**Swapping Germs**

By: McKenna, Maryn, Scientific American, 00368733, Dec2011, Vol. 305, Issue 6

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Section:

The Science of Health

A potentially beneficial but unusual treatment for serious intestinal ailments may fall victim to regulatory difficulties

Marion Browning of North Providence, R.I., was at her wit's end. The 79-year-old retired nurse had suffered from chronic diarrhea for almost a year. It began after doctors prescribed antibiotics to treat her diverticulitis, a painful infection of small pouches in the wall of the colon. The regimen also killed friendly bacteria that lived in Browning's intestines, allowing a toxin-producing organism known as Clostridium difficile to take over and begin eating away at the entire lining of her gut.

For months Browning was in and out of her doctor's office, getting big-gun antibiotics to suppress the C. difficile infection. Each time a course of treatment ended she would feel better for a while. But her strain of C. difficile was stubborn: a few of the destructive bacteria always survived. Within a few days they would begin multiplying, and the racking diarrhea would recur. After four rounds of antibiotics, her gastroenterologist told her that he had done all he could think of. He recommended that she see Colleen Kelly, a clinical faculty member at Brown University's medical school, who was trying something new.

Kelly proposed a treatment that sounded both logical and strangely unmedical. Normally, she told Browning, the friendly bacteria that reside in the human intestine maintain a seesawing balance that keeps pathogenic bacteria in check. That equilibrium can be temporarily disrupted--as with standard antibiotic treatment--but it nearly always returns to stability. Browning's own bacterial community had lost that ability, probably for good. Still, there was a way to restore normality, Kelly said. She could replace Browning's bacteria completely, by inserting into her colon a diluted sample of stool from someone whose intestinal health was good. If the good bacteria in the donated stool took hold and recolonized her intestine, the C. difficile would be crowded out, and she would be cured.

Browning had never heard of such a procedure--variously called **fecal** transplant, **fecal** bacteriotherapy or **fecal** flora reconstitution--but she was ready to try anything. Kelly asked her to recruit a healthy donor. Browning chose her 49-year-old son. In the fall of 2009 Browning performed the bowel-cleansing routine that precedes a colonoscopy, while her son took an overnight laxative. Kelly diluted the donation, then used colonoscopy instruments to squirt the solution high up in Browning's large intestine. The diarrhea resolved in two days and has never recurred.

"I can't understand why more doctors aren't doing this," says Browning, now 80. Yet a complex combination of federal regulations and research rules--along with just plain squeamishness--could keep the procedure from helping potentially thousands of people who might benefit.

[A GROWING THREAT](http://web.ebscohost.com/ehost/detail?sid=a0d45c3e-3e6f-4076-a872-4016ba5458ca%40sessionmgr15&vid=31&bk=1&hid=9&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#toc)

Browning is not alone in being a success story. In medical journals, about a dozen clinicians in the U.S., Europe and Australia have described performing **fecal** transplants on about 300 C. difficile patients so far. More than 90 percent of those patients recovered completely, an unheard-of proportion. "There is no drug, for anything, that gets to 95 percent," Kelly says. Plus, "it is cheap and it is safe," says Lawrence Brandt, a professor of medicine and surgery at the Albert Einstein College of Medicine, who has been performing the procedure since 1999.

So far, though, **fecal** transplants remain a niche therapy, practiced only by gastroenterologists who work for broad-minded institutions and who have overcome the ick factor. To become widely accepted, recommended by professional societies and reimbursed by insurers, the transplants will need to be rigorously studied in a randomized clinical trial, in which people taking a treatment are assessed alongside people who are not. Kelly and several others have drafted a trial design to submit to the National Institutes of Health for grant funding. Yet an unexpected obstacle stands in their way: before the NIH approves any trial, the substance being studied must be granted "investigational" status by the Food and Drug Administration. The main categories under which the FDA considers things to be investigated are drugs, devices, and biological products such as vaccines and tissues. Feces simply do not fit into any of those categories.

The physicians performing the transplants decry the regulatory bottleneck because new treatments for C. difficile infection are critically needed. C. diff, to use the common medical shorthand, has risen in the past 30 years from a recognized but tolerated consequence of antibiotic treatment to a serious health threat. Since 2000, when a virulent new strain emerged, cases have become much more common, occurring not only in the elderly but in children, pregnant women and people with no obvious health risks. One study estimated that the number of hospitalized adults with C. diff more than doubled from about 134,000 patients in 2000 to 291,000 patients in 2005. A second study showed that the overall death rate from C. diff had jumped fourfold, from 5.7 deaths per million in the general population in 1999 to 23.7 deaths per million in 2004.

C. diff has also become harder to cure. Thanks to increasing antibiotic resistance, standard treatment now relies on two drugs: metronidazole (Flagyl) and vancomycin. Both medications are so-called broad-spectrum antibiotics, meaning that they work against a wide variety of bacteria. Thus, when they are given to kill C. diff infection, they kill most of the gut's friendly bacteria as well. The living space that those bacteria once occupied then becomes available for any C. diff organisms that survive the drugs' attack. As a result, roughly 20 percent of patients who have had one episode of C. diff infection will have a recurrence; 40 percent of those with one recurrence will have another; and 60 percent of those who experience a second bout are likely to suffer several more. Some victims with no other options must have their colon removed. (A new drug, fidaxomicin, which was approved for C. diff infection by the FDA in late May, may lead to fewer relapses because it is a narrow-spectrum antibiotic.)

[A SIMPLE PROCEDURE](http://web.ebscohost.com/ehost/detail?sid=a0d45c3e-3e6f-4076-a872-4016ba5458ca%40sessionmgr15&vid=31&bk=1&hid=9&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#toc)

The details of how the **transplantation** of microbes eliminates C. diff infection have not been well studied, but Alex Khoruts, a gastroenterologist and immunologist at the University of Minnesota who has performed two dozen **fecal** transplants over the past two years, has demonstrated that the transplanted bacteria do take over the gut, replacing the absent friendly bacteria and outcompeting C. diff. In 2010 he analyzed the genetic makeup of the gut flora of a 61-year-old woman so disabled by recurrent C. diff that she was wearing diapers and was confined to a wheelchair. His results showed that before the procedure, in which the woman received a **fecal** sample from her husband, she harbored none of the bacteria whose presence would signal a healthy intestinal environment. After the transplant--and her complete recovery--the bacterial contents of her gut were not only normal but were identical to that of her husband.

Most clinicians who perform **fecal** transplants ask their patients to find their own donors and prefer that they be a child, sibling, parent or spouse. "For me, it's aesthetic," says Christina Surawicz, a professor of medicine at the University of Washington, who has done transplants on two dozen patients and published an account of the first 19. "There's something very intimate about putting someone else's stool in your colon, and you are already intimate with a spouse."

To ensure safety, the physicians performing the procedure require that donors have no digestive diseases and put them through the same level of screening that blood donation would require. That process imposes a cost in time and logistics because standard rules for medical confidentiality require a donor to be interviewed separately from the potential recipient. It also carries inherent financial penalties. The donor's lab work most likely will not be covered by insurance; the transplant procedure may or may not be covered by the patient's insurance.

Proponents have come up with work-arounds for those possible barriers. Khoruts no longer uses related donors--which requires finding a different individual for every case--but instead has recruited a cadre of "universal donors" from among local health care workers. (He has seen no change in how often the transplants "take.") Last year Michael Silverman of the University of Toronto boldly proposed a yet more streamlined solution: having patients perform the transplants at home with a drugstore enema kit. A drawback, he cautioned in Clinical Gastroenterology and Hepatology, is that too much of the stool solution might leak out for the transplant to take. Nevertheless, seven patients with recurrent C. diff have safely performed the home version, he wrote, with a 100 percent recovery rate.

[NEXT STEPS](http://web.ebscohost.com/ehost/detail?sid=a0d45c3e-3e6f-4076-a872-4016ba5458ca%40sessionmgr15&vid=31&bk=1&hid=9&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#toc)

Even without large-scale rigorous investigations of **fecal** transplants, the medical community appears to be coming around to the practice. The Journal of Clinical Gastroenterology editorialized in September 2010 that "it is clear from all of these reports that **fecal** bacteriotherapy using donor stool has arrived as a successful therapy." Albert Einstein's Brandt recently suggested in the same journal that **fecal** transplants should be the first treatment tried for serious C. diff infection rather than a last resort. Increasing research interest in the influence of gut flora on the rest of the body--and on conditions as varied as obesity, anxiety and depression--will likely bring pressure for transplants to be adopted more widely.

Currently three clinical trials of **fecal** transplants have begun in Canada. In the U.S., however, the research logjam persists. An FDA spokesperson said in an interview that there is no way to determine how the agency might rule on an investigational application until the application is brought. That tosses the initiative back to Kelly and her collaborators, who include Khoruts and Brandt. They hope to file with the FDA before much longer, but Kelly admits to being apprehensive over the possible outcome.

"We hope they will not ask things that we cannot answer," she says. Medical centers need to be able to study the procedure, Kelly argues, "because people are trying it on their own."

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PHOTO (COLOR): Straight poop: Bacteria shed from the intestine (some of which are colored purple here) make up much of human feces.

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By Maryn McKenna

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**Fecal transplants being used to treat difficult C. diff cases**

By [Diane Suchetka, The Plain Dealer](http://connect.cleveland.com/user/dsuchetk/posts.html)
on January 03, 2013 at 8:00 AM, updated January 03, 2013 at 5:58 PM

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CLEVELAND, Ohio -- For years, hospitals have struggled to help patients overcome the life-threatening gut infection [Clostridium difficile](http://www.nlm.nih.gov/medlineplus/clostridiumdifficileinfections.html), or C. diff, a stubborn bug that often won't respond to repeated rounds of antibiotics.

Now doctors are looking more and more to a treatmentthat has almost instant results in some of the sickest of patients.

The remedy operates on the premise that antibiotics wipe out beneficial bacteria that help people combat serious infections such as C. diff. And it puts that good bacteria back into their digestive tracts so they can overcome the disease.

The success rate is remarkable.

"Seventy-four percent of patients get better in three days," says [Dr. Lawrence Brandt](http://www.einstein.yu.edu/departments/medicine/divisions/gastroenterology-liver-diseases/faculty/profile.asp?id=2519), a New York gastroenterologist who's been using the treatment since 1999. "But I've had patients who've felt better in three hours."

It's also less expensive than the most common treatment for recurrent C. diff, the heavy-duty antibiotic [Vancomycin](http://www.nlm.nih.gov/medlineplus/druginfo/meds/a604038.html), which can cost patients about $60 a pill, or $1,200 for a 10-day course.

The only hitch: Many find the treatment repulsive.

It's called a [fecal transplant](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3365524/), which means exactly what you think.

One reason people don't know about fecal transplants -- also called bacteriotherapy or human probiotic infusions -- is that access is not always easy.

Only about 15 doctors in the United States have made them an established part of their practices, says [Dr. Colleen Kelly](http://med.brown.edu/gastroenterology/Faculty/Kelly.html), a gastroenterologist who teaches at Brown University's medical school and has been performing fecal transplants for the past four years. None of the doctors on the list she keeps are from Ohio or any of the surrounding states.

There are a number of reasons why more physicians don't provide the treatment, says [Dr. Cliff McDonald](http://www.cdc.gov/media/subtopic/sme/mcDonald.htm), a medical epidemiologist and senior adviser for science at the U.S. Centers for Disease Control's division of Healthcare Quality Promotion.

One, he says, is that it's so unappealing.

Transplants can be performed in a number of ways. Most often, doctors use a colonoscopy-like procedure, sedating a patient and depositing liquified, donated stool through a tube in the rectum. But sometimes they use a nasogastric tube, that goes through the nose, down the throat and into the gut. Other times, the stool is administered as an enema.

"And nobody in training teaches you how to do it," says Kelly, who practices at the [Women's Medicine Collaborative](http://www.womensmedicine.org/) in Providence, R.I. "My first one, I had no idea how to start."

Besides that, Kelly says, doctors can't always get the OK from the medical institution they're affiliated with.

"There's so much red tape. You have to bring it in front of so many people. And all it takes is one person saying, 'Hmm, I'm not comfortable with this.' "

But the big thing, McDonald says, is that no one has done a randomized, controlled trial.

Until now.

The doctor heading the new study is Kelly, who grew up in North Olmsted and graduated from the medical school at Ohio State University. She's working on it with Brandt, chief of gastroenterology at [Montefiore Medical Center in New York](http://www.montefiore.org/),using a grant from the [National Institutes of Health](http://www.nih.gov/).

When the study is finished, sometime in 2014, about 50 patients will have undergone transplants, half using donor feces, and the other half, the control group, using their own. It's a double-blind study, so neither the patients nor the doctors will know who received which treatment.

"My real hope is that this study will provide the randomized, controlled, double-blind proof that people need," Kelly says. "And it will show that it is safe.

"So if [doctors] come up against a barrier at their hospital, they can say, 'Look, I have the science to prove it.' "

Researchers are recruiting patients for other fecal transplant studies in the United States and elsewhere. Some of those studies are looking into other uses for the procedure -- to treat [ulcerative colitis](http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0001296/), for example, or [inflammatory bowel disease](http://www.cdc.gov/ibd/) in children.

Shirley Kaiser hopes the study will help more people like her.

In August, Kaiser, who's 78 and lives in Harrison, in Ohio's southwest corner, drove 12 hours to the [Mayo Clinic](http://www.mayoclinic.com/) in Minnesota for a fecal transplant.

After eight years of severe C. diff-induced diarrhea, she couldn't believe how quickly she felt better.

"As soon as I got up off that gurney," she says. "And the next morning, my daughter said. 'Mom, you even look better.' "

When her C. diff was bad, it made her so weak she couldn't walk her dog a half a mile down the street without having to sit on the curb to rest.

She threw away soiled clothes.

And she spent entire days in her bedroom. It was close to the bathroom and some days she had to race there four or five times. On her worst day, she counted 37 trips.

She tried Vancomycin -- she only had to pay $30 of the $1,100 cost for a 10-day supply -- but as soon as she stopped taking it, her symptoms were back.

Her transplant turned all that around.

Since she's had it, she hasn't been sick once.

"To me, it's just a miracle that I found people that could do this," Kaiser says.

"I just want people to know there's a treatment available.

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"We've got to get the word out. People don't know there can be a solution."

She wants to spread the word, she says, because she knows how frightening C. diff is.

The bacterium lives in the colonand produces hard-to-kill spores that cause cramps, abdominal pain and severe diarrhea in about 500,000 people in the United States a year.

It can lead to blood poisoning.

It can damage colons so badly they have to be removed.

And it kills.

Every year in the United States, an estimated 14,000 to 30,000 people die from the disease. And it's said to contribute to 100,000 additional deaths.

There's a reason it's such a troublemaker.

Because its spores are so hardy, they survive on bed sheets, countertops, hospital curtains and other surfaces where people can pick them up months or years later.

Most of us have trillions of healthy micro-organisms in our gut to fight it off. But for many people, C. diff strikes after a round of antibiotics has killed off good micro-organisms, leaving the body with little natural ammunition to fight the disease.

Doctors know that getting that good bacteria back into the colon takes care of the problem.

Yogurt and over-the-counter probiotics don't work because they contain so few strains of bacteria and they're not the strains believed to squelch C. diff.

That leaves doctors with the fecal transplant.

For now, the treatment isn't regulated by the [U.S. Food and Drug Administration](http://www.fda.gov/). But that could change in the future.

And it doesn't usually cost patients much. Because insurance doesn't typically cover the doctor's fee to administer the treatment, many doctors don't charge for it. Insurance often pays for office visits, the colonoscopy-like procedure to administer it and testing of the donor for HIV, hepatitis and other diseases.

It's been used in veterinary medicine for decades.

But as the incidence of C. diff began increasing in recent years, more and more doctors adopted it for human use.

Australian gastroenterologist [Dr. Thomas Borody](http://www.cdd.com.au/pages/clinical_staff.html) performed his first in the mid-1980s. The story, as detailed in the magazine [The Scientist](http://www.the-scientist.com/), began when a woman came to him with an inflamed colon that wasn't getting better. Borody began researching alternative treatments and stumbled upon a paper published in 1958 that described four cases in which a similar condition was treated with feces from healthy donors.

"So I looked at the method and kind of made up the rest of it," Borody told the magazine.

Within days, the woman's colitis was gone.

And it never came back.

In more recent years, researchers have published documentation of human use dating back to 4th-century China. Then, a well-known traditional Chinese medical doctor described giving patients liquefied feces to drink as a treatment for severe diarrhea and food poisoning.

Now with more doctors offering the treatment, there's more documentation of how well it works.

Doctors who have tracked their cases, report that about 90 percent of patients get better after the first transplant; 95 percent after a second one.

And because it's so successful, the medical community is searching for ways to make it more palatable.

[Dr. Alexander Khoruts](http://www.med.umn.edu/gi/faculty/khoruts/home.html), a gastroenterologist at the [University of Minnesota Medical Center](http://www.uofmmedicalcenter.org/index.htm), is one of the researchers trying to isolate the good bacteria that cures C. diff so that a more palatable treatment, such as an easy-to-swallow capsule, can be developed.

"As long as it's done the way it's done now," Khoruts says, "it's never going to move beyond the fringe."

Others are looking into the effect that the trillions of bacteria and other micro-organisms in our guts have on diseases such as [Parkinson's](http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0001762/), [autism](http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0002494/) and [obesity](http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0004552/).

A study in mice, for example, found that lean mice that received fecal transplants from obese mice became fat. And a small study in humans indicates they might respond in the same way.

As Khoruts says, it will be decades before we know exactly how all the microscopic organisms in our guts affect our health.

"We could say in the 19th and 20th centuries, the biggest achievements were in conquering infectious disease," he says.

But with all this sanitation and hygiene and anti-bacterial everything, he says, we may have unleashed a slew of other diseases.

"This is the big question right now," he says.

"This is why everybody is so excited about this new frontier."

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<http://www.psychologytoday.com/blog/evolutionary-psychiatry/201111/will-stress-injure-your-gut>

**Will Stress Injure Your Gut?**

Psychological stress can cause changes in the gut bacteria.

Published on November 24, 2011 by [Emily Deans, M.D.](http://www.psychologytoday.com/experts/emily-deans-md) in [Evolutionary Psychiatry](http://www.psychologytoday.com/blog/evolutionary-psychiatry)

Believe it or not, the integrity and [happiness](http://www.psychologytoday.com/basics/happiness) of our gut is extremely important to the efficient and serene workings of our noggin. Much of the [neural](http://www.psychologytoday.com/basics/neuroscience) output of the brain is directed down the vagus nerve to the stomach and intestines, and there's a lot of back talk the other direction. This communication between the gut and brain is poorly understood, but good communication and a healthy gut is vital to good health, both mental and physical. Not only can an unhealthy gut affect the brain and mood (what is your mood when you are nauseated or constipated?), but mood can also affect the gut (remember your stomach churning when it came to taking that important but difficult exam, or just before the last job interview?)

Bottom of Form

Recently, researchers have begun to explore the gut-brain interaction more seriously, beginning with our rodent friends. Earlier this year, a paper about [stress](http://www.psychologytoday.com/basics/stress) and mice and the gut microbes came out that was a jaw-dropper, and certainly worth a closer look.  "[Exposure to a social stressor alters the structure of the intestinal microbiota:  Implications for stressor-induced immunomodulation.](http://www.ncbi.nlm.nih.gov/pubmed/21040780)"  The [associated editorial](http://www.ncbi.nlm.nih.gov/pubmed/21168480) is worth a read as well, if you have access.  Also, the journal it comes from,[*Brain, Behavior, and Immunity*](http://www.sciencedirect.com/science/journal/08891591)is my favorite academic journal by far. If inflammation itself is truly behind the pathophysiology of [psychiatric](http://www.psychologytoday.com/basics/psychiatry) disorders (and there is a lot of data suggesting this is the case), then somewhere in the archives or future of this publication will be the holy grail linking inflammation via [diet](http://www.psychologytoday.com/basics/diet) and lifestyle to actual brain pathology.

This paper is a nice start.  First some fun facts.  The external surfaces of the body (that includes the gut, by the way, as we are a funny tube within a tube) are populated with microbes.  So populated, in fact, that 90% of the cells that make up the roving bacteria party + human host are the commensal microbiome.  Yup.  90% of you (by cell number) is them.  Most of these colonizers and symbiotes live in the intestine, especially the large intestine.  In the Matrix world of commensal species, the large intestine is Zion.

Here's the crazy thing - we know very little about these species.  Mostly because the vast majority seem to be absolutely dependent upon us (as we turn out to be symbiotically dependent on them). They can't be cultured without the host in a lab.  They need a living working gut, where they flourish, but are difficult to study.   That means we didn't have the capability even to catalog the species of gut bacteria until we could practically and relatively cheaply sequence DNA in large amounts, so not until the last seven years or so.

The beasties live in a "largely stable climax community" in our guts as the result of natural selection for species best adapted to our habits and personal nooks and crannies.  Fortunately, the beastie community is pretty [resilient](http://www.psychologytoday.com/basics/resilience), but factors such as a change in diet and antibiotics will obviously transiently affect the population.  In addition, exposure to stress also changes the population of beasties, the details of which are more clearly elucidated by the work in this paper.

The beasties do all sorts of nice things for us, really.  They make vitamin K, several B vitamins, and eat up carcinogens and other nasties.  Their health and composition are definitely related to the pathology of [obesity](http://www.psychologytoday.com/conditions/obesity) and of diabetes (at least in mice).  And, not surprisingly, these bacteria impact the immune system.

Germ-free animals raised in sterile environments without commensal microbiota have a different sort of intestinal immune system, with a lower amount of intestinal antibodies and fewer immune cells.  Colonizing these sterile mice will result in normalization of the gut immune system.  Alterations in the intestinal microbiota has been linked to asthma in animals and humans, suggesting that the beasties modulate adaptive and innate immunity.



http://www.flickr.com/photos/harlequeen/5752256334/

It is well known that some of those cytokines and immune system chemicals that are produced in the process of inflammation are known to be elevated in the case of [depressive disorders](http://www.psychologytoday.com/conditions/depressive-disorders). Chemicals with names like IL-6, TNF alpha, and interferon gamma.  Interferon gamma is known to actually cause [depression](http://www.psychologytoday.com/basics/depression/symptoms).  Who cares?  Well, translocation of gut bacteria through the gut lining into the comparatively sterile body interior results in a systemic increase in IL-6 and the other cytokines.  We talked about that a little bit in relation to [depression](http://evolutionarypsychiatry.blogspot.com/2011/02/depression-and-leaky-gut.html) and [chronic fatigue](http://evolutionarypsychiatry.blogspot.com/2011/03/leaky-gut-and-chronic-fatigue-syndrome.html) in previous posts.  Psychological stress in humans, such as caring for a sick relative or chronic work stress, is associated with elevated cytokines IL-6 and TNF alpha.  So the question asked by these researchers (and subsequently answered) is - does psychologic stress change the microbiota population, and is that related to a cytokine change within the body?

The experiment itself was complex and consisted of several different arms, and many mice made the ultimate sacrifice (along with their gazillion commensal microbiota).  In short, some mice were mostly left alone, others were given antibiotics and stress, others just exposed to mean "aggressive mice," others were restrained, and others given antibiotics and restrained...

So what happened to the microbiota and the levels of cytokines in these various experiments?  Well, the mice exposed to stress had definite changes in internal beastie populations.  In general,  exposure to stress (the mean mouse, or restraint) led to "a reduction in microbial diversity and richness."   In addition, exposure to the stressor led to a significant increase in IL-6 levels.  Interestingly, the specific genus of the population of microbiota were significantly related to the generation of IL-6.  TNF-alpha and INFgamma were also increased in stressed mice, but not significantly.

In the antibiotic-treated mice (with a pummeled microbiota), the IL-6 did not increase in response to stress.  Antibiotics reduced the amount of bacteria about 100-fold, so while it didn't eliminate the commensal bacteria by any extent, it made a good dent in the population.

Taken together, these results tell us that stress affects our gut bacteria, which affect our immune system and cytokines.  We know those increases are related to changes in psychological states.

The editorial quote of note:

The strength of implementing a truly integrative systems approach when studying stress physiology has never been clearer than in the work by Michael Bailey and his colleagues in this issue of the journal.  These scientists investigated the impact of stressor exposure on multiple physiologic symptoms, including the intestinal microbiota and the immune system.  These data reveal dynamic interaction between these systems when orchestrating the innate immunological stress response.

So yes, *they* control your brain (well, at least a mouse's brain, but I don't have a compelling reason to think that humans are immune from the general principle).  To some extent.  Best keep the beasties happy. Fermented foods (such as saurkraut, kefir, kimchi, and yogurt), probiotics, and avoiding too much alcohol, sugar, and processed food can help quite a bit. Have a happy holiday season!

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