



SPLASH! milk science update JUNE 2012 issue

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This month, we bring you a synthesis of recent papers in RNA sequencing of bovine milk cells, insights on the evolutionary biology of milk, important discoveries on the synergy of milk sugars with gut bacteria and gut cells, and surprising links between probiotics and happiness.

Enjoy!

Recipe for cow's milk revealed

Spock: "Captain, it's a unique liquid formulation taken by their young to accelerate growth and development, enhance deductive reasoning and it protects them from alien invasions."

Kirk: "Can we use the replicator to make enough to save them?"

Spock: "Unlikely Captain. We have little understanding of how the liquid is synthesized. Perhaps the new research from the Medrano Lab will help."

Three recent scientific papers^{1,2,3} report the exploitation of rapidly advancing new technology that gives a clearer picture of the molecular machinery making milk in the mammary gland.



- **MILK'S RECIPE CHANGES THROUGHOUT THE STAGES OF LACTATION**

Milk provides essential nutrients and calcium for rapid postnatal growth and development of the young. It also provides much more. Some of milk's specialised components promote maturation of intestinal tissues and rapid growth of other tissues in the suckling young. Complex sugars in milk are thought to enhance brain development and an array of milk components protects the young from microbial infections. Milk is a complex mixture of many components, each with a specific and very active biological role.

The molecular machinery synthesising milk in mammary tissue is thought to be similar in most mammalian species and, in general, the components in milk from different species are also similar.

Despite these similarities in design features and components, milk is exquisitely and uniquely formulated in each mammalian species by varying the quantities of its components to perfectly match the needs of its young, which can be born at very different stages of development. While newborn livestock can stand, walk, and run within a few hours of birth, the same developmental milestones in humans are not reached until about 12-18 months of age. This may explain why there are large differences in the relative quantities of many of the same components of cow and human milk.

What is the molecular machinery that makes milk and how is its composition fine-tuned to the particular growth and developmental needs of the young of each species? These are big biological and evolutionary questions with few and only fragmentary answers at present.

The major scientific limitation to answering these questions has been the inability to identify all of the cogs in the machinery and then understand how they work together to produce milk. Rapid technology development is now enabling the first full view of all of the cogs in this world of biological complexity within the mammary cell.

- **MANY GENES CONTRIBUTE TO THE MACHINERY OF MILK PRODUCTION**

Genes encode the protein components in milk, like the caseins, and they also encode the proteins in the cellular machinery that makes all of the other components in milk, like its various sugars and fatty acids. Genes use an

intermediary called messenger RNA (mRNA) in the process of making proteins. mRNA is the 'courier' that transports the plans for protein designs from head office to the construction site where the proteins are synthesised within a cell. There is typically one plan for each protein, although some individual plans have multiple options that produce different versions of the same protein. The molecular sequence of mRNA can be used to indirectly identify each protein.

There are about ten to twenty thousand mRNA plans in each cell. The proteins made from these plans have many specialised functions. Some proteins help maintain the normal life of a cell while others become part of specialist machinery, like that producing milk in mammary cells.

The milk-producing machinery was previously investigated by peeking through small scientific cracks and seeing only a few components, or cogs, at any one time - a bit like trying to fully appreciate the splendour of the Mona Lisa when viewed through a small kaleidoscope.

Rapid technology development over the last few years now enables a much better understanding of the biological machinery that makes milk. The courier (mRNA) carrying all of the plans for proteins in a cell can be captured and the thousands of protein plans can be simultaneously and rapidly read in great detail. This new technology reveals all of the genes active in mammary cells during milk production. Previously, only a few genes could be investigated at any one time.

Most people appreciate the rapid advances in computer technology, which has doubled in power about every eighteen months for several decades. Amazingly, new DNA sequencing technologies, which includes the ability to sequence mRNA, has increased in capacity by about 10,000 times over the last five years!

This new technological capability has far-reaching consequences in biology, and examples of its power to reveal new information about the milk synthesis machinery are demonstrated in the three publications^{1,2,3}.

Wickramasinghe and colleagues³ circumvented an age old problem. How do you investigate the milk synthesis machinery in mammary tissue of a dairy cow without invasive surgery to remove samples of the tissue? Milk contains a small number of intact cells. Some of these are mammary cells, which have been dislodged from mammary tissue. Wickramasinghe and colleagues analysed the mRNA content of these mammary cells using a new generation of DNA sequencing technology.

They identified nearly twenty thousand individual mRNA at peak lactation in these cells, which surprisingly corresponded to about 90% of all genes in the cow. The most abundant mRNA encoded the plans for proteins like the caseins, which are secreted from mammary tissue into milk. These investigations also revealed many more details about the intricate machinery making milk.

The different stages of lactation have different mRNA emphases. For example, while about 9,000 genes each had the same level of activity in all stages of lactation, about as many again showed large changes in their level of activity (i.e. the level of mRNA that a gene produces) throughout the lactation cycle. The later lactation stages were enriched for mRNA that encode proteins involved in immune defense, an essential function of milk. They also demonstrated that milk proteins causing bitterness in infant formula and poorer quality Swiss cheese were less prevalent during early lactation. In addition, genes involved in producing fatty acids in milk showed marked changes in the different stages of lactation.

These findings may have direct industry relevance as they indicate that milk has quite different components and presumably properties when taken from different stages in the lactation cycle.

- **MILK-PRODUCING GENES HAVE MANY GENETIC VARIATIONS (e.g. over 100,000 SNP) THAT CAN BE EXPLOITED DURING GENETIC SELECTION OF DAIRY CATTLE.**

In a follow up study, Wickramasinghe and colleagues² documented all of the mRNA that may be involved in making proteins necessary for the synthesis and breakdown of milk sugars, including simple and complex milk sugars, as well as sugars that become part of the structures of some milk proteins. This is a complex and poorly explored area. They identified 92 genes involved in these processes. Again, the activities of these genes were often different in the different stages of lactation.

One of the by-products of sequencing mRNA using new DNA sequencing technology is the discovery of very large numbers of small genetic differences between individuals. These are called single nucleotide polymorphisms, or SNP. Canovas and colleagues¹ from the same group identified over 100,000 SNP from their analysis of mRNA in mammary cells naturally present in cow's milk.

These SNP are valuable to the dairy industry. They highlight differences between breeds, confirm parentage, and aid in the development of molecular tools that allow more rapid selection of elite performing animals entering breeding programs.

The quantity of SNP identified also suggests there is still considerable genetic diversity in dairy cattle despite extensive inbreeding. This can be used to great advantage in future selective breeding programs.

The technology development underpinning the many discoveries reported in these three scientific papers has been very rapid, and it was unpredicted even less than a decade ago. The dairy industry is uniquely placed to capture benefit from this new technology as a result of its extensive milk production records, control on breeding, and emphasis on genetic selection of elite performing animals. Both the knowledge and industry applications this technology will help generate in the next decade will be amazing and perhaps equally unpredictable.

¹Canovas A, Rincon G, Islas-Trego A, Wickramasinghe S, and Medrano JF. (2010) SNP discovery in the bovine milk transcriptome using RNA-Seq technology *Mammalian Genome* 21, 592-598.

²Wickramasinghe S, Hua S, Rincon G, Islas-Trego A, German JB, Lebrilla CB, and Medrano JF. (2011) Transcriptome profiling of bovine milk oligosaccharide metabolism genes using RNA-sequencing *PLoS ONE* 6, e18895.

³Wickramasinghe S, Rincon G, Islas-Trego A, and Medrano JF. (2012) Transcriptional profiling of bovine milk using RNA sequencing *BMC Genomics* 13, 45.

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Dinosaur aunts, bacterial stowaways, and insect milk

- **Ancient "milk" helped animals lay eggs in dry places.**
- **Of milk constituents studied, only particular oligosaccharides are unique to humans.**
- **Bacteria is passed from mother to offspring via milk.**

Milk is everywhere. From the dairy aisle at the grocery store to the explosive cover of the Mother's Day issue of Time magazine, the ubiquity of milk makes it easy to take for granted. But surprisingly, milk synthesis is evolutionarily older than mammals. Milk is even older than dinosaurs. Moreover, milk contains constituents that infants don't digest, namely oligosaccharides, which are the preferred diet of the neonate's intestinal bacteria (nom, nom, nom)! And milk doesn't just feed the infant and the infant's microbiome; the symbiotic bacteria are IN mother's milk.

Evolutionary origins of lactation

The fossil record, unfortunately, leaves little direct evidence of the soft-tissue structures that first secreted milk. Despite this, paleontologists can scrutinize morphological features of fossils, such as the presence or absence of milk teeth (*diphyodonty*), to infer clues about the emergence of "milk." Genome-wide surveys of the expression and function of mammary genes across divergent taxa and experimental evo-devo manipulations of particular genes yield critical insights. As scientists begin to integrate information from complementary approaches, a clearer understanding of the evolution of lactation emerges.

In his recent paper,¹ leading lactation theorist Dr. Olav Oftedal discusses the ancient origins of milk secretion. He contends the first milk secretions originated ~310 million years ago (MYA) in synapsids, a lineage ancestral to mammals and contemporaries with sauropsids, the ancestors of reptiles, birds, and dinosaurs. Synapsids and sauropsids produced eggs with multiple membrane layers, known as amniote eggs. Such eggs could be laid on land. However, synapsid eggs had permeable, parchment-like shells and were vulnerable to water loss. Burying these eggs in damp soil or sand near water resources- like sea turtles do- wasn't an option, posits Oftedal. The buried temperatures would have likely been too cold for the higher metabolism of synapsids. But incubating eggs in a nest would have evaporated water from the egg.



Dinosaur eggs

The synapsid egg was proverbially between a rock and a hard place: too warm to bury, too permeable to incubate. Luckily for us, a mutation gave rise to secretions from glandular skin on the belly of the synapsid parent. This mechanism replenished water lost during incubation, allowing synapsids to lay eggs in a variety of terrestrial environments. As other mutations randomly arose and were favored by selection, milk composition became increasingly complex, incorporating nutritive, protective, and hormonal factors.¹ Some of these milk constituents are shunted into milk from maternal blood, some--although also present in the maternal blood stream--are regulated locally in the mammary gland, and some very special constituents are unique to milk. Lactose and oligosaccharides (with lactose at the reducing end) are two constituents unique to mammalian milk, but are interestingly divergent among mammals living today.

Mammalian and primate divergences: Consequences for milk composition

Among all mammals studied to date, lactose and oligosaccharides are the primary sugars in milk. Lactose is synthesized in mammary glands only. Urashima and colleagues² explain that lactose synthesis is contingent on the mammalian-specific protein alpha-lactalbumin. Alpha-lactalbumin is very similar in amino-acid structure to C-type lysozyme, a more ancient protein found throughout vertebrates and insects. C-type lysozyme acts as an anti-bacterial agent. Oligosaccharides are predominant in the milks of marsupials and egg-laying monotremes (i.e. the platypus), but lactose is the most prevalent sugar in the milk of most placental (aka eutherian) mammals.² Interestingly, the oligosaccharides in the milk of eutherian mammals are most similar to the oligosaccharides in the milk of monotremes. Unique oligosaccharides in marsupial milk emerged after the divergence of eutherian mammals. Marsupial and monotreme young seemingly digest oligosaccharides. Among eutherian mammals, however, young do not have the requisite enzymes in their stomach and small intestine to utilize oligosaccharides themselves. Why do eutherian mothers

synthesize oligosaccharides in milk if infants don't digest them?

Last month, SPLASH associate editor Anna Petherick's post "[Multi-tasking Milk Oligosaccharides](#)" revealed that oligosaccharides serve a number of critical roles for supporting the healthy colonization and maintenance of the infant's intestinal microbiome. Beneficial bacterial symbionts contribute to the digestion of nutrients from our food. Just as importantly, they are an essential component of the immune system, defending their host against many ingested pathogens. The structures of milk oligosaccharides have been described for a number of primates, including humans, and data are now available from all major primate clades; strepsirrhines (i.e. lemurs), New World monkey (i.e. capuchin), Old World monkey (i.e. rhesus), and apes (i.e. chimpanzee). Among all non-human primates studied to date, Type II



Long-tailed macaques

oligosaccharides are most prevalent (Type II oligosaccharides contain lacto-*N*-biose I). Type I oligosaccharides (containing *N*-acetylglucosamine) are absent, or in much lower concentrations than Type II.³ In human milk, there is a much greater diversity and higher abundance of milk oligosaccharides than found in the milk of other primates. Most primate taxa have between 5-30 milk oligosaccharides, humans have ~200. Even more astonishingly, humans predominantly produce Type I oligosaccharides, the preferred food of the most prevalent bacterium in the healthy human infant gut- *Bifidobacteria*.^{2,3}

Human infants have bigger brains and an earlier weaning than do our closest ape relatives. Many anthropologists have hypothesized that constituents in mother's milk, such as higher fat concentrations or unique fatty acids, underlie these differences in human development. But only oligosaccharides, a constituent that the human infant does not itself utilize, are demonstrably derived from our primate relatives.⁴ At some point in human evolution there must have been strong selective pressure to optimize the symbiotic relationship between the infant microbiome and the milk mothers synthesize to support it. The human and *Bifidobacteria* genomes show signatures of co-evolution, but the selective pressures and their timing remain to be understood.

Vertical transmission of bacteria via milk

In the womb, the infant is largely protected from maternal bacteria due to the placental barrier. But upon birth, the infant is confronted by a teeming microbial milieu that is both a challenge and opportunity. The first inoculation of commensal bacteria occurs during delivery as the infant passes through the birth canal and is exposed to a broad array of maternal microbes. Infants born via C-section are instead, and unfortunately, colonized by the microbes "running around"

the hospital. But exposure to the mother's microbiome continues long after birth. Evidence for vertical transmission of maternal bacteria via milk has been shown in rodents, monkeys,⁵ humans,⁶ and... insects. Yes, INSECTS!

A number of insects have evolved the ability to rely on nutritionally incomplete food sources. They are able to do so because bacteria that live inside their cells provide what the food does not. These bacteria are known as endosymbionts and the specialized cells the host provides for them to live in are called bacteriocytes. For example, the tsetse fly has a bacterium, *Wigglesworthia glossinidia*,* that provides B vitamins not available from blood meals. Um, if you are squeamish, don't read the previous sentence.



Matryoshka (a.k.a. Russian nesting dolls)

The authors are not yet certain of the specific nutritional role that these bacterial endosymbionts play in the bat fly host. The bacteria may provide B vitamins, as other bacterial symbionts of blood-consuming insects are known to do. My main question is what is the exact role of the bacteria in the milk gland tubules? Are they there to add nutritional value to the milk for the larva, to stowaway in milk for vertical transmission to larva, or both?

Conclusions

The studies described above represent new frontiers in lactation research. The capacity to secrete "milk" has been evolving since before the age of dinosaurs, but we still know relatively little about the diversity of milks produced by mammals today. Even less understood are the consequences and functions of various milk constituents in the developing neonate. Despite the many unknowns, it is increasingly evident that mother's milk cultivates the infant's gut bacterial communities in fascinating ways. A microbiome milk-cultivation, if you will, that has far reaching implications for human development, nutrition, and health. Integrating an evolutionary perspective into these newly discovered complexities of milk dynamics allows us to reimagine the world of dairy science.

**I submit the tsetse fly and its bacterial symbiont (*Wigglesworthia glossinidia*) for consideration as the number one mutualism in which the common name of the host and the Latin name of the bacteria are awesome to say out loud! Bring on your challenger teams.*

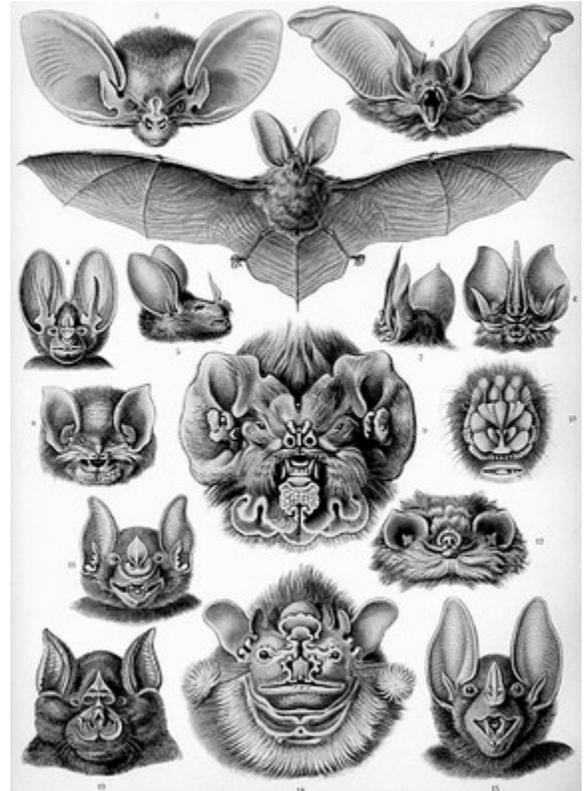
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3. Taufik et al. (2012) Structural characterization of neutral and acidic oligosaccharides in the milks of strepsirrhine primates: greater galago, aye-aye, Coquerel's sifaka, and mongoose lemur. *Glycoconj J*. 29: 119-134.

4. Hinde K & Milligan LA. (2011) Primate milk synthesis: Proximate mechanisms and ultimate perspectives. *Evol Anthropol* 20:9-23.

Hosokawa and colleagues⁷ recently revealed the Russian nesting dolls that are bats (*Miniopterus fuliginosus*), bat flies (Nycteribiidae), and endosymbiotic bacteria (proposed name *Aschnera chenzii*). Bat flies are the obligate ectoparasites of bats.⁸ They feed on the blood of their bat hosts, and for nearly their entire lifespan, bat flies live in the fur of their bat hosts. Females briefly leave their host to deposit pupae on stationary surfaces within the bat roost.^{7,8} Bat flies are even more crazy amazing because they have a uterus and provide MILK internally through the uterus to larva! Male and female bat flies have endosymbiotic bacteria living in bacteriocytes along the sides of their abdominal segments (revealed by 16S rRNA). Additionally, females host bacteria inside the milk gland tubules, "indicating the presence of endosymbiont cells in milk gland secretion".



Chiroptera (bats) from Ernst Haeckel's Kunstformen der Natur, 1904

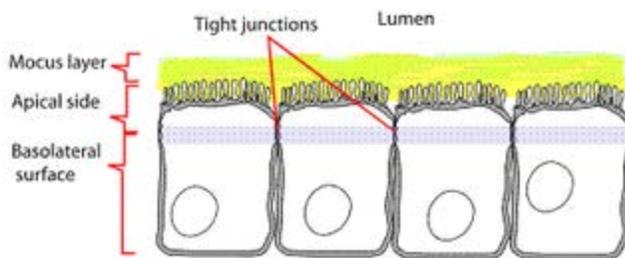
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Milk sugars keep gut cells together

<p>Beneficial Bifidobacteria + Human Milk Oligosaccharides =</p> <ul style="list-style-type: none"> • closed gaps between gut cells • decreased inflammation

Newborn infants have leaky guts. That is, the normal gaps between the cells in their intestinal epithelia--known as tight junctions--are poorly developed. In a recent paper, Maciej Chichlowski and colleagues in David Mills' lab at the University of California, Davis, find that certain bacteria, whose establishment in the infant gut is favoured by human milk oligosaccharides (HMO), promote the expression and proper positioning of tight junction proteins. Crucially, the bacteria only do this when grown on HMO. In other words, HMO aid in the physical development of a baby's intestine through the actions of gut bacteria.



How did the Mills lab show this? They took two types of gut cells (Caco-2 and HT-29 cells), two types of bifidobacteria, or "Bifs", (*B. infantis* and *B. bifidum*), and two things the Bifs eat (HMO and lactose). They then incubated the gut cells with either of the two Bifs. Next, the researchers measured the expression of various proteins made in the gut cells that form part of tight junction complexes. The two types of gut cells yielded different results, and different sorts of proteins underwent different changes in their rate of production.

Tight junctions between gut cells

But, importantly, there were some obvious hikes in the expression of key tight junction proteins when the gut cells had been incubated with HMO-fed bacteria compared to when they were incubated with lactose-fed bacteria of the same species. For example, Caco-2 cells made 5.7 times more of the protein JAM-A (junction adhesion molecule) when these cells were incubated with *B. bifidum* grown on HMO compared to when the *B. bifidum* was grown on lactose. HT-29 cells made twice as much of the protein ZO-1 when grown with HMO-fed *B. infantis* than when grown with lactose-fed *B. infantis*. Immunofluorescent microscopy provided further insight into these changes in protein levels. Occludin, another tight junction protein, was left flailing in the cytoplasm of gut cells grown alongside lactose-fed Bifs. Meanwhile, in gut cells incubated with HMO-fed Bifs, it was neatly shepherded towards the area around the tight junction.

Sugar-induced synergy

The authors offer some other intriguing examples of intestinal cell stimulation by HMO-fed Bifs. They report that an HMO diet somehow enables *B. infantis* to stick to gut skin cells better. This, they suggest, happens probably because of changes in the expression of genes in the gut cells, induced by the bacterium, that cause the gut cells to bind and signal to the bacterium more successfully. In their test, 8.5% of lactose-fed *B. infantis* cells stuck to a monolayer of HT-29 cells, while 26.5% of HMO-fed *B. infantis* cells clung on.

Lastly, Chichlowski et al. considered how feeding Bifs with HMO might have an indirect influence on the immune system in the gut. As with the proteins that compose the tight junctions, the authors measured the expression of several proteins in the two types of gut cells, but this time the proteins they chose were known to have a role in immunomodulation. The authors report that *B. infantis* grown on HMO causes Caco-2 cells incubated alongside to make

more of the anti-inflammatory cytokine, IL-10, and hikes by a multiple of seven the expression of a factor called SELPLG (compared to *B. infantis* grown on lactose).

What does this mean? The latter experiment points towards HMO having a kind of prophylactic influence on the human body, Chichlowski writes that HMO could possibly lower the odds that a breast fed infant will develop chronic inflammatory disease later in life. Intriguingly, the changes in the levels of cytokines might explain the changes in the distribution of tight junction proteins that were illuminated by fluorescent microscopy. This is because cytokines are known to influence the association of tight junction proteins with the cytoskeleton.

All in all, these new findings add weight to the re-characterization of HMO as more active players than was previously imagined in the interplay of infant gut, bacteria, and milk. The results prompt as many questions as answers. More work is needed to understand how HMO-grown Bifs influence the development of the intestine's structure and immunological function. The achievement of Chichlowski's paper is to make clear that they do.

Chichlowski M, De Lartigue G, German JB, Raybould HE, Mills DA. (2012) Bifidobacteria Isolated From Infants And Cultured On Human Milk Oligosaccharides Affect Intestinal Epithelial Function. *J Pediatr Gastroenterol Nutr.*

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Probiotics for health, happiness, and "swagger"

Contributors: Daniela Barile, Matthew Lange

- **Health: Milk-derived, but not plant-derived, prebiotics improve symptoms of irritable bowels.**
- **Happiness: Yogurt supplemented with *L. rhamnosus* reduces stress and anxiety in mice.**
- **Reproduction: Mice fed a yogurt supplement are more desirable for mating and have more offspring.**

While we have long known that prebiotics can be beneficial for gut health, surprising new studies suggest that milk-derived prebiotics may also affect our happiness and our love life. Probiotics are beneficial gut bacteria, whereas prebiotics are foods consumed by probiotics. Our own consumption of prebiotics and/or probiotics can alter our gut microbiota (the microbes naturally present in our gut) by altering the ratios of beneficial, synbiotic, and parasitic species.

Current evidence demonstrates consumption of milk-derived prebiotic oligosaccharides (e.g. trans-galacto-oligosaccharides) reduces symptoms of several severe gastrointestinal disorders. Because certain prebiotics are consumed preferentially by specific gut bacteria, health benefits from prebiotics are linked to the relative populations of each genera of bacteria. Especially noteworthy is the promising new research linking the consumption of therapeutic dairy prebiotics with their ability to selectively feed on one particular microbial genus: beneficial bifidobacteria.

Inflammatory Bowel Disease (IBD) encompasses a variety of inflammatory diseases and is now the most common gastrointestinal disorder, affecting an ever-growing number of Americans, on the order of millions, with astronomical effect on the annual health care costs. Novel and cost-effective approaches to treat IBD are much needed. The problem starts with an alteration of the microbiota, and researchers now believe microbiota may also be part of the solution.

Three recent clinical studies in humans affected by IBD have shown the positive effects of probiotic bifidobacteria supplementation through decreased inflammation and the diminishing of other symptoms [1-3]. These species of bacteria are normally found in high numbers in the gut of healthy breast-fed infants; however, as we age, they species become a minority--especially in patients affected by IBD. When that happens, other types of bacteria, such as *Bacteroides vulgatus* and Enterobacteriaceae prevail.

In a new study recently appearing in the Journal of Nutrition, researchers investigated the specific mechanism of action responsible for the beneficial effects of milk sugars on the inflamed gastrointestinal tract [4]. They used a mouse model of colitis (caused by a pathogenic bacterium,



Crypt branching, H&E stain, often a consequence of IBD
By Nephron (Own work), via Wikimedia Commons

Helicobacter hepaticus) and found that just after 4 weeks of treatment with Galacto-oligosaccharides, the symptoms of colitis were greatly reduced compared to a placebo-fed group. This pronounced effect was associated with a 1.5 fold increase in fecal Bifidobacteria as well as cellular expression of anti-inflammatory mediators.

However, before we jump to the conclusion that all prebiotics can cure IBD, we must note that other clinical trials, using plant-derived prebiotics, were not so successful and actually made the symptoms of colitis worse [5]. Because we are just starting to understand the interaction between the milk-derived oligosaccharides, the beneficial bacteria, and their interaction with the human body, more studies are needed to clearly establish the link between milk-derived molecules and their apparent benefits.

Prebiotics may play important roles outside the gut as well. Highlighting the importance of gut microbiota on the gut-brain axis of emotion and thought, another study appeared in the Proceedings of the National Academy of Science [6]. This study reported on the effects of a yogurt, supplemented with *Lactobacillus rhamnosus*, fed to mice with emotional symptoms (like stress and anxiety) that are commonly associated with irritable bowel symptoms. This study demonstrated that mice receiving the treatment were less anxious and stressed. Surprisingly, the researchers found the probiotic diet caused changes in the brain receptors for a class of neurotransmitter called GABA. While the global consequences of the receptor's changes are not known yet, it is fascinating to discover that the bacteria can have an influence on our brain and behaviour.



by their larger testicles. Males receiving the probiotic yogurt were able to mate more successfully and produced more offspring than the control group, while females on the probiotic diet weaned larger litters. Overall fecundity for both males and females was increased in the probiotic-fed group.

There you have it: probiotic consumption is associated with feeling better, reduced stress, decreased fatigue, and increased attractiveness to mates. While this science is still in its infancy and needs to be further proven and understood, a spoonful of probiotics seems like a more tantalizing way than ever to enhance your health and mood after a long stressful day at work.

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Often we associate happiness with self-confidence--which in turn may be reflected in our body language---but could probiotic consumption actually translate into increased sex appeal? Perhaps the most unexpected side effect associated with the consumption of probiotics was reported on the Scientific American Journal earlier this month [7]. A group of researchers from the Massachusetts Institute of Technology was investigating the effect of probiotic yogurt consumption on obesity when they stumbled on a side effect that was, for a lack of a better word, remarkable. Indeed, the male mice in the study receiving the probiotic yogurt were certainly noticed by the females who were likely attracted by the male's shinier fur and the "sexy swagger" induced

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