cockroaches**

*By Lisa-ann Lee – New Atlas Website*

They’ve been around for the past 300 million years, outlasting the dinosaurs and teaming up with evolution to outsmart our attempts to get rid of them. Now, Japanese researchers at Hokkaido University have revealed yet another reason why we have been unable to put a dent in their populations: femalesolidarity.

Cockroaches, along with termites, snakes and sharks, have long been known to be capable of “virgin birth” or parthenogenesis, a form of asexual reproduction that occurs without fertilization. What is less known are the factors that trigger this process. Is the absence of male cockroaches the only condition necessary for asexual reproduction to take place or does the social environment play a part too? Given that cockroaches are social creatures that live in groups, the Hokkaido University researchers believed that there had to be factors other than male-absent conditions. To test their hypothesis, the researchers conducted 11 sets of experiments with different groups of American cockroaches, a common pest. The control group comprised a male and female that were allowed to mate. Others comprised virgin females that were kept in isolation; in groups of
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up to five; and with castrated males. In addition, the researchers also added female sex pheromones – which are secreted in greater quantities by virgin females than those that have already mated – to containers housing single roaches to see if they would regard it as a male-absent signal and produce more eggs as a result.

What they found was that group-housed females, especially those with three or more insects, produced egg cases faster than any other group. In addition, the egg cases were produced in a synchronized manner. Bizarrely enough, this behavior was shared even by those kept in different containers. Furthermore, the group-housed females also produced their second batch of egg cases at shorter intervals than those kept alone (an average of 18 versus 27 days).

On the other hand, the presence of the castrated males and female sex pheromones did little to boost the production process. The researchers had included the former to find out what effect (if any) cohabitants of a different sex would have on the egg-laying process and discovered that it took the female cockroaches that were grouped with the castrated males almost the same amount of time to produce egg cases as the isolated specimens, thus suggesting that the promotion of asexual production depends on the females being able to discern the cohabitants’ sex.

There was also a difference in the viability of the eggs. Only 30 percent of those laid asexually hatched, compared to around 47 percent of the ones produced by sexual reproduction. This could explain why the egg production process ramps up when virgin female cockroaches are grouped together, say the researchers. Synchronizing egg production in grouped females might result in their offspring hatching at around the same time. The nymphs would be able to increase their fitness by aggregation and the sharing of resources, which could counter the lower hatching rate of the asexually produced eggs.

According to the scientists, the female solidarity exhibited in this experiment is consistent with other observations of roach behavior. Rarely do fights ever break out among unmated females that are housed in the same container. Instead, they are often found huddling close together, whereas unmated males paired together will often fight until the antennae of both individuals are amputated.

Males? We don’t need no stinking males

That said, while the hatchability rate of asexually produced eggs is generally lower than those laid via conventional means, the roaches that hatch from these eggs are nevertheless still able to form and maintain a colony for at least three generations without a male’s input, as evidenced by the colony that formed when the researchers placed 15 random adult females in a container. Just over three years later, it had grown to comprise more than 300 females produced by fifteen females in a larger container have maintained a colony for more than three years, whereas those produced by one female die out fairly quickly. In addition to the increased fecundity of group-housed females, the synchronized egg production could also assure higher survival rates via the aggregation of similarly aged larvae.”

While this may be an impressive feat of female solidarity in the insect world, it does not bode well for human societies. Given that female American cockroaches already have several advantages over males that allow them to adapt to new habitats – for a start, they have longer lifespans and their larger body size protects them from environmental changes – their ability to reproduce asexually and maintain colonies for several generations makes them a health threat to be reckoned with, given the way they transfer disease. Hence the importance of understanding how they reproduce so that more effective cockroach traps can be built, say the researchers.

“The traps utilizing sex pheromones to attract only male cockroaches are not sufficient,” says Nishino. “Understanding the physiological mechanism behind the reproductive strategies should help us find more effective ways to exterminate pest cockroaches in the future.”

The study was published in the Zoological Letters. Source: Hokkaido University