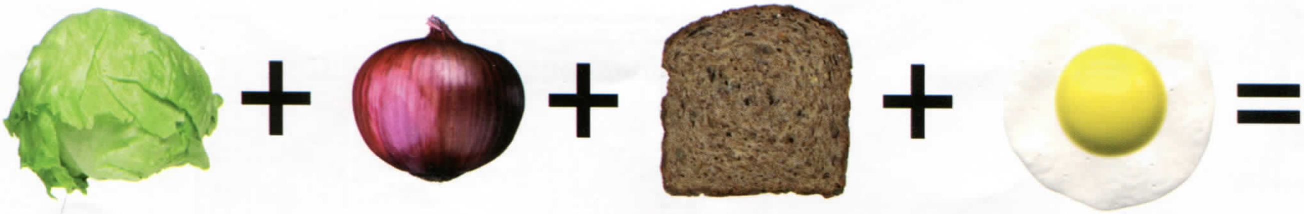
Bring them your lettuce leaves, your onion skins, your bread and eggs...



Methane-O-Matic

by Claire B.Dunn Photos by Wendy P. Osborne

In Dr. David L. Johnson's lab, they call it "garage sale science." Johnson, an environmental chemist who reigns over the space on the fourth floor of Jahn Laboratory, acknowledges that his homemade machinery – a pair of experimental anaerobic digesters – resembles contraptions that could have been sketched by Rube Goldberg, the Pulitzer Prize-winning cartoonist famous for drawing complicated mechanisms that perform simple tasks.

"It's kind of like a Rube Goldberg thing," Johnson said. "You know: Do you really need all this to heat your soup?"

Heating canned vegetable soup was, indeed, the first application of Johnson's experiments in turning food waste into methane. But if it works the way he and his research team hope, the project could contribute to sustainability, reduce carbon emissions and reduce the flow of the waste stream.

"We want to use as much food waste as we can and turn it into as much methane as possible, using the smallest, most efficient system we can devise," he said. "We want this to be able to work on whatever people usually put in their compost pile in their backyard. And it would be a little bit different for everybody because everybody eats different things."

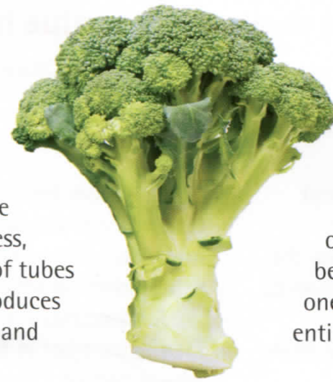
A lack of literature on the subject of making methane from food waste led Johnson to become self-educated on the subject of digester construction. The two units in his lab are cobbled together with inexpensive equipment; some pieces were donated by ESF colleagues and some were discovered at garage sales, including one 3-foot-tall plastic tube that Johnson's wife spotted along the roadside and sagely recognized as usable. The tube now serves as part of the filtering process.

The first machine, which Johnson calls a spiral plug-flow digester, is coiled like a chubby white snake on the counter in his lab. For six months, he and his team of student researchers have been stuffing it full of vegetable waste, pressing the lettuce leaves and onion skins into it with a piston that is whimsically graced by another garage sale find: a brass handle in the shape of an eagle's head that once was the handle of a stylish walking stick.

Dr. David Johnson, left, and Lindsay Perez EFB '10 prepare the digester to remove a batch of fertilizer.

Perez checks the volume of liquid removed from the digester.

Johnson cuts up food waste in preparation for feeding the digester.



As the students push the food through the spiral, it breaks down through a natural process, emitting methane that is collected in a web of tubes that run through the lab. The process also produces liquid effluent that looks like cloudy iced tea and could, with a bit of modifying, be used as greenhouse fertilizer.

"This has been here for six months, and it's working," Johnson said. "So this demonstrates that it can be done. We're trying to push it now and make it go faster."

The second digester is something Johnson calls an "intermittently stirred tank reactor." It is fed nearly every day with two liters of a concoction that looks like broccoli soup. This concoction is made mostly from vegetable waste with some bread and eggs that are run with water through a machine much like a garbage disposal. It goes into the tank, where it mixes with a series of bacteria.

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The first bacteria make the mixture soluble. The second break the material down further and produce acetic acid. The third consume the acetic acid and produce methane. The end products are the methane and the strong-smelling liquid that could be used as greenhouse fertilizer if the odor could be lessened.

"We're working in a chemistry lab here, but everything we're working with is naturally occurring," said Nate Brady, who graduated from ESF in May. He and classmate Robert Bullard used the composting work as their undergraduate research project.

The research team must maintain a delicate balance of pH, temperature and bacteria ratios within the tank because too much heat or too little nutrition can put one species of bacteria out of commission and halt the entire process.

"The one has to eat the acetic acid as fast as the other makes it or the whole thing goes south," Johnson said.

Johnson's experiments began with what he jokingly refers to as his "epiphany," brought on by his attendance last year at a conference of the National Council for Science and the Environment. The focus of the gathering was "Climate Change: Science and Solutions."

"I just got stoked," he said. "I said to myself, 'Why am I studying house dust? Who cares? I ought to be studying alternative energy and climate change.'"

So the environmental chemist, who had spent years developing analytical techniques for determining the presence of heavy metals in house dust and soil, turned his attention to the long-term issues of climate change and alternative energy.

He was intrigued with a centuries-old idea: using waste to produce methane. But he wanted to update it. Instead of the human and animal waste commonly used in such an operation, he wanted to use only food waste. And he wanted to figure out how to do it, with consistent results despite a variety of feedstocks, on a scale that would be convenient for use by restaurants, for example, or groups that operate community gardens.

The chunks of food are ground with water in a recirculating garbage disposal.

The resulting thick liquid "soup" is heated to 100 degrees Fahrenheit.

A batch of warm "soup" is added to the digester, replacing the liquid that was removed earlier.

"I said 'Why compost it when you can make methane from it?' And they saw the value in that,"

— David Johnson

Early in the process, he consulted with student members of the College's Green Campus Initiative committee and redirected food preparation waste from the on-campus Gallery snack bar from GCI's compost operation to his methane experiment.

"I said, 'Why compost it when you can make methane from it?' And they saw the value in that," he said.

The Sheraton University Conference Center also supplies food waste for the digesters and will scale up its contribution this summer, when Johnson and master's student Gary Bonomo begin to scale up the operation. They plan to use the old campus greenhouse to house a digester that could process more than 50 pounds of food waste a day, as opposed to the 2 pounds a day that were processed in the early months of the experiment.

The project has already pulled in collaborators from other ESF departments. Dr. Stewart Diemont in the Department of Environmental Resources and Forest Engineering, whose research includes natural treatment systems, has a graduate student, Hui Lin, working on the project.

Diemont is using an ecological treatment system to treat the water that flows out of the digesters. The liquid goes into a worm composter, and the worms use the organic matter to produce rich compost that can be used as plant fertilizer. Eventually, the liquid ends up in an aerobic tank where food-producing plants, such as tomatoes, can grow. From there, the liquid can go into an algal growth chamber where algae use the nitrate in the liquid as a fertilizer. The result is algae that can be used as a feedstock for biodiesel production or some other high-value product.

Lin's work focuses on making the system work most efficiently as she figures out water-flow rates, plant growth rates, the ratio of energy to benefits and the potential for more value-added products.

Johnson has another partner in Mary Ann Keenan, a visiting faculty member in the Department of Environmental Studies, who is part of a committee working to implement Johnson's project. Keenan's focus is cultural ecology, which she describes as "the marriage of humans and the environment."

"If you don't know how humans operate, how can we expect to study the environment as any sort of change agent?" she said.

Keenan and Johnson have met with faculty members and students at the Syracuse University Whitman School of Management to devise ways to make the project commercially viable. A team of students from the two schools presented their plan, called "Food2Joules," as part of Whitman's 2009 Panasci Business Plan Competition. They earned $5,000 in seed money by finishing third.

Johnson described the operation on a historic day. For the sake of some visitors, Bullard attached a Bunsen burner to the methane supply and lit a match. It worked. Johnson immediately emptied a can of vegetable soup into a copper-bottom pot and set it over the burner to heat for lunch. Bullard was so impressed with the significance of the event that he took a picture with his cell phone camera.

Johnson stuck his finger into the pot. "The soup is heating," he said. "This is the first actual application of the methane process. That stuff started out as tomatoes and scrambled eggs and it ended up heating soup. And around and around we go. That's why we call it carbon recycling."

^ Some of the fertilizer is stored for later analysis.

^ A plastic tube is part of the process for removing CO2 from the biogas.

^ This experimental plug-flow digester has been in use continuously since Aug. 24, 2008.