

Chlorophyll

The Wonder Pigment

Chlorophyll, the green plant pigment, a 'real life force' of living beings, besides synthesizing food, is a great source of vitamins, minerals and other phytochemicals. Adding chlorophyll rich food to our diet fortifies our body against health disorders.

CALL it by any name, 'Green Gold' or 'Plant Blood', chlorophyll is a proven pigment of life. But few have any idea about chlorophyll's wonders.

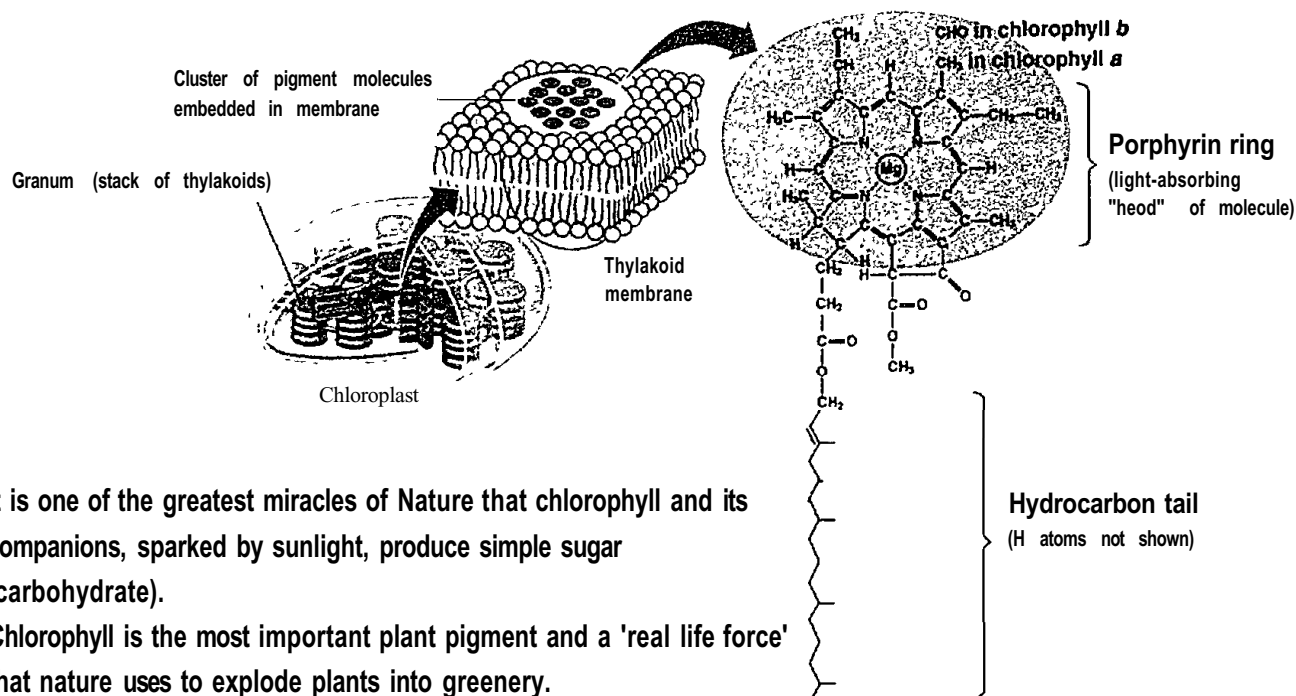
Chlorophyll is the most important plant pigment and a 'real life force' that nature uses to explode plants into greenery. It is not a single compound, but made up of two classical components—the bluish black chlorophyll-a, with composition $C_{55}H_{72}O_5N_4Mg$, and dark green

chlorophyll-b, with composition $C_{55}H_{72}O_5N_4Mg$.

Chlorophyll is photoreceptive, absorbs blue and red spectrum of the visible light (at wavelengths 400-700 nm) and reflects the unabsorbed spectrum in the green region. It is the green reflection that makes plant parts look green. The colours in flowers and fruits are due to other pigments. The spectacular show of green turning to brilliant shades of yellow and red in autumn before plants shed leaves is

nothing but manifestation of pigment change, from one to another.

Chlorophyll is quite delicate, it cannot work alone. It is also not very stable under bright sunlight. If there is too much ultraviolet, the process of photosynthesis begins to release an excess of damaging molecules called 'free radicals', which could destroy the sensitive chlorophyll. But they don't; the plant has its own built-in antioxidants. Inside, hidden by the dark green of the chlorophyll, vitamins, the



yellow and orange pigments, are at work to quell them. Chlorophyll is present in the membrane of disc-like structures called 'chloroplasts', which are like chemical factories powered by the sun to synthesize carbohydrates. A leaf has about 500,000 chloroplasts per square millimeter.

It is one of the greatest miracles of Nature that chlorophyll and its companions, sparked by sunlight, produce simple sugar (carbohydrate). The process is called 'photosynthesis', which beyond doubt is the most fundamental of all biochemical reactions and one that helps plants to grow, flower, produce seed and sustain life on Earth.

Chlorophyll and Human Blood

It's a good old grandmother's saying, "More pretty colours you eat, lovelier you will be." The wisdom behind the saying became scientifically convincing when Dr. Richard Martin Willstatter, a German chemist, showed a striking resemblance of chlorophyll with human blood. The hemoglobin of human blood, composed of carbon, hydrogen, oxygen

and nitrogen atoms, grouped around a single iron atom, is similar in composition except that chlorophyll's centerpiece is magnesium instead of iron.

Plants and people have a lot in common than we might have realized. The hundreds of enzymes that organize physiology inside a plant's body, turn glucose into all kinds of vitamins, antioxidants, and other chemical moieties and various biochemical reactions inside our body use glucose as fundamental source of energy! Chlorophyll is often described as the 'blood of plants' and chlorophyll-rich foods have been linked with increasing hemoglobin content. Tributes to late Prof Willstatter for elucidating chlorophyll's chemical structure, and conclusively showing it's close resemblance to human blood. His several years of extraordinary work and masterly experimental skills at the University of Zurich, Switzerland, earned him the Nobel Prize for chemistry in 1915. His investigations on chlorophyll and enzymes paved way for the foundation of modern biochemistry.

The colours in flowers and fruits are due to other pigments, such as

carotenoids and anthocyanins. Taking cue, human beings started using about 2000 pigments in food to enhance the eating pleasure, and thus unknowingly availed their incredible health promoting properties. In 1919, Steenbock curiously observed that while yellow corn and "yellow" vegetables (such as carrots, sweet potatoes, etc) eliminated symptoms of vitamin A deficiency in rats, the white ones such as corn, parsnip, and potato did not. The carotenoids and proteins act as light harvesting complexes in photosynthesis and protect the photosynthetic system from UV effects.

Some say drinking one ounce of the juice squeezed from long blades of wheat grass is equal to eating 2.5 pounds of green leafy vegetables. However, there is no substitute for diets rich in green vegetables and fruits.

Feature Article

Free Radicals and Antioxidants

The frequently used terms, free radicals and anti-oxidants are jargons to many and therefore it is necessary to understand them first. Our body cells produce highly reactive atoms when oxygen interacts with certain molecules. They are called free radicals, which are needed in energy production, and also for killing bacterial invaders and flushing out body cells, which are outlived. But if unchecked or present in excess, free radicals start chain reactions, like dominoes, with anything they come across such as cell membrane, DNA, mitochondria, or enzymes leading to the poor functioning or death of body cells. A cut up apple turning brown and vegetable oils turning rancid are examples of oxidation by free radicals.

Free radicals lead to health problems such as cataracts, premature aging, arthritis, cancer etc. But our body is greatly protected and our life extended by a constant flow of phytochemicals that act as antioxidants. They may be pigments, vitamins, minerals or enzymes. The well known are vitamin C, vitamin E, and beta-carotene. Antioxidants work as a major police force counteracting the damage by binding with them. More importantly antioxidants return to the surface of the cell to stabilize rather than damage other cellular components. Except for vitamin D, and a bit of vitamin K, our body cannot

manufacture antioxidants. Their deficiency increases vulnerability to various diseases. Vegetables and fruits, particularly deep green, bright yellow and red ones, are very rich in phytochemicals. Adding them to our diet in combinations is like fortifying our body against diseases and ill health.

Chlorophyll's Effect on Cancer

Cancer research exploring cures and prevention measures has been trying the effects of chlorophyll on cancer cells. In the mid 1980s, Dr. Roderick Dashwood of Oregon State University discovered that rainbow trout fed on Aflatoxin-B1 (AFB1), together with chlorophyllin, a chlorophyll derivative, commonly extracted from the alfalfa grass, had greatly reduced damage to their liver DNA, compared to trout receiving AFB1 alone. The results were the first scientific confirmation of the chemo-protective effect of chlorophyll. John Groopman and Tom Kensler at the Johns Hopkins University experimenting on rats found similar results.

AFB1 is one of the most potent carcinogens produced by certain species of fungi (e.g. *Aspergillus flavus*) in moldy peanuts, corn, rice etc. Interestingly, AFB1 came to be recognized as a potential human liver carcinogen only after it was identified as the cause of outbreaks of liver cancer in rainbow trout hatcheries in the Pacific Northwest in the 1960s. Hot, humid

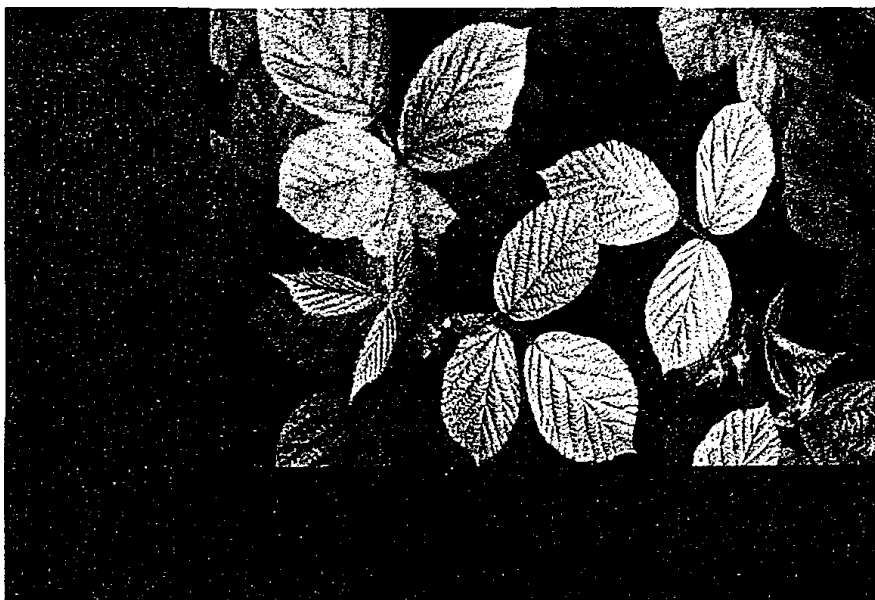
regions of Africa and Asia have the highest rates of liver cancer due to consumption of inadequately stored grains and nuts. In another finding, chlorophyll fed to laboratory animals reduced absorption of three dietary-carcinogens: heterocyclic amines (found in cooked muscle meats), polycyclic hydrocarbons (found in smoked and barbecued foods), and AFB1.

Most human cancers are due to mutations in the genes that control cell division. Mutations induce uncontrolled cell growth giving rise to cancer in the lung, blood, bone etc. Anti-mutagenic chlorophyll form tight complexes with certain chemicals, suspected to cause cancer, such as AFB1, polycyclic hydrocarbons found in tobacco smoke, heterocyclic amines found in cooked meat, while they are still in the digestive tract thus reducing the amount reaching the susceptible tissues.

Chlorophyll-rich Vegetables

While all green plants contain chlorophyll a, and most vegetables that we eat contain both chlorophyll a and chlorophyll b, some vegetables contain particularly high amounts of total chlorophyll. Best studied of all the vegetables is spinach (*Spinacia oleracea*), with this vegetable containing about 300-600 milligrams per ounce.

The National Cancer Institute of the United States, which spent over \$20 million in researching the anticancer potential of plant foods, found that the members of the cabbage family (Cruciferae) such as Broccoli, Brussels, Cabbage, Cauliflower, and Collards green, Mustard greens, Radish, Turnip and the members of carrot family (Umbelliferae) such as Celery, Cilantro, Parsley, Beet, Parsnips, possess several cancer-fighting phytochemicals. The green collards alone were found to contain 10-15 such compounds (organosulfur) in comparison to about 100 found in rest of the plants. A cup of cooked collard greens provide 57.6% of the daily value (DV) of vitamin C, 8.3% of the DV of vitamin E, and an amazing 118.9% of the DV of vitamin A. Other green vegetables rich in micronutrients are spinach, drum stick leaves, lettuce, cucumber, beans and green peas.



Feature Article

Chlorophyll in Algae

Amazingly, some freshwater and marine algae, yet to find place in our daily diet, are rich in chlorophyll and are treasure troves of several micronutrients. The single celled algae, Chlorella and spirulina, have several astounding properties and are near perfect examples. A 10 g biomass of an ideally grown Chlorella, contains about 280 mg of chlorophyll, and spirulina about 115 mg. Chlorella, by far the richest source of age fighting RNA and DNA, has high concentrations of nucleic and amino acids and about 20 different vitamins and minerals. It improves immune system functions, heavy metal and pesticide detoxification and anti-tumor activity. It is the number one selling health food supplement in Japan.

Spirulina is a *natural* source of vitamin B12, iron, chromium, selenium and essential fatty acids (GLA). Indeed, it contains 50 times more iron than spinach and 10 times more bone building calcium than milk. It is reported to lower cholesterol and triglyceride levels in the blood and support cardiovascular function.

Kelps, the giant seaweeds, go perfect with the phrase 'take sea vegetation without hesitation'. Kelps contain mucilaginous alginates, which are like most fibres, gums and mucilages, swell in the intestine and absorb toxins and heavy metals. Japanese studies have shown that regular consumption of kelps reduces breast cancer risk.

Chlorophyll Juices

Though nothing can replace a sound diet, exercise and a positive attitude, it is really wonderful that something so simple as green grasses can give us strength to combat life's pitfalls. Green grasses indeed are the only vegetation many herbivores eat to meet their nutritional requirement. We know that to the great herds of the plains that survive the dry season or winter, nature provides the most nutritious of foods, even to their young ones with green sprouting grasses. These grasses contain about the same vitamins and minerals as dark green vegetables. Wheat, barley and alfalfa are considered the most nutritious of the green grasses.

Young barley and wheat grasses from sprouted grains are frequently used in juices and drink blends. Their

leaves contain a multitude of enzymes, carotenoids, vitamins such as folic acid, and minerals. The young barley juice powder contains 13 times as much carotene as that of carrots, 55 times as much vitamin C as that of apples and five times as much iron as that of spinach. It also contains boron and manganese. Wheat grass claimed to prevent greying of hair and tooth decay, helps strengthen the walls of the body cells and improves the immune system. When young, they have a different chemical makeup. For example, wheat grass has 32 g of protein per 100 g, while wheat flour has only 13 g. The wheat grass has about 23,000 International Units (IUs) of vitamin A per 100 g, while wheat flour has none.

Greens in Green Tea

Green tea guards against cardiovascular disease in many different ways. It lowers cholesterol and blood pressure and reduces platelet aggregation. It's epigallocatechin gallate (EGCG), an antioxidant, is reported to be at least 100 times more effective than vitamin C and 25 times than vitamin E at protecting cells and DNA from damage, believed to be linked to heart disease and cancer. It contains volatile oils, vitamins, minerals and polyphenols that lessen the risk of cancers and stimulate production of immune system cells. According to Chinese legend, an emperor discovered green tea accidentally 4,000 years ago, since then, traditional Chinese medicine has recommended green tea for headaches, depression, digestion, and to prolong life.

Chlorophyll's other Benefits

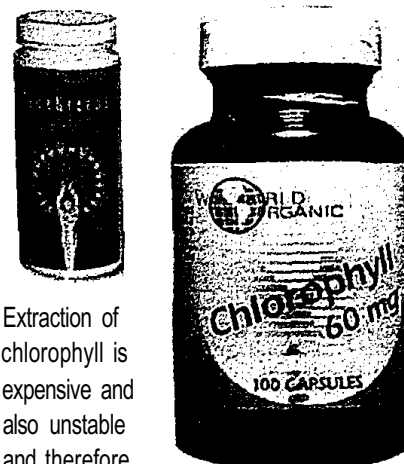
Chlorophyll has been used in folk medicine as a deodorizer.

It is effective for those suffering from halitosis (bad breath) and can be used for a freshening gargle.

It is used in treating diabetic foot ulcer, constipation and hemorrhoids (swelling of veins around lower rectum), used to neutralize the acidifying and stimulating effect of excess protein, sugars and starch.

Chlorophyll is used as a colouring agent in products such as soaps, candy and in formulations for skin health and glow.

Carotene associated with chlorophyll is converted into vitamin



Extraction of chlorophyll is expensive and also unstable and therefore, most of the health stores sell it's derivative as liquid or as easy-to-swallow capsules

A, which is essential for normal growth, good eye-sight and healthy skin.

Magnesium in chlorophyll improves immune potential by increasing phagocyte activity or the microbe gobbling efficiency of white blood cells.

Chlorophyll as Supplement

When we think of supplementing our foods, we think of vitamins and mineral supplements, but not chlorophyll. How does one take chlorophyll? Eat green plants! Our busy lifestyle does not permit to extract juice or grow our own sprouts, instead we try to get the benefits of green foods through capsules, tablets or powder of dehydrated or freeze dried forms of wheat grass, blue green algae, or different cereal grasses.

Chlorophyll or its derivative, chlorophyllin is not toxic. Extraction of chlorophyll is expensive and also unstable and, therefore, most of the health stores sell it's derivative as liquid or as easy-to-swallow capsules. When taken orally, chlorophyllin may cause green discoloration of urine or feces or yellow or black discoloration of the tongue. Some say drinking one ounce of the juice squeezed from long blades of wheat grass is equal to eating 2.5 pounds of green leafy vegetables. However, there is no substitute for diets rich in green vegetables and fruits.

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