A plant physiologist casts a critical eye on the current chlorophyll craze

AN UNCOLORED VIEW OF CHLOROPHYLL

By ARTHUR W. GALSTON

I HOPE THAT THE person who proposed as the title of this talk*, "The Magic of Chlorophyll," had his tongue well in his cheek, because I come not to praise chlorophyll, but to bury it.

I should make it clear at the outset that I have nothing against chlorophyll per se. As a plant physiologist I am aware that my livelihood depends upon the fact that plants are green, upon the fact that there is a substance known as chlorophyll which possesses certain wonderful—one might say even magical—properties.

Chlorophyll, as you know, is the green pigment of plants. It is universally distributed in green leaves and stems, but is absent from most roots and the white areas of variegated leaves.

Chemically speaking, there are at least two chlorophylls, differing from each other in only minor respects. They are both composed of carbon, hydrogen, oxygen, nitrogen and magnesium, and the organic chemist knows them as substituted tetrapyrroles grouped around a central core of magnesium.

In the plant, chlorophyll does not occur randomly dispersed throughout the leaf, but, rather, is localized in little bodies called chloroplasts, which are about the size and shape (but not the color) of our red blood corpuscles. Chlorophyll in the chloroplasts is closely bound to other chemicals which are important to its stability and function.

Now, every student of elementary plant physiology knows how to get chlorophyll out of the chloroplasts and out of the leaf. He merely immerses a leaf in some appropriate solvent such as methyl alcohol or acetone, and the green pigment readily passes out into the solvent. The solvent may then be evaporated away, leaving the chlorophyll-containing pigments behind.

The chlorophyll thus extracted is quite unstable, especially in light, and is also insoluble in water. It may be readily converted into a stable water-soluble derivative known as chlorophyllin by first treating it with alkali to remove the long-chain phytol substituent, and then by replacing the magnesium core of the molecule with copper or nickel. It is these simple procedures, long known to plant physiologists, which have resulted in the booming new multi-million-dollar chlorophyll industry.

What is it about chlorophyll that is so exciting and interesting? We know, in the first place, that it is chlorophyll which absorbs the light energy that makes possible the fixation and reduction of atmospheric carbon dioxide to sugar. This process of photosynthesis is of basic importance to all of us, for without it, animal life on earth would be impossible.

The sugars and other organic materials formed by green plants constitute the basic fuels for all of us, for when we walk, pound a typewriter, or sing a lullaby,

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we are using the energy released by the combustion of sugars in our body. Thus we are all essentially machines operating on solar energy. The green plant is the gear that makes that solar energy available to our bodies, and chlorophyll, in some way that we do not yet completely understand, is a key component of this gear.

Recently, it has become quite clear that what chlorophyll does is, in a way, magical. Everyone knows what a stable material water is. You can apply great quantities of heat to water and you don't decompose it: all you do is vaporize it. If you take hydrogen and oxygen, which are the components of water, they will ignite explosively to make water. If you want to tear water apart, you must expend just as much energy to do it as was liberated by that explosion. You have to electrolyze it or do something else very drastic.

It has now been found that chlorophyll does, in fact—with the aid of light energy—tear this stable water molecule apart. The oxygen produced from this disruption of the water molecule is released into the air. This, incidentally, is very fortunate for us because we all require oxygen, and if plants didn't release it, we would run out of it eventually. The hydrogen which is left behind after the release of oxygen furnishes a sort of reservoir of reducing power which somehow gets funneled to the carbon dioxide, converting it eventually to sugar.

What chlorophyll does in a plant

I do not mean to deliver a lecture on elementary plant physiology, but I should like to sum up here again what chlorophyll does in a plant. It dismembers a water molecule, using light energy to do the job. This results in the liberation of oxygen and eventually in the formation of sugar, both of which products make our existence possible. We may not actually eat sugar, of course: we may eat, instead, the protein of a cow. But, after all, the cow in turn has eaten a plant product to make the meat we eat. Ultimately, as the Bible says, all flesh is grass.

Chlorophyll doesn't accomplish this tremendous job by itself. In the chloroplasts there is an abundance of protein and fat, and the chlorophyll cannot function, so far as we know, without being firmly attached to the protein and fat. This fact immediately makes us a bit suspicious of so-called water-soluble, unattached chlorophyll—which is added to toothpaste, for instance.

An analogous situation exists in the red pigment of our blood, which we call hemoglobin. The heme, or the red part of this compound, is chemically very similar to chlorophyll—but it is attached to a protein, or globin, to make hemoglobin. In the same way, you have a chlorophyll protein which is completely analogous with the hemoglobin, and unless the protein is there you get no chemical activity.

We know, then, that chlorophyll is necessary for green plants. What does it do to animals? There are—I am pleased to state—at least two recognized medical uses for chlorophyll—though I had to do a good deal of digging in the literature to find them.

First, chlorophyll is known to stimulate the production of healing tissues—so-called granulation tissue—in certain types of lesions. If you have a peptic ulcer, for instance, some doctors will recommend a preparation of chlorophyll, together with aluminum hydroxide and magnesium trisilicate. This is mixed up into a paste, which you take into your stomach and, if you are lucky, you will lose your ulcers.

I do not speak from personal experience, but I would guess that there are probably better things to take for ulcers. However, this is a use of chlorophyll which has in the past been recommended, and one can claim that it has medical validity.

The second accepted use is the one that has given rise to the current fad. Gangrene, as you may know, is essentially a rotting of the flesh in deep-seated wounds. Certain gangrenous lesions, usually incurred as a consequence of military activity, may become rather foul-smelling. It was found some years ago that the application of chlorophyll pastes to this particular type of lesion would decrease the unpleasantness of the odor associated with them.

You now have the necessary background for understanding the chlorophyll boom, and for seeing how a bright brain, in an effort to "make an honest buck" could launch an attempt to deodorize the American public. You begin with two scientific facts:

1. Certain kinds of lesions that smell bad are made less obnoxious if you smear chlorophyll poultices on them.

2. Chlorophyll in the plant results in the production of oxygen, thus "purifying the air."

Clearing the air

The manufacturers of air-purifiers were the first to take advantage of these facts. I think you are familiar with the use of these products. You take the magic bottle and put it in the corner of the room in which, let us say, you are cooking onions. Now that magic little bottle, containing miracle-working chlorophyll, absolutely kills the odor of the onions in the room.

How does this magic bottle work? As a matter of fact, it operates on a very old principle: If you can't lick 'em—join 'em. They can't really lick that onion odor, but they *can* prevent you from smelling it—or from smelling anything else, as it turns out. What they accomplish is the deadening of your sense of smell by means of a volatile anaesthetic, such as formaldehyde. The job is done, and *you* won't smell any onions, but the smell is still there. Thus chlorophyll appears to have nothing whatever to do with the deodorizing effect of this preparation.

After the air-purifiers came the production of water-soluble chlorophyllin from alfalfa—apparently by the classical methods well known to students of elementary plant physiology. It is this water-soluble product which

The author—and subject. Dr. Galston, a plant physiologist, is Associate Professor of Biology at the California Institute of Technology. In the laboratory picture at the right he is holding a separatory funnel containing an extract of leaf pigments. The chlorophyll appears as the dark liquid at the top of the funnel.

has now found its way into soaps, toothpastes, gargles, hair tonics, inner soles for shoes, dog food, baby diapers, and other products almost too numerous to mention.

Frankly, I don't think any of these products containing either chlorophyll or chlorophyllin do what they are represented as doing. But my feeling definitely represents a minority opinion, for about $100,000,000 worth of chlorophyll-containing products were sold during the last fiscal year. I think that our most charitable appraisal must be that we have here a case of a little bit of truth going a very long way.

Recently, the American Medical Association and the American Dental Association felt called upon to issue statements on this subject. Cautiously, and in diplomatic language, they have said that present evidence does not indicate that the claims made for these various products are in fact justified. To my knowledge, no refutation of this statement has ever been made by any company manufacturing a chlorophyll product.

A question of ethics

This brings up a question of ethics—and perhaps a question of the duties of government. Here are the American people willingly parting with a good deal of money for products that are, to put it mildly, not what they are represented as being. Should this waste be permitted?

I don't know whether most people would feel they were being imposed upon if such products were compulsorily withheld from the market until their claims were proved. Americans are very jealous of their freedom, and probably the freedom to be gypped is one of the freedoms we all treasure. However, we do have a Pure Foods and Drugs Administration, and a Federal Trade Commission, and these organizations do have some jurisdiction over such matters.

You may remember back to the days when a certain "vegetable compound" was sold as a cure for almost any feminine ailment. A lot of extravagant claims were made for the compound, but the only effective principle in it turned out to be ethyl alcohol. Eventually, as a result of the intervention of federal agencies, the manufacturers were required to state this fact.

Many extravagant claims have similarly been made by cigarette manufacturers—and are now being made by manufacturers of chlorophyllin-containing products. Perhaps, if we are going to have a Pure Food and Drugs Administration, we ought to support it to the extent that it can conduct policing operations effectively.

Get your chlorophyll here

What if I am wrong in this one man's appraisal of chlorophyll? Suppose that chlorophyll does all these things that manufacturers claim for it? If that is the situation, I have a very simple recommendation. You undoubtedly have some green plants growing around your home; there is abundant grass on the Caltech lawns; and there is lots of spinach in the market. Just buy some, or pick some, and eat it. You will get more chlorophyll that way than you will in any of the chlorophyll products.

I think the best summary and conclusion that I can make of this problem is contained in a little poem that appeared recently in *Chemical and Engineering News*. It went like this:

"Why reeks the goat on yonder hill
Who seems to dote on chlorophyll?"