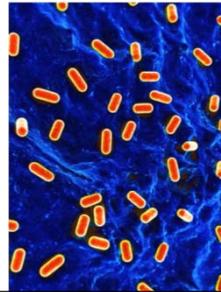


## The Pros of Probiotics: It's All About the Gut

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Richard Collins, MD, "The Cooking Cardiologist"  
Susan Buckley, RD



## The Pros of Probiotics

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- It turns out that we are only **10% human**: for every human cell that is intrinsic to our body, there are about 10 resident microbes
- These are mainly harmless freeloaders, beneficial bacteria and, in only a tiny number of cases, pathogens.
- To the extent that we are bearers of genetic information, more than 99% of it is microbial!

## The Pros of Probiotics

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- Researchers are increasingly starting to recognize gut microbiota as an unappreciated “**organ**” of the **human body**
- It may be even more apt to view your body as a “super organism” composed of symbiotic microorganisms!
- Researchers use the word “**microbiota**” to refer to all the microbes in a community and “**microbiome**” to refer to their collective genes.

## The Microbiome

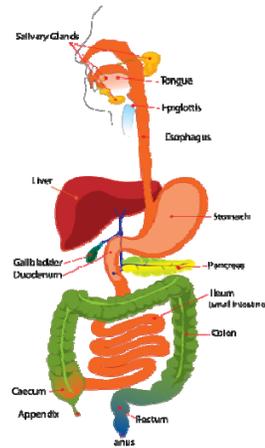
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- About **90% of our cells are bacterial** - the number of bacterial cells in the gut is estimated to be 10 to the power of 14 (*one hundred trillion*)
- The bacterial genes outnumber human genes by a factor of 99 to 1!
- The bacteria perform essential functions that we cannot

## The Pros of Probiotics

Your GI tract is about **30 feet long!**



## The Pros of Probiotics



- Probiotic: *Live bacteria* that help maintain a healthy ecosystem in the body
- First known description of probiotics occurred in 1908 when a Russian scientist named Ellie Metchnikoff observed that rural Europeans who regularly consumed **fermented milk** products had *longer life spans*

## Gut bacteria influence diverse facets of wellness

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- The profile of gut bacteria affect many aspects of physiology:
- Digestion
- Immune defenses
- Cardiovascular health
- Glucose homeostasis
- Body composition
- Endocrine function
- Cellular health
- Mental and emotional wellness



## The Pros of Probiotics

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- It appears increasingly likely that this “second genome,” as it is sometimes called, exerts an influence on our health ***as great and possibly even greater than the genes we inherit from our parents.***
- But while your inherited genes are more or less fixed, it may be possible to ***reshape, even cultivate, your second genome.***



## The Pros of Probiotics

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- Microbiologists at Stanford Univ., suggest we would do well to begin regarding the human body as “***an elaborate vessel optimized for the growth and spread of our microbial inhabitants.***”
- This humbling new way of thinking about the self has large implications for human and microbial health, which turn out to be inextricably linked.



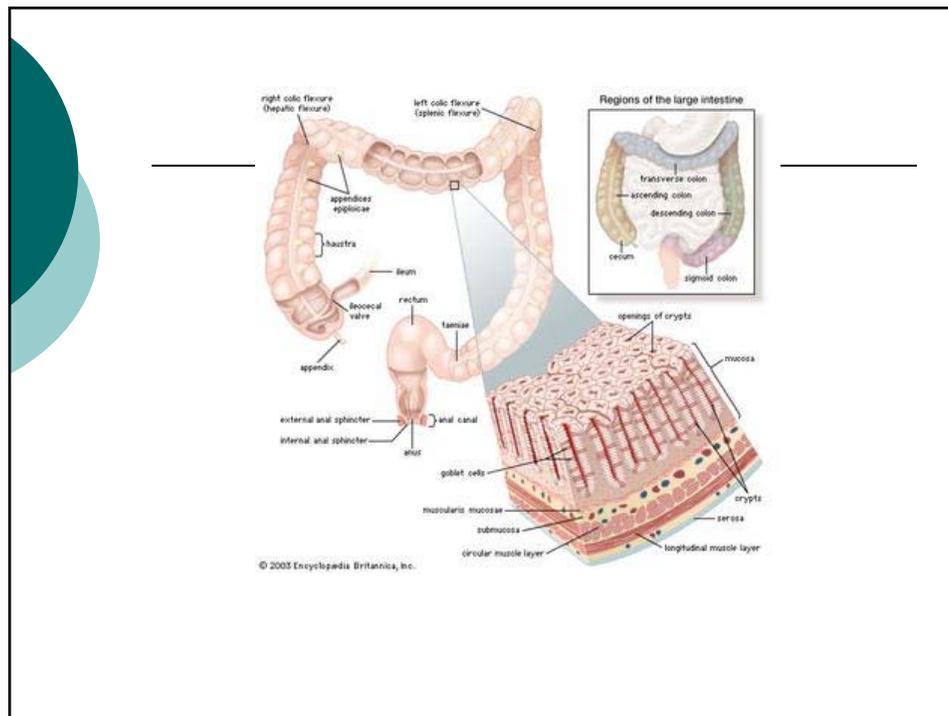
## The Pros of Probiotics

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- Disorders in our internal ecosystem — a loss of diversity, say, or a proliferation of the “wrong” kind of microbes — may predispose us to obesity and a whole range of chronic diseases, as well as some infections.

## The Pros of Probiotics

- Various markers for **inflammation** are common in people with metabolic syndrome, the complex of abnormalities that predisposes people to illnesses like cardiovascular disease, obesity, Type 2 diabetes and perhaps cancer.
- One theory is that the problem **begins in the gut**, with a disorder of the microbiota, specifically of the all-important **epithelium** that lines our digestive tract
- The term "epithelium" refers to layers of cells that line hollow organs (like the GI tract) and glands.



## The Pros of Probiotics

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- This internal skin of our GI tract — the surface area of which is large enough to cover a **tennis court** — mediates our relationship to the world outside our bodies
- More than **50 tons of food pass through it in a lifetime!**
- The microbiota play a critical role in maintaining the **health of the epithelium**: some bacteria, like the bifidobacteria and *Lactobacillus plantarum* (common in fermented vegetables), seem to directly enhance its function.





## The Pros of Probiotics

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- These and other gut bacteria also contribute to its welfare by feeding it.
- Unlike most tissues, which take their nourishment from the bloodstream, epithelial cells in the colon obtain much of theirs from the short-chain fatty acids that **gut bacteria** produce as a byproduct of their fermentation of plant fiber in the large intestine.
- Colon needs: plenty of healthy bacteria and good sources of **fiber** to be healthy



## The Pros of Probiotics

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- But if the epithelial barrier isn't properly nourished, it can become more permeable, allowing it to be breached.
- Leaky gut
- Bacteria, endotoxins — which are the toxic byproducts of certain bacteria — and proteins can slip into the blood stream, thereby causing the body's **immune system** to mount a response.
- This resulting **low-grade inflammation**, which affects the entire body, may lead over time to metabolic syndrome and a number of the chronic diseases that have been linked to it.

## The Pros of Probiotics



- Researchers fed a high-fat, “junk food” diet to mice
- The community of microbes in their guts **changed** much as it does in humans on a fast-food diet
- The junk-food diet also made the animals’ gut barriers notably **more permeable**, allowing endotoxins to leak into the bloodstream.
- This produced a low-grade inflammation that eventually led to **metabolic syndrome**.
- At least in mice, **gut bacteria can initiate the inflammatory processes associated with obesity and insulin resistance by increasing gut permeability.**

## The Pros of Probiotics

- These and other experiments suggest that inflammation in the gut may be the cause of metabolic syndrome, not its result, and that changes in the microbial community and lining of the gut wall may produce this inflammation



## The Pros of Probiotics

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- Fecal transplants have been used in a number of experiments with humans to affect pathogens as well as metabolic syndrome
- “[Fecal transplants](#),” which involve installing a healthy person’s microbiota into a sick person’s gut, have been shown to effectively treat an [antibiotic](#)-resistant intestinal pathogen named *C. difficile*, which kills 14,000 Americans each year.

## Fecal transplant

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- Fecal transplants are a promising approach for **treating recurrent *C. difficile* infections**, a common cause of potentially life-threatening diarrhea.
- In a report in *Oxford Journals*, a woman successfully treated for a relapsing *C. difficile* infection with a fecal transplant rapidly **became overweight for the first time in her life**.
- The stool donor, the woman's daughter, was **overweight**.
- The report suggests that donor screening for these transplants should exclude those who are overweight.

## Fecal Transplant

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- The unnamed woman weighed 136 pounds -- but gained 34 pounds over the next 16 months -- going from a healthy [body mass index](#) to an obese one, according to a case study published in an Oxford Journal called Open Forum for [Infectious Diseases](#).
- "The patient said: 'From the moment I had the fecal transplant, I felt like a switch flipped in my body,'" said Dr. Colleen Kelly, a gastroenterology at the Warren Alpert School of Brown University. "She felt like prior to the fecal transplant, she had never had to worry about weight."

## The Pros of Probiotics

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- A similar experiment was performed recently on humans by researchers in the Netherlands: when the contents of a lean donor's microbiota were transferred to the guts of male patients with [metabolic syndrome](#), the researchers found striking **improvements** in the recipients' insulin sensitivity, an important marker for metabolic health.
- Somehow, the gut microbes were influencing the patients' metabolisms.

- Our resident microbes also appear to play a critical role in training and modulating our **immune system**, helping it to accurately distinguish between **friend and foe**
- Some researchers believe that the alarming increase in **autoimmune diseases** in the West may owe to a disruption in the ancient **relationship** between our bodies and their “old friends” — the microbial bacteria with whom we coevolved

- Humans have spent the ~~better part of a century~~ doing our best to wreck the human-associated microbiota with a multi-fronted war on bacteria and a diet notably detrimental to its well-being.
- Researchers now speak of an impoverished “Westernized microbiome” that is lacking in sufficient quantities and diversity of healthy bacteria





- Most of the microbes that make up a baby's gut community are acquired during birth — a process that exposes the baby to a whole suite of maternal microbes.
- Babies born by Caesarean, however, a comparatively sterile procedure, do not acquire their mother's vaginal and intestinal microbes at birth.

- Their initial gut communities more closely resemble that of their mother's (and father's) skin, which is less than ideal and may account for higher rates of **allergy**, **asthma** and **autoimmune problems** in C-section babies: not having been seeded with the optimal assortment of microbes at birth, their immune systems may fail to develop properly.
- Every year, about 30% of babies born in the U.S. are delivered by cesarean section



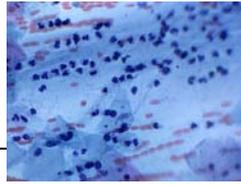
- Study published Jan. 2014 in the *JAMA Pediatrics*
- Introducing healthy bacteria to the gut of newborns appears to **decrease their likelihood of developing colic**
- Colic, characterized by lengthy crying, is believed to be related to digestive problems and sometimes likened to an infant form of irritable bowel syndrome (approx. 20% of infants suffer from colic in first 3 months)

- In the study, parents administered 5 drops of a solution containing *Lactobacillus reuteri*, a bacterium well-studied for its health effects, or a placebo to 589 healthy infants daily for the first 90 days of life
- At 3 months, babies who received the probiotic exhibited significantly less crying time (average of 38 minutes versus 71 minutes of inconsolable crying a day – fewer spit ups and more bowel movements (less constipation).



- Researchers found that colic symptoms and development of other gastrointestinal diseases later in life appear to be **linked**
- This study was the largest human study of probiotics on colic to date
- Researchers said that colonies of *Lactobacillus reuteri* appear to reduce intestinal **inflammation**, improve movement in the intestines and lessen sensitivity to pain

- Scientists can't yet say with confidence exactly what a "healthy" microbiome should look like.
- But some broad, intriguing patterns are emerging.
- **More diversity** is probably better than less, because a diverse ecosystem is generally more resilient — and diversity in the Western gut is **significantly lower** than in other, less-industrialized populations.



- The gut microbiota of people in the West looks very different from that of a variety of other geographically dispersed peoples
- For example, the gut community of rural people in West Africa more closely resembles that of Amerindians in Venezuela than it does an American's or a European's.
- These rural populations not only harbor a **greater diversity** of microbes but also a different cast of lead characters.

- American and European guts contain relatively high levels of **bacteroides and firmicutes** and low levels of the prevotella that dominate the guts of rural Africans and Amerindians
- Why are the microbes different? It could be the diet, which in both rural populations features a considerable amount of whole grains (which prevotella appear to like), plant [fiber](#) and very little meat.



- As for the lower biodiversity in the West, this could be a result of our **profligate use of antibiotics** (in health care as well as the food system), our diet of **processed food** (which has generally been cleansed of all bacteria, the good and the bad), **environmental toxins** and generally less exposure to bacteria in everyday life.
- Your microbial community seems to stabilize by age 3, by which time most of the various niches in the gut ecosystem are occupied.
- That doesn't mean it can't change after that; it can, but not as readily.

## The Pros of Probiotics

- A change of diet or a course of antibiotics, for example, may bring shifts in the relative population of the various resident species, helping some kinds of bacteria to thrive and others to languish.
- Can new species be introduced? Yes, but probably only when a niche is opened after a significant disturbance, like after a round of antibiotics.
- Just like any other mature ecosystem, the one in our gut tends to resist invasion by newcomers.

## The Pros of Probiotics

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- Our resident microbes work to keep pathogens from gaining a toehold by occupying potential niches or otherwise **rendering the environment inhospitable** to foreigners.
- The robustness of an individual's gut community might explain why some people fall victim to [food poisoning](#) while others can blithely eat the same meal with no ill effects.

- 
- Our gut bacteria also play a role in the **manufacture** of substances like **neurotransmitters** (including serotonin); **enzymes and [vitamins](#)** (notably Bs and K) and other essential nutrients (including important amino acid and short-chain fatty acids); and a suite of other signaling molecules that talk to, and influence, the immune and the metabolic systems.

## The Pros of Probiotics

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- Some of these compounds may play a role in regulating our stress levels and even temperament
- When gut microbes from easygoing, adventurous mice are transplanted into the guts of anxious and timid mice, they become more adventurous.
- The expression “thinking with your gut” may contain a larger kernel of truth than we thought.

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- In just the last few years, evidence has mounted from studies in rodents that the gut microbiome can influence ***neural development, brain chemistry and a wide range of behavioral phenomena, including emotional behavior, pain perception and how the stress system responds***
  - When researchers tweak the balance between beneficial and disease-causing bacteria in an animal’s gut, it alters the brain chemistry and can lead the animal to become either more bold or more anxious



- Studies show that even **mild stress** can tip the microbial balance in the gut of humans, making the host more vulnerable to infectious disease
- Gut bacteria produce hundreds of neurochemicals that the brain uses to regulate basic physiological processes as well as mental processes such as **learning, memory and mood**

- Gut bacteria manufacture about **95% of the body's supply of serotonin** which influences both mood and GI activity
- Probiotics can send messages to the brain
- Gut bacteria, such as probiotics, both **produce and respond** to the same neurochemicals – such as GABA, serotonin, norepinephrine, dopamine, acetylcholine and melatonin – that the brain uses to **regulate mood and cognition**



- Your brain and your bacteria “**talk**” **to one another**
- Researchers in 2008 at the Univ. of Technology in Australia found that during exam week, university students’ stool samples contained fewer lactobacilli than they had during the relatively untroubled first days of the semester



- In a 2004 study in the *Journal of Pediatric Gastroenterology and Nutrition*, and the Univ. of Wisconsin – Madison found that infant monkeys whose mothers had been stressed by loud noises during pregnancy had fewer *Lactobacilli* and *Bifidobacteria*
- *Stress-induced changes to the microbiome may help explain why more than half of people with chronic GI disorders like Crohn’s disease, ulcerative colitis and IBS are also **plagued by anxiety and depression***

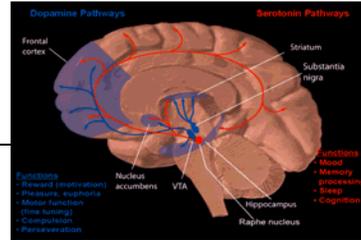


- Study published in the *British Journal of Nutrition* in 2011 found that a 30-day course of probiotic bacteria (a mix of *Lactobacillus helveticus* and *Bifidobacteria longum*) led to **decreased anxiety and depression in healthy human volunteers**

## Psychobiotic

- Psychobiotic: Probiotic with impact on behavior
- Research in *Biological Psychiatry* define a psychobiotic as a “live organism that, when ingested in adequate amounts, produces a health benefit in patients suffering from psychiatric illness.”
- Of the large numbers of probiotics, only a small percentage have an impact on behavior and may qualify as psychobiotics

## The Second Brain



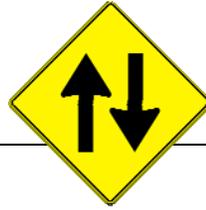
- The gut is the “second brain”
- The gut contains a complex and vast network of neurons that communicate with the brain, but also work independently to regulate digestion
- Gut neurons use the same neurotransmitters and neuropeptides as the brain itself
- ***Gut bacteria can generate neuroactive metabolites*** that can be absorbed and distributed to the CNS, where they affect mood, emotions and behavior

## The Pros of Probiotics



- For decades, we have known that emotional state has an unlimited capacity to affect digestion
- • Motility
- • Secretions
- • Appetite
- More recently, research shows that gut bacterial populations also are affected by mental state
- Example: Stress alters gut *Lactobacilli* and *Bifidobacteria* populations.

## The Pros of Probiotics



- New research clearly reveals a **two-way street**
- Gut microbes communicate with the brain through a variety of mechanisms
- These microorganisms can influence *emotions, mood, stress management and behavior*

## A link between the early microbiome and personality



- 2011 study compared normal 8-week-old mice with mice who had no intestinal bacteria
- The researchers transplanted microbes from young mice that were timid, into the guts of mice who were risk-takers.
- The timid mice became outgoing, and the outgoing mice became timid.

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- These studies, which have evaluated very young animals, have documented **dramatic changes in behavior and mental state.**
  - Whether this exact response occurs in adult humans is the subject of further research.



## Mental Health

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- Although in its early stages, the emerging field of research focused on the human microbiome suggests an **important role for the gut microbiota in influencing brain development, behavior and mood in humans.**
- The recognition that the gut microbiota interacts bidirectionally with other environmental risk factors, such as diet and stress, suggests promise in the development of interventions targeting the gut microbiota for the prevention and treatment of common mental health disorders.



## Mental Health

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- There have been a rapidly increasing number of observational studies **documenting diet quality and the prevalence of risk for depression.**
- These associations have been consistently observed in adults, adolescents and children across a multitude of different countries and cultures.



## Mental Health

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- A recent systematic review and meta-analysis, including results from 13 observational studies, concluded that a **healthy diet is significantly associated with a reduced odds for depression**
- Similarly, a meta-analysis of 22 studies investigating the protective effects of adherence to a Mediterranean-style diet on brain diseases demonstrated that **higher adherence was associated with a reduced risk for depression as well as cognitive decline**

## Mental Health

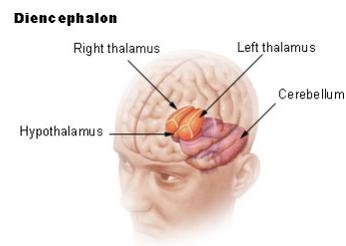
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- Moreover, increased consumption of unhealthy, sugar and fat-rich foods is related to an **increased risk** of psychological symptomatology in children and adolescents

## The Pros of Probiotics

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- Very small doses of microbes can affect at least three limbic structures involved in the processing of emotions related to stress responses and mood
- Hypothalamus
- Amygdala
- Hippocampus



## Clinical evidence supporting the utility of probiotics for relaxation and stress management

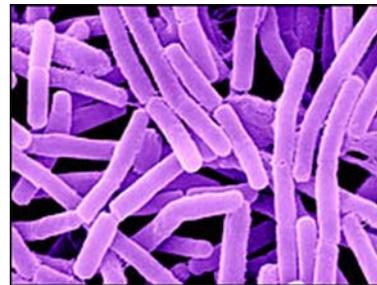
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- 39 subjects were randomized to receive either 24 billion CFU *Lactobacillus casei* or a placebo daily for 2 months
- Significant increases in *Lactobacilli* and *Bifidobacteria* were detected in those receiving this probiotic compared to placebo
- Significant support for **general relaxation** was also evident in subjects taking the probiotic, with no difference in placebo
- **This study, among others, provides evidence that supplementation with one strain can support the growth of other health-promoting species already residing in the intestine**
- Rao et al. *Gut Pathog.* 2009

## Effect of probiotics on mood: Human research

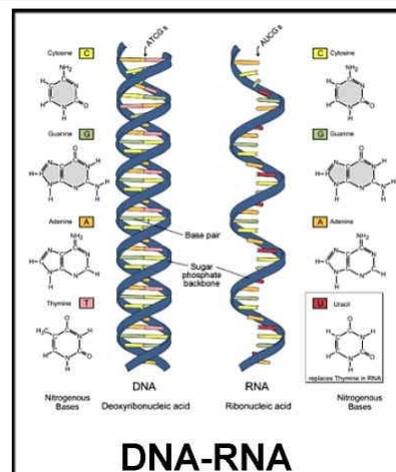
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- Double-blind, placebo-controlled trial of 132 healthy subjects, mean age 61.8 years
- A probiotic containing milk drink or a placebo were consumed daily for 3 weeks
- Subjects in the lowest third of the mood assessment at baseline reported being happier after taking the probiotic
- Benton *et al. Eur J Clin Nutr* (2007) 61(3):355-61



- So why haven't we evolved our own systems to perform these most critical functions of life?
- Why have we outsourced all this work to a bunch of microbes?
- One theory is that, because microbes evolve so much faster than we do (in some cases a new generation every 20 minutes), they can respond to changes in the environment — to threats as well as opportunities — with much greater speed and agility than “we” can.

- Exquisitely reactive and adaptive, bacteria can swap genes and pieces of DNA among themselves. This versatility is especially handy when a new toxin or food source appears in the environment.
- The microbiota can swiftly come up with precisely the right gene needed to fight it — or eat it.



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- This plasticity serves to extend our comparatively rigid genome, giving us access to a tremendous bag of biochemical tricks we did not need to evolve ourselves.
  - “The bacteria in your gut are continually reading the environment and responding,” says Joel Kimmons, a nutrition scientist and epidemiologist at the Centers for Disease Control and Prevention in Atlanta.
  - “They’re a microbial mirror of the changing world. And because they can evolve so quickly, they help our bodies respond to changes in our environment.”

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- Preliminary results indicate that a pristine microbiome — of people who have had little or no contact with Westerners — features **much greater biodiversity, including a number of species never before sequenced**
  - Researchers say these vibrant, diverse and antibiotic-naïve microbiomes may play a role in Amerindians’ markedly **lower rates of allergies, asthma, atopic disease and chronic conditions like Type 2 diabetes and cardiovascular disease.**
  - Each American generation is passing on fewer microbes, with the result that the Western microbiome is being **progressively impoverished**

## Example: The microbiome and metabolic health

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- Amount of body fat is linked to the relative abundance of the two dominant types of gut bacteria, the Bacteroidetes and the Firmicutes
- These differences affect whether calories are stored or utilized.
- Transplanting the “lean microbiota” to the overweight mice promotes improvements in body composition, and *vice versa*

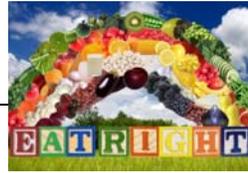
## Fattening Microbes

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- Scientists studied gut bacteria from pairs of twins in mice in which one sibling was lean and one was obese
- They transplanted the lean twin’s bacteria into one group of mice and obese twin’s bacteria into another
- A month later, the mice that got the lean twin’s bacteria were still lean
- But the mice that got the obese twin’s bacteria were **fatter, even though they ate no more food!**

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- Then, scientists housed each mouse that had been given what one could call the “slimming microbes” in a cage with a mouse that had been given the “fattening microbes”
  - The mice received the microbes only 5 days earlier, so those given the fattening microbes hadn’t yet gained weight
  - Since mice eat each other’s feces, their gut microbes got mixed. Which microbes won?

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- The slimming ones
  - They invaded the mice with fattening microbes so all the mice stayed lean
  - One explanation: mice with fattening microbes (and obese people) have fewer and less diverse microbes in their gut than mice with slimming microbes (and lean people)
  - Researchers speculate that the lack of diversity of microbes leaves open niches that can be filled by microbes associated with leanness



- But there was a catch . . .
- The slimming microbes invaded mice with fattening microbes only if the mice with fattening microbes ate a **diet that's high in fruits and vegetables and low in saturated fat**
- Eating a healthy diet encourages microbes associated with leanness to quickly become incorporated into the gut
- A diet high in saturated fat and low in fruits and vegetables thwarts the invasion

- Of course mice aren't human
- But preliminary findings in humans are intriguing
- Some studies find that ***Bacteroidetes*** bacteria are more common in **lean** people
- ***Firmicutes*** bacteria are more common in **obese**

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- Researchers put 12 obese people on a low-calorie diet for a year
  - As they lost weight, they acquired *Bacteroidetes* and lost *Firmicutes*
  - Scientists overfed 12 lean and 9 obese people for 3 days
  - Bacteria didn't change in the obese people, but the lean people at 3,400 calories a day, had their *Firmicutes* increased and their *Bacteroidetes* decreased
  - The overfed people who had a 20% increase in *Firmicutes* and a 20% drop in *Bacteroidetes* **absorbed 150 more calories per day from their food**

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- Researchers speculate that people are more likely to gain weight when gut bacteria are more efficient at breaking down food, enabling the body to absorb more calories
  - They theorize that less efficient bacteria allow food to pass more quickly through the intestines
  - Two people could eat the same bowl of cereal but one person may extract 95 calories while the other may get only 70

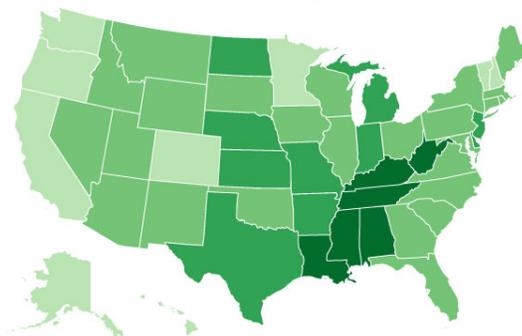
## Antibiotics and Obesity

- Study in New England Journal of Medicine
- States where doctors prescribe more antibiotics also have the highest obesity rates
- Researchers found a surprisingly wide variation among the states – and the rates – expressed in terms of prescriptions per 1,000 people

## Antibiotics and Obesity

Antibiotic prescriptions per 1,000 people, 2010

500-699 700-899 900-1,099 1,100-1,299



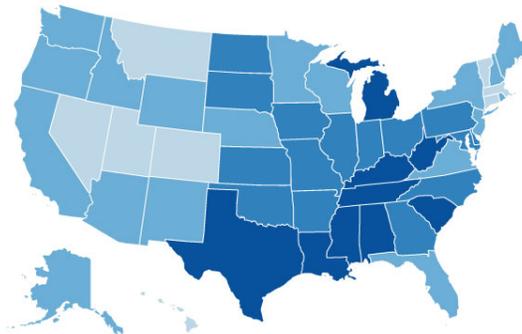
Source: CDC

Mother Jones

## Antibiotics and Obesity

Obesity rate by state, 2010

20%-23.5% 23.5%-27% 27%-30.5% 30.5%-34%



Source: CDC

Mother Jones

## Antibiotics and Obesity

- Researchers were surprised
- They initially expected to find certain correlations – for example, higher prescription rates in states with large elderly populations
- Not the case – for example Florida, which has a sizable elderly population, but only average antibiotic prescription rate
- Only one very strong correlation: **states with higher rates of antibiotic use also tended to have higher rates of obesity**

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- Researchers can't explain the connection between obesity and high rates of antibiotic prescription
  - Might be reasons why more obese people need antibiotics
  - But it also could be that antibiotic use is ***leading to obesity***

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- 2012 New York University study found that antibiotic use in the first 6 months of life was **linked with obesity later on**
  - Another 2012 NYU study found that mice given antibiotics gained more weight than their drug-free counterparts
  - Livestock operations routinely dose animals with low levels of antibiotics to promote growth and weight gain



- Farmers have been performing a great experiment for more than 60 years by giving subtherapeutic doses of antibiotics to their animals to make them gain weight.
- Scientists aren't sure exactly why this practice works, but the drugs may favor bacteria that are more efficient at harvesting energy from the diet.
- "Are we doing the same thing to our kids?" he asks.
- Children in the West receive, on average, between **10 and 20 courses of antibiotics before they turn 18!**



- And those prescribed drugs aren't the only antimicrobials finding their way to the microbiota; scientists have found antibiotic residues in meat, milk and surface water as well.
- There is also concern about the use of antimicrobial compounds in our diet and everyday lives — everything from chlorine washes for lettuce to hand sanitizers.
- We're using these chemicals precisely because they're antimicrobial. And of course they do us some good. But we need to ask, what are they doing to our microbiota?

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- No one is questioning the value of antibiotics to civilization — they have helped us to conquer a great many infectious diseases and increased our life expectancy.
  - But, as in any war, the war on bacteria appears to have had some *unintended consequences*.



## What About Heart Health

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- Research suggests that daily supplementation with *Lactobacillus reuteri* NCIMB 30242 helps to support healthy cholesterol levels in adults with moderately elevated cholesterol
- Several studies have shown reductions in LDL-C of 8.9% - 11.6%
- Plasma fibrinogen and CRP also reduced (less blood clotting and inflammation)
- Cardiovia at amazon.com



## Asthma

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- The Western diet most likely has more to do with the asthma epidemic than has been assumed so far because developing asthma is related to the amount of fruit and vegetables consumed research has shown
- Gut bacteria ferment the dietary fibers contained in them and the resulting fatty acids enter the blood
- As a result the short chain fatty acids influence the immune response in the lungs, research by the Swiss National Science Foundation found



## Asthma

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- **Increasing numbers** of people in the West have developed allergic asthma in the past 50 years
- Experiments in mice show that the lack of **fermentable fibers** pave the way for allergic inflammatory reactions in the lungs
- Mice were put on a standard diet with 4% fermentable fibers or given a low-fiber diet with merely 0.3% fermentable fibers
- This low fiber diet is largely comparable to the Western diet, which contains no more than 0.6% fibers on average

## Asthma



- When the researchers exposed the mice to an extract of house dust mites, the mice with the low-fiber diet developed a stronger allergic reaction with much more mucus in the lungs than the mice who received a diet enriched with fermentable fibers
- How does this work?
- Fibers reach the intestine, where they are **fermented by bacteria** and transformed into short-chain fatty acids
- These acids then enter the bloodstream and **influence the development of immune cells in the bone marrow**

## Asthma

- Attracted by the extract of house dust mites, these immune cells wander into the lungs, where they eventually **trigger an allergic response**
- Researchers noted that the examined aspects of the immune system in this experiment are virtually **indistinguishable in mice and humans**





## Asthma

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- Human infants with fewer types of intestinal bacteria seem to be at increased risk of developing asthma according to a new study in *Clinical & Experimental Allergy*
- Researchers assessed the varieties of gut bacteria in 47 infants and then followed them until they were 7 years old
- At that age 17% had chronic asthma
- The cases of asthma were connected to **low diversity of intestinal bacteria** when the children were 1 week and 1 month old



## Intestinal cancer

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- Colorectal cancer -- cancer of the colon and rectum -- is the second leading cause of cancer mortality in America.
- Colon cancer occurs in the large intestine.
- If the cancer is in the last 6 inches of the colon (the rectum), it is considered rectal cancer

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- Eating plenty of fruits and vegetables, as well as foods rich in omega-3 fatty acids, folate (such as whole grains and leafy green vegetables), and calcium (such as sea vegetables and kale), can help reduce the risk of colorectal cancer.
  - Limiting alcohol consumption, quitting smoking, and reducing the intake of high fat and fried foods, particularly red meats, may also protect against developing colorectal cancer.
  - Evidence from a wide range of sources supports the assumption that the link between diet and colorectal cancer may be due to an imbalance of the intestinal microflora.



## Colorectal Cancer

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- Moreover, accumulating evidence suggests that the ingestion of probiotics may be able to play a preventive role in the onset of Colorectal cancer
- The precise mechanisms are not clear.
- However, it is conceivable that they include: alteration of the intestinal microflora; inactivation of cancerogenic compounds; competition with pathogenic microbiota; improvement of the host's immune response

## How quickly can you alter your population of microbes?

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- Harvard University scientists found that **within 2 days** of changing subject's diets, the bacteria changed also
- 9 volunteers went on 2 extreme diets for 5 days each
- First diet was all about meat and cheese: breakfast was eggs and bacon, lunch was ribs and briskets and dinner was salami and prosciutto and cheeses



- Then after a break, the 9 volunteers began a second diet of **fiber-rich foods** from plants: breakfast was granola cereal, lunch was jasmine rice, onions, tomatoes, squash, garlic, peas and lentils; dinner was similar and snacks were bananas and mangoes
- Researchers analyzed the volunteers' microbiomes before, during and after each diet

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- The various bacteria species shifted **within a day after the food was ingested**
  - The kinds of genes turned on in the microbes changed in both diets
  - During the meat eating diet – microbes that love bile – *Bilophila* – started to dominate the volunteers' guts
  - Bile helps the stomach digest fats so people make more bile when their diet is rich in meat and dairy fats

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- ***Bilophila* promotes inflammation** and a recent study showed that *Bilophila* caused inflammation and colitis in mice
  - Recent study at the Cleveland Clinic found that gastrointestinal bacteria “burp” out a chemical called TMAO (trimethylamine N-oxide) after people consume red meat or eggs.
  - **TMAO increases the risk of heart attack and stroke**, which may help explain why eating those foods increases the danger of heart disease more than a vegetarian diet

## Ways to increase the good bacteria in your gut

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- Be slower to take, or give your children, antibiotics (in no way is this an argument for the rejection of antibiotics when they are medically called for)
- Relax the sanitary regime in your homes and encourage children to play outside in the dirt and with animals — deliberately increasing their exposure to the variety of bacteria
- Eliminate or cut back on processed foods, due to lack of fiber and out of concern about additives.

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- Place less faith in probiotic supplements than in **prebiotics** — foods likely to encourage the growth of “good bacteria” already present.
  - The safest way to increase your microbial biodiversity is to eat a variety of polysaccharides or fiber





- While probiotic-foods contain live bacteria, **prebiotic foods** feed the good bacteria already living in your digestive system. You can find prebiotics in foods such as **asparagus, Jerusalem artichokes, bananas, oatmeal, onions, leeks, red wine, honey, maple syrup, and legumes.**
- Consider eating prebiotic foods on their own or with probiotic foods to perhaps give the probiotics a boost

- The Western diet doesn't feed the gut, only the upper G I.
- All the food has been processed to be readily absorbed, leaving nothing for the lower G I.
- But it turns out that one of the keys to health is **fermentation in the large intestine**
- And the key to feeding the fermentation in the large intestine is giving it lots of plants with their ***various types of fiber, including resistant starch (found in bananas, oats, beans); soluble fiber (in onions and other root vegetables, nuts); and insoluble fiber (in whole grains, especially bran, and avocados***

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- With our diet of swiftly absorbed sugars and fats, we're eating for one and depriving the trillions of the food they like best: complex carbohydrates and fermentable plant fibers.
  - The byproduct of fermentation is the **short-chain fatty acids** that nourish the gut barrier and help **prevent inflammation**.
  - And there are studies suggesting that simply adding plants to a fast-food diet will mitigate its inflammatory effect.

## Fermented Foods

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- Add Fermented Foods to your diet as well
- *Fermented foods* can contain large numbers of probiotic bacteria, like *L. plantarum* and bifidobacteria: keifer, yogurt, kimchi, Sauerkraut, miso soup, tempeh
- One of the easiest ways to get probiotics in your diet is by adding acidophilus milk - milk that has been fermented with bacteria such as *Lactobacillus acidophilus* or Keifer
- Buttermilk -- generally milk that is cultured with lactic acid bacteria -- is also rich in probiotics.



Two jars of Living Kraut Seasoned Sauerkraut are shown. The labels are white with black text and feature a small logo at the top. The jars are filled with a yellowish, chunky substance, likely sauerkraut, and have gold-colored lids.

- Sauerkraut: contains probiotics
- Choose **unpasteurized sauerkraut** because pasteurization (used to treat most supermarket sauerkraut) kills the helpful bacteria.
- Sauerkraut -- and the similar but spicy Korean dish kimchi -- is also loaded with vitamins that may help ward off infection.



A bowl of tempeh, a fermented soybean product, is shown. The tempeh is cut into small, golden-brown cubes and is served with green beans and cherry tomatoes. The bowl is white with a floral pattern around the rim.

- Tempeh: made from a base of fermented soybeans, this Indonesian patty produces a type of natural antibiotic that fights certain bacteria.
- In addition, tempeh is very high in protein. Its flavor has often been described as smoky, nutty, and similar to a mushroom.
- Tempeh can be marinated and used in meals in place of meat

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- The less a food is processed, the more of it that gets safely through the gastrointestinal tract and into the eager clutches of the microbiota.
  - Al dente pasta, for example, feeds the bugs better than soft pasta does; steel-cut oats better than rolled; raw or lightly cooked vegetables offer the bugs more to chomp on than overcooked, etc.
  - This is at once a very old and a very new way of thinking about food: it suggests that **all calories are not created equal and that the structure of a food and how it is prepared may matter as much as its nutrient composition.**

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- The components of a microbiota-friendly diet are already on the supermarket shelves and in farmers' markets



## What About Supplements?

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- The probiotic marketplace is largely unregulated
- It's impossible to know what, if anything, you're getting when you buy a "probiotic" product.
- One study tested 14 commercial probiotics and found that only one contained the exact species stated on the label.

## Probiotic Identity

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**pure**  
encapsulations

Probiotic identity: Is it the right organism?

Lactobacillus plantarum Lp-115  
Genus species strain

## Colony Forming Units

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- CFU is an acronym commonly seen on products containing probiotics. It stands for "colony forming unit" and is a measurement of some of the good bacteria and yeasts inside.
- **A colony forming unit** is a bacteria or yeast that is capable of living and reproducing to form a group of the same bacteria or yeasts.
- Microbiologists use CFU to describe **the number of active, live organisms** instead of the number of all the bacteria - dead, inactive and alive
- **Only the viable organisms are considered to be probiotics.** "Viable" means that the microbes are capable of living under the proper circumstances.

## Supplements

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- Although the evidence is not clear cut, probiotics have been studied as a treatment for many conditions and their symptoms
- Irritable Bowel Syndrome or abdominal pain: Align, VSL# 3, YoPlus, Activia, Culturelle (pharmacy and grocery store)
- Diarrhea from Antibiotics, Viral Infection: Culturelle, Actimel, FloraStor (pharmacy)



## Supplements

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- Traveler's Diarrhea: Culturelle, FloraStor (pharmacy)
- Vaginal Infection: Jarrow ferdophilus (health food store)
- Cold and Flu: Metagenics Ultra Flora Plus DF (Wise Pharmacy in Littleton)



## What's in YOUR Gut?

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- Researchers at the University of Colorado at Boulder, in collaboration with the Human Food Project, have created an open-access, crowd-funded project, "American Gut" They will tell you not only which microbes are in your system but also what they are doing

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- Part of National Institutes of Health's Human Microbiome Project, a \$195 million undertaking that aims to characterize the microbial communities found at several sites on the human body: nasal passages, oral cavities, skin, GI tract, urogenital tract
  - [www.humanfoodproject.com/americanugu](http://www.humanfoodproject.com/americanugu)
  - For \$99 participants receive a list of the dominant microbes in their gut and several visualizations showing how they compare with the population at large

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- Ultimately, as the research advances, participants can learn if their own microbes are “good” or “bad” and what, if anything, they can do about it
  - Scientists hope to use this information to understand how diet and lifestyle affect people's microbial makeup
  - They want people who are athletes, non-athletes, meat-eaters, vegetarians, people who have autoimmune disorders, diabetes, etc.

○ So, what's in YOUR gut??????

