BUGS AND THE FUTURE OF MEAT

By XiaoZhi Lim

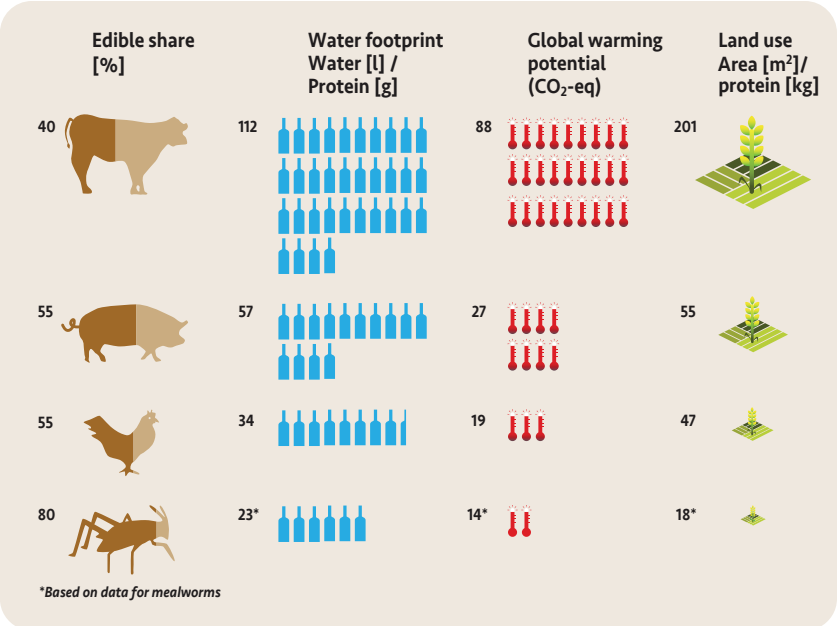
Raising insects for food is a growing business. Could they one day replace beef, chicken, and pork on plates everywhere?

SHUTTERSTOCK

Robert Downey Jr. wants you to eat insects. He said as much in early 2021 during a virtual appearance on "The Late Show with Stephen Colbert." The Iron Man actor is such a big fan that the investment company he started pledged more than $220 million in funding for a French mealworm product company called Ynsect.

But Downey isn't in it for the money. He says that eating bugs, or entomophagy, might just be the alternative to beef, pork, chicken, and seafood that we need to help protect the environment.

His enthusiasm is based on an idea that has the attention of several researchers, conservationists, and international agencies, including the Food and Agriculture Organization (FAO) of the United Nations. And yes, money talks, too. Market researchers expect the global edible bug market to grow nearly 30% over the next five years, reaching $3 billion by 2027.



RS GRAPHX, INC./ SOURCE: U.N. FAO, 2021

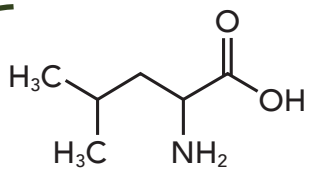
Compared to cattle, pig, and chicken farming, raising insects requires less water, produces fewer greenhouse gas emissions, and uses less land. (CO_2-equivalent, or CO_2-eq, is a unit of measurement for the global warming potential of various greenhouse gases.)

WHAT'S SO GREAT ABOUT PROTEIN?

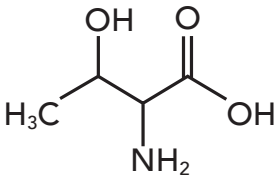
Proteins are probably best known for their role in building muscle. But they play critical roles virtually everywhere in our bodies, from our skin to our brains. They spur important reactions in the body, provide structure, and ferry other molecules to their destinations.

Our bodies make proteins from organic compounds called amino acids. Amino acids contain two functional groups—an amino group ($-NH_2$) and a carboxyl group (-COOH)—and a unique side group. Of the 20 amino acids we need to stay healthy, our bodies can produce 11. To get the other nine essential amino acids, as they're called, we need help from our diets. Meats, including beef, fish, and poultry, supply us with all nine essential amino acids. We can also get them from nuts, legumes, grains, and vegetables, but you have to mix and match these sources to get all nine.

Single food choices, such as individual meats, that give us all nine essential amino acids are called complete proteins. Many insects also fall into this category.



Leucine



Threonine

Essential amino acids are those that our bodies need but can't make. Leucine and threonine are two of the nine essential amino acids—note the amino ($-NH_2$) and carboxyl (-COOH) groups. Our bodies can produce the other 11 amino acids.

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So, what's all the buzz about? The gist of it is this: Raising land animals that give us much of our protein contributes significantly to greenhouse gas emissions that drive climate change. Plant-based foods, such as nuts, legumes, grains, and vegetables, also contain protein and have a much lower environmental footprint than meat, but they might not satisfy everyone's tastes.

Insect farming could be a more sustainable solution to help meet the world's growing nutritional needs.

"There are huge environmental benefits," says Arnold van Huis, a tropical entomologist at Wageningen University in the Netherlands and the first author on the FAO's seminal 2013 report on edible insects. When compared to other animal protein sources, van Huis says, farmed insects "emit less greenhouse gases, they need less land, and they need less water."

So, insects could be well-positioned to help feed the world, while having a smaller impact on the planet. And, the best part—according to proponents—they're tasty!

PUTTING BUGS ON THE MENU

Most people who have grown up in the United States, Canada, or the European Union tend to shun insects.

"We're fairly eco-phobic," says Valerie Stull, an environmental health scientist at the University of Wisconsin-Madison, describing a common Western view. "We build our houses, and we put screens on our windows, and we keep everything closed. And whenever there's like an insect in our house, we want to kill it or get rid of it."

To many Americans, Canadians, and Europeans, bugs such as roaches and fleas are a sign of uncleanliness.

But most insects don't signal dirt and disease. There are more than 1 million species of insects that have been discovered in the world—scientists think there could be as many as 10 million. About 1,900 have been documented as edible, according to FAO reports, and an estimated 2 billion people in 130 countries eat insects, from locusts in Thailand to maguey worms in Mexico.

One way to change our relationship with insects, Stull says, is to interact with beneficial insects that we view more positively. Bees for example, are well liked, as they pollinate our food and give us honey.

The next step is to re-think our ideas about what constitutes food.

"We all grew up with a certain idea of what is food and what's not, but that idea is not the same around the world," Stull says.

Stull remembers the first time she ate insects, while on a family trip to Costa Rica as a young teenager.

"We were eating at a fancy restaurant, and they served us citrus ants," Stull says. "I remember being very nervous and squeamish about trying these, but then when I actually did, I was really surprised, because they tasted like food."

We've seen such attitude changes throughout history. Lobsters, for example, were once plentiful and inexpensive, but are now pricey delicacies in a lot of places. Ironically, from a taxonomic standpoint,

lobsters are pretty much giant insects of the ocean. Crustaceans and insects are both in the arthropod phylum.

"Why do we think a lobster is good food, but a cricket is bad?" Stull says.

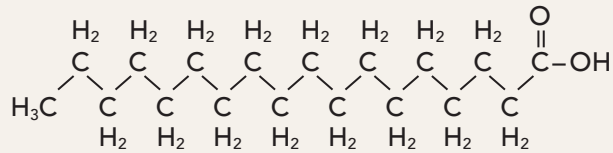
BUGS—A SUPERFOOD?

Most experts don't want to say it yet, but insects might qualify as "superfoods." There's no scientifically based definition for this term, but many people use it to refer to nutritious foods rich in compounds with potential health benefits beyond what "normal" foods offer.

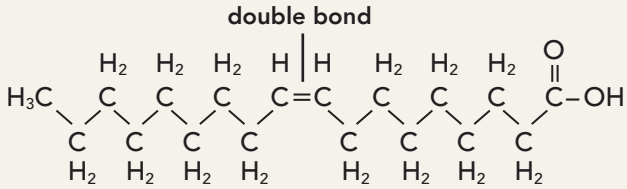
Of course, bugs are a diverse group, and the species will differ in terms of nutritional value. But overall, compared to meat from beef, insects could be a healthier protein source, because they contain more **polyunsaturated fatty acids**, says van Huis. Fatty acids are carboxylic acids (R-COOH) with long chains of 12 to 20 carbon atoms.

While we need a variety of dietary fats to absorb fat-soluble vitamins, including vitamins A and D, to build cell membranes, and to help blood clot, too much of the **saturated fats** found in red meat could harm our heart. Conversely, polyunsaturated fatty acids, such as linoleic acid found in vegetable oils and nuts, are not only considered good fats, but also essential fats—our bodies need them but cannot make them.

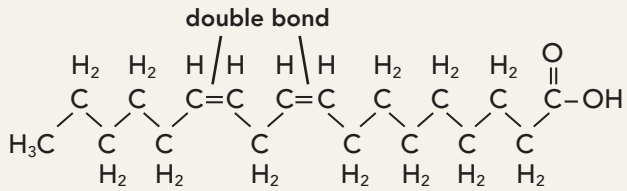
Stearic acid
$C_{18}H_{36}O_2$
A saturated fat



Oleic acid
$C_{18}H_{34}O_2$
A monounsaturated fat



Linoleic acid
$C_{18}H_{32}O_2$
A polyunsaturated fat



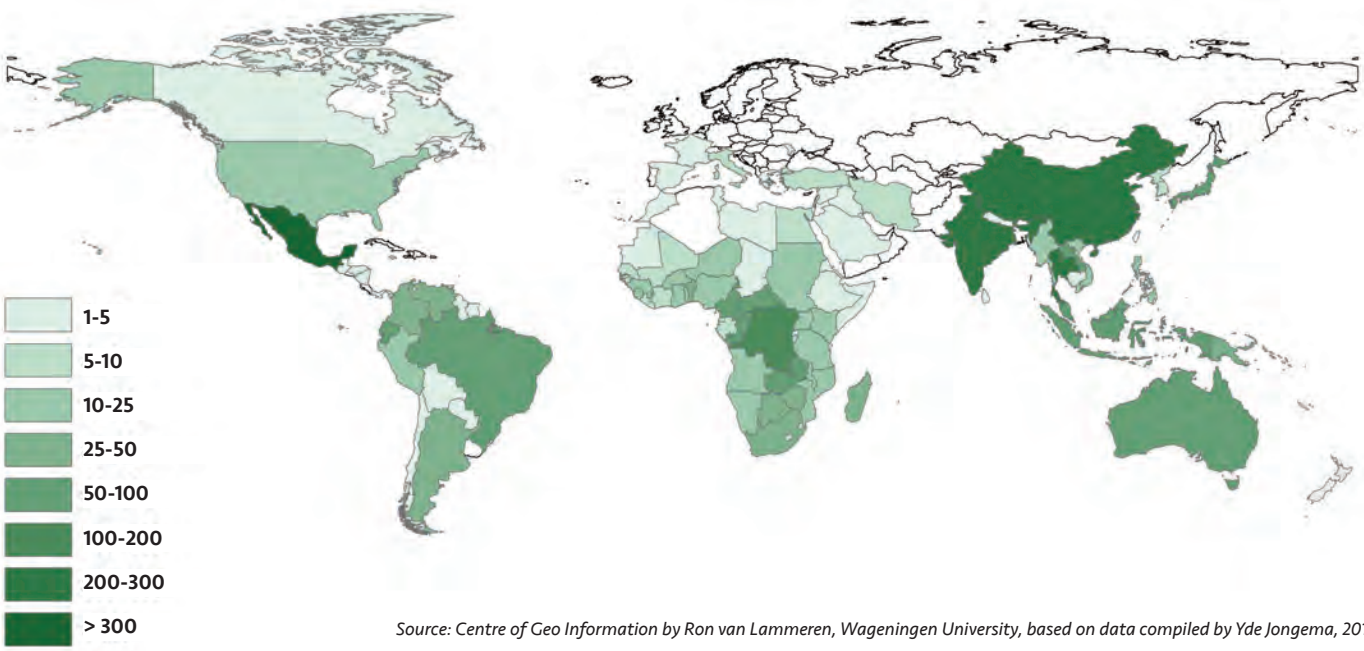
Fatty acids are carboxylic acids (R-COOH) with long carbon chains of 12 to 20 carbon atoms. A saturated fatty acid is one that is "filled" to capacity with hydrogen atoms. That is, each available carbon bond holds a hydrogen atom, and the carbon atoms are bonded to each other in the chain with single bonds. Fatty acid chains containing one (mono-) or more (poly-) double bonds between carbon atoms (C=C) are called unsaturated.

Insects are also a good source of micronutrients, including iron, zinc, calcium, and magnesium. Micronutrients are elements that occur in very small amounts in the body, but are essential to good health.

Additionally, insects in the diet could help address iron and zinc deficiencies, which are common in developing countries. In economically advanced countries, preschool children and pregnant women who need extra iron are also susceptible to iron deficiencies.

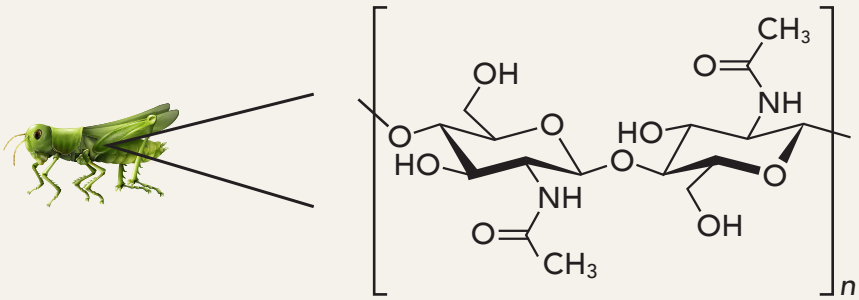
The iron content in insects is unique because

RECORDED EDIBLE INSECT SPECIES, BY COUNTRY

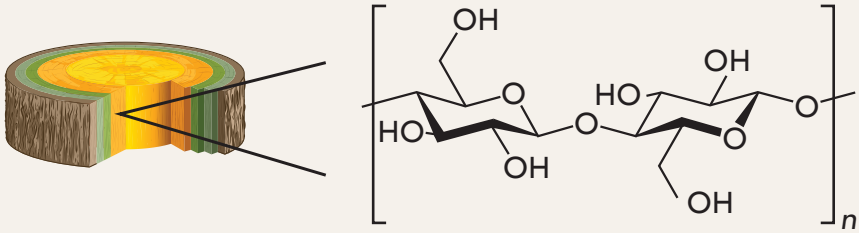


Source: Centre of Geo Information by Ron van Lammeren, Wageningen University, based on data compiled by Yde Jongema, 2017

CHITIN VS. CELLULOSE



Chitin, $(C_8H_{13}O_5N)_n$



Cellulose, $(C_6H_{10}O_5)_n$

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insects provide both heme and non-heme iron, Stull says. "Typically, heme iron is found in animal protein, while non-heme iron is found in plant protein." Heme iron is bound in hemoglobin, a red blood cell protein that supplies the muscles and other organs with oxygen. Heme iron is more easily absorbed by the human body than non-heme iron.

Another potential health benefit of insects is that they provide fiber in the form of chitin, which is found in bugs' exoskeletons. Chitin is the second most abundant natural **polymer**, after cellulose, which is a type of fiber in fruits, vegetables, and cereals. Polymers are large molecules made up of repeating chains of smaller chemical units known as **monomers**.

One possible downside of eating insects that van Huis can think of is that people might have an allergic reaction to them, particularly if they are also allergic to dust mites or to crustaceans.

Nutritious or not, a critical part of getting more people to eat bugs could depend on whether they like the taste.

If you've never tried one, you might wonder what bugs taste like. They are often described as nutty, but this doesn't do justice to their range of flavors.

Daniella Martin, also known online as "Girl Meets Bug" and the author of Edible, compared sauteed waxworms to mac and cheese in a Huffington Post article. She also wrote that filets of giant water beetles tasted like "melon soaked in banana-rose brine, with the consistency of red snapper." Scorpions draw comparisons to popcorn, shrimp, and crab.

If the idea of eating whole insects is too hard to swallow, a gateway bug would be the one Downey touted to Colbert: a powdered version that you can toss into smoothies or muffin batter.

What bug flavors do you want to discover?

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REFERENCES

Orkusz, A. Edible Insects versus Meat—Nutritional Comparison: Knowledge of Their Composition Is the Key to Good Health. *Nutrients*, April 6, 2021: https://www.mdpi.com/2072-6643/13/4/1207 htm [accessed Feb 2022].

Stull, V. and Patz, J. Research and Policy Priorities for Edible Insects. *Sustainability Science*, June 27, 2019: https://doi.org/10.1007/s11625-019-00709-5 [accessed Feb 2022].

Van Huis, A. Insect Pests as Food and Feed. *Journal of Insects as Food and Feed*, Aug 10, 2020: https://www.wageningenacademic.com/doi/pdf/10.3920/JIFF2020.x004 [accessed Feb 2022].

FROM PESTS TO FOOD

Insects can severely damage agricultural crops, causing devastating losses for farmers. Humans have been battling insect pests as far back as the ancient Sumerian civilization some 4,500 years ago. The Sumerians used elemental sulfur as a pesticide, but in the last century, synthetic pesticides have largely taken over.

There are serious side effects from using pesticides to manage insects that feed on crops—a top one being the collateral damage to other insects. Neonicotinoids, a class of pesticides that attack insects' nervous systems, were developed to control insects like the corn rootworm, which causes an estimated $1 billion in crop losses every year in the United States. But scientists are increasingly finding that neonicotinoids also hurt beneficial insects such as pollinating bees.

A win-win solution for controlling insects that damage crops might simply be to harvest and eat them. In fact, that was what happened in Thailand with the Bombay locust during the 1960s and 1970s. The locusts attacked maize crops, and at first, the Thai government responded by spraying pesticides on them. But the pesticides didn't work, so between 1978 and 1981, Thai farmers instead began harvesting the locusts. Today in Thailand, the Bombay locust is no longer a pest, but one of the most popular street food snacks, called *patanga*.

The United States has its own pest-turned-food story, though a short-lived one. Swarms of the Rocky Mountain locust used to devour everything in their wake in the Midwest in the 1870s. One swarm in Nebraska in 1874 covered approximately 198,000 square miles, an area twice the size of Colorado. The swarms subsided in the 1890s, and the locust is now extinct. But while they were still plentiful, the U.S. Department of Agriculture advocated for eating the critters to simultaneously control the pest and help starving families whose crops failed. One entomologist wrote that the locust, when "boiled and afterward stewed with a few vegetables and a little butter, pepper, salt, and vinegar, made an excellent fricassee."