Feeling your vitality leaking away?
It could be Leaky Gut Syndrome.

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We eat to nourish our bodies and give ourselves energy and vitality. However, if we suffer from Leaky Gut Syndrome, the very food we are eating may be draining our energy away, creating vague symptoms, and may eventually lead to disease. Leaky Gut Syndrome allows food to leak through the intestine and into the body in an undigested state. The body then launches an attack against the wayward food. War ensues, casualties are heavy in terms of tissue damage and organ exhaustion, and the invader is labeled as an allergen. The body is now allergic to this food and instead of giving energy, it has a draining affect on the body as each time it is eaten, a small war breaks out. Thus, because of Leaky Gut Syndrome, we are no longer eating for vitality but rather being drained of it. Leaky Gut Syndrome is much more prevalent than one would think. Dr. Fratkin states in his article "Leaky Gut Syndrome: A Modern Epidemic", that in his practice, Leaky Gut Syndrome accounts for 50% of the chronic complaints, as confirmed by laboratory tests (Fratkin, online, p.1).

Leaky Gut Syndrome may be caused by several mechanisms including inflammation, fungi or pathogenic bacteria overgrowth, parasites, drug or food reactions in the gut, to name just a few. Food and other antigens which have leaked through the intestine cause the body to launch an immune response to rid itself of the foreign matter. It is when and where the body launches its immune responses which leads to the various diseases. Below is a list of clinical conditions associated with altered intestinal permeability, or Leaky Gut Syndrome (Pizzorno, 1998, p. 115):

Aging
Alcoholism
Ankylosing spondylitis
Asthma
Celiac disease
Crohn's disease
Eczema
Endotoxemia
Food Allergy
Hives
HIV positive
Infantile colic
Inflammatory bowel disease
Inflammatory joint disease
Intestinal infections
Irritable bowel disease
Malabsorption
Malnutrition
Psoriasis
Reiter's disease
Rheumatoid arthritis
Schizophrenia
Trauma
Ulcerative colitis
Urticaria (hives)

This paper will discuss Leaky Gut Syndrome, the mechanism by which it acts, and suggest some of its causes. Several tests to diagnose the condition in addition to a protocol to address the syndrome will also be presented. Let us begin by defining and understanding the nature of this condition.

CLINICAL DEFINITION OF LEAKY GUT SYNDROME

Leaky Gut Syndrome is a disorder in which the intestinal lining is more permeable or porous than normal. The abnormally permeable intestinal lining allows toxic materials (undigested foods, bacteria, toxins, parasites, etc.) to pass into the body that would normally be eliminated from the body. This puts undue stress on the liver, lymphatic system, and immune response system as these organs and systems must clear the body of the excess toxins. This disorder has far reaching affects in terms of health. Let us now explore the small intestine, where leaky gut syndrome occurs.

Small Intestine

Function

The small intestine is most known for it's role in assimilating nutrients from food in which to nourish and feed the body. However, the small intestine must protect against harmful substance and therefore is also a part of the immune system. It is responsible for both, absorbing nutrients from food and keeping unwanted substances out. These unwanted substances are called antigens and they cause immune responses as the body tries to rid itself of them. Let us first examine the structure of the small intestine and then the mechanism by which the body responds to antigens. "Food represents the largest antigenic challenge confronting the human immune system"(Murray and Pizzorno, 1997, p. 467). Thus, the very substance we need for life, food, also presents the greatest challenge to our immune's system who's chief role is to preserve life.

Description

Let's begin with a description of the small intestine which is where Leaky Gut Syndrome strikes. The small intestine is, on average, 6 meters long in an adult. The intestine surface has a number of folds called valvulai conniventenes which increase the surface area of the intestine by about three-fold. Located on the entire surface of the small intestine are literally millions of small villi which project about 1 mm from the surface. These villi enhance the surface area another ten-fold.

The villi are covered by epithelial cells. Each epithelial cell has a brush border consisting of about 600 microvilli, 1 micron in length and 0.1 microns in diameter sticking out of the cell. These microvilli increase the intestinal surface another 20-fold. The surface area of the small intestine has been increased 600-fold giving it's original 6 meters in length a total absorptive surface area of 300 square meters. This large area is responsible for absorbing nutrients to feed the body and keeping foreign invaders out. The intestinal tract is the largest organ of immune surveillance and response in the human body (Wallace, 2000, p.18). This entire area is vulnerable to Leaky Gut Syndrome.

MECHANISM OF LEAKY GUT SYNDROME

As stated above, the intestine is composed of many finger like structures called villi, and each villi is covered by many epithelial cells. The epithelial cells are bound together by desmosomes with the space in-between them being called a tight junction (See figure 1). Mixed in with the epithelial are cells which secrete mucous, called goblet cells (See figure 1).

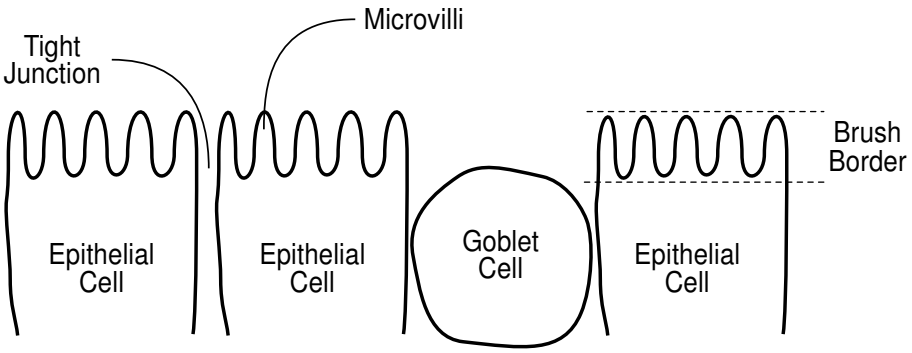

Figure 1

The epithelial cells transport molecules into the body by one of two mechanisms. Intracellular, where the molecule is absorbed into the cell and then passed into the body, or paracellular, where the molecule slips between the epithelial cells through the tight junctions. It is by way of one of these two transport mechanisms that nutrients enter the body. The same mechanisms protect the body from unwanted toxins or antigens.

If the villi or its epithelial cells become damaged or irritated, the goblet cells increase their mucous production. The increased mucous, along with the damaged cells and villi, prevents the body from absorbing nutrients which leads to malnutrition. The gap between the two epithelial cells, the tight junction, is very important in keeping large molecules out of the body. Disruption of tight junction increases the size of the molecules absorbed into the body. A large, macromolecule will cause an immune response in the body. Therefore, if the epithelial cells are damaged or atrophy, the intestinal walls become "leaky", allowing unwanted particles to pass into the body. This is what is termed "leaky gut " and results in leaky gut syndrome.

CAUSES OF LEAKY GUT SYNDROME

Leaky gut may be caused by many factors including, but not limited, to the following: immune system reactions, food allergies, alcohol, antibiotics, nonsteroidal anti-inflammatory drugs (NSAIDs), celiac disease, coffee, intestinal dysbiosis, malnutrition, pancreatic insufficiency, deficient levels of secretory IgA, and stress. These

causes will be briefly discussed. Additional causes of leaky gut , which will not be discussed, include: HIV infection, intestinal infection, aging, and giardiases.

Immune System

Terms:

Antigen: Any substance that, when introduced to the body, causes the formation of antibodies against it.

Antibody: Proteins manufactured by the body that bind to antigens to neutralize, inhibit, or destroy them.

Basophil: A type of white blood cell which contains histamines and other chemicals that are involved in allergic reactions.

Complement: A normal constituent of plasma that, when it combines with an antigen-antibody complex, completes the reactions that kill the invading pathogen.

Histamine: A chemical that leads to distention of nearby capillaries promoting inflammation.

Ig: Stands for immunoglubulin.

IgA: Also known as Secretory IgA (sIgA) is present in saliva, tears, and milk. Secretory IgA binds to pathogens, preventing them from penetrating the mucosal membrane and gaining entry into the body.

IgD: Found on the surface of antibody-forming cells.

IgE: Produces typical allergy or immediate hypersensitivity reactions such as hay fever, asthma, hives, and anaphylaxis. Principle, or "normal" function is the expulsion of parasites.

IgG: Also know as gamma globulin. The major circulating antibody which enters tissues freely. Currently there are four subgroups known; IgG1 to 4. IgG (and IgM) activate complement.

IgM: Captures and binds antigens to form large insoluble complexes which are readily cleared from the body.

Immune Complex: Antibody-antigen bound together.

Immunoglubulin: Antibody.

Macrophage: Cells which scavenge foreign bodies and cell debris.

Mast Cell: A cell, found in many tissues of the body, that secretes histamine and other inflammatory chemicals.

Pathogen: Disease producing microorganism.

Phagocyte: A cell capable of engulfing bacteria and other particulate material.

Function

When the immune system is functioning properly, it is able to resist almost all types of innate organisms and toxins that damage tissue by one of four methods: phagocytosis of bacteria and other invaders by white blood cells and other cells of the macrophage system; the destruction of organisms by the acid secreted in the stomach; the epithelium or surface layer of cells which acts as a physical barrier; the destruction of foreign organisms or toxins by chemical compounds in the blood stream.

However, the immune system does not always work properly: the stomach may not be producing enough acid to kill the bacteria and other organisms being ingested; the intestinal lining may be damaged letting antigens cross over into the blood stream (leaky gut); the system may be overwhelmed by the sheer number of antigens in the intestine or entering the blood stream and unable to clear or destroy them. Any one of these problems may lead to tissue damage and or disease.

Mechanism

According to Gell and Coombs there are four distinct ways in which the immune system reacts to a food antigen and causes tissue damage (Great Smokies, 1999, p. I-6). Often this tissue damage happens at the first point of contact where the antigen meets with the immune system, specifically the intestinal lining. Keep in mind that an antigen is any substance which causes the formation of antibodies against it. Antigens include undigested proteins, toxins, and other substances that stimulate the immune system. Let us look at the four ways the immune system attacks antigens, the diseases they may cause, and their role in Leaky Gut Syndrome.

Type I

Type I or immediate hypersensitivity reactions cause responses such as asthma, hives, and anaphylaxis (accounts for only 10-15% of all food-allergies) (Murray, 1993, p.251). The reaction occurs less than 2 hours after eating the allergen and is IgE mediated. IgE is a class of immunoglobulins that is distributed throughout the body. The cells synthesizing IgE are predominantly found in association with mucosal tissues such as those found in the nose, mouth, and gastrointestinal tract (nutramed.com, online, p.1). During the first exposure to an antigen, the body produces immunoglobulin IgE antibodies, which bind to the surfaces of basophil and mast cells. With further exposures, when the antigen binds with the attached antibody, the basophil or mast cell releases histamine, leukotrienes, and other chemicals that induce the inflammatory response. The release of these chemicals initiates a variety of responses: vasodilatation, increased capillary permeability, increased mucous secretion, and constriction of smooth muscle tissue.

The location of the mast cell during a reaction determines the symptoms experienced. For instance, if the reaction takes place in the nasal passage, you get sinus congestion; in the bronchioles, it's constriction (asthma); in the skin, hives and eczema; in the synovial cells that line the joints, arthritis; in the intestinal mucosa, inflammation resulting in malabsorption; in the brain, headaches, loss of memory, and inability to concentrate (Great Smokies, 1999, p. I-7). If the mast cells release chemicals in the ears, nose, and throat, then there may be itching in the mouth and there may be trouble breathing or swallowing (pharminfo.com, online, p.3). A severe Type I reaction results in Anaphylaxis which may result in death if not treated immediately.

Type II

Type II or cytotoxic reactions result in the destruction of cells. "It has been estimated that atleast 75% of all food allergy reactions are accompanied by cell destruction" (Murray, 1993, p.251). Cytotoxic reactions involve either IgG or IgM antibodies. These antibodies bind to cell-bound antigens (antigens which have attached themselves to a cell), and by doing so, activate the factors which cause the destruction of the complex. In other words, the antigen-antibody complex binds to a cell and the immune system destroys the cell along with the antigen-antibody complex to which it is bound. An example of this would be immune hemolytic anemia where antigen-antibody complexes bind to red blood cells. The red blood cells are then destroyed along with the antigen-antibody complex. This results in a lack of red blood cells, or anemia. More to the point, intestinal cells are normally the cells which are destroyed because the intestine is where the antigen and the immune system first meet.

Type III

Type III or immune complex-mediated reactions involve IgE and IgG immune complexes and usually occur atleast 2 hours and sometimes days after exposure to the antigen (Murray, Pizzorno, 1998, p.468). The immune complexes are formed when the antigens bind to the antibodies. These complexes are usually cleared from circulation by the phagocytic system. However, if the complexes are deposited in the tissues, the tissues may become damaged. Tissue may be damaged further by the presence of histamines and other amines that increase the vascular permeability and increase the number of immune complexes being deposited in the tissues. Rheumatoid arthritis may be caused by this mechanism. The complexes are deposited between the joints and inflammation ensues.

Type IV

Type IV or T-cell-dependent reactions occur usually within 36 to 72 hours after contact with the allergen. These delayed reactions are mediated primarily by T-lymphocytes and result when an allergen makes contact with a mucosal surface such as the intestinal tract. This type of reaction does not involve antibodies. Examples include poison oak, allergic colitis (inflammation of the colon), and regional ileitis (inflammation of the ileum). Inflammation of the intestinal lining leads to Leaky Gut Syndrome.

In summary, when the immune system is working properly, it fends off antigens and protects the body from harm. However, when it is baraged with antigens from the foods we eat or other sources, it can actually cause damage. Since the intestinal lining is where most antigens first come in contact with the immune system, this is most often where the damage occurs. An overwhelmed or over active immune system may contribute greatly to leaky gut syndrome.

Food Allergies

Food allergies and Leaky Gut Syndrome go hand in hand; the relationship is circular. It is difficult to determine which causes which. This is similar to the proverbial question, "Which came first, the chicken or the egg". It has been shown that following exposure to allergenic foods, permeability sharply increases, thus food allergies cause "leaky gut" (Galland, 1995, p.62). It is also well known that a permeable or "leaky gut" is one of the chief causes of food allergy.

It is believed that at least 60% of all Americans, both healthy and sick, suffer from symptoms associated with food reactions (Pizzorno, 1998, p.212). Infact, nutritionally oriented physicians believe that food allergies are the leading cause of most undiagnosed symptoms and contribute to most chronic diseases (Pizzorno, 1998, p.212). Diseases associated with food allergies are similar to those of Leaky Gut Syndrome, and once again it is hard to separate the two.

Food allergies and food intolerances may be caused by several factors including heredity, gut permeability, an overly sensitive immune system, poor digestion, or an excessive exposure to a limited number of foods. For example, in terms of hereditary, if both parents have allergies, then the child has a 67% chance of having allergies, while if only one parent has allergies, child's chances of having allergies drops to 33% (Murray, 1993, p. 250). Blood type also plays a role. According to Gittleman, people with type O blood have a greater predisposition to celiac disease, a type of food intolerance (Gittleman, 1997, p. 33). Celiac disease is characterized by an inability to digest foods that contain gluten. Finally, as the famous Greek physician Hippocrates noted in relationship to milk and gastric upset, "to many this has been the commencement of a serious disease when they have merely taken twice in a day the same food which they have been in the custom of taking once..."(Murray, 1993, p.248). The average American gets about 80% of their calories from only eleven foods (Braly, 1992, p. 48). Eating the same foods too often, especially if a leaky gut condition already exists, is a sure way to develop allergies (Braly, 1992, p. 48).

The foods which people are most commonly allergic to are the foods most commonly eaten, the staples of the American diet. They are as follows (Braly, 1992, p. 230, Pizzorno, 1998, p. 212):

Corn	Milk	Pork	Oranges	Coffee
Wheat	Cheese	Beef	Tomatoes	Chocolate
Rye	Yogurt	Shellfish	Potatoes	Malt
Soy	Eggs	Peanuts	Bell peppers	Cayenne
Oats	Rice	Barley		

However, determining which food one is reacting to is not always easy. Reactions to foods are not always immediate, they may be delayed. The immediate reactions, IgE mediated reactions, are thought to account for only 10% to 15% of all food allergies (Murray, 1993, p. 251). Some researchers claim that delayed food reactions may

account for up to 90% of all allergy symptoms (Barrie, 1987, section 2, p.1). This makes identifying the allergenic food difficult.

Technically there are food allergies and food intolerances. A food allergy occurs when the immune system generates an antibody in response to the ingested food. A food intolerance is when the body is unable to digest and process a food correctly usually due to a lack of a certain enzyme or enzymes. Food intolerance can lead to food allergies however, if particles of the undigested food manage to enter the blood stream and cause an immune reaction (Balch and Balch, 1997, p.110). However, both food intolerances and food allergies cause intestinal damage and result in increased intestinal permeability. Celiac disease is an example of a food intolerance to the gluten protein in grain, while anaphylactic shock triggered by eating a peanut is an example of a food allergy.

"When proteins are not digested to amino acids, dipeptides, or short chain polypeptides, they retain their antigenic properties" (Great Smokies, 1999, p. I-5). With this in mind, let us explore the mechanism by which food causes Leaky Gut Syndrome**.** A person eats a food to which they have become intolerant. The food is inadequately digested in the stomach and small intestine so that intact proteins come into contact with the cells lining the intestine. Antibodies in and on the intestinal lining combine with the food protein, initiating an inflammatory reaction. The inflammatory reaction causes damage to the nearby intestinal cells, continued exposure results in progressive damage to the intestinal cell lining. The damaged lining decreases the surface area of the intestine, resulting in fewer nutrients being absorbed, and allows antigens to "leak" into the body. Thus, this is an explanation of how food causes Leaky Gut Syndrome.

Conversely, here is the mechanism by which Leaky Gut Syndrome causes food allergies. An undigested protein "leaks" accross the intestinal lining and is tagged as an antigen, antibodies are made, and a food allergy is born. The person is now sensitized to this food and whenever it is eaten, the body will launch an immune response damaging nearby cells which again leads to Leaky Gut Syndrome if the "nearby" cells are in the intestinal lining.

Common signs and symptoms of food allergy consist of the following (Pizzorno, 1998, p.213):

- Dark circles under the eyes (allergic shiners)
- Puffiness under the eyes
- Horizontal creases in the eye lower lids
- Chronic non cyclic fluid retention and bloating
- Chronic swollen glands
- Chronic diarrhea
- Chronic infections
- Chronic Fatigue
- Eczema
- Hives
- Canker sores
- Asthma
- Excessive mood swings
- Bed wetting
- Irritable bowel syndrome

Food reactions are one of the most common causes of Leaky Gut Syndrome and ironically enough, Leaky Gut Syndrome causes food allergies. The two go hand in hand, each excasberating the other. Therefore it is extremely important to eliminate any foods

from the diet which may be causing reactions and irritating the gut. It is only in this manner that the gut may begin to heal and Leaky Gut Syndrome may be addressed.

Alcohol

According to Dr. Braly, alcohol, even in moderation, appears to cause an increase in permeability of the gastrointestinal tract (Braly, 1992, p.318). When alcohol passes through the stomach and intestinal tract it causes subtle cellular damage in the lining of these digestive organs. In time, alcohol damages these organs to the point where they become increasingly porous, allowing large, incompletely digested food particles to pass directly into the blood stream (Occhipinti, online, p.1). A study conducted by Bjarnason of 36 non-intoxicated alcoholics indicated that not only did they have higher intestinal permeability than controls, but that this condition could last for up to two weeks after they had stopped drinking (Bjarnason, 1984, abstract). Additionally, alcohol inhibits the breakdown of nutrients into usable molecules by decreasing secretion of digestive enzymes from the pancreas (Occhipinti, online, p.1). This results in undigested foods which ferment in the intestinal tract resulting in increased gut permeability.

Antibiotics

The small and large intestines are host to over 400 different kinds of bacteria (Fratkin, online, p.2). The beneficial bacteria breaks down complex foods, synthesizes vitamins like B_{12} and Biotin, and performs various other functions which are required for healthy metabolism and immune responses. For example, beneficial bacteria breaks down hormone secretions, including estrogen, which are discharged into the small intestine by the liver (Fratkin, online, p.3). If there is not enough beneficial bacteria to break down the estrogen, and if the intestinal permeability has been altered, the estrogen may be reabsorbed into the body. The estrogen may then be deposited in estrogen sensitive areas such as the breast, uterus, or ovaries, which may lead to fibroids and tumors (Fratkin, online, p.3). Dr. Fratkin believes that this reabsorption of estrogen is also responsible for premenstrual syndrome (Fratkin, online, p.3).

Antibiotics cause damage in two ways, they destroy beneficial bacteria and foster the growth of pathogenic fungi, including candida, and yeast. When healthy, beneficial bacteria plays a crucial role in protecting the body against fungi (Candida albicans) and amoebic (parasitic) infections. Antibiotics kill the beneficial bacteria, and by doing so, they allow harmful bacteria to multiply. Harmful bacteria results in intestinal damage and Leaky Gut Synrome.

Aspirin/NSAIDs

Aspirin and ibuprofen-type drugs, also called NSAIDs (nonsteroidal anti-inflammatory drugs) are commonly used for pain relief and for inflammation. Studies have shown that NSAIDs disrupt the intestinal barrier function and cause increased permeability (Pizzorno, 1998, p.120). The most common side affect of these over the counter seemingly safe drugs is gastrointestinal bleeding. When a NSAID is combined with alcohol, the chances of developing gastrointestinal bleeding go up by a factor of four

(Mindell and Hopkins, 1999, p. 287). It is estimated that 41,000 people a year are hospitalized from the side effects of taking too many NSAIDs and some 6,000 people a year die from complications directly related to NSAIDs (Mindell and Hopkins, 1999, p. 286).

It is ironic that many people take NSAIDs for relief of arthritic pain when intestinal permeability is thought to be a key factor in the disease process. The British Medical Journal reported that taking aspirin before consuming an allergenic food results in more of the allergy-provoking food being absorbed (Balch & Balch, 1997, p.112). Food allergies are believed to be an initiator of the rheumatoid arthritis process, while the removal of allergenic foods from the diet has been shown "to offer significant benefit to some individuals with rheumatoid arthritis" (Pizzorno, 1998, p.184). However, NSAIDs promote the allergenic condition by contributing to Leaky Gut Syndrome. Since the very thing people are taking to relieve the symptoms of arthritis are causing the disease, it is a vicious cycle.

Celiac Disease

Celiac disease is also known as non tropical sprue, gluten-sensitive enteropathy, or celiac sprue (Murray and Pizzorno, 1998, p.325). Celiac disease, characterized by gluten intolerance, appears to be largely genetic. This disease, once considered rare, may be more prevalent than previously thought. A study published in the *Scandanavian Journal of Gastroenterology* found that increased anti-endomysium antibodies (AEA), a strong indicator of celiac disease, was present in as many as one in every 250 healthy American blood donors (Not, et. al, 1998). In Europe, subsequent small intestinal biopsies have confirmed celiac disease in all those with AEA positivity (Not, et. al., 1998). This leads one to believe that there may be many undiagnosed cases of celiac disease in the Untied States.

Celiac disease is an inflammatory condition of the small intestine precipitated by the ingestion of wheat and other gluten containing grains such as barley, rye, and oats. It is believed to be the gladian portion of the gluten which is the allergen or irritant (Murray, Pizzorno, 1998, p.325). The biopsy of a celiac patient reveals a blunted or flattened intestinal surface (Gottschall, 1997, p35). The cause of this damage is believed to be the immune system trying to neutralize the gladian portion of the gluten protein and damaging the intestinal tissue in the process (Murray, Pizzorno, 1998, p.326). This damage results in increased intestinal permeability leading to food allergies.

Ann Louise Gittleman states in her book, "Your Body Knows Best", that people with type O blood have a greater predisposition to celiac disease and that they often suffer from milk intolerance (Gittleman, 1997, p.33). These are not unrelated. Celiac disease damages the intestinal lining which can lead to milk intolerance. The enzyme lactase which is needed to digest lactose, present in milk, is located in the brush border cells of the villi. Damaged villi results in a deficiency of the lactase enzyme. Without the lactase enzyme to digest the lactose, the lactose ferments and aids in the growth of harmful intestinal microbes (Gottschall, 1997, p.26). A gluten free diet appears to be the

only solution at this point in time to treat celiac disease. A long-term gluten free diet appears to normalize permeability tests (Vogelsang, et.al., 1998, abstract).

Coffee

Foods consumed while drinking a cup of coffee are appear more likely to pass into the blood stream in a partially digested state (Braly, 1992, p.47). Thus coffee may increase gut permeability and add to the allergen load in the body.

Dysbiosis (Flora imbalance)

Intestinal dysbiosis occurs when unwanted microorganisms such as bacteria, yeast, and protozoa, colonize the gut, bind to the mucosal wall, and in some cases penetrate the gut barrier. An example of one such pathogenic fungi is Candida albicans. Candida, in its fungal form, may cause intestinal permeability by putting down 'roots' into the intestinal wall allowing comparatively large molecules to pass through into the bloodstream (Martin, 1995, p.1). The harmful bacteria competes with the host for the food in the gut causing malnutrition, and damages the intestinal lining. Bacterial overgrowth may be caused by hypochlorhydria (insufficient HCl), maldigestion, or stasis (stagnation, sluggish bowel movement, constipation) (Galland, 1995, p.64).

Damage from bacterial overgrowth is caused by bacterial enzyme activity. Bacterial mucinase destroys the protective mucus coat of the intestinal lining, while proteinases (protein enzymes) degrade pancreatic and brush border enzymes and attack structural proteins (Galland, 1995, p.64). Unhealthful bacteria in the gut can ferment carbohydrates and produce excess gas, bloating, and abdominal distention. The bacteria can break down protein via putrefaction to produce vasoactive amines (Murray and Pizzorno, 1998, p.139). Vasoactive amines cause constriction and relaxation of blood vessels by action on the smooth muscle which surrounds the vessels. This leads to increased gut permeability ("leaky gut"), abdominal pain, and altered gut motility.

A study published in the journal of *Annals of the Rheumatic Diseases* in 1993 demonstrated that many people with rheumatoid arthritis exhibit small intestine bacterial overgrowth and that the severity of symptoms is related to the level of disease activity (Murray and Pizzorno, 1998, p.139). Dysbiosis causes damage to the intestinal lining resulting in leaky gut syndrome and may exacerbate such diseases as arthritis.

Malnutrition

Under normal conditions, the intestinal epithelium cells have the fastest rate of reproduction of any tissue in the body (Galland, 1995, p.62). The old cells slough off and a new epithelium is generated every three to six days (Galland, 1995, p.62). The energy demands for this rapid cell turnover must be met if the healing and replacement of the damaged cells in the epithelium is to occur. The small intestine must obtain 50% of the energy it needs from the food actually present in it (Emsley and Fell, 1999, p.36). If the intestinal lining is damaged and the energy needs are not met, hyperpermeability ensues

(Galland, 1995, p.62). Therefore, proper nutrition and an epithelium healthy enough to absorb the nutrients provided by the food are essential for combating Leaky Gut Syndrome.

Pancreatic Insufficiency

Pancreatic insufficiency may result in increased intestinal permeability via several mechanisms. The pancreas secretes lipases, proteases, and amylases which are enzymes responsible for the breakdown of food in normal digestion. Insufficient secretion of these enzymes results in poorly or partially digested foods. These undigested foods are fermented by the bacteria in the gut and toxic by-products such as indole, phenol, skatole, methane, putrescine, cadaverine, and hydrogen gas are produced (Tyler, 1999, p.1). These toxins act on the mucosal epithelial cells and compromise the integrity of the gut causing intestinal permeability, adding to food sensitivity problems, and allowing the toxic by-products to cross the intestinal wall into the body. The toxic by-products may also damage the beneficial bacteria in the gut causing chronic imbalances in the intestinal microflora, or dysbiosis. A deficiency in pancreatic enzyme proteases also adds to dysbiosis in that proteases are largely responsible for keeping the small intestine free from parasites, including bacteria, yeast, protozoa, and helminths, or parasitic worms (Murray & Pizzorno, 1998, p.127). This imbalance contributes to intestinal infection and inflammation as the harmful bacteria takes hold. Intestinal infection and inflammation may also lead to increased intestinal permeability (Tyler, 1999, p.1).

sIgA Deficiency - Secretory IgA

Secretory IgA (sIgA) is a key immunological component of gut barrier function. It is found in large amounts in saliva, gastrointestinal fluid, and breast milk. It coats the entire course of the intestinal tract and combines with lumen antigens (antigens passing through the gastrointestinal tract) including undigested food, toxins, etc. Once combined with an antigen it prevents it from adhering to the gut lining and thus prevents its absorption into the body.

Decreased sIgA may be caused by a genetic predisposition, by chronic attack on the mucosa (intestinal lining), by pathogenic bacteria, parasites, yeast, stress, or by exposure to toxic compounds. Decreased sIgA is associated with dramatic increases in the absorption of food allergens and microbial antigens (Murray, Pizzorno, 1998, p.467). Unbound antigens attach to the intestinal lining, cause irritation, immune responses, and result in intestinal permeability, or leaky gut syndrome.

Stress

Stress compromises digestion. When a person is experiencing stress, the sympathetic nervous system (the flight or fight response) is activated. When in the sympathetic mode, the body shunts blood to the brain, heart, and long muscles so that the person may fight or flee in response to the stress. Blood however, is shunted away from the digestive tract where it is needed for proper digestion. This results in decreased enzyme secretion and peristalsis, allowing food to sit in an undigested state. The undigested food may then ferment, causing damage to the mucosal lining. Additionally,

stress reduces the secretion of secretory IgA. This may result in unbound antigens that attach, irritate, and are absorbed into the intestinal lining (Murray and Pizzorno, 1998, p.140). The results of eating when stressed may be malnutrition, toxicity, and Leaky Gut Syndrome.

In contrast, when eating in a relaxed state, the parasympathetic nervous system is activated. The parasympathetic nervous system is responsible for digestion, repair, restoration, and rejuvenation. When the body is in the parasympathetic mode, blood is shunted to the digestive tract, the pancreas secretes digestive enzymes, the intestines contract, food is digested and absorbed, and toxins and waste products are cleared from the intestinal tract. The parasympathetic mode is reached when one is in a relaxed, non-stressed state. Therefore, it is critical to be in a relaxed state while eating so that proper digestion can take place.

Toxins/Food Additives

Over 3,000 chemicals (substances produced by a chemical process) are added to the American diet in addition to over 10,000 chemical contaminants from the environment (Braly, 1992, p.47). All told, there are about 8 to 15 pounds of potentially harmful chemicals consumed per person annually (Braly, 1992, p.47). These chemicals have far reaching affects. For example, in the early 1970s Feingold found that about 50% of children with hyperactivity were improved on a diet that excluded artificial color, preservatives, and naturally occurring salicylates (Middleton, et.al., 1998, p.1173). Some of the chemicals added to our foods have the ability to change the digestive process and distort the permeability of the intestinal lining (Braly, 1992, p.47). In addition to the physical damage toxins may cause, the sheer number of them may overwhelm our intestinal immune system. There may not be enough secretory IgA to bind all the toxins. This results in toxins adhering to the mucosal lining, irritating the lining, causing damage and gaining access into the body. It is important to limit exposure to toxins whenever possible. In terms of food, this means eating an organic, whole foods, unprocessed diet. Commercially grown foods may have residues of pesticides, herbicides and other chemicals. Processed foods are full of artificial, man-made ingredients, many of which the body does not recognize and cannot digest. Anything the body cannot recognize as food is considered an enemy, and the body will try to rid itself of it. Subjected to a large amount of toxins, the body's clearing mechanisms such as the digestive tract, liver, immune and lymph systems may become overwhelmed resulting in general body toxicity and disease.

TESTS

In summary, there are many factors and mechanisms which may cause the gut to become permeable leading to Leaky Gut Syndrome. These factors include, but are not limited to, immune responses, food allergies, alcohol, antibiotics, nonsteroidal anti-inflammatory drugs (NSAIDs), celiac disease, coffee, intestinal dysbiosis, malnutrition, pancreatic insufficiency, deficient levels of secretory IgA, and stress. The challenge is to determine which factor or factors are causing the increased permeability and elliminate it

or them. There are several tests which are useful in for diagnosing leaky gut syndrome and its causes. In this section, the following tests will be briefly discussed:

Test	Diagnosis
Lactolose/Mannitol Absorption Test	Leaky Gut and Food Allergies
Comprehensive Digestive Stool Analysis (CDSA)	Digestive Wellness
Food Challenge Tests	Food Allergies/Sensitivities
Skin-Prick Test	Food Allergies (IgE only)
Enzyme-Linked Immunosorbent Assay (ELISA)	Food Allergies/Sensitivities

Lactolose/Mannitol Absorption Test

The lactolose/mannitol absorption test may be used as a diagnostic tool for leaky gut syndrome, to determine suspect food allergens or sensitivities (Galland, 1995, p. 62), and is the only non-invasive functional test for celiac disease (Vogelsang, Schwarzenhofer, Oberhuber, 1998, abstract).

The lactolose/mannitol absorption test uses two non metabolized sugar molecules (mannitol and lactulose) to test for intestinal permeability. The first sugar molecule, mannitol, is used to test for diffusion through the cells (transcellular uptake). The molecule is a small enough to passively diffuse into and through the intestinal mucosa cells. The second sugar molecule, lactulose, is a larger molecule and is used to assess the integrity of the mucosal lining. This larger molecule may gain access across the intestinal lining only by passing between the cells (paracellular uptake) through the tight junctions. To perform the test, the patient mixes pre-measured amounts of lactulose and mannitol and drinks the solution. A urine sample is then taken 6 hours later and the results assessed (Great Smokies, 1999, p.G-32). The results are interpreted as follows:

High levels of mannitol and low levels of lactulose indicate a healthy intestinal lining.
Low levels of both mannitol and lactulose are indicative of malabsorption.
High levels of both sugars are indicative of increased permeability, or "leaky gut".
A high level of lactolose with a low level of mannitol may be indicative of "leaky gut" and malabsorption.

The lactulose/mannitol ratio also supplies useful information. An elevated ratio indicates that the pore size of the gut mucosa has increased, allowing larger, possibly antigenic, molecules access into the body.

To determine suspect allergens with the lactolose/mannitol absorption test, the test is first taken while fasting, the suspect food is then eaten, and the test is retaken . If the test produces an increase in lactulose excretion (signifying hyperpermeability) or a decrease in mannitol excretion (signifying malabsorption), food intolerance is likely and warrants further investigation (Galland, 1995, p.64). However, if the initial fasting mannitol absorption is low, suspect malabsorption. Look for evidence of celiac disease, intestinal parasites, ileitis, small bowel bacterial overgrowth and other disorders associated with malabsorption (Galland, 1995, p.64). If the initial fasting lactulose is

elevated, or if the initial fasting lactulose/mannitol ratio is elevated, consider the possibility of mild inflammatory bowel disease or gluten enteropathy (Galland, 1995, p.64).

Comprehensive Digestive Stool Analysis (CDSA)

The Comprehensive Digestive Stool Analysis (CDSA) is a battery of laboratory tests which evaluate digestion, intestinal function, intestinal environment, and absorption by examining the stool (Murray, Pizzorno, 1998, p.129). The test will show if proteins, carbohydrates and fats are being properly digested, the amount and type of bacteria in the intestine, levels of secretory IgA, pH levels, and a myriad of other pertinent parameters. The results of this test are very useful in determining which part of the digestive system needs treatment or support. Due to the complexity of the test and interpretation, it will not be discussed further in this paper, although this test is strongly recommended as a diagnostic tool.

Food Allergies

Food allergies and intolerance may be tested for either by a food challenge or laboratory testing. The food challenge test is considered to be the definitive method or "gold standard" for diagnosing food allergies and food intolerance (Pizzorno, 1998, p.117), however it is very time consuming and requires discipline and motivation. The laboratory methods can supply immediate identification of suspected allergens, but they are generally expensive and are considered less reliable and somewhat controversial.

There are many different types of laboratory tests specifically for allergens, and food sensitivities, however, for the purposes of this paper, only the two most popular tests will be discussed: the skin prick test and the blood test, specifically the ELISA (enzyme-linked immunosorbent assay) blood test. Both types of tests diagnose food allergies by attempting to measure the levels of antibodies relative to food antigens. The ELISA test diagnosis allergies and sensitivities, where the skin-prick test only tests for allergies.

Food challenge

The food challenge test is an experimental test which challenges the patient with suspected allergens while carefully monitoring for reactions. There are two basic food challenge tests, the elimination or oligoantigenic diet and the pure water fast, each is followed by a food challenge. There is also an adjunct test, the coca pulse test, which may be used in combination with the other two food challenge tests.

In the elimination or oligoantigenic diet the person eats a very restricted diet of hypoallergenic foods and foods that are rarely eaten, or special hypoallergenic diet for one week to one month. A typical hypoallergenic diet consists of lamb, chicken, potatoes, rice, banana, apple, and cabbage family vegetables (broccoli, cabbage, brussel sprouts, etc.). The diet must be adjusted, however, so that no suspected allergens are eaten. Symptoms caused by food will typically disappear after the 5th or 6th day while

on the restricted diet (Murray, 1993, p.254). After the designated cleansing time, the person begins to reintroduce foods at the rate of one food for every 2 days. The reactions to any food allergies should be increased, making the spotting of sensitizing food easier. A careful record must be kept of when the food was reintroduced and what the reaction was.

The pure water fast followed by a food challenge requires fasting on water only for 5 days, symptoms should disappear by 4th day. Then foods are slowly reintroduced one at a time while keeping careful notes. The immune system should be in a hyperreactive state as a result of giving it a rest and therefore, the symptoms should be more acute and pronounced (Murray & Pizzorno, 1998, p.470). This fast is only to be done by people who are physically and mentally capable of a 5 day fast and doctor supervision is highly recommended.

The coca pulse test may be used by itself but is best used in conjunction with a food challenge during the re-introductory period. The test is conducted by first taking the resting pulse. This pulse is taken before eating a suspect food. Take the pulse in the morning for a full minute. A suspect food is then eaten and the pulse rate is immediately retaken for a full minute. The pulse rate is then taken again at 30 minute, 60 minute, and 90 minute intervals. If your pulse rate has gone up or down by more than 10 beats a minute, the suspect food is thought to be an allergen (Page, 1998, p.433).

Skin-Prick

The skin-prick or skin-scratch test is very popular among allergists. A patient's skin is scratched or pricked with a needle that contains the suspected allergen. After a period of time, the skin is examined for reactions. If there is a reaction, it is thought that an allergy exists. This test is limited, and not definitive. It only tests for IgE-mediated allergies, which accounts for only 10-15% of all food allergies. Furthermore, although a negative skin-prick test is strong evidence against a food allergy, a positive food skin-prick test is only slightly to moderately predictive of a food allergy. Only 50% of all positive skin-prick challenges were able to be confirmed by DBPCFC(double blind positive confirmed food challenge)(Burks, Sampson, 1999, abstract). This test appears to be both limited in that it only tests for IgE related immune responses, and is not definitive in that it results in false positives.

Enzyme-Linked Immunosorbent Assay (ELISA)

The enzyme-linked immunosorbent assay (ELISA) test appears to be the best and most popular laboratory blood test currently available because it is both reasonably priced and convenient (Murray, Pizzorno, 1998, p.471). The test uses an enzyme bonding process to detect antibody levels (Great Smokies, 1999, p. I-9). This test is able to measure IgE, IgG, and IgG4, antibodies. This enables the test to identify both immediate (IgE) and delayed (IgG) onset allergic reactions. Measuring IgG antibodies is very important since they are estimated to be involved in 80% of food allergy reactions (Murray, 1993, p.251).

CONCLUSION

It is time to start eating for vitality! It is time that foods start nourishing our bodies instead of slowly draining away health in the form of diseases, vague symptoms, and allergic reactions. The underlying cause of food's adverse affect is, more often than not, Leaky Gut Syndrome. To gain the most from our foods and suffer the least amount of ill effects, we must support the gut in its task of assimilating food into the body and acting as a barrier against harmful substances. This means supporting the integrity of the intestines and protecting them from damage. The paper has discussed Leaky Gut Syndrome, the diseases associated with it, where it occurs, its mechanism, its causes, tests to diagnose it and food reactions. It is my hope that through proper nutrition and lifestyle, people may heal their intestines, and thus gain energy and vitality.

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