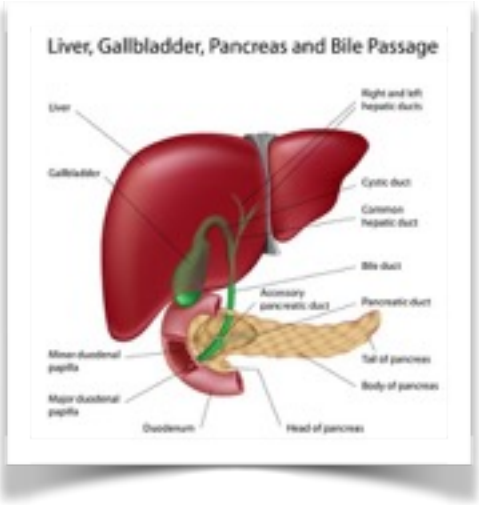
Homework: Our Body at Work
GS10 Study Group: Functional Anatomy

Part One: Liver and Gallbladder

This section is very long! The bowels, liver, and nutrients are responsible for almost all dis-ease in the body. In a society where the bowels, liver, and nutrient supply are under constant attack. Understanding these systems is vital to helping your clients.



The liver is one of the largest organs in the human body. The liver in an adult weighs about 3.1 pounds. It is found in the right upper abdomen, below the diaphragm. It takes up most of the space under the ribs and some space in the left upper abdomen.

The blood supply of the liver is unique among all organs of the body. This is due to the hepatic portal vein system. Blood traveling to the spleen, stomach, pancreas, gallbladder, and intestines passes through capillaries in these organs and is then collected into the hepatic portal vein. **The collected blood is delivered to the tissues of the liver where it is processed before being passed on to the rest of the body**.

There are six main functions of the liver:

1. **Digestion**
2. **Metabolism**
3. **Detoxification**
4. **Storage**
5. **Production**
6. **Immunity**

Many functions are sequences so the information below is a mixture of processes we need to understand to work with clients exposed to chemicals, low nutrition, missing parts (surgery), and less than optimum organ functioning for a variety of reasons.

DIGESTION & METABOLISM

The liver plays an active role in the process of digestion by producing **bile**. Bile is a mixture of water, bile salts, cholesterol, bilirubin, and the conjugated toxins from the 2 phases of liver detoxification. Hepatocytes in the liver produce bile, which then passes through the bile ducts to be stored in the gallbladder. The gallbladder is a hollow, muscular and pear-shaped organ. It is about 3 inches in length and 1.5 inches in width at its widest point.

When food containing fats reaches the **duodenum** (first section of the small intestine), the duodenum releases a hormone that stimulates the gallbladder to release the bile. Bile travels through the bile ducts and is released into the duodenum where it **emulsifies** fat.

Emulsification of fats is when large fat globules are turned into smaller particles. The smaller fat particles are further broken down by the enzyme lipase (produced by the pancreas) so they may be absorbed in the intestines.

The liver makes bile and the gallbladder stores bile until it is prompted for release.

Bile Has Two Main Functions:

1. Bile acids are the end products of cholesterol metabolism. Bile acid production is how the body disposes of excess **cholesterol**. In addition, the bile contains many waste products. The waste products include the conjugated toxins from the 2 phases of liver detoxification (carcinogens, xenobiotic chemicals, pharmaceuticals and heavy metals…) and bilirubin. When hemoglobin is broken down in the liver, bilirubin is conjugated and excreted through the bile.
2. Bile acids are **critical for digestion and absorption of fats and fat-soluble vitamins** in the small intestine. Bile acids have a detergent action on dietary fats which causes fat globules to break down (emulsified) into microscopic droplets. Emulsification is important because it greatly increases the surface area of fat, making it available for digestion by **lipases, which cannot get the inside of lipid droplets**.

Large amounts of bile acids are secreted into the intestine every day, but only a small quantity of bile, about 5%, is not absorbed back into the blood and reused. Each bile salt molecule is reused about 20 times, often two or three times during a single digestive phase.

Gallstones

Cholesterol is insoluble in water solutions, but in bile, it is made soluble by bile acids and lipids like lecithin. Gallstones, most of which are composed predominantly of cholesterol, **result from processes that allow cholesterol to precipitate from solution in bile.**

Precipitation is the creation of a solid in a solution. The solid formed is called the ‘precipitate'. The chemical that causes the solid to form is called the ‘precipitant’. The gallstone is a precipitate (bile has crystallized). The precipitant is usually a combination of factors that cause an imbalance.

Some factors that contribute to gallstone formation: low food-based trace minerals (not seawater/saltwater), low phosphorous to calcium ratios, low pH of the small intestine (candida, parasites, antacids), low choline (found in phospholipids, like phosphatidylcholine or lecithin) dehydration at cellular level, low fiber, low betaine (beets are high in betaine and fiber), high sugar/carbohydrates, fatty liver, toxic liver, and more.

Most gallstones remain in the gallbladder and are harmless, but they can be pushed out of the gallbladder along with bile and potentially block the neck of the gallbladder or one of the bile ducts. Blockage of the gallbladder or cystic duct may result in cholecystitis, a painful inflammation of the gallbladder. Blockage of the common bile duct may result in jaundice and liver damage, while blockage of the ampulla of Vater (very rare) can lead to pancreatitis.

Metabolism is usually divided into two categories:

Catabolism, the breakdown of organic matter and capturing of energy.
Anabolism, the use of energy to build cellular components like proteins and nucleic acids.

The chemical reactions of metabolism are organized into metabolic pathways, in which one substance is transformed through a series of steps into another substance. This transformation is carried out by enzymes. **Enzymes** act as catalysts that allow the reactions to proceed or proceed more rapidly.

Bilirubin present in bile is a product of the liver's digestion of worn out red blood cells. Kupffer cells in the liver catch and destroy worn out red blood cells and pass their components to hepatocytes. Hepatocytes **metabolize** (breakdown) hemoglobin, the red oxygen-carrying pigment of red blood cells, into heme and globin. Globin protein is used as an energy source for the body. **The iron-containing heme group cannot be recycled by the body and is converted into the pigment bilirubin and added to bile to be excreted from the body.**

Carbohydrate Metabolism

The liver plays an important part in maintaining normal blood glucose levels. Hepatocytes control many different metabolic pathways and use dozens of enzymes to control glucose levels. Two important control examples are:

1. Excess glucose entering the blood after a meal is quickly taken up by the liver and converted to glycogen (a process called glycogenesis). Later, when blood concentrations of glucose begin to decline, the liver breaks down the stored glycogen into glucose (glycogenolysis) and exports it back into the blood.
2. When the liver's glycogen reserves become exhausted (the person has not eaten for several hours), the liver cells activate groups of enzymes that begin producing glucose out of amino acids, fats, and non-hexose* carbohydrates (gluconeogenesis). *The hexoses include primarily glucose, fructose, galactose and mannose.

The liver converts **excess** carbohydrates and proteins into fatty acids and triglyceride, which are then exported and **stored in adipose tissue (body fat)**.

Fat Metabolism

Fatty acids are usually ingested as triglycerides, which cannot be absorbed by the intestine. They are broken down into fatty acids and monoglycerides by the pancreatic enzyme lipase. The liver reassembles some of the fatty acids back into triglycerides. Fatty acids are the most commonly stored and circulating forms of energy.

"The best source of energy for eukaryotic organisms are fats. Glucose offers a ratio 6.3 moles of ATP per carbon while saturated fatty acids offer 8.1 ATP per carbon. Also the complete oxidation of fats yields enormous amounts of water for those organisms that do not have adequate access to drinkable water. Camels and killer whales are good example of this, they obtain their water requirements from the complete oxidation of fats." - chemwiki.ucdavis.edu

Fat/Lipid metabolism is carried out predominantly by the liver. Important examples of the role of the liver in fat metabolism include:

1. The liver oxidizes triglycerides to produce **energy in the form of ATP.** Oxidation involves the removal of an electron (or hydrogen). When a molecule is oxidized it releases energy. Adenosine triphosphate (ATP) is considered by biologists to be the “energy currency” of life. It is a molecule that stores the energy we need to do just about everything we do. “Living things can use ATP like a battery”.
2. A bulk of the **lipoproteins** are produced in the liver. Many enzymes, transporters, structural proteins, and antigens are lipoproteins. Well known lipoproteins include HDL and LDL. The primary function of plasma lipoproteins is to transport dietary lipids in the circulation; these water−insoluble substances include, **cholesterol** and **fat−soluble vitamins.**
3. The liver synthesizes large quantities of **cholesterol** and **phospholipids**.

The cell membrane (plasma membrane) surrounds the cytoplasm of a cell. Its function is to protect the integrity of the interior of the cell by allowing certain substances into the cell, while keeping other substances out. Phospholipids are a major component of all cell membranes.

Cholesterol molecules are important for maintaining the consistency of the cell membrane. They strengthen the membrane and keep the phospholipid tails from coming into contact and solidifying. This ensures that the cell membrane stays fluid and flexible. Cholesterol is found in every cell of your body and plays a role in facilitating cell signaling (the ability of your cells to communicate with each other).

Protein Metabolism

Proteins are are large molecules (macromolecules), consisting of one or more long chains of amino acids. The process of breaking down protein into amino acids occurs primarily in the small intestine. There are 9 essential amino acids (need to be supplied by the diet): histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. The liver produces non-essential amino acids.

When there is an excess of protein intake, amino acids are broken down in the liver. The amino group is removed (deamination) from the amino acid and converted to ammonia. Ammonia is very toxic and if not rapidly and efficiently removed from the circulation, will result in central nervous system disease. Enzymes convert ammonia to urea or uric acid so it may be excreted in the urine.

The liver is also responsible for the production of most of the plasma proteins. Albumin, the most common protein found in the blood, provides the body with the protein needed to both maintain growth and repair tissues. Albumin is made almost exclusively by the liver.

“A key systemic function of the liver is serum protein production. The liver normally synthesizes the majority of serum proteins, including complement proteins, albumin, fibrinogen, clotting factors, transport proteins, protease inhibitors and lipoproteins. **These proteins are involved in the systemic transport of nutrients, in the regulation of blood osmotic pressure and act as inactive precursors of several innate immune mediators.** The liver also has a central role in detecting and responding to inflammatory signals from other sites in the body.”

(Robinson MW, Harmon C, O’Farrelly C. Liver immunology and its role in inflammation and homeostasis. *Cellular and Molecular Immunology*. 2016;13(3):267-276. doi:10.1038/cmi.2016.3.)

DETOXIFICATION & IMMUNE FUNCTION

There are two main cell types in the liver: Kupffer cells and Hepatocytes. While detoxification is a widely known function of the liver, newer research has revealed an extensive list of immunological tasks preformed by the liver. Researchers are now proposing that the liver is also an innate immune organ, an immune organ, and a lymphoid organ.

Hepatocytes protect the body from injury by biotransforming **toxins** and **drugs** and by **deactivating hormones**. Biotransformation is the process whereby a substance is changed from one chemical to another by a chemical reaction within the body. This “detox” reaction requires enzymes to make substances water soluble, so they can be excreted from the body in the urine and feces.

Hepatocytes also produce 80–90% of the circulating innate immunity proteins in the body. “These proteins include bactericidal proteins that directly kill bacteria, opsonins that assist in the phagocytosis of foreign bacteria, iron-sequestering proteins that block iron uptake by bacteria, several soluble factors that regulate lipopolysaccharide signaling, and the coagulation factor fibrinogen that activates innate immunity.”

(Zhou Z, Xu M-J, Gao B. Hepatocytes: a key cell type for innate immunity. *Cellular and Molecular Immunology*. 2016;13(3):301-315. doi:10.1038/cmi.2015.97.)

Kupffer cells are well known as a type of macrophage that captures and breaks down old, worn out red blood cells but, the role of Kupffer cells also includes immune function. Most bacteria that enter the bloodstream are taken up and eliminated within the liver. This elimination depends on the Kupffer cells and the bactericidal neutrophils that travel to the liver in response to infection.

The immune function role of the liver should not be underestimated. **Approximately 75% of the hepatic blood supply arrives from the intestine via the portal vein.** This blood supply contains a constant stream of food antigens, environmental antigens, and molecules from the microflora of the gut.

“These gut-derived molecules must be tolerated by the hepatic immune system, which, at the same time, is poised to respond to danger. In the healthy liver, constantly changing metabolic and tissue remodeling activity, combined with regular exposure to microbial products, results in persistent, regulated inflammation. These inflammatory processes act in a tightly controlled fashion and are stimulated to additional activity only when the liver is required to rid itself of hepatotropic pathogens, malignant cells or toxic products of metabolic activity. Failure to clear such dangerous stimuli and resolve inflammation, leads to chronic infection, autoimmunity or tumor growth.”

(Robinson MW, Harmon C, O’Farrelly C. Liver immunology and its role in inflammation and homeostasis. *Cellular and Molecular Immunology*. 2016;13(3):267-276. doi:10.1038/cmi.2016.3.)

“Intestinal bacteria play a key role in the maintenance of gut-liver axis health. **Disturbances in the homeostasis between bacteria and host-derived signals at the epithelial level lead to a break in intestinal barrier function and may foster "bacterial translocation", defined as the migration of bacteria or bacterial products from the intestinal lumen to mesenteric lymph nodes or other extraintestinal organs and sites.** While the full repertoire of gut-derived microbial products that reach the liver in health and disease has yet to be explored, the

levels of bacterial lipopolysaccharide, a component of the outer membrane of Gram-negative bacteria, are increased in the portal and/or systemic circulation in several types of chronic liver diseases. Derangement of the gut flora, particularly small intestinal bacterial overgrowth, occurs in a large percentage (20-75%) of patients with chronic liver disease. In addition, evidence implicating the gut-liver axis in the pathogenesis of metabolic liver disorders has accumulated over the past ten years."

(Compare D1, Coccoli P, Rocco A, Nardone OM, De Maria S, Cartenì M, Nardone G. Gut-liver axis: the impact of gut microbiota on non alcoholic fatty liver disease. *Nutr Metab Cardiovasc Dis.* 2012 Jun;22(6):471-6. doi: 10.1016)

"Approximately 500,000 to one million lymphocytes can be retrieved from 100 mg of normal human liver tissue… The lymphoid repertoire includes significant numbers of T-cells, B cells, natural killer (NK) and natural killer T (NKT) cells…The hepatic lymphocyte repertoire includes conventional and unconventional lymphocyte sub-populations of both the innate and the adaptive immune system."

(Bogdanos DP, Gao B, Gershwin ME. Liver Immunology. *Comprehensive Physiology*. 2013;3(2):567-598. doi: 10.1002/cphy.c120011.)

While the immune function of the liver is often overlooked its role in detoxification is well known. The liver plays several roles in detoxification: it filters the blood to remove large toxins, synthesizes and gets rid of bile full of fat-soluble toxins, and uses enzymes to breakdown and change the toxins. This later method is done in two phases.

The liver transforms toxins and deactivates hormones in two phases:

PHASE 1 The cytochrome P450 enzymes alter/change/breakdown the target molecule (toxin or hormone). These enzymes use haem iron to oxidize molecules which makes them more water-soluble for elimination. After the enzymes have broken down the substances, some very toxic end products (metabolites) remain and they must be quickly shuttled to Phase 2.

During the Phase 1 process, free radicals are produced and if there are too many it can damage the liver cells. The most important antioxidant for neutralizing the free radicals produced in Phase 1 is glutathione. Glutathione is also required for one of the key Phase 2 detoxification processes. When high levels of toxin exposure produce so many free radicals from Phase I detoxification that the glutathione is depleted, the Phase 2 processes dependent upon glutathione stop.

Sulfur is required for the proper structure and biological activity of enzymes. If you don't have sufficient amounts of sulfur in your body, the enzymes cannot function properly. The power of glutathione is the sulfur (SH) chemical groups it contains. Sulfur-rich foods include garlic, onions and the cruciferous vegetables (broccoli, kale, collards, cabbage, cauliflower, watercress, etc).

Clients with insufficient Phase 1 detoxification will experience intolerance to caffeine, perfumes and other environmental chemicals, and have an increased risk for liver disease. while those Clients with an overactive Phase 1 system will be relatively unaffected by caffeine drinks.

There are many supplements and foods we can use to enhance Phase 1 detoxification. The most important ones are B-complex vitamins, choline, inositol, vitamin C with bioflavonoids, iron, the herb milk thistle, glutathione, indoles and sulfur from cruciferous vegetables, and adequate meat/protein/amino acids.

The amount of glutathione found in foods is very low, glutathione is primarily made by the body. Glutathione is produced by cells using glutathione precursors - amino-acids glutamate, glycine and cysteine. Cysteine is a limiting factor, cysteine is an amino acid that your body combines with glutamic acid and glycine to make glutathione.

You can boost the amount of glutathione production by consuming fresh, raw foods. Foods like spinach, avocado, tomatoes, peppers, broccoli, cabbage, Brussels sprouts, beets, garlic, squash, apples, peaches, bananas, melons, turmeric, cinnamon and cardamom. Sufficient protein is also necessary for the body to produce glutathione. Selenium is necessary for formation of glutathione containing enzymes.

Milk Thistle contains silymarin, a chemical extracted from the seeds that helps to prevent the depletion of glutathione in the liver. Silymarin is a group of flavonoids (silibinin, silidianin, and silicristin) involved in the repair of liver cells damaged by alcohol and other toxic substances. Silymarin also reduces inflammation and is a strong antioxidant that helps new liver cells from being destroyed by these same toxins.

Betaine, also known as trimethylglycine is a powerful liver detoxifier that is made in the body. It's involved in liver function, cellular reproduction, production of carnitine, and it has a role in metabolizing the amino acid homocysteine. The highest concentrations of betaine are found in beets and beet greens. Individuals with bile acid insufficiency can also benefit from taking bile salts derived from either ox bile or bovine bile salts. Studies with mice suggest betaine treatment may treat non-alcoholic fatty liver (NAFL) while reversing hepatic insulin resistance.

There are no clear symptoms to identify NAFL, it is usually diagnosed with a biopsy. It is estimated that up to 33% of the adult population and 10% of the children have NAFL.

"Nonalcoholic fatty liver disease (NAFLD) is now the most common cause of chronic liver disease in children and adolescents in the United States…NAFLD is a complex metabolic disease that is strongly associated with visceral adiposity and insulin resistance. Day and colleagues proposed a "two-hit" hypothesis, which has been further refined by others. **Most experts believe that fat accumulation in the liver is the first step but alone may not be enough to induce progressive liver damage.** Additional co-factors or hits including oxidative stress (from deficiency of dietary antioxidants, glutathione depletion, mitochondrial dysfunction, hormonal imbalance, hypoxia from obstructive apnea), lipotoxicity, adipocytokines, alterations in mitochondrial permeability and stellate cell activation, among others, are potential mediators in inducing persistent liver injury leading to NASH (nonalcoholic steatohepatitis)."

(Loomba R, Sirlin CB, Schwimmer JB, Lavine JE. Advances in Pediatric Nonalcoholic Fatty Liver Disease. *Hepatology (Baltimore, Md)*. 2009;50(4):1282-1293. doi:10.1002/hep.23119.)

PHASE 2 enzymes attach substances to the toxin (conjugation) so they may be made safe for elimination through the bile and kidneys. There are six conjugation processes. **Heavy metals in particular can make these enzymes dysfunctional**.

The Six Conjugation Processes:

1. **Glutathione conjugation** (attaching toxins to glutathione) helps to detoxify and eliminate poisons in the liver, lungs, intestines and kidneys. Glutathione helps the body get rid of a wide variety of chemical compounds.

Heavy metals inhibit the replenishment of glutathione. This pathway can be inhibited by deficiencies of selenium, vitamin B2/riboflavin and zinc. Nutrients that help to raise glutathione levels include vitamin C, alpha-lipoic acid, protein and the amino acids glutamine and methionine, sulfur rich foods and cruciferous vegetables.

N-acetyl-cysteine is a precursor to glutathione, which enhances cellular detoxification and helps protect the liver and other tissues from damage by free radicals. N-acetyl-cysteine can be particularly helpful for chemical or heavy metal poisoning but….**high doses of vitamin C with bioflavonoids must be used with NAC.**

2. **Amino acid conjugation** is also known as acylation. The toxins are attached to amino acids, especially **glycine**. A low protein diet can inhibit acylation. When acylation is disturbed, it decreases bile production, which results in the poor assimilation of fats and fat soluble vitamins.

Amino acid conjugation detoxifies compounds like benzoate, aspirin and toluene (a widely used industrial solvent). This action may be enhanced by alkalizing the pH and taking the amino acid glycine. Glycine rich foods include sesame seeds, spirulina, seaweed/ bladderwrack, eggs, beef, chicken, lamb, pork, shellfish, and wild game animals.

3. **Sulfation** eliminates toxins by attaching them to sulphate. This is the primary pathway for eliminating excess neurotransmitters, several drugs and environmental toxins, some food additives and toxins from intestinal bacteria. Non-steroidal anti-inflammatory drugs inhibit sulfation.

Sulfation can be enhanced by protein, amino acids like methionine and cysteine, taurine, glutathione, MSM, garlic, onions and cruciferous vegetables, N-acetyl-cysteine, vitamin B1/ thiamine and B2/riboflavin, and magnesium.

4. **Glucuronidation** is when glucuronic acid,a metabolite of glucose, is attached to toxins. This pathway is used as a **back-up** for sulfation or glycination. It is used to eliminate chemical and bacterial toxins, excess steroidal hormones (like estrogen), toxins from fungal infections and a variety of chemical toxins. Aspirin and benzodiazepines (many anxiety drugs) will inhibit glucuronidation.

5. **Acetylation** attaches acetyl Co-A to toxins. Acetyl-CoA is an important molecule in metabolism and used in many biochemical reactions. It is referred to as the "Hub of Metabolism" inside cells. The structure group is linked to pantothenic acid. People who are chemically sensitive, have strong seasonal allergies, or are very sensitive to drugs and herbs (small amounts only) may have inefficient acetylation.

Acetylation is used to eliminate excess histamine, serotonin, sulfa drugs, chemicals like hydrazines (found in rocket propellants and fuels, chemical reactants, medicines, and in cancer research.). Deficiencies of B2/riboflavin, B5/pantothenic acid, vitamin C, L-carnitine, and CoQ10 inhibit acetylation.

6. **Methylation** attaches the amino acid methionine to toxins. **This process occurs in every cell of the body** and helps the body get rid of excess hormones and neurotransmitters, including steroidal hormones like estrogen, adrenaline, dopamine, melatonin, histamine and serotonin. It also helps eliminate homocysteine and a variety of chemicals.

Homocysteine is a common amino acid found in the blood and is acquired mostly from eating meat. High levels of homocysteine **and** low levels of betaine, B6, B12, and folate increases inflammation which leads to heart and blood vessel disease.

Many important processes rely on methylation, including the metabolism of lipids and DNA. Scientists suspect that adequate methylation of DNA can **prevent the expression** of harmful genes, such as cancer genes.

Besides the amino acids methionine, cysteine, serine, and glycine, methylation can be enhanced with B-vitamins (B6, B12, folic acid, B2/riboflavin, and choline), betaine, magnesium and SAM-e. Magnesium is essential for the methylation enzyme.

STORAGE AND PRODUCTION

The liver also plays an important role in vitamin and mineral storage. The recognized stored nutrients include B12, iron, copper, zinc, vitamins A, C, D, E, and K. Fat-soluble vitamins (A, D, E, and K) are essential for human health and must be obtained from foods.

Vitamin A

About 80% of the body's vitamin A stores are concentrated in fat droplets within the stellate cells of the liver. Retinol, the basic form of vitamin A, is obtained from animal foods. The liver produces vitamin A from beta-carotene (found in plant foods) but the conversion rate depends on several factors. The health of the intestines and gallbladder function are two factors. Beta-carotene is absorbed within the intestine (intestinal inflammation reduces absorption of nutrients) and beta-carotene is only converted into vitamin A **in the presence of bile acids**.

Vitamin A has many functions in the body. It is essential for cell division, gene expression, and regulation of the immune system. It is also needed for the eyes adjustment to light changes, bone growth, tooth development, and reproduction. The skin, eyes, and mucous membranes of the mouth, nose, throat and lungs depend on vitamin A to remain moist. The combination of supplemental vitamin **A and iron** seems to reduce anemia more effectively than either supplemental iron or vitamin A alone.

No increase in the risk of vitamin A-associated birth defects has been observed at doses of preformed vitamin A from supplements below 3,000 mcg/day (10,000 IU/day). Vitamin A from beta-carotene is not known to increase the risk of birth defects. Generally, signs of toxicity are associated with **long-term consumption of vitamin A in excess of ten times the RDA** (8,000 to 10,000 mcg/day or 25,000 to 33,000 IU/day). Vitamin A deficiency is a known risk factor for severe measles.

Vitamin D

Vitamin D is synthesized in the skin through a process that requires sunlight, or it can be obtained from the diet. Dietary sources include cholecalciferol (vitamin D_3, animal origin) and ergocalciferol (vitamin D_2, plant origin). Whether obtained from the diet or sunlight, **vitamin D must be converted** to its bioactive form, 1α,25-dihydroxyvitamin D_3, by the action of cytochrome **P450 enzymes in the liver and kidney**. More than 50 genes in tissues throughout the body are known to be regulated by 1,25-dihydroxyvitamin D_3.

Vitamin D toxicity (hypervitaminosis D) induces abnormally high blood calcium levels (calcium comes out of the tissues and bones to "match up" with the vitamin D. This could result in bone loss, kidney stones, and calcification of organs like the heart and kidneys if untreated over a long period of time. Hypercalcemia has been observed following daily doses of greater than 50,000 IU of vitamin D (doctors love to give this amount to people as D2). Overall, research suggests that vitamin D toxicity is very unlikely in healthy people at intake levels lower than 10,000 IU/day.

Vitamin E

Vitamin E is a blanket term for eight different naturally occurring nutrients—four different tocopherols and four different tocotrienols. The focus of studies has been on alpha-tocopherol. Vitamin E is a potent antioxidant that protects fats from oxidative damage. Vitamin E is a is incorporated into the lipid (fatty) part of the cell membrane. It stabilizes and protects the cell membrane from toxic compounds and oxidative damage. In addition to maintaining the integrity of cell membranes throughout the body, alpha-tocopherol also protects the fats in low density lipoproteins (LDLs) from oxidation.

Vitamin E has several other functions that are not related to its antioxidant capacity. It inhibits platelet aggregation (blood clots), and affects the activities of molecules and enzymes in immune and inflammatory cells. The developing nervous system of babies appears to be especially vulnerable to vitamin E deficiency. Children with severe vitamin E deficiency at birth rapidly develop neurological symptoms if not treated with vitamin E.

Vitamin K

There are three types of vitamin K:

1. Vitamin K1, or phylloquinone, is found naturally in plants, especially green vegetables.
2. Vitamin K2 (menaquinone) is made by the bacteria that line your gastrointestinal tract.
3. Vitamin K3 (menadione) is a synthetic form that has led to toxicity in infants injected with it - **It is my understanding that K1 is now used in hospitals when giving the shot to infants immediately after birth.**

Although vitamin K is a fat-soluble vitamin, the body stores very small amounts that are rapidly depleted without regular dietary intake. Vitamin K deficiency results in impaired blood clotting, easy bruising and bleeding, nosebleeds, bleeding gums, blood in the urine, blood in the stool, tarry black stools, or extremely heavy menstrual bleeding (lack of vitamin C and bioflavonoids will also result in easy bruising and bleeding). In infants, vitamin K deficiency may result in life-threatening bleeding within the skull.

Vitamin K2 is needed for proper bone density. Your body needs vitamin K to use calcium to build bone (and fatty acids, phosphorus, vitamin D, trace minerals, protein…) Bones are a living tissue that goes beyond needing more calcium. A number of studies have shown that vitamins K1 and K2 are effective against cancer.

Iron

Except for the iron in the hemoglobin of the blood, by far the greatest proportion of iron in the body is stored in the liver in the form of *ferritin*.

Although many people don't think of iron as being a nutrient, you might be surprised to learn that **low iron is the most common nutritional deficiency in the U.S.** Almost 10% of women are iron deficient, according to figures from the Centers for Disease Control and Prevention." - WebMD

"Anemia is common in the elderly and occurs in up to 23 percent of adults ages 65 and older." "The condition has also been linked in studies to an increased risk of early death."- Kristine Yaffe, MD at the San Francisco Veterans Affair Medical Center.

A published study in *Neurology* (11 year study with 2,552 older adults) - *"***The research found that people who had anemia at the start of the study had a nearly 41 percent higher risk of developing dementia than those who were not anemic."**

Copper

According to recent surveys, only 25% of the US population consume the amount of copper a day estimated to be adequate by the US Food and Nutrition Board of the National Academy of Sciences.

Foods that are especially rich in copper include most nuts (especially brazils and cashews), seeds (especially poppy and sunflower), chickpeas, liver and oysters. Natural foods such as cereals, meat and fish generally contain sufficient copper to provide up to 50% of the required copper intake in a balanced diet.

Copper combines with certain proteins to produce enzymes that act as catalysts to help a number of body functions. Some help provide energy required by biochemical reactions. Others are involved in the transformation of melanin for pigmentation of the skin and still others help to form cross-links in collagen and elastin and thereby maintain and repair connective tissues. This is especially important for the heart and arteries. **Research suggests that copper deficiency is one factor leading to an increased risk of developing coronary heart disease.** There are four copper-containing enzymes that oxidize ferrous iron into ferric iron. Ferric iron is the form of iron that can be carried to to the site of red blood cell formation.

Zinc

“Zinc plays an essential role in Phase One detoxification. A deficiency of zinc doesn't stop Phase One detoxification, but shifts the activity of Phase One enzymes in a direction that encourages the formation of cancer-promoting chemicals. In my clinical experience, zinc deficiency, as measured by low plasma zinc levels, is quite common in the United States. Few foods are really rich in zinc, so supplementation is often useful.” - Leo Galland, MD, Integrative Medicine

Zinc is an essential trace element required for normal cell growth, development, and differentiation. It is involved in DNA synthesis, RNA transcription, and cell division and activation. It is a critical component in many zinc protein/enzymes, including critical zinc transcription factors. Zinc deficiency/altered metabolism is observed in many types of liver disease, including alcoholic liver disease (ALD) and viral liver disease.

“Early research has looked at the use of zinc for herpes types 1 or 2. Several studies used combination treatments, so the exact role of zinc is unclear. However, most results suggest that zinc may be a safe and effective alternative treatment for herpes types 1 and 2.” - MayoClinic

Zinc reduces the amount of copper your body absorbs, and high doses of zinc can cause a copper deficiency. For that reason, many doctors recommend that you take 2 mg of copper along with a zinc supplement.

Vitamin B12

Vitamin B12 is bound to the protein in food. **Acid in the stomach releases B12 from protein during digestion.** Once released, B12 combines with a substance called intrinsic factor (IF) in the stomach. In the intestines it is then bound to R-protein in the intestines, and finally it is metabolized in the liver to methyl-cobalamin for use in blood and nerve cells. It must also be metabolized to adenosyl-cobalamin for use in mitochondria cells. This is a very complex set of actions and not everyone does this effectively.

Methyl B12 sublingual is an effective way to supplement this vitamin. Vitamin B12 is also a methyl donor in Phase 2 liver detoxification.

“There are many causes for vitamin B_{12} deficiency. Surprisingly, two of them are practices often undertaken to improve health: a **vegetarian diet** and **weight-loss surgery…** It’s a good idea to ask your doctor about having your B12 level checked if you: are over 50 years old, take a proton-pump inhibitor (such as Nexium or Prevacid) or H2 blocker (such as Pepcid or Zantac), take metformin (a diabetes drug), are a strict vegetarian, have had weight-loss surgery or have a condition that interferes with the absorption of food”

(https://www.health.harvard.edu/blog/vitamin-b12-deficiency-can-be-sneaky-harmful-201301105780)

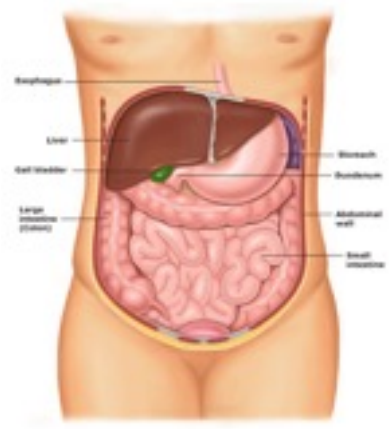
Metformin is the most widely used oral hypoglycaemic drug and it is associated with a decrease in B12.

Part Two: Digestion - Stomach, Pancreas, and Intestines

PROTEIN AND PROTEASES

Proteins are essential for life, so understanding how protein digestion and absorption work is essential. Proteins are used by the body for repairing and building cells and for creating enzymes, neurotransmitters, DNA, RNA, and more.

Proteins are **very complex** organic compounds made up of nitrogen containing compounds known as amino acids. Proteases are the enzymes that break the proteins into amino acids so the body may use them. Proteases are also called proteolytic enzymes or systemic enzymes.



Proteases are used throughout the body (systemically), not just for the digestion of food. They break down parasites, fungus, and bacteria which are composed of protein and even some viruses have a protein film coating. In the blood the proteases can break down undigested protein, cellular debris, and toxins, sparing the immune system this task.

They also break down harmful substances produced at sites of injury or inflammation and play an important role in preventing and eliminating blood clots. When proteases are at work outside of the digestive process they are often referred to as systemic enzymes.

A protease deficiency compromises the immune system and can lead to edema (fluid retention) anywhere in the body, including swelling of the hands and feet or fluid in the ears. Toxic colon syndrome (a buildup of toxins in the large intestine) is another result of the inability to digest protein. Protein, when digested properly, supplies acidity to the blood. If protein isn't digested, the blood acquires excess alkaline reserves, which must be continuously dumped via the kidneys into the urine.

You may have read that your body needs to be more alkaline but this is over-simplifying a very complicated topic. Your body's average blood pH is 7.35 to 7.45, which is slightly alkaline. Your stomach needs an acidic environment to work properly and has the highest acidity in your body (pH 2 - 4). Your colon requires a slightly acidic environment (pH 5.5 - 7). Even within your blood supply there is variation – blood that has circulated around your stomach has a lower pH than blood in other parts of your body.

Protease supplements can be taken with meals to increase digestion of protein. Between meals, protease helps alleviate infections (bacterial and viral), and enhances the immune system in general. Proteases are vital during inflammatory conditions, especially those associated with soft tissue trauma from an accident or surgery.

There are three principal proteases in the digestive system: pepsin, chymotrypsin and trypsin. During the process of digestion, these enzymes, each of which is **specialized in breaking links between specific types of amino acids**, **work together** to break down dietary proteins into their components Pepsin only works in the acidic environment of the stomach. If the stomach is not acidic enough to activate pepsin, complete protein digestion is inhibited.

Wikipedia: “Protein digestion occurs in the stomach and duodenum in which 3 main enzymes, pepsin secreted by the stomach and trypsin and chymotrypsin secreted by the pancreas, break down food proteins into polypeptides that are then broken down by various exopeptidases and dipeptidases into amino acids.” **So, the digestion of protein is very complex and requires at least 3 enzymes to get the process in motion and many additional enzymes to complete the process.**

DIGESTION

Digestion starts in the brain in anticipation of food. When food enters the mouth your chewing action stimulates the production of salivary amylase, an enzyme in saliva that starts the digest the starch. The mass of chewed food is called a *bolus*. You voluntarily swallow it, but the rest of the digestion-absorption process is involuntary.

Stomach

A ring-like muscle called the lower esophageal sphincter relaxes, allowing the chewed food to enter. Peristalsis (muscle contraction) mixes the chewed food with gastric secretions containing gastrin, hydrochloric acid (HCl), and digestive enzymes to produce a thick slurry called *chyme*. Gastrin is a hormone that stimulates the stomach to secrete gastric juice.

Parietal cells in the stomach produce two important secretions: intrinsic factor and hydrochloric acid.

- Intrinsic factor is a glycoprotein that binds to the **vitamin B_{12}** in the stomach and allows the vitamin to be absorbed in the small intestine.
- Hydrochloric acid doesn’t eat away at the stomach mucosa (lining) because you also have cells that secrete mucus to protect your stomach wall. Hydrochloric acid **protects the body by killing many of the bacteria, parasites, and other microorganisms naturally found in food.** Hydrochloric acid also helps to digest proteins by denaturing/unfolding them so it is easier for enzymes to break them down.

Cells in the stomach produce two digestive enzymes: pepsinogen and gastric lipase.

- When pepsinogen reaches the acidic pH found in the stomach it becomes the active enzyme pepsin. Pepsin is the only protein enzyme capable of digesting collagen, one of the main components of connective tissue in animals.
- Pepsin is most efficient in breaking peptide bonds between hydrophobic and aromatic amino acids such as phenylalanine, tryptophan, and tyrosine.
- Gastric lipase is an enzyme that digests fats by removing a fatty acid from a triglyceride molecule.

Stomach mucus is also rich in bicarbonate ions, which neutralize the pH of stomach acid. Baking soda is sodium bicarbonate and is an excellent way to settle/neutralize stomach acid pains while providing bicarbonate for the body. Another benefit of baking soda is its ability to promote a more alkaline pH balance in the body.

All antacids may inhibit digestion so it is best to use it between meals. Antacids that stop the stomach from producing HCl may result in bacterial infections because they remove the first line of defense. Baking soda is high in sodium. It's not safe in high doses and shouldn't be used for long periods of time. Individuals who have edema, liver disease, kidney disease, or high blood pressure (salt sensitive high blood pressure) should not use baking soda.

PANCREAS

The pancreas is located behind the stomach and is surrounded by other organs including the small intestine, liver, and spleen. It is about six inches long and is rather flat. It has both an exocrine and an endocrine functions.

Exocrine Function:
When the chyme starts to enter the small intestine from the stomach, the pancreas releases bicarbonate to neutralize the acid (HCl was in the stomach). The mucosa of the small intestine does not have as much protective mucus as the stomach.

The pancreas also produces and releases **enzymes** for digestion. Pancreatic enzymes continue the digestion of food in the small intestine after plant enzymes, pepsin, and hydrochloric acid have begun the digestive process in the stomach. There are approximately 22 pancreatic enzymes. In addition to the proteases, lipase and amylase, the pancreas produces many other digestive enzymes, including ribonuclease, deoxyribonuclease, gelatinase and elastase.

Endocrine Function: The endocrine component of the pancreas consists of islet cells that create and release hormones directly into the bloodstream. Two of the main pancreatic hormones are **insulin, which acts to lower blood sugar**, and **glucagon, which acts to raise blood sugar**. Maintaining proper blood sugar levels is crucial to the functioning of key organs including the brain, liver, and kidneys.

ENZYMES AND SMALL INTESTINE

Lipase is an enzyme that the body uses to break down fats in food so they can be absorbed in the intestines. Because of their lack of water-solubility, the majority of the fats do not enter the portal circulation (liver). They are packaged with cholesterol and coated with proteins to form particles called chylomicrons. The lymphatic vessels transport the chylomicrons to the bloodstream. Supplementing with digestive enzymes that include bile salts and lipase often help those with liver and gallbladder issues (or removal of gallbladder), or complain of stomach issues after eating healthy fatty foods (avocados, eggs, fish oil).

The alpha-**Amylases** breaks down starch into the sugars called disaccharides and trisaccharides. They are converted by other enzymes to glucose to supply the body with energy. β-amylase breaks starch into maltose. Various sugars are produced during digestion or occur naturally in the food. Some of the enzymes used in the breakdown of sugars are maltase, sucrase, and lactase. Lactase breaks down the sugar lactose that is in cow's milk. Lactase is absent in most adult humans.

Proteases: Proteases represent a diverse set of enzymes that act on the peptide bonds within proteins. They can be divided into the type of bonds they break, including serine, threonine, cysteine, aspartic and metallo proteases. The two proteases trypsin and chymotrypsin are grouped into the serine protease family.

The two major pancreatic proteases are **trypsin** and **chymotrypsin.** They are stored in an inactive state within special cells (the active state would result in the enzyme eating the cell!) Once trypsinogen and chymotrypsinogen are released into the small intestine, they must be converted into their active forms in order to digest proteins.

Trypsin and chymotrypsin digest proteins into peptides but they cannot digest proteins and peptides into single amino acids. Some of the other proteases from the pancreas have that ability, but the final digestion of peptides into amino acids is largely due to **peptidases on the surface of small intestinal epithelial cells.** Dipeptidyl **Peptidase** IV (DPP IV), a type of **protease**, has been shown to break down the proteins in gluten and **casein**.

To absorb all of the nutrients your body requires, the walls of the small intestine are wrinkled and folded, which increase its surface area threefold. The folds are covered with tiny fingerlike projections called *villi*, which, in turn, are covered, by microscopic projections called microvilli. This combination of folds and projections increases the absorptive area of the small intestine 600-fold. Each square inch of mucosa contains around 20,000 villi.

If the small intestine is inflamed from food intolerances, improper pH, parasites, candida, lack of nutrients to keep the tissue healthy… **it will inhibit the passage of nutrients.**

“Independent of the cause and location, inflammation - even when minimal - has clear effects on gastrointestinal morphology and function. These result in altered digestion, absorption and barrier function. There is evidence of reduced villus height and crypt depth, increased permeability, as well as altered sugar and peptide absorption in the small intestine after induction of inflammation in experimental models, which is supported by some clinical data. Identification of inflammatory factors which may promote the process of gastrointestinal dysfunction as well as clinical research to verify experimental observations of inflammatory modulation of gastrointestinal function are required. Moreover, nutritional strategies to support functional restitution are needed.”

Peuhkuri K, Vapaatalo H, Korpela R. Even low-grade inflammation impacts on small intestinal function. *World Journal of Gastroenterology : WJG*. 2010;16(9):1057-1062. doi:10.3748/wjg.v16.i9.1057.

Because amino acids have very small dimensions, they are able to penetrate the intestinal lining. From this point on, they enter the blood stream/portal circulation (through the liver). Digested nutrients that leave the digestive tract take a detour to the liver before entering the general bloodstream. Amino acids entering the liver require processing before they can be used as an energy source.

Once in the bloodstream, amino acids, sugars, and fats are transported by liquid blood plasma and red blood cells to various tissues, depending on where cell structures need to be created or repaired.

COLON

Peristalsis (muscle contractions) pushes food waste, fiber, and any foreign materials through the small and large intestines. More water and salts are absorbed from the large intestine. As the contents move downward feces is formed. Feces consists of water, fiber, intestinal secretions and dead bacteria. It is eventually pushed through the anus. The large intestine absorbs essential vitamins produced by gut bacteria, and it reclaims water from feces.

Part Three: Pituitary, Thyroid, and Adrenals

The pituitary is a pea-sized gland located at the base of the brain. It is often called the "master gland" because it secretes several hormones that regulate the entire body. The pituitary gland has 2 lobes.

1. **Anterior lobe** - only has an endocrine function (7 hormones are secreted out/into the bloodstream).
2. **Posterior lobe** - only secretes 2 hormones but it is the link to the hypothalamus. The hypothalamus produces the releasing and inhibiting hormones, which stop and start the production of other hormones throughout the body.

So, the pituitary is the "master gland" as far as production of hormones but it is the hypothalamus that gives the orders. The hypothalamus is a small almond sized gland located in the brain, above the pituitary gland and brain stem.

Posterior lobe hormones:

- Anti-diuretic hormone (ADH) helps control urine production and manages the water balance in the body.
- Oxytocin is the hormone that produces contractions of the uterus during childbirth.

Anterior lobe hormones:

- Growth hormone (GH) regulates bone and tissue growth and helps maintain a balance of muscle and fat tissue in the body.
- Thyroid-stimulating hormone (TSH) signals the thyroid gland to make T3 (triiodothyronine) T4 (thyroxine). T3 and T4 help control your body's metabolism.
- Luteinizing hormone (LH) regulates testosterone production in males and estrogen production in females.
- Follicle-stimulating hormone (FSH) signals sperm production in males and egg development and ovulation in females.
- Adrenocorticotropic hormone (ACTH) stimulates the adrenal glands to produce other hormones, such as cortisol.
- Prolactin regulates the development of breasts and breast milk in females.
- Melanocyte–stimulating hormone targets those cells producing melanin, which controls our skin color.

"**Vitamin A** deficiency and the **iodine** deficiency disorders affect > 30% of the global population… Vitamin A deficiency has multiple effects on the pituitary-thyroid axis; vitamin A status modulates thyroid gland metabolism, peripheral metabolism of thyroid hormone, and production of thyrotropin (TSH) by the pituitary." and "These results suggest that **vitamin E** may play an important and potent role in hormone production in the pituitary-gonadal axis in humans…" Zimmermann. Interactions of vitamin A and iodine deficiencies: effects on the pituitary-thyroid axis. Int J Vitam Nutr Res. 2007 May;77(3):236-40.

Vitamin E has a cellular effect on the thyroid gland, along with the adrenals and pituitary gland. Vitamin E also works closely with selenium, as both are important for the proper conversion of T4 to T3.

Nutrition is directly related to the health of the endocrine system. The same vitamins, minerals, fats, and amino acids needed for proper liver function, cell building, enzyme function, etc. are need for all systems. While some items may seem like they are related to only one system it is a false way to view the body. Iodine is one example.

Thyroid

The function of the thyroid gland is to take iodine and convert it into thyroid hormones: thyroxine (T4) and triiodothyronine (T3). These cells combine iodine and the amino acid tyrosine to make T3 and T4. Every cell in the body depends upon thyroid hormones for regulation of their metabolism. Iodine is a vital micronutrient required at all stages of life; fetal life and early childhood being the most critical phases of requirement.

"While major portion of iodine is concentrated in the thyroid gland, **the non hormonal iodine is found in a variety of body tissues including mammary glands, eye, gastric mucosa, cervix and salivary glands.** With the exception of mammary tissue the function of iodine in these tissues is still not clear. Accumulation of iodine in the breast plays an important role during breast feeding in fetal and neonatal development; however such iodine has also proven to have antioxidant function. In the presence of hydrogen peroxide and peroxidase, iodide acts as an electron donor, thereby decreasing damage by free oxygen radicals. On the contrary, breasts with inadequate iodine stores are prone to get damaged by accumulating high levels of malondialdehyde, a product of lipid peroxidation." Ahad F, Ganie SA. Iodine, Iodine metabolism and Iodine deficiency disorders revisited. *Indian Journal of Endocrinology and Metabolism*. 2010;14(1):13-17.

In addition to iodine, the thyroid is dependent upon selenium. Organic compounds of selenium are better absorbed and include selenomethionine and selenocysteine. Inorganic compounds of selenium include selenite and selenate. Selenomethionine is found in vegetable sources, especially cereals.

"Selenium is incorporated into body proteins in place of methionine; therefore, supplements containing selenomethionine are those which have more bioavailable selenium. In turn, selenocysteine, a selenium analogue of the amino acid cysteine, is found mainly in animal foods. The inorganic forms (selenate and selenite) are the components of dietary supplements." (Ventura M, Melo M, Carrilho F. Selenium and Thyroid Disease: From Pathophysiology to Treatment. *International Journal of Endocrinology*. 2017;2017:1297658. doi:10.1155/2017/1297658.)

Adrenal

The adrenal glands secrete almost 50 hormones, including adrenalin, cortisol, estrogen and testosterone. Many of the hormones secreted help to regulate your body's response to stress. When people are under ongoing, chronic stress adrenal fatigue is often the result. Adrenal fatigue is a collection of symptoms that result from no longer functioning optimally. Chronic exposure to stress means that your adrenals are releasing cortisol too often.

Chronically high cortisol levels in the blood have been linked to:

- Lowered immunity
- Decreased bone density and muscle tissue
- Increased blood sugar and insulin resistance
- Increased abdominal fat
- Problems with mental function

Recovering and preventing adrenal fatigue requires both nutrition and addressing the stress levels. Cutting back on work and activities, letting go of negative emotions like guilt or anger… Engaging in stress-relief activities like gentle exercises, prayer/meditation, reading uplifting books instead of TV, stop watching the news and violent movies…

Nutrition for Adrenals: B-complex vitamins with 25-50 mg of B6 in the formula, vitamin C with bioflavonoids, calcium and magnesium, an herbal blend of valerian root, passionflower, withania, and licorice, and an herbal blend to gently feed and stimulate the liver (dandelion, nettles, bladderwrack/kelp, and yellow dock). Eliminate caffeine, alcohol, grains, sugar, and all processed food.

"Animal studies have proven that **iodine** normalizes elevated adrenal corticosteroid hormone secretion related to stress and reverses the effects of hypothyroidism on the ovaries, testicles and thymus in thyroidectmized rats. Iodine may also have a role in immune function; when placed in a medium containing 10^{-6} M iodide, human leukocytes synthesize thyroxine."

(Ahad F, Ganie SA. Iodine, Iodine metabolism and Iodine deficiency disorders revisited. *Indian Journal of Endocrinology and Metabolism*. 2010;14(1):13-17.)

Part Four: Lymphatic System

The circulatory and lymphatic system are interconnected. In the circulatory system, blood flows from the heart, through the arteries, and into capillaries that surround all cells. When blood reaches the capillaries, some of blood plasma (the liquid portion of the blood) seeps out of the capillaries and into the space surrounding cells. The space surrounding the cells in filled with fluid and is called interstitial fluid. When the plasma enters this fluid-filled space it is called tissue fluid.

So, the liquid portion of blood is called blood plasma until it seeps out of the capillaries and into the fluid that surrounds the cells - then it is just tissue fluid. Because this tissue fluid fills the space outside of each cell in the tissues of the body it is called interstitial fluid.

The lymphatic system is a complex network that includes of organs, ducts, and nodes. It transports the fluid called lymph. Lymph is the name given to interstitial fluid which enters the lymphatic vessels. So, when the fluid surrounds the cells of all our tissues it is called interstitial fluid and when this same fluid enters the lymphatic vessels it is called lymph.

"**Extracellular fluid** usually denotes all body **fluid** outside of the cells. The remainder is called intracellular **fluid**. In some animals, including mammals, the **extracellular fluid** can be divided into two major subcompartments, interstitial **fluid** and blood plasma. The **interstitial fluid** is found in the **interstitial** spaces, also known as the tissue spaces."

Some tissue fluid/interstitial fluid returns to blood capillaries by osmosis. (Osmosis is the process by which fluids and substances dissolved in them pass through a membrane until all substances involved reach a balance.) The rest of the tissue fluid enters the lymphatic vessels.

Lymphatic Fluid

Lymph/lymphatic fluid contains unused nutrients and proteins, hormones, fatty acids, bacteria, fungi, parasites, toxins and cellular waste products. It also contains the immune cells, lymphocytes and dendritic cells.

The three main functions of the lymphatic system are:

- Return unused proteins and fluid to the blood circulation to maintain a low interstitial fluid protein concentration and maintain the correct pressure needed for the blood capillaries. Edema occurs when the lymphatic system is unable to take-up the interstitial fluid - this results in increased pressure.
- Transport fats (called chyle) from digestion to the blood. The fats are absorbed into the lymphatic lacteals in the villi of the small intestine. They then travel in the lymph and enter the circulation through the thoracic duct.
- Defend the body - immune cells travel through the fluid and they reside in the lymph nodes.

Lymphatic Organs, Ducts, and Nodes

LYMPH NODES are located in all areas of the body (except in the brain and spinal fluid column). Many are close to the surface where you can feel them when they are swollen and some are strategically placed deep in the body. There are 600 to 700 lymph nodes in the human body that filter the lymph before it returns to the circulatory system.

The lymph nodes contain 2 regions within them – these include the cortex and the medulla. The nodes contain white blood cells that can attack any bacteria or viruses they find in the lymph as it flows through the lymph nodes. The cortex contains predominantly B-lymphocytes and some T-lymphocytes.The B lymphocytes mature completely within the bone marrow while the T lymphocytes exit the bone marrow immature and attain maturity within the thymus.

The **SPLEEN** is the largest lymphatic organ in the body and it has multiple functions. Blood is filtered in the spleen's narrow passages within the organ. Healthy blood cells can easily pass but old or damaged red blood cells are broken down by large white blood cells. The spleen will save any useful components from the old blood cells, including iron, so they can be reused in new cells.

The spleen stores platelets and white blood cells so when it is filtering the blood it is capable of "capturing" bacteria, viruses, and other foreign particles. When the spleen detects potentially dangerous bacteria, viruses, or other microorganisms in the blood it, along with your lymph nodes, creates an army of lymphocytes.

Lymphocytes (T cells and B cells) are a type of white blood cell that produces antibodies. Antibodies and white blood cells stop infections from spreading through the body by trapping and destroying them. Half of all monocytes in the body are stored in the spleen. Monocytes are a type of white blood cell that can engulf a solid particle (bacteria, viruses, nutrients…). The spleen also helps control the amount of blood in the body.

THYMUS functions include T-lymphocyte maturation, development, and control. It lies behind the chest bone just above the heart. T-cells are an important part of the immune system.They are white blood cells that coordinate the body's immune response against viruses, parasites and bacteria. “Although previous studies showed the thymus was only active in childhood and then atrophied, in 1998 these UT Southwestern researchers reported in *Nature* that the thymus gland continues to produce T-cells throughout life. Their study involved patients with damaged immune systems due to HIV.” (http://www.unisci.com/stories/20011/0302012.htm)

TONSILS AND ADENOIDS are also part of the lymphatic system. The tonsils protect the body from potential infection of invading pathogens into the respiratory system and the digestive system. Digestive system? Only because of definitions: The digestive system is a series of hollow organs joined in a long, twisting tube from the mouth to the anus.

Lymphatic Congestion

There is no “pump” for the lymphatic system (like the heart). It moves through the body in a series of one-way valves. As your muscles contract or you move around, you're squeezing the lymph vessels in your body and causing the lymph to move toward your neck to the thoracic duct.

When you have been sitting down for a long time and not moving your feet, your feet may get a little swollen. The swelling is the fluid that leaked from your capillaries into the interstitial space of your feet. When you start moving your feet around, walking, you'll eventually push that fluid into your lymphatic system through those one way ducts and up toward your neck. EXERCISE is crucial for lymphatic movement.

When your lymph is congested your body looks for alternative ways to get rid of “trash”. Creating mucous out of it is the common response. Excess mucous in the morning or regular drainage during the day is a signal that the lymphatic system is in trouble. When faced with congestion, the system will also route the “trash” to your skin. This results in acne, eczema, dry skin, especially around the neck and face.

When lymph is congested the lactic acid, toxins, bacteria… will accumulate in the fluid around cells. You live and die at the cellular level. Cells exposed to “trash” may experience starvation (nutrients not flowing in), and mutation (toxins damaging the cell walls and getting in to damage DNA).

The breast is surrounded by a heavy concentration of lymph nodes. Congestion in this area caused by tight or underwire bars, not breast feeding, not exercising, not massaging, contributes to breast cancer.

When children develop lymphatic congestion then their ears do not drain properly resulting in various ear-related issues. Food intolerances and allergies may result in small intestine inflammation that will inhibit lymphatic (and essential fatty acids) movement through the intestines. Diets too low in protein will decrease the pressure of interstitial fluid. Decreased pressure equals stagnation (the proteins and plasma create the pressure). Stagnation is the enemy of your lymph system.

The lymphatic system is crucial for health.

Exercise
Avoid foods that are common food intolerances (wheat, dairy, soy, corn)
Drink the proper amount of water
Massage your breasts
Limit the time you use underwire bras and never sleep with sports bras
Keep you bowels and liver functioning at optimal levels

Poke root is an excellent herb to use (combined with other herbs) when addressing the issue of lymphatic cleansing and health. Additional herbs, diet changes, and supplements should address the cause of lymphatic congestion and support the organs and tissues in danger because of the stagnation. Where there is a need to clean up the lymphatics you will find a need to cleanse all organs and the blood.

_____ END

NOTES

Many important processes rely on methylation, including the metabolism of lipids and DNA. Scientists suspect that adequate methylation of DNA can **prevent the expression** of harmful genes, such as cancer genes.

What does the prevention of expression infer?

“The science of epigenetics is our key to health and vitality, because unlike the science of genetics which relegates our role in our health to an “afterthought”, because after all: “it’s in our genes”, **epigenetics states that what is produced, expressed at the genetic level is connected to the lifestyle choices we make.** By the choices of the foods we eat, the supplements we take and even by the thoughts we think and the emotions we feel. All these factors are predominant influences in what shows up as our bodies and as our chemistry for better or for worse, because they all effect our genes.”

“In fact gene activity depends on a wide variety of nutrients which can function as on-off switches. What this really means is that **we can literally feed our genetics, for better or for worse.** The latest scientific literature shows that genetics is not a hard-wired, fixed and rigid system, but rather a flexible and responsive biochemical milieu that adapts to environmental and chemical changes during the lifetime of it owner.”

Human detoxification enzymes can be genetically modified to improve their performance and increase their numbers, AT THE GENETIC LEVEL! That means better detoxification of poisons. Vegetables are loaded with these substances. The cruciferous vegetable are especially important in this regard, broccoli, kale, cauliflower, cabbage and Brussels sprouts, but all plant materials contain some phytonutrients that up the production of detoxification and anti-cancer genetics. - http://pharmacistben.com/health/in-your-genes-so-what/

IODINE (A MIX OF NOTES AND FINDINGS I DID NOT REFERENCE)

Iodine is a trace element that is naturally present in some foods, added to others, and available as a dietary supplement. Iodine is an essential component of the thyroid hormones thyroxine (T4) and triiodothyronine (T3). Thyroid hormones regulate many important biochemical reactions, including protein synthesis and enzymatic activity, and are critical determinants of metabolic activity. They are also required for proper skeletal and central nervous system development in fetuses and infants

Iodine rarely occurs as the element, which is a gas, but rather as a salt; for this reason, it is referred to as iodide and not iodine. Iodide is quickly and almost completely absorbed in the stomach and duodenum. When iodide enters the circulation, the thyroid gland concentrates it in appropriate amounts for thyroid hormone synthesis and most of the remaining amount is excreted in the urine. **The iodine-replete healthy adult has about 15–20 mg of iodine, 70%–80% of which is contained in the thyroid - the thyroid is not the only organ or system that requires iodide.**

Median urinary iodine concentrations of 100–199 mcg/L in children and adults, 150–249 mcg/L in pregnant women and >100 mcg/L in lactating women indicate iodine intakes are adequate. Values lower than 100 mcg/L in children and non-pregnant adults indicate insufficient iodine intake, **although iodine deficiency is not classified as severe until urinary iodine levels are lower than 20 mcg/L**.

According to WHO, a median urinary iodine concentration of 150–249 mcg/L indicates adequate iodine nutrition during pregnancy, **while values less than 150 mcg/L are considered insufficient** . **Analyses of NHANES datasets covering time periods from 2001 to 2008 indicate that a substantial portion of pregnant women in the United States are iodine insufficient.**

In the United States, salt manufacturers have been adding iodine to table salt since the 1920s, although it is still a voluntary program. The U.S. Food and Drug Administration (FDA) has approved potassium iodide and cuprous iodide for salt iodization while the WHO recommends the use of **potassium iodate due to its greater stability,** particularly in tropical climates. According to its label, iodized salt in the United States contains **45 mcg iodine/g salt (between 1/8 and 1/4 teaspoon).** However, the majority of salt intake in the United States comes from processed foods, and food manufacturers almost always use non-iodized salt in processed foods. If they do use iodized salt, they must list the salt as iodized in the ingredient list on the food label

During pregnancy and early infancy, iodine deficiency can cause **irreversible** effects. Under normal conditions, the body tightly controls thyroid hormone concentrations via TSH. Typically, TSH secretion increases when iodine intake falls below about 100 mcg/day. TSH increases thyroidal iodine uptake from the blood and the production of thyroid hormone. **However, very low iodine intakes can reduce thyroid hormone production even in the presence of elevated TSH levels.**

“If a person's iodine intake falls below approximately 10–20 mcg/day, hypothyroidism occurs, a condition that is frequently accompanied by goiter. **Goiter is usually the earliest clinical sign of iodine deficiency**.” **EXCUSE ME BUT: Goiter is the result of long-term and severe deficiency. Most people have low iodine levels and the consequences of such without ever getting goiter!**

In infants and children, **less severe iodine deficiency can also cause neurodevelopmental deficits such as somewhat lower-than-average intelligence** as measured by IQ. Mild to moderate maternal iodine deficiency has also been associated with an increased risk for **attention deficit hyperactivity disorder** in children. In adults, mild-to-moderate iodine deficiency can cause goiter as well as impaired mental function and work productivity secondary to hypothyroidism. Chronic iodine deficiency may be associated with an increased risk of the **follicular form of thyroid cancer**.

People with marginal iodine status who eat foods containing goitrogens
Consumption of foods that contain goitrogens, substances that interfere with the uptake of iodine in the thyroid, **can exacerbate iodine deficiency**. Foods high in goitrogens include soy and cassava, cabbage, broccoli, cauliflower, and other cruciferous vegetables. Deficiencies of iron and/or vitamin A may also be goitrogenic. These issues are of concern primarily for people living in areas prone to iodine deficiency. *For most people, including most of the U.S. population, who have adequate iodine intakes and eat a variety of foods, the consumption of foods containing goitrogens in reasonable amounts is not a concern.* **MOST OF THE US? Most of the people in US are deficient in vitamins A, all Bs, C, E, D, K, iodine, magnesium, zinc…**

The RDA is **150 micrograms (but our thyroid contains 15-20 MG).** According to Dr. Michael B. Schacter of the Schacter Center for Complementary Medicine, in iodine deficiency states it can take up to a year to become sufficient in iodine using a RDA dose.

There are 5 main forms of Iodine:

Potassium Iodide – This is the standard form of iodide delivery. It is the form suggested in the literature for protection from radioactive Iodine 131. It is 76.5% iodine, the remaining 23.5% being composed of potassium.

Potassium Iodate is 1 molecule of potassium with one molecule of iodine associated covalently with 3 molecules of oxygen. It is considered to be 60% iodide. The remaining 40% being composed of oxygen and potassium.

Iodine and Iodide- although used synonymously they are electrically different. Iodide is reduced or negatively charged iodine. And iodine is the active element is its uncharged state. Some literature suggests that different people and conditions respond differently to iodide and iodine. If you are using a blend (Lugol’s or Ioderol or Iodizyme HP) you’re getting both forms and that seems to me to be a better option than just the iodide form (as in SSKI or KI) , although general consensus among the experts is mixed.

Colloidal iodine is food based iodine and is the form available for herbal and kelp based tinctures and tablets and capsules.

Several other important points include:
No one really knows how much iodine is needed for good health or protection or total saturation in an emergency condition. It's mostly speculation and there isn't much research available.

Remember: not all iodine preparations contain the same concentrations of active iodine.

Lugol's Solution Iodine:
Contains 6.3 mg of molecular iodine/iodide per drop. This solution is one-third molecular iodine (5%) and two-thirds potassium iodide (10%). Studies show that the best form of iodine is one that includes molecular iodine (I2). It has been shown that breast tissue prefers this non-toxic mono elemental-based iodine. Lugol's Solution has been shown to increase respiratory tract secretions and inhibit thyroid hormone secretion. One Malaysian study found that patients taking Lugol's solution experienced a sharp decline in unwanted hormonal secretions during a period of ten days.

Potassium Iodide:
Comes in tablets, with servings ranging from 0.23 to 130 mg. This closely-bound inorganic form of iodine has been shown to only offer 20% assimilation to bodily tissues. Studies show that potassium iodide blocks the uptake of radio-iodine in the thyroid gland, thus lowering the chances of developing thyroid cancer [2]. Moreover, potassium iodide has been used in emergency treatments for hyperthyroidism

How a Gallbladder Flush works:

"When we consume any food that contains fat or oil, as the food moves from the stomach into the duodenum, the presence of fats in the duodenal area signals to the gallbladder, which then contracts and squirts an amount of bile equal to the quantity of fat or oil detected in the food. The bile acts like a detergent, making the fats into a water-soluble solution."

"When a person consumes 4 ounces of oil at a time, this is far more oil than the body is designed to consume. Therefore, when such a large volume of oil moves into the duodenum, it causes the gallbladder to spasm radically and releases a larger volume of its contents, which will contain not only bile, but also cholesterol balls and possibly gallstones."

"Of the hundreds of thousands of Gallbladder Flushes taking place around the country, there is an extreme few that ever have any problems at all with the Gallbladder Flush. The greatest fear a person may have is quite unfounded, but that fear is: "What if something gets caught and won't release?" The only way this can be a problem is if a person were to panic and run to the hospital. The hospital only has expensive and painful solutions surrounded by volumes of projected fear. Remember well! This procedure is very simple, and if you suspect any problem whatsoever, simply take another 8 ounces of the juice and oil combination and the problem is solved!!"